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**Information technology frameworks in LIS:  
exploring IT constructs as sources of  
conceptual alignment**

By

**Maria Inês Durão de Carvalho Cordeiro**

Thesis submitted for the Degree of Doctor of Philosophy  
at the University of London

**University College London**

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## **ABSTRACT**

Library and Information Science (LIS) and Computing/IT are closely related fields as both have at their very core the same object of concern: information and information services. Yet, weaknesses in the transfer of knowledge between the two domains have been apparent at both the conceptual and practice levels.

The first question investigated in this thesis is what characterizes the relationship between LIS and IT and what have been its limitations and constraints. It is found that IT knowledge acquisition and transfer have been fragile and poorly consolidated, despite the history of common interests and interactions. As a result, the conceptual foundations of library information systems are still very much the same as they were in the analogue environment. However, deeper forms of IT knowledge are critical for the re-conceptualisation and redesign of library services in the face of the changes brought about by the network environment.

These findings led to the investigation of a second question: how to enhance IT knowledge in LIS with durability and beyond the level of practical skills. This part of the research considered the hypothesis that the evolution of IT, and its conceptual underpinnings, can be a source of possible building blocks for common knowledge between LIS and IT. To explore this idea the field of computing/IT was analysed through the perspective of interoperability. A set of trends/concepts was identified as having potential applicability beyond the realm of technical IT systems, notably in the articulation of strategies for IT, information and organizational management.

Overall, the study points out the need for a more effective participation of LIS in both the technical and social processes of IT production, reproduction and transformation. The conclusions suggest that a stronger appropriation of the ontology and languages of IT can help to overcome the limitations of the typical IT views in LIS and contribute to a more integrated model of communication between the fields.

### **DECLARATION OF AUTHORSHIP**

I hereby declare that that the work and text of this thesis is my own work, including figures and tables, except where explicitly and individually indicated otherwise.

Maria Inês Durão de Carvalho Cordeiro

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## LIST OF ABBREVIATIONS

AACR	Anglo American Cataloguing Rules
ACM	Association for Computing Machinery
ACM/SIGIR	ACM Special Interest Group on Information Retrieval
AI	Artificial intelligence
AIS	Association for Information Systems
ALA	American Library Association
ANSI	American National Standards Institute
API	Application programming interface
APDU	Application protocol data unit
ARL	Association of Research Libraries
ARPA	Advanced Research Projects Agency
ASIS	American Society for Information Science
ASIST	American Society for Information Science and Technology
ASN1	Abstract Syntax Notation One
ATS	Author title subject
B2B	Business to business
BER	Basic Encoding Rules

BSR	Basic Semantic Registry
CAD	Computer aided design
CASE	Computer software aided engineering
CAUSE	College and University Systems Exchange
CDROM	Compact disc read only memory
CIMI	Consortium for the Computer Interchange of Museum Information
CIO	Chief information officer
CLIR	Council on Library and Information Resources
CLR	Council on Library Resources
CMS	Content management system(s)
CNI	Coalition for Networked Information
CORBA	Common Object Request Broker Architecture
CQL	Common Query Language
DAMS	Digital asset management system(s)
DBMS	Database management system(s)
DC	Dublin Core
DCE	Distributed Computing Environment
DCE RPC	Distributed Computing Environment Remote Procedure Call
DCMES	Dublin Core Metadata Element Set
DCMI	Dublin Core Metadata Initiative
DCOM	Distributed Component Object Model
DLF	Digital Library Federation
DLI	Digital Library Initiative
DNER	Distributed National Electronic Resource
DOM	Document Object Model
DTD	Document type definition
DTP	Distributed transaction processing
EAI	Enterprise application integration
ebXML	Electronic Business Extensible Markup Language
EC	European Commission
ECDL	European Computers Driving Licence
ECIA	European Council of Information Associations
EDI	Electronic data interchange
EDIFACT	EDI for Administration, Commerce and Transport
eLib	Electronic Libraries Programme
ER	Entity relationship
FOLDOC	Free On Line Dictionary of Computing

FTP	File Transfer Protocol
GII	Global information infrastructure
GILS	Global Information Locator Service
GUI	Graphical user interface
HCI	Human computer interaction
HEFC	Higher Education Funding Councils (of England, Scotland and Wales)
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IA	Information architecture
ICDL	International Computer Driving Licence
ICT	Information and communication technologies
IDL	Interface definition language
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IFIP	International Federation for Information Processing
IFLA	International Federation of Library Associations and Institutions
ILL	Interlibrary loan
IM	Information management
IMLS	Institute of Museum and Library Services
IMS	Information management system(s)
INFORMS	Institute for Operations Research and Management Sciences
INCITS	InterNational Committee for Information Technology Standards
IR	Information retrieval
IS	Information Systems
ISBD	International Standard Bibliographic Description
ISD	Information systems development
ISO	International Organization for Standardization
IT	Information technology(ies)
ITU	International Telecommunication Union
JISC	Joint Information Systems Committee
JSTOR	Journal Storage: The Scholarly Journal Archive
KM	Knowledge management
LC	Library of Congress
LIS	Library and Information Science (or Studies)
LITA	Library and Information Technology Association
LMS	Learning management system(s)

LSP	Linked Systems Project
MARC	Machine Readable Cataloging
MARCXML	MARC21 XML Schema
MDA	Model Driven Architecture
MIA	MODELS Information Architecture
MIS	Management information system(s)
MLA	Museums, Libraries and Archives Council
MODELS	MOving to Distributed Environments for Library Services
MODS	Metadata Object Description Schema
NARA	National Archives and Records Administration
NASA	National Aeronautics and Space Administration
NCCP	National Coordinated Cataloging Program
NCLIS	National Commission on Libraries and Information Science
NEH	National Endowment for the Humanities
NIDR	Network information discovery and retrieval
NII	National Information Infrastructure
NISO	National Information Standards Organization
NLM	National Library of Medicine
NSF	National Science Foundation
OAI	Open Archives Initiative
OAI PMH	OAI Protocol for Metadata Harvesting
OASIS	Organization for the Advancement of Structured Information Standards
OCLC	Online Computer Library Center
ODP	Open Distributed Processing
ODP RM	ODP Reference Model
OI	Organizational Informatics
OID	Object identifier
OMG	Object Management Group
ONIX	Online Information eXchange
OO	Object-oriented, or orientation
OPAC	Online public access catalogue
OSI	Open Systems Interconnection
RDBA	Remote database access
RDBMS	Relational database management system
RDF	Resource Description Framework
RDFS	Resource Description Framework Schema
RFC	Request for comments

RLG	Research Libraries Group
RLIN	Research Libraries Information Network
RMI	Remote method invocation
RPC	Remote procedure call
RSS	RDF Site Summary
SDK	Software development kit
SGML	Standard Generalised Markup Language
SLA	Special Libraries Association
SMTP	Simple Mail Transfer Protocol
SOA	Service oriented architecture
SOAP	Simple Object Access Protocol
SQL	Structured Query Language
SR	Search and retrieve (protocol)
SRU	Search and Retrieve URL Service
SRW	Search and Retrieve Web Services
SSM	Soft Systems Methodology
TCP/IP	Transmission Control Protocol/Internet Protocol
UAP	Universal Availability of Publications
UBCIM	Universal Bibliographic Control and International MARC
UDDI	Universal Description, Discovery and Integration
UDT	Universal Dataflow and Telecommunications
UKOLN	UK Office for Library Networking
UML	Unified Modelling Language
UNIMARC	Universal MARC Format
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
W3C	World Wide Web Consortium
WAIS	Wide Area Information Servers
WSDL	Web Services Description Language
WSMF	Web Services Modelling Framework
WWW	World Wide Web
XML	Extensible Markup Language
XSL	Extensible Stylesheet Language
XSLT	Extensible Stylesheet Language Transformations
ZIG	Z39.50 Implementors Group
ZING	Z39.50 International: Next Generation



**PART I**  
**INTRODUCING THE RESEARCH**

## **CHAPTER ONE**

### **RESEARCH PROBLEM, BACKGROUND AND PROJECT**

#### **1.1 Introduction**

The relationship between IT and library organizations and services dates back to the 60s. It has been growing in importance at many levels, from the management of discrete internal operations to the renovation of services that are externally provided by libraries. This relationship has become, at an ever growing pace, deeply and widely embedded in the practical realm of libraries, paralleling the very same pervasive effects that IT has brought to the wider information environment within which libraries operate.

Therefore, as for many other organizations (Tansey, 2003: Chap. 2, 5), IT has become a critical factor for libraries to succeed in their goals and objectives. Although nowadays comprehensive, the criticality of IT in libraries has been evolving and becoming more diffuse (Lynch, C., 2000). In that evolution, a persistent and growing problem has been the nurturing of professional competences to cope with both technology management and with the management of organizational objectives by making the most of technology and changes associated with it (Hawkins, 2000). Coping with new competences in this context involves aspects of change and innovation whose implications are unclear. According to Feather (2003),

“the issue is whether this change is a fundamental re-conceptualisation of activities and their purpose, or whether it is merely a change, albeit very significant, in techniques and mechanisms”.

It is generally felt, at the various technical and managerial levels, that different professional groups of library and information management and computing/IT, have been working in library settings without attaining a common, or satisfactorily shared, culture (see, e.g., Lynch, C., 2003). This observation extends to the relationship of LIS departments (either library institutions or schools) with the technology markets (Baker, D., 2004: 224; Pace, 2003: 90-91, 130-33).

Beyond the question of practical IT usage skills, this means a lack of stabilized forms of cross-domain knowledge, important to enable integration of technology and strategy (Bloomfield, et al., 1997a: 1-9). Such an integration implies the building of interfaces for goal alignment and for communication, deemed essential to overcome the problems that derive from the “cumbersome nature of organizations” and the

“obscure, unpredictable and dynamic nature of technology” (Goodman & Lawless, 1994: Chap. 1, 3). As goals and objects of management reside in the application realm, the consequences of a poor integration of the different fields/actors involved have become more problematic for libraries and for the library professionals, than for technologists. Two major explanations are commonly found for this problem.

The first is the rapid pace and complexity of technological developments, difficult to cope even within the technological fields (Denning, 2002), and the steady growth in general demand for technological skills and expertise (Handel, 2003; 2003a). Libraries have adopted IT extensively but in library settings the demand for technological expertise has been more usually for immediate, pragmatic needs of implementation and exploitation of off-the-shelf library information systems, largely relying on third-party vendors’ services (Kochtanek & Mathews, 2002: 6-7), rather than for the planning and development of new library-oriented technologies, technological applications or services (Pace, 2003: 16, 131). Most representative of this situation is the case of systems librarians whose role and educational requirements are still diffuse after more than two decades of clearly differentiated activities, while there is “general agreement that the knowledge required of systems librarians covers three broad areas: library operations, information technology, and management” (Dorrian, 1998: 14).

With the expansion of network technologies and the globalization of information resources, the trend is towards the integration of library technological assets and services in larger, more complex and distributed environments, requiring the convergence of expertise from across many different layers of professional activity (Lavagnino, 1997; Rosenblatt, 1999). In this context, technology is no longer perceived just as ‘product’, ‘tool’ or ‘set of tools’, confined to the performance of given tasks. It is rather an object of management that focuses on systems design and people and policy issues, with implications for a new kind of leadership requiring strategic management of IT (Baker, D., 2004). This leadership should be knowledgeable about IT, though not necessarily heavily technical, and is deemed central to the redefinition of organizations’ objectives and to the efficacy of their considerable IT investments (Green, 2003).

The second major explanation for poor integration of IT and strategy in libraries comes from the significant differences in background between library and information professionals and technologists. In most cases, their educational

backgrounds are opposite extremes of the academic universe, with library practitioners coming from humanities and IT staff from computer science or engineering. This has reflections on issues of labour division, organizational structures and roles, especially in positions where the focus is on the management of library technology (Hughes, 1989; Lovecy, 1994; Pugh, 1997; Dorrian, 1998; Gordon, 2003). Very often, however, the discussion tend to focus, not on questions of IT management and strategy, but on implications of IT for general matters of the profession, such as those of identity, jurisdiction, values, power, status and relevance (Estabrook, 1989; Abbott, 1998; Danner, 1998; Ray, M., 2001).

Finally, LIS educational programmes have had difficulty in finding durable and responsive forms of interdisciplinary education related to IT (Smith, L., 1992; Klein, 1996; Sutton, S., 1999; Wilson, T. D., 2000; Saracevic & Dalbello, 2001; Coleman, 2002). Overall, these difficulties may indicate a lack of approaches that are durable and effective, i.e., conceptually integrated, relevant to practice without being limited to practical skills, and extensible for different levels of application (Varian, 1997; White, 1999; Buckland, 2000, 2001). Again, the drawbacks are especially illustrated by the case of systems librarians, with important consequences for their profiles and activities (Woodward & Meadows, 1994; Wilson, T. C., 1998: Chap. 3; Xu, H. & Chen, 2001).

This Section introduced the relationship of libraries and IT as the research area and the issues of knowledge integration between the fields as the research problem. The remainder of this Chapter proceeds with a closer definition of the selected area of investigation and respective background, in Section 1.2. Following from this, an analytical framework is elaborated, in Section 1.3, to organize a literature review of the problem, provided in Section 1.4. The research focus, including research questions, objectives and expected outcomes are then presented in Section 1.5. The Chapter closes with the explanation of the research theoretical framework and method, in Section 1.6.

## **1.2 Research context and background**

Since the early days of library automation there has been strong implications of IT in the management of organizations. As IT evolved, it has implied periodical changes in procedures, standards, choices and redesign of systems and services

(Kimber, 1974: 9-16). The actual evolution of IT with its pervasiveness and diversification of choices has reinforced the need for the strategic management of IT (Pearlson & Sounders, 2004: Chap. 1, 2). Baker, D. (2004) reminds us that “a strategy is likely to be produced in relation to some kind of challenge” and recalled Corral's definition of strategic planning as

“a process of relating an organization and its people to their changing environment and the opportunities and threats in the marketplace. [...] It is particularly concerned with anticipating and responding to environmental factors, taking responsibility for change [...] It is a tool for ordering one's perceptions about future environments in which one's decisions might be played out” (Corral, 1994, cited by Baker, D., 2004: 2).

But for Baker, D. (2004) strategic planning of IT is not only about future, despite the strong emphasis on the management of change (see Ibid.: 31).

“Tensions can arise between strategic and operational management, one emphasising the long term, the other the immediate requirement. In practice, operational management should be at least partly concerned with what will happen more than 12 months ahead, and strategic management cannot be solely about what life will look like in five year's time. The need for an integrative approach to the strategic and operational is particularly important in the case of technology management” (Ibid.: 3).

Different levels of an organizational reality are involved with the prerequisites for effective technology management listed by Baker, D. (2004), inspired in Twiss & Goodridge (1989):

“Sensitivity to trends in the total business environment; a long term orientation; top management commitment to change; cross-functional integration; a high level of communications, both top-down and bottom-up; flexibility to enable a rapid response; an external orientation; creativity and a responsiveness to new ideas; the presence and encouragement of internal entrepreneurs; responsibility for all aspects of a change programme vested in one person; identification, capture and transfer of new knowledge; a focus on user needs and receptivity to user ideas; investment in education and training to support the change” (Baker, D., 2004: 31).

Many of these requirements point to more than the tangible benefits of IT. For Baker (2004) they also stress the need to add value to the organization by stimulating knowledge “to manage, develop and exploit IT to the full. And it is arguably this intangible benefit that is most important to the future success of the organization” (Ibid.: 33). But the complexity of actual problems of knowledge integration between libraries and IT extends far beyond mere recognition and methodical advice. They have at their core two major factors: the pressure of professions and organizations in

coping with a rapidly changing technological and informational environment, and the difficulties in bringing together different disciplines, professions and organizational structures.

There can be a multiplicity of perspectives to approach the problems of IT knowledge integration, as they can be linked to many aspects of the vast range of general IT impacts for which there is no single, comprehensive, model (Collins, E., 1997). Therefore, the relationship of IT and libraries can be charted in a variety of ways and viewpoints, from the overwhelming and highly diversified body of academic and professional literature. Thus, a manageable approach was needed.

The approach taken was to define a framework of analysis and literature review (see 1.3) that adopts principally a management point of view, i.e., considering the need to manage different levels of IT knowledge acquisition and application in an organization or project. This approach is framed by the objectives of Organizational Informatics (Kling, 1993), itself a part of the larger field of Social Informatics (Kling, 2000a; Kling, et al., 2000), as the knowledge of and about IT and systems design and management is a key factor not isolated from organizational and social contexts. What follows is the context and background for such a framework.

### **1.2.1 A question of alignment**

Governance of IT implies recognition of the complexity and continuous change of organizations where it is embedded, of differentiation of activities and levels of decision, and of the need for a range of integration mechanisms that balance the differentiation (division of tasks) and the organization's objectives (Peterson, O'Callaghan & Ribbers, 2000). This perspective requires what is usually referred to as 'strategic alignment'.

As explained by Papp (2001), "the concept is more than two decades old" but "it has never been more timely than in today's fast paced, dynamic business environment". Also termed 'business-IT alignment', this is a view that, according to Henderson & Venkatraman (1993), assumes

"the need to create a *strategic fit* between the position of an organization in the competitive product-market arena and the design of an appropriate administrative structure to support its execution. This assumption is consistent with the generally accepted axiom that strategic choices in the external and internal domains should be consistent" (Ibid.: 472-473).

The Strategic Alignment Model proposed by Henderson & Venkatraman (1993) (Fig. I-1) remains the most influential in the literature of operational research (see e.g., Butler & Fitzgerald, 1998, Papp, 2001). According to them, the ‘strategic fit’ is “inherently dynamic” and

“a critical lever for attaining this dynamic capability is not a specific set of sophisticated technological functionality but the organizational capabilities to leverage technology to differentiate its operations from competitors” (Henderson & Venkatraman, 1993).

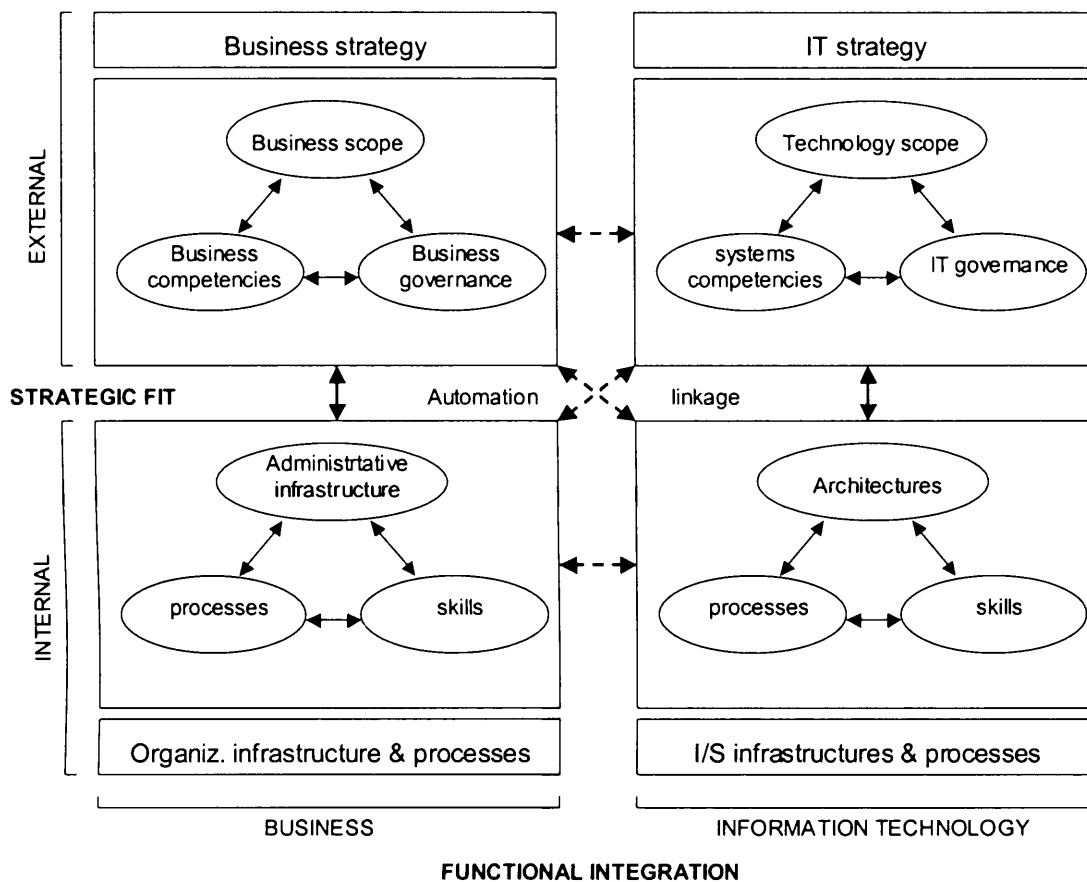


Fig. I-1 *Strategic alignment model* (from Henderson & Venkatraman, 1993)

The model comprehends two types of integration between business and IT domains: strategic integration, i.e., “the capability of IT functionality to both shape and support business strategy”; and operational integration, i.e., “the link between organizational infrastructure and processes and IS infrastructure and processes” (Ibid.).

## 1.2.2 Different perspectives and instantiations of alignment

The Henderson & Venkatraman's model shows four dominant alignment perspectives (Fig I-2): 'strategy execution' and 'technology transformation', under the view of business strategy as the driver, and 'competitive potential' and 'service level', having technology strategy as the enabler and driver.

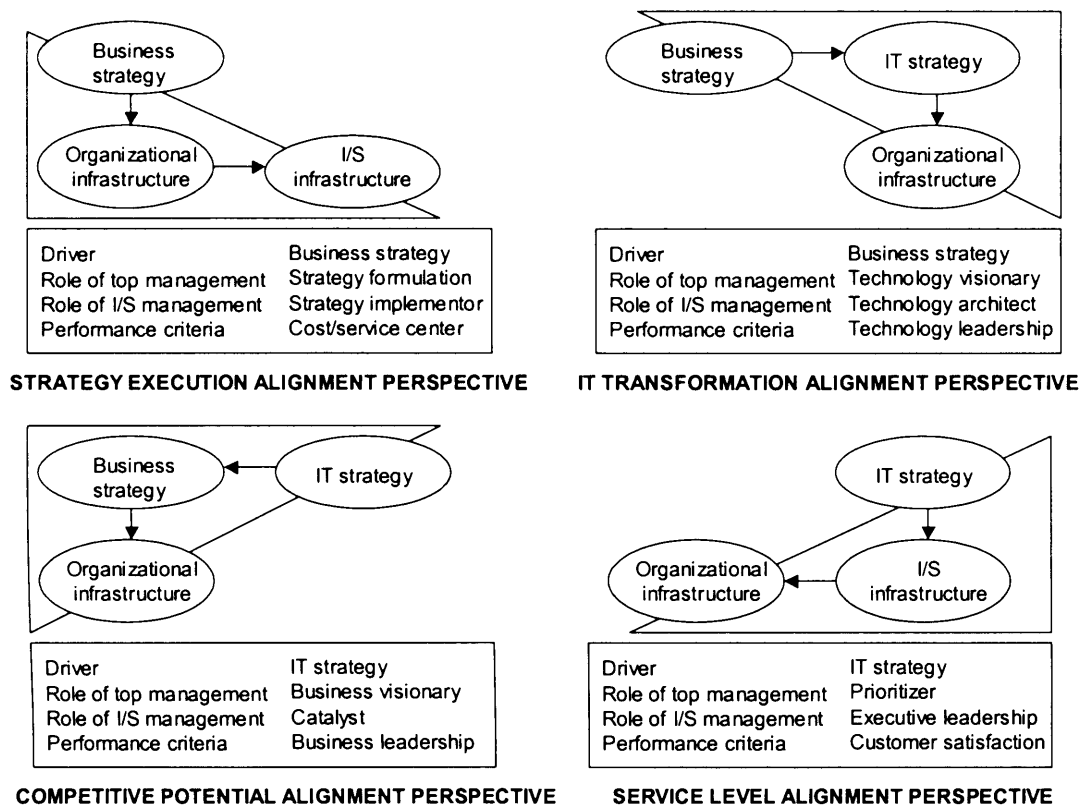


Fig. I-2 *Different perspectives of alignment*, (from Henderson & Venkatraman, 1993)

A first managerial implication of the model is that technology transformation must be driven by business strategy. Yet,

“too often [...] line management is engaged in the process of strategy execution but delegates – explicitly or implicitly – the responsibility for technology transformation” (Ibid.).

In turn, if the link between IT strategy and organizational infrastructure is not clear there may be a lack of understanding of ‘competitive potential’ and ‘service level’, leading to

“significant probability of failure for investments made to transfer business processes, because of an inability to provide the information necessary to execute the processes”(Ibid.).



It follows that managers “need to reconceptualize the scope and power of IT strategy” and the “criteria to assess the performance of the IT function” as well (Ibid.).

These ideas were also synthesized by Proper & Bosma (2000). Based on Tapscott & Caston’s (1993) explanation of the enabling effect of IT, they see the understanding of the role of technology as an issue of ‘organizational maturity’, for which strategic alignment is important. However, they advanced from the level of ‘strategic alignment’ to that of ‘systemic alignment’, i.e., the appreciation of what the notion of alignment means in the context of information systems design. Their systemic view comprises three levels of systems involved in business-IT alignment: the ‘organizational system’, the ‘information systems’ contained within the organizational systems; and the ‘computerized information systems’ (the IT) contained within the information systems (Fig. I-3).

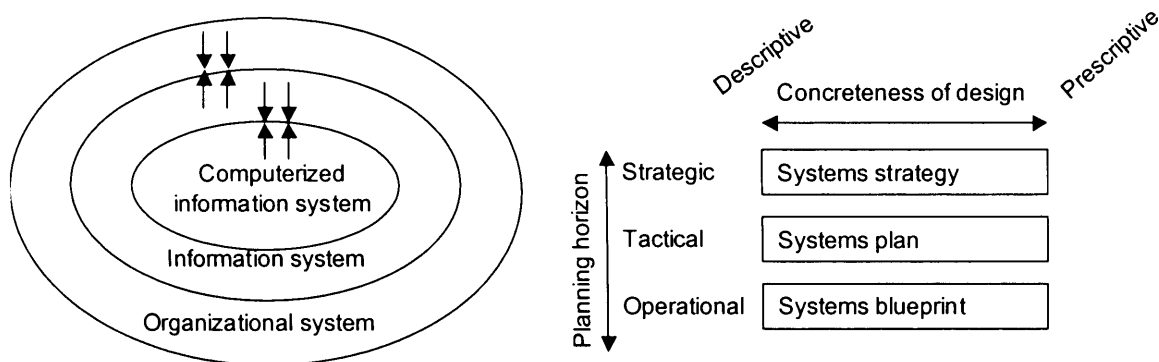


Fig. I-3 *Business-IT alignment: three systems/levels of design*  
(from Proper & Bosma, 2000: 5, 8)

Proper & Bosma (2000) argued that a business-IT alignment implies two co-evolving systems and that it “should take place at the strategic, the tactical as well as the operational level of these systems”. This means different levels of concreteness for design artefacts, ranging from descriptive (like models, more close to the strategic angle) to prescriptive (e.g., stating rules and principles). Thus, different levels of knowledge about IT have to be conveyed and exchanged in the alignment dialogues. Yet, the reach of IT descriptions (e.g., models) and prescriptions (e.g., standards) is most often hampered by the world view, concepts and language internal to the technical fields, or subfields, where given IT artefacts are produced. Not only the world view, concepts and language of managers and users may be different from

that of technologists, they are also influenced by a larger range of factors. Here resides one fundamental problem for imparting IT knowledge among the participants of heterogeneous technical and managerial communities. Different members have different concerns, but have also different frames of reference. This is yet another level to take into consideration when talking about IT alignment.

### **1.2.3 Alignment and frames of reference**

According to Orlikowski & Gash (1994), while technology is a core element in organizations, and thus there are aspects of the frames of reference of their members that concern technology, “most discussions of social cognition do not specifically address technology per se, emphasizing instead strategy, innovation, or change management” (Ibid.). Drawing on social cognitive research and on sociological literature that analyses collective cognitions and social constructions about technology, Orlikowski & Gash proposed the concept of ‘technological frames’ to refer to the different interpretations of technology, i.e., the “underlying assumptions, expectations and knowledge that people have about technology” (Ibid.). Based on empirical research, they suggested that

“where the technological frames of key groups in organizations – such as managers, technologists and users – are significantly different, difficulties and conflict around the development, use and change of technology may result” (Ibid.).

In order to analyse such differences, Orlikowski & Gash defined the notion of ‘congruence’ in technological frames as referring to the alignments of frames on key elements or categories. ‘Congruent’ frames are not identical frames “but related in structure (i.e., common categories of frames) and content (i.e., similar values on common categories)” (Ibid.). While congruence in technological frames signifies a reasonable amount of implicit agreement (about major expectations, processes, nature of use, of a given technology) incongruence “implies important differences in expectations, assumptions or knowledge about key aspects of technology” (Ibid.). Besides the differences in technological frames between groups with different backgrounds, incongruence may also occur between players with different roles in an organization. Furthermore, as explained by Merali (2001, 2002), congruence in organization’s knowledge processes is also an important aspect of their fit with the

environment, “enabling organizations to share information, expertise and processes across boundaries”, in a dynamic, adaptive way.

The recognition of the existence of several levels of knowledge about IT is, thus, a relevant element in a framework of analysis about IT in organizations, both internally and in relation to the environment.

The research problem delineated so far concerns knowledge integration in the relationship between libraries and IT. Due to the vastness of perspectives that can be taken to analyse it, a selective approach was designed to shape the literature review about the subject.

### 1.3 Analytical framework

This Section presents the framework of analysis (Fig. I-4) developed from the ideas collected in the previous section. It expresses three different levels of criticality of IT for libraries: operational, conceptual and epistemic. These levels are articulated with three major aspects regarding the knowledge, management and use of IT: tactics, knowledge and strategy. They represent different integration layers with different concerns, often meaning different professional groups. They can be thought of as a succession of degrees, or perspectives, of IT absorption.

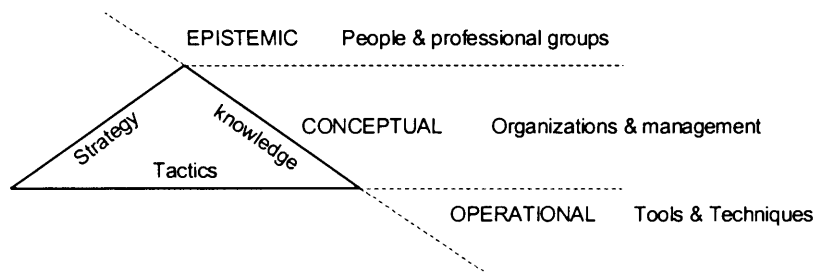


Fig. I-4 *A framework for analysis and literature review*

The first level - operational - is the one that has been more in evidence in actual library services, i.e., putting IT into practice in order to get library work done and services provided in cheaper and/or more efficient ways. It is essentially connected to tactical decisions and operational actions regarding technology. It focuses on implementing and maintaining previously defined, or already existing, service architectures. The expression of this level is principally in IT technical realizations.

At the immediate level, the library as an 'organization' emerges with IT implications of a higher order, more comprehensive and of a managerial nature. This level is strategic and conceptual, not just tactical and operational. Expressions of this level are the questioning of library purposes, the 'business' models of library services, their market relevance and their sustainability in face of IT possibilities.

Next, at an even higher and more abstract level, appear the implications of IT for libraries as clusters of varied professional communities with different cultures. This level is, among other aspects, epistemic. It concerns people as individuals and as groups in their perception, mental modelling, knowing and sharing of fundamental concepts underlying IT. It connects people to organizations where they develop their practices but it also extends the influence of IT to the more diffuse space of their background knowledge and of their professional and disciplinary identities.

At the extremes of the framework, both the operational and the epistemic areas are represented as open spaces where the complexity generated by IT developments flourishes, but in different ways and contexts. While the complexities of the operational level are the diversity and rapid changes of the technological realm itself (the concrete diversity and detail of actual IT tools and techniques), the complexities of the epistemic level are essentially social, cognitive and communicational, therefore essentially abstract and diffuse. The fact that these are open spaces that develop in opposite directions (downward and upward) expresses the indefinite distance and nature of the possible connections between them.

A final aspect to emphasize in this framework is that both the operational and the epistemic levels impinge upon the centre – the strategic and conceptual aspects of organizations – and affect strongly what happens in it.

## **1.4 Literature review**

The framework explained above is next used to organize a high level review of the literature about the relationship between IT and libraries. The review follows the three levels of the framework and covers professional and academic works that have discussed the nature of the relationship between libraries and IT and issues arising from it.

### **1.4.1 The tactical and operational level**

The following overview presents the main traits of the evolution of IT in libraries at the tactical and operational levels. The intention is not to cover the immense body of literature about library automation, library staff familiarization with IT or adjustments in library staff education and training, but rather to highlight the position of this level in the evolution of IT in libraries from the syntheses provided by leading authors. A more detailed account reflecting the literature, will be provided in Chapter 2, as an interpretive analysis of transformation of paradigms and models of IT management.

Tactical and operational aspects of IT in libraries encompass a variety of topics mostly expressed by professional literature, including some literature about disciplinary issues and policy measures intended to promote and facilitate the acquisition of IT skills in libraries. The general profile of this literature includes the provision of basic concepts of IT infrastructure, components of traditional library information management systems, notably MARC data, criteria for their selection, basic guidance on their management and practical introductions to novel aspects of the information environment such as the WWW, electronic publishing and digital libraries, linking technologies, etc. (see, for example, Kimber, 1974; Cooper, 1996; Rowley, 1996; Kashyap, M., 1999; Kochtanek & Mathews, 2002; Ratzan, 2004).

This is mostly literature that explains library processes and general characteristics of the solutions for automating them, as well as descriptions of discrete technological components for practical purposes, often intermixed with management of organizational aspects to implement and exploit them (e.g., Lancaster & Sandore, 1997; Gaur, 2003). There is abundant literature in LIS journals expanding this profile in myriad topics and discrete aspects and experiences.

Most of this literature pertains to what Lynch, C. (2000) called the automation stage of IT in libraries whose history, he noted, is still to be written. As a matter of fact there is a lack of a comprehensive synthesis of this body of literature that could ascertain its prevalent pragmatic nature. Such a prevalence is congruent with the opinion of authors who provide some synthesis of stages of IT in libraries, when they characterize, or suggest, the course of developments as from 'modernization' to 'transformation' (Borgman, 1997; Battin & Hawkins, 1998; Lynch, C., 2000).

The general understanding that can be extrapolated from these syntheses is that in the modernization stage, adoption of IT is mostly endogenous and essentially a matter of new means for old processes, in layers of new technical tools and skills added to those already in place. In the transformation stage, after the expansion of the network environment, IT adoption becomes more exogenous and is the source of new processes, rather than just new means. These new processes are generated in direct connection with transformations of the external environment, manifesting themselves in profound changes of the information market.

This is where IT changes start to affect more profound levels of the library reality. The popularization of network technologies and the affordability of sophisticated computer capabilities raised the level of demands by end-users and created competition between digital information services. The emergence of electronic publishing, digital libraries and the integration of libraries in more complex networks of services, as in an academic campus, are the major factors commonly mentioned to explain the beginning of the transformation stage, i.e., a stage of expectant redesign of services and operations. Again, authors usually point out in different ways the varied problems that the context raises, notably: the urgency to cope with practical mastery of rapidly changing technologies of common usage, and the general sense of uncertainty about the sustainability and durability of technological choices available, about the directions and ways of re-aligning existing systems, or about the goals and return on investments of IT assets.

The general interpretation of the evolution of IT in libraries, and many of the descriptions of its discrete aspects, parallels the account given by Davidson, W. (1993) of the three distinct phases of business transformation by IT, perceived from field research at leading enterprises: automation, enhancement and redefinition (Fig. I-5, next page).

Phase 1 – Automation – begins with automating “existing activities to reduce cost and raise capacity [...], expands to encompass a broader range of applications to optimise operations” (Ibid.). This phase focuses on achieving operating excellence, whose metrics and parameters are productivity, velocity, quality, business precision and customer service.

Phase 2 – business enhancement – “begins once the focus shifts explicitly from optimising internal operations to enhancing transactions and relations with customers” (Ibid.). This is a customer-focused phase, where there are “new services

in the form of an augmented flow of information to the customer, new customer service functions, and new features and options” (Ibid).

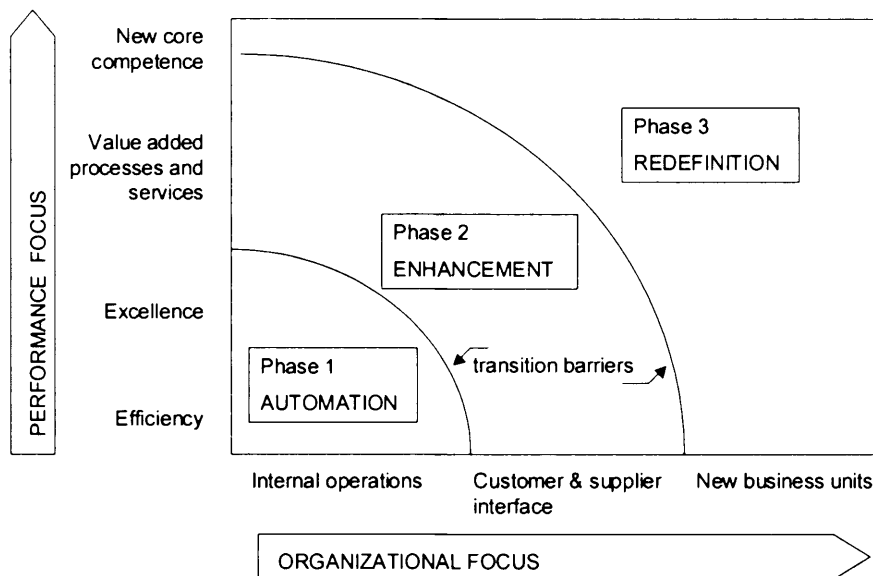


Fig. I-5 *The three phases of business transformation* (from Davidson, W., 1993)

In Phase 3 – business redefinition and new business development – “enhanced services may become independent as stand-alone businesses” and in some cases “they have grown to surpass the original core business in market value” (Ibid). Despite the new opportunities created by enabling technologies this phase encounters “strong transition barriers” (Ibid). These are connected to emergent needs of strategic alignment, both internally and externally.

For Davidson, the initial barrier for Phase 3 is essentially conceptual, and “the enterprise can become paralysed attempting to implement a large number of unrelated initiatives” (Ibid.). Other possible barriers are financial justification and the absence of perceived tangible benefits, organizational resistance and inertia, uncertainty or failure in customer acceptance, legal and regulatory constraints to new services, and also technical barriers derived from insufficient or inadequate technology monitoring, planning and forecasting. Many of these aspects are addressed in the following Section.

## 1.4.2 The conceptual and strategic level

On this level a wide spectrum in the content of literature about IT and libraries is considered: at one end that dealing with expectations and predictions; at the other, topics regarding actual organizational or conceptual impacts in the library world.

### 1.4.2.1 Expectations and predictions

Expectations and predictions have been feeding most of the abundant literature about the future of libraries regarding the potential of IT and how it is seen to exert, or not, radical changes in future conceptions of the information environment and of libraries. Early and most cited classics that preceded any actual automated information systems were Vannevar Bush (1945) and Licklider (1965). While the first did not specifically address library audiences, the second provided a specialist study at the request of the CLR (Council on Library Resources). The following landmark in the 'library of the future' literature would come from the heart of the profession itself with the work *Towards paperless information systems* by Lancaster (1978). This work, followed by *Libraries and librarians in the age of electronics* (Lancaster, 1982) forecasted the inevitability of a total transformation that, even though it proved wrong in many aspects, marked the beginning of a prolific and turbulent era of professional writings about the future of libraries.

Sapp & Gilmour (2002, 2003) studied the predictions and speculations in the professional literature for the period of 1975-2000. Using a citation-tracking method they gathered academic librarianship references related to Lancaster's (1978) work. Their account articulates the evolution of main lines of concern: perspectives of institutional disembodiment and collision of unprecedented futuristic visions (e.g., Thompson, J., 1983) with balanced visions of hybridism (e.g., De Gennaro, 1984); concerns about the weakening sustainability of libraries as they were versus the enlarged role they would play in the scholarly environment; impacts on the profession at the level of education, status, organizational positioning and technical and managerial skills and competences.

Until the 90s, most of this literature is prospective and argumentative, fed by interrogations and advocacy concerning survival and viability of institutions and



about the identity of the profession. Veaner (1985, 1985a), for example, synthesized all these concerns as they were felt and discussed in the mid 80s, when social, technical and managerial profiles of the profession became a hot topic in the face of IT changes. More pressure was added to all these concerns in the following years, as digital libraries emerged and the network environment and electronic publishing were flourishing.

According to Sapp & Gilmour (2003), the first half of the 90s saw professional and institutional concerns being addressed more programmatically, in writings that take planning and strategic points of view, combining analysis of change factors with proactive lines of action (as, for example, in Buckland, 1992; Dougherty & Hughes, 1993 and Follett, et al., 1993). New concepts emerged suggesting the need to revise models, such as the primacy of access services, 'access versus ownership', acquisition on demand, etc. Nevertheless, the literature scanned by Sapp & Gilmour (2003) suggests that the evolution towards library reconceptualizations was slow in providing a more clarified path. In part this was due to the expanding range of practical concerns requiring immediate attention on the ground, such as issues of cost, licensing and copyright of electronic information.

The same can also be inferred from the overview by Drabenstott (1994), in an essay that gives the feeling of what were the perceived challenges and prospects until the mid 90s (Ibid.: 1994: 161-76).<sup>1</sup> A paradigm shift was acknowledged, but uncertainty about its meaning was paramount, underlining the following aspects: the 'scary' changes being introduced by electronic publishing and its emerging new business models; fears about the sustainability and relevance of library services, forecasts for staff changes in occupation, especially towards support to end-users and finally, the urgency for staking claim to the 'new territories' of the digital future. Among these, a strong exhortation for library institutions and schools not to sit back and wait, especially in coping with "retooling [...] in the technology of the day" (Ibid.: 175).

The expansion of the Internet and the WWW (World Wide Web) has been, since the mid 90s, the major factor affecting expectations, predictions and concerns about IT and the future of libraries, as it brought the infrastructure to realize much of what was understood as the information society. As reviewed by Sapp & Gilmour (2003), much of the literature of this period

“exhibited a realization that, in fact, libraries in the year 2000 would be much like the libraries of the current day, and that the revolution in library services fuelled by technology was still far from complete”.

Significant examples of realistic assessments of earlier predictions, along with reinforcements of the validity of the long standing library missions and functions, can be found in authors such as Nunberg (1993), Feather (1994), Miksa & Doty (1994), Crawford & Gorman (1995), Benton Foundation (1996), Daedalus (1996), Odlyzko (1997), Hawkins & Battin, eds. (1998), Crawford (1999), Lancaster (1999), Agre (2003).

Some of the above references represent the overcoming of the first futuristic stage of the electronic futures of libraries, but other were also responses to a second wave of utopian assumptions brought about by the WWW. The new Web context strengthened novel aspects useful for library conceptions, such as the role of mediation and filtering in the overwhelming and scattered, but actually available, information environment. Yet, in general, the understanding and strategies to cope with it did not advance much. The IT potentials have been openly recognized but continue to contrast with the uncertainty of the profession and the sense of unmanageability of the information world. Questions about the nature and model of library roles and of librarians' functions, or issues of scalability and sustainability of library services, not only remain unanswered, but they also attained, with the WWW, a totally new dimension.

Furthermore, the WWW favoured the trend towards the generalization of a terminology which is more abstract and wider than that previously used in connection with library and information services. This is the case with the growing usage of terms like 'knowledge', 'learning', 'memory' which appear even more associated both with IT and computing or with information institutions, their functions and the activities of their professionals. More than good metaphors for conveying new strategic visions of services, these terms tend to be too easily trivialized by the popular and utopian discourses about technology. Being loose and trivial, they help obscure the real issues. According to Kling & Lamb (1996),

“technologically utopian analyses dominate the popular discourse and are commonplace in discussions of future developments in professional discourse” while “ empirical oriented accounts [...] have less rhetorical power to capture the imagination of readers” and “don't appeal to many scientists and professionals”.

Kling & Lamb (1996) analyzed the discourse of controversies about computerization in the framework of changes in electronic publishing and digital libraries. They focused on popular, professional and scholarly literature and differentiated and compared strengths and limits of different genres: utopian and anti-utopian<sup>2</sup> for writings not based on empirical observation; and social realism, social theory and analytical reduction, in the case of empirical studies.<sup>3</sup> The first group corresponds to the mainstream views, attaining larger audiences and, despite key limitations, they should not be dismissed as they can foster future developments. But, as they transcend reality, they can also be highly misleading. The second group, though more credible, exerts less influence in the general environment as it constitutes a specialist stream. It is aimed at particular audiences that are even more restricted as the genre moves from social realism to social theory and to analytical reduction, the last considered the most inaccessible except to academic specialists.

The term 'audiences' here should not be taken as an indication of 'professional audiences' versus 'general public'. In fact, socio-technical approaches and empirical genres, that would be more attractive to scientists and professionals, often appear to be dismissed or not practised. As Kling & Lamb (1996) noted,

"some technologists dismiss social realist accounts as 'primarily anecdotal' and they have little patience for social theory. It is ironic that computing -- which is often portrayed as an instrument of knowledge -- is primarily the subject of popular and professional literatures that are heavily weighted towards the less reliable utopian genres. Conversely, the more trustworthy empirically anchored genres often have much less appeal in the scientific and engineering communities".

For Day, M. T. (1998), who studied the 'transformational discourse' that has inundated society and organizations since the 70s, LIS

"has both helped to create this form of discourse with its visions of electronic libraries and scholarly workstations and has been heavily influenced in turn because the application of information technology is everywhere assumed to have a transformational effect on modern organizations, especially organizations such as academic libraries that specialize in 'knowledge work'" (Ibid.).

Like Kling & Lamb (1996), Day, M. T. (1998) also distinguished between utopian and social scientific discourse. For him, "by and large, this scholarly literature on the social effects of computerization has had little influence on LIS literature" (Ibid.).

#### **1.4.2.2 Organizations and conceptual impacts of IT**

Despite the criticality of IT for libraries, in the sense that they are data intensive organizations and they have been relying even more on IT to produce and deliver their services, most of the literature about IT in libraries does not carry socio-technical analyses and empirical methods.

For Kling & Lamb (2000), the success of IT projects, and hence the credibility of its prospects in the so-called new digital economy is, by and large, an organizational problem. It is also essentially a problem of dealing with change, and Organizational Informatics (OI) is the research branch that allows a better understanding of IT in such a context. According to Kling & Lamb (2000), results of OI research suggest that “many organizations have trouble in changing their practices and structures to take advantage of IT”. For them, this explains in part the lack of success of new business models and strategies, notably new trends in management, such as business process re-engineering or, more recently, knowledge management (Ibid.).

The same authors pointed out the lack of understanding of information systems as socio-technical networks, i.e., of clear co-requisite organizational changes in IT implementation projects, which often lead to failure. “IT should not be conceptualized simply as a ‘tool’ that can be readily applied for specific purposes”. Yet, for them, IT as a tool has been the most common approach and they call it “the standard approach” versus the “socio-technical” approach. They compared the two models to characterize the conceptions of IT in organizations with different approaches and concluded that the ‘standard model’, more attractive to technophiles, is responsible for most misleading and simplistic assumptions that feed false optimism and for omissions that are management traps. Among the assumptions are beliefs in the sufficiency of business models, in the immediacy and goodness of IT effects, in the ease in making knowledge and expertise explicit. Omissions count aspects that can have significant effects in the outcomes of IT implementations, such as the lack of consideration about ‘incentives’ for IT adoption and about organizational politics (Ibid.).

Socio-technical understanding is, thus, critical for effective IT use, and one fundamental aspect is the knowledge about the ways in which organizations and people practise, absorb and support knowledge about IT. This is not usually the most

robust aspect of an organization and the scene gets more complex when the use of inter-organizational computer networks becomes the norm. In the library and information services world most of the literature that discusses the relationship with IT does not fit into the socio-technical model, supported by empirical analysis, but is rather closer to the Kling & Lamb 'standard model' which, in turn, can be seen as an expression that fits the 'operational' level of our framework (Fig. I-4, p. 26).

Research into aspects of IT in libraries that goes beyond the operational level, implying organizations and related conceptions, can be roughly divided into three major streams (Fig. I-6): theoretical and critical approaches to IT in libraries, studies in change management and research in convergence of IT departments and libraries.

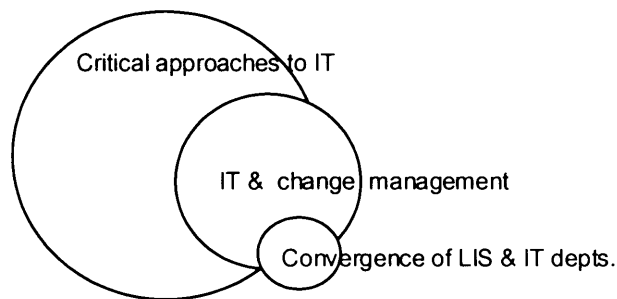


Fig. I-6 *Three levels of conceptual impacts of IT in libraries*

These three levels overlap partially in many aspects that are difficult to disentangle. The distinction, however, is useful to show, from broader to narrower aspects, the kind of concerns that can be found in the literature about library organizations and conceptual impacts of IT.

### **a) Critical approaches**

In the field of Information Systems research, Orlikowski & Baroudi (1991) defined critical studies as those that

“aim to critique the status quo, through the exposure of what are believed to be deep-seated, structural contradictions within social systems, and thereby to transform these alienating and restrictive social conditions. [...] the critical perspective recognizes that the capacity to enact change is constrained, because humans become alienated from their potential by prevailing systems of economic, political and cultural authority. In the light of this alienation, an important objective of critical research is to create awareness and understanding of the various forms of social domination, so that people can act to eliminate them”.

Critical approaches to IT are scattered in the LIS literature, whenever the role of libraries and society is discussed, especially when there are conflicting issues between the library mission and ethos and other information stakeholders in the market. However, purposively elaborated analyses rooted in critical theories are not so frequent in LIS. They are well represented in Buschman, ed. (1993), a compilation of essays seeking to align with scholarship raised in other areas of academe, where the role of technology is critically scrutinized in relation to work, power, education and media. For Buschman (1993a) there is a lack of critical approaches in LIS literature which

“at best, asks incomplete questions about how best to implement electronic resources without raising critical questions about them. At worst, our literature is plainly celebratory, often exhortative, and full of vague and dire threats of the results if we do not embrace information technology more thoroughly and enthusiastically”.

According to Buschman (1993a) the impact of IT should not be studied “after the fact of its introduction. This approach has, in effect, excluded technology from detailed scrutiny [...]”. Buschman, ed. (1993) is a rare case of a book specifically intended for librarianship audiences that brings together reflections on technology from different scholarly arenas on the role of libraries and librarians in the face of the civic, cultural, ethical and educational values. While these broad aspects are not focal to the topic of this thesis, the contribution about IT and the librarianship labour process by Winter (1993) should be noted as an interpretive account that suggests the need for a synthetic intellectual vision in face of the tangled situation created by IT, that tends to feed reductionism and oversimplification.

Buschman (2003) expanded his arguments, and provided cases about what he claims to be a general uncritical position of the LIS profession, schools, the policy agencies, the institutions and their management, regarding the ‘information capitalism’, a threatening characteristic of the market-oriented public philosophy that appears to drive the cultural institutions and that is deeply connected with the changes brought in by IT. The uncritical acceptance of the discourses about information and the ‘information age’ was also pointed out by Day, R. (2001).

Analysing the interdisciplinary literature on the ‘information society’ with implications for LIS, Harris, Hannah & Harris (1998) offered a basis for a critical vision of the LIS institutions and profession, alternative to the most common view, technologically determined and based on influential works such as those of Bell

(1974) and Lancaster (1978). Harris, Hannah & Harris (1998) critically assessed the literature, highlighting its effects on the self-understanding of the profession, its possible developments and identity crisis (Ibid.: Chap. 4) and endorsed a holistic vision of the post-industrial landscape where the historical, economic and political aspects are cultural forces that shape the future of libraries along with technologies (Ibid.: 122). Regarding the exploitation of IT in organizations, the authors recognized some fundamental limitations that are not exclusive to libraries.

“All organisations, including those in the for-profit sector, have struggled with the promise and problems inherent to information technology. [...] Libraries, like many other organisations, have been slow to recognize that implementing information technology requires more than buying a computer and software from a vendor [...]. The reliance of most libraries on ‘turnkey’ systems has also fostered the erroneous view that implementing information systems is as simple as flipping a switch. [...] the integration of information technology into libraries will not be done easily, quickly, or cheaply. This fact, too often overlooked by the paperless society cheerleaders, grows out of a complex set of variables, such as the historical tradition that so strongly controls the discussion of the library in the contemporary society, the lack of sophisticated understanding of information technology and its uses, inadequate attention to the implementation problems inherent in the utilization of information technology, and resistance to change in the management styles” (Ibid.: 117).

Other authors, more close to IT, have provided critical analyses that expand on some of these aspects. Agre, for example, discussed critically many of the premises and assumptions underlying common beliefs in the positive, linear changes and revolutionary power of IT, or its inevitable consequences. His analyses go beyond the sociological scan of the context by including his interpretations of the contradictions in the field (e.g., the perspectives of computer work and librarianship, in the university environment) and argue that the real questions are on underlying social structures such as the market, institutions, professions and ideologies (Agre, 1995, 1997, 2000, 2000a, 2002, 2003). For him, the ‘institutional’ world around IT is of utmost importance for the fit between institutions and technologies.

“Institutions [...] are the enduring categories of social roles, legal systems, linguistic forms, technical standards, and so on through which human relationships are conducted. [...] An institutional field is an enduring ensemble of institutional categories; examples include particular historical forms of the market, the political system, or the university” (Agre, 2003).

Arguing for a role of social theory in design, Agre has contended that 'institutional' design is as important as systems design and both should be intertwined in order to prevent "certain institutional pathologies" (Agre, 1997). That is to say, "it is crucial to design technology and governance at the same time" (Agre, 2000). For him, the conceptual analysis for good design should look "for common traps that can confine a project's concepts within the bounds of unnecessary assumptions" (Agre, 2003). He exemplified this idea with the traps "that may afflict the unwary designer of digital libraries" (Ibid.). They are:

"The trap of presupposing standardization [...]. The trap of deriving political consequences straight from the technology [...]. The trap of automation [...]. The trap of assuming rapid change [...]. The trap of all-or-nothing change [...]. The trap of command-and-control computing [...]. The trap of inventing a new world [...]. The trap of blaming 'resistance' [...]. The trap of assuming away intermediaries [...]. The trap of technology and economics-driven scenarios [...]. The trap of designing for a limited range of cases [...]. The trap of presupposing transparency" (Ibid.).

Some of these ideas of 'institutional design' and 'traps' (wrong assumptions) are connected to the next topic, the management of change in organizations.

## **b) Change management**

Change management deals with the design of organizational structures, action programmes and management styles as enablers of transformations deemed important for attaining organizational goals such as productivity, efficacy, market influence and innovation. As explained by Day, M. T. (1998), computerization and the underpinning 'information' ideology have provoked a flow of 'change' or 'transformation' discourse that has affected the literature on management.

"The rapid spread of discourse focused on the transformational potential of computers derived, in part, from its intrinsic, aesthetic, and moral appeal and, in part, from the rhetorical gap it fills between the highly specialized discourses of elite scientific and technical communities and the unspecialised popular discourses of mass society. [...] Popularized business management discourse about transformational leadership and organizational reengineering has arisen in the last few decades to fill a similar rhetorical gap" (Ibid.).



Aspects of change management related to IT in libraries have been approached by different authors since library automation entered the field (e.g., Gorman, M., 1979; Lynch, B., 1979; Shaughnessy, 1979; Dougherty & Heinritz, 1982; Marsterson, 1986; Prince & Burton, 1988; Underwood, 1990; Evans, M., 1991; Creth, 1993). Most of them focuses on issues of changing roles and requirements for staff and departments, notably towards more flexible organizational structures.

Edwards, Day & Walton (1993) identified implications for libraries in a retrospective overview of the literature relating to change, management and IT in the academic world. Changes in the management of networked libraries are perceived as more profound than with library automation. The emphasis is on strategic planning, leadership, the emergence of new roles such as that of the Chief Information Officer (CIO) and on the convergence between library and IT departments. There is a general belief in the vital role of libraries in the new networking environment: "In increasingly decentralized information services, the library has the opportunity to become a centralized area of expertise" (Ibid.). But there is also recognition that the literature is "full of advice" and that "research is needed to enable a clearer picture of the real impact on current changes on the function of libraries and on their personnel" (Ibid.).

During the second half of the 90s there is a clear trend to underline the learning aspects of change management in issues of staffing and human resources management in libraries (e.g., Stoffle, 1996; Steele, 1997; Clayton, 1997; Garrod, 1997; Oxbrow, 1998; Banwell, Day & Ray, 1999; Pugh, 2000).

In a study on the processes of innovation implementation illustrated with case studies, Clayton (1997) derived a set of propositions and considerations around a range of aspects chosen as innovation enablers: attributes of innovation, resources, characteristics of organizations and leadership. Although IT and IT knowledge do not appear as separate enablers of innovation they may be considered implied. Knowledge and skills are seen as directly influential on the degree of innovation implementation (Ibid.: 57); organizational learning, i.e., "the capacity to reassess and alter organizational culture, norms, objectives and policies" is considered an important factor (Ibid.: 87-93), and leadership and vision are deemed central to innovation (Ibid.: Chap. 5).

Banwell, Day & Ray (1999) reported a study on managing organizational change in the hybrid library aimed at identifying a strategy and courses of action. Five development stages were identified against which managers can benchmark the developments in their institutional settings. The matrix explicitly considers the relationship with IT at various levels. At the institutional level, stage 2 (change) requires “closer working relationships between the library, computing and academic departments”; and stage 4 (embedding) requires “increased flexibility of staff and systems”. At the Library and Information Services level, stage 1 (baseline) includes “recognition for the need for an IT Development Manager; stage 3 (congruence) requires “converged library/IT/other support services” and stage 5 (full integration) includes “cross subject working groups, multi-disciplinary systems and cross functional institution” (Ibid.: 31-34).

The most recent and comprehensive study of change management in libraries, including an analysis of change, applicable management theories and case studies was provided by Pugh (2000). Change in current library environments facing uncertainty created by technological imperatives is characterized (Ibid.: Chap. 1): discontinuity instead of incremental change, increased diversity of different cultures and modus operandi, increased pressure on new skills, demands for more knowledge and better expertise. For Pugh, all these characteristics require new models and strategies of management that acknowledge the social dimension of IT, notably the “idea of the organization as an information system” (Ibid.: 4), the need to forge new structures and cultures to cope with diversity, and organizational learning support.

The general idea one gets from the literature scanned is that of an evolution from a focus on change for adaptation to IT, notably with automation, to a focus on change as innovation, and transformation, through IT, in more complex, networked, environments. But rather than exhibiting substantial evidence of actual change in library organizations, the literature continues to consist principally of identification of barriers, like fears or economic constraints; of advice on and advocacy of methods and plans of action for implementing change, e.g., by flattening hierarchical organizations, and on the redesign of processes and jobs, by recommending task-competencies and task-skill training (see, e.g., Penfold, 2000; Tam & Robertson, 2002; Spacey, Goulding & Murray, 2003). The discourse analysis of change management literature carried out by Day, M. T. (1998) seems to confirm this:

“Patterns discovered so far suggest that current LIS rhetorical strategies continue to operate within a modern grammar of organizational motives that reproduces existing forms of organizational life rather than radically transform them” (Ibid.).

Markus (2004) proposed the concept of ‘technochange’ which he claims to differ from the typical additive approach of IT project management (centred on costs, schedules and solutions’ functionality) plus the traditional organizational change programmes which,

“are generally not effective on their own because they take as a given the IT ‘solutions’ developed by a technical team. Consequently, the potential for the IT ‘solution’ to be misaligned with important organizational characteristics, such as culture or incentives, is great” (Ibid.).

By ‘technochange’ Markus means a different approach with more structured and complete interventions in which “tasks, jobs and organizational processes all change along with IT” (Ibid.). That is, management that is tailored to each project/situation and integrating both perspectives, rather than just getting the IT solution right (performing as promised) and people tasked to getting it running. This is an understanding of change and IT management that is founded on the principles of alignment explained in the Section 1.2.1.

### **c) Convergence**

Forging new structures is an aspect directly linked to the movement towards integration, or at least common administration of library and computer departments, known as ‘convergence’. This trend appeared especially in academic settings since the 80s, in the US (Battin, 1984; Cimbala, 1987; Heterick Jr., 1990; Lowry, 1990; Rosser & Penrod, 1990; Machovec, 1991; MacDonald, 1992; Woodsworth & Maylone, 1993; Sullivan & Calhoun, 1995; Lippincott, 1996; CLIR, 1997a; Davis-Millis & Owens, 1997; Hirshon, 1998; Bernbom, Lippincott & Eaton, 1999; Beagle, 1999; Oden Jr., et al., 2001; Bailey & Tierney, 2002; Bolin, 2005) and the UK (Naylor, 1988; Brindley, ed., 1989; Gardner, 1989; Edwards, Day & Walton 1993; Lovecy, 1994; Royan, 1994; Collier, 1996; Fielden, 1996; Garrod & Sidgreaves, 1997: 1.5, 3.7, 3.8; Pugh, 1997; Milne, 1998; Rusbridge, 1998; Garrod, 1999; Lewis & Sexton, 2000; Pinfield, 2001: 12.4); and later, from the mid-nineties, in Australia

(O'Brien, 1993; Reid, 1993; McLean, 1997; O'Brien & Sidorko, 2000; Sayers, 2001).<sup>4</sup>

An early empirical study on the needs for cooperation between computer centres and libraries was provided by Hughes (1989), laying down strategic and managerial recommendations on the topic. Royan (1994), Pugh (1997), Hirshon (1998) and Bolin (2005) analysed the outcomes of convergence initiatives in many settings. Despite the benefits of convergence being generally acknowledged, and the continuous growth of the advocating literature (see Beagle, 1999; Hardesty, ed., 2000; Lewis & Sexton, 2000; O'Brien & Sidorko, 2000; Oden Jr, et al., 2001; Bailey & Tierney, 2002) convergence did not become the norm.

This may indicate that the foundations for merging are not well enough established, beyond the local contingencies and administrative outcomes expected in each institution. This was one of the conclusions of the Garrod & Siedgraves' (1997) literature review on the matter. Cases analysed by Pugh (1997) revealed some interesting aspects: staff participation in the convergence process has been low, with the library having a more significant involvement and a larger share of managerial responsibility (Ibid.: 38-39). For Pugh, there is "some superficial evidence of a library take-over based on a greater political maturity of librarians and library services" (Ibid.: 48), an aspect that is also corroborated by CLIR (1997a) and Hirshon (1998: viii) and mentioned by Ray, M. (2001).

The trend towards an integrative management of library and IT/computing services indicates a closer approach and more regular interactions, eliciting awareness for training and exchange among both communities. Nevertheless, there is no clear evidence that the trend has had a significant impact on deepening the common grounds of their diverse professional activities (Fielden, 1996; Battin & Hawkins, 1998; Ray, M., 2001; Blackmer, 2002). That is to say, the extent to which convergence has contributed to reshape the content and reach of both professional sides remains undetermined. For example, in the literature about systems librarianship (see 1.4.3.1) there is almost no mention of the experiences with and benefits of convergence.

The organizational demands and expectations of convergence are more than the operational management of resources and services. They also target vision, strategy and innovation (Davis-Millis & Owens, 1997; Hirshon, 1998; Beagle, 1999; Banwell, Day & Ray, 1999; Bailey & Tierney, 2002, Blackmer, 2002). Attention to

strategy is present in the convergence literature and the strategic management of IT is also a recognized concern in LIS (Baker, 2004). But for vision, strategy and innovation to be jointly attained by both IT and LIS communities, shared knowledge is the important aspect, beyond appropriate management methods and shared skills. Aspects that can affect forms of shared knowledge are approached next.

### **1.4.3 The epistemic level**

The epistemic level deals with knowledge and knowing, i.e., the processes at the level of individual ‘knowers’ and the paths in social groups that make knowledge possible. This is not the place to scrutinize how differently these concepts may be understood, or to analyse the large and scattered geography of studies about knowledge that are fundamental to LIS as a discipline (see, e.g., Budd, 2001), to libraries as service organizations (see, e.g., Owen & Wiercx, 1996) or to library professionals as having special epistemic abilities with a role in research processes in fields other than LIS (Johanson, 1997; Kling, 2000; Hjørland, 2002).

While our focus is on knowledge about IT and how it is engendered and perceived in the professional library environment, the pervasiveness of IT effects makes it important to recall such a fundamental and long-standing relationship between LIS, knowledge and knowing. For two reasons: first, because we live in a context where IT is a major enabler of knowledge activities and has been transforming the context and means in which they occur, often connected to the sphere of libraries as services; second, because libraries as organizations are themselves subject to the same IT effects and impacts, and so is the professional knowledge needed to their objectives.

Cronin (2003), for example, pointed out a number of IT related factors that produce sometimes simplistic, distorted or misleading new conceptions of scholarly communication and publishing:

“diversity of the communication ecosystem [...] velocity and variety of experimentation [...] lack of discursive consistency and semantic validity [...] tendency to talk deterministically with regard to the effects and impacts of ICTs” (Ibid.: 4-5).

For Cronin, beyond the disciplinary realm there is the need to consider the many different epistemic cultures that intervene in the transformed publishing environment, a “very complicated ecosystem, the contours of which are still blurred”

(Ibid.: 16). Libraries are part of that ecosystem, thus most aspects highlighted by Cronin apply to the relationship of libraries and IT. Two major aspects of the relationship are often discussed: the connections through interdisciplinarity, as an allegedly characteristic feature of the knowledge areas in question; and the chasms between the cultures of IT and library professionals.

#### **1.4.3.1 Interdisciplinarity**

Interdisciplinarity is one of the main characteristics that are invariably included in any definition of the field of education or practice of LIS, as well as in other areas that bring together information and technology. This characteristic is all too often underlined either as a major strength or as an explanation for the fuzziness of such areas. Smith, L. (1992) reviewed and synthesized interdisciplinary studies in LIS and found a significant discrepancy between expectations and reality.

“A common finding of the empirical studies is that there is relatively little borrowing of ideas, as measured by citations, in contrast to the enumerative lists identifying the various disciplines that authors judge should be relevant to library and information science” (Ibid.: 260).

In LIS and related areas the expectations about interdisciplinarity tend to be indistinct. This may be because, first of all, interdisciplinarity is a natural imbalance of the conventional order of knowledge. In addition, interdisciplinarity is often seen as lateral and peripheral, which is no longer the case nowadays (Klein, 1996). Furthermore, as explained by Klein (1990: Chap. 3), interdisciplinarity is not the mere juxtaposition or intersection of different areas of knowledge or expertise. This is what may be said of a multidisciplinary phenomenon, activity or realization. What interdisciplinarity implies is, beyond that, the construction and sharing of synthesis (Bugliarello, 2000) i.e., a minimum of useful common concepts that ensures something more than the localized and short-term results of multidisciplinary activities.

The disciplinary areas involved in multidisciplinary undertakings relating libraries to IT are diffuse in many ways, because they became epistemologically complex. Except for the part of Computing which is rooted in Mathematics, these areas lack a strong disciplinary affiliation, in the classical sense. This is what happens with the fields of Information Management, Information Systems and IT

itself. Additionally, with the exception of the LIS elements that come from the Humanities and Social Sciences, all are relatively young, having a developmental course that has been marked by constant change, as computerization evolved. Also, they appear to share a common set of disciplinary problems, in identity issues, internal coherence and viability, questions that are usually explained by the multitude of reference disciplines, the diversity of protagonists and audiences and the vastness of subject coverage.

These problems are well known in LIS and appear alongside gaps between education and practice, be it at the industry, the market or the organizations' level. The very same problems populate Information Management (Wilson, T. D., 1989; Wilson, T. D., 2002; Macevičiūtė & Wilson, 2002) and Information Systems (Checkland & Holwell, 1998: 37; Ellis, Allen & Wilson, 1999; Adam & Fitzgerald, 2000). These three disciplinary fields have yet another aspect in common: their difficulty in clarifying their relationship with IT. While this relationship is diffuse in LIS, an identity distinct from IT has been a constant point of debate either in Information Management (Taylor & Farrell, 1992; Holtham, 1995; Wilson, T. D., 2002) or in Information Systems (Alter, 1999, 2000; Bacon & Fitzgerald, 2001; Mora, et al., 2003; Benbasat & Zmud, 2003).

Finally, there is the dispersal and the apparent lack of interrelation between all these fields in both education and research. For example, the field of Information Management, whose content may be seen as implicit in LIS, is as diverse as the content of courses, or job functions labeled with the term (Wilson, T. D., 1989, 2002; Apostle & Raymond, 1997). The LIS relationship to Information Systems is even looser, if not almost absent, as shown by Ellis, Allen & Wilson (1999).

What seems to prevail is a state of generalized confusion that is also linked to the current state of the discipline/professions of Computing and IT. According to Denning (1998; 2002) IT has evolved to a composite set of sub-disciplines and branches largely out of the control of academe, therefore uncoordinated and lacking a coherent link to the pragmatic realm, dominated mainly by industry (Denning, 1999; Roberts, 2000; Denning & Dunham, 2003).

All these are disciplinary aspects that do not contribute to making the relationship between IT and LIS easy, primarily at the level of education and research. In this respect, the emergence of new requirements to cope with practical needs has motivated the introduction of new topics and courses, changing

designations and the position of LIS in academe and eliciting collaboration with other departments. But the overall panorama is unstable, confused and essentially focused on practical knowledge and skills (Sutton, S., 1999; Buckland, 2000, 2001). For special or emergent areas the situation is not better as, for example, in the education provision in topics related to digital libraries (Spink & Cool, 1999; Saracevic & Dalbello, 2001; Coleman, 2002).

As noted earlier, the best example of LIS lacking a good interdisciplinary response to professional needs is the situation regarding the functions of systems librarians, which go as far back as when library automation started. Despite being needed for decades, with even more diversified demands, the function still relies principally on self on-the-job education (Woodward & Meadows, 1994; Lavagnino, 1997; Wilson, T. C., 1998: Chap. 3; Gordon, 2003), scattered and contingent, usually not paralleling the importance of institutional IT investments. The same can be said of the senior positions of CIO (Chief Information Officer) or equivalent. According to Hawkins & Battin (1998),

“in contrast to the historic and relatively static educational program for librarians, there has never been a clear career path for the role of chief technology officer, a position that has drawn talent from the rank of technologists, faculty members and professional administrators. The traditional patterns of preparation are not adequate to the new age of information and technology, though the demand is at its highest point” (Ibid.).

A final aspect to note is that most of the LIS literature that tackles IT topics is either technical, as ‘borrowed content’ for practical explanations of technologies and tools towards skills acquisition, or focuses on organizational effects of the IT diffusion in libraries. IT and Computing, at a higher conceptual level are almost absent. There are some approximations to this level in works that introduce, for example, systems thinking views of the field (see 1.6.1) but these have brought little discussion of technological concepts as such.

#### **1.4.3.2 Different cultures**

The ‘clash of cultures’ between IT and library services has been often mentioned (Hughes, 1989; Woodsworth & Maylone, 1993; West & Smith, 1995; Davis-Millis & Owens, 1997; Foley, 1998; Hawkins & Battin, 1998; Garten &



Williams, 2000; Lewis & Sexton, 2000; Ray, M., 2001; Bailey & Tierney, 2002; Blackmer, 2002). In this literature, however, the epistemic stance, i.e., the potential of IT and LIS conjunctions as learning environments, appears to be poorly explored. Hirshon (1998) explained that

“not only are the two cultures of library and computing very different, but in reality there are far more than two cultures. Both organizations actually encompass multiple subcultures. Within the computing arena, academic and administrative computing staff often have different outlooks, as do hardware and software support specialists. User services staff in computing organizations have different cultures than programmers or technicians. Libraries have a long history of cultural differences between public services and technical services librarians, and media specialists also have their own cultural heritage. It is a continuous challenge for the new integrated organization to bring out the best from each of these diverse cultures as it develops a holistic organization” (Ibid.: 9).<sup>5</sup>

Strategies to enhance library staff’s knowledge of IT are usually focused on skills for the consumption of IT products, and this only has limited effects. Pugh (2000) noted that while “the standard assumption seems to be [to] add new skills to the existing base” there is now a “need for higher and higher level of technological competence and insight” (Ibid.: 12). For Battin and Hawkins (1998) “continuing incremental changes to an entrenched conservative tradition” are elusive, and the transformation process has been “so slow, so disorderly, so expensive and so resisted”.

“The initial incremental nature of technological change encouraged the widespread belief that the new technologies could be easily integrated into existing management systems. As a result, the discontinuous revolutionary potential of digital technology and its implications for wrenching changes in enshrined assumptions have been widely ignored, misunderstood, and feared” (Ibid.).

Addressing the learning issues, Pugh (2000) highlighted the importance of context dynamics:

“The kind of learning that takes place in bureaucracies and hierarchical systems is limited and confined by structure, process and content. Most modern organizations will demand that knowledge and information can be used in a variety of contexts, and sometimes out of context” (Ibid.: 37).

Context is, in fact, central to define and give sense to the activities, ways of thinking and communication in professional communities. A common finding of contemporary social informatics literature is the reciprocal relationship that exists

between IT and the contexts of its practice (Sawyer & Eschenfelder, 2002). In a changing context, the variables of change are unstable and actual activities are developed by heterogeneous groups of professionals bringing different backgrounds, visions and values. The result is a combination of different contexts or, as it became currently termed, 'cultures'.

The framework defined at the outset (Fig. I-4, p. 26) suggests the idea of different perspectives of 'culture' in respect of IT: technical culture, at the baseline, management culture at the middle and epistemic culture at the top line. The use of the term adopts here the new sociology position that refers to 'culture' as embodied within practice, rather than being just an expression, or a reflection, of a given social order of things. As McCarthy (1996) put it,

"culture is no longer understood as principally ideational - contained in ideas, symbols, or signs that reside solely or principally in texts (treatises of law and religion), or even in things (art, iconography), or in traditions. Rather, culture is studied as cultural practices, a term that refers simultaneously to collective forms of action and thought" (Ibid.: 25).

From this perspective, 'cultures' are "diachronic accessories to synchronic structures" (Ibid.: 58) and 'knowledges' as cultures are diverse and 'situated' (Ibid.: 111).

Knorr-Cetina (1999) explored the concept of 'epistemic cultures' as cultures of knowledge settings, and their diversity as an important characteristic of contemporary science, of which they are a structural feature. She pointed out the lack of understanding of the "contemporary machineries of knowing" (Ibid.: 5) and the fact that the current focus on knowledge in the 'knowledge society' tends to see "knowledge as an intellectual or technological product rather than as a production context in its own right" (Ibid.: 6). The lines of reasoning have been most often economic, with the 'output' being still the main focus, rather than production contexts, which remain usually "uninterrogated" (Ibid.: 6-7). She advocates a definition of knowledge that emphasises practice "within structures, processes, and environments that make up specific epistemic settings" (Ibid.: 8).

"Not only does the expansion of expert systems result in a massive increase in the technological and informational products of knowledge processes. It also amplifies the processes themselves, as knowledge related contexts and structures. A knowledge society is not simply a society of more experts, more technological gadgets, more specialist interpretations. It is a society permeated with knowledge cultures, the whole set of

structures and mechanisms that serve knowledge and unfold with its articulation” (Ibid.: 7-8).

Knorr-Cetina formulated these ideas to preface a research work in two fields in natural sciences. Yet, they apply broadly to what happens with the knowledge production versus knowledge consumption contexts, e.g., in scholarly communication and publishing (Cronin, 2003) or, for what matters to this research, to knowledge contexts regarding IT in libraries. Understanding why and how there are different cultures at stake, and exploring how to bridge them as epistemic cultures, is important to strengthen heterogeneous communities of practice and for interdisciplinarity efforts in educational and research organizations.

Organizational practices and educational activities have different goals, yet the usual dichotomy between practice and theory is elusive (Wenger, 1998: 48). Meaning and language are fundamental elements to both practice and theory and an important link between them. As a signifying practice, culture consists of “webs of significance” and the analysis of it is “not an experimental science in search of law but an interpretive one in search of meaning” (Geertz 1973: 5, cited by McCarthy, 1996: 20). For McCarthy (Ibid.: 25-26), the new approach to knowledge as ‘culture’ is linked to the theoretical and practical significance of language.

“Cultural practices refer to many institutions, classes and groups that compete in their articulation of the social meaning of things, to the many sites and positions from which ideas and knowledges are developed, and to the conflicts arising out of the struggle to stage performances and to affect audiences. [...] the same cultural ideas, words and images often mean different things to different groups. And furthermore, the meaning of something is continually subject to change both because social objects are multicode and because there is a multiplicity of *language*” (Ibid.: 26).

These remarks apply especially to differences in meaning and languages of many fields that are raised or highlighted by changes in ‘knowledges’ connected to IT (Kling, 2003). In the words of Cronin (2003) discussing scholarly communication and publishing, not only there are “tribal customs” with different formalities and rhetorical types, but there is also a “lack of discursive consistency and semantic stability”.

#### 1.4.4 Conclusions

The research context and background provided to approach the problem of poor knowledge integration between IT and LIS highlighted a managerial perspective of IT in libraries as organizations. Under this perspective an analytical framework was used to review the pertinent literature. The framework considered three major levels of analysis: operational, conceptual and epistemic.

On the operational level, more connected to tactical decisions and to the usage of IT tools and techniques, the review characterized the interactions between IT and LIS as insufficient to cope with all the challenges raised by the network environment. It revealed that the barriers to better integration of evolving technologies and organizations have not been substantially different from other sectors. While interactions at this level have immediate effect, they do not create long-lasting integration strengths per se, i.e., they have contributed little to cope with the barriers for 'enhancement' and 'redefinition'. Among other reasons, this is because of the transience of concrete technological artefacts and also because their adoption and use is not necessarily rooted in broader conceptual and strategic objectives.

On the conceptual level, which is primarily the level of organization and management, three different aspects were analysed.

The review of 'expectations and predictions' showed that for a long period libraries have been influenced by social beliefs about IT, generating misconceptions that have weak connection to managerial and technical grounds. The review of 'critical approaches' detected that, despite their social responsibility and role regarding information, libraries have not been the focus or the motive for systematic critical approaches to IT. Yet, the critical analyses surveyed suggest that the general understanding of the relationship between LIS and IT has been, to a great extent, deterministic or limited to the surface of a mechanistic absorption of IT artefacts in institutions. 'Change management', elicited by IT impacts in library operation, has received growing attention since automation. From a first stage of changing for adjustment to IT requirements, it has evolved to address broader strategic aspects that may change the understanding of IT as an organizationally embedded factor.

The topic of 'convergence' conveys the perception that integration of LIS and IT is central to organizations' success but actual convergence appears to be far from attaining evident results in all expected areas. The literature suggests that the sharing

of knowledge and expertise between library professionals and technologists is among the most deceptive aspects of convergence.

The third branch of this literature review expands this subject, on the epistemic level. The interdisciplinarity links to Computing/IT appear to be diffuse and not strong enough for a responsive preparation of LIS to cope with current technological challenges. On the other hand, the 'clash of cultures' continuously pointed out between IT and library professionals, seems to indicate that the long way already covered together in practice settings is not enough, per se, for raising the common knowledge needed.

Studies of sociology of knowledge have emphasized the importance of understanding knowledge as culture, i.e., as social practice embodied in a multiplicity of knowledge production systems, with their structures and languages. There is also indication that research on specific knowledge cultures is needed to advance the knowledge that links organizations and groups to their underlying technological and informational structures.

#### **1.4.4.1 The missing subject matter: IT**

From all the scanned literature, one aspect has turned out that should be highlighted for its absence: the general lack of analyses based on, or starting from, IT artefacts, their concepts and language. In many points of this literature review there is reference to the need of 'fit' between IT and library institutions and professionals. Yet, the literature lacks, by and large, discussions of the technology itself. This is especially true in writings of a theoretical or conceptual nature, usually devoted to contextual aspects of using IT, not to IT itself, while the professional texts describing particular technologies or applications exhibit principally a practical approach, focused and narrow, for basic learning for operational purposes.

This 'absence', i.e., the predominant concentration on IT contexts and the lack of attention to the IT concepts and artefacts themselves, is not particular to LIS as it has been recognized, for example, in Information Systems research (Orlikowski & Iacono, 2001; Holmström, 2001). Orlikowski & Iacono (2001) analysed ten years of a leading research journal and concluded that the IT artefact is under-theorized, i.e., the focus of attention is usually everything that pertains to the context of IT use, without discussion of IT itself.

“The outcome is that much IS research draws on commonplace and received notions of technology, resulting in conceptualisations of IT artefacts as relatively stable, independent, and fixed. As a consequence, IT artefacts in IS tend to be taken for granted or are assumed to be unproblematic. [...] Articulations of the nature and role of technology, and theories of its interdependence with social contexts are also missing from classic social theory, where technology is either ‘black-boxed’ and treated as monolithic [...] or it ‘vanishes’ from the view in the preoccupations with social constructions [...]. Processes such as innovation and change are conceptualised largely in socio-economic terms [...]. Technology, as the quintessential ‘thing’ dissipates into the atmosphere around us, or it becomes emblematic of our ‘age’. We throw it up as a banner of our times, but then instantly let it recede from view by stereotyping or ignoring it” (Ibid.).

In LIS, apart from some general concepts pertaining to information retrieval, a few other cases can be mentioned as theorizations based on Computing / IT concepts. There have been suggestions for the use of principles underlying conceptual database schemas to MARC (Leazer, 1992) and to the design of cataloguing processes/rules (Taniguchi, 2002; 2004); for object-oriented thinking application in structuring of cataloguing data (Heaney, 1995), and for the use of formal ontologies to design and support relationships of bibliographic entities in ways alternative to relational databases (Weinstein, 1998).

The most important outcome of this trend towards conceptual modelling of bibliographic processes and data is FRBR (Functional Requirements for Bibliographic Records). This conceptual study adopted the E-R (Entity–Relationship) model of data analysis to reassess and redefine the constituencies of bibliographic records (IFLA, 1998; Le Boeuf, 2002) and quickly became a cornerstone for many experiences in redesigning access to and collocation of bibliographic entities in catalogues. It has also contributed to start discussions on rethinking cataloguing principles and rules on the basis of a new theoretical foundation (see, e.g., Le Boeuf, 2003 and IFLA, 2004).

This trend indicates the pertinence of reusing concepts and techniques long used in IT. But its relatively recent occurrence, not until the 90s, shows that the conceptual intertwining of LIS and IT has not been the norm since the days when bibliographic catalogues became automated. On the other hand, while bibliographic data is central to LIS, it is still a very particular and confined aspect of the design and management of IT systems that currently support library services. Broader technical

overviews or conceptual analyses of IT that can inform design and management of library services at a high level have been basically absent from LIS research.

Conceptual changes underlying the evolution of IT have been poorly reflected in the professional literature used for education, training and guidance serving the operational/tactical level. The same applies to literature that deals with service, organizational change and strategic management, usually more focused on management methods and guidance in their adoption and implementation, rather than on IT itself (e.g., Lancaster & Sandore, 1997; Gaur, 2003; Baker, 2004).

## **1.5 Research focus and questions**

### **1.5.1 Introduction**

From the literature review it is clear that in the relationship between LIS and IT the sharing of knowledge is a central issue, but most common approaches to IT in LIS do not tackle this perspective in particular. The two major endeavours for IT knowledge acquisition have been educational programmes, most confined to adding to the field content from other disciplines or from the IT market itself, and training and learning on the job, which are situational and contingent. Altogether they have not been sufficient to trigger the development of deeper and more stable common knowledge between LIS and IT as academic or professional fields.

The sharing of knowledge among the fields is complex, notably when IT is involved and the management of organizations and their objectives is paramount. Knowledge production and interchange are not confined to formal education, rather they imply practice and the recognition of its epistemic value. The present research embraces the problem of IT knowledge in LIS from an integrative perspective, i.e., by trying a conceptual investigation that is not alien to knowledge gained from practice. This means the assumption that the research, while not linked to a given project or actual practice setting, should involve significant experience with library IT practice environments. In adopting this position, it is expected that the object of research is not subject to the many and varied constraints that impinge upon either the political, administrative, economic and pedagogic issues and traditions of educational environments or the priorities, particularities and other organizational bias of actual libraries.

The notion of practice (see also pp. 57 and 343) is understood not just as the actual performance of activities learned a priori, but also of activities often requiring novel combinations of both known and unknown subjects, concepts, tools and techniques. This is the richness of practice environments and the challenge of organizations in managing IT and information assets.

### **1.5.2 Major assumptions**

One main argument of this study that there is need for better integration of IT and LIS in order to facilitate conceptualizations of and strategies for library and information services that can enhance responsiveness to the challenges of digital networks. These challenges are at least partially unknown and emerge from actual environments.

Major assumptions behind this research are:

- the centrality of IT for conceptualizing, modelling and managing library structures and information services;
- the importance of understanding IT within organizational frameworks, bound to cultural and social contexts; and
- the relevance of analysing technical concepts/languages to enhance cross-sectoral understanding of IT.

Other assumptions derive from the above. They relate to the centrality of learning and knowledge in organizational environments, to epistemological understandings of interdisciplinarity and to the key role of communication and language. Learning is one of the most emphasized aspects of applying to libraries the theories of change management brought from other areas, assuming that professional knowledge acquisition is no longer the exclusive prerogative of formal education and training. It is also something that has to be managed in the actual life of organizations, alongside other more traditional aspects of management, because knowledge is an asset that influences the effective management of other assets.

As Boisot (1998) explained, knowledge assets are “stocks of knowledge from which services are expected to flow for a period of time that”, as opposed to physical assets, “may be hard to specify in advance” (Ibid.: 3).



Besides,

“the open-ended value of knowledge assets means that there is no one-to-one correspondence between the effort required to create them and the value of services they yield. Knowledge assets, in contrast to pure physical assets [...] are non-linear with respect to the effects they produce” (Ibid.).

The hypothesis explored by Boisot is that an organization’s

“distinctive competences, its capabilities, and its technologies can be viewed as emerging from the discontinuous impact of its knowledge assets on the spatio-temporal and energy systems that make up its physical assets [...] this hypothesis profoundly transforms how we think of [...] organizational and managerial processes, and challenge much of the established practice” (Ibid.: 4).

Our framework of analysis presented in Fig. I-4 (p. 26) parallels these ideas. Boisot’s (1998) hypothesis, as he explained, “invites us to rethink the conventional and mechanistic conceptualisation” (Ibid.: 4) of organizations, and assumes technologies, competences and capabilities as the holistic concepts in which an organization’s knowledge assets manifest themselves <sup>6</sup> at different levels. In the management view, knowledge is the sense-making that supports action, i.e., it is not a goal per se but a means to build and lever the organization’s capabilities and competences. These encompass a range of concepts which Sanchez (2001) defined in the following way:

“Skills are the abilities an individual has to do things. Competency is the set of skills that an individual can use in doing a given task. Capabilities are repeatable patterns of action that an organization can use to get things done. Capabilities reside in groups of people in an organization who can work together to do things. Capabilities are thus a special kind of asset, because capabilities use or operate on other kinds of assets (like machines and the skills of individuals) in the process of getting things done. Competency is the ability of an organization to sustain coordinated deployments of assets and capabilities in ways that help the organization to achieve its goals” (Ibid.: 7).

Organizational learning (Argyris & Schon, 1978; Senge, 1990; Senge, et al., 1994; Sanchez, 2001) is, thus, a concept central to management and is part of its “supply chain” (Yuva, 2002). Actual people learning in actual activities, pursuing actual objectives, often addressing multidisciplinary problems, i.e., ‘communities of practice’ (Davenport & Hall, 2002; Wenger, McDermott & Snyder, 2002) became an important concern in management theories regarding knowledge.<sup>7</sup>

While communities of practice are not new, and they exist everywhere, the recent managerial focus on them stems from the globalization of knowledge in the information economy and the “imperative to develop a *knowledge strategy* along with a business strategy” (Wenger, McDermott & Snyder, 2002: 7).<sup>8</sup> In this context, ‘practice’ is a “set of frameworks, ideas, tools, information, styles, stories and documents that community members share” (Ibid.: 29). It denotes

“a set of socially defined ways of doing things in a specific domain: a set of common approaches and shared standards that create a basis for action, communication, problem solving, performance and accountability” (Ibid.: 38).

Community does not necessarily imply homogeneity; on the contrary, the concept became important precisely to cope with the issues that arise when such groups are heterogeneous, distributed, across boundaries and short-lived. What is aimed at with community in this context is “enough common ground for ongoing mutual engagement” and “a shared understanding of what aspects of its domain are codifiable and which are not, and what to do in each case” (Ibid.: 39).

The learning envisaged in strategies to support heterogeneous communities of practice is, therefore, different from and more complex to analyse than learning activities in the educational environment. The aspect that is often common to both is discussion about interdisciplinarity. Building educational interdisciplinary strategies is important to improve future perspectives of multidisciplinary work in actual environments, and hence of heterogeneous communities of practice. What is really problematic is to get such strategies sufficiently early, in time to cope with changes in the real world. This is especially true in all areas dealing with computing and IT. Furthermore, as explained earlier, these are all fields undergoing complex situations in their disciplines that at the same time demand and restrain interdisciplinarity.

It is true, however, that what makes us talk about different ‘cultures’ is in great part a result of different backgrounds, anchored in different types of knowledge and expertise that are essentially disciplinary. But, as noted earlier, ‘cultures’ is more than that, deriving from different experiences, different abilities and traditions on how to conceptualize, different communication patterns, different ontologies and languages to express and communicate ideas. Differences, difficulties and challenges encountered in practice are powerful motivators of cross-sectoral integration.

This is at the heart of what Roy (2000) calls the “new epistemology”, i.e., the “discrediting of the linear theory” as the “necessary result of the reductionist absurdity that the whole can be made up from parts” (Ibid.: 53). In these terms Roy refers to the classic proposition that “basic science leads to applied science leads to engineering and technology” (Ibid.: 53).

“The new epistemology for pull science, connects science and technology and human needs. It starts with felt needs, moves to careful observations, especially of ‘anomalies’ and exceptions and curiosities, of the whole, suggest new opportunities. From such ‘observations’ one works back to technology, which pulls out the relevant applied science. This is followed by careful analysis and optimisation and perhaps in a few cases pull out some science, new understanding and maybe ‘new principles’ ” (Ibid.: 53).

Finally, communication is central to cross-domain interactions and domain or discipline languages, with all that language subsumes, become fundamental. Ontologies, vocabularies and languages may be particular to a given discipline, domain of knowledge, area of activity or technology, but concepts and ideas, in levels above the operational endeavour, are usually not.

This last assumption opens a way to the exploration of forms of shared knowledge that pull new explanatory and predictive knowledge (science and design) from normative and action-oriented knowledge that govern practices (Bugliarello, 2000). Domain ontologies and languages reflect both normative knowledge and practices of the domain, so they can offer a focal point for explorations towards improving cross-domain interactions. Svenonius (2000), for example, illustrated this in a synthesis of intellectual foundations of information organization, raised around the conceptual framework of a ‘bibliographic language’, and aimed at audiences wider than LIS.

### **1.5.3 Research questions**

There are two major premises behind this study. First, the research should consider an epistemic approach that combines disciplinary as well as organizational and cultural issues, taking into account perspectives drawn from LIS, Information Systems and Computing /IT. Second, the exploration of common conceptual building blocks for the communication between the fields should connect directly to the central axis of their relationship, i.e., the technology itself and its underpinning

concepts. This premise moves the research from the more common focus on IT effects and impacts to the understanding of fundamental concepts of IT itself. From these premises the study addresses two major research questions (in which LIS is used to mean both libraries and their disciplinary field):

**Question 1 - Is the relationship between LIS and IT characterized by sharing conceptual foundations that facilitate conveying IT knowledge into LIS; or is it predominantly confined to the operational needs of IT artefacts consumption?**

This question requires an investigation into the nature of the relationship of LIS to IT in order to determine whether or not Computing/IT has been conceptually embedded into library practices and LIS theoretical thinking. This part of the research comprises Part II of the thesis (Chapters 2 and 3) and elaborates on a selection of the aspects already approached in the literature review, using two major perspectives.

First, Chapter 2 will analyse the main lines of the evolution of IT in library practices and policies, in order to reach conclusions about the degree of alignment between the IT environment, notably the IT industry, and the library as an organization. Characteristics such as an essentially ‘additive’ strategy followed by libraries in consuming IT, or a systematic delay of the industry in providing up-to-date library technology, may be evidence of such a lack of alignment, not only in strategic terms but also in the congruence between the predominant frames of reference of the respective communities. The lack of a common conceptual basis to feed congruent frames of reference can be also revealed by a diffuseness of concepts and models for library services in the digital environment.

The second perspective will be provided by Chapter 3, focusing on the paradigms, and commonalities and differences of the various disciplinary fields involved in the LIS/IT relationship: their conceptions, populations and actual interchanges. If, despite the common claims of interdisciplinarity, they overlap little in concepts, agents, languages and show little interchange, that can be seen as confirmation of weaknesses in sharing conceptual knowledge.

A case study of the Z39.50 protocol, provided in Chapter 7, will seek to confirm and illustrate in more concrete terms the difficulties in IT knowledge sharing among the different communities.

A consequence from identifying weaknesses through answering Question 1 is the need to seek ways of improving IT knowledge integration in libraries and LIS. It is the principal argument of this thesis that IT itself, as it evolved since the rise of distributed systems, may provide the building blocks for a shared conceptual basis that can serve more than the management of IT technical systems and the respective technical communities. Therefore, this possibility is explored by a second research question.

**Question 2 - Is the technical background of computing/IT a persistent barrier to knowledge sharing with LIS? Or is the evolution of computing/IT providing a set of integrative concepts that can serve as a durable and extensible common conceptual basis?**

This question addresses the knowledge sharing problem by exploring the hypothetical potential of IT constructs as sources of conceptual alignment, i.e., of contributing to the congruence between the frames of reference of IT and non-IT communities, library professionals in this instance. The answer to this question is provided in Part III (Chapters 4 to 6) of the thesis.

Because the problem is diffuse and requires a holistic approach, the hypothesis is backed by a systems thinking framework and by the understanding of IT as being socially constructed and reconstructed (see section 1.6.1), rather than being just confined to pure technical expertise. However, it is also recognized that the answer to the question demands a thorough analysis of technical matters, though at a high level. Therefore, this part of the research will focus on the evolution of computing/IT since the development of distributed systems. The objective is to find major changes, underlying the various technologies, that can represent long-standing conceptual trends that are amenable to audiences, and applicable to management situations wider than those of the computing professions.

The criteria to test the hypothesis are of two kinds. One is to seek confirmation that the general trend in IT is towards constructs that are even less confined to purely algorithmic approaches and that the construction and management

of computer-based applications tends to be even more workable by lay people, as it happens in many cases with the Web technology. If this is the case, the trend justifies the claim of even greater demands for the interplay of different ‘knowledges’ and stakeholders surrounding IT, that should not be limited to just the operational use of concrete IT tools. A second criterion is to verify whether or not a representative set of foundational IT trends and concepts (i.e., not episodic or limited to particular technologies or products) can be found that convey high-level vocabulary and meaning, useful and usable in and beyond IT management, e.g., in organizational design, strategy definitions, process reengineering, information services modelling, etc.

Should this be the case, this set of trends and concepts can give support to the claim that IT itself can be a source from which to build the congruent frames of reference between IT and non-IT communities needed for the strategic IT alignment in organizations in general, as argued in Chapter 1, and for libraries and LIS, as argued in Chapters 2 and 3.

## **1.6 Research method**

### **1.6.1 Theoretical framework**

The general philosophy behind this study is that of ‘systems thinking’ as an intellectual positioning to overcome the problems that complexity and constant change pose to the traditional scientific approach. This conceptual basis provides the systemic perspective needed for the interdisciplinary goals of this research. It is based on the assumption that “systems are wholes with exclusive properties that have values that are not necessarily similar to the values of their parts’ properties” (Mora, et al., 2003). A systems is a set of interrelated components which effects on the whole “cannot be reproduced by a part independently” (Ibid.) Common to all types of systems are the following properties: “(i) wholeness, (ii) emergence, (iii) hierarchy, (iv) organization, (v) communication, (vi) control and (vii) complexity” (Ibid.).

This philosophy is itself a part of the environment of the computing and information systems evolution and of its understanding in business environments (e.g., Tansey, 2003: Chap. 2; Gharajedaghi, 1999). It is also congruent with many

current views of the 'ecological' nature of technological developments and their societal implications since the development of computer networks (e.g., Rennie & Mason, 2003; Leydesdorff, 2003) i.e., in their complex, unanticipated, systemic, self-organizing and recursive nature. The ecosystem metaphor has been used by a diversity of authors in different fields in relating technology development and use.

Arguing for ways of enhancing the adaptiveness of the library community over the long term, in face of a rapidly changing environment, Heilprin (1991) and Van House & Sutton (1996) used ecology and evolutionary metaphors. Cronin (2003) and Agre (2003) referred to the environment of technological changes in scholarly communication and publishing as an ecosystem. Nardi & O'Day (1999) and O'Day & Nardi (2003) conveyed the idea of systemic interdependencies between local systems and their components, comprehending "people, practices, values and technologies in a particular environment" (Nardi & O'Day, 1999: 49). The environments are "settings as information ecologies" and "library as information ecology" lends itself to an analysis of issues such as diversity and locality, co-evolution and identification of keystone species (O'Day & Nardi, 2003). Lanzara & Morner (2004) used the ecology metaphor to explore the patterns of knowledge making and sharing in open source software development.

Systems thinking is a fundamental philosophical background of Information Systems as a discipline (Saraswat, 1998; Checkland, 1999; Mora, et al., 2003) and is conceptually and methodologically influential in the development and management of information systems (Avgerou & Cornford, 1998: 126-129; Checkland & Holwell, 1998). As explained by Checkland (1999: Chap. 3-4), beyond its importance for social sciences in general, 'systems thinking' is especially relevant in areas such as Management which involve organizational, technological and human dimensions, as a framework for methodologies intended to identify, design and implement human activity systems. 'Systems thinking' is behind Checkland's *Soft Systems Methodology*, developed for tackling unstructured problems that have strong social intervention and cannot be adequately addressed by the 'hard systems' approach of the engineering profession (Ibid.: Chap 5-6).

In LIS, 'systems thinking' has also been used to frame, or to refer to holistic analysis of library services, its components, interactions and environment (Foskett, 1972, 1974; Brookes, 1976; Orr, 1977; Smith, D., 1980; Boland Jr, 1983; Buckland, 1988-1999: Chap. 4; 1991: Chap. 3; Gray, C., 1995; Svenonius, 2000: 3-4; Stuart

& Moran, 2002: 43-45; Weech, 2004). Kashyap, M. (1999: Chap. 1, 2) and Baker (2004: Chap. 4) provided overviews and frameworks based on systems thinking specifically oriented for the management of technology in libraries.

Another theoretical underpinning of this study is Giddens's Structuration Theory (Giddens, 1984) which has been influential in Information Systems research (Rose, 1998; Poole & DeSanctis, 2004). Giddens provided this theory as an attempt to reconcile the dualism between 'structure' and 'agency' in social sciences, i.e., the opposition of subjective and objective dimensions of social reality. The theory is a model of social systems where structure and action are not apart but interdependent, i.e., 'structure' (social rules and resources) is used by knowledgeable 'agents' which have the transformative capacity to monitor and reflexively change the structure.

"In structuration theory 'structure' is regarded as rules and resources recursively implicated in social reproduction; institutional features of social systems have structural properties in the sense that relationships are stabilized across time and space. 'Structure' can be conceptualised abstractly as two aspects of rules – normative elements and codes of signification. Resources are also of two kinds: authoritative resources, which derive from the co-ordination of the activity of human agents, and allocative resources, which stem from control of material products or of aspects of the material world" (Giddens, 1984: xxxi).

The duality of structure is a notion central to the structuration theory according to which "the structural properties of social systems are both medium and outcome of the practices they recursively organize. Structure is not 'external' to individuals [...]" (Ibid.: 25). Structure is, thus, dependent on action and is both the medium and the outcome of the process of structuration, i.e., of the production and reproduction of social practices.

"Analysing the structuration of social systems means studying the modes in which such systems, grounded in the knowledgeable activities of situated actors who draw upon rules and resources in the diversity of contexts, are produced and reproduced in interaction" (Ibid.: 25).

The relevance of the structuration theory for studies about the relationship between IT and given application fields, relates to a non-deterministic perspective of technological change. As noted by Edwards, P. (1995), the relationship between IT and society is often viewed in terms of the 'impacts' of the computer advancements on organizations and people. But technological change is itself a social process:



“technologies can and do have ‘social impacts’ but they are simultaneously social products which embody power relationships and social groups and structures [...]. Social impacts and social production of artefacts in practice occur in a tightly knit cycle. [...] Computers rarely ‘cause’ social change in the direct sense implied by the ‘impact’ model, but they often create pressures and possibilities to which social systems respond. [...] These questions are especially important precisely because the computer is not only inserted into an organization or a culture, but frequently embodies particular images of how the organization or culture functions and what the roles of its members should be. Once introduced, a computer system, by embodying these images can help institutionalize and rigidify them. What is needed is an awareness of the ‘web of computing’ [...], that is, of the ways in which a new computer system will be inserted into an existing network of social relationships. Neither a ‘social impacts’ nor a ‘social products’ approach will produce an adequate picture of this interaction; only an image of technological change as a social process is likely to be robust enough to capture the flavor of how computers work in society” (Ibid).

While some limitations are claimed about Giddens theory for applied research in information systems (Rose, 1998; Thompson, M., 2004), it provides an epistemological and ontological perspective that is relevant for conceptual studies and that has been used to theorize on and analyse the relationship between social change and IT (e.g., Orlikowski, 1992, 2000). Furthermore, it has been the basis of other theories, such as AST (Adaptive Structuration Theory), an expanded structuration model encompassing new concepts such as ‘appropriation’, for “describing and studying the interplay between advanced information technologies, social structures and human interaction” (De Sanctis & Poole, 1994). Some of the concepts pertaining to structuration theory and related theoretical constructs, such as that of ‘technological frames’ (Orlikowski & Gash, 1994; Cano, 2003) inspired the reflections brought in the present study.

### **1.6.2. Epistemology and method**

The problems in focus are complex, evolving and emergent, and imply factors and relationships that are uncertain and intangible in many ways, for which objective methods, detached from knowledge gained in practice, are inadequate. The question of method and the epistemological assumptions behind it are an important aspect for the present study. But, as noted by Day, R. (1996) ‘method’ is not just a set of steps in conducting research. Its discussion raises issues of tradition and scientific validity

that are connected to the place of a given field, or science, in the universe of academic knowledge.

As explained by Day, R. (1996),

“one of the difficulties LIS has had in establishing itself as a science within the modern university is the difficulty it has had in defining a methodology that is intrinsic to it. This is the result of the more primary problem of finding an object that is distinct, autonomous, and ‘objective’. [...] Not only has LIS traditionally had a variable and mobile ‘object’ of study with information, but in a larger culture, the classical positivist method that LIS has traditionally tried to measure itself against as a science is simply, no longer valid”.

Referring to the “epistemological crisis in modern science”, notably the critic of the classical positivist methods, Day argued that

“the traditional elements of knowledge – object, method and theory – are, at the least, social elements and are constructed moments within information flows and knowledge production. The crisis of modernist science gives LIS a central role to play in thinking the process of science, now understood as processes of information. [...] as a form of knowledge, LIS too must reflectively examine its own historical construction and its methodological procedures in terms of the information flows around and through it” (Ibid.).

Implications for LIS research suggested by Day are the need to

“examine the forces and relations of production that shape it and other academic disciplines [...] beyond the institution of LIS [...]; [engage] with the deconstruction of ‘scientific management’ currently occurring with such areas as organizational studies [...]; call into question the traditional relation of theory and practice and come to articulate both these terms as functions of social praxis within a variety of areas and institutions [...]; [and to provide for a] “conceptual expansion through a critique of fundamental vocabulary [leading] toward an expansion of the field and the production of new research priorities and agendas” (Ibid.).

The research questions defined for the present study fit into Day’s perspectives and suggestions and justify an interpretivist approach on the same lines of thought proposed by Cornelius (1996). Cornelius reviewed criticisms and limitations, from within LIS, about the so-called scientific and quantitative models, and drew on new movements in social philosophy to propose interpretation as a better epistemology, in order to attain high-level theories for the field.<sup>9</sup> Such movements, traced through Dilthey, Weber, Shutz, Gadamer and Habermas, (Cornelius, 1996: 14), focus on the value of the hermeneutic tradition and are rooted in phenomenology.

Interpretation is defended by Cornelius (1996) as a method for the “theoretical task [of] seeking a way of developing an understanding, and uncovering meaning, for and within information studies” (Ibid.: 6), that is more powerful than the traditional scientific methods of logical positivism or logical empiricism, to develop high-level theories that take into account the perceptions from within practice (Ibid.: 9-20).

“Without a clear and conscious high-level theory, there is no basis for a clear understanding either of where the field presently stands or where it is going. The myriad inputs from a range of other strong disciplines, the burgeoning range of information-handling professions, and the increasing pace of technological change make it increasingly difficult to state simply and with confidence what is that librarians or other information workers do in a way that makes sense for those practicing in all aspects of the field, including research and education” (Ibid.: 6).

Other authors have defended an epistemology for LIS research based on phenomenology and hermeneutics (Capurro, 1985, 2000; Bennett, 1988; Benediktsson, 1989; Budd, 1995, 2001; Benoit, 2002; Wilson, T. D., 2003; Hansson, 2005).

Budd (1995) assumes the phenomenological framework as a philosophical position that is “more than a method or set of methods”. For him, it is an epistemological foundation whose main elements are important for LIS as a social science (Budd, 2001: Chap. 6). Wilson, T. D. (2003) presented phenomenology as an integrative framework that since the 80s has marked the shift from the predominantly positivist model of information science towards “a number of new tendencies revealed most strongly in research on information behaviour”. This turn towards a ‘new canon’ for research in LIS, closer to developments in social sciences is also acknowledged by Horn (1998) and Benoit (2002) and is represented in the overview of research method trends provided by Powell (1999). Benoit emphasized the need to understand the different philosophies - positivist, interpretive and based on critical theory - behind uses of language in LIS (Benoit 2002) and in information systems design (Benoit, 2001).

The benefits of hermeneutic or interpretive approaches argued by most of the authors mentioned above are the multiple possibilities of those approaches for a field without a unitary object of research, the multidisciplinary activity they can foster, a closer relationship with other social sciences and with library practice, and a more

holistic understanding of research issues and of LIS as a field of study. These two last aspects are often especially stressed in face of the multidisciplinary and rapidly evolving nature of the field and of the frequently mentioned issues of research relevance regarding practice.

The background of hermeneutics, its evolution in the streams of social theory and their impacts in LIS were discussed by Benediktsson (1989), Cornelius (1996) and Budd (1995, 2001). Although there is a common background to interpretivism and hermeneutics in philosophy and the social sciences, there are diverse currents and positions about the notion of interpretive (*Verstehen*) understanding. Aspects fundamental to such differences are the role of the researcher, of his/her framework of reference and pre-understanding of the object of research. Schwandt (2003) explained that there are several views in this respect. One comprises the interpretivist traditions known as objectivist or conservative hermeneutics. Authors in these traditions, agree that it is possible

“to understand the subjective meaning of action (grasping author’s beliefs, desires and so on) yet do so in an objective manner. The meaning that the interpreter reproduces or reconstructs is considered the original meaning of action. So as not to misinterpret the original meaning, interpreters must employ some kind of method that allows them to step outside their historical frames of reference. Method, correctly employed, is a means that enables interpreters to claim a purely theoretical attitude as observers [...]. The theoretical attitude or the act to scientific contemplation at a distance requires the cognitive style of the disinterested observer. This, of course, does not necessarily deny the fact that in order to understand the intersubjective meanings of human action, the enquirer may have to, as a methodological requirement, “participate” in the life worlds of others” (Ibid.: 98-299).

In this view there are two dimensions to *Verstehen*: as the process by which we interpret meaning from interactions in our everyday life and as the method proper to social sciences by which, in an intellectual process, the inquirer gains knowledge about an object. In this process, known as the hermeneutic cycle,

“the interpreter objectifies (i.e. stands over and against) that which is to be interpreted. And, in that sense, the interpreter remains unaffected by and external to the interpretative process” (Ibid.: 300).

Another view of the notion of interpretive understanding is that of philosophical hermeneutics, that is found in the works of Gadamer (1988, 2004) and Taylor, C. (1978; 1985), inspired by Heidegger. Philosophical hermeneutics is

opposed to objectivist understanding, i.e., to the idea that meaning exists outside and independently of interpreters, waiting to be discovered or reconstructed. In philosophical hermeneutics, understanding is not a method, a procedure, an isolated activity, but it is rather a condition of the human being, a practical experience that is lived. According to this view, there is no distinction, i.e., no different steps, between understanding and interpretation. Besides, interpretation is produced with the engagement of the interpreter's standpoints, prejudgements and prejudices, because "tradition is not something that is external, objective and past – something from which we can free and distance ourselves" (Schwandt, 2003: 301).

The interpreter risks his/her biases and prejudgements in the encounter with the object of research, and

"understanding is something that is produced in that dialogue, not something *reproduced* by an interpreter through an analysis of that which he or she seeks to understand. The meaning one seeks in 'making sense' of a social action or text is temporal and processive and always coming into being in the specific occasion of understanding." (Ibid.: 302).

Budd (2001) explained broadly the contemporary debate on these matters in relation to the few studies of hermeneutics in LIS. He contrasted the views of Scheiermacher and Betti from those of Gadamer. In the first case, the focus is on the author of the text, or actor of an action, and meaning is something objectified, considered determinate and knowable, the text being assumed a representation of the author's or actor's intentions. In this position resides the criticism about Benediktsson (1989). In the second case, following Gadamer, the emphasis is put on the 'text' itself, the author's or actor's intention is considered as not absolutely decidable, and the context brought in to the interpretation is that of the interpreter's frame of reference, thereby allowing different interpretations. This is the framework of Cornelius' (1996) approach which Budd highlighted as the one that best serves a connection between theory and practice, attaining understanding of the LIS praxis, i.e., involving both its technical stances plus its ethical and social basis (Budd, 2001: 273-290). Cornelius (1996) himself explained his option, differing from the views of Bennett and Benediktsson, in similar terms:

"I firmly reject the idea of objectivation of mind, if that means that there is only one way of regarding a particular text. Similarly, the concentration that Benediktsson and Bennett saw in Ricoeur on constructing an analysis of text to discover authorial intention or original meaning must also be rejected, because my concern is not to recreate a past state of mind but to

discover and describe a current, shared, intersubjective environment” (Ibid.: 25).

The same arguments are claimed for the interpretive approach of the present study. One objective is to use representations of the various aspects that relate LIS to the Computing/IT and Information Systems fields, in order to build an interpretation that can improve the understanding of the reasons and effects of the poor integration among them. A second objective is to use representations of IT, IT artefacts and their evolution, to seek an understanding of their meaning and a high level interpretation that could contribute to a shared, intersubjective, knowledge environment. For both these objectives, the interpretive approach taken by Cornelius was inspirational.

In addition, taking into account that the research questions of this study relate LIS to other fields, it is worth noting that non-positivist approaches are also recognized both in Computer Science and Information Systems and, therefore are not foreign to any of the fields implied. In Computer Science, the limitations of rationalistic views have been acknowledged alongside the value of phenomenology and hermeneutics for meaning, representation and interpretation in systems design in general (Winograd & Flores, 1986: Chap. 3, 72-76; Dahlbom & Mathiassen, 1995: 215-221) or in HCI in particular (Dourish, 2001, 2001a). In Information Systems, the phenomenological perspective has been considered important to overcome the limits of traditional teaching and research in information systems analysis, design and development (Ciborra, 1998; Mingers, 2001). For Chalmers (2002), in current systems that use ongoing analysis of usage patterns (e.g., recommender systems) there is a trend to involve hermeneutical approaches to language. Fonseca & Martin (2005) defended “ontology engineering as a hermeneutic enterprise” by which the activities for “the representation of diverse ontologies can be a setting within which users with different conceptual schemas can learn to understand one another”.

The interpretive approach has been advocated as an alternative or a complement to positivistic methods for studying technology in organizations, thus emphasizing the need to understand phenomena in the context of given cultural settings and from the perspective of participants (Walsham, 1995; Trauth, 2001; Weber, R., 2004). Moreover, as dynamic environments require dynamic systems, i.e., demand greater understanding for adaptation of systems in production, the

interpretive approach is adequate to cope with “design as ongoing” (Lycett, Kanellis & Paul, 1997).

Many of the above references subsume a close link to practice and experience. Understanding from interpreting experience and practice, even from indirect sources, is fundamental to provide high-level theories and to avoid detachment from the actual field. With the hermeneutic orientation defended by Cornelius (1996), one can reach

“understanding of our situation, of one another, and of ‘foreign’ societies, we are constantly in dialogue, and our position becomes transformed by the process of understanding as we develop meanings. As a method, an epistemology, and an environment it offers the comfort of sustained meaning, even as a relativist and local phenomenon, and does not require agreement to universal statements or conformity to a rigid and possibly unattainable logic. It is firmly rooted in our interpretation of experience” (Cornelius, 1996: 18-19).

As a long-term practitioner in the field, the researcher has first hand knowledge of the context being analysed and interpreted. Being a library professional long involved with IT, concerned with both the management by, and of, technological resources in libraries, the researcher carries experience of the lack of sufficient integration that exists between the IT and LIS, and of its consequences, both at the individual and organizational levels. This position provides the ground for a necessary pre-interpretive stage (Cornelius, 1996: 46), i.e., the gathering of what is representative as content of the ‘practice’ under analysis. It also may contribute to the relevance of the research, i.e., its potential to change the researcher practice environment, as the interpretation is motivated by gaps understood through practice.

### **1.6.3 Research techniques**

Qualitative studies that use interpretive methods often apply techniques by which a researcher collects data from natural settings through participant observation, interviewing, survey questionnaires, and/or organizational document analysis. From the research questions defined it is clear that these forms of fieldwork would be limited for the scope of the present research. Therefore, the research technique is essentially conceptual and the data collection is mostly based on

reviewing existing literature representative of the knowledge and practices being analysed, having the personal experience of the researcher as a background.

The sources encompass opinion, theoretical and speculative literature as well as secondary research, i.e., using reports and outcomes from other research projects.

According to Cornelius (1996: 19),

“the interpretive approach is founded on experience, and the basis of its argument is what can commonly be agreed on as experience. The character of evidence can be extended beyond what would commonly be regarded as typical everyday experience by including within that experience the body of descriptions and interpretations that are ever present in the minds of practitioners. Thus, it is legitimate to include as evidence statements culled from serious, seminal, or influential literature [...]. In collecting and organizing the evidence, the task is to build and present a “text”, or account, which can be the basis of or the informant of the interpretation”.

Following Cornelius’ ideas, such a ‘text’, as evidence in the present study, is intended to be descriptive and explanatory of the issues relevant for the research questions. Although interpretation is already present in the selection and explanation of issues, it consists principally in an exploration of structures rather than facts, towards devising contributions to conceptual changes in the interdisciplinary domain in question.

The research carried out to build the overview of the evolution of the relationship between libraries and IT took into account the quality of the sources in terms of representativeness of the different aspects analysed, in technical and managerial terms, irrespective of the country or type of library. However, the selection shows a clear predominance of Anglo-American literature, mainly concentrating on libraries in university environments. This is justified by two reasons: first, because the university sector is very strong in the library community, thus accounting for a large share of the literature; second, because from the qualitative point of view, university environments exhibit the most advanced and complete set of issues regarding the use and the management of IT in libraries.

On the other hand, as the investigation developed to characterize other fields linking LIS and IT the sources used were mixed, both from LIS and the fields in question. The research to identify and describe the major lines and attributes of the Computing/IT evolution was based almost exclusively on literature intended for the audience of the field but selected from authoritative sources of the respective professional and academic domains, both in technical and opinion terms. This part of



the research developed in a recursive learning manner, exploring different levels of literature in successive cycles, building on continuously gained knowledge from the part of the researcher.

In general terms, the method used three major stages for each principal aspect of the research, adapted from the three stages suggested by Cornelius (1996: 46-47). The first was a pre-interpretive stage in which the 'rules' and 'standards' of the problem or object of analysis were identified in order to provide the main elements of content that best represent it. The second was a stage of interpretation in which the account was reconstructed in the researcher's terms to provide an explanation and justification for common or diverse meaning regarding the synthesis of used sources. The third stage, which in Cornelius is a post-interpretive stage "where the practice is altered to meet the requirements of justification" (Ibid.: 46) corresponds to the conceptual constructs that are offered as responses to the research questions.

#### **1.6.4 Research design**

Given the vastness of the fields implied in the research questions, the investigation was designed to achieve meaningful results in a tractable way. For the first research question a broad overview of the relationship between libraries/LIS and IT was envisaged in order to provide evidence and explanation for the weaknesses of shared knowledge between the different communities.

The strategy to address the second question necessitated a criterion for delimitation of the technical content to analyse, due to the magnitude and complexity of the areas implied. In order to avoid limitations of scope that could hamper the high-level and encompassing view desired, a vertical concern was chosen, i.e., one that crosses all levels of information systems development and management. For these reasons interoperability was the concept selected around which the evolution of computing and IT was explored and relevant content was identified, captured and organized.

A road-map of the research is presented in Fig. I-7 (next page). It shows the main foci/groups of Chapters of each stage. The presentation of the thesis in four Parts broadly corresponds to these stages.



distributed systems, and concludes with the analysis of interoperability and the World Wide Web.

Part IV, consisting of Chapter 7 and 8, brings the research back to the library focus, with a new socio-technical perspective over the relationship between LIS and IT. Chapter 7 presents the case study of Z39.50, an interoperability standard which is essentially an IT development but original to the library field, raised throughout the same period of technological changes analysed in Part III. The advances and drawbacks of the standard, the successes and failures of its implementation, together with recurrent issues of nominal expectations and poor understanding of the underlying problems, provide more concrete evidence of the lack of absorption of IT concepts in LIS, while showing the difficulties in the communication and interchange with the mainstream IT communities.

Chapter 8 closes the study by synthesizing and discussing the major findings regarding the two research questions. It provides a high-level characterization of the relationship between LIS and IT, based on the findings of Part II and Chapter 7; and elaborates on the integrative potential of IT concepts in the light of the trends identified in Part III, framed by the theoretical thinking exposed in Part I (Section 1.6.1).

### **1.6.5 Validity**

Being a conceptual study with no collection of empirical data, other than the long professional experience of the researcher, a set of objective variables could not be defined and the hypothesis had to be tested in high-level, conceptual terms only. Interpretation involves the subjectivity of the researcher from the outset throughout the study. Nevertheless, control of subjectivity and bias was attempted by self-examination of pre-suppositions, by selectivity of sources and by recurring cycles of literature analysis. While limitations are acknowledged, it is recognized that the kind of research questions addressed in this thesis were not amenable to substantially different methods.

One aspect important for the relevance of the research is the role of the researcher as interpreter, bringing a pre-understanding of the fields and problems to be addressed. According to Bradley (1993),

“Pre-understanding is the fusion of knowledge, training, experience, interpretation and ways of thinking and articulating that individuals bring to any situation [...], the sum of what the researcher brings to the inquiry. [...] While these assumptions, like the assumptions underlying other research traditions, are probably resistant to both proof and conclusive refutation, it is possible, and highly desirable in the interests of methodological pluralism, to explore assumptions that underlie all research in the context of their usefulness in understanding particular research problems”.

The choice of research problem was motivated by the experience of the author as a systems librarian since the late 80s. This provided the needed ‘meaningful participation’ of the researcher, i.e., the pre-understanding of the lack of sufficient integration that exists between the IT and LIS facets, and of the managerial consequences of various kinds that can derive from that. While potential bias has to be acknowledged, it “is not easily purged from interpretive methods without disabling its interpretive core” (Sutton, B., 1993). However, the credibility of the representations provided in this study of the problems and fields involved – LIS, Information Systems and Computing/IT - is sustained by the selection and extent of sources used.

The study explores the links among these fields and proposes some conceptual models to understand IT at a high level, with no claim for solving particular applied problems or for having exhausted the possibilities in terms of points of view, content or conceptualizations of the topics covered. The meaningfulness of the study, on the other hand, does not derive essentially from the level of detail or objectivity of facts or technologies that are described and interpreted. Rather, it relies on the usefulness of the articulation of a synthesis of the knowledge about the relationship between LIS and IT and of the conceptual contributions towards their better integration.

In interpretive studies, as noted by Bradley (1993), understanding “is the knowledge and insight that the researcher develops during the research process”. The improved understanding and integration of IT knowledge by the researcher, and the relevance of this for her professional activities gives an indication of the usefulness and validity of the research carried out for other professionals with similar concerns.

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## Notes to Chapter 1:

<sup>1</sup> This essay is the closing part of an analytical bibliography on the 'future of libraries', containing 220 references from 1983-1994.

<sup>2</sup> Some examples given by Kling & Lamb (1996) for utopian authors are Stonier (1983); Toffler (1980), Koch (1991). Cited as anti-utopian are, for example, Reinecke (1984); Weizenbaum (1976) and Winner (1992).

<sup>3</sup> For Kling & Lamb (1996) social realism uses empirical data to examine computerization as it is actually practised and experienced, with the most common methods being those of journalism; social theory applies to studies that are based on explicitly developed concepts and theories that transcend specific situations; and analytical reduction is used in studies based on tightly defined conceptual frameworks, using a few key concepts.

<sup>4</sup> The references provided are illustrative, especially regarding practical cases, as the bibliography on the matter is extensive. More complete bibliographies can be found in Garrod & Sidgreaves (1997: Appendix G – Review of the literature, especially Sec. 5), Pugh (1997), Hirshon (1998), Blackmer (2002a) and in the bibliography compiled by Beth Picknally Camden available at <http://www.lib.virginia.edu/ptpl/biblio.html>.

<sup>5</sup> Because of the rapid pace and variety of contexts of IT development, the phenomenon of different 'cultures' raising barriers to evolution is also acknowledged within the computing / IT world. See, for example, Abiteboul, Buneman & Suciu (2000) about the database versus Web technology culture, and Rajlich, et al. (2001) on the issues of knowing the (different) culture and context of a given legacy system in order to provide for its maintenance and evolution.

<sup>6</sup> Boisot (1998: 5) uses the term 'technology' "to depict sociophysical systems configured so as to produce certain specific types of physical effects"; 'competence' "to depict the organizational and technical skills involved in achieving a certain level of performance in the production of such effects" and 'capability' "to depict a strategic skill in the application and integration of competences".

<sup>7</sup> According to Wenger, McDermott & Snyder (2002: x) the "field of knowledge management had gone through a first wave of focus on technology. A second wave dealt with issues of behaviour, culture, and tacit knowledge, but mostly in the abstract. A third wave now is discovering that communities of practice are a practical way to frame the task of managing knowledge. They provide a concrete organizational infrastructure for realizing the dream of a learning organization".

<sup>8</sup> As explained by Cox (2004), the concept of communities of practice has undergone some evolution, by the same seminal authors, from theoretical analysis to a more "managerialist stance". The latter is the perspective taken here.

<sup>9</sup> The need of a new epistemological framework for LIS was also emphasized by Radford & Budd (1997), Radford (1998) and Trosow (2001). This idea is also present in other authors that criticized views of the methodological debate limited to the quantitative versus qualitative question (Bradley & Sutton, 1993; Wildemuth, 1993; Olson, 1995; Sandstrom & Sandstrom, 1995; Liebscher, 1998; Riggs, 1998; Wilson, T. D., 2002a). Recent examples of the growing attention to epistemological issues in LIS can be found in Fallis, ed. (2002), Herold, ed. (2004) and Hjørland, ed. (2005).

## **PART II**

### **OVERVIEW OF THE RELATIONSHIP BETWEEN LIS AND IT**

#### **Introduction**

The general objective of this Part is to answer the first research question of the study: is the relationship between LIS and IT characterized by sharing conceptual foundations that facilitate conveying IT knowledge into LIS; or is it predominantly confined to the operational needs of IT artefacts consumption?

As explained in Section 1.5.3, two chapters are devoted to this matter. The first, Chapter 2, reviews the importance, extent and characterization of the different phases of IT application in libraries, with the aim of understanding the degree of alignment, as well as the barriers to it, between the IT environment and library organizations, including the evolution in IT knowledge acquisition by library staff. Following this, Chapter 3 explores the relationship between the two from the disciplinary viewpoint, encompassing LIS and other fields related to the provision and management of IT, in order to identify, and understand, weaknesses in the sharing of conceptual knowledge.

Mention of IT outside the analysis of disciplinary fields refers to IT goods and services as provided by the industry and applied by organisations.

Both chapters highlight the ever growing blur between the conceptual and technical ‘spaces’ where documentation, information and IT come together. With the popularization of IT and the advancement of network technologies, this blur reveals an increasing number of factors and intersection of fields, competencies and functions that were previously more distinct or at least more independent. All the fields involved, and the respective activities, become more complex and prone to emergent changes whose identification demands a retrospective understanding, in temporal terms, and the articulation of a broad range of aspects.

Today’s information prominence is realized through the use of IT resources of a varied nature made available by the complex IT industry - hardware, software, services – that grew as part of the concept of an information economy (Tansey, ed., 2003: Chap. 2). The impact of IT in changing the information market has been perceived as the distinctive characteristic of the post-industrial economic era (Shapiro & Varian, 1999; Evans & Wurster, 2000). But the societal and

organizational effects of IT reach far beyond mere business models and economic effects. While the use of IT in libraries has been motivated by efficacy and economic reasons, IT is even more intertwined with the proper object of the business of libraries: it has become the ‘technology of information’, as important as the technology of the printed world but allegedly with wider and more profound implications for the societal goals that libraries are bound to.

For all these reasons, libraries are among the organizations where the prospects and effects brought about by IT can be at the same time more critical and more diffuse than in business. According to Lynch, C. (1995), it has not been easy to discuss technology issues as such in the context of libraries, because they are “a nexus where public policy, sociologies, economics and technology are balanced against each other”. Therefore, the relationship between libraries and IT is complex and lends itself to a multitude of perspectives. The main perspective taken in these chapters is that of the management of and through IT, and of the competences needed to effect such management.

In order to guide the analysis and account provided in this Part, an analytical model was designed to identify the elements pertinent for the objectives of this study (Fig. II-1).

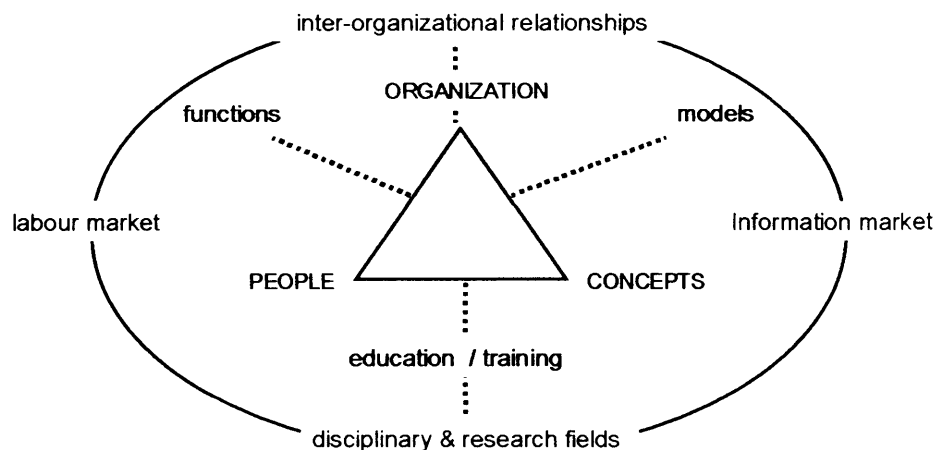


Fig. II-1 *Relationship between LIS and IT: an analytical model*

The model builds around three central elements:

- organizations, defined by their purposes, constituencies and working models, which are reflected in the information systems they generate and manage;
- people, represented by the professional activities and implied competences, i.e., knowledge, skills and values applied in practice;
- concepts, i.e., the abstractions that constitute fundamental blocks of knowledge that support professional activities and serve the purposes and objectives of organizations.

The analysis carried out in this Part is focused first on the three central elements of the diagram; it then expands outwards, touching wider zones of contextual influence, such as the inter-organizational relationships, the information and labour markets and the configuration of disciplinary fields. In between, other aspects were also approached as they reflect the characteristics of the relationship between libraries and technological communities. These aspects occupy different zones of the depicted relationships and are ‘models’ (of organisations, systems, services, etc.), ‘functions’ (of organizations and people) and ‘education/training’.

Most often, the influence relationship is seen from the outside upon the inside elements considered in this model. This is evident from the frequent concerns with the ‘application’ or the ‘effects’ of IT on organizations and people. In this thesis, however, attention was also given to how LIS people, organisations and the disciplinary field have seen, understood and managed IT. The analysis was conducted in such a way as to provide perspectives from different fields, building on the assumption that a two-way relationship between the related fields is needed and that it is possible to characterize the relationships even when their expressions are weak or absent.

With this model there is no intention to provide an exhaustive analysis of each aspect depicted but rather to provide a map to locate the principal questions in their complex context. It is, therefore, assumed that not all aspects are equally explored and developed.



## **CHAPTER TWO**

### **LIBRARIES, TECHNOLOGIES AND PEOPLE**

#### **2.1 Introduction**

This Chapter addresses the first research question of the study, by characterizing the past and current embeddedness of IT in libraries. The objective is to determine whether the field shares conceptual knowledge with IT or maintains a predominantly operational approach to IT. This is verified by identifying weaknesses in library/IT alignment and barriers to library transformation with/through IT.

To this aim, the Chapter analyses the evolution of the application of IT in library organizations. The relationship with the environment, e.g., the positioning of libraries in the information market by means of supporting policies, is also considered as well as the influence of IT on future models of library service and on demands for the education and training of library professionals.

#### **2.2 Organizations and technology: from modernization to transformation**

In the analytical model presented above (Fig. II-1, p. 78), the perspective of ‘organizations’ provides the evolution of IT in libraries and the perception of underpinning models. The evolution reveals stages and concerns that are different throughout time and that can be synthesized into three main phases: library automation, library systems networking and library in the Internet/WWW environment. As noted earlier in the literature review, most analysts have identified these phases with developments that correspond, successively, to stages of modernization followed by innovation and transformation (Montague, 1978; Lowry, 1990; Borgman, 1997; Lynch, C., 1993a; 2000; Duff, 2003).<sup>1</sup> The first two are essentially stages of automation, i.e., of modernization and innovation of already existing processes and the third, since the development of data networks but mostly after the Internet expansion, is connected to more fundamental changes that lead to transformation.

Borgman (1997) and Lynch, C. (2000) provided the representations that are most often cited. Borgman pointed out the different phases of library automation goals as: “(1) efficiency of internal operations, (2) access to local library resources,

(3) access to resources outside the library”; further, she identified as a fourth stage the present one which is mostly concerned with achieving “the interoperability between information systems necessary to build a GII” (Ibid.). Lynch’s subtitles for the three stages are: “computerizing library operations”, “the rise of public access” and “the content goes electronic” (Lynch, C. 2000).

It should be noted that these phases do represent different stages that can be concurrent, i.e., overlap in time. They are not absolutely delimited and transitions between them do not mean necessarily that a given level of issues is completely solved. In fact, there is often an accumulation of new issues over many of the preceding phases. The stages, highlighting the most influential topics and concepts are depicted in Fig. II-2.

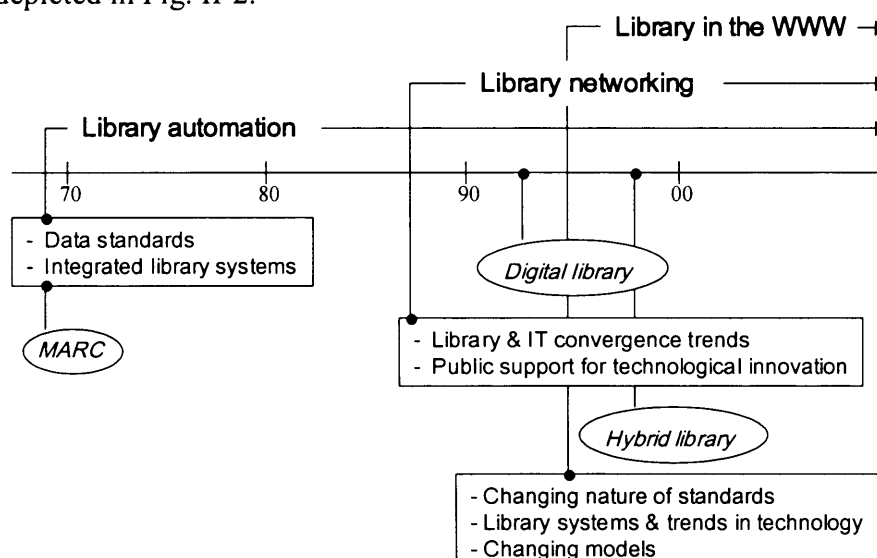


Fig. II-2 *Phases of IT in libraries, most influential topics*  *and concepts*

### 2.2.1 Library automation

Library automation,<sup>2</sup> which occupies almost entirely the relationship between libraries and IT between the 60s<sup>3</sup> and late 80s, is essentially a stage focused on rationalization of library operations, improving internal workflows, such as cataloguing, acquisitions and later circulation (Reynolds, 1985; Heterick Jr, 1990; Borgman, 1997), reducing drastically labour-intensive processes and also modifying in the same measure the main library product, the public catalogue. In this phase three aspects should be highlighted. First, automation has essentially been providing little more than the simple transfer of earlier, manual, models of library operation, in

which few, marginal, aspects can be considered as innovation, i.e., “experimenting with new capabilities that technology makes possible” (Lynch, C., 2000).

The second aspect is an important difference regarding automation processes in the business environment, at the time. Instead of investments individual to each organisation, libraries established collaborative inter-institutional efforts towards standards for machine-readable data and bibliographic networks which paved the way for shared cataloguing and for the establishment of major library consortia to offer computer bibliographic utilities, such as the Online Computer Library Center (OCLC) (Smith, K., ed., 1998) and the Research Libraries Group/Research Libraries Information network (RLG/RLIN), and offices for research into library matters such as the Office for Scientific and Technical Information (OSTI) later transformed into the British Library Research and Development Department (BLRDD) (Meadows, 1994). From this stage remains one of the most particular aspects of the relationship between libraries and IT, in technical terms. It relates to data standards, notably machine readable cataloguing (MARC) which conveys into the computer environment all the information constructs that libraries had been developing for decades (Hagler, 1997). Therefore, major achievements of this phase were not of a local managerial nature only, as was mostly the case in business (Borgman, 1997; Rosenblatt, 1999).

The third aspect deals with the kind of relationship libraries have had with IT through the so-called integrated library management systems. In this respect, automation did not always mean a close relationship with IT as such, in terms of required professional knowledge. Before the late 1970s, the development of library systems was mostly ‘in house’ or specifically sponsored by institutions. As the market developed, since the early 1980s, commercial library systems were made available changing the professional concern from ‘how to develop’ to ‘how to select’ systems, (Montague, 1978; Reynolds, 1985; Borgman, 1997; Lynch, C., 2000; Groenewegen, 2004). Like in other application areas, commercial software packages have been reproducing operational models as generally perceived for a category of organisation, business or process, helping to maintain rather than to change them. While software packages allow a significant reduction of initial investments, and their more rapid return, the fact is that they decrease the need to master IT in terms of design and development. Library management systems have been provided as ready

to use, therefore they have been essentially acquired, deployed and understood from the 'user' perspective.

The first generation of commercial systems was still rather insular, "often based on specialized hardware and/or operating systems lacking industry standard network capabilities" (Lynch, C., 1989). Furthermore, the nature of technology provision was also highly limitative. For almost two decades, not only IT systems were completely proprietary, in both hardware and software, but also the usual model was that of a single IT provider. Even after this situation started to change by the end of the 1980s, with systems becoming more based on standard platforms, the industry offering was still large scale integrated systems, highly proprietary, permitting little customization (Lynch, C., 1989; Borgman, 1997; Pasquinelli, ed., 1997) for which the local library IT expertise required was considerably limited. Reviewing library automation literature of this first phase, Shaw & Culkin (1987) recognized the lack of research in the area and the slowness of the profession in exercising control of library systems design.

This kind of problem would persist throughout later stages (see Pace, 2003), overlapping with other newer aspects of IT in libraries. From a computer systems design perspective, Saltzer (1992) noted that the availability of IT, e.g., "high-resolution desktop displays, megabyte/second data communication rates; client/server architecture and large capacity storage", was not enough. He identified various areas needing extensive engineering work to create workable solutions with these technologies, such as "getting the right modularity, arranging for an orderly transition from traditional methods, and identifying solutions that scale up in size in a satisfactory way" (Ibid.). Also, a number of research questions needed to be addressed, in areas such as information retrieval, linking and persistence.

In 1993, the Follett Report also underlined that library systems were "being left behind by developments elsewhere in the computer industry", unresponsive to innovation and still "largely based on closed proprietary technology" (Follett, et.al. 1993: Chap. 7). For Heseltine (1993), the library automation industry had reached "a critical point of generational change" after having "undoubtedly failed to innovate" for several years. One reason was the business model of the industry, strongly based on monolithic "turnkey systems" where the hardware component had been an important part of the business and where the high level of integration among different modules made it difficult to innovate without investments from scratch.

While Heseltine (1993) anticipated the trend towards software-only vendors and suppliers as integrators, where “mini-modules of specialized functionality” could be provided by other than the principal system supplier, Leeves, ed. (1994) reported that client-server technology and SR/Z39.50 were still “future developments” for many of the library systems vendors in the European market (Ibid.: 11, 24). In the same year, KPMG (1994) provided a review of the market in Europe by surveying systems, vendors and libraries, revealing that library concerns were moving from the traditional housekeeping functionality to better integration of networked resources. Drawbacks pointed out by libraries included lack of technologically advanced systems, a significant level of dissatisfaction in the relationship with IT suppliers, and lack of flexibility and adaptability of the systems in use. But the supplier’s view was that libraries

“often request new technology, such as systems based upon client-server architecture, without either really understanding what the technology is or can offer, or being able to explain its potential benefit to the library in terms of improving the institution’s ability to conduct its business” (Ibid.).<sup>4</sup>

This kind of ‘disadjustment’ between the market offering and library needs and understandings of IT, was still noted in later surveys. Murray, I. (1997) analysed a group of recently migrated libraries/systems, to assess their benefits and outcomes, especially in reference to the drawbacks and lack of innovation identified by the Follett, et al. (1993: Chap. 7) and KPMG (1994) reports. He found that systems were more frequently purchased on a software-only basis, and complied with the characteristics of the so called ‘third generation’ systems, i.e., highly integrated application systems using mainstream technologies, client-server architectures, standard operating systems, programming languages and relational database management systems (RDBMS), as well as support for standard protocols such as Structured Query Language (SQL) and Z39.50. But in terms of functionality, systems were procured to deliver basically the same kind of service provided by the system to be replaced, with added facilities for end-user autonomy (self-reservations, self-check, self-renewals, etc.). Although the network aspects were the most important for libraries, Murray, I. (1997) could not find explicit concern with “vision and innovation in the list of desirables” of the procurement processes, which were essentially pragmatic and revealed the difficulty of library staff in keeping up with the latest technology developments.

A final aspect that characterizes the automation phase and still continues is difficulties in library-vendor relationships. According to Pace (2003), a systems librarian experienced with working for both libraries and vendors, despite the history of collaboration and many cases of library systems co-development, there has been a mismatch of understandings between them, a lack of sufficient fusion of competences and a poor communication:

“library vendors failed to recognize the expertise, experience, and know-how that libraries can bring to the table [...] many librarians handled vendors with kid gloves. The relationship seemed more like dealing with an overly sensitive or reactive mate than with someone who traded products for dollars. (An interesting parallel can be drawn here from the way that some librarians approach a systems department; it is the technology, I contend, that sparks fear and trepidation, and not necessarily the people behind it)” (Ibid.: xiv-xv).

### **2.2.2 Library networking**

Library networking is the second stage of library automation, emerging from the late 80s up to the mid 90s, to which some authors associate the stage of innovation. Coinciding with the expansion of data networks and the Internet, it has been driven not by internal management efficiency but rather by environmental changes, to which libraries were forced to react “rather than methodically exploiting them” (Lynch, C., 2000). This is the age of retrospective conversion of card catalogues, of networked OPACs and union catalogues, of abstracting and indexing services going online, of interlibrary-loan systems, all resulting from the driving force of networks which changed the demand patterns over library services (Borgman, 1997; Lynch, C., 2000).

Micro-technologies, client-server systems and networks expanded and deepened the importance of technology for libraries (Pasquinelli, ed., 1997). Networking could rapidly bring many advantages for the end-user, but at the cost of a variety of new technical, planning and policy issues added to those of local automation. Not only technical problems arose “when systems not designed for a network environment [were] placed on a network” (Lynch, C., 1989) but also new barriers were found that inhibited the effective use of networked information resources, especially in an integrated way that required interoperability standards (Lynch, C., 1990; 1990a; Lynch, C. & Preston, 1990). The professional literature

from this period reveals two different levels of concern: the level of technical issues, related to the exploration of new network protocols and architectures, and the level of economic, social and organizational aspects.

At the technical level, this stage brings a closer relationship of the library field to IT developments, in efforts towards networking of library systems and services based on interoperability solutions. This is the area where libraries did pursue innovation through evolving IT itself, by developing and prototyping protocol standards such as Z39.50 (to be addressed specifically in Chapter 7). From the mid-eighties to the mid-nineties there is an immense body of technical literature, showing how leading library organizations were involved both in disseminating new technology and being directly committed to defining and building IT specifications and standards for network applications (see for example, Buckland & Lynch, 1987; McCallum, 1987, 1990, 1993; Lynch, C., most references from 1989-1994; Lynch & Preston, 1990; Dempsey, 1992; Turner, Tallim & Zeeman, 1992; Dempsey, Russell & Kirriemuir, 1996; Denenberg, 1996; Holm, ed., 1994, 1996).

However, it was not before the mid 1990s that libraries saw a critical mass of implementations of interoperable services using Z39.50, due to a variety of reasons in some cases illustrative of the relationship between libraries and IT. One reason was the slow development of the standard. It took so long that it was overtaken and delayed by changes in the mainstream network technology (Lynch, C., 1997b).<sup>5</sup> Besides, there was an actual inability of library systems suppliers to innovate their products (Heseltine, 1993; Dempsey, Mumford & Tuck, 1993; Leeves, ed., 1994: 11, 24) and, due to its complexity and flexibility, the standard was difficult to understand by both libraries and vendors (Lynch, C., 1997b). Furthermore, since the prototype phase, there were problems of mismatch in protocol implementations. But the most typical and problematic issues were due to functional and semantic differences among systems, which took a long time to be clarified (Moen, 2001).

Other characteristics of this stage affected the relationship of library organizations with IT. The convergence of networking and information resources, with the rise in electronic resources available on the Internet, raised significant expectations, opening perspectives for new models of running information management resources and services. They called for policy measures, encompassing organizational and economic matters, as important as the technical ones (Lynch, C. & Preston, 1990).

As public network infrastructures become available, the dominant model of the 'self-contained' library, as a centralized single-node system, began to evolve to a distributed model. One consequence was the unparalleled increase in the growth and cost of library technological infrastructure (Pasquinelli, ed., 1997), requiring sustainability strategies on top of the already difficult situation in other traditional library costs such as collection development. University libraries were among the first especially to feel the impact of such issues. Views from the field at that stage pointed to paradigm shifts under way. But, as stated by Heterick Jr. (1990) several "thorny societal problems" inhibit the paradigm change, such as the "classic economic model of the library" with free services versus the cost of integrating information from commercial online services and copyright law problems associated with digital information, for which policy actions and collaborative efforts were needed.

In this context emerged, in the beginning of the 90s, organizations such as the Coalition of Networked Information (CNI), gathering the efforts of the Association of Research Libraries (ARL), the College and University Systems Exchange (CAUSE) and Educom (Heterick Jr, 1990; Lynch, C., 1990); and the UK Office for Library and Information Networking (UKOLN) (Meadows, J., 1994). General accounts of the implications for libraries provided by policy bodies show the broad range of emerging aspects: infrastructures and standards for service provision, a more demanding scholarly communication environment, changes in the publishing industry and copyright law, access services to online materials, integrity and preservation of digital assets, privacy and anonymity of users (Follett, et al., 1993; Foster, 1993; HEFC, 1993; Lynch, C., 1993).

All these aspects were quite suddenly brought to the realm of library concerns, as libraries were faced not only with new local technological demands, but also with new external competitors in terms of information services provision. The idea of 'virtual' or 'digital libraries' was already growing fast among publishers and in computer research departments, bypassing the actual library in the same way as micro-publishing in the Internet was bypassing the traditional publishing channels (Lynch, C., 1993). Drabenstott (1994) synthesized the professional discourse and the plethora of issues already under discussion at the time, most of which would remain for a long time, including problems of identity and definition and, above all, the perception of non-sustainability of traditional services and the uncertainty about



future service models. Ongoing changes were difficult to understand and the future ahead was not easy to predict for libraries or other kinds of systems of organized knowledge (Lynch, C., 1995; Floridi, 1996).

It became apparent that library functions were enlarged, and that the importance of managing technological resources was rising almost to the same level of the management of information resources (Owen & Wiercx, 1996). Furthermore, it became clear that these two aspects tend to converge with the growth of the online information universe. In such a context, two different streams of action emerged with direct impact on the relationship of libraries and IT. One is the convergence of library and computing organisational structures. The other is the emerging support of policy and funding bodies towards technological innovation in libraries.

#### **2.2.2.1 Library and IT convergence trends**

With the generalization of network services, partnership or, at least, strategic co-ordination of libraries and computing departments was perceived as a critical management factor and elicited a repositioning of libraries in the context of their parent organizations.

“Typically the relationship between academic librarians and computer professionals has been one characterized by unease, caution, lack of knowledge and understanding, and occasionally outright mistrust. Over the past two decades, a small number of professionals from both organizations have worked together successfully but it has been a relationship based on the library ‘purchasing’ services from the computing center” (Creth, 1996).

As summarized in the literature review (1.4.2.2 c), convergence is a trend that has been flourishing since the 80s especially in the USA and UK, and later in Australia. Interest on the topic has been a constant in the academic library environment. As noted by Peters (1994) this trend is part of a larger transformation in higher education institutions.

As explained by Lovecy (1994), Pugh (1997), Hirshon (1998) and Seiden & Kathman (2000), there have been different reasons for, approaches to and outcomes of convergence. The trend towards integration has been reflecting the shift in requisite skills for both technologists and librarians (Hawkins & Battin, 1998; Hawkins, 2000), but most initiatives have been essentially of an operational nature, to cope with greater complexity in delivering complementary aspects of new end-

user services, such as instructional, reference and digital library services. As advocated by policy bodies such as the CNI (e.g., Heterick Jr, 1990; Lippincott, 1996) and the Joint Information Systems Committee (JISC) (e.g., Follett, et al., 1993: Chap. 4, § 90-91; John Fielden Consultancy, 1993: §2.25-2.30), convergence targets efficacy goals. The intervention of these organizations provides fundamental evidence that library, computing and communications communities were “viewed as part of a system whose whole is more than the sum of its parts” (Heterick Jr, 1990) and that there should be “equal weight to information as to systems which transmit, store and manipulate it” (Lovecy, 1994). Fieldwork done by Woodsworth, Maylone & Sywak (1992) on the correlations between library and computing jobs found significant overlap on several important aspects.

Backed or not by policy orientations, the motivations for convergence have been about two main aspects: creating a common management space, as well as a conceptual space, often referred to as ‘commons’ or ‘information commons’.<sup>6</sup> The management space is that of a complex and costly infrastructure, either in technical, human or informational resources. In this perspective convergence seeks solutions for operational efficacy, budget constraints and better planning (MacDonald, 1992; Lovecy, 1994, Sullivan & Calhoun, 1995). Besides the reduction of costs, in itself alone considered the wrong reason for convergence (Hirshon, 1998), other situational motivations of various kinds, ranging from institutional politics to personal factors (e.g., Lewis & Sexton, 2000) have often intervened in convergence decisions.

The conceptual space is based on the belief that sharing complementary staff expertise can better support service planning and delivery. Strategically, coordination or merging seek the creation of an academic environment that “attempts to provide a seamless continuum of patron service from planning and research through presentation into final service” (Bailey & Tierney, 2002; Boone, 2003). Conceptual and functional models, such as those suggested by Beagle (1999) and Bailey & Tierney (2002) translate this objective.

As noted by Davis-Millis & Owens (1997) a great deal of analysis has been done on the pros and cons of merging but “relatively little attention has been paid to the benefits of sharing cultures, or even to descriptions of the respective professional cultures”. Allen (1995) analysed the scant literature on the topic of collaboration barriers, including personality studies, without deriving substantive conclusions apart from identifying organizational differences and professional values. On the other

hand, the situation within computing centres has been itself under new pressures and confusion. In an organizational analysis of an US academic computing centre, McCombs (1998) found disfunctionalities, lack of control and a sense of alienation and chaos, mostly attributed to the inability of leadership positions to create common values in the rapidly changing technological environment.

Other general aspects can be observed about IT/computing and librarianship cultures (Cain, 2003). The need to take into account culture differences is usually acknowledged in the convergence literature, alongside recognition of pros and cons that can be either attenuated or exacerbated with mergings (Lovecy, 1994; Lippincott, 1996; Hirshon, 1998). There is often a past history of competing visions about the criticality of their missions; it can be attenuated by an approach that first uses concurrent investments in specific projects (Davis-Millis & Owens, 1997). According to US literature, when a new coordinator position is created (CIO or equivalent position)<sup>7</sup> it is more often occupied by a librarian or otherwise skilled manager than by computing staff (CLIR, 1997a; Hirshon, 1998: VIII).

Librarians are often regarded as having a greater service orientation, with a richer background in terms of managing capabilities, and a more homogeneous knowledge that provides a shared philosophy and common values. IT/computer staff are seen as more technically oriented, with more diverse backgrounds and experiences and less of a common professional philosophy (Davis-Millis & Owens, 1997; CLIR, 1997a). In a partnership that goes directly into full operation, the quality of leadership becomes crucial to overcome aspects such as the “resistance culture of limited responsibility” or the “chauvinist culture of expertise” (Bailey & Tierney, 2002). In the Garrod and Sidgreaves’s (1997) study, “separate ‘computing’ and ‘library’ cultures were found to persist even in integrated or converged services” (Ibid.: Abs.).

The literature on convergence suggests that on the administration (e.g., planning and budgeting management) and operational levels (e.g., integration of service provision to end-users) the benefits of convergence are usually recognized, and attained in many cases. However, there is no substantial evidence that convergence became the norm and this is attested by the continuance of abundant literature advocating it. Generalizations are difficult because practical cases and their assessment criteria are hard to compare, as convergence realization shows different flavours and problems, according to the variety of its possible forms, from full

integration (physical, administrative, and operational), managerial coordination (separately managed units responding to the same manager) to other more informal agreements of coordination.

Managing organizational change is a concern that brings the convergence problem to a wider realm of issues (Farley, Broady-Preston & Hayward, 1998) that occupy a great deal of the convergence literature, in aspects such as strategic goals, alternative to bureaucratic organizations, changing structures and sometimes job names, resistance and competing views, etc. While individual case literature is usually positive (e.g., Davis-Millis & Owens, 1997; Foley, 1997, 1998; Halbert, 1999; Lewis & Sexton, 2000; O'Brien & Sidorko, 2000; Oden Jr, et al., 2001) there is no evidence that the attainment of functional objectives necessarily requires an organizational merging (Davis-Millis & Owens, 1997; Lynch, C., 1998a).

On the other hand, when the focus is on the strategic fit, the main emphasis is often on issues of leadership, but without advancing analysis of what that leadership requires in terms of common LIS and IT knowledge. For example, regarding convergence retrospectively, McLean (1997) considered that “moves towards the cultural convergence of the two major groups have made little or no progress in most cases” and that “the concept of one-stop-shop with the customer’s convenience as the pivotal point has proved very difficult to achieve in practice”.

Pugh (1997) highlighted the fact that convergence is “much more than integrating support services” and “dealing with planned change”. It is a matter of organizational development where, among other aspects, the learning climate, holistic approaches and job enlargements are essential, to cope with “unpredictability and the inevitability of change as a permanent factor in organizations” (Ibid.: 105-106). However, exploration of accompanying strategies, or of side effects of convergence towards nourishing common knowledge beyond the surface of coordinated information desks is almost absent, though frequently present in intentions. For Garrod & Sidgreaves (1997)

“There is little doubt that the new information environment requires a vast range of different skills drawing both on those of library professionals, as well as others from computing. The skills and even the personal characteristics of the library professional are widely different to those of the computer scientist. There is as yet little evidence to suggest that these can effectively be combined in a hybrid professional” (Ibid.: 3.4).

This may indicate that, although effective in many aspects, the conceptual space implied in convergence has been essentially limited to collaboration forms at the operational level, not really attaining significant changes at the epistemic level. It appears, according to Blackmer (2002), that many convergence or co-operative initiatives end by being essentially “useful examples of collaboration, but [do] not address systemic change”.

One conclusion that can be made is that while convergence seems an obvious way to deepen knowledge among members of heterogeneous communities of practice, it alone has not proved sufficient. That is to say, the fact that those communities come together in the same place, or structure, under the same budget or direction is no sufficient answer to the needs of IT knowledge in libraries. One may think that what happens is that in cases where such knowledge is advanced it remains localized, personalized, with little reflection on the library profession as a whole.

#### **2.2.2.2 Public support for technological innovation**

In the ‘networking’ stage, policy and funding programmes were established to help libraries adapt to and innovate with the new technological environment.<sup>8</sup> Inter-institutional initiatives became a novel facet of the library and information landscape, creating opportunities for institutions to experiment and develop solutions in a shared, often international, environment including industry partners. In computing research this brought a renewed interest in library and information topics, although in a first phase largely unrelated to existing library processes and organizations.

First among the support programmes was the European Commission (EC) Action Plan for Libraries, developed since 1985 with consultations and pilot projects, later established as part of successive funding Programmes.<sup>9</sup> Between 1990 and 1998 more than 80 projects, plus concerted actions, studies and workshops were funded. They covered a variety of aspects, from enhancing standardization, accessibility and harmonization of practices, all dealing with penetration of IT in innovative, cost-effective and knowledge transfer ways among an extensive range of institutions, international in scope (European Commission, 1999). One important aspect has been the significant percentage of industry partners, mostly software developers, in building solutions for prototype services and tools (European Commission, 1999a).

Such activities aimed at an 'European library space' in terms of experimenting with solutions and exchanging know-how, but not so much in terms of developing a regular space of equally advanced and equipped IT structures/services, as this was beyond the scope of the programmes. Projects would be undertaken according to the partners' potential contributions and opportunities, not always coinciding with local priorities or with the best timing to fit with ongoing services. However scattered in terms of topics/focus of development, and somewhat aside from the daily libraries operation, these projects have long created a positive culture of IT awareness and interchange with publicly available results. Nevertheless, it has been recognized that in many cases the results have not been duly exploited after prototype demonstration (Stork, 1998).<sup>10</sup>

Since 1998 a specific unit of the Directorate-general Information Society, DigiCult, has been addressing digital heritage and cultural content issues, encompassing a wider range of institutions and projects.<sup>11</sup> To frame this new larger area of research and development, DigiCult sponsored a strategic study that provided an in depth analysis of the technological state-of-the art regarding cultural services and applications from libraries, museums and archives, as well as legal frameworks and recommendations for policy and decision makers, with a five year planning in mind (European Commission, 2002).<sup>12</sup> With studies of such a scope, DigiCult has contributed to clarify the fact that major issues and the supporting technologies for the cultural sector are common to a variety of institutions and processes. This can help to overcome the traditional boundaries of technical specialist domains, encouraging rethinking of strategic and managerial aspects and linking specific projects to mainstream technologies.

In the UK, the eLib Programme was established in 1994 by the JISC, following the recommendation of the Follett Report (Follett, et al., 1993). eLib developed between 1994-2001 in three phases, evolving from a broad range of topics in phases 1-2 (50 projects, covering five major areas: electronic publishing, learning and teaching, resources access, supporting studies and training and awareness) to a more comprehensive and cohesive approach, with fewer projects, under the concept of 'hybrid library', in phase 3. The last, from 1997 onwards, concentrated essentially on integration problems and had four major components: the hybrid library itself, large scale resource discovery, preservation and turning early projects into services (Rusbridge, 1998).

As a development programme, eLib differed from European programmes, in having a closer and more systematic approach to reality in the field, allowing a follow up and aggregation of results and giving birth to major large-scale services, especially in the area of resource discovery, as the Distributed National Electronic Resource (DNER).<sup>13</sup> eLib included an area specifically devoted to professional awareness and training (Garrod, 1997; Garrod & Sidgreaves, 1997; Mulvaney, 1997) and formative and summative evaluation components (Davies, et al., 1997; Banwell, Day & Ray, 1999; Whitelaw & Joy, 2000, 2001).

Another strand of funding technological innovation concerns digital libraries, notably through the Digital Library Initiative (DLI) jointly launched in 1994 by the National Science Foundation (NSF), the National Aeronautics and Space Administration (NASA) and the Advanced Research Projects Agency (ARPA).<sup>14 15</sup> In its first phase (1994-1998), DLI funded six research projects (Griffin, 1998) led by university consortia and essentially oriented by computing research. Prior 'digital library' experiments, some dating from the 1980s (see Drabenstott, 1994: 111-122) and part of them, such as ARIEL and the American Memory Project, were projects within library settings. Nevertheless, it was with the DLI that the term 'digital library' became common and the focus on digital libraries gained momentum.

In this context, the term got a strict connotation with the digital medium of contents and with new technological solutions developed as research prototypes, i.e., most often disconnected from actual, socially grounded, service environments and from the experience of traditional libraries (Levy & Marshall, 1994; Lamb, R. 1996a; Borgman, 1999a; Levy, 2000; Lynch, C. 1999b, 2003a). This helped to obscure the concept under futuristic misleading visions (Garrett, 1993; Lynch, C., 1993: 1, 9-10) while understanding was hampered by the different connotations of the terminology describing digital libraries (Arms, W., 1995). The term and concept of 'digital library' became a common theme of controversy (Kuny & Cleveland, 1996; Collier, 1997; Harter, 1997; White, 1997; Battin, 1998; Greenberg, 1998; Rusbridge, 1998; Borgman, 1999; 2000: 34-52; Lynch, C., 1999b), much of it in reaction to the fact that it had established itself as a research area principally in computing.<sup>16</sup> At first, this divide did not foster the relationship of libraries and computing, but rather augmented the confusion in a complex and rapidly changing information environment (Brophy, 1999: 9).

In terms of funding opportunities, the bias towards computing research was overcome later when, since 1998 (DLI2, 1998-2004), DLI sponsorship was extended to libraries and other cultural sector organizations.<sup>17</sup> In the same year NSF and the UK JISC issued a joint call for international proposals (Wiseman, Rusbridge & Griffin, 1999). In both the DLI and other library funding programmes there has been a number of significant projects involving library institutions, collections and services. In fact, it has been recognized that many of the actual ‘digital library’ concerns and issues had already been tackled in projects under the EC library programmes, even before DigiCult (see Stork, 1998), or eLib (see Rusbridge, 1998).

After ten years of funded digital library research, the mismatch of communities and objectives became recognized (e.g., Greenstein & Thorin, 2002) and explicitly articulated in discussions for a ‘post-DL’ research agenda. It became apparent that

“this [DL] venture would stretch the bounds of computer and information science, and, indeed, require the articulated confluence of multiple computer and information science disciplines” (Friedlander, ed., 2003: 1).

For Lynch, C. (2003c), despite situated in computing research, “the significant accomplishments of digital libraries” have been shaped by traditional conceptions, limited “mostly to incremental rather than transformative progress”. A future agenda should be inclusive of the functions of traditional memory institutions and address the “vast unmet needs” they are facing at “the individual and social levels” (Ibid.).

### **2.2.3 Library information networking and the WWW**

From the period before the WWW expansion, two major aspects must be retained as important social and organizational drivers of, or constraints on the ongoing relationship between libraries and IT. First, libraries got involved in providing or participating in network infrastructure services, with a contextual scope wider than before. This added extensive technical, management and financial efforts to cope with the emergence of new technologies, especially infra-structural, in order to adjust to the environment and enhance institutional services with access-oriented strategies. But, while extending the pragmatic field of library/IT collaboration, these efforts did not specifically change the traditional model of library and information management and its relationship to IT (Creth, 1996).<sup>18</sup> Second, libraries entered upon a stage of re-positioning for stake-holding information services. They began to



envisage new roles, especially in universities. Strategic alliances and cooperative activities expanded beyond the library world and new connections to the IT world were fed by project environments.

Most of the challenging issues identified in the early 1990s – either problems, expectations or trends – intensified rapidly with the expansion of the WWW, making the library and information environment more complex and unsettled (McClure, Moen & Ryan, 1994; Steele, 1995). From the second half of the 90s, comes what Lynch, C. (2000) considered the third “and probably final – epoch of automation”, overcoming modernization itself, and opening the way to transformation. The demands shift quickly from online information retrieval services to the delivery of electronic content. Libraries were pressed to expand their roles as distributors/publishers of online materials, as providers of technological support to diversified activities, in a turmoil of organizational, social, legal and economic issues.

Collection development and management, especially regarding journals, has been among the major changing aspects (Branin, Groen & Thorin, 1998; Lynch, C, 1999b). Costs became intolerable for library budgets (Lesk, 1996; Odlyzko, 1997a, 1999), the WWW grew as a major publishing environment (Cheney & Papadakis, 2000) with the publishing stakeholders seeking alternative models in the electronic market (Creth, 1997; Machovec, 1997; Ubell, 1997; Lynch, C., 1999a; Bide, 2001) and questioning library functions and strategies (Atkinson, 1996; Geyer-Schulz, et al., 2003). Besides costs, more controlled copyright restrictions have been affecting electronic library redistribution services (Ou, 2003) or biasing the selection of analogue materials to convert to digital (Smith, A., 2000).

Although these changes are all rooted in technological aspects, and have elicited questions of how to move technologically from managing collections to managing content (Conway, 2002), the front line of library concerns have been essentially managerial, stressing collaborative approaches such as collective purchasing/licensing of current materials through consortia (Ball, 2002) or undertaking shared efforts in converting retrospective materials (JSTOR, 2002).

Roles of library and information professionals have also seen considerable changes. New roles and skills sets are in place by the use of IT, other are envisioned as IT-enabled forms of repositioning the professional's value in the digital environment (Fourie, 2004). With regard to end-user services, for example, roles

have diversified, as in reference and library instruction services for which new needs and ways of realizing them have emerged (Lancaster & Sandore, 1997: 28-40; Griffiths, 1998; Newton & Dixon, 1999; Youngman, 1999; Allen, 2001; Baruchson-Arbib & Bronstein, 2002). In many cases they are extensions of already existing functions, but others mean a progressive engagement in new collaborative activities, e.g., with teaching staff for the development of educational Web based materials (Day & Armstrong, 1996; Iannuzzi, 1998; CLIR, 1999; Elliot & Spitzer, 1999; Kotter, 1999; Rader, 1999) or the integration of course management with library services (Cohen, D., 2002; Markland, 2003; Shank & Dewald, 2003).

### **2.2.3.1 Standards**

A third aspect that especially marks the context of the WWW stage is the spread and speed in the development of new 'standards' elicited by the network environment and generated by ad-hoc industry groups, Internet communities and research projects. In many cases they are just informal proposals for standard solutions, not standards in the strict sense and, thus, the term became popular for a variety of things. New standard development processes started to emerge as an alternative to the costly, time consuming and less participative processes of formal standard bodies (Lynch, C., 1993: 90; 1998b). Palme (1995), for example, illustrated this by comparing the standard making processes of the International Organisation for Standardisation/ International Electrotechnical Commission (ISO/IEC) with those of the Internet Engineering Task Force (IETF), and Bosak (2001) discussed the role of industry groups with the case of the Organization for the Advancement of Structured Information Standards (OASIS).

Although for libraries the concept of a standard has for a long time encompassed de facto standards (McCallum, 1996; Williamson, 1996), the new standards philosophy of the WWW environment has been very sensitive to libraries (Caplan, 2000). LIS is a field with a strong traditional standards-based culture that was already experiencing issues in adjusting its standards to the online environment (e.g., Standards, 1993).<sup>19</sup> In the Internet environment, the diversity of networked information objects and spaces, and their underlying NIDR (network information discovery and retrieval) models pose a range of problems that closely touch many areas of library activity (EU-NSF, 1998a; Lynch, C., 1995a; Brisson, 1998).<sup>20</sup>

In “embedding older information spaces with new ones”, especially in the WWW which is a “general-purpose information space”, a range of problems and limitations arise for resource description and classification, for levels of aggregation and granularity, and discovery processes and mechanisms (Lynch, C., 1995a). How this has been problematic for libraries is well illustrated with the confusing state of affairs generated by the proliferation of metadata standards,<sup>21</sup> their different communities, organizations and languages (Svenonius, 2000; Miller, P., 2004);<sup>22</sup> their heterogeneous visions, values and objectives (Gilliland-Swetland, 2004); their often redundant efforts, that should seek common ground (Caplan, 2004); their different correlation to innovation, due to different speeds, agendas, grades of flexibility and relevance to new practices (Caplan, 2000; 2000a; Gorman, G. ed, 2004).

Furthermore, as Caplan (2000) noted, in the “big seas” of technology and standards of the WWW the library world is only a “small fish”. There is a growing number of technological standards in place on which libraries have little impact or no control, because they are mainstream, serving much wider and richer constituencies. Besides, even within smaller spheres, like the digital library research community (which Caplan refers to as “un-community”), or its relationship with libraries, she noted “the balkanisation of efforts” (Ibid.).

Protocol standards, for example, can be seen as an example of this balkanization (Pace, 2002) and the same can apply to the results from digital libraries research projects. For Lynch, C. (2000), while libraries can make use of content and technologies developed in digital libraries, they have not yet been reconfigured by them and one of the reasons is that from the very start many of these projects did not involve libraries and were “designed to explore technology rather than to offer sustainable services” (Ibid.).<sup>23</sup> These perspectives of digital libraries being, in their “young” (not mature) phase, usually outside library operational environments and in the quest for “killer applications” were also recognized by Greenstein & Thorin (2002: 6, 10).

“Like the Holy Grail, these killer apps were elusive and appeared to different seekers in very different places – in data and metadata formats, in network protocols, even in systems and system architectures. The logic of their appeal is simple enough. Digital libraries are complicated to build and hard to maintain. Complexity is compounded by the fact that few libraries have more than a handful of appropriately skilled research and development staff. The killer application was the silver-bullet solution

that promised to propel the library into a networked age without undergoing the fundamental restructuring, staff retraining, and soul-searching mission reorientation that information technologies seem to have forced on virtually every other organization known to late twentieth-century society” (Ibid.).

In the open context where Web search services and digital libraries proliferated, the diversification of standards (or simply proposal of ‘solutions’ put forward to the WWW community) and their adoption patterns have been biased by market or research competitiveness. The advantages of speed, more openness and less formality for innovation, raise two main tensions. One is the opening to a proliferation of choices, which is opposite to the very aim of standards. Both speed and multiple choice are aspects that contrast with the slowness and orthodoxy of standard development in LIS, where professional activities have been by tradition strongly standard-based, at very detailed levels, but relying on widespread official consensus built upon long negotiating processes, led by long-term responsible agencies. According to Allen (1995), despite the greater efficiencies that LIS standards have created, there is also the “insidious effect of standardization in stifling creativity”. The other tension comes from the belief that inter-domain boundaries will be eliminated just by common simple standards. While they can bridge different domains at the lower common denominator level, they also can create difficult balances and create new misunderstandings if requirements or expertise of sophisticated information spaces are ignored (see, for example, Dillon, 2003 and Beall, 2004, regarding Dublin Core).<sup>24</sup>

For these reasons new standards have difficulty in moving forward library information systems transformation. Changing in-production services through technological advances implies standards’ options, whose cost of adoption has long-term implications. Therefore, changes cannot be undertaken without confidence in their long-term validity, especially if they are structural and not merely complementary to solutions already in place. The dependence of and implications for underlying IT systems is paramount and the uncertainty about technological choices is also a factor in favour of conservatism. On the one hand this explains the continuous trend for pilot studies, experimentations and projects to be developed aside from the current working structures of libraries. But, in turn, this may effect incomplete views, distance from practice and retardation of in depth innovation implementation.

### **2.2.3.2 Library systems and trends in technology**

In the second half of the 1990s there was a growing demand for library management systems to fit the Web environment in order to integrate externally held resources, accommodate multimedia information and respond to institutional digital projects, as well as tools for user empowerment and autonomy. The wide range of top technological topics and trends, provided by LITA (Library and Information Technology Association) experts since 1999, gives an idea of the expanding field of interest to libraries (LITA, 1999-2005).

Library systems started to show trends to support networked information resources, notably Web connections through embedded URLs and Z39.50 (Healy, 1998: 11-14; Akeroyd & Cox, 1999). But there are also missing functionalities, such as systems or interfaces to systems that support authentication, rights management and paying mechanisms (Healy, 1998: 14), not to mention functionalities for internal management purposes (Akeroyd & Cox, 1999).<sup>25</sup> According to Healy (1998), the librarian's perspective of the library management system was changing, although the time was essentially one of transition and a clearly defined role was difficult to envisage. The concept of integration – for so long attached to library systems – became crucial and understood at a broader level, with the traditional library management system being less and less the sole support of a library information system.

“With the Web flourishing, and creating both chaos and new opportunities, libraries are moving with a sense of urgency to adopt technologies that will allow them to capitalize on the opportunities they see. For many libraries the concept of integration has taken on a new meaning. Many library leaders now view the network as the centre of the library's technology infrastructure. Unwilling to wait for one holistic library technology solution, if one will ever exist, libraries are choosing components from a range of technology options. They are integrating these components into an overall technology framework. The library management system is but one component that links to other systems, databases, and technologies, with the Web as the common denominator” (Healy, 1998: 4).

Akeroyd & Cox (1999) also corroborated this trend and pointed out new functions and new software development models being addressed by library projects that focus on the design of systems that respond to digital and hybrid libraries requirements, for example the Agora Hybrid Library Management System. The

library systems marketplace started to show a trend to globalisation, in commercial and technical terms (Pace, 2003: 12-15), which has advantages but also drawbacks, for example in coping with the culture and practice of diverse professional communities, or multilingual aspects (Evans, 2000).

In face of the dynamics and new models of distributed information management emerging rapidly in the WWW (Pottenger, Callahan & Padgett, 2001), vendors started to announce strategies for new applications to extend the capabilities of existing systems by incorporating new products, sometimes developed elsewhere. These include not only functionality, such as meta-search solutions and reference linking software, but also provision for OPAC content enrichment, e.g., with bookjacket images, content tables and abstracts (Kochtanek, 2001; Breeding, 2002) and solutions for managing digital collections (Pasquinelli, ed., 2002).

Future directions for automated library services draw more from the context than from internal, specific domain requirements (Rhyno, 2003). There is a trend towards the development of, discussion about and use of a growing range of management technologies which are not exclusive of library needs and are also of interest to archives, museums and other cultural and scientific institutions, or commercial enterprises (MacDougall, 1999; Lavagnino, 1999; Lynch, C., 1999c; Rosenblatt, 1999; Pinfield, 2001a; European Commission, 2002; Lynch, C., 2002a; Yeates, 2002; Lynch, C., 2003b). A plethora of new classes of technologies/products emerged that is far from stabilized. These include portal solutions to integrate consistent Web access and personalization and authentication services to diverse components of a complex set of information systems, independently managed (Cox & Yeates, 2002); content management systems (CMS) to maintain Web-based dynamic resources (see Vine, 2001); digital asset management systems (DAMS) for mass storage, preservation, reuse and accountability of digital repositories (Geser, et al., 2002; Day, M., 2003); learning management systems (LMS) to manage documentation and online communication related to course activities (Lynch, C., 2002).

Particular technologies and tools that have captured attention of the library field have much in common with electronic publishing and digital library services. They range from solutions for persistent identifiers and reference linking (Shafer, 1999; Shafer, et al. (n.d.); Caplan & Arms, 1999; Van de Sompel, 2000; Grogg, 2002; Brand, 2003, O'Neill, J., 2003),<sup>26</sup> to aggregation of metadata based on wide

interoperability solutions such as the Open Archives Initiative (OAI) <sup>27</sup> (Van de Sompel & Lagoze, 2000; Lagoze & Van de Sompel, 2001, 2003; Brogan, 2003), personalization services (Lynch, C. 2001c), access service authentication and accountability (Lynch, C., 1998; Glenn & Millman, 1998; Hunt, 2001; Harris, McLeish & Paschould, 2003); metasearch tools (Dorner & Curtis, 2003; Brogan, 2003; Pace, 2004; Elliott, 2004; NISO, 2004-2005), and virtual reference desk (VRD) solutions (Sloan, 1998; Chowdhury, 2002; Penka, 2003).

Many of these may appear combined in practice, in one product or as assemblages from several parties, in solutions for complex information environments (see, e.g., Sykes, Paschoud & Cooper, 2003). The way they are combined, the various combined functions, the objectives and capabilities of the underlying services are complex, diversified and evolving and cannot be linearly assumed in an instance of a given 'type' of solution, e.g. 'library portals' (Dempsey, 2003).

Besides function-oriented technologies there is also the general impact of mainstream technologies, e.g., XML in different aspects of library related applications (Rhyno, 2003), notably in handling bibliographic data (Carvalho & Cordeiro, 2002; 2003; Cordeiro & Carvalho, 2003a; Carvalho, Cordeiro, et al., 2004). Another fundamental aspect that has entered the realm of libraries' IT is digital preservation, bringing deep concerns that are 'invisible' at the functional, immediate, level but that involve thoroughly the IT management strategies, requiring an holistic and comprehensive understanding of how technological environments change, and the mastery of sophisticated IT knowledge of a novel kind to library management (Cordeiro, 2004).

With this vast array of new technologies, functionalities, standards and concerns, the place of the integrated library system appears diminished and its future is not clear. Some commentators have argued that this is the end of the integrated library system as we have known it for at least two decades, i.e., off-the-shelf systems inclusive of all functionality needed. For many, the solution lies in strategically integrating functionality from different products (Yeates, 2002) and a new era of "integrating" (not integrated) systems is the way ahead (Kenney, 2003).

Although taking some of the directions described above, the market solutions for library systems have evolved slowly in integrating new technologies and functions (Ebenezer, 2002; Pasquinelli, ed., 2003; Felstead, 2004). Among other reasons is the fact that in such a specialist and relatively small market, product

enhancements take place only when there is sufficient customer demand. New customer demands, however, follow the same patterns of diversity and rapid change of technology, i.e., they are far from being clarified and stabilized. Besides, the library IT business is also changing quickly, in terms of the sources and modes of delivery of IT, but changes may point to contradictory models.

For example, on the one hand, there is myriad third party software ('add-on' solutions) for specific functionalities that libraries need to combine with the core library system (Maquignaz & Miller, 2004). Part of these tends to appear as open source software (Chudnov, 1999; Morgan, 2002; Cervone, 2003; Chawner, 2004), often bypassing the traditional library systems vendors, and its adoption can be seen as a "resurgence of homegrown systems" (Pace, 2003: 21-23). On the other, there is the availability of application service providers (ASP), a mode of outsourcing that extends the 'single vendor' and 'packaged' model from software provision to the maintenance of operational services (Richardson & Hopkins, 2004). Moreover, while the general trend in mainstream technologies is the combination of pieces of functionality from different sources, the market for library solutions tends to concentrate, through mergers and acquisitions between companies (Pace, 2003: 12-14).

In this context, the relationship between libraries and IT has found new challenges but also new gaps that are much harder to cope with than the previous phases of automation. It is even more difficult to cope with the knowledge needed for tactical and strategic decisions, and for the management of diversified operational services. While the traditional library management system is still the central piece of IT support for library operations, discontinuities are felt and there is a sense of disintegration of many aspects of the traditional model, and yet no clear vision of a stable framework for reconfiguration.

### **2.3 Changing models**

"The lessons of the several minor revolutions we have witnessed over the last two decades is this: the technology will rapidly evolve no matter what we do. We have to decide what purposes we want to accomplish with the current state of the art and plunge in, with the full knowledge that we are chasing something we can never catch" (Ayers, 2002).



Throughout the various stages of IT in libraries, a growing range of concerns has been raised, deepening the interdependency between technological issues and library operations, management, missions and strategies. A complex and inextricable set of different issues – sociological, economic, legal and public policy matters – has been surrounding the technological aspects, making the relationship between libraries and IT even more difficult to understand and advance.

The concept of ‘digital library’, with its many understandings, has shaken the traditional conceptions in fuzzy ways and widened the discussion space of what a library is. The different views and questions were summarized by Harter (1997), as in Table II-1.

Table II-1 *Potential properties of a digital library* (from Harter, 1997)

<b>NARROW VIEW</b> (based on traditional library)	<b>BROADER VIEW</b> (a middle position between the extremes)	<b>BROADEST VIEW</b> (loosely based on current Internet)
objects are located in a physical place	objects are located in a logical place (may be distributed)	objects are not located in a physical or logical place
objects are information resources	most of the objects are information resources	objects can be anything at all
objects are selected on the basis of quality	some of the objects are selected on the basis of quality	no quality control; no entry barriers
objects are organized		no organization
objects are subjected to authority control	some aspects of authority control are present	no authority control
surrogates of objects are created	surrogates are created for some objects	no surrogates of objects are created
surrogates are "finely searchable"	surrogates and objects are finely searchable	only objects are searchable
authorship is an important concept	concept of author is weakened	no concept of author
objects are fixed (do not change)	objects change in a standardized way	objects are fluid (can change and mutate at any time)
objects are permanent (do not disappear)	disappearance of objects is controlled	objects are transient (can disappear at any time)
access to objects is limited to specific classes of users	access to some objects is limited to specific classes of users	access to everything by everyone
services such as reference assistance are offered		the only services are those performed by computer software (AI)
human specialists (called librarians, etc.) can be found		there are no librarians
there exist well-defined user groups	some classes of objects have associated user groups	there are no defined user groups (or, alternatively, infinitely many of them)
use of library is free for specified user groups	use of library requires payment for some services and/or user groups	use of library requires payment

Thinking about library models has been stimulated by the successive changes introduced by IT in the library environment, i.e., changes are such that elicit interrogations about the basic lines of reasoning about libraries. Different kinds of models can be approached reflecting different views. These can be mainly based on one or several concepts, focusing on general roles and functions, on operational, organisational, technological or economic aspects. Peter Brophy (1999, 2002) summarized the major background concepts behind the understanding of traditional library models – collection-centred, giving prominence to knowledge gathering and preserving; user-centred, focusing on access and individual needs; or agent of social change, as in the case of public libraries.

Changes in thinking about library models have arisen since the introduction of 'library automation'. Cotta-Shönberg (1989) pointed to the predominance of functional structures (departmentalization) in libraries, "which often leads to predominance of internal processing functions over service functions" (Ibid.), stressing the potential and advantages of automation in developing alternative structural models, more service-oriented. According to Lowry (1990) the first stage of automation did greatly change the character of

"fundamentally nineteenth century institutions that could be characterized as labour intensive craft workshops [...] centered around specialized skills and knowledge applied to complex manual filing systems [serving mostly a] storage and retrieval role which libraries undertook as part of the task of managing information represented in the print-form codex" (Ibid.).

The network phase raised other, more substantial questions. Owen & Wiercx (1996) underlined the knowledge mediation model of a library on the basis of networking structures. They change not only the function of libraries, but also their role in the information chain, which has to be "reconsidered together with other parties (including publishers and parent organisations, e.g., universities and government organisations)" (Ibid.: 3.6). The co-operative network model extends the concept of a networked library to a space where libraries can function either as i) server libraries – taking the task of developing fully networked services, e.g., in a specific domain, as an extension of their traditional services; or as ii) client libraries - in this case not developing full-scale services in given areas, but acting as an interface to the relevant server libraries (Ibid.: 16).

With the expansion of the WWW and the proliferation of electronic information services, library models become more diverse and less understood. The paucity of research in this field and the need to explore new information management needs and new performance indicators for emerging models of electronic library services was pointed out by Brophy & Wynne (1997) and MacDougall (1999). They referred to a model of library services composed of a similar set of main functions: resource discovery, resource delivery, resource utilization, infrastructure provision and resource management.<sup>28</sup>

Brophy (2002) reviewed the trends and highlighted the idea of the 'hybrid library' which integrates features, functions, advantages and drawbacks from both the printed and digital world, as they cannot possibly subsume one another, at least in terms of content. The conceptual trend pointed out by Owen & Wiercx (1996) is reinforced by the MIA (MODELS Information Architecture): the library as a network intermediary, as a "broker" for distributed services to which integrated access is provided.<sup>29</sup> Technological means extend some of the roles and functions that in some ways already existed in the traditional library, e.g., the library as a memory institution, adding digital objects to the traditional collection model; the library as a learning centre, prolonging the social and educational roles; the library as a community resource, enlarging the direct information support to local communities. In many cases there is the need for new features in access systems, with even more personalized, controlled and business-oriented features. The evolution from gateway services to portals illustrates this (Brophy, 2002).

These trends point to management conceptions more oriented by competitiveness, towards enhancing the value and demand of contents and services in the information market. Pace (2003: Chap. 2, 4) argued for a more competitive attitude on the part of libraries, by not ignoring the models of the new Web information businesses in order to make the most of library expertise and resources in the new environment.

"Only recently has discussing the 'business of libraries' become possible without the usual abhorrent reaction from libraries who view business and libraries as so diametrically opposed as to be enemies" (Ibid.: 71).

The strategic and business concerns have been central to cultural policies that encourage the use of IT by institutions through management approaches that are less traditional to them. For example, the Digicult Study, which focused on the need to

unlock the value of cultural heritage, proposes a progressive strategy for memory institutions (libraries, archives and museums) towards a “cultural e-business model”. The model foresees a user-centric and demand-driven operation of institutions, but subsumes a digital integration of the organization as a whole, rather than a casuistic approach to Internet services.<sup>30</sup> Technology is considered a systemic factor for restructuring cultural organizations and restructuring is a condition for a good adaptation to the “network logic” (European Commission, 2002: 80-82).

In the library environment this means a clear shift in the traditional models of using IT in which the dominant concerns have been the ‘information-processing’ and ‘housekeeping’ of collections. This is the rationale behind the tradition of complete, monolithic library management systems. Building networked, multi-party, distributed and flexible systems seems to be the future for library technology infrastructure (Bazillion, 2001). This is part of a fundamental change by which, according to Yeates, libraries should be understood not only as “extended enterprise but also as externalised enterprise” (Yeates, 2002).

As noted by Brophy (2002), there is no single way of thinking about library models. Any model is incomplete, as it is an abstraction that forcedly highlights given technological or social dimensions. The discussions about models reflect the need to foresee systems with clear purposes, coherent and sustainable, that may respond to social and institutional goals equally clearly defined. In these presuppositions, theoretically right, reside the difficulties in anticipating future library models. There is a rapid pace of transformation of the technological and informational environment, changing the functions and forms of realization of market stakeholders, but in an indeterminate manner. The same happens with the substantial changes in users’ needs, expectations and requirements.

In this context, libraries as information systems have difficulty in redefining and adjusting their goals and requirements. They have to accommodate services that are founded simultaneously on earlier models, in order to assure continuity of functions and services, and on emerging objectives and requirements that are difficult to define clearly. This is emphasized by Ray, K. (2001) for whom the modern and postmodern features of libraries coexist, but the organization and assumptions that shape them are still the modern ones:

“libraries are by their very nature ‘modernist’ institutions. They embody the values of orderliness, reliability, predictability and rationality. They are of necessity rule bound, mechanistic, linear organizations”. [...] Postmodern organizations might best be described as chaotic systems. Such systems possess structure but may shift at any moment to adapt to changing conditions. They continually reorganize themselves in response to their environment. They are poised on the edge of chaos. This image of the edge, the organization that exists on the boundaries of colliding cultures emphasizes the ambiguous but vital nature of postmodern organization.”

The ‘modern’ features still shape the library organising principles and practices, while the technological challenges are essentially bound to the ambiguity and flexibility of the postmodern condition. The tension between these two aspects may explain, for example, why novel undertakings such as digital libraries started by being external to traditional libraries, or why the concepts /models of digital libraries are still far from achieving a consensus the reaches beyond mere work definitions (Lynch, 2003a). What seems clear, from the start, is the existence of maladjustments and discontinuities in which the traditional models are not simply replaced. The same is recognized in respect to the scientific communication system for which Hurd (2000) suggested a prospective model containing both ‘modernized’, i.e., “that employ technology to support and update traditional functions” (Ibid.) and ‘transformed’ processes, i.e., “changed in fundamental ways or new functionalities that did not exist in the print-based system” (Ibid.).

This perception indicates that the nature of questions and issues is not just a matter of technological stages. Rather, transformation issues have wider causes and consequences (see, e.g., Davies, et al., 1997; Davies, Scammell & Hall, 1997, regarding the evaluation of the eLib programme). The line between ‘continuous change’ and ‘radical transformation’ is not clear for libraries and the same is true, for example, for the understanding of the nature of the ‘information society’ (Gault & McDaniel, 2002). These views are in agreement with the way Lougee (2002) interpreted and qualified the evolution of research library roles since the 90s, comprising three major phases: distributed, open and diffuse.

The “distributed” phase, coinciding with the growth of distributed systems, during the nineties, is marked essentially by the emergence of new standards for creating, structuring and disseminating digital content, and by the maturation of tools and systems that allow invisible mediation between content and user. In this phase

the perception that library functions could become irrelevant contrasts with the potential for libraries in harnessing the capabilities to strengthen their services. The “open” phase, from the end of the 90s, is marked by the trend of “open paradigms”, realizing in practice a fundamental shift from models of central control to new mechanisms for coordination and collaboration. The open source software development, the OAI movement and e-print archives (Pinfield, Gardner & MacColl, 2002) are examples of collaborative models underlying the building of open distributed structures. Publication concerns shift from “publication as content to publication as process”. Sustaining collaborative activities with diverse stakeholders becomes critical for libraries (Lougee, 2002: 2-3).

Phase 3 – “diffuse” is the current one. It is characterized by the library as a “diffuse agent”, as libraries incorporate more distributed technologies and become essentially based on collaborative models for developing content and services.

“With the incorporation of distributed technologies and more open models, the library has the potential to become more involved at all stages, and in all contexts, of knowledge creation, dissemination, and use. Rather than being defined by its collections or the services that support them, the library can become a diffuse agent within the scholarly community.” (Ibid.: 4).<sup>31</sup>

In Lougee’s representation of the main traits of library in the different phases of its relationship with the environment there is an implicit parallel with the concepts inherent to the evolution of the underlying technology. This idea gives strength to one central argument of this thesis, that IT itself, and the conceptual knowledge about how it came into being as it is, may provide clues, understandings and building blocks for the re-conceptualization of realities that are connected to it.

## **2.4 People and technology**

The change of paradigm identified above introduce new conditions for the way organizations manage technology and information assets that are essentially supported by technological means. The sphere of influence of technological competences is enlarged and blurs the frontiers between the management of technology and the management of information (Charkes, 1995; Myburgh, 2000). These changes have a direct connection with people’s professional functions and

competencies, how they are nurtured and understood in terms of IT knowledge. The objective of this section is to analyse such aspects.

The growing influence of IT has intensified the pressure to include technological matters in library professionals' education and training. There is also an increase in discussions about issues of relevance of the profession, identity, professional image and status, aspects that can appear either threatened or reinforced by the very same IT factor (see, e.g., Birchall, Deakin & Rada, 1994; Arms, W., 1997, 2000; Abbott, 1998; Danner, 1998; Ray, M., 2001). Often all these aspects have been discussed at a mixture of levels that make the technological issues even less clear in the debate about education and training.

From the very beginning, library automation itself forced the emergence of a continuous training, retraining or retooling of library professionals, to cope with demands in computer-related skills (Yuan Zhou, 1996; Jones, B., et al., 1999). Training on the job for new skills has been a solution though it is often felt to add to the stress, inadequate time and workload that automation already provoked (e.g., Palmini, 1994; Jones, D., 1999). Diversified ways have been suggested and used towards retraining (e.g., Tennant, 1995) but, at least for a generation of professionals, the informality and contingency of such training have been a drawback, with eventual exceptions where medium-term institutional training projects have been arranged, e.g., the TAPin Project <sup>32</sup> (Mulvaney, 1997; Mynott, et al., 1999). Another aspect that is frequently mentioned in the literature about training and new skills is the appeal for self-teaching, highlighting personal initiative and qualities (e.g., Hastings & Tennant, 1996). This may also indicate a weakness in frameworks and structures of IT skills and knowledge acquisition.

LIS education has regularly included aspects of IT and computing since library automation began to take place. Especially since the 80s (see Smith, L., ed., 1983), when IT courses became more often mandatory, curricula included basic knowledge and skills for using computers with applications of general use, introductions to programming and system's analysis and online searching techniques (Marsterson, 1986; Collier, 1989). The debate over IT demands in LIS education flourished especially with the expansion of the networked environment. The need to revise curricula and diversify the existing courses was thoroughly acknowledged (Feather & Mann, 1993; Corbin, 1993; Wilson, T. D., 1993; Kinnell, 1994; Rowley, 1995; Wormell, 1995; Parry, 1996; Pors & Schreiber, 1996) but the place of IT in library

education was not felt clear in terms of the implications for professional identity and for the coherence of a knowledge base already scattered and with undefined boundaries (Enser, 1995; Elkin, 1996; Van House & Sutton, 1996).

Projects were developed to help restructure LIS curricula, e.g., CRISTAL-ED<sup>33</sup> (Drabenstott & Atkins, eds., 1996) and KALIPER<sup>34</sup> (Durrance, 2000; Pettigrew, 2000); or to analyse needs, requirements and practices in the field to scope future guidelines in job design and staff update, as in the SKIP Project (Garrod, 1997; Garrod & Sidgreaves, 1997).<sup>35</sup> It has been recognized that the new environment requires a mix of disciplines and competencies and that the new professional “must grasp a holistic view of information systems [...] by using and shaping current and emerging digital systems technologies” (CRISTAL-ED, n.d.). It has not been easy, however, to cope with the challenges in developing LIS programs, and “identifying a manageable focus”, as case studies are scarce, the discipline is evolving, the technology focus is overwhelming, the definition of ‘information professional’ versus ‘librarian’ is loose and in cooperative programme development LIS is weaker than other fields like Business, Management, Computer Science or Engineering (Wallace, 2002).

Library associations too, published new guidelines for curricula and job competencies (e.g., SLA, 1996-2003; ECIA, 1999; IFLA, 2000). But the literature for changes in library staff requirements that relate to IT most often emphasize two aspects: mastering IT through skills, at one end, and personal qualities, such as leadership, at the other end (see, e.g., Youngman, 1999; Garrod, 1999; Ward, S., 1999; Stephens, 1999; Hawkins, 2000; Steele & Guha, 2000; Winston, ed., 2001; Wittenborg, Ferguson & Keller, 2003).

Most library schools have introduced revisions in their curricula and new courses to cope with technological change (Beheshti, 1999, Pettigrew, 2000). But schools take different strategies, between “expansion or divestment and contraction” (Wilson, T. D., 2000), from merging with different faculties to closing (Hildreth & Koenig, 2001). The instability of the place of LIS within academia, market competition factors and different institutional practices and motivations have all been generating dispersal and ambiguity in the designations and contents of schools, courses and job positions, mostly in relation to the changes motivated by technology (Pettigrew, 2000; Croneis & Henderson, 2002). Besides dispersal, ambiguity and controversy about curricula on the topic of IT (e.g., Calvert, 2001; Koteles &



Haythornthwaite, 2002; Gorman, M., 2004), the main focus has been primarily directed to 'skills' in a utility sense, following a tradition that has been mostly practice-based (Bonnice, 1999). Yet, this tradition has not attenuated the difficulties in matching the world of practitioners and the world of schools (Moran, 2002) and research (Haddow & Klobas, 2004).

Furthermore, this new wave of IT emerges in an educational framework where the place and stance of information technologies always lacked a background coherence in LIS as a whole, and among its main traditional strands: information retrieval and library automation. As explained by Downie (1999), LIS "can be partitioned into two schools: the user centered school and the system-centered school", broadly corresponding to Librarianship and Information Science.

Information retrieval (IR), pertaining to the Information Science branch, is the older branch relating LIS and IT, with a theoretical level directly linked to Computing, of which it is a speciality. It has long been considered part of the LIS curriculum and an area of academic research (Aström, 2002). But, as noted by Saracevic (1997, 1999) and Ellis, Allen & Wilson (1999), over time the field of IR has split into two major branches: IR as the study of computer theories and algorithms, more close to Computer Science but less populated; and user studies, a larger branch more close to social sciences. Not only has the classic, more systems-oriented IR field seen a decrease in productivity compared to user studies, but also the connections between these two branches of IR have been weak (Saracevic, 1997, 1999).

According to Saracevic (1997), this reflects the existence of two different models in terms of IR education: the Shera model versus the Salton model, named after those who pioneered them.<sup>36</sup> In the Shera model, the predominant one, the approach has been to append new courses to the traditional library curriculum, without revising it as a whole. Therefore, IR and Information Science became essentially one of the specialty areas of Library Science (this will be further discussed in Chapter 3). According to Wilson, A. & Hermanson (1998) "despite being a sensible bonding, it has also, to some degree, been a forced union". For Saracevic (1997),

"the strength of the Shera model is that it posits education within a service framework, connects education to professional practice and a broader and user-oriented frame of a number of other information services and relates it to a great diversity of information resources. The weakness is a total lack

of teaching of any formalism related to systems, such as development and understanding of algorithms. The majority of researchers in the human-centered side [...] came from or are associated with this educational environment” (Ibid.).

The Salton model of IR education, on the other hand, is primarily a laboratory and research approach, using Computer Science methods.

“The strength of the Salton’s model is that it: (i) starts from a base of a firm grounding in formal mathematical and other methods, and in algorithms, and (ii) relates directly to research. The weakness is in that: (i) it ignores the broader aspects of information science, as well as any other disciplines and approaches dealing with human aspects, that have great relevance to both outcomes of IR research and research itself, and (ii) it does not incorporate professional practice where these systems are realized and used. [...] Consequently, this is a successful, but narrowly concentrated education in IR as a specialty of computer science, rather than in information science” (Saracevic, 1997).

Saracevic concludes that the two educational approaches have been independent of each other and that

“there is no educational integration of the systems- and user-centered approaches. The evident strengths that are provided by Shera’s and Salton’s model are not put together. Their weaknesses are perpetuated” (Ibid.).

Library automation has been the other strand of LIS education in IT. It has been considered at a practical and managerial level mostly, more often focused on criteria for applications’ selection and use (see, e.g., Lancaster & Sandore, 1997: Chap. 14) than on knowledge acquisition about underlying IT. Because automation has been based on commercial software packages, the most common approach has been the familiarization with applications and learning data standards, notably MARC, often understood more as an extension of cataloguing than, for example, as a topic of data administration. In between the two edges – how to choose and how to use library applications - there has been a lack of IT and of IT management, even when LIS programmes include introductions to database systems, programming languages, etc., as horizontal matters, in courses that are essentially of computer literacy. The skills issue, implied in computer literacy, can be seen as a generational problem, as IT concepts, frameworks and assumptions appear differently to different generations, but the main issues are not just about IT (Oblinger & Oblinger, 2005a; Hartman, Moskal & Dziuban, 2005).

Childers (2003) reviewed the history of the 'computer literacy' concept, whose meaning has changed over time, not free of controversy, along and intertwined with 'information literacy' (see also Bawden, 2001; Brandt, 2001). As explained by Talja (2005), most common perspectives of computer literacy show important limitations, notably in the so-called 'generic skills approach' that has been dominant in LIS (Marcum, 2002). According to Childers (2003), as long ago as 1983, for example, it was pointed out that the use of the 'literacy' metaphor is misleading and even against its objective, as it implies a kind of 'universality' of basic knowledge on computers that produces decisions about education made "in a kind of panic". For him, and despite the controversy, computer literacy is still a necessity with implications for library professionals. While computer literacy is a "general measurement" it should also be qualified in terms of different levels of proficiency, of which he proposes three, in a 'Computer Proficiencies Chart' (Ibid.) Its content and levels are not far from what is established by the ECDL/ICDL (European Computer Driving Licence/ International Computer Driving Licence), a general-purpose skills certification programme launched by the European Commission in 1996 with the support of CEPIS (Council of European of Professional Informatics Societies). The ECDL programme is often the basis of LIS postgraduate courses (e.g., Poulter & McMenemy, 2003).

An alternative to the 'computer literacy' concept was put forward by the National Research Council (1999) in a study that introduced the term 'fluency' and the accompanying concept of FITness (FIT - fluency in information technology). The strengths of this approach (Denning, 2000) reside on highlighting two aspects usually not included in the 'literacy' baggage: a concern with the understanding of concepts and principles of a computer system, and with the intellectual capabilities that enable people to apply problem-solving methods by using computers in a complex and changing environment. In FITness, the distance from (not conflict with) literacy is, thus, the recognition of other levels of IT knowledge beyond skills. This idea has been emphasized in many ways in Oblinger & Oblinger, eds. (2005).

The main arguments behind this thesis follow this perspective, when arguing that there has been lack of IT and IT management knowledge in LIS. Although the problem of computer related knowledge encompasses the whole profession in its diverse activities, this is best illustrated with the situation regarding systems librarians, whose activity, more than thirty years old, is managerial and strategic,

beyond technical. Despite being even more critical and diversified, these functions, in some cases with formal job definitions,<sup>37</sup> have no curricula, or simple unit courses especially offered by LIS schools (Muirhead, 1994a; Woodward & Meadows, 1994; Jordan, 2003; Wilson, T. C., 1998: Chap. 3; Gordon, 2001; Xu, H. & Chen, 2001; Seadle, 2003; Tyson, 2003). The description of qualifications for job announcements have been as invariably vague as “experience in IT” (Foote, 1997) and knowledge is often acquired by self-teaching, on the job and in an ad hoc way, with all the inherent limitations and costs, especially for institutions. This is even more relevant today than it was in 1994, when Muirhead stated that

“the systems post can be seen as a microcosm of the information professions at large in the face of dramatic social, political, economic and technological changes. It is an indicator of how we as a profession are facing up to and coping with these challenges and as such should promote critical self-examination not just among those concerned with automation but all areas of library and information services” (Muirhead, 1994).

The range of activities of a systems librarian is large, not only technical, and is growing. It is even less confined to a given library application package, as the distributed environment develops with new functionalities needed, new types of software solutions and many options in design integration that have implications with organisational structures and their strategies (Muirhead, 1994a; Lavagnino, 1997, 1999; Ross & Marmion, 2000; Pfohl & Hayes, 2001; Guinea, 2003; Jilovsky, 2003).

“The Web has added a new emphasis to technology decision-making by bringing the library’s network environment more firmly into the mix. Deciding how services should be made available on the Web and what is the best way to move content from in-house authoring to a community, campus, or global audience, is now and almost intrinsic part of meeting a library’s technology needs” (Rhyno, 2003).

But the situation today remains confusing, precarious, insufficient, ad-hoc, not duly professionalized, be the job held by IT staff with some knowledge of librarianship or, as it is more frequent, by a librarian with some IT knowledge (see, e.g., Goddard, 2003). Current surveys confirm these problems (Chavez-Villa & Perezrul, 2003; Gordon, 2003: App. A) showing that for most systems librarians currently on the job, the competencies needed were not acquired in school, but through self-study and random experience. In many cases the systems librarian post equates that of a CIO which, according to Hawkins (2004), is still fuzzy.

“Today, twenty years later, the concept of a CIO still lacks definition: it has a variety of meanings, manners of being defined and operationalized, and methods for integration within the campus infrastructure, accompanied by an equally diverse set of realistic and unrealistic expectations. As a result, the job of selecting a CIO can be confusing” (Ibid.).

Education in the field of digital libraries is also illustrative of the current state of affairs relating LIS and the IT/Computing areas. An international survey by Spink & Cool (1999) revealed few courses devoted to digital libraries. Those available were almost exclusively in the US, offered mostly by LIS schools, followed by some computing departments. According to Saracevic & Dalbello’s (2001) survey, education has had little connection with the growing number of digital libraries. These have been developed and maintained by different communities with competing visions: the research community, mostly from computer science, and the practice community, mostly from libraries.

“While they work and proceed independently of each other, they can be considered two ends of a spectrum, which has yet not met in the middle” (Ibid.).

They analysed course content (categorized broadly in tools, environments, objects and a combination of these) revealing that in LIS programmes digital library education is mostly placed in the technology context (tools). Above all, the survey highlighted the difficulty in analyzing and judging the level of integration and pertinence of existing courses to digital library education. Descriptions were a mix and match of approaches that altogether “represent a pandemonium typical of the general uncertainty” (Ibid.). For the authors, the major problem is still the lack of purpose and definition about what are the matters that define digital libraries and how they should be approached.

Searching for a possible model of an interdisciplinary digital library curriculum, Coleman (2002) compared major lines of LIS and Computer Science curricula and the characteristics of the fields as disciplines, and found that they are

“increasingly related professional and occupational categories with potential for interdisciplinarity curriculum development [...and have] a unique chance to reflect, articulate and re-consider the disciplinary culture of their respective disciplines and professions” (Ibid.)

In order to better understand these different disciplinary cultures, this analysis will proceed in the next Chapter, focusing on ‘concepts’ through the disciplines. But

to close this section about ‘people’ two remarks should be made that bridge the two Chapters. The first, as noted by Sutton, S. (1999), is that changes are essentially discontinuous and difficult to understand due to the convergence of many disparate fields. The second is, following Buckland (2001), that not only has ‘information technology’ been used in many ambiguous ways, but also the status of LIS in most universities is that of a ‘professional’ education, where “utility” comes first. This “discourages interest in the nature of the field” and the important “design” aspects of information and information services risks being ignored (Buckland, 2000)

What this observation suggests is, first of all, an apparent lack of ‘philosophy’ behind practices. This lack was also noted by Varian (1997) and White (1999), the first also pointing out an aspect that is relevant for the topic of the next Chapter, which is the difference between knowledge and skills. In LIS, as for any other area, it is not easy to define how to ‘infuse’ IT into curricula in useful and long-lasting ways. As suggested by Clayton-Pedersen & O’Neill (2005),

“education must enable individuals to discover what they need to know rather than just having static knowledge. Society will need college graduates with mental agility and adaptability”.

## **2.5 Conclusions**

From the analysis carried out in this Chapter in order to answer the first research question it is possible to conclude that, despite the long history of IT application in libraries, there has been little development in the sharing of conceptual foundations that facilitate conveying IT knowledge into the library field beyond the operational needs of IT artefacts consumption. It is also clear that changes in the informational / technological environment reinforce the need for libraries to improve their IT alignment and this, in turn, puts new demands on the type and extent of IT knowledge required. The remainder of this section elaborates on the main aspects that contribute to these findings.

The evolution exposed in Section 2.2 suggests a general interpretation of the evolution of IT in libraries that parallels the account given by Davidson, W. (1993), of the three phases of IT in organisations - automation, enhancement and redefinition. In libraries, these phases have been characterized as stages of automation, innovation and transformation, where innovation corresponds broadly to the introducing of networks and transformation to the period starting with the

WWW. Building on Davidson (1993), a synthesis of the evolution of IT in libraries is provided in Fig.II-3 (below), showing three main axes of analysis: technological, organizational and performance.

The technological focus shows three viewpoints for changes: at the base technology (e.g., operating systems, programming languages and DBMS) there is an evolution from proprietary to industry to open standards; at the application level (e.g., application software and query languages) the developments are from proprietary to domain interoperability (e.g., with Z39.50) to cross-domain interoperability (e.g., portal technologies and harvesting protocols such as OAI).

The organizational focus moves from local concerns and domain standards, characteristic of the automation phase, to global networked operations with the Internet. The concerns with cross-domain standards rise with the WWW, both at the syntax (e.g., XML-based technologies) and semantic (e.g., Dublin Core) levels, along with growing demands for collaborative solutions (e.g., course management, e-print archives, virtual reference, personalization and recommender systems, etc).

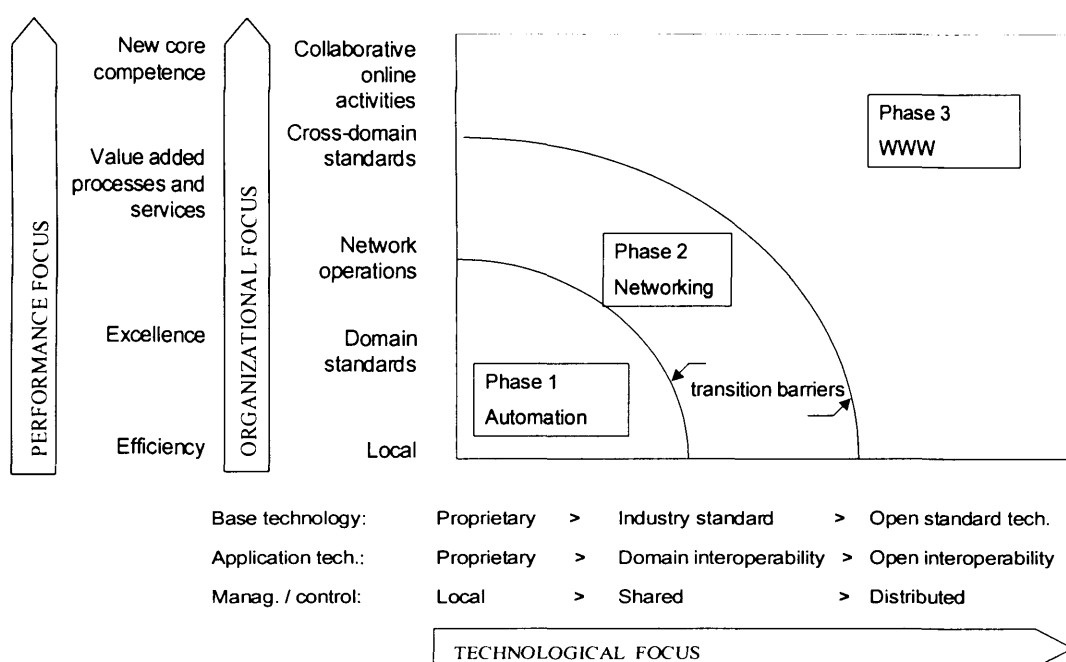


Fig. II-3 *The three phases of IT in libraries* (developed upon Davidson, W., 1993)

The performance focus evolves from efficiency and excellence, i.e., from centred on improving traditional features of existing systems, to encompass value added services for reasons of competitiveness and user demands elicited from

characteristics of the mainstream technological environment. All these aspects have accelerated discussions about new core competences for organizations and people.

While the recognition of the three phases, outlined in Fig. II-3, gives a general indication of a development towards alignment with the environment, there are transition barriers (summarized in Table II-2) that indicate aspects problematical to IT alignment in library organizations, especially in what concerns the 'transformation' phase.

Table II-2 *Transition barriers to library transformation through IT*

	CHARACTERISTICS & CHANGES OF THE ENVIRONMENT	BARRIERS TO LIBRARY IT ADAPTIVITY
LIBRARY IT INDUSTRY	Small, concentrated market; prominence of single vendor model	High dependency on IT vendors
	Weak customers demand; poor communication	Low IT mastery & innovation requirements; poor communication
	Low economic impact	Non-profit activities; weak investment power; public funding dependency
	'Subventionism'; innovation partly fostered by cycles of public funding programmes	Innovation often explored aside from current library structures and activities
INFORMATION & IT MARKET AT LARGE	Growing competitiveness	Lack of business strategy
	Rise in demands from wider & more diversified audiences	Target audiences can become undefined; pressures to cope with new layers of end-user services, not always structural
	Distributed systems & componentization of technological solutions	Experience with IT management focused on operations and based on single integrated systems mostly
IT KNOWLEDGE	Growing diversity of sources, stakeholders, standards & conversation channels; rapid pace of change	IT education & training based mainly on skills; lack of conceptual background to enable agility
GENERAL PERCEPTION OF IT	IT as pervasive, affordable, accessible, dynamic and adaptive to changing personal working environments	IT as a 'tool' for pre-determined, subsidiary routines, hooked on long-standing structures; a 'black box', an unquestioned 'given'; general belief in the positive effects of IT

Many of the barriers to technological innovation and transformation in libraries have been attributed, since automation, to the fact that the library sector is not strong enough, in terms of business and organizational demands, to foster the library IT industry. Policy measures and funding programmes for library IT innovation,



continuously run since the beginning of the 90s, attest this and, while helping to create awareness and some organizational competences, they have not changed the market in significant ways. These difficulties are further compounded by other factors with the challenges posed by the WWW stage.

While the initial barriers were essentially technical and operational, with the transitions to the networking and WWW phases they also have become conceptual, i.e., raising issues of an organization's mission, scope and structure, of systems' boundaries and audiences. It became more difficult to understand, and articulate different orientations and technical languages across a variety of professional (e.g., library IT, Web publishing and search industries) and scientific communities (e.g., institutions involved in scholarly communication) all concerned with, or interested in information management systems.

From the account given in section 2.3, it is difficult to anticipate both the functional definition of solutions that will be needed to manage the library of the future and their possible models. Nevertheless, one can interpret the changes in paradigm and identify major underlying aspects.

A model of these changes is proposed in Fig. II-4 (below) and II-5 (next page). Broadly speaking, libraries as systems, and information systems supporting library activities, are evolving from hierarchical, contained and defined to distributed, open and diffuse models.

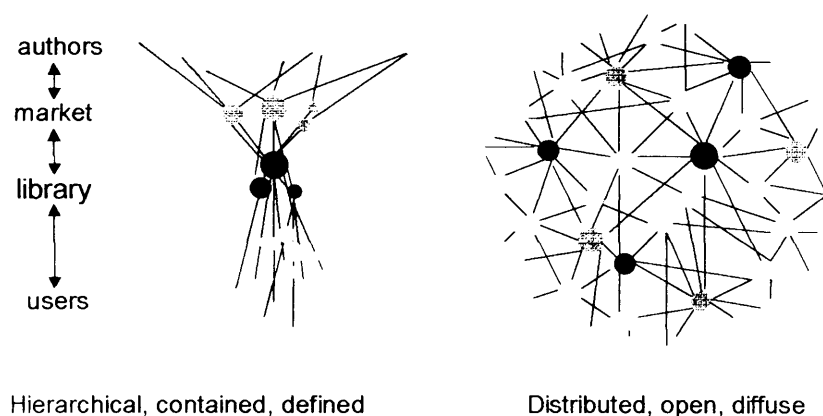


Fig. II-4 *The changing model of the library environment*

The characteristics of this general pattern of change are suggested in Fig. II-5.

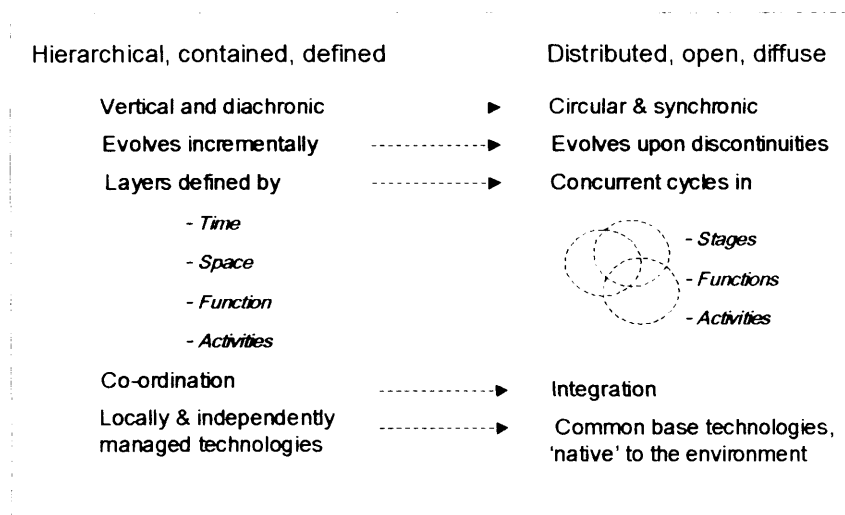


Fig. II-5 *Paradigm change in library environment interactions*

They indicate substantial alterations in the position, roles, communication directions, channels and languages of the stakeholders relating IT and library services. There is a complex interplay of agents, roles, and technology, creating a different framework for decision-making. The changes apply to information management systems supporting library related activities and to the type of knowledge needed to deal with their planning, development and operation. In technological terms, future systems will have to support integration with the environment, rather than just co-ordination with other systems or sets of systems (e.g., other libraries) and will tend to be supported by, or at least be conversant with, technologies that are 'native' to an environment, such as Web technologies, broader than any domain. It is suggested that the patterns of interaction among people that decide on, manage and use such systems will change accordingly.

In the face of the above changes in paradigm, the demands of competencies to manage IT in libraries reach largely beyond the traditional operational support with medium-term periodical decision processes for library systems procurement, or reliance on long-established and proved technologies and standards. The rapid and intertwined changes in the technological and information market pose issues of strategy and currency that demand a more profound and agile relationship between LIS and IT, through competencies that are acquired and used by people.

As seen in Section 2.4, not only has there been a lack of internal coherence and stability in education regarding IT matters but education has been also essentially oriented to the practicalities of IT use rather than to IT strategy and management. The changes synthesized above suggest that the latter aspects are paramount. For IT strategy and management to be effective in organisational terms and in the professional culture, there is need to reinforce the conceptual understanding of IT, along with currency of practical IT knowledge.

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## Notes to Chapter 2:

<sup>1</sup> Not all authors use this terminology, but the same basic understanding is generally occurring. Ruth Davies (1987) considered “period of technology upheaval: 1960s-1980s; period of technology absorption: 1980-2000” (Davies cited by Drabenstott, 1994: 42). Buckland (1992: 18, 42) identified broadly three phases: i) paper library, ii) automated library and iii) electronic library, where documents are stored in electronic form. For Lancaster & Sandore (1997: 238) there are two major phases: in the first, lasting for about thirty years, technology is used to manipulate electronic records related to printed materials, while the second phase is characterized by the inclusion of library materials in electronic form. Duff (2003) suggested four electronic epochs: offline, online, CDROM and Internet.

<sup>2</sup> Automation is a term that has been used in the library world interchangeably with ‘mechanization’, ‘computerization’ and ‘informatization’. This is a broad spectrum of slightly different meanings, especially in an historical context (see Reynolds, 1985: 4). In IT management, for example, it means automated mechanisms and procedures in their purest sense, which exist to operate without human intervention and where machines are controlled by other machines. This is not the sense in the present and following chapters, where automation means the use of IT to support human work processes, in this case traditional library processes.

<sup>3</sup> See overviews of early stages of library mechanization and automation in Reynolds (1985: Part I), Tedd (1987), Jacquesson (1992: 13-25), Meadows, (1994: Chap. 4), Malinconico (1997) and Duff (2003).

<sup>4</sup> The survey also highlights that suppliers tend to “improve existing systems and extending services rather than developing a major new product”; and that their basic characteristics are those of small and medium enterprises, i.e., small turnover, living upon immediate opportunities rather than long-term planning, with small capability for significant investment efforts, and generally with a low level of market understanding (KPMG, 1994).

<sup>5</sup> This aspect refers to the confusing choices and controversy between OSI and TCP/IP that existed until 1995, when version 3 of the standard was approved (see more information in Chapter 7).

<sup>6</sup> These terms are also used elsewhere in a broader context, to discuss the issues of Internet as a commons and the change in regulations and mechanisms to control access to the body of formerly public “commons” in information. See, for example, Onsrud (1998), Lessig, (2002) and Bollier & Watts (2002). See also Section 6.2.1.

<sup>7</sup> In this context the term CIO refers to job positions that embrace both computing and library information services. The term may have different meanings for different organizations and the same role and responsibilities may be titled differently. A comparison of position titles / levels used in computing and library services shows, for example, that CIO was already used for computing only (Hirshon, 1998:1, 24). See also Woodsworth, Maylone & Sywak (1992) and Mech (2000). A bibliography about CIO in higher education can be retrieved from the Educause library at [http://www.educause.edu/asp/doclib/subject\\_docs.asp?Term\\_ID=147](http://www.educause.edu/asp/doclib/subject_docs.asp?Term_ID=147).

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<sup>8</sup> Such programmes are framed by more general policy frameworks, such as the US National Information Infrastructure (NII) Act, 1993 (<http://thomas.loc.gov/cgi-bin/query/z?c103:h.r.1757:>), the Bangemann Report, 1994 (<http://europa.eu.int/ISPO/infosoc/backg/bangeman.html>) in Europe; the ITU (International Communication Union) Buenos Aires Declaration, 1994 (<http://www.itu.int/itudoc/itu-d/wtdc/wtdc1994/badecle.txt>); and the US Global Information Infrastructure, 1995 ([http://www.eff.org/Infra/Govt\\_docs/gii\\_co-op\\_iitf\\_agenda.html](http://www.eff.org/Infra/Govt_docs/gii_co-op_iitf_agenda.html)).

<sup>9</sup> Support for technological library innovation was covered by the Telematic Programmes, under the 3rd (1991-1994) and 4th (1994-1998) Framework Programmes. Since 1999 onwards, under the 5th Framework Programme, libraries are included in the key action III – Multimedia Content and Tools of the IST – Information Society Technologies programme.

<sup>10</sup> For a detailed statement on the EU's experience with library projects, state of affairs regarding the EU information society policy, and need for further funding at the end of Telematics for Libraries Programme, see European Parliament (1998: Part B).

<sup>11</sup> Under the 5<sup>th</sup> Framework (1998-2002) 110 DigiCult projects were funded, involving 506 organisations from 35 countries from both the private and public sector (40% cultural actors, 30% industry and 30% research) (see <http://www.cordis.lu/ist/ka3/digicult/home.html>).

<sup>12</sup> The study analysed the situation and perspectives of the cultural sector regarding services delivered over digital networks, from 1996 to 2006. It revealed that the optimistic visions of 1996 were unrealistic compared to the actual situation in 2001. Early assumptions did not prove for cultural institutions in terms of market success, low costs of market entry, knowledge of user demands, good policy support, expected deregulation of telecom monopolies, new employment opportunities, favourable financial climate, fast evolution of delivery infrastructure and availability of easy to implement IT tools, high potential for content owners, promise of rapid transformation of organizational structures through networking and substantial increase of cross-sectoral partnerships (European Commission, 2002: Chap. IV).

<sup>13</sup> The idea of the DNER evolved from eLib 3 (Rusbridge, 1998) envisaging the provision of high-quality online resources accessible from any location, easily navigated and cross-searchable by subject or data type. Since 2002 DNER ceased as an independently named initiative, but its features and activities were integrated with the JISC Information Environment (see [http://www.jisc.ac.uk/index.cfm?name=ie\\_home](http://www.jisc.ac.uk/index.cfm?name=ie_home)).

<sup>14</sup> See the initial programme guidelines at <http://www.nsf.gov/pubs/stis1993/nsf93141/nsf93141.txt>, and Griffin (1998). An overview of the DL programmes and related actions is provided by Friedlander, ed. (2003).

<sup>15</sup> Besides the funding programmes mentioned, other organizations have been created to promote and co-ordinate digital library efforts, in the form of consortiums such as the Digital Library Federation (DLF) established in 1995 (<http://www.diglib.org/dlhomepage.htm>) or the Canadian Initiative on Digital Libraries (CIDL) founded in 1997 (<http://www.collectionscanada.ca/cidl/cidle.html>).

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<sup>16</sup> The discussion around this issue – electronic, virtual, digital, and other metaphorical terms such as ‘without walls’, ‘without frontiers’, etc., - is more conceptual than terminological. It evolved from the stance of ‘means’ or format of realization towards other more purposive, functional or holistic terms such as ‘gateway’ or ‘hybrid’ libraries by which the divide between ‘digital’ and traditional libraries was absorbed. See also Knight (1998), Oppenheim & Smithson (1999) and Pearce, Cathro & Boston (2000).

<sup>17</sup> The National Library of Medicine (NLM), the Library of Congress (LC) and the National Endowment for the Humanities (NEH) became DLI co-sponsors, and the Institute of Museum and Library Services (IMLS), the Smithsonian Institution (SI) and the National Archives and Records Administration (NARA) became partners.

<sup>18</sup> For example, the annotated bibliography provided by Liu (1995), covering the literature about the Internet and libraries since 1990, shows a predominance of awareness, instruction, public services, electronic publishing, etc., rather than specific aspects of technical services and systems, apart from few articles about protocols.

<sup>19</sup> Discussions about library standards at this stage refer to “obeisances” (Sweeney, 1993) and “white elephants” (Brunt, 1993: 23, citing Maurice Line). Pat Oddy (1993: 16) recognized that existing codes were focused on “a single environment linear catalogue” and, referring to the implications of the WWW on catalogue standards, used the quotation “bewitched, bothered and bewildered” (Oddy, 1995: 45). In this respect see also Svenonius (2000: 62-66, 79-82).

<sup>20</sup> For Lynch (1995a), the concept of NIDR is raised as a synthesis of disciplines. It builds on the concept of ‘information spaces’ and focuses on network information resources - “digital objects, collections of digital objects, or information services on the network” combining resource discovery – “a complex collection of activities that can range from simply locating a well-specified digital object on a network all the way through lengthy iterative research activities” – with retrieval – “the process of actually making use of a networked information source” (Ibid.).

<sup>21</sup> A simple comparison between the agendas of the 1992 workshop (Standards, 1993) and the *Bicentennial Conference on Bibliographic Control for the New Millenium*, held by the Library of Congress in 2000 (<http://www.loc.gov/catdir/bibcontrol/>) shows the increasing diversity and complexity of issues. By September 2000, the *Schemas Project: Forum for Metadata Schema Implementers* (<http://www.schemas-forum.org/>) had identified 21 standard initiatives covering a total of 89 separate metadata standards, mostly related to record formats (<http://www.schemas-forum.org/stds-framework/1.html>). The Schemas Project provided syntheses of the changing metadata landscape until 2002.

<sup>22</sup> As noted by Svenonius (2000), the issues in bibliographic standards arise from the current trend in “increasing formalization of information organization as an object of study” which is “pervading scholarly disciplines generally”, using different ‘languages’, while at the same time the bibliographic control objectives become more difficult to define and operate in an “open-ended” context (Ibid.:193-194, 22-23). Paul Miller referred to the “hazy semantic and procedural fortresses within which disciplines sequester themselves, girded about with the strong walls of obfuscation and specialist language” (Miller, P., 2004).

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<sup>23</sup> Also, the technology transfer from digital library projects to the industry has not been easy (see, e.g., Wedgeworth, 2000).

<sup>24</sup> Dublin Core, or DC, stands for Dublin Core Metadata Element Set (DCMES). Developed by the Dublin Core Metadata Initiative (DCMI) since 1995, the set was first issued in 1998 (Version 1.0) and is currently in version 1.1 (2004). In 2001 the DCMES was endorsed by the NISO – National Information Standards Organization (ANSI/NISO Z39.85, 2001) and in 2003 by the ISO (ISO 15836, 2003).

<sup>25</sup> The lack of capabilities of library management systems as decision support systems, i.e., in providing good exploitation facilities for existing data beyond the catalogue functions, is an old claim (see, e.g., Lancaster, ed., 1983; Lancaster & Sandore, 1997: Chap. 5) that is still justified. Reports from library systems are usually very rudimentary and not specific of given functions, e.g., on holdings and circulation data for objectives of collection development. The fact that such an important aspect of automation, which is the link to management, has been overlooked, makes evident the incompleteness of the traditional automation processes, focused mostly on technical services and the catalogue.

<sup>26</sup> See also Chapter 7, note 31.

<sup>27</sup> The *Open Archives Initiative* (<http://www.openarchives.org/>) was launched in 1999 aiming at the creation of a means to facilitate interoperability among digital libraries or digital repository services by sharing the respective metadata. The OAI-PMH (Protocol for Metadata Harvesting - <http://www.openarchives.org/OAI/openarchivesprotocol.html>) is the central piece of this initiative. See also Suleman & Fox (2001). See also Section 6.2.1.

<sup>28</sup> This set of functions is explained by Brophy & Wynne (1997: 4-5). The model advanced by MacDougall (1999) includes also three other functions: access negotiation, resource capture, store and access and advisory and education services.

<sup>29</sup> MIA - *MODELS* (MOving to Distributed Environments for Library Services ) *Information Architecture* (<http://www.ukoln.ac.uk/dlis/models/>) is a conceptual framework for the analysis and development of distributed and hybrid architectures of information services.

<sup>30</sup> Three main stages of evolution are presented: IT applied in standalone mode for single department functions with no user online access (1960-1980); IT applied with network facilities but still single department/functions (1981-1990) and online access for external users (1991-2000). The stage from 2001 onwards is where the envisaged e-business model can be realized, implying complete internal integration and restructuring (European Commission, 2002).

<sup>31</sup> To explain the diffuse role of libraries Lougee (2002) explores changes occurring either by stretching or by breaking with traditional library functions: collection development based on federation of resources, libraries acting as publishers, metadata standards and techniques for access that expand and complement traditional ones, diversification of user services (e.g., virtual reference and instruction services), more distributed and collaborative organizational models, and the change in the concept of the library as place for collections to infrastructure facilities, local and networked, both physical and virtual (Ibid.: 5-21).

<sup>32</sup> TAPin- *Training and Awareness Programme in Networks*, (<http://www.cie.uce.ac.uk/cirt/projects/past/tapin.htm>).

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<sup>33</sup> CRISTAL-ED - *Coalition on Reinventing Information Science, Technology and Library Education*, is a collaborative project of the University of Michigan School of Information supported of the W.K. Kellogg Foundation (<http://www.si.umich.edu/cristaled/>).

<sup>34</sup> KALIPER - *Kellogg-ALISE Information Professions and Education Reform Project* ([http://www.alise.org/conferences/nr\\_kaliper598.html](http://www.alise.org/conferences/nr_kaliper598.html)) was a two year project starting in April 1998.

<sup>35</sup> SKIP - *Skills for new Information Professionals* (<http://www.ukoln.ac.uk/services/elib/projects/skip/>) was a project of the Training and Awareness area of eLib, to study the IT skills required by staff, and their roles, in the UK higher education institutions.

<sup>36</sup> Jesse Shera (1903-1982), whose work on library education is conveyed in Shera (1972). Gerard Salton (1927-1995) pioneered the knowledge base of automated text information retrieval (Salton, 1989), notably with SMART (System for the Mechanical Analysis and Retrieval of Text). See also Pao (1989: 237), Chu (2003: 11) and Raber (2003: Chap. 8).

<sup>37</sup> See, for example, FLICC (Federal Library And Information Center, US) Personnel Working Group. *Sample KSAs for Librarian Positions GS 9-12 - Systems Librarians* (<http://www.loc.gov/flicc/wg/ksa-sys.html>).



## **CHAPTER THREE**

### **CONCEPTS, DISCIPLINARY FIELDS AND PRACTICE**

#### **3.1 Introduction**

The objective of this Chapter is to contribute to the first research question of this study by investigating the relationship between LIS and IT through the analysis of the disciplinary domains involved. The aim is to find whether or not there is evidence of these disciplinary domains sharing concepts and channels of communication that contribute to the enhancement of IT knowledge in LIS. This is verified by analysing the fields involved in the LIS/IT relationship in order to clarify whether or not the claims of interdisciplinarity that are commonly suggested in connection to IT correspond to significant actual interchanges in conceptual thinking.

From this perspective, the present Chapter expands the analysis carried out in Chapter 2 by taking a closer look at the level of 'Concepts' of the framework depicted in the Introduction to Part II (Fig. II-1, p. 78). Chapter 2 already highlighted that changes in the technological and information environment increase the variety and levels of understanding and mastery of IT in libraries. It was clear that there are at least three levels of IT usage by library professionals, i.e., professionals as end-users of IT tools of general use and of library information management systems; professionals as teachers of library end-users in the usage of public services and resources, and professionals as IT systems managers. It was patent that, while experience with IT in libraries is long, it has not been reinforced by strategies to enhance knowledge absorption beyond IT skills.

One major conclusion of Chapter 2 was that the relationship has been essentially operational, as generally happens with automation. In other aspects in which professionals get education involving a theoretical level related to IT, such as matters like IR, the relationship with practical reality is compartmentalized and weak. The current Chapter analyses further the relationship between LIS and IT from the point of view of the various fields that shape the background and ontology of the groups that come together in library IT undertakings. This includes LIS itself and the fields of Information Management, Knowledge management, Information Systems and Computing/IT.

Three reasons justify the choice of these fields. The first, is the need to progress the understanding of the relationship between LIS and IT in the disciplinary plane, because the issues shaping disciplines do affect practice. Secondly, because in the environmental changes that surround library organizations, and their inherent demands concerning IT, many aspects addressed by other fields become involved. It is important to understand their actual and potential connections with LIS. Thirdly, approaching these fields is also part of getting knowledge of the changing environment, because they are, as object and subject, an important part of it.

### **3.2 Limitations of ‘information’ as a conceptual node**

One aspect common to the various fields being analysed in this Chapter is, as already pointed out in Section 1.4.3.1, the claim of interdisciplinarity. The fragility of what is often termed interdisciplinarity for these areas is well illustrated with the problem of defining information.

The expansion of IT has raised ‘information’ to the level of a key concept in society, culture, economy and science. Its emergence and rapid spread to many areas, notably through communication studies, philosophy and computing, is linked both to scientific and technological advances (e.g., Dretske, 1981; Machlup & Mansfield, 1983; Young, 1987). ‘Information’ can have multiple referents and bear many diverse meanings (Yuexiao, 1988), but the term is always the same, in popular or scientific discourse. Furthermore, it is even more used to qualify other equally loose and difficult to define concepts like ‘information age’ (Hobart & Schiffman, 1998: 1-8), ‘information society’ (Duff, 2000), ‘information professions’ (Apostle & Raymond., 1997; Abbott, 1998; Danner, 1998), ‘information management’ (Wilson, T. D., 2002), ‘information technology’ and ‘information systems’ (Alter, 2000).

One might presume, however, that in technical and scientific terms, there is academic or theoretical consensus that renders the concept operational for each specific community. This is far from being the case and even when in a given area work definitions exist, the term is still prone to confusion and different interpretations at least from the perspective of other fields. As noted by Raymond, B. (1997), “confusion with regard to the meaning of key terms inevitably obscures important issues”.

LIS is just one among many areas where scientific conceptualizations of information developed, but they have not produced a distinct terminology, or sufficient consensus to link different theories and practices in useful ways (Belkin & Robertson, 1976; Meadow & Yuan, 1997; Capurro & Hjørland, 2003). Conceptualizations can range from information as predominantly perceived in the objective manner of exact sciences, as something physical and measurable, as in the engineering perspective of Shannon's mathematical theory of communication (Shannon, 1948);<sup>1</sup> to the technical and technological views of IR in the way it emerged, in the 50s, eminently system-oriented; to other more subjective perspectives developed since the 70s, i.e., the cognitive approach to information as an object of Information Science, subsuming notions of interaction and of social levels of understanding (Wilson, T. D., 1981, 1984; Belkin, 1990; Ingwersen, 1992; Wersig, 1997; Todd, 1999; Saracevic, 1999); to the more diffuse notion of information as a basic property of the universe, basic as matter and energy, existing independently of the perception of it (Stonier, 1990, 1991);<sup>2</sup> or information simply viewed as "the characteristics of the output of a process" in any discipline or domain, as proposed by Losee (1997).

This brief introduction to information conceptualizations shows that, in LIS, definitions of information take into consideration both the content and medium of what is transmitted, as recorded knowledge, and the cognitive, intangible and situational process of the human recipient. The scope is large and the possible perspectives of study are multiple, leading to definitions of information and knowledge that may be formulated in a variety of theoretical ways, associated with different philosophies, methods and taxonomies.

Saracevic (1999) identified three levels in the sense of 'information': information as signals or messages for decisions, involving little or no cognitive processing; information that directly involves cognitive processing (interaction with human cognitive structures, such as reading a text); and information in context, implying the previous levels, i.e., information that is a message cognitively processed and involves a situation, with motivation and intentionality, and is connected to a social context. For him, this broadest definition is the level to be addressed by Information Science.

To cope with the ambiguity of the term, Buckland (1991: Chaps. 1, 4, 5, 11; 1991a) differentiated three categories according to usage: "information as-process"

when referring to someone being informed, and his/her knowledge being modified; “information-as-knowledge”, when information has been received and transformed into knowledge; and “information-as-thing” when used attributively for objects, such as data and documents, regarded as of informative potential.

These operational distinctions have been used to simplify the practical understanding of the objects of management and study in LIS. However, they do not solve ambiguities or change the common usage of terms. In the case of “information-as-thing”, for example, not only concepts such as ‘document’ evolve (Buckland, 1997), but there is still a common trend to interchange ‘data’, ‘document’, ‘documentation’, or ‘library’ with ‘information’. This can blur reference to particular roles, constituents and functions of institutions, systems, professional activities or research foci (Raymond, B., 1997: 13-14; Hjørland, 2000).

As noted by Agre (1995), information is not “a unified phenomenon with a single fate”, of a definite character, as expressions such as ‘information measurement’, the ‘future of information’, ‘information overload’, or expressions related to information commoditization may suggest. Information is bound to ideologies and social structures, which are not neutral, rather they are “contingent products of human activity”.

The situational nature of the information concept was underlined by Wersig (1997). He noted that after the introduction of the cognitive viewpoint further developments of information theory, all

“have in common that they do not insist on only one meaning of information” and that “information theory changes from the definition of information to the definition of situations in which something like information is central” (Ibid.).

Summarizing the different theory developments (constructivist, systems theory, action theory and modernization theory) Wersig devised a common core concept – complexity - behind such a diversity. For him, a future direction could be an “integrated theory of information [...] described as a theory of complexity reduction” where information would be “the amount of complexity to be reduced or that has been reduced” (Ibid.).

From the perspective of activity theory, Hjørland (2002a) highlighted the essentially cultural nature of the information processing mechanisms and the role of a professional community or system regarding information definitions. “Criteria for

information are neither universal nor individual but linked to specific roles in society” and “the best way to understand information in information science is to study the knowledge domains as ‘discourse communities’ ”(Ibid.). These are dynamic and arbitrary and the sophistication and effectiveness of a given IR system depends essentially on mastering the dynamic of the domain’s discourse.

“The implications for Information Science are that one should give up the search for an ideal language for knowledge representation, for one ideal algorithm and for one universal law or model of information seeking behaviour” (Ibid.).

Wilson, T. D. (2002a) suggested a theory of integrative levels for the multiple approaches to information that determine not one but many “information sciences”.

“Quite simply, the concept takes different forms at different integrative levels. When the computer scientist thinks of information [he/she] is thinking of units of complexity such as bits and bytes [...].The information retrieval specialist [...] conceives of information in terms of strings of symbols, matching query strings against indexed strings. The librarian sees information in terms of the macro containers [...] of various kinds, and, indeed of a higher level of organization, the library” (Ibid.).

Conceptualizations of information in other areas of close interest to LIS, such as Information Systems or Computing/IT, are not less complex. It is not the intention here to expand this aspect, but rather give, with the LIS example, an idea of the multifaceted views that information, as a core concept, can elicit. The apparent neutrality and generalization of the trope ‘information’ in sciences, professions, institutions and activities, moreover when associated to IT, may indicate that this crossing-over element can be in itself little more than an empty abstraction (Hjørland, 2002a). Therefore, it is difficult that theoretical discussions about a common object so diffuse as information can, alone, help to clarify the relationship between those disciplines that have ‘information’ at their core (Raber, 2003: 8-9). What is problematic in practice is the confluence zones of different professional communities. As put by Agre (1995),

“Information is not a natural category whose history we can extrapolate. Instead, information is an element of certain professional ideologies, most particularly librarianship and computing, and cannot be understood except through the practices within which it is constructed by the members of those professions in their work. The future of librarianship is not contingent on the future development of something called information; to the contrary, the category of ‘information’ is contingent on the future development of the various institutions that now constitute it. [...]

Inasmuch as information technologists and librarians both define themselves as dealing in information, it is common to suppose that advances in the technology will undermine librarianship and heavily automate or even eliminate libraries, or else that librarians will migrate in a natural way from the management of physical information artifacts to digital information media. Yet analysis of this question requires an appreciation for the strategic neutrality of "information" as an ideological category in the definition of both professions. In each case, the strategy of providing generically defined services to an extremely diverse range of institutional customers has historically required that only a limited range of accommodations can be made to the specific structures and requirements of each" (Ibid.).

In LIS, or in Information Science in its strict sense, as in all related areas that deal with data, knowledge, information, communication, texts or documents, the ambiguity around information has not only hampered consensus of theoretical frameworks but has also inhibited the inter-relationship of different professional groups and academic fields, notably those related to IT (Buckland, 1991, 1991a, 1997; Wersig, 1993; Meadow & Yuan, 1997; Hjørland, 2000; Raber, 2003: Chap. 1; 10). What seems to be common are certain characteristics and problems of these areas, in several aspects that were already introduced in Section 1.4.3.1, concerning interdisciplinarity. This perspective will be expanded in the next section, starting with LIS, followed by Information Systems and Computing/IT.

### **3.3 LIS: two paradigms, two different relationships with technology**

LIS, Library and Information Science (or Studies, as it is also often designated) is currently the most used term to name the area of professional activity, education and research of library and related information services. As the name indicates it combines the older field of Librarianship and the newer area of Information Science, whose origins share a disciplinary relationship with Computer Science. The term LIS became common but the concept remains diffuse, with different paradigms without an agreed, or at least a clearly perceived, synthesis (Miksa, 1992; Apostle & Raymond, 1997; Saracevic, 1997, 1999; Buckland, 1999; Hjørland, 2000a). The two major paradigms are Library Science and Information Science (Miksa, 1992; Saracevic, 1999). This duality is relevant to analyse because it is closely related to IT, either in historical or in current terms (Buckland, 1999).

The difficult articulation of the two paradigms has contributed to the ‘lack of identity’, sense of dismissing or fragmentation which has been emphasized by the growing importance and pervasiveness of IT, turning issues of professional status and jurisdiction into especially sensitive matters (Estabrook, 1989; Wilson, T.D., 1995; Apostle & Raymond, 1997; Spring, 1997; Abbott, 1998; Danner, 1998). Another consequence is the different relationships of each paradigm with Computing/IT.

### 3.3.1 Discussion of views and concepts

Miksa (1992) identified two major paradigms modelling the LIS field. They complement each other yet they do not produce a unitary vision just by simple juxtaposition, as in the LIS denomination. The first paradigm is the library as a social institution, whose ideology, concepts, terminology and methods draw essentially from the areas of education and sociology, notably sociology of knowledge. This paradigm focuses on the idea of the library itself, as a social organization with “its material, organizational and intellectual properties that serve as means to express its functions”, deemed central to social change because of “the special needs associated with systematic knowledge transfer on a societal scale” (Ibid.). The second paradigm draws on the ideas related to “the process of information movement as a system of human communication” (Ibid.), initiated with communications engineering in the 50s. It evolved into two main, interrelated, streams: first, information as a physical phenomenon, i.e., as a flow that can be measured, processed, controlled and divisible into discrete units; and, later on, information as ideas, meaning, related to semiotics, semantics and situational contexts (Ibid.).

Fig.II-6 provides a general synthesis of the main concepts, reference disciplines and values of the two paradigms.

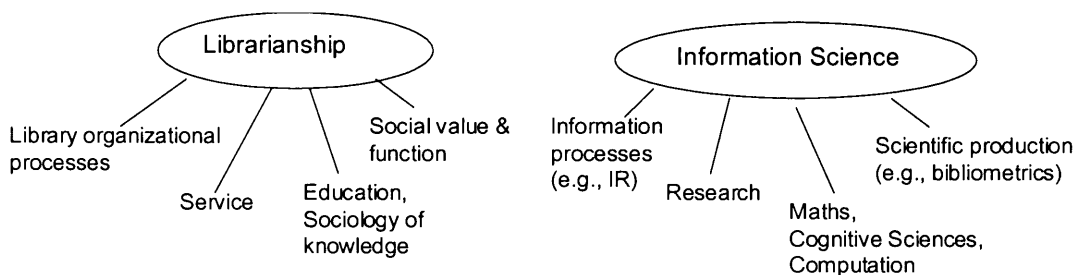


Fig. II-6 *The Librarianship and Information Science paradigms*

Differences between the paradigms appear in the type of problems addressed, theoretical questions and conceptual frameworks, tools, approaches and strengths in relation to other disciplines. Hawkins, D. (2001) illustrated this with an Information Science map derived from the analysis of the subjects used in LISA and ISA databases.<sup>3</sup> Both sides have different approaches and relationships to Computing/ IT (Saracevic, 1999). According to Miksa (1992), while the two paradigms do not collide, and the second is usually understood as contributing to realize the goals of the first, they do not connect successfully because of their individual weaknesses.

The 'library' paradigm weakness resides in two aspects: the implicit simplistic view of "social change" and the "institutional" weight, which assumes the survival of this kind of social organization as the condition to fulfil similar social needs in the future. Weaknesses of the "information" paradigm are its conceptual base, primarily focused on optimizing the "transfer" of messages by IR systems, emphasizing the information movement as a linear and logical process, mostly singularly conceived. These aspects neglect the non-linear and logical aspects of human information processing as well as the social nature and context of information movement (Ibid.).

Miksa's (1992) remarks are important because they point to weak links between two different IT frameworks in LIS, neither of them being sufficient to address the full set of IT-related aspects of LIS. This gives indication, at least, of an incongruent, or not well rooted, relationship between the fields. What is important here is not the question of a unitary view of LIS. Cornelius (1996), for example, argued that there "can be parallel legitimate discourses or languages in and of the field" which translate "parallel conceptions of the field" and "dismisses alternative incompatible views" (Ibid. 1). For him, "each conception is intellectually significant, to varying degrees, and expresses an intellectual purpose of the profession and characterizes its social structure and its ambitions" (Ibid.:138) which show "a subtlety and suppleness in the field" (Ibid.: 210).

But despite encompassing Information Science within LIS (Ibid.: 183), Cornelius' interpretation of Information Science recognizes issues that are congruent with other authors' competing paradigms. Information Science is rooted in a positivistic epistemology and difficult to identify as social science, bears characteristics and sometimes claims of a separate discipline, and has a more distant relationship with library practice (Ibid.: 162). This is especially the case of IR, in its



branch of experimental Computer Science which "remained unsuccessful as a conception of practice" in LIS (Ibid.: 177).

This is also the view of Saracevic (1999). Information Science, taken in its strict sense, with its theoretical background, history, purpose, type and content of activity, has a stronger and more specific relationship with Computer Science. They share areas of research, theories and methods that have wide application, but their common object of research – information – has different frameworks for each side. Besides, "while information science is not about technology, the problem of providing effective computer applications pervades the field". Yet, "computer science is about symbol manipulation, whereas information science is about content manipulation" (Ibid.).

It can be argued that both content and technology have also pervaded the library field. But the perspectives and scope, although interrelated, are different. And the links between the research-oriented field of Information Science and the professional, practice-oriented field of Librarianship, are weak (Ibid.).

Historically, in the 20<sup>th</sup> century the two paradigms held competing views with a link to the evolution of technology for documentation and library service (Buckland, 1996; Bowles, 1999). Using the case of the Chicago Graduate Library School, Buckland (1996) pointed out a US gap in the librarianship interest on the technological advances taking place in engineering environments, which were not ignored by European documentalists, especially during the period before World War II. This gap may explain some of the origins of the contentious aspects of "information science vs. library science" following a

"temporary de-emphasis of design and technology contributed to a prolonged failure of identity and direction in the academic departments of library and information studies" (Ibid.).

The resulting two major traditions in LIS are designated by Buckland (1999) as "document tradition" and "computational tradition".

"Both traditions have been deeply influenced by technological modernism: standards, codes and rules, systematic organization, purposive information systems developed cooperatively: machinery for collective progress!" (Ibid.)

But because of their different foundations, orientation and practice, convergence is not easy, in practical terms. Firstly,

“convergence of diverse professional practices is likely to be inhibited because occupations are social structures, characterized by different educational programs, social differences [...] and different professional associations” (Ibid.).

Secondly, such convergence is difficult in academic terms for several reasons. The LIS position being that of professional schools (i.e., not academic in the sense of ‘liberal arts’) is limitative for its conception and influential power (i.e., being interesting for other areas). According to Buckland (1996a), LIS could well qualify to address “the nature and role of technology, of information technology, and, indeed, of information itself” because these aspects are “generally weak and obsolete” in the ‘liberal arts’ environment (Ibid.). On the other hand, the scope of professional programmes is difficult to balance. As the landscape for LIS is increasingly complex, it is less homogeneous and a “general, ecumenical education program [...] could easily be too superficial or too complex” (Buckland, 1999).

### **3.3.2 Some ontological implications**

Different in their background, focused phenomena and methods, the two paradigms do not seem to fit together to provide a comprehensive and sound basis for LIS, suggesting a poor exchange and absorption of concepts between the more traditional and the more technologically oriented sides of the field. This can be illustrated in many issues, from the lack of sharing of essential working concepts, to more general aspects such as the understanding of the professional community and its values, or the perception of the influence of IT on LIS professionals’ profiles.

Buckland (1999a), for example, illustrated the distance between the two paradigms regarding the centrality of the concept of ‘vocabulary’. While the ‘document tradition’ is well rooted “in the concerns of the humanities and qualitative social sciences”,

“the ‘formal tradition’, [including] all those techniques and technologies based on logic and algorithms [...] and historic traditions of information retrieval as reflected in meetings of ACM SIGIR [...] is at odds with the variability of human language and human behaviour” (Ibid.).

The lack of coherence and identity may also open opportunities for diverse understandings of the profession and, in the same measure, may induce false ideas of the field based on loose connections to other fields. For example, identity issues have

raised discussions of core values for the profession as a whole. For Weissinger (2003), discussing the competing philosophies and paradigms (Zwadlo, 1997; Radford & Budd, 1997) in this framework,

“The issue that remains [...] is whether a LIS community with its own distinctive worldview actually exists. [...] The idea that there is a coherent LIS community with its own worldview is really counter-intuitive. Numerous articles about the field’s professional image and status attest to this as does the lack of consensus about professional core values [...]. Rather than belonging to a scientific or strictly professional community with a distinctive professional worldview, it is more accurate to say that librarians belong to a much broader community or, perhaps, to multiple communities” (Weissinger, 2003).

On the subject of the influence of IT on conception and construction of the idea of the profession vis à vis the technological changes, Apostle & Raymond (1997) provided evidence of how the apparent integration of paradigms has led to loose and unquestioned assumptions about the ‘information professions’. Raymond, B. (1997: 8) analysed the way the ‘information’ paradigm evolved and how it finally merged with the ‘library’ paradigm, generalizing a set of key assumptions that lack substance and connection with the reality. For example, that the concepts of

“ ‘information industry’ and ‘information profession’ are interdependent [and] employment prospects for LIS graduates in the ‘emerging information market’ are optimistic” (Ibid.).

For Raymond, B. (1997: 13) the confusion, misuse and overuse of the ‘information’ paradigm goes “a long way to discrediting librarianship” (Ibid.). The confusion presents

“a major obstacle to any rational analysis of the role of libraries and librarians.[...] Such usage affects every aspect of professional library discourse: the nature of education for librarianship, the definition of the library profession and its relationships with such professions as management, journalism, accounting, education, and computer science. [...] is “conducive to an exaggeration of the scope and extent of the skills of librarians, and tends to obliterate the difference between various libraries and their functions. It helps to create an artificial semantic cross-over between general library services and the highly specialized activity of information centers” (Ibid.).

The result, according to Raymond, is that false ideas and illusions proliferate, with negative impacts: false identity of roles (all librarians equating to professional information managers and providers, of whatever type; false identification of

librarianship with Information Science (with all librarians equating to information scientists); computer-based library technology being seen as the dominant aspect of current libraries of any type; and so forth. For Raymond, B. (1997) such assumptions seem to underlie the common understanding of and about the library profession and they misrepresent, reduce and diminish the variety of roles, functions, requirements and understandings that pertain to the library world. On the other hand, these false assumptions create an elusive impression of IT absorption into LIS that does not enhance the real IT knowledge needs in the profession.<sup>4</sup>

The remarks provided by Miksa (1992) and Apostle & Raymond (1997) about the effects of the ‘false’ merging of different paradigms are congruent with the position of other authors such as Wilson, T.D. (2000) and Buckland (2001) regarding different possible LIS curriculum orientations, or of Hjørland (2000a) who provided a model to analyse the relative position of specialization of library job functions. One of the highlighted aspects of this model is the recognition that functions that are more systems-oriented fall into the ‘generalist’ zone of the field.

Expanding the circle of analysis to areas of research and activity that are applicable to environments wider than LIS, and that emerged more recently, may also reveal other aspects important to understanding the difficulties of its relationship with IT. The first area is that of Information Science.

### **3.4 Information Science as a LIS technological branch**

This Section will explore the weaknesses and strengths of Information Science in terms of the connections to IT that it brought to LIS.

Information Science emerged during the last half of the 20<sup>th</sup> century from the need to cope with the ‘information explosion’ and the rise in complexity of sciences and scientific output. The movement was informed by earlier investigations in the area of documentation, some common to the library world, such as the studies of theory of scientific classification by Bliss (1929) or the five laws of library science that Ranganathan began to develop in the thirties, others not, like the development of statistical methods for quantitative studies of documentation, such as those by Bradford, Lotka and Zipf.<sup>5</sup>

Fostered by the opportunities of the computing developments, and started as the activity of scientists providing information services to their scientific

communities, Information Science became recognized through the establishment of professional associations, and their publications, from the 50s.<sup>6</sup> These aimed to gather richer and more diverse contributions from various fields and to address a range of concerns that was wider than those of the library field (Vickery & Vickery, 1987: 11-12; Appendix 1; Ingwersen, 1992; Cornelius, 1996: 157-158; Buckland, 1999; Saracevic, 1999; Norton, 2000: 13-15).

### **3.4.1 Definitional and identity issues**

More than thirty years after its inception, Information Science is still considered “an emerging discipline” (Williams, J.G. & Carbo, eds. 1997), or a field in quest of a disciplinary status (Webber, S., 2003). Issues of identity and definition have been a constant.<sup>7</sup> There are two main perspectives, or orientations in considering the object of information in Information Science, the physical and the cognitive, providing different paradigms for the field (Ellis, 1992; Raber, 2003: Chap. 2) upon which a wealth of definitions have appeared. Williams, J. G. (1997) defined Information Science as

“the study of information as a phenomenon, a process, a system, a product, and a service which extends human cognitive capabilities through the systematic application of information processing functions using appropriate technologies and methodologies”.

For Saracevic (1999), Information Science is

“a field of professional practice and scientific enquiry addressing the problem of effective communication of knowledge records – ‘literature’ – among humans in the context of social, organizational and individual need for use of information [...]. To provide for the need, Information Science deals with specifically oriented information techniques, procedures and systems”.

While these can be considered fairly accepted definitions, Information Science is still bound to many possible interpretations, according to different perspectives and underlying concepts. Wersig (1993) pointed out that the offspring of sciences and technologies in the second half of the 20<sup>th</sup> century raised the need for discipline-like fields to cope with the complexity whose outcome is not “statements about how something works, but strategies to deal with problems”. It follows that the “new situation of knowledge, caused by the development of sciences [...and] the

phenomenon of ‘informatization’ [...] requires a science of a new type”. For Wersig, the identity and definitional problems of Information Science come from behaving like a classical discipline and from having to “deal with classical disciplines which unavoidably have little understanding of the newness of the situation” (Ibid.).

“If there is something like information science or whatever this field may be called, it will not have a theory, but a framework of broad scientific concepts or models and reformulated common concepts which are interwoven under two aspects: how they have developed and how they can be put together from the viewpoint of the problem of knowledge usage under postmodern conditions of informatization” (Ibid.).

Cornelius (2002) synthesized the still existing tendency to seek a unifying theory of Information Science, and argued that the field is not undertheorized despite “the lack of a theory of information has become a perennial lament”. Problems with the initial model based on Shannon arose from the ambiguity of some concepts of the model, namely associated with the meaning and measurement of information. As the theories of Information Science evolved from the process of transfer to the act of receiving information, to the character and situation of the receiver and to the social nature of such a situation, the theory got more problematic and less amenable to a single, general theory, rather implying different domains of enquiry. According to Cornelius (2002) the move from the individual atomistic view of cognitivism to the social dimension of information elicited other approaches, e.g., constructivist, for which a single grand theory is not the point.

“The scholarly or scientific desire to have a theory that explains basic concepts in the field [...] is understandable. The behavioural need [...] in order to establish a field’s claim of academic status [...] is equally understandable but less productive. Information science should be clear why it seeks a theory of information” (Ibid.).

For Wilson, T. D. (2002a), because information “is not a unitary concept [...] there cannot be a unitary information science” but many “information sciences” (Ibid.). Defining information science for the purposes of academic curricula has been an area of disagreements.

“Some argue for inclusion of logic, mathematics, and programming; others for the inclusion of linguistics, philosophy, and economics, and so on. [...] Which information science curriculum we decide to produce will depend upon the nature of the local market for the product of educational institutions, the market for research in the field, and the competencies of local academic staff” (Ibid.).

To sum up, controversies and conflicting about the scope and definition of Information Science are still open (Norton, 2000: Chap. 1): they derive essentially from the difficulties with the concept of ‘information’ and from the fact that information as an object of professional and scientific attention can be bound to many objectives, i.e., lends itself to a wide range of different ‘problems’ of study (Saracevic, 1999). Moreover, as noted by Bates (1999), from an outside perspective much of the paradigm of Information Science “lurks below the water line, largely unconscious and unarticulated”. Looking at the multidisciplinary links of Information Science and to its actual relationship with IT may shed some light on such a loosely articulated reality.

### 3.4.2 Multidisciplinary links, scope and content

While Information Science has been characterized by multiple disciplinary connections, many authors recognize a weak cross-fertilization with other disciplines. Since its inception Information Science has been targeted to fulfil many diversified needs in face of the changing information and technological environments (Borko, 1968), covering a wide range of concerns and activities that would encompass areas such as Mathematics, Linguistics, Psychology, Library Science, Engineering and Computer Sciences (Otten & DeBons, 1970).

Ingwersen (1992a) traced two major trends in the first phase of Information Science settlement, with respect to reference disciplines: one, moving towards the field of communication, suiting researchers studying the behaviour and interaction of the human elements in information transfer; and the other focusing mainly in systems and IT, towards Computer Science (Fig. II-7).

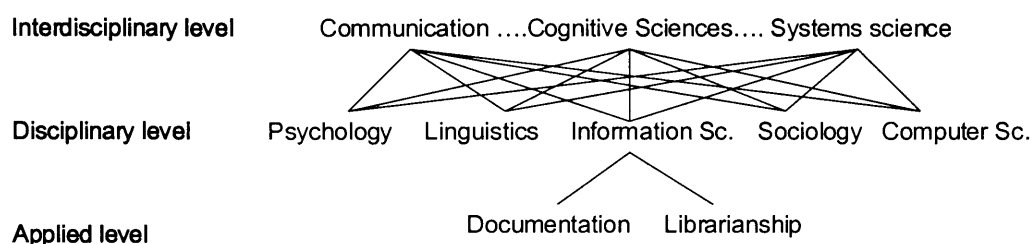


Fig. II-7 *Information Science viewed as one of several sciences on information*  
(from Ingwersen, 1992a)

For Ingwersen (1992a) some exaggerated conceptions of the scope of Information Science have made the field more vulnerable and incoherent in theoretical terms. This was the case with the less applied levels of the DeBons “informatology”, understood as “the study of the fundamental principles underlying the structure and use of information”, and of the Vickery & Vickery proposition of Information Science being the “scientific study of the communication of information in society” (Ibid.).

A major shift occurred from 1977-1980 in the maturing of the scope of Information Science, upon the works of several researchers, among them Brookes<sup>8</sup> and Belkin,<sup>9</sup> who introduced a cognitive approach in Information Science that has dominated most of the theoretical ground ever since. They helped properly to formulate the ‘problems’ to be addressed by Information Science and, thus, to specify its areas of activity. Following this evolution, Ingwersen (1992a) identified four major sub-disciplines of Information Science: informetrics; information management, information retrieval systems design and information retrieval systems interaction. The concentration of information studies around these areas has been confirmed by bibliometric studies of the Information Science domain.

The most extensive of such studies was conducted by White & McCain (1998), based on a co-citation analysis of 120 authors and covering a period of 23 years. The study showed two major clusters: one, denominated “domain” cluster, includes a variety of works about analytical studies of literatures, their structures, studies of texts, scientific communication, social context of information, information uses, information seeking behaviour, theories of information, etc. The other cluster concentrates on IR theory, processes, algorithms, systems, human computer interaction, user studies, library systems, etc.

The results of the White & McCain (1998) study are generally congruent with similar previous studies, which they reviewed. The same picture of the field was later generally confirmed by Åström’s (2002) bibliometric study, adding some more light on the relationship between Information Science and Librarianship, where the latter appears more clearly as a subdiscipline, sharing the space of the user and bibliometric studies (the soft IR).<sup>10</sup>

Hawkins, D. (2002) summarized bibliometric studies of Information Science electronic journals and conducted his own analysis. Author affiliation showed a preponderance of academic institutions and the subject distribution gives prominence



to topics related to networked information (such as models, electronic publications and publishing, virtual libraries, the Internet) IR coming in seventh place only.

### **3.4.3 Actual relationships with Computer Science and IT**

The actual disciplinary relations of LIS and Computer Science live in some of the core areas of the Information Science output. The White & McCain (1998) study showed important characteristics of the field: (i) a clear configuration of two major subdisciplines, in a polarization that has been maintained throughout the years, with one less populated cluster of those interested in literatures and communication (bibliometrics and user studies) and another, more populated, around the traditional IR; and (ii) the lack of a set of strong central authors. For the authors, “the field consists of several specialties around a weak center” (Ibid.).

Across this landscape the relationship of LIS with Computer Science and IT is variable and the following sections summarize some of its major aspects.

#### **3.4.3.1 Dichotomy between IR and user studies**

Saracevic (1999) considered the White & McCain results a good picture of the actual structure of the field, and noted several aspects. First, the lack of integration and cohesion between the two main clusters: the information cluster (called by White & McCain the ‘domain cluster’) and the technological cluster focusing on IR (or ‘retrieval cluster’). They are “largely unconnected”, which is a sign of the lack of integrative views, and a weakness for the field as a discipline. This was also noted in another study, by Ellis, Allen & Wilson (1999). Second, is the split of the IR cluster into two distinct groups: one mostly centred on systems, following the traditional IR model as formulated in the 50s, mainly related to computer research and not considering users and user interactions; the other, more concentrated in the cognitive, interactive and contextual side of the process, addressing user issues.

The lack of linking between these two groups, with two different approaches to IR, had been already underlined by Saracevic (1995, 1997). There are “two camps, two islands, with, unfortunately, relatively little traffic in-between” (Saracevic, 1999), a situation evident in the literature of IR conferences.<sup>11</sup> The few integrative

views usually come from the user-centred approach, but the overall result towards incorporating both sides is poor.

“The mantra of human-centred research is that the results have implications for system’s design and practice. Unfortunately, in most human-centred research, beyond suggestions, concrete design solutions were not delivered. On the other hand, the system’s side, by and large ignores the human side and user studies, and is often completely ignorant of them. As to design, the stance is “tell us what you want to do and we will do it”. But nobody is really telling, or if telling, nobody is listening” (Ibid.).

All these aspects may help to explain the difficulty in relating IR theories with the practice of actual systems and with the more practice-oriented library professional education. This aspect will be further addressed in the next Section.

### **3.4.3.2 Information Science and expert systems**

Besides the traditional areas of IR application in classical database systems, for many years Computer Science has been addressing other fields of interest to Information Science. This is the case with AI (artificial intelligence) applications, in the form of expert systems, i.e., performing functions that use knowledge-bases and reasoning techniques, also called intelligent agents when executing tasks autonomously on behalf of humans or other systems (Hendler, 1999). Intelligent IR has for long been an area of promise (Capurro, 1985; Croft, 1987; Hanne, 1997; Olmstadt, 2000; Chu, 2003: Chap. 12). Zainab & Silva (1998) studied the patterns of the literature on expert systems in LIS: a total of 679 references for the period 1950-1997, whose significant peak is in the 80s, decreasing dramatically since the beginning of the 90s. For almost half of that literature the topic preferences are online search and retrieval front-ends and interfaces, therefore largely covering IR. Applications in reference services, classification and indexing and cataloguing show a rather modest expression.<sup>12</sup> Olmstadt (2000) focused especially on the potential of expert systems for cataloguing, concluding that one of the major constraints to successful projects is the difficulty of conveying cataloguing expertise, in spite of the rather complete set of documented standards underlying practice.

Lancaster & Warner (2001) investigated the actual applications of expert systems in libraries and information services and concluded that they have been almost non-existent. In most cases they were experimental systems that never moved

beyond the idea or the prototype, in spite of the literature frequently suggesting their existence (Ibid.: 40, 116). Nevertheless, expert systems have been effectively applied in many other areas of potential interest to libraries, especially in intelligent text processing, which implies IR in many ways, and in machine translation (Ibid.: 43-58). Future prospects for expert systems application in libraries appear linked to the WWW environment, especially with agent technology, i.e., software that can autonomously perform functions usually in need of human interaction, for purposes of search and retrieval, recommender and user support functions, etc. (Ibid.: 59- 73; Chap. 5). However, the authors raised questions about the feasibility of developing such systems (e.g., tools for reference service support) without Information Science professionals' contribution, and the extent to which individual or institutional efforts in expert systems are viable, because they require a strong component of technological expertise (Ibid.: 123-129).

#### **3.4.3.3 Information Science and Web technology**

Many of the Web technologies have been raised in the computer science and IT practitioners' environments, especially the field of digital libraries and, more broadly, of the semantic Web. The poor quality of general purpose search Web systems has been extensively analysed and many Information Science authors point out the ignorance of basic expertise in terms of information management and IR, suggesting weak theoretical relationships.

In Computing, it has been noted that the background and literature of the Web and database technology appear to be quite different (Abiteboul, Buneman & Suciu, 2000: 2-5). In the field of IR, Belew (2000) provided a rare example of a work conveying a comprehensive overview of IR theories, concepts and perspectives, taken from the classical background of Information Science but adjusted and directed to the novel environment of the Web. While the traditional IR evaluation criteria cannot be simply transposed to Web IR services (see the overview provided by Greengrass, 2000: 187-208), notably to Web search engines, many of the criteria should apply (Chu, 2003: 202-205). Yet, the connections between traditional IR and the Web seem weak. On the other hand, there are larger issues associated to the Web, digital libraries and data warehouses (e.g., unique identification and persistence,

digital preservation, data mining) that are not covered by traditional IR (Kowalski, 1997: 20-21).

For Saracevic (1999), the “Web-based proprietary IR expanding and flourishing outside the field” of Information Science continues what was already true for traditional IR at the market level, where solutions always tended to be proprietary, and the “wheel being reinvented a number of times”. Bergman (2001) analysed the structure of the Web information environment and demonstrated, quantitatively and qualitatively, the differences between the ‘surface Web’ and the ‘hidden Web’, i.e., systems based on traditionally structured information management that include traditional IR features. Bates (2002) claimed that improvements in the design of Web retrieval capabilities cannot ignore several basic concepts and techniques of IR.<sup>13</sup> Brooks (1998, 2002) highlighted the relevance of librarianship experience, in face of the similarity of problems between the semantic Web and large bibliographic systems. He also questioned the expectations based solely on the semantic Web mechanisms, on the basis of the completely “open” nature of the Web and its “unconstrained environment” (Brooks, 2003), arguing that to attain the qualities of classical IR systems requires the re-creation of closed environments on the Web “behind passwords in venues such as intranets, enterprise computing, and digital libraries” (Ibid.).<sup>14</sup>

Smith, A. G. (2000) conducted a survey of the search features of eleven digital libraries available on the Web, which indicates the lack of implementation of a wide range of search features present in any classic library database, which should not be ignored in digital libraries for the sake of their effectiveness.<sup>15</sup> Some of these aspects were also found in a similar review by Meyyappan, Chowdhury & Foo (2000).

Analyzing the theme of digital library evaluation, Saracevic (2000) highlighted the diversity in viewpoints, criteria and methods, mostly due to the lack of definition of ‘digital libraries’ from the outset, and to differences in backgrounds and concerns among the various communities raising them. For him, this lack of basic common understanding for evaluation was not an issue in the traditional library world despite its heterogeneity. He suggested, first of all, an adaptation of traditional library, IR and human-computer interaction/interfaces criteria, thus acknowledging all the theoretical and practical expertise already existing in such areas.

A conclusion at this point should remark two aspects, both underlined by Saracevic (1995, 1997, 1999). First, within Information Science, the weak links between the IR computer-oriented research area and the human and social research of information needs and use, which is the prevalent area of research in LIS. Second, that new technologies and areas of research, such as Web information services and digital libraries, have been outside the traditional IR field, therefore most often emerging aside from the Information Science field.

### **3.5 The management strand**

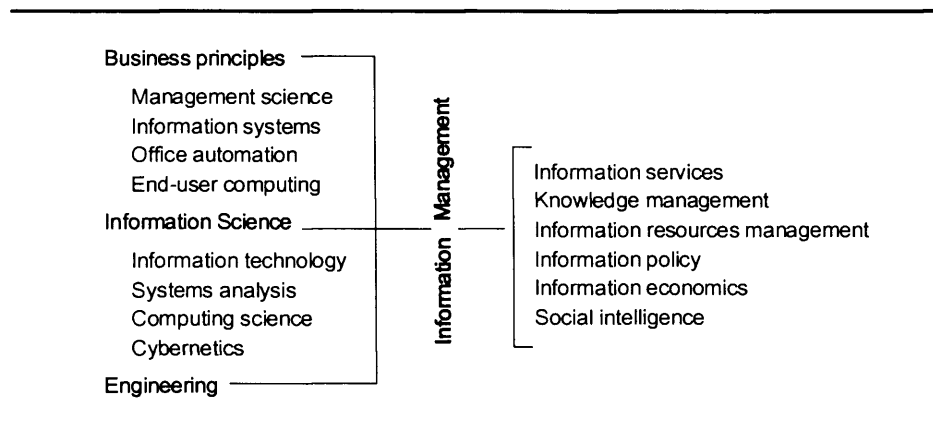
Three other fields of information work - Information Management (IM), Knowledge Management (KM) and Information Systems (also referred to as IS, within this section) - emerged and expanded along with Information Science. They were fostered by management pressures regarding the increasing value of information for organizations and businesses, and of the investments and adequacy of underlying technological systems. Like Information Science, all these fields are wider than LIS, yet overlapping in many respects.

#### **3.5.1 Information Management**

This Section will provide a very brief introduction to ‘information management’ definition and issues, and is not intended to cover the literature. Emergent in the 80s,<sup>16</sup> the IM concept has been used in a wide range of fields – from business and management to organization research, information and communication technology, information systems, information science and librarianship - and defined in several different ways. Taylor & Farrell (1992) proposed a framework for IM with a mix of components organized around three main areas: business principles, information science and engineering (see Table II-3, next page).

An encompassing view such as this is frequently overlooked and different definitions are usually related to given function(s) of a given domain. While there is no unique way of defining IM, it is the managerial link to the purposes, processes and means of organizations that constitutes the main tenet of IM (see Best, 1995; Kirk, 1999; Rowley, 1998).

Table II-3 *Typology of IM components* (from Taylor & Farrell, 1992)



Macevičiūtė & Wilson (2002) provided selections of IM definitions from various fields, including from authors related to LIS. According to Rowley (1998),

“In general terms, information management can be viewed as a response to, and a search for new and improved means of controlling the information explosion and the resulting increasing complexity of decision making by improving the flow, the control, the analysis and the synthesis of information for decision makers”.

Wilson, T. D. (2002) defined IM as

“the application of management principles to the acquisition, organization, control, dissemination and use of information relevant to the effective operation of organizations of all kinds. ‘Information’ here refers to all types of information of value, including data resources [...]. Information management deals with the value, quality, ownership, use and security of information in the context of organizational performance”.

The elements of IM are explained by Wilson, T. D. (2002) as a set of concepts and concerns such as: information requirements or needs, information life cycle, information resources in its various types, information economics, information management tools, information audits or assessments, information mapping, communication audits, information access, networks and intranets, issues of access, privacy and security, information policy and strategy.

The actual content covered by what can be considered IM research was surveyed by Macevičiūtė & Wilson (2002), based on a selection of core journals publishing research articles in IM, to assess the evolution between 1989 (when a similar survey was done, see Wilson, T. D., 1989) and 2000. The list of 1989 topics is extensive and collected under 10 different categories. These were summarized into

five for the 2000 survey: economics of information, information management practice, information systems and technology, information policy and strategy and information use and users.

The survey showed that the principal areas remain the same, yet artificial intelligence declined substantially and systemic approaches are more often applied. As for topics, information economics showed a shift to market economics, the concern with human factors and organizational culture increased, information networking and telecommunications policies became important topics and the application areas proliferated significantly. Among the new topics is knowledge management, which the authors do not consider a new application field but rather a new term (Macevičiūtė & Wilson, 2002).

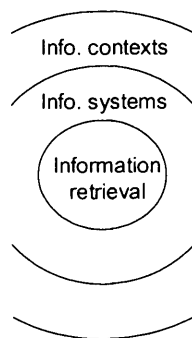
Among the aspects that make the concept of IM confusing and often ill defined is the relationship between IM and the management of the supporting technology. As explained by Holtham (1995), while this relationship is critical it is not always balanced and clarified. Bent (1995) argued that this distinction is fundamental for understanding IM. For Wilson, T. D. (2002), the lack of clarity about 'information management' in the literature has been aggravated by the introduction of new overlapping terms or usages, as in Information Resources Management (IRM) (Trauth, 2003), often used to encompass not only information resources in the sense of data and documents, but also computer systems and IT in general which, therefore, "become characterized as an information resource" (Ibid.).

Rowley (1998) noted two dimensions in IM, the management of the information process and the management of data resources, being therefore a "practice-based discipline that has both technical, most broadly in the sense of systems based, and behavioural dimensions" (Ibid.). She proposed a holistic framework for the knowledge, research and practice of IM which has 'information retrieval' and 'information systems' at the core, surrounded by 'information contexts', with different information processing agents for each level (Fig. II-8, next page).

Many of the IM constituents are embedded or implicit in library practices and activities, whether or not the term is used. But, in the words of Wilson, T.D. (2002), in the LIS field the concept of IM is

"identified with an emerging market for information workers (managers) whose perception of information embraces data, organizational

intelligence, competitive intelligence, external information resources of all kinds and the associated technology (manual or machine) for handling these different sources”.



	Level	Information processor	Information managers	Definition
Info. contexts	Information retrieval	Individual	Database designers, HCI Designers, indexers, users	Information as subjective knowledge
Info. systems	Information systems	system	Systems analysts and designers	Information as useful data, Information as thing
Information retrieval	Information contexts	Organisation	Strategic information Managers, strategic managers, organisational scientists	Information as a resource
	Information environments	Society	Governments, multinational corporations, Educational institutions	information as a commodity Information as a constitutive force in society

Fig. II-8 *A framework for IM and levels of information processing and management* (from Rowley, 1998)

In terms of education, the content of IM included in LIS curricula is as diverse as the basis for its definition. According to Wilson, T. D., in the UK and US, for example, IM topics have been introduced in LIS curricula, but producing different mixes of elements depending on the strengths of staff at each school. The lack of clarity about IM derives not only from this but also from different interpretations of the term and from ambiguously designated position titles, and respective requirements (Wilson, T. D., 1989, 2002).

### 3.5.2 Knowledge Management (KM)

During the last half of the 20<sup>th</sup> century, new terms/concepts emerged in the business environment accompanying a succession of managerial strategies and methods such as Total Quality Management and Business Process Reengineering or driving concepts like ‘excellence’ and ‘downsizing’ (Collins, D., 2000). Among these is the notion of ‘knowledge work’ emerging in the 80s and rising in importance to the point of constituting a theoretical focus of management (Ibid.: Chap. 10).

In the 90s, KM emerged from management consultancies as a new strategic field important for organizational performance (Wiig, 1997; Prusak, 2001), with strong implications for information management. Starting with organizational



learning (see 1.5.2) and addressing issues of knowledge transfer, notably practices and other forms of non-formally externalized expertises (Nonaka & Takeuchi, 1995), it quickly resulted in a new labelling for a range of activities, methods and software packages, in a mix of levels from which the supporting IT solutions have been one particularly visible face (see Mack, Ravin & Bird, 2001; Marwick, 2001; Cobos, Esquivel & Alamán, 2002, for overviews of types of KM technologies).

Centring KM on IT conveys an incomplete representation of the issues at stake (Lueg, 2002) and has contributed to bringing KM to the status of a 'management fad' or an IT fashion, whose time will pass, because KM systems appear to be prone to fail (Malhotra, 2004). Notably, it fails to integrate the different perspectives, or dimensions of knowledge (Dueck, 2001), here residing a great deal of the 'KM paradox'; that is, KM itself "suffers from the problems it is trying to address, i.e., problems to do with the distribution and lack of integration across, in this case, disciplinary boundaries" (Swan & Scarbough, 2002).

Besides, under the dominance of IT, rather than a new field of activity, KM may appear as just the conjunction of certain aspects of the management of people with the management of information (e.g., Wilson, T. D., 2002), an understanding extensively developed by Wilson, T. D. (2002b) in a critical examination of the KM literature and practices. This is a reaction from a field like LIS, whose expertise has for long included the problems of understanding data, information and knowledge, and the practices of managing information.

Different tones of this position can be found in the literature, most having in common a critique of the technically led KM vision. This was reviewed by Davenport & Cronin (2000) for whom KM is much more than Information Management. It is also the management of know-how, incorporating business processes, which introduces novel questions, simply foreign to the classical IM and having implications for a variety of management aspects and disciplines.

For example, some authors, while recognizing the need of the KM function, question the value of intangible assets like knowledge (Martin, W., 2000; Yates-Mercer & Bawden, 2002) and the constraints to knowledge transfer, i.e., the difficulties of transforming tacit knowledge which is soft (i.e., non-codifiable) into hard (explicit) forms and claim that KM essential issues are not just technical and technological, but rather problems of the culture of organizations, of their institutionalized values, norms, procedures, structures and languages (Huber, 2001;

Sutton, D., 2001; Kimble & Hildreth, 2002). Others criticize the lack of consideration of the 'politics' of knowledge in organizations (Malhotra, 2000; Marshall & Brady, 2001). The difficulty in defining a common conceptual core for the wide range of areas implied in 'knowledge' and 'learning' threatens KM by a "potential fatal fragmentation" (Gray, P. & Meister, 2003).

The views from the Information Systems (IS) field (see 3.5.3) are especially relevant, as IS has a central place in the interconnection of management and IT, being also the main endeavour for KM education, along with Computing (Chaudhry & Higgins, 2004). For Spiegler (2000) "knowledge management is, indeed, a separate branch of inquiry" but "not yet mature".

"It suffers from a lack of agreement on the definition of knowledge, confusing knowledge with data or information, leaving it as a black box, or having KM and MIS indistinguishable. As such it leaves a taste of buzz" (Ibid.).

According to Alvesson & Kärreman (2001),

"most researchers, as well as their informants, seem to have problems in specifying and making explicit what they refer to as knowledge and as ways of knowing. As a paradoxical contrast, most knowledge management researchers report little doubt about the capabilities of the knowledge management system".

Upon the analysis of KM discourse in six major research journals, Schultze & Leidner (2002) noted the tendency for optimistic views of KM and the underlying IT systems, a lack of critical approaches and research being biased by epistemological assumptions and methodological choices. Smith, H., & McKeen (2003, 2003a), through a focus group analysis with knowledge managers from a variety of industries, confirmed most of the above characterizations of the KM function: uncertainty and lack of consensus in objectives, achievable goals, role, positioning and demonstrability of the value of the function in organizations.

Most of these issues were confirmed in a Delphi study by Scholl, et al. (2004), who identified three major contrasts in the variety of KM foci: while knowledge sharing is most often the central theme, there is recognition of the importance of considering the whole life-cycle of knowledge (production, storage, distribution, application); another contrast exists between the focus on "intelligent IT-solutions and on human resources"; finally, the third contrast is the differences about the definition of knowledge and KM.

In LIS, all these aspects have been compounding the complexity and fuzziness of its relationship with IM and IT (Corrall, 1998; Davenport & Cronin, 2000; Dillon, M., 2002; Davenport, 2004; Davenport & Prusak, 2004). However, there is a level of understanding of KM that has been defended as useful to the challenges of re-conceptualizing the nature of library information assets, roles and services, especially in the networked digital environment. This conceptual KM understanding was presented by Davenport & Cronin (2000), assuming the need for a holistic view of KM that can help to change the traditional decoupling from “structure and process” that exists in libraries, i.e., between the library’s and the user’s organizational nature, goals and actual uses of information. For them, KM should be understood as

“a continuous interplay in organizations of codified and uncoded knowledge, private and public knowledge that feeds the incremental conversion of tacit to explicit, and explicit to tacit. [...] In many cases of LIS design, 'users' have been de-coupled from structure and process in LIS, on the one hand aggregated and decontextualized to the point of being extraneous to products which they are then 'trained' to use; on the other hand, described at a level of local detail that makes design idiosyncratic (Ibid.).

This view, stressing the importance of the interlinking between the library and its users’ environment, underpins many of the writings about and experiences of KM related to libraries, especially in academic networked services (see, e.g., Cronin, 2001; Branin, 2003; Newman, 2004) where the role of the library has been extended to novel functions such as Web publishing and the integration of collaborative systems, e.g., course management, e-print archives and virtual reference systems. For Davenport & Prusak (2004), KM thinking can provide answers for the demise of corporate libraries, and offer new models, centred on the concepts of expertise and network. But, as they also recognize, “the issues are bigger than the library”.

It is worth noting that this vision of KM as a conceptual source to extrapolate models for changing library services was put forward in Smith & Dalrymple, eds. (1993), notably by Lucier (1993), thus before the boom of research in KM. From this conceptual perspective, rather than being directly concerned with each specific function/underlying IT system, KM is principally focused on the high-level of design of informational spaces and, therefore, broadly connected to strategic management (Snyman & Kruger, 2004), encompassing issues of leadership and change management, communication and relationship management across organizations, beyond the discrete aspects of skills, content generation and IT capabilities.

In conclusion, one can view the emergence of KM as a logical progression from IM towards a more complex, encompassing and abstract level, where the nature of the issues is changed, to a much greater extent than the progression from the data to information views of computer-based systems (Dillon, M., 2002). As noted by Riedl (2002), stressing the situated, organizational design underlying KM,

“Talking about knowledge management means talking about processes, tools and people. [...]. In practice, most people talk about content structures or about social activities, both of which are important, but even together, they only cover a minor part of the problems”.

For LIS, inasmuch as with IM, the perspectives of KM are twofold: KM for the betterment of libraries as organizations, in the management of its objectives and resources, and KM as a component of library service design and activities towards the goals of their parent organizations and of their users.

### **3.5.3 Information Systems**

Most definitions of Information Systems (IS) endorse generally the aim of providing organizations and people with the means, usually computer-based, that meet their information needs in ways congruent with their businesses, organizational goals and strategies. The nature of the field is, therefore, closely related to both management and IT. IS emerged as an active field in the 60s to fill a gap not addressed by computer scientists, the application of computers to business. In this respect, it covers information and IT management in general, as organizational assets. Especially particular to Information Systems are topics such as information system development methods (Hirschheim, Klein & Lyytinen, 1995; Avgerou & Cornford, 1998; Hirschheim, Iivari & Klein, 1998),<sup>17</sup> business-IT strategic alignment (Knights, Noble & Willmott, 1997; Luftman, Papp & Brier, 1999; Luftman, 2000; Chung, Rainer, Jr & Lewis, 2003), IT sourcing (McKeen, et al., 2002) and management information systems (Palvia, et al., 2003).

A distinctive feature of IS is its philosophical background. IS was fostered by the philosophical and scientific movement of systems theory, pivoted by works like those of von Bertalanffy (1972) and fed from many disparate scientific areas such as biology, philosophy, psychology, computing, cognitive sciences and the more eclectic cybernetics (Saraswat, 1998; Checkland, 1999; Mora, et al., 2003). The

Systems world-view is a response to the limitations of traditional scientific enquiry, providing an holistic perspective, more amenable to a complex, dynamic and uncertain environment. Such a perspective “requires a simultaneous understanding of the environmental, organizational, technological, and human dimensions of the system” (Saraswat, 1998).

The field has developed its own professional bodies,<sup>18</sup> conferences and publications, yet researchers’ affiliation spread across many areas (Adam & Fitzgerald, 2000). Deemed nowadays critical, and exploding in terms of education demands in many well established academic areas, notably management and business (Watson, et al., 1999), IS remains, after about 40 years, a still emerging and difficult to define discipline (Checkland & Holwell, 1998: 37; Cohen, E., 1999; Ellis, Allen & Wilson, 1999; Adam & Fitzgerald 2000). For Robinson & Richardson (1999) the field undergoes a fundamental disciplinary crisis in terms of distinctiveness, coherence and viability. Several reasons have been put forward to explain the situation.

First, is the diversity and the overlap with many other established areas, from which it draws the protagonists, topics, theories and methods. This makes the field confusing in conceptual terms, difficult to distinguish from IT and characterized by a sense of lack of a central set of concepts and body of theory (Alter, 1999, 2000; Mora, et al., 2003).<sup>19</sup> Bacon & Fitzgerald (2001) presented a systemic framework of the IS field content with five main areas, showing the relative position and function of each (see Fig. II-9, next page).

The confusion is compounded by the ambiguity and proliferation of terminology, the very broad and encompassing definitions provided by reference works or professional bodies (Ellis, Allen & Wilson, 1999; Robinson & Richardson, 1999), the extensive range of IS topics for its various audiences (Checkland & Holwell, 1998: 38), the variability of names used to designate the field (Gorgone, et al., 2002: 10) or the breadth of areas included in the IS model curricula (Gorgone & Gray, eds, 2000; Gorgone, et al., 2003).

A second aspect is the weak institutionalization of the field (Robinson & Richardson, 1999). IS has a difficult status in terms of identity and relevance regarding Computer Science, Engineering, and Management and Organization studies, among whose departments the IS interests, curricula and protagonists can float (Checkland & Holwell, 1998:10; Lucas, 1999; Ives, et al, 2002, Avison, 2003).

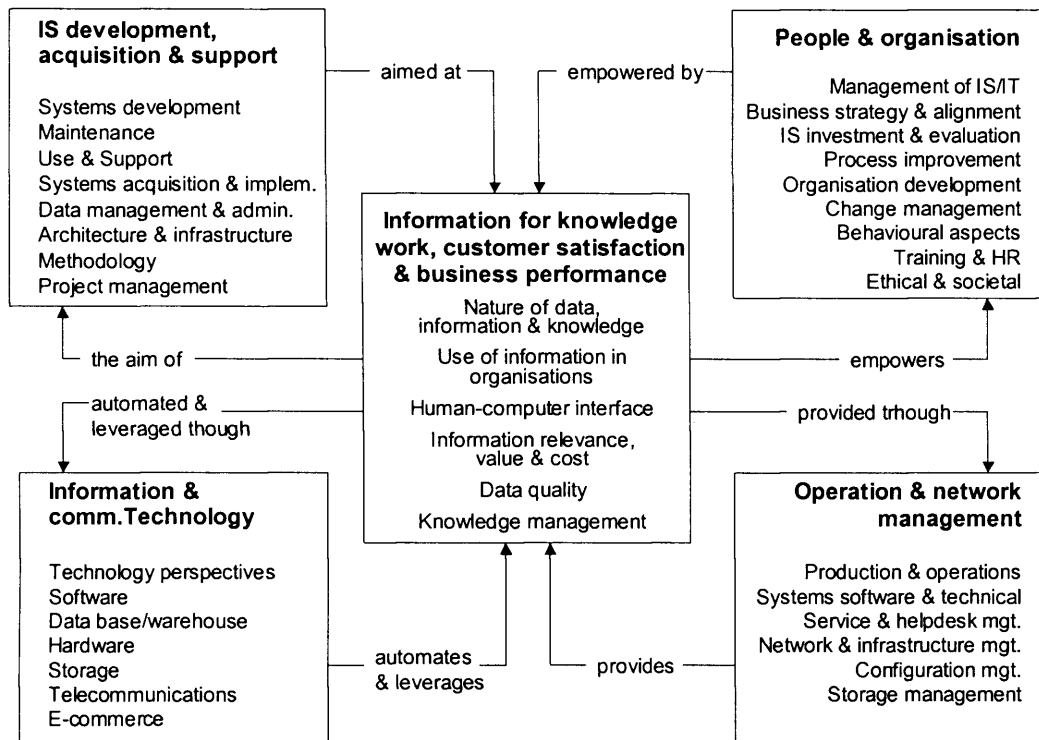


Fig. II-9 *A systemic framework for the field of Information Systems*  
(from Bacon & Fitzgerald, 2001)

A gap between theory and practice, i.e., the weak relationship between the research products and the practitioners' needs, has also been pointed out (Robinson & Richardson, 1999; Adam & Fitzgerald, 2000). The field is populated by different research communities, developed upon different factors (topics, financing, academic environment, methods and research strategy, etc.) which seem not always to contribute to a natural complementarity and cooperation (Loebbecke, et al, 2003).

The relationship with other disciplines has been the focus of persistent discussion about the status of the field. According to Baskerville & Meyers (2002) the conventional wisdom is that the field is "an applied one, drawing upon other, more fundamental, disciplines" (Fig. II-10).

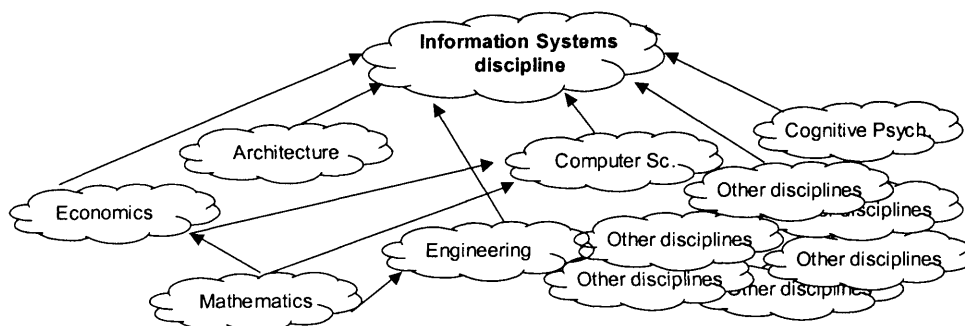


Fig. II-10 *Conventional viewpoint: IS as a consumer of concepts at the end of an intellectual food chain* (from Baskerville & Myers, 2002)

Based on the recognition of a body of knowledge (concepts, theories, processes and applications) that is particular to IS, Baskerville & Meyers (2002) proposed a critique of such a conventional viewpoint and, reinforcing the advantages of mutual exchange in a knowledge network, they advanced the idea of IS as a reference discipline for other fields (Fig. II-11).

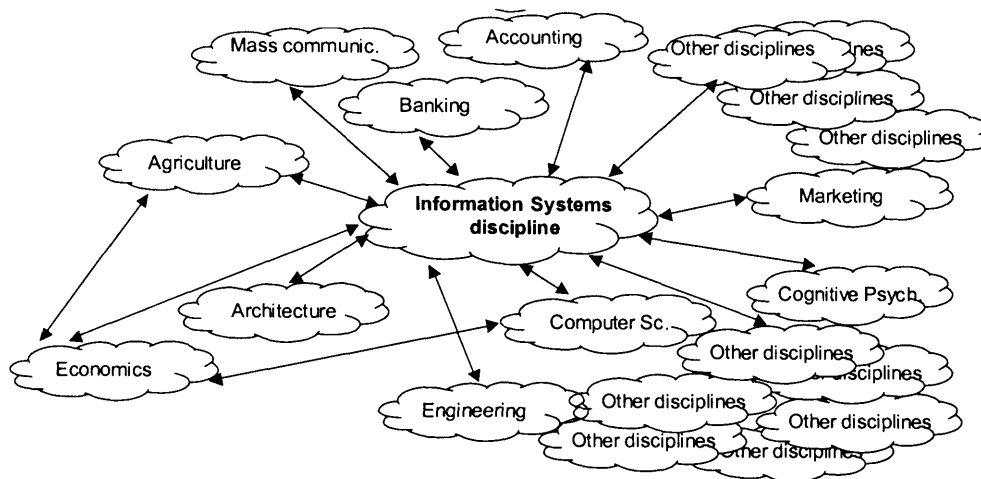


Fig. II-11 *Revised viewpoint: IS as a reference discipline in a discourse with other reference disciplines* (from Baskerville & Myers, 2002)

The evolution of IS, as well as the general understanding of its nature and foci is far from stabilized. For Adam & Fitzgerald (2000) the development course of IS as an academic field has built up a lack of cumulative tradition and, within the industry, the situation is not better. They interpreted a staged evolution where “the field does not appear to have resolved any of the problems caused by different aspects of its evolution” (Fig. II-12).

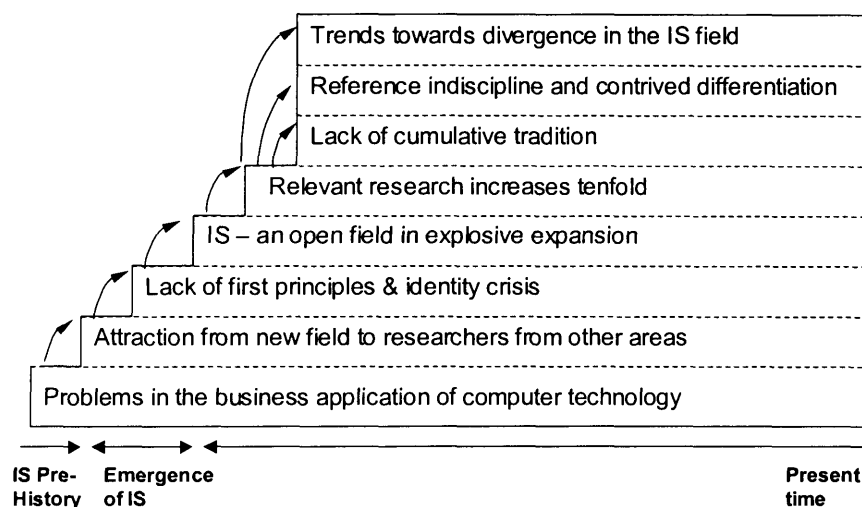


Fig. II-12 *Forces and tensions shaping the historical evolution of the IS field* (from Adam & Fitzgerald, 2000)

For Adam & Fitzgerald (2000) this development of a new field with an eclectic and pluralistic foundation parallels what happened with other social sciences, notably sociology. From their historical analysis both Robinson & Richardson (1999) and Adam & Fitzgerald (2000) suggested that the observed problems were inevitable and even necessary for the development of the field. For them, a single paradigm and the emancipation from other areas are not probable or even absolutely needed, therefore the fragmentation and loose definition of the IS field will continue.

While in social and theoretical terms this seems understandable, there are some practical consequences that should not be disregarded. First is the lack of interaction with other multidisciplinary fields that have been less bound to managerial concerns and whose communities should profit from the content and outcomes of IS. This is the case of the relationship between IS research and organization studies (Orlikowski & Barley, 2001) and Information Science (Ellis, Allen & Wilson, 1999). Secondly, the disparateness and lack of understanding of the IS field can be also seen as a reflection of the more general and pragmatic understanding about what the very field of IT is constituted of nowadays, and what changes it is going through. As IT pervades professions and organizations through actual information systems, both aspects are relevant to understand the way they are perceived in theoretical, managerial and technical terms.

### 3.5.3.1 Information Systems and Information Science

Khazanchi & Munkvold (2000) provided a classification of Information Systems and its reference disciplines, in which Information Science is included (Fig.II-13).

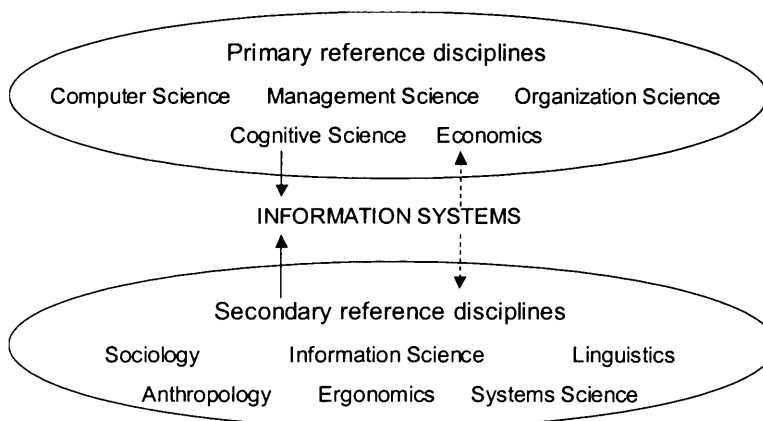


Fig. II-13 *Information Science as a reference discipline of Information Systems*  
(adapted from Khazanchi & Munkvold, 2000)



But the actual relationship between Information Science and Information Systems is poor. This was scrutinized by Ellis, Allen & Wilson (1999) through an examination of the literature of both fields and by citation and co-citation analysis of the most relevant researchers in each field. The analysis revealed that despite a considerable overlap in research topics there was almost none in relation to the assessment by co-citation.<sup>20</sup> The relationship between the domains is tenuous and the authors concluded that they have conjunct subjects but are disjunct disciplines.

“Information science research tends to be concerned with information content of systems and with the development of more effective services, while IS [information systems] research is more concerned with formal organizational relationships to data and the development of more efficient computer-based systems” (Ibid.).

Explanations include the “socialization process of practitioners in different fields” and “institutional pressures” of various kinds contributing to maintain the separateness. In the academic environment the common situation of both fields is that of “subordinate faculties” lacking power to defend their separate identity. (Ibid.) For example, by 1997, both Information Science and Information Systems were still considered “an emerging discipline” (see Williams, J.G. & Garbo, eds., 1997, for Information Science, and Mingers & Stowell, eds., 1997, for Information Systems).

For Ellis, Allen & Wilson (1999) there is not so much a need to remedy the lack of conversations between the fields through some kind of disciplinary integration, because no conflict exists between Information Science and Information Systems. But integration is important at the practical level for certain educational programmes and the authors provide some examples where that is already starting to happen.

The poor relationship between the two fields remains one sign of the confusion among the various fields that tackle information, organizations and IT. Such a confusing state does not contribute to an effective IT-related culture and has technical and organizational consequences, notably repercussions in the messiness (e.g., Cormack & Cater-Steel, 2002), failures (e.g., Warne, 2002) and inadequacy of systems that derive, in the words of Du Plooy (2003), from the “technological utopianism [...] of our mechanistic heritage”.

For the LIS field, the link to Information Systems is important in terms of research and education and can contribute to clarify, for the different professional

and organizational activities, what levels of technological competence should be mastered, why, what for and from where they can be drawn.

This leads us to the situation of the last branch of the broad information-related area analysed in this Chapter: the field of Computing/IT field, its constituencies, characteristics and changes it is going through.

### **3.6 Information Systems and the general landscape of Computing/IT**

Checkland & Holwell (1998) provided a summary of reasons why the broad field of Information Systems and IT remains in a confusing state.

“Firstly, this a relatively new field [...]. Secondly, the rate at which thinking about the field has developed has not matched that at which the technology has changed. [...] Thirdly, [...] the nature of changes brought about by IS and IT is that they extend beyond the mere use of tools to cover deeper cultural change. The field is bound to be a hybrid one, with many candidates for inclusion [...] IT without being sharply defined, is usually regarded as a collection of both practices, techniques and devices concerned with collecting, storing, processing and distributing data or information” (Ibid.: 8-9).

According to them, this confusion is extended when “IT” is meant to include some aspects proper to Information Systems, like system analysis, which involves a close relationship to “real world management problem situations” in “designing human activity systems” usually absent from the ‘hard’ systems view (Ibid.).

The general sense of these remarks is also echoed from within Computing/IT, by leading figures of the field. Denning (1998), tracing the general evolution of computing and IT in terms of education, research and production of IT goods, identified two main branches in the population of the field. One is the computer scientists themselves who have been residing essentially in a research realm (the ‘inventors’), more close to mathematics and computational science. The other is that of the pragmatists, more linked to the grounds of the industry, having ‘software engineering’ as its most visible face. Denning explains how the field as a whole developed out of the control of the academic environment, in a complex way, evidencing several important dichotomies: research versus application, researchers versus practitioners, education versus training, general versus professional education. These dichotomies have had an impact on the complex and scattered nature of the IT field which, he argues, has not been delivering what users, students and professionals

expect. According to Denning the whole area should be reunified around the concept of profession (for him “computing professions”) rather than that of a discipline.

For Denning & Dunham (2001) the “IT professions have been grappling with four dilemmas. They are: skills, breadth versus depth, design and licensing”.

Denning (2002) reported the existence of over forty organized professional groups in computing and IT (Table II-4), which he presented arranged into three major groups.

Table II-4 *Subdivisions of the IT field* (from Denning, 2002)

IT-Specific disciplines	IT-Intensive disciplines	IT-Supportive occupations
Artificial intelligence	Aerospace engineering	Computer technician
Computer science	Banking and financial services	Help desk technician
Computer engineering	Bioinformatics	Network technician
Computational science	Cognitive science	Professional IT trainer
Database engineering	Digital library science	Security specialist
Computer graphics	E-commerce	System administrator
Human computer interaction	Genetic engineering	Web services designer
Network engineering	Information science	Web identity designer
Operating systems	Information systems	Database administrator
Performance engineering	Public policy & privacy	
Robotics	Instructional design	
Scientific computing	Knowledge engineering	
Software architecture	Management information systems	
Software engineering	Multimedia design	
System security	Transportation systems	
	Telecommunications	

“The IT-specific disciplines are the core technologies of computer science and engineering; the people working in these disciplines are called *computing technologists*. The IT-intensive disciplines are the other branches of science, engineering, and commerce that innovate in IT as part of their work. The IT-supportive occupations are relatively new professional specialties that support and maintain IT infrastructure. These groups all share a common scientific core in IT but have different professional practices and concerns. Taken together, these groups constitute the emerging Profession of Information Technology” (Ibid).

According to Denning (2002), while computer technologists tend to remain out of the ‘pragmatists’ field of action, the IT field “has progressed little beyond a collection of crafts” and the “proliferating collection of IT specialties has not begun to coalesce into a clearly defined and coherent profession that practitioners can identify with.” Among other effects, computing technologists have been away from the ‘customers’ or ‘consumers’ of the IT output (Denning & Dunham, 2003).

The IT output is mostly dominated by the industry which, for reasons of demand which universities cannot possibly cope with, has been providing a great

deal of the education and training in the field (Denning, 1999; Roberts, 2000). There are consequences for both IT education and IT consumers in the society at large.

“Ours is a field of buzz words whose meanings have blurred under a barrage of flashy vendor advertisements. Nowhere is the blur more obvious than with four words at the very foundation of our profession. The distinction between “data” and “information”, once carefully observed by computing professionals, has all but disappeared. Knowledge” has been trivialized to the content of databases. “Practices” are no longer seen as an important form of knowledge. Our sloppiness with these terms undermines our credibility with others, who wonder whether to believe our claims for a solid scientific basis, for effective professional education, for productivity enhancing business systems, or for safe and dependable software” (Denning, 2002).

The high dependency on the industry, reflected in the common belief of ‘the market intelligence’ (meaning ‘let the market decide’), was also noted by Engelbart (2002) as one of the problems with the quality of what the IT market delivers because “whatever it is that the market ‘knows’, its knowledge is fundamentally conservative in that it only values what is available today” (Ibid.).

For Denning (2002) there is a “perplexing problem of poor cooperation between university and industry education” which the ‘IT schools movement’, by embracing a professional education not isolated from application fields and in cooperation with other departments, is trying to solve (Denning, 2001). Denning’s points of view and concerns are shared by Mitchell (2003) who analysed actual changes going on in the field of IT education in universities, noting trends towards new integrative views. These trends go in line with the ideas anticipated by Dahlbom & Mathiassen (1997) towards a less mechanistic view of computing/IT. As suggested by Finkelstein, L. & Hafner (2002) and Mitchell (2003), such trends include conceptions of IT work as a ‘continuum’ (Fig. II-14) where design is a major factor.

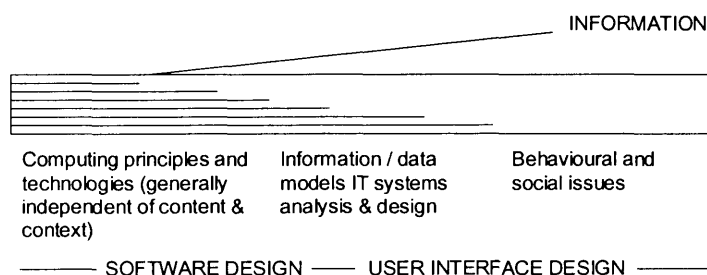


Fig. II-14 *The subject matter continuum of the broad IT discipline*  
(from Finkelstein, L. & Hafner, 2002)

These conceptions reinforce the holistic view of Information Systems as well as the importance of the Information Management function with all its socio-technical aspects, all sharing a space with IT where there have been some important gaps, either intellectual or in the relationship between theory and practice.

### **3.7 Conclusions**

This Chapter was developed in order to contribute to the first research question of this study by investigating whether there are shared conceptual foundations that facilitate conveying IT knowledge into LIS. With this aim, the characteristics and relationships of the various disciplinary fields that are included in, overlap with or surround LIS in relation to IT were analysed. The initial assumption was that the degree of conceptual mastery that a given field has over the technologies it uses can be appreciated from the relationship that such a field maintains with the knowledge areas underlying them. The analysis justified the premise because the relationships are not clear or straightforward.

The major conclusion is that the relationships between the fields analysed do not show an actual sharing of concepts, theories, agents and literatures that match the common claims of interdisciplinarity. Therefore, the disciplinary axis cannot be seen as having been a major channel to feed IT knowledge into LIS.

In this respect, the analysis provided two important indications. The first is that, despite nowadays LIS being seen as an area close to the fundamentals of the current information environment, largely intertwined with technology, the actual areas of knowledge, theory and research bringing LIS and IT together have not expanded in the same measure. They continue to be limited to niches. The second indication is that one should not expect (or wait for) the answer to the issues of the relationship between LIS and IT to be 'served' solely from academic endeavour, i.e., through possible re-organizations of the field, e.g., by redefinition of formal educational programmes. The remainder of this Chapter explains and discusses the major findings.

The overview provided in the Chapter suggests a picture of LIS as a field with scattered roots and supported by different traditions in which IT has not found a common solid ground, i.e., a clearly understood place within the field conceptual structure(s) that could provide fruitful integration.

What the analysis was targeted to seek, and could not find, was indication of structures to support the acquisition of IT knowledge, not simply IT skills, i.e., a conceptual framework where shared content from other IT-related fields could fit without changing the nature or the main structure (or even the name) of the field.

The relationship among the fields analysed is evident, and recognized in theory, but their expressions are fuzzy. Rather than ‘conversations’, they appear more as monologues. While the fields recognize each other, they do so in many different manners. This suggests, first of all, a lack of maturity in the relationships, which may be a sign of poor demands from the practice stakeholders, towards more clarified disciplinary frameworks. In terms of activity, LIS (or Information Science) subsumes many aspects of IM and KM, but these are still very loose fields. In theoretical terms, LIS is not absent from the landscape of Information Systems and Computing/IT, but it may appear in different positions, and the actual connections are very restricted or even almost absent. For example, theoretical aspects proper to LIS that are directed to improve IT-based information systems, such as IR, seem to be even more ignored by the IT and information services stakeholders on the market, especially since the development of the WWW.

One thing that is clear is that the fields analysed have different populations of ‘producers’ and ‘consumers’. These populations overlap little, so there is a lack of a critical mass of sources for integrative perspectives. Different professional or academic groups have different perspectives of some common problems and objectives, or similar general perspectives but taken from different standpoints, focusing on different selections of matters, thus producing more or less different understandings. It is thus difficult to chart the whole set of fields in a definite manner.

Yet, it is possible to sketch a very broad picture that expresses the multidirectional, non-hierarchical, nature of the fields and highlights the main points of connection (see Fig. II-15, next page), i.e.,

- the management of technical IT systems (linked to the IT external environment);
- the management of information contexts; and
- the management of organizations, processes and structures (linked to the external information and business environment).

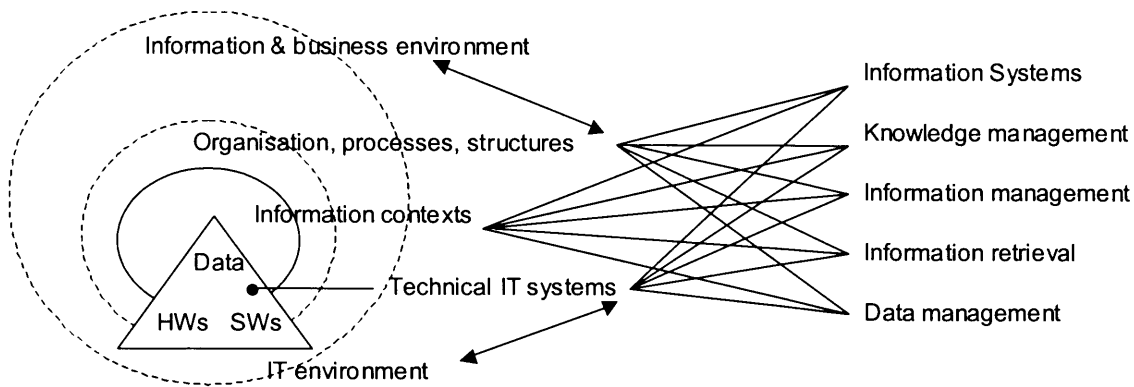


Fig.II-15 *IT-related fields and their management connection points*

The multiplicity of perspectives and foci come also from the diversified disciplinary affiliations, extensiveness of content, issues of identity, unclear relationships to Computing/IT, a field which suffers from many of the same issues. In a rapidly changing IT environment, these are all factors that do not help integrating perspectives and the building of conceptual structures that could allow integration by ‘knowing’ the essential without necessarily ‘doing’ the details; that is to say, sharing common understandings of a field without having to pertain to the respective academic or professional group. For LIS, the situation suggests that intermediate operators for conceptual communication are missing in the relationship with other fields that are the main providers of knowledge about IT.

The analysis did not reveal answers as to why the analysed fields share most of the characteristics that are problematic and so little of the subject matter they are supposed to share, in a durable manner. From the overall picture one may only hypothesize that this is because: i) all these fields are young and unsettled; and ii) because the content and professions of IT are far from stabilized.

All fields analysed have continuously been through phases of professional redefinition and scientific re-framing almost since their inception. The analysis revealed that the disciplinary discussions about frontiers and identities does not provide answers to effective needs and tends to be divorced from practice. In practice, the confluence of the fields exists. It has been producing multidisciplinary groups that complement collaborations in practice settings. They do not share a common culture because they lack communion of theoretical frames. Yet, for better or worse, they have been doing the job. But, as explained in Chapter 2, the library work in relation to IT is getting more complex, demanding and structural.

One fundamental difficulty to get the job done is communication among different stakeholders operating with different concepts and using different technical languages. One main argument of this thesis is that conceptual communication is a promising locus to help to bridge between the fields of LIS and IT: finding common conceptual building blocks/vocabularies that may serve to enhance communication in practice not only may facilitate the job but also may contribute to enrich the discipline. Languages, when established, i.e., used, can be studied, improved, even normalized and theorized.

This also applies to ‘languages’ that emerge in conversations between fields that need and want to engage in conversations while maintaining their own technical languages. They emerge from practice, not from disciplinary programmes. As in the development of natural languages, a common language to bridge LIS and IT is more likely to emerge from practice, i.e., by exploration, usage and sedimentation without being restricted by a priori theories.

The concept/term of ‘information architecture’ (IA), newly (re)emerged in practice from the need to bridge different technical communities in the context of the WWW, is a good example of this.

### **3.7.1 Information architecture: a new conceptual perspective for IT knowledge integration**

In face of the context summarized above, the concept of IA may offer a new plan upon which to develop new ways of rethinking and re-articulating the relationship between the different fields related to IT. The use of ‘architecture’ is not new in IT (Ganek & Sussenguth, 1999) or in Information Systems (Schmidt & Bernus, 1998). It has also been used in software engineering especially since the development of object-oriented methodologies and of software componentization <sup>21</sup> (addressed in Chapter 5), in which ‘design’ and other ideas like ‘patterns’ (Gamma, et al., 1995) and ‘frameworks’ (Kiziltan, Jonsson & Hnich, 2000) have been stressed. Design and architecture are also not new in information modelling for communication (Wurman, ed., 1997; Tonfoni, 1998) having impact on information seeking and IR (Dahlström & Gunnarsson, 2000). However, it was with the development of the WWW that IA gained a popular projection, related to the



building of Web sites (Rosenfeld & Morville, 1999). Morrogh (2002: 6) defined IA as being

“primarily about the design of information environments and the management of an information environment design process. Information architecture’s roots are in multiple fields, including visual design, information design, library science, computer science, social informatics, and engineering psychology (more commonly known as ‘human factors’). All are occupations focused on the creation, communication (presentation and organization), management (storage, retrieval and distribution) and preservation of information or maximizing the relationship between humans and technology. Each has its own history, traditions, best practices, and technical languages. Until the advent of personal computers, the digitisation of all media, and the maturation of the Internet, these disciplines were worlds unto themselves”.

Although popularized with the WWW, the concept and principles of IA – such as the coherence of content, along with an adequate articulation between content, people, processes and technologies – are valid for any kind of information system irrespective of context and underlying technology. IA has the same integrating potential within or outside the Web environment. Its advantages to integrating work, knowledge and activities related to IT have been recognized by authors from both Information Systems (Kimble & Selby, 2000) and LIS (Dillon, A., 2002; Latham, 2002; Gilchrist & Mahon, eds., 2004). However, seeing IA as another, emerging discipline, or profession (e.g., Morrogh, 2002), does not contribute to integrate or illuminate the problematic issues that cut across existing fields and professional groups. Rather it leads to diversion, continuing a useless trend in just renaming activities, which often contribute to earlier forms of the newly named activity being ignored or bypassed, thus augmenting the fuzziness of the conjunction of fields.

IA can bring a new perspective to the relationship between areas of disciplinary convergence – Computer Science as the manipulation of symbols and Information Systems as the manipulation of content - and areas of practice convergence, i.e., in engineering application areas and in IT as industry output. Without having to have a body of disciplinary theory, the concept suggests, first of all, the idea of interdisciplinarity. Not only the ‘architecture’ metaphor is intuitive and powerful but, significantly, it also makes a bridge between two kinds of spaces otherwise opposite: the physical and virtual spaces. Furthermore, as Haverty (2002) noted, the nature of IA is essentially inductive and this gives support to emergent phenomena that characterize the current world of information and technology, such

as the growing need for higher levels of a “more comprehensive knowledge of an entire design-build process” (Morrogh, 2002: 6).

In sum, one can advocate the potential of IA on the basis of its independent but aggregative nature. It can be applied far from the original context without confusion, and its semantic is sufficiently simple to be understood, i.e., successfully applied, by a variety of technical audiences. Thus, it has potential to structure conversations within heterogeneous communities of practice with a variety of concerns, perspectives, concepts and languages.

In Fig. II-16, the concept of ‘architecture’ is used to give an image of the relationship of LIS and IT. It depicts the content that mediates between LIS as a discipline (on the top) and the communities of practice, i.e., the multidisciplinary groups that realize actual IT-based library undertakings (at the bottom).

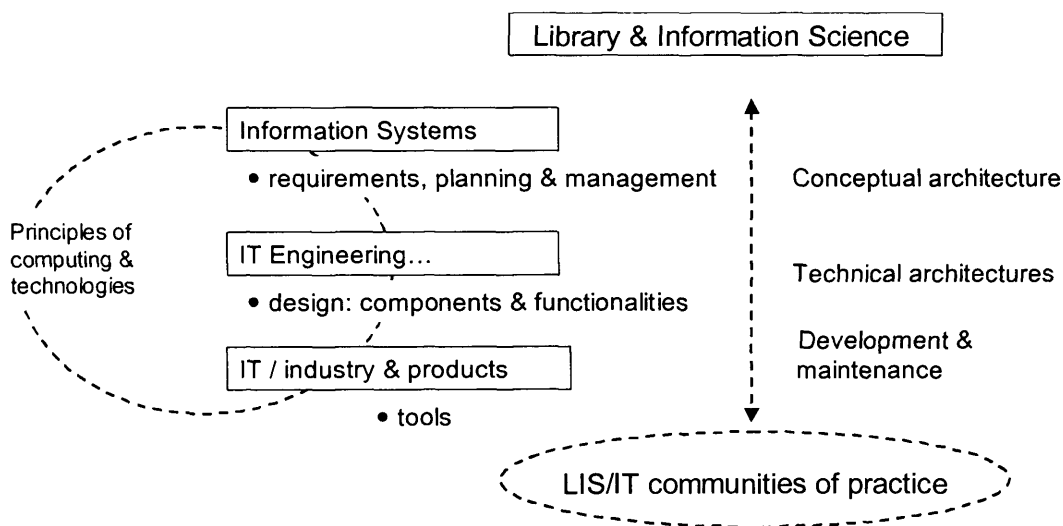


Fig. II-16 *The relative position of LIS and LIS/IT communities of practice regarding the broad area of IT-related fields*

In libraries, the work related to IT-based systems is often, by necessity, more close to the industry, its actual products and services (that provide, as in construction, the tools and materials applied in actual development and maintenance) and progressively more distant from the higher, more conceptual, levels of IT engineering (which, as in construction, prepare the architectures for various technical subsystems of a ‘building’) and of Information Systems (the level of the overall

conceptual architecture of a building, i.e., ensuring the suitability to the purpose and inhabitants, the aesthetics, the overall quality management, etc.).

Working only with the concepts of the industry of tools and materials is the same as raising a building just with builders, with no engineers, designers or architects. Besides the risk, their concepts and language are too particular to help in higher level decisions. Understanding the need for designers and architects is a good step. Often, designers, engineers and architects are said to be behind the offerings of the industry, coming with the builder, its tools and materials, but that is rarely enough. The best for the owner of the development is to get at least a minimal understanding of the concepts and languages of engineers, designers and architects, so to be able to interact with them, to judge upon choices, etc.

The illustration above does not exemplify the application of IA framework in an information system. But it helps to highlight some conclusions of this Chapter while showing the potential of the concept. IA is a notion above and independent of all parts, and it may comprehend a diversity of layers and perspectives: goals and requisites, components and functionalities, etc. It is also open to various levels: planning, normative, managerial, of technical execution, of exploitation...and maintenance. Furthermore, it is a concept applicable to different magnitudes: from simple information objects or its components to the most complex systems.

In the light of this concept, the study will proceed, in Part III, to explore from the evolution of technology and its trends, fundamental concepts that may serve as building blocks of a common, high-level, 'architectural' language to talk about useful components and attributes of information systems.

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### Notes to Chapter 3:

<sup>1</sup> Wersig (1997) called this developmental stage of Information Science the “Shannon and Weaver phase”. The transition from this first phase is well illustrated by the collection of papers presented to the annual sessions of the ASIS Special Interest Group on the Foundations of Information Science (SIG/FIS) from 1978 to 1981 (Heilprin, ed., 1985).

<sup>2</sup> These are examples of theories that are sub-disciplines in communication and computer science and physics, respectively. In the first case see IEEE Information Theory Society <http://golay.uvic.ca/index.html>; A new branch of physics related to Stonier theories is Information-Physics (see, for example, <http://newton.umsl.edu/infophys/>).

<sup>3</sup> See also Hawkins, Larson & Caton (2003) who, in continuation of this research, proposed a new taxonomy for the field.

<sup>4</sup> After an extensive review of the LIS literature, Apostle & Raymond (1997: 33) hypothesized that “*information management* jobs constituted a conglomerate of quite dissimilar occupations, only loosely gathered together under the umbrella *information* concept, and that the optimistic predictions of a growing demand for MLIS degree holders in that market could probably not be substantiated empirically”. To examine this hypothesis they conducted a series of labour market studies in Canada (Apostle & Raymond: Chap. 4-7), and concluded that the actual prospects of work offer outside the library sector were very low, and that specific skills obtained in LIS courses were of direct relevance only within a rather narrow band of the total spectrum of information-related jobs (Ibid.: 106-107).

<sup>5</sup> In the late 20s and early 30s, Lotka and Bradford provided the earlier studies of bibliometrics, and Zipf introduced the study of word frequency in texts. Major texts of these authors are reprinted in Meadows, ed. (1987). See also Chen & Leimkuhler (1986), and Meadows (2002).

<sup>6</sup> Information Science became established with the creation of the UK Institute of Information Scientists (IIS) in 1958 and of the American Society for Information Science, in 1968, formed from the former American Documentation Institute (ADI), created in 1937.

<sup>7</sup> Wellisch (1972) reported thirty-nine different definitions of Information Science in the literature between 1959 and 1971. Schrader (1984) studied about 700 definitions of Information Science and its antecedents, from 1900 to 1981, highlighting the conceptual and terminological confusion in the use of designations related to information. Wersig (1992) described Information Science as a “rather confusing” field “mainly because it never had a serious understanding of itself reaching further than establishing systems/organizations dealing with something one might call information” and recognized the lack of an “accepted body of theory available [...] because it was never needed for the engineering approach and because all the chunks imported from other disciplines were never able to provide a basis for a scientific discipline in its own right” (Ibid.). According to Rayward (1996) the historical understanding of Information Science and its relationship to Library Science or Computer Science is a very difficult task because of “misunderstandings and confusions” that arise from a “terminological chaos” of many definitions and interdisciplinary views.

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<sup>8</sup> Brookes (1980-1981) developed a framework based on Karl's Popper ontology of the 'three world model' (Popper, 1972:153-161) which helped to specify foci: Information Science should be identified with interactions between 'world 3', objective knowledge, i.e., recorded knowledge generated by humans, and 'world 2', the subjective, mental, knowledge. Brookes' fundamental equation of information science is a model of information transfer that has exercised some theoretical hegemony in the cognitive viewpoint of IS (e.g., Todd, 1999).

<sup>9</sup> Belkin (1978) formulated the problem of Information Science in terms of "facilitating the effective communication of desired information between human generator and human user" thus restricting the area of study to specific phenomena of communication, not all communication processes.

<sup>10</sup> Differences in the literature covered and methods used allowed this additional interpretation of the concept spaces of the field. While White & McCain (1998) focused on major Information Science research journals and used co-citation only, Åstrom (2002) covered also major journals of librarianship and, in addition to co-citation analysis, used co-occurrence of keywords to better identify topics.

<sup>11</sup> The camp of the user-centred approach, starting in the late 70s and developing in the 80s, is more related to ASIS while the systems' approach group is more connected to ACM/SIGIR. An overview of the content analysis of 25 years of SIGIR conferences is provided by Smeaton, et al. (2002).

<sup>12</sup> The time frame for the peak of interest in expert systems corresponds to a phase when the field, with automated library operations being already common, could take practical benefit from AI. But the short span of that interest derives from coinciding with the delusion phase about the prospects of AI in the market, which explains the steadily decrease.

<sup>13</sup> For Bates (2002) this includes "classifications, ontologies, indexing vocabularies, statistical properties of databases (including the Bradford Distribution), and staff indexing support systems".

<sup>14</sup> According to Brooks (2003), "Social agreements take precedence over technology in closed Webs where the Web is reduced to a communications venue. Predictability in structure and meaning is the fundamental facilitator permitting in-house Web crawlers to harvest topical metadata for the retrieval benefit of the local community. In a closed Web, one can build a legacy database and do IR".

<sup>15</sup> None of the analysed systems provided the wide range of features of traditional online services. Main features lacking include: Boolean searching, browsing of search terms, adjacency and proximity operators, links to related items, use of controlled vocabularies, alternative data display modes.

<sup>16</sup> An historical account is provided by Wilson, T.D. (2002).

<sup>17</sup> Hirschheim, Iivari & Klein (1998) provided an overview of the five major approaches to information systems development (ISD). SSM (Soft Systems Methodology), developed by Checkland since the 70s (Checkland, 1999; Checkland & Holwell, 1998) is among the best known and has been the basis of other ISD methodologies.

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<sup>18</sup> The most prominent organization is AIS - The Association for Information Systems (<http://www.aisnet.org/>) founded in 1994. In 1998 it merged with ISWorld (<http://www.isworld.org/>) a learning organization providing Web resources to the Information Systems community. In 2001 it merged with ICIS - The International Conference on Information Systems, founded in 1980 at the University of California, Los Angeles (<http://www.aisnet.org/icisnet/>). Links exist between AIS / ICIS and the Association for Computing Machinery (ACM), the International Academy for Information Management (IAIM), the International Federation for Information Processing (IFIP), the Institute for Operations Research and Management Sciences (INFORMS), and the Society for Information Management (SIM). An example of a national body for IS is the UKAIS – The United Kingdom Academy for Information Systems (<http://www.ukais.org/>).

<sup>19</sup> Alter (1999) presented a general theory of the field, intended for understanding by both practitioners and researchers in either the business or IT environment. It is formed by a set of high level concepts and relationships which include the notions of “work system, six elements of a work system, a work system’s environment, information systems, content versus plumbing, viewing a project as a work system, and viewing an information system project as part of a work system project” (Ibid.: 7).

<sup>20</sup> Due to the disparate nature of Information Science the analysis was done considering separately its two major strands, user studies (US) and information retrieval (IR). Information Systems (IS) was taken in a single set. The three sets, each containing the citations of the most cited authors in each field, were relatively large and similar in size: all between 4.500 and 4.800 citations. The overlap between the IS and US found 152 citations only. The overlap between IS and IR was even lower, with 72 citations only.

<sup>21</sup> A compilation of chronology, definitions and bibliography about ‘architecture’ in the software domain is available from the *Carnegie Mellon Software Engineering Institute* at <http://www.sei.cmu.edu/architecture/definitions.html>.

## **PART III**

### **IT AS A SOURCE OF CONCEPTUAL ELEMENTS FOR ALIGNMENT**

#### **Introduction**

Part III of the thesis addresses the second research question of the study: is the technical background of computing/IT a persistent barrier to knowledge sharing with LIS? Or is the evolution of computing/IT providing a set of integrative concepts that can serve as a durable and extensible common conceptual basis?

The aim is to investigate whether or not the changes in the nature of IT systems tend to make them less mechanistic and more amenable to the strategic and managerial intervention by lay people; and, if this is the case, did IT concepts emerged that contribute to changing the predominant views of IT by library professionals and to aligning their frames of reference with the IT community.

As mentioned in Section 1.5.3, this investigation is conducted in three chapters comprising the evolution of major concepts, methodologies, frameworks and languages that have been raised in computing and IT, from the rise of distributed systems to the WWW environment. As explained in the research design (see 1.6.4), the analysis is conducted from the viewpoint of interoperability, which was chosen as the central aspect because this approach involves all levels of information systems development and management, around which the evolution of IT will be explored.

The first chapter of this Part, Chapter 4, elaborates on the concept of interoperability and explains where and how it is realized, what problems and requirements it raises and what technical aspects have the most strategic and long lasting effects for interoperability solutions in particular and for the quality of information management in general.

Chapter 5 provides a high level view of paradigm shifts and major conceptual trends in computing and IT that are behind the developments in distributed systems and interoperability. Finally, Chapter 6 analyses features and trends of distributed systems and interoperability in the WWW environment, thus completing the overview of concepts and technologies in the current environment.

The remainder of this introduction provides explanation of some general terminology that will be used throughout the following chapters, together with introductory notes about the relevance of the approach taken in this Part of the thesis.

While Part II addressed the broad socio-technical perspective of the relationship between libraries, or LIS, and IT, Part III is focused on information management systems (IMS), i.e., systems that support information work and information processes by means of IT (Tansey, 2003: 7).

In this context, an IMS is a designed and purposeful system (Checkland, 1999: 119) composed of technological tools, information assets and services that are targeted to the needs of a group, a specific activity or business, or the objectives of an organization. The term is used here in a very general sense that overlaps with the more commonly used term of ‘information system’, whose definition may vary but basically refers to any computer-supported human-activity system. Therefore, IMS is here understood as defined by Bernus & Smith (1998):

“An *information system* is a system for collecting, processing, storing, retrieving, and distributing information within the enterprise and between the enterprise and its environment. The information system is a *functionally defined subsystem* of the enterprise, i.e., it is defined through the services it renders”.

The preference for the expression IMS is dictated by the need deliberately to express, and underline, information management goals. As explained by Graves, Knoblock & Lannom (2002) the changes brought about by the advances in networking and computing technologies have been impacting on the goals, problem space and requirements of information management. Not only “information management has developed unevenly and incompletely in different contexts and in differing ways” but also “currently workers contributing to information management come from a wide variety of backgrounds”, e.g., librarians, computer scientists and system engineers (Ibid.:21).

“Merely advocating multi-discipline projects rarely produces success. People from all these disciplines must be willing to learn from each other before they can collaborate effectively [...] since none of these disciplines is adequate by itself” (Ibid.: 22).

The panel study developed by Graves, Knoblock & Lannom (2002) analyzed different application domains.<sup>1</sup> They identified a “shared set of critical technical challenges in information management” (Ibid.: 16) all around the main problem of interoperability, and provided recommendations on five topics: knowledge representation and management, data integration, collaboration and security, usability and application-oriented research (Ibid.: 22-27). An extensive list is



provided of research topics to address new technology requirements for information management. The set of topics represents challenges that cannot be addressed solely by the technological communities, yet no interested party can do without some kind of technological knowledge. The study illustrates the need for better understanding of technology and for identifying technology requirements in order to advance information management in ways that can constitute a “common scientific umbrella” (Ibid.: 22).

Due to the widespread variations in concepts/terminology used by the multiplicity of computing/IT professions, such a “common scientific umbrella” needs, first of all, a high level definition of what is understood by an IMS, its components and relationships. In this thesis, an IMS is defined as having three major interrelated components/views: ‘information assets’, ‘information processing resources’ and ‘information activities’ (Fig. III-1):

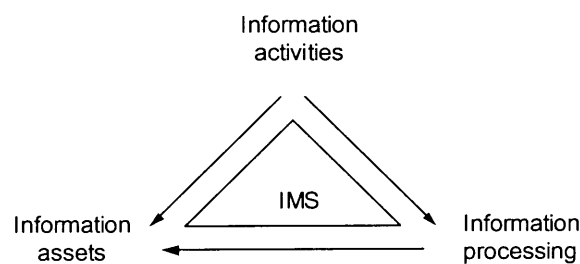


Fig. III-1 *The major views of an IMS and their ‘use’ relations*

- ‘Information assets’ are aggregations of information records with intended or perceived attributes (Oppenheim & Stenson, 2003), i.e., representations gathered in any form of structured and purposeful information object or its parts, or a system or system component (a text, a graphic, a file, a database system or its parts);
- ‘Information processing’ resources refer to any kind of actual IT tools and methodologies used to enable the communication, use and transformation of information records and assets. In this sense, information processing resources encompass all forms and levels of IT, comprising hardware and software;
- ‘Information activities’ is used here to mean all kinds of actions in using IT resources to build, manage and deploy information records or assets, either by human or machine agents.

‘Information activities’ – information retrieval and rendering, communication, use, transformation and/or any other transactions - implies the correlation of information agents, information objects and data (Fig. III-2).

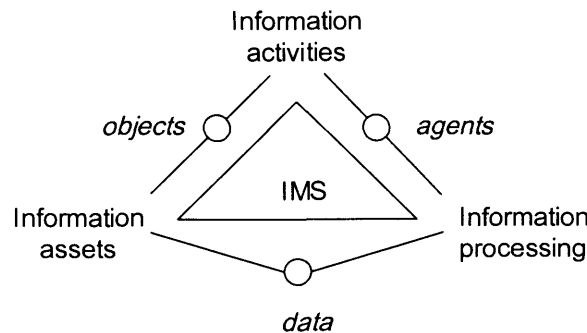


Fig. III-2 *The correlation of objects, agents and data*

‘Information agents’ are the system’s action activators, as users of its services and exploiters of its resources. They may be human agents or automated agents, in the latter case belonging to the system or being external to it. ‘Information objects’ are information records, or their aggregations, designed and purposeful. They may pertain to the real world of primary information records or they may be systems representations of any kind of real world object, entity, fact, event or transaction. ‘Data’ are aggregations of components of information objects, primary or surrogate, encoded according to a given scheme and translated in binary form for computer processing. Behind these views, are the systems’ main internal components, represented in Fig. III-3, which identifies also the physical and logical levels where such components operate.

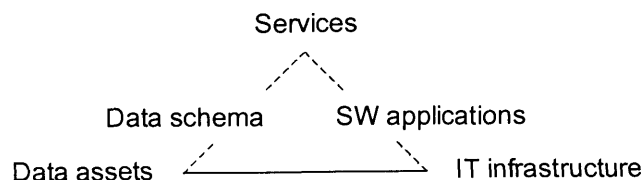


Fig. III-3 *Major internal components of IMS: the physical (\_\_\_) and logical (----).levels*

At the logical level – meaning all elements that have an existence beyond physical implementation - three major components intervene in turning data into actionable information:

- services, i.e., the activity or set of activities performed by a system component on behalf of a client, which may be another system component or an external agent (Finkelstein, A., 1998);<sup>2</sup>
- data schema, i.e., the formalized conventions that enable data to be processed, in order to compose, transform, communicate, or generate an information object, either primary or surrogate;
- information processing tools, namely database systems and software applications which process data.

The last two levels are interrelated and are both the most critical for the quality of information services, including interoperability.

## **CHAPTER FOUR**

### **INTEROPERABILITY: CONCEPTS, EVOLUTION AND TRENDS**

#### **4.1 Introduction**

This Chapter is the first step to answer the second research question, especially its first part - is the technical background of computing/IT a persistent barrier to knowledge sharing with LIS? The answer depends on an investigation on whether or not the conceptual changes in the evolution of IT have been contributing to lower the barriers to knowledge sharing with LIS.

This may be verified through the identification of IT trends that: i) are integrative in nature, i.e., that represent/demand the participation of non-IT communities; and ii) are supported by constructs and vocabularies whose understanding and application in a variety of IT management situations do not require a technical background in Computing/IT.

The analysis is centred on the topic of interoperability, chosen as a cornerstone for the understanding of IT developments since the 80s, both in technical terms and in respect to the growing inter-relationship with the organizational and social aspects of information systems.

The Chapter discusses the concept of interoperability, summarises the most important areas of IT where the concept applies, identifying trends in the type and level of concerns in the evolution of interoperable systems, namely with distributed systems. The synthesis provided is of a high level, i.e., not concerned with the comprehensiveness of technical details and instance examples that would be expected in a study of a more technical nature.

#### **4.2 Interoperability: roots, meanings and reach of the concept**

Interoperability underlies most of the expectations about the potential of networks, beyond simple information transfer, although it rarely appears explicitly, at least outside the technological literature. The expectations are about new ways of making the most of networked resources of any kind, which are believed to affect significantly the nature and life of information agents (persons, organizations and systems), information assets and information processing, in many areas of human

activity. The concept is intimately linked to communication objectives, communicability of information assets, effectiveness of communication and processing tools and, therefore, of information activities. Interoperability has been a major driving concept through which it is possible to analyse many of the technical, technological and organizational changes in information systems.

#### **4.2.1 Interoperability as a general concept**

There is no unique meaning for interoperability, as it refers to qualities or functional capabilities that can occur with different kinds of entities and processes. Often absent from general language dictionaries, the term has become frequent in the field of IT, especially in networking. But even in this context it is far from easy to define (Moen, 2001: 87), as it encompasses a large spectrum of issues of a different technical nature (Lynch & Garcia-Molina, 1995). Furthermore, the pervasive effects of networking have brought interoperability to the top of concerns in many other areas, not strictly technical, making it more difficult to define, in a clear and comprehensive way (Miller, P., 2000).

The concept of interoperability is open to various interpretations according to the type of technology sought, the industry sector or the domain approached. A generic definition usually states that it is “the ability of a system or product to work with other systems and products without special effort” (WhatIs.Com, 1996-2005) i.e., in a more or less transparent way. This implies that interoperable entities share certain qualities and conditions that reduce or eliminate not the diversity but the additional effort that differences could cause. That is to say, qualities and conditions that enable degrees of seamless use of two or more interacting systems or products, usually according to prescribed methods in order to achieve some predictable results. The focus of such methods are compatibility issues and specifications for interface devices between the systems or products.

Thus, in practice the concept involves a set of agents in a situation of mutual relationship having a common goal to attain. In most industrial areas, being interoperable is achieved by standardization of physical components, i.e., the compatibility is achieved by normalization of, usually static, interfacing devices. When information is involved, interoperability means mediation of heterogeneities rather than simple standardization. As heterogeneities among information systems

are not of a definite and confined nature, it is useful to integrate particular views and instances of the concept under the following three major assumptions: that information system interoperability is multidimensional, multidisciplinary and multi-level.

#### **4.2.2 Information systems interoperability is multidimensional**

When interoperability goals involve information, simple standardization is often not feasible or even desirable. Information systems interoperability is difficult to attain precisely because it aims at coping not only with heterogeneities but also with the dynamism of information activities and of the systems that support them. Beyond the issues of transport and communication of data and information, dynamism is also implied in understanding and reusing what is communicated, in different endeavours, i.e., by a diversity of agents and processing tools that may not be static or once and for all defined (EU-NSF, 1998, 1998a).

Therefore, instead of just a set of qualities and conditions that can be set out by a pre-defined group of standards - as happens with physical devices mostly - information interoperability is better defined as a goal because it is an ongoing process requiring continuous commitment (Miller, P., 2000; Johnston, 2001). A goal that corresponds to a vision, to which many technological, technical, managerial, organizational and political levels contribute. To convey the varied dimensions of interoperability better, some authors distinguish between its diverse types.

Miller, P. (2000) subdivided the notion of interoperability into i) technical, ii) semantic, iii) political/human, iv) inter-community, v) legal and vi) international interoperability. For Johnston (2001) these are facets of the problem, rather than “bounded sectors”. He emphasized their inter-connected nature and identified four major dimensions: i) technical interoperability, ii) semantic interoperability, iii) inter-community interoperability and, finally, iv) human, organizational and political interoperability. In the context of digital libraries, Arms, W., et al. (2002) addressed the multidimensional nature of interoperability in three major levels of interoperability agreements: i) technical agreements, ii) content agreements and iii) organizational agreements.

The increasing attention to wide visions of interoperability demonstrates the importance of the subject and the emergence of a growing variety of factors

influencing it. Nevertheless, wide visions often fail to systematise clearly what are the core stances of interoperability realization, i.e., where it actually takes place, and what are the background and surrounding factors that may affect its attainment. One example of the kind of ambiguities that may occur is when ‘semantic interoperability’ is presented as something aside from ‘technical interoperability’, e.g., in Johnston (2001). While it may be strongly affected by community or organizational factors, the concept pertains entirely to the technical realm and even permeates the technological one, as the need successfully to convey meaning does not depend on data/information representation only but also on matching the behaviour of software components pertaining to different systems.

What follows is a list of example situations where a variety of statements and perspectives regarding information interoperability can be found, from a diversity of contexts:

- in IT/IS policies at a governmental <sup>3</sup> or institutional <sup>4</sup> level;
- in international domain-focused initiatives and standards;<sup>5</sup>
- in agreements and requisites for cross-institutional services;<sup>6</sup>
- in perspectives from computing research organizations;<sup>7</sup>
- in industry standardization efforts;<sup>8</sup>
- in vendor strategies to support interoperability in specific products;<sup>9</sup>
- in awareness and research services for interoperability standards and good practices;<sup>10</sup>
- in profiles or specifications for consistent implementation of a given interoperability standard.<sup>11</sup>

The examples given, while illustrative of the multiplicity of contexts/actors/foci and issues related to information interoperability, are not exhaustive. A general trait that can be observed in the evolution of this kind of sources/literature throughout the 90s is the gradual change of focus from discrete standards or sets of standards, to more encompassing perspectives expressed by terms like ‘organizational strategy’, ‘architecture’ and ‘environment’, framing the issues of interoperability. This is noted here, anticipating some of the aspects that will be developed in the remainder of this Chapter, just to illustrate the complexity of the subject and the difficulty in providing a high level definition or description of information interoperability that is at the same time comprehensive and accurate.

Fig. III-4 attempts to sketch such a comprehensive description, positioning the range of factors/levels implied, their relationships and directions of mutual influence.

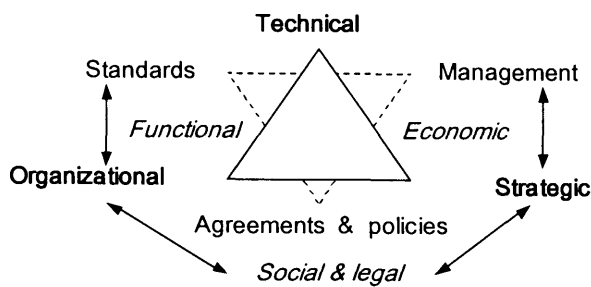


Fig. III-4 *Dimensions of interoperability: levels of decision (—), execution (....) and rationale (italic)*

First, there are three major dimensions at the decision level: the technical, the strategic and the organizational. At the top level are technical solutions, meaning that the strongest influence is bottom up, from strategic and organizational factors to technical decisions. In turn, the inverted triangle in the background represents the major types of factors affecting the realization (the execution level) of the technical solutions: ‘standards’ and ‘management’ (closer to the technical level) and ‘agreements & policies’ regarding the external environment (closer to organizational and strategic aspects). Here, the influence is mostly top-down, in the sense that the feasibility of agreements and policies is strongly influenced by the possibility of adopting common standards and sustaining non-conflicting managerial interests.

Finally, there are contextual factors, those that inform the rationale of interoperability decisions. And these combine, in the background, all the six factors previously identified. Functional aspects are mostly in between the organizational needs and objectives and the standards to be adopted. Economic considerations and constraints are in between managerial decisions and strategic orientations. Finally, there is a multiplicity of social and legal aspects that relates both to organizational aspects and strategy and provides a more or less fertile ground for agreements and policies.

Distinguishing all these dimensions/factors is useful in order to facilitate the identification and understanding of the nature of the problems to be tackled. This is important because the matter is complex and different aspects are often dealt with separately. In fact, all sorts of aspects related to information systems interoperability, such as strategic objectives, policy definitions, organizational goals, technical requirements and methods, standards and guideline formulations, etc., can be



expressed in many different contexts and forms, using different terminology, technical or not, depending upon the specific matters, objectives and audiences.

#### **4.2.3 Information systems interoperability is multidisciplinary**

There is not a single professional framework for interoperability matters. Even within computing, interoperability issues cut across many of its conventional divisions (Finkelstein, A., 1998). Besides, not all technical and technological interoperability issues are amenable to the same degree of formalization, i.e., of being documented or having a standardized description with the same level of disambiguation or completeness. This is especially the case when ‘understanding’ is concerned, i.e., in semantic interoperability, where the ability to interoperate depends not only on communicating information representations (understanding form) but also on effectively communicating intended meaning (understanding content).

The multidisciplinary nature of information systems interoperability makes it difficult to formulate one single technical definition for it. One can find as many definitions as the areas concerned, with different scopes, according to the level of detail required for the aspect, or issue, being focused upon.

Definitions and brief introductions to the most fundamental concepts/areas concerned with information systems interoperability, and most commonly found in technical literature, are addressed in the following sections. The terms/definitions provided below are not all mutually exclusive, and show overlap and close relationship. However, they present useful approaches to understanding the span of different technical areas of interoperability in IMS development and management.

##### **4.2.3.1 System interoperability**

System interoperability - when ‘system’ is taken as ‘information system’ as a whole - is usually the most general and comprehensive concept, referring to the “ability of disparate applications, operating systems and communications systems to be linked together and then behave as a single entity” (Kramer, Papazoglou & Schmidt, eds., 1998: xxv). However, some authors (e.g., Sheth, 1999; Ouksel & Sheth, 1999; Kashyap, V. & Sheth, 2000: Chap. 1) use the term ‘system interoperability’ to refer to the lower level of interoperability that deals with

heterogeneities at the platform level (basically hardware and operating system) and other components of the information system base structure (database management systems, file management systems). At a higher level, they distinguish ‘syntactical, structural and semantic interoperability’, all aspects to consider in dealing with information heterogeneities. According to Mylopoulos (1998),

“System interoperability is concerned with the features of infrastructures which enable systems to exchange data and use each other’s functions. Application interoperability, on the other hand, is concerned with semantic issues of information exchange and application program sharing among interoperating systems”.

Another way to define systems interoperability is by reference to the major properties that should be managed in an interoperable system, as provided by Finkelstein, A. (1998):

“Interoperable systems are systems composed from autonomous, locally managed, heterogeneous components, which are required to cooperate to provide complex services”.

Autonomy is an important aspect to be managed in interoperable systems, because the challenge is to find “the best balance between the compatibility required for cooperation and the concomitant loss of autonomy and heterogeneity” (Ibid.).

For Finkelstein, A. (1998) an interoperable system implies the notion of a distributed system whose logical organization comprises at least three layers: data, shared services and applications. Interoperability functions and tools fit mostly into the middle logical layer, but they are not unaware of the integration capabilities allowed by the adjacent layers. Areas of interoperability research that connect different layers are shown in Fig. III-5.

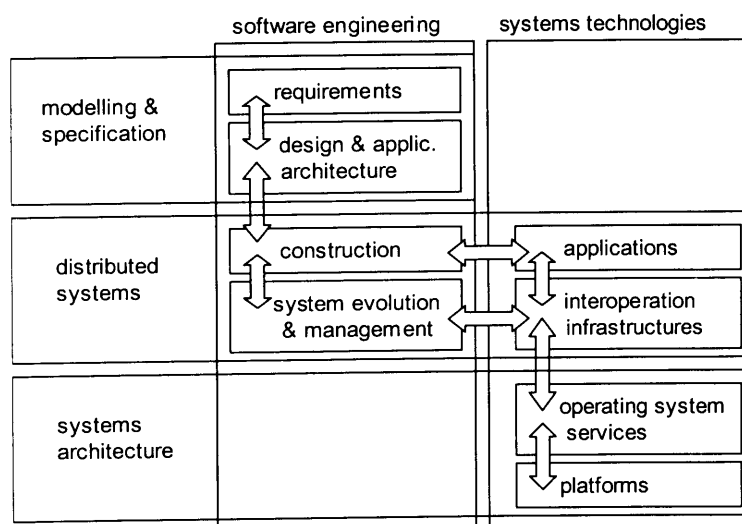


Fig. III-5 Areas of interoperability research (from Finkelstein, A., 1998)

Developments carried out in specific technical areas are approached in the following sections.

#### **4.2.3.2 Database interoperability**

From a database management viewpoint, interoperability is generally understood as the ability to “support access to multiple autonomous databases without a (common) global schema” (Litwin, Mark & Roussopolous, 1990), or the “ability to query them in a manner independent of the discrepancies in their structure and data semantics” (Gingras, et al., 1997). Database interoperability can address issues of database query languages, in their capabilities (Ibid.) and in the optimization of query processing (Kossman, 2000); issues of data schema integration (Renner, Rosenthal & Scarano, 1996; Parent & Spaccapietra, 1998), or both (Goh, Madnick & Siegel, 1994).

Database interoperability was among the first concerns in systems interoperability and received most of the attention in interoperability research, notably until the expansion of the Internet, as integrated access to disparate database resources had been a major problem since the development of local networks. Concepts such as multidatabase systems, or federated database solutions (see next section) emerged with a different range of options for more or less tight, or loose, logical integration (Busse, et al., 1999).

#### **4.2.3.3 Data interoperability**

In data management, interoperability relates to the ability of sharing and re-using data among systems in a domain or across several domains. It relies strongly on the existence of metadata, or ‘data about data’. Metadata is, therefore, a crucial aspect for interoperability, but from two different perspectives: metadata as ‘data about data’ and metadata as ‘data’ itself.

##### **a) Metadata as formal ‘data about data’**

As ‘data about data’, metadata evolved from the need to manage data in order to support its coherence, consistency, quality and database systems integration capabilities (Marco, 2000: Chap. 1). Since the 70s, it led to the development of

specific data management methods and resources, like data dictionaries or, more recently, repositories (Bobak, 1997; Marco, 2000; Tannenbaum, 2001),<sup>12</sup> for whose design and maintenance there have been specific software applications (see, for example, Bobak, 1997: Chap. 13, 15; Marco, 2000: Chap. 4). With networking, metadata management has evolved from the single database or application view towards solutions that tend to integrate data specifications from across the whole set of an enterprise's systems. Basically, the main pressure has been to overcome the "information tunnel" syndrome explained by Tannenbaum (2001: 15-16)<sup>13</sup> or, in other words, the "content silo trap" referred to by Rockley, Kostur & Manning (2003: 5-12), defending unified strategies for enterprisewide content management.

Metadata can be of many kinds, depending in first place on the nature of the data it refers to: discrete information objects, formulated according to structures often designated as 'metadata formats' (a set of defined and organized data elements chosen to built surrogates of an object); or a set of organized representations of real-world entities, information objects or not, as in a database. The description of a metadata format or a database schema is metadata about the information object or database, while the description of data elements included in the format or schema are metadata regarding the real entities such elements represent. Metadata solutions to bring together disparate metadata, like mappings between different database schema or metadata formats, are yet another kind of metadata, meta-metadata (Benion, 1990: Chap. 3; Tannenbaum, 2001: Chap. 12).<sup>14</sup>

Metadata can also refer to data about software components, as explained by Orso, Harrold & Rosenblum (2001), who proposed a general format and unique tags for each information aspect deemed important to document a piece of reusable code. In this case, metadata relates to specifications describing static and dynamic aspects of a software component intended for use in systems and contexts other than those of the component developer. This is metadata to assist application developers in the reuse of the component in an effective and easy manner, by which the internal implementation details of the component are hidden but sufficient information is provided to evaluate, test, deploy and customize it when integrating it in other applications.

In sum, from the perspective of 'data about data', metadata subsumes intentional documentation about a data set and follows the need to 'validate' and to 'explain' data, by defining and documenting aspects of its structure, syntax,

semantics and sometimes behaviour. The documentation can be more or less comprehensive and detailed, and can take several forms, for various aspects and purposes. Thus, it can be just the specification of data elements pertaining to a given data set, object, or service. In addition, or separately, it can be a data model, i.e., a higher level representation of the components of a data set including their internal relationships and the relationships to the activities they should support in the environment for which they were created (Benion, 1990: Chap. 4; Marco, 2000: Chap. 9). Also, it may consist of, or include, an ontology, which is yet another higher level, intended to clarify the set of concepts/terms that characterise/define the knowledge space of a given information system or a domain (Gruber, 1993; Guarino, 1998; Guarino & Welty, 2000).

Kutsche & Sünbül (1999) explained how explicitly managed metadata, in its different levels and purposes, is a fundamental base for the architecture of heterogeneous distributed information systems (Fig. III-6).

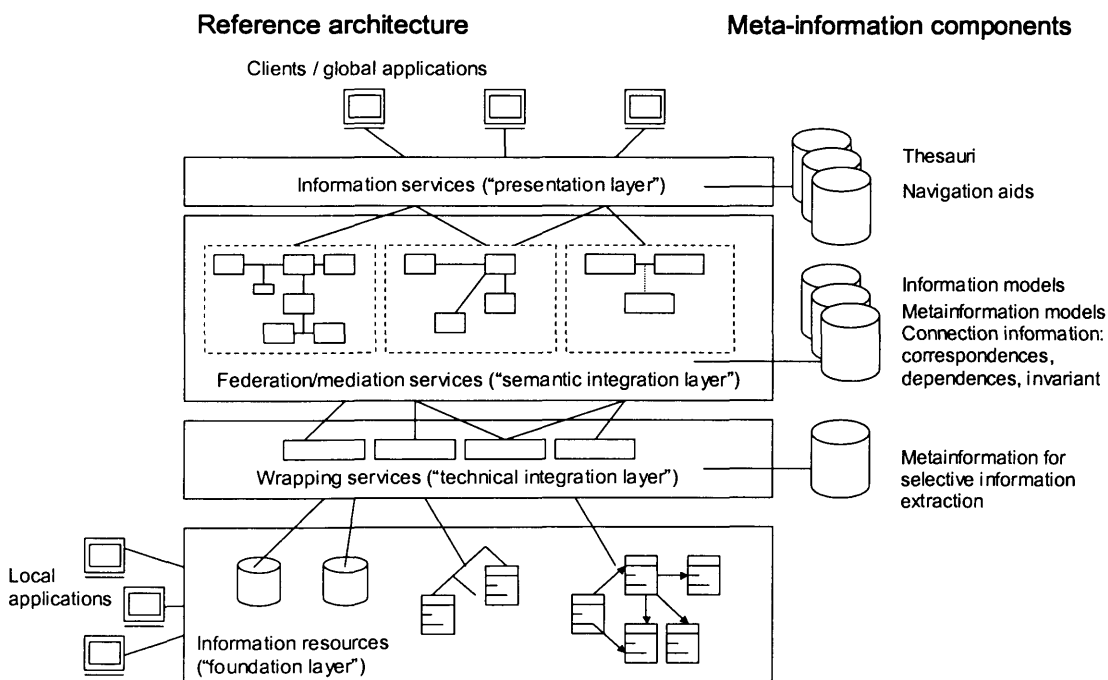


Fig. III-6 *A metadata-based reference architecture for heterogeneous distributed systems* (from Kutsche & Sünbül, 1999)

Kashyap, V. & Sheth (2000) presented several examples of projects stressing the crucial role of metadata in architectures for information brokering, i.e., intermediation services to resolve problems of information flow caused by the growing number of heterogeneous information sources available.

The need to share data across a variety of systems and to overcome the problems of managing legacy (often undocumented) systems has motivated metadata standardization initiatives (Newton, 1996) and many efforts for domain and cross-domain standardization of data models and schemas. More importantly, it has stressed the need for data registries and for independent conceptual frameworks for the specification and standardization of data elements and data models. Such a framework is provided by the ISO/IEC 11179 and ANSIINCITS 285 standards.<sup>15</sup> One example of an international metadata registry used by the industry is the Basic Semantic Registry (BSR).<sup>16</sup>

## **b) Metadata as data itself**

As ‘data’ itself, metadata is actual content that populates metadata structures. Beyond the structure, this content has been the ‘substance’ on which many solutions for accessing distributed heterogeneous information resources have been based. Various models of information systems federation <sup>17</sup> were developed since the 80s to integrate disparate data sources, namely in databases (Busse, et al., 1999). To a great extent they rely on integrating the existing or, deliberately supplemented, metadata, through the creation, or assumption, of a common federated schema.

While this guarantees, at least, syntactical and structural data interoperability, it rarely ensures the complete range of semantic interoperability, e.g., if the data sources use different semantic values (vocabulary) for the same information. Besides the cost of maintaining federated architectures (i.e., common schemas), they cannot scale easily. Their relatively static nature is a major drawback, especially because vocabularies are not static (Wiederhold, 1992, 1994, 1999; Seth, 1999; Kashyap, V. & Sheth, 2000: Chap. 2).

Furthermore, the increase in available heterogeneous information sources, notably with the Internet, has extended the interoperation problem far beyond the world of structured databases, thereby motivating research for alternative solutions for information brokering services. Some approaches point to future solutions based on independent mediation services, i.e., not dependent solely on the data sources to be exploited, or even not assuming any pre-existing semantic agreement at that level, as in federations.

Such services are envisaged for independent software modules to perform various functions and capabilities, including reasoning, in order to exploit knowledge encoded in vocabularies and ontologies (Wiederhold, 1992, 1992a, 1994, 1996, 1999; Kashyap, V. & Sheth, 2000: Chap. 2).<sup>18</sup> Although mediators work at a higher level than the base data sources, the issue still involves data interoperability because these knowledge bases have to be built and maintained partly in an automated way, partly with the participation of data/subject domain experts.

The growing focus on the semantic level, so far the weakest aspect of data interoperability, has been stressed by the WWW environment, raising the interest for shared and reusable forms of metadata as data, whose types are varied, covering a wide spectrum from ontologies to any kind of more or less structured and detailed vocabularies (McGuinness, 2001). The topic of metadata in the context of interoperability and the WWW is further elaborated in Chapter 6 (see 6.3.2).

#### **4.2.3.4 Software interoperability**

In software engineering, interoperability can be defined as “the ability of two or more software components to cooperate despite differences in language, interface, and execution platform” (Wegner, 1996). It “seek[s] to smooth the integration of both legacy and new applications” (Howie, Kunz & Law, 1996).

The objective is, for example, to overcome representation heterogeneities among resources written in different programming languages (e.g., C++, Java) or specification heterogeneities, i.e., focusing on common expressions of data type attributes rather than just mapping data representations, which are hidden (Wileden, et al., 1991; Wileden & Kaplan, 1999). Interoperability mechanisms for this are APIs (application programming interfaces) and solutions like CORBA (Common Object Request Broker Architecture),<sup>19</sup> which treat data form and structure at the interface level (Emmerich, 2000: 132-140). This kind of mechanism, however, does not cope with semantic interoperability issues, i.e., the problems of meaning and information heterogeneity, for which software solutions have been researched (Ganguly, Rabhi & Ray, 2001).

This is an area that overlaps with data interoperability at the level of vocabularies and ontologies. ‘Mediation’ is an architectural concept that has been proposed for software solutions to cover this level of integration, which is different

from simply data integration (Wiederhold, 1996). Mediators are software modules intended to access, abstract, generalize and transform disparate data in order to convey information from different data sources in operational ways that are independent of them (Wiederhold & Genesereth, 1997; Wiederhold, 1999).

Howie, Kunz & Law (1996) provided a good summary of strategies for software interoperability, in architectures and middleware solutions, methodologies for applications design and reusability of software components, or reverse software engineering regarding migration of legacy software (see also, for example, Robertson, 1997). Howie, Kunz & Law (1996) distinguished three different viewpoints in software interoperability (Fig. III-7).

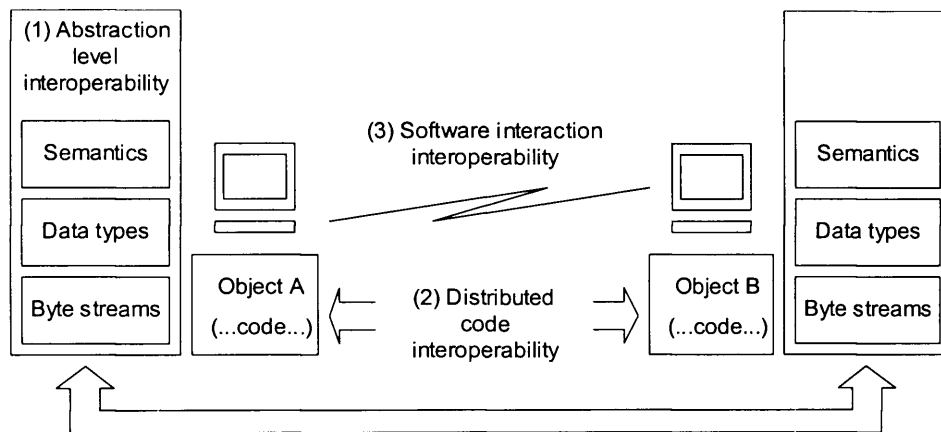


Fig. III-7 *The three main viewpoints of software interoperability* (from Howie, Kunz & Law, 1996: 6.5)

The three main viewpoints depicted in Fig. III-7 are:

“The most common approach is to investigate the level of abstraction at which databases and/or applications can be integrated (view 1). A more recent development is to extend the object-oriented (or software component) paradigm so that objects can be distributed across network machines and still constitute a logical application (view 2). This is at a fine level of granularity and deals with the technical issues of integration software. By contrast, a third view is to consider the integration of applications, regardless of whether they are distributed or even object-oriented. Such an approach assumes an agreed abstraction level at which knowledge is shared or communicated (view 3). It focuses on the integration of network-based applications and assumes the functional and behavioral requirements of the system are met within the applications themselves” (Ibid.).



Several trends in software engineering, such as object-orientation, middleware, compositional software, pattern-based software development and agent technologies, are very important for interoperability, because they promote interchange and reusability and enable solutions for interoperation that are not bilaterally specific (Putman, 1998). They are part of the most significant changes in paradigm that have been taking place in computing since the 80s, and will be approached in Chapter 5.

#### 4.2.4 Information interoperability is multi-levelled

The concepts/areas introduced above have shown how differently interoperability can be viewed and that the various kinds of problems it raises do not pertain wholly to the same technical area. Several technical areas are involved and although they work together they can be developed independently. There are, thus, different levels of concerns and functions in the practical realization of interoperability. An informal illustration of this was provided by Royster (1996), in Fig. III-8.

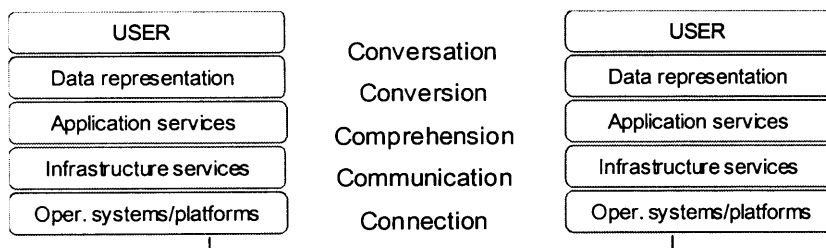


Fig. III-8 *The five C's of interoperability* (from Royster , 1996)

This layered view expresses the hierarchy and dependency of different interoperability stances which are technically defined in the OSI model (ISO/IEC 7498: 1984-1997) (see also Section 4.3.3a).

The layers allow the reduction of complexity by identifying the boundaries of each layer and their relationship to adjacent layers. For information systems interoperability they can be considered in two major groups: the physical and the logical levels of interoperability (Fig. III-9, next page).

The logical levels encompass both data/information and application software.<sup>20</sup> The physical level is that of the supporting infrastructure and data transmission, having a longer tradition in direct connection with the history of data networks (Kramer, Papazoglou & Schmidt, 1998).

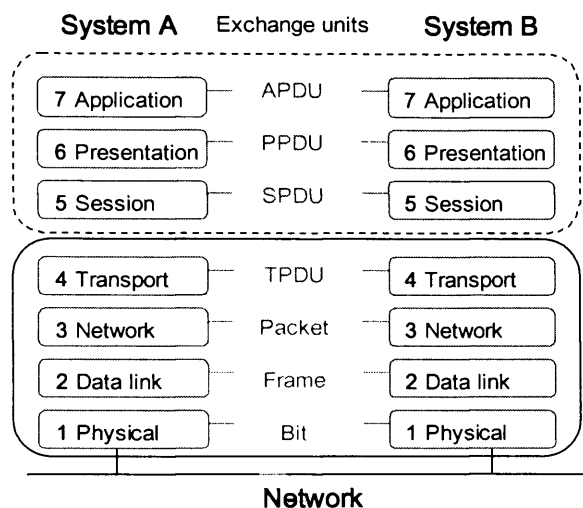


Fig. III-9 Levels of data (—) and information (---) exchange in the OSI model

The upper levels are concerned with exchanging information, while the lower ones mostly concern data. There cannot be information interoperability among systems without the lower levels of data link and data transport, yet these do not address the problems of information interoperability, which are of a different nature mostly, and cover what is usually considered ‘semantic interoperability’.

The semantic interoperability level implies sharing knowledge about systems components that are involved in information exchanges. The requirements of this level have always been recognized as far more demanding and diversified than those considered at the physical level (Sciore, Siegel & Rosenthal, 1994; Heiler, 1995; Sheth, 1995; Park & Ram, 2004) because:

- Data to be exchanged has to be well interpreted, i.e., to be understood according to the meaning intended at the source. This requires systems understanding each other’s logical structure, syntax and semantics of data. Beyond the complexity of these issues, especially when systems were independently designed, there is a growing scale of diversity made available in the global network;
- What is needed in information exchanges is not only understanding about data regarding information assets such as structured databases or files, but also information regarding programs that operate with such data;

- Information and data assets, and software components as well, are dynamic to suit the needs of autonomously managed systems. Therefore, static compatibilities, such as those at the syntax level, are not enough. Dynamism is among the factors that create more complexities in interoperability, as it generates not only more heterogeneities but also degrees of unpredictability.

One useful perspective to clarify the different levels of interoperability is to analyse the levels of heterogeneity in information systems (Fig. III-10).

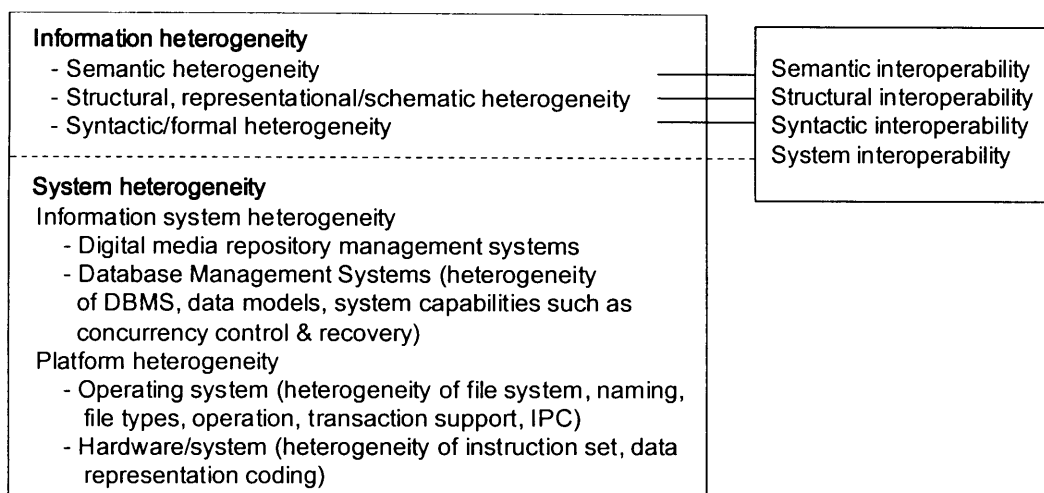


Fig. III-10 *A taxonomy of heterogeneity and interoperability*  
(from Kashyap & Sheth, 2000: 2)

The evolution of interoperability development stages has been bottom-up, as explained by Sheth (1999), who presented three generations of interoperability research. The first generation, roughly until the 90s, focused on system interoperability essentially (with emphasis on common data models, database schema translations, access integration at the query level) in the context of multi-database systems or federated databases, over proprietary communication infrastructures.

Other trends characterise the second generation, starting with the Internet and being reinforced with the WWW and the emergence of large scale distributed computing. At this stage there is a growing variety of data sources, encompassing structure databases, semi-structured data and non-textual digital media. This stage provided increasing attention to data and information objects management, diversifying metadata needs and types and leading to a multitude of ad hoc standard initiatives, also covering important aspects of systems interconnection and infrastructures for distributed computing using middleware technologies.

Examples of application domains eliciting and contributing to the developments at this stage are electronic commerce and digital libraries. Syntactical and structural (schematic) interoperability developed significantly (e.g., Z39.50 and Dublin Core), but forms of semantic interoperability were limited (Paepcke, et al., 1998; Sheth, 1999). For Sheth (1999),

“Although there are several uses and interpretations of semantics in information systems, our view is that future information systems will need to support a more general notion that involves relating the content and representation of information resources to entities and concepts in the real world. [...] That is, limited forms of operational and axiomatic semantics of a particular representational language framework are not sufficient. [...] In essence, we need an approach that reduces the problem of knowing the contents and structure of many information resources to the problem of knowing the contents of easily-understood, domain-specific ontologies, which a user familiar with the domain is likely to know or understand easily”.

The third (and present) generation shows a growing scale of older issues and is marked by developments at the level of Web technology, e.g., the Extensible Markup Language (XML) at the syntactic level, and the Resource Description Framework (RDF) for structural interoperability. At this stage, the main focus for essential research is semantic interoperability (Ouksel & Sheth, 1999; Sheth, 1999, Kashyap, V. & Sheth, 2000; March, Hevner & Ram, 2000; Partridge, 2002; Aberer, et al., 2004; Park & Ram, 2004; Kashyap, V., 2004). Three main enablers for future semantic interoperability were identified by Sheth (1999):

- terminology (and language) transparency, meaning support for independently-managed ontologies and vocabularies;
- context-sensitive information processing, through modelling and representing context for information objects on the basis of similarities found in the semantics associated with them; and
- information correlations between independently managed network resources, e.g., through linking systems that can fit easily with the Web technology.

### **4.3 Interoperability and distributed systems**

Interoperability advantages and requirements are closely linked to the development of distributed systems, as both emerged and developed alongside networks. Therefore, benefits and properties of distributed systems are directly relevant to interoperability. This Section will synthesize major properties of distributed systems that have opened the way or endorsed requirements for development of interoperability, as well as the different kind of conceptual approaches that have emerged in areas of IT activity to cope with the increasing complexity of knowledges and standards involved in distributed systems.

In a general definition from an internal and organic point of view, distributed systems are systems formed by a number of components which are themselves computer systems, connected in a network, where applications are executed using a number of processes that reside in different components (Crowcroft, 1995: ix; Blair & Stefani, 1997: 3; Emmerich, 2000: 4-8). A more general and 'external' definition, such as proposed by Tanenbaum & van Steen (2002: 2) highlights one of the main advantages of distributed systems from the user's point of view: it is a collection of independent computers that appears to its users as a single coherent system. In between these definitions many others can be found, each stressing a particular area of concern or viewpoint.

The motivations for distributed computing emerged with the fall in the cost of processor and memory computer components, the development of network technologies, the increase in number of different applications required by users and the limitations of large centralized computer systems to respond to real interactive user needs. Although such motivations were already apparent in the early 70s, the necessary developments in hardware and software were only available in the 80s, in ways that could render affordable the settlement of production environments based on networked machines. During the 80s, the wide application of workstations, local networks and client-server technologies started radical transformations in the use and management of IT in organizations (Coulouris, Dollimore & Kindberg, 1994: Sec. 1.4). Distributed hardware resources and more processing power in the hands of end-users progressively raised new requirements in the way such resources, and the benefits of distribution, should be managed.

#### **4.3.1 Properties and benefits of distributed systems**

The benefits of distributed computing are usually justified by the advantages of resource sharing, concurrency, fault tolerance, scalability, transparency and openness (Blair & Stefani, 1997: 4-7; Emmerich, 2000: 14-27). The first three of these characteristics have to do with efficiency in managing and deploying a set of IT resources. Resource sharing is the major motivation, for optimization of either informational or technological assets, while at the same time increasing workgroup productivity. Concurrency facilitates distribution of workload among several machines, or among different processors of the same machine, allowing parallel execution of processes. Fault tolerance is better enabled within a distributed architecture through the possibility of creating redundancies and alternative resources for recovery processes.

The remaining characteristics - scalability, transparency and openness - are highly desirable qualities that, although not exclusive to distributed systems, provide benefits especially important to interoperability. Scalability relates to the capability of a system to operate effectively on different scales, thereby making the system more or less extendable for future needs. Transparency is the ability of a system to hide the complexities of the distributed system by providing the user (at any level: end-user, programmer, etc.) with an integrated view of it. Finally, openness is the ability of a system to accept new components, physical or logical, without unintended disruption of those already in existence.

These are all target qualities of interoperable systems because, when interoperating, they are in fact extending each other, scaling certain functions beyond individual systems and they are expected to work in a seamless way, i.e., transparently. But these characteristics are not all equally measurable or affordable in all systems, or in all kinds of systems components. It depends on the combination of other dimensions of distributed systems: type and extension of heterogeneities to be bridged when integrating separately developed systems; autonomy, i.e., the degree of local control and management intended for each component; and the possibilities of distribution support technologies, e.g., middleware.

These factors combined produce different types/integration levels of distributed information systems and supporting architectures. According to the constraints for data, information and software interoperability, they can allow

different degrees of autonomy, adaptability and scalability. The terminology to qualify solutions in this respect varies, but ‘loose-coupling’ and ‘tight-coupling’ have been basic terms to designate the degree of integration vs. dependency that components in a distributed system may exhibit. Fig. III-11 shows the position of the major types of integration in distributed systems regarding the degrees of autonomy, adaptability and scalability.

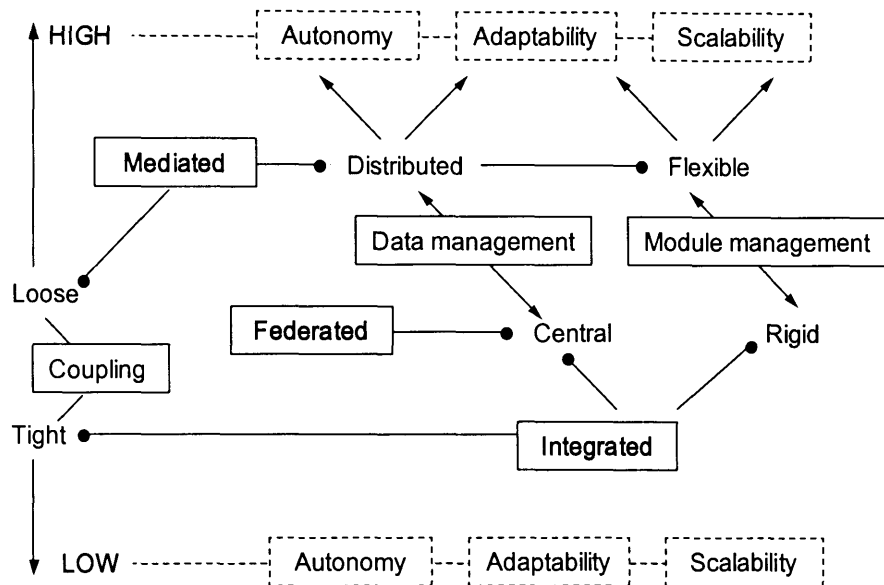


Fig. III-11 *Different types and levels of integration in distributed interoperable systems*

Generally, loosely-coupled systems are desirable as they allow better levels of autonomy, and tend to facilitate openness, through fewer external dependencies and more flexibility, than tightly-coupled ones. Yet, they usually address the simpler levels of heterogeneity or rely on fairly sophisticated intermediation solutions. On the other hand, tightly-coupled systems, which characterize the earlier forms of interoperation, can overcome a significant number of levels of heterogeneity but often at the cost of autonomy and openness (Crowcroft, 1995: 11-14; Finkelstein, A., 1998; Busse, et al., 1999).

Distributed computing has thus many forms and it evolved rapidly with the expansion from local network technologies to the available global network infrastructure, reshaping organizations' IT-based systems. A major impact has been a dramatic increase in the need to relate to the external environment, interoperating with other systems in the same or different domains. From this perspective transparency and openness, the latter balanced with autonomy, became fundamental concepts.

Together, these concepts have expanded the concept of architecture as they have stressed the objective of interworking, i.e., to “navigate the space between diversity or conflict and agreement or commitment” in the words of Pohl, et al. (1998). The requirements to satisfy such an objective are, for distributed informational, technical and business environments, shared goals, mutual understanding, heterogeneous partial knowledge, and local management activities (Ibid.).

#### **4.3.2 Transparency, openness and architectures**

As the need to cope with heterogeneities beyond organizational systems' frontiers increased, the quality of information activities a system could support became even more dependent on a growing diversity of third party systems, so transparency and openness became the crucial system qualities for interoperability.

Transparency is among the first qualities of distributed systems to receive the greatest attention. The spatial notion is the first connotation of transparency in distributed computing because IMS resources are not confined to a single location. But location is just one of the many aspects of transparency. For example, the ODP – *Open Distributed Processing* Reference Model (ISO/IEC 10746: 1996-1998: Part 1; see Section 4.3.3 b) establishes at least eight types of distribution transparency <sup>21</sup> for masking various aspects of implementation or of system behaviour which users – human or system components - do not need to be aware of (Crowcroft, 1995: 6-7; Blair & Stefani, 1997: 23-34; Kramer, 1998; Emmerich, 2000: 19-26; Coulouris, Dollimore & Kindberg, 2001: 23-25).

In systems design, transparency means that

“computational specifications are intended to be distribution-transparent, i.e., written without regard to the very real difficulties of implementation within a physically distributed, heterogeneous, multi-organizational environment. The aim of transparencies is to shift the complexities of distributed systems from the applications developers to the supporting infrastructure” (Bond, Duddy & Raymond, 1998).

Similarly, in human computer interaction (HCI), transparencies hide complexities at the human end-user interface, more often referred to as ‘user-friendliness’. In fact, HCI transparencies also subsume system transparencies that



can even reach the total disappearance of the explicit computer environment (Stephanidis, 2003).<sup>22</sup>

Beyond hiding complexity, transparencies also require solutions to cope with heterogeneities, e.g., the case of access transparency – which focuses on hiding differences in data representation and invocation mechanisms (Coulouris, Dollimore & Kindberg, 2001: 23). As seen in the previous Section (4.2) heterogeneities in information systems span a wide range of aspects – system infrastructure, databases, data, metadata and software - for which there are different requirements and approaches towards transparency.

Openness, on the other hand, “remains the most slippery of the issues, in the sense that it presents such a wide range of challenges”, in the words of Finkelstein, A. (1998). Openness is a property that is now inherent, as fundamental, for distributed systems, though a distributed system is not necessarily an open one, in the same way that a collection of autonomous and heterogeneous components does not constitute an interoperable system (Ibid.). In the *ODP Reference Model* (see Section 4.3.3 b), openness is

“the property enabling both the contribution of portability (i.e., the ability to execute different components on different processing nodes without modification), and interworking (i.e., the ability to support meaningful interactions between components, possibly residing in different systems)” (ISO/IEC 10746: 1996-1998: Part 1, sec. 6.1).

Openness is not only linked to scalability, i.e., capabilities of a system to develop in extension, but is also closely related to transparencies, signifying qualitative capabilities to integrate support for more heterogeneities, i.e., the potential of a system or system component to enable interoperability and portability (Blair & Stefani, 1997: 9), meaning integration of and coordination with more, different, components or systems. For Crowcroft (1995), the openness in a distributed system is also closely related to the level of autonomy:

“Openness is a requirement of the autonomy of different users to acquire, install and operate different appropriate systems while maintaining consistent distribution mechanisms across all user’ systems” (Ibid.:2).

In practical terms, the openness potential of a system is intentional and depends on conformity to particular groups of standards or agreements. Because of the expanding range of aspects in the need for standards and agreements in open distributed systems it became necessary to frame groups of standards in agreed sets

of concepts that provide a structure and reduce complexity. This has stressed the notion of architecture. Architecture is understood as the way – suggesting different possibilities - in which aggregation and coordination of the several components of an organizational system is prescribed, specified or realized. Conceptually, architecture encompasses many categories of principles, and conveys style and structural stability which are adapted to given human activities. As an expression, it communicates particular values of style, qualities, functions and techniques of components (Nell, 1996).

With the development of networks and distributed systems, the notion of systems architecture evolved dramatically, just as the concept of ‘system’ itself evolved (Ganek & Sussenguth,, 1999; Bernus & Schmidt, 1998), expanding to a wide range of different practical viewpoints. In the ODP Model, architecture is a “set of rules to define the structure of a system and the interrelationships between its parts” (ISO IEC 10746: 1996-1998: Part 2, sec. 6.6). The Model establishes five major viewpoints to break down the different perspectives of information systems: ‘enterprise’, ‘information’, ‘computation’, ‘engineering’ and ‘technology’ (ISO/IEC 10746: 1996-1998: Part 1, sec. 6.2.1).

Each viewpoint is a different projection of the system, representing different levels of abstraction and concerns (Table III-1).

Table III-1 *Viewpoints: levels of abstraction and their users*  
(adapted from Crowcroft, 1995: 4)

Viewpoint	Discipline	Areas of concern	What is specified	Main users
Enterprise	Management Economics Social sciences	Human & social issues Management & finance Legal concerns	Requirements	Managers
Information	Data models Knowledge Representation	Information models Information flow Information structure	Conceptual design & specifications	Inf. management specialists
Computation	Software engineering	Appl. & process design & develop. (concurrency models, abstract data types, distrib. algorithms)	Design& development	SW engineers & appl. programmers
Engineering	Operating systems Database systems Communication systems	Distributed systems infrastructure Application support Transparencies: naming, building, etc.	Infrastructure building blocks	Database, operating systems & communica tion specialists
Technology	End - products of relevant disciplines	Technology	Technology	Implementation & maintenance staff

Viewpoint frameworks vary for different purposes, to help the building of systems specifications in, for example, software engineering (Nuseibeh, Kramer & Finkelstein, 2003) or federated databases (Benchikha, Boufaida & Seinturier, 2001). Information systems architecture has, thus, several dimensions and each may be referred to as an architecture, e.g., information technology architecture, information architecture or enterprise architecture, depending on the focus of particular building blocks, constraints, modelling methodologies and languages.

#### **4.3.3 The importance of reference models**

The need to cope with increased complexity and heterogeneity raised the importance of modelling and of architectures as formalizations according to shared conceptual frameworks, usually referred to as ‘reference models’ which often include, explicitly or not, the term/concept of ‘architecture’. They represent a kind of meta-standard under which the multiplicity of specific agreement levels and standards can be sensibly integrated. According to Averill (1994),

“A reference model is a description of the frame of reference for one or more standards. A frame of reference can be thought of as a set of conceptual entities, and their relationships, plus a set of rules that govern their interactions. At the highest level of abstraction, a reference model is a standard. It prescribes the highest level of architectural structure contained in the model”.

But reference models are not actual standards in the usual sense, rather they constitute a new kind of normative level. They are aimed at defining contexts, to separate and clearly interrelate different concerns, thereby serving as integrative and generative frameworks for groups of actual standards. While reference models are descriptive, i.e., are “a rational architectural structure that integrates standards”, standards are essentially prescriptive, because they constitute a “criterion set up by consensus as a test of quality” and to draw a “boundary around compliant variations”. Hybrid reference models, on the other hand, are both descriptive and prescriptive, i.e., “its prescription is well below the highest level of abstraction contained in the reference model” (Ibid.).

Reference models, which emerged since the 80s in the areas of IT and information systems, are expressions of holistic concerns related to the management of complex knowledge work environments. This was acknowledged, for example, by

Oksala, Rutkowski & O'Donnell (1996) from a review of the major treatises on the subject. They noted not only the increasing involvement of non-technical forces (e.g., political) <sup>23</sup> but also an evolution of focus towards business imperatives and the use of conceptual models and perspectives from other areas.

Averill (1994) explained the importance of reference models for organizational performance and knowledge environments, as depicted in Fig. III-12.

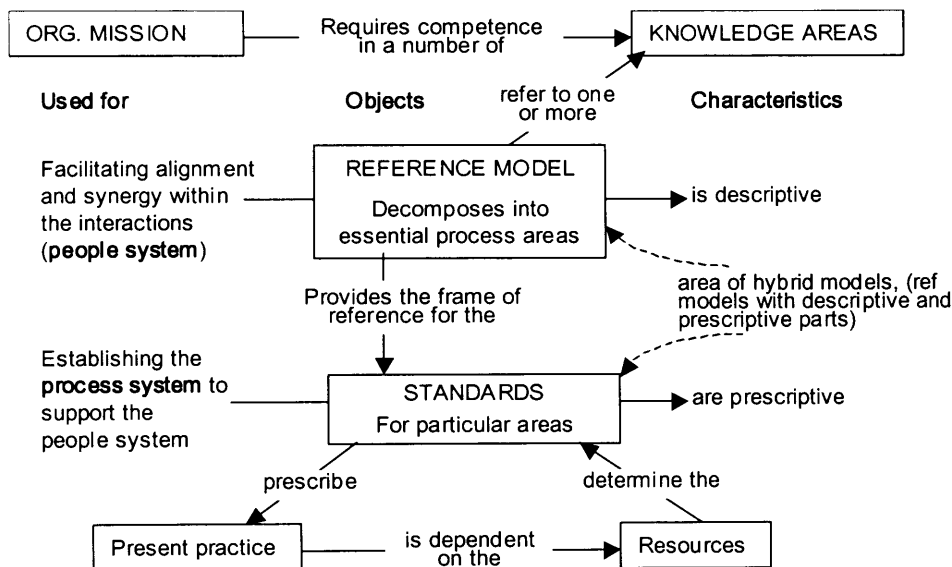


Fig. III-12 *Entity-relationship diagram of reference models, standards and organizations* (from Averill, 1994)

Brief descriptions of some of the most representative reference models for IT and information systems are next provided.

#### a) OSI Reference Model

First introduced in 1984 <sup>24</sup> by the ISO, the OSI (Open Systems Interconnection) Reference Model (ISO/IEC 7498: 1984-1997) establishes the principles and concepts of a network architecture defined in terms of a vertical stack of layers, each layer providing services and calling upon services of the adjacent layers (see fig. III-9, p. 193).<sup>25</sup> The layered approach offers systems implementers the advantage of separating the networking tasks into logical smaller pieces, thereby making it much easier for products from different vendors to interoperate, when they follow the same standard model, i.e., provide at least one specific protocol for each of the levels defined in the model (Coulouris, Dollimore & Kindberg, 2001: 78-79).

Despite being an important conceptual advancement, OSI did not receive significant acceptance and the seven layers remained almost theoretical, for two main reasons. First, it was conceived as far too complex for business feasibility and, because it followed a very long and theoretical development process, it was bypassed by the advances of actual technology, namely of the Internet, whose specifications very quickly attained the status of de facto standards (Criticisms, n.d.; Crowcroft, 1995: 181-182). Thus, the full OSI model was never realized in practice, in terms of actual specification of protocols for the complete range of layers.

Internet protocols have effected a much simpler network architecture, not fitting the same OSI layer distinctions, but distinguishing only ‘lower’ (transport) and ‘upper’ (application) levels of protocols. TCP/IP became the norm taking the place of OSI protocols for the lower level, while application protocols such as HTTP, FTP and SMTP use a layer that joins the three upper OSI levels of OSI (Coulouris, Dollimore & Kindberg, 2001: 79; Tanenbaum & Steen, 2002: 67). Existing OSI protocols for the application level, as it is the case of Z39.50 (see Chapter 7), tended to be adapted to run directly over TCP/IP.

Despite the different course of developments verified in network technology, the essentials of the OSI model remain foundational. Beyond many technical aspects that remain valid, the conceptual approach has been influential ever since it was designed and has been followed in many endeavours. It is an approach to reducing complexity by controlling the diversity of issues at the different levels of abstraction, in a structured way that allows the identification, separation and solution of the issues in each layer with the minimum of dependencies regarding the other layers.

## **b) ODP Reference Model**

The ODP - *Open Distributed Processing Model*, also referred to as ODP – RM (Reference model) establishes a generic architecture for the standardization of open distributed processing, i.e., addresses “constraints on system specification and the provision of a system infrastructure that accommodates difficulties inherent in the design and programming of distributed systems” (ISO/IEC 10746: 1996-1998: Part 1, sec. 6.2). First of all, the model defines the set of properties that an ODP system should hold. To achieve such goals – notably interoperability and portability of applications - the architecture provides a framework for open distributed processing

standards under which multiple manufacturers can collaborate in the provision of different components of distributed systems.

The architecture is based on an object modelling approach to system specification; on specifying a system in terms of separate but interrelated viewpoints; on the definition of a system infrastructure providing distribution transparencies for system applications; and on a framework for assessing system conformance (Ibid.). The reference model is composed of four parts, each providing a different set of informations.<sup>26</sup> As noted by Bond, Duddy and Raymond (1998), it “provides a big picture that organizes the pieces of an ODP system into a coherent whole” and “it does not try to standardize the components of the system nor to unnecessarily influence the choice of technology”.

Viewpoints and transparencies, discussed in the previous Section, are important features of the model. The viewpoints framework (shown in Table III-1) provide different sets of concepts, structures and rules for each viewpoint so that they can be worked out separately and then fitted together in a coherent whole. Different types of transparencies are defined for an ODP system as well as the engineering functions to support them. Being conceptually important for any aspect of open information systems specification, the ODP reference model has been particularly fruitful in software engineering, notably for compositional software, in general, and especially for middleware.

### **c) MDA – Model Driven Architecture**

MDA is a reference architecture focusing on standardizing object-oriented applications developed with a set of standards specified by a large industry consortium, OMG (see note 19). Endorsed by OMG in 2001, MDA superseded OMA (Open Management Architecture) (Bond, Duddy & Raymond, 1998), the reference model for standardization of the infrastructure to support CORBA, a middleware standard. Primary goals of MDA are portability, interoperability and reusability of software applications.

The MDA rationale continues that of OMA in prescribing types of models to be used and adds the possibility of data and application model definitions being machine-readable. This approach to system development is advantageous for flexibility and integration because it is possible to automate the production from the

design stage, and new implementations with new technology can be easily integrated using the same design, thus facilitating applications testing and maintenance (Miller, J. & Mukerji, 2003).

MDA is based upon a set of OMG's modelling standards: UML - *Unified Modeling Language*, a language that applies the object-oriented paradigm and contains the features needed for modelling in a general-purpose perspective; MOF - *Meta-Object Facility*, a common meta-model for all of OMG's modelling specifications, allowing derived specifications to work together; XMI - *XML Metadata Interchange*, a standard that defines an XML interchange format for UML metamodels and models; and CWM - *Common Warehouse Meta-model*, a comprehensive meta-model that enables the designing, of building and managing data warehouse applications (these standards will be approached again in Section 5.4.3).

The MDA relation to ODP is worth noting here from two aspects. First, MDA applies common general principles, such as the separation of concerns and viewpoints. Secondly, it can be considered an instantiation of the ODP Reference Model (Bond, Duddy & Raymond, 1998), in that it is a concrete set of defined components for which there are corresponding specifications.

Viewpoints specifically considered in MDA are: a computation independent viewpoint, meaning that the details of the structure and processing of the system are hidden; a platform independent viewpoint, i.e., aiming to reuse the same specifications from one platform to another; and a platform specific viewpoint which combines the platform independent viewpoint with an additional focus on the detail needed for a specific platform (Miller, J. & Mukerji, 2003).

#### 4.4 Conclusions

This Chapter has provided a broad overview of the evolution of interoperability in IMS, showing the range of technical problems, information management factors and different stakeholders that combine for its attainment. Two general findings can be drawn from this Chapter that convey part of the answer to the second research question of this thesis, especially its first part, namely, is the technical background of computing/IT a persistent barrier to knowledge sharing with LIS?

First, the evolution of interoperability in information systems clearly exhibits changes in the nature of the problem, and consequently in the nature of the underlying IT systems and expertises. The latter become more varied and even less limited to the traditional expertise of IT professions (e.g., programming), involving even more a diversity of other areas from management in general and information management in particular. This trend gives indication of the IT environment becoming more open to receive, and prone to elicit non-IT participations, thus offering a context in which the lack of a common technical background in Computing/IT tends to be less central to, or at least not the sole aspect affecting knowledge exchanges.

Second, the advances in interoperability solutions have increased the complexity of IT systems in terms of the number of viewpoints and components, at the same time increasing the number of underlying standards, technical specializations and languages. While this may be seen as a complicating factor for knowledge exchanges, it has also created higher levels of abstraction for the development and specification of IT systems. These levels of abstraction not only provide common layers of communication shareable by different IT specializations but can also offer a new plane for communication with non-technologists. This is made possible by the emergence of a general abstract vocabulary for the main properties and components of IT-based information systems that does not presume detailed knowledge of the underlying IT technical levels. This gives it the potential to contribute to lowering the barriers to knowledge exchange.

Both these findings indicate that the lack of a common technical background in Computing/IT is not a persistent barrier to knowledge sharing with LIS.



The remainder of this Section provides a synthesis and discussion of the aspects contributing to the major findings referred to above.

The evolution presented in this Chapter shows that the areas of interest to interoperability have widened from syntactic and structural to semantic aspects of data and information, and from distribution to openness in terms of supporting IT systems. Fig. III-13 summarizes the focal aspects and main directions of the evolution of information systems interoperability.

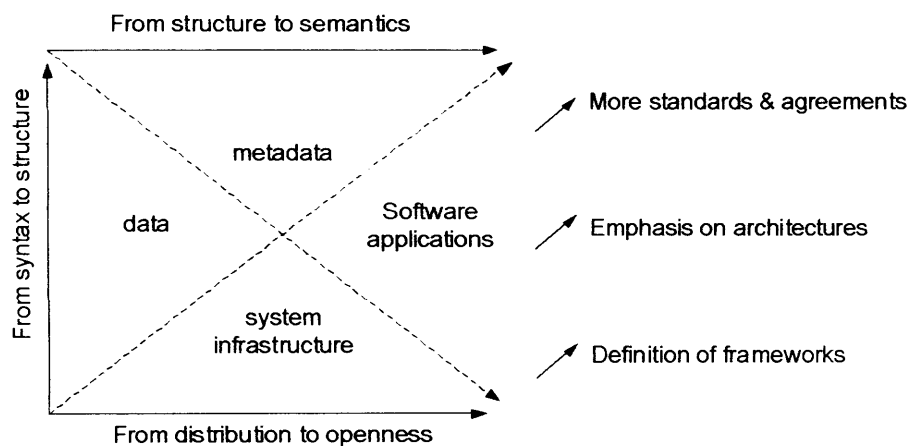


Fig. III-13 *Directions of evolution and the widening space of information systems interoperability*

From a quite confined technological area, initially related principally to infrastructure operations (platforms and communications), interoperability evolved to require even more growing attention from areas of expertise which are shaped by social, organizational and managerial factors, such as information management. One can think of the endeavour of this wider collaboration of expertises as a social system that exhibits some of the fundamental characteristics of systems interoperability.

One characteristic is the trend towards the increase in specialization and number of components of a system and the principle of separation of concerns, leading to a growing diversity and detail of specifications and standards. Another is the dependency of higher levels upon the proper working of the whole set of underlying levels, and the existence of attributes and characteristics of a system that are not localised to one level or a subset of systems levels, but only emerge at the level of the whole, eliciting the definition of frameworks and highlighting architectural concepts.

The transposition of these characteristics of computer-based information systems to the organizational and social levels where interactions with IT take place has relevant impact on the diffuseness of attention and interactions and on the kind of knowledge required. The diffuseness is related to the amalgamation of areas that become connected to problems present in information systems, bringing interactions among many views of the world, cultures and vocabularies.

Ouksel (1999) provided an open systems framework for social interaction (Table III-2) that is illustrative of the various levels from which the diffuseness brought about by the evolution of interoperability expands.

Table III-2 *Open systems framework for social interaction* (from Ouksel, 1999)

SOCIAL WORLD	beliefs, expectations, commitments, contracts, culture...
PRAGMATICS	intentions, communication, conversations, negotiations....
SEMANTICS	meanings, propositions, validity, truth, signification, denotations...
SYNTACTICS	formal structure, language, logic, data, records, deduction, software, file....

The impact on knowledge required is augmented and different areas become interwoven. On the side of the IT professions, for example in software engineering, there is a growing need to encompass some theoretical knowledge and practical techniques drawn from philosophy, cognitive and social sciences, e.g., cognitive psychology, anthropology, sociology and linguistics (Nuseibeh & Easterbrook, 2000). The separation of concerns and increasing specialization requires deeper knowledge of IT for interactions at intermediate levels. There is a growing need for comprehensiveness, i.e., for understanding the characteristics of IT artefacts, phenomena and tools in a more holistic manner. This applies also to information professionals from fields other than IT.

The holistic perspective is important not only in socio-technical interpretations but also with regard to knowledge about actual technologies. In this respect, a background in the aspects of IT evolution and trends that are connected to interoperability can inform and illuminate cross-domain IT conceptualizations. This

justified the last section of the present Chapter (Section 4.3), which provided an overview of concepts pertaining to distributed systems.

Beyond the management of heterogeneities, reflected for example in the tension between distribution and autonomy, other properties of distributed systems such as transparency and openness cut across many levels of information systems and may be transposed to the organizational realm. They are concepts that elicit ontological and methodological reflections on the way people, their knowledge and activities, and organizations, their goals and structures, relate to information systems conceptions, design and management.

A significant expression of the trend towards an increasing interrelationship with other areas that are not part of the IT traditional background is the growing importance of the notion of systems architecture, demonstrated in this Chapter and already approached in Section 3.7.1 as a new conceptual perspective for IT knowledge integration in LIS. The generalization of the architecture metaphor can be seen as a social response to the growing complexity underpinning IT-based information systems and to the need to articulate activities from diversified domains. This response is well exemplified, for example, by the ‘viewpoints’ perspective of information systems and in the emergence of reference models.

Overall, the study of interoperability conveyed in this Chapter points to a growing area of concern, where agreements needed to make interoperability operational extend beyond each individual system or group of given systems to encompass the organizational and ‘people’ systems that co-exist with them. It is also patent that the need for levels of abstraction and formality are higher than previously and concepts such as architecture and design, which are less bound to algorithms and mathematical knowledge are emphasised, therefore being articulated in technical languages that become more amenable to understanding and reuse by non-technologists.

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## Notes to Chapter 4:

<sup>1</sup> In this study, the domains analysed were digital libraries, mission operation and logistics and science data management.

<sup>2</sup> According to Finkelstein, A. (1998), what differentiates a service from the conventional concept of a function is “its granularity - it tends to be a relatively complex composite; its longevity –it tends to be relatively short lived, services are frequently changed and reconfigured; its independence – a service has an independent definition which may not be in the control of any of the agents contributing to it”.

<sup>3</sup> For example, in 1997 the UK Government established a strategic framework for e-government and the modernization of public services in which interoperability is one of the building blocks (Great Britain. Cabinet Office, 2000: 20) implying a standards specific framework (Great Britain. Cabinet Office, 2000a). This covers policies and standards for data integration, assigning an important role to XML, for systems interconnection and even a specific Portal Schemas Project “to manage the generation and timely delivery of agreed XML data schemas required for government services delivered through the Portal” (Ibid.: 17).

Another example is the activity of the US CIO Council (<http://www.cio.gov/index.cfm>), a forum created in 1996 to improve practices related to information systems of the Federal Government agencies. In 1997 the CIO Council issued a comprehensive *Interoperability Reference Guide* (CIO Council & IAC, 1997) established jointly with the IAC - Industry Advisory Council (<http://www.iaconline.org/>). A more recent IAC strategy for interoperability is provided by Dodd, et al. (2003).

<sup>4</sup> The US Department of Defense (DoD) is a good example of a distributed institutional environment where the concept of interoperability has been considered crucial, leading to the establishment of policies for IS and for IS interoperability, expressed in the DoD *JTA – Joint Technical Architecture*, developed since 1996 (US DoD, 1996-2003). The *JTA* provides “a foundation for a seamless flow of information and interoperability among all tactical, strategic, and sustaining base systems that produce, use, or exchange information electronically. To mandate standards and guidelines for system development and acquisition [...]” (US DoD, 1996: 1-2). The *JTA* covers in detail a wide range of standards in information processing (Sec. 2), information transfer (Sec. 3), information modelling, metadata and information exchange standards (Sec. 4), HCI (Sec. 5) and information security (Sec. 6).

<sup>5</sup> The domain of learning, education and training, for example, has received particular attention at an international level, with implications in a multitude of other domains, notably through the activity of the IMS Global Learning Consortium, (<http://www.wimsproject.org/aboutims.html>). IMS major goals are to “define the technical specifications for interoperability of applications and services in distributed learning, namely metadata (<http://www.imsproject.org/metadata>), and to support the incorporation of the IMS specifications into products and services worldwide”. One result is the *Standard for Learning Object Metadata* (IEEE 1484.12.1: 2002) addressing the exponential problem of discovery, management and use of learning objects by “defining a structure for interoperable descriptions” (Ibid.: ii) of such objects.

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<sup>6</sup> See, for example, the range of issues covered in *Guidance on interoperating with the Distributed National Electronic Resource (DNER) for product suppliers* issued by the JISC, whose strategic objective was to “enable integrated, seamless and flexible access to a wide range of resources for users in the Further and Higher Education systems across the United Kingdom” (Miller, P. & Wise, 2001).

<sup>7</sup> See, e.g., the perspectives and recommendations about investing in interoperability in the context of the NII, by the *Computer Systems Policy Project* (CSPP, 1994) and the Computer Research Association (Vernon, Lazowska & Personick, eds., 1994: Recommendation C8 – *Interoperability*).

<sup>8</sup> See Siegel (2000) for a statement about the benefits of computer industry specifications for interoperable enterprise applications, as those developed by the OMG (see also Note 19).

<sup>9</sup> See the interoperability strategy defined by *Microsoft* for its products (Microsoft, 2001).

<sup>10</sup> At an international level a relevant example is the European Commission's *Open Information Interchange* (OII) service maintained from 1995-1999 and continued until 2003 by the Diffuse Project (<http://www.diffuse.org/>, accessed 21 December 2002), aimed at providing a comprehensive directory of standards and specifications designed to facilitate the exchange of information in electronic form, both existing and emerging, of interest for a wide variety of developers, product and service providers, and end-users. An example at the national level is the *UKOLN Interoperability Focus* (<http://www.ukoln.ac.uk/interop-focus/>), established in the beginning of 1999, under the auspices of the *JISC* and *Re:source* (*The Council for Museums, Archives and Libraries*), now MLA (Museum, Libraries and Archives Council).

<sup>11</sup> See, in this case, the interoperability arguments given in the *ZTexas* and *Bath* profiles of the Z39.50 standard for search and retrieval across different library catalogues; and particularly the *ZTexas Profile Recommendations for indexing MARC 21 records to support ZTexas and Bath Profile bibliographic searches* (TZIG & Moen, 2000: App. A).

<sup>12</sup> In this context, a repository is more than a data dictionary, being therefore a more powerful tool for design and management of data because, besides definitions of data objects, it includes also definition of business objects (entities of any kind involved in the business) and process objects (systems or activities that intervene in manipulating data) (Bobak, 1997: Chap. 14).

<sup>13</sup> That is, data defined and managed according to separate processing requirements. “Even though the same data may be required in more than one tunnel, it is usually not easy to go from one tunnel to another. In many case[s], data is typically converted to tunnel-resident information, reflective of a limited set of requirements” (Tannembaum, 2001: 16).

<sup>14</sup> There are other perspectives to distinguish different levels of the metadata concept. Benion (1990), for example, defined three views of data in a system: the conceptual, or global view, which corresponds mainly to ‘metadata formats’; the internal view, corresponding to information about how and where data is stored; and external views, i.e., views of data provided for each program or application. While all these views of data have to have metadata (be defined and documented) in a system, the conceptual view, being independent of the method and internal (physical) implementation, is therefore the most important for e.g., reusability, as it determines the data independence level of a system, i.e., the separation of data definition from the specification of programs used to process it (Ibid.: Chap. 3).

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<sup>15</sup> ISO/IEC 11179: 1995-2005 includes provisions for consistent description of metadata and the activities needed to manage data elements in a registry. It is divided into 6 parts. The first provides a framework of concepts and context for the remaining parts, and includes a glossary. The following parts are: Part 2 – *Classification for data elements*, Part 3 – *Basic attributes of data elements*; Part 4 – *Rules and guidelines for formulation of data definitions*; Part 5 – *naming and identification principles for data elements* and Part 6 – *Registration of data elements*.

ANSI/INCITS 285: 1998 is a US standard that specifies the structure of a data registry, stated in the form of a conceptual data model. It was first published in 1996.

In 1998 a *11179 Metadata Registry Consortium (formerly named Coalition)* was created (<http://hmrha.hirs.osd.mil/mrc/>, accessed 2001.10.24) to foster implementations of metadata registries based on ISO 11179 and to influence commercial vendors to support the standard in their tools.

A good example of a domain data registry implementing ISO 11179 is the *EDR – Environmental Data Registry* ([http://oaspub.epa.gov/edr/just\\_brow\\$.startup](http://oaspub.epa.gov/edr/just_brow$.startup)), maintained by the US EPA - *Environmental Protection Agency*, in the context of a quite comprehensive data standards program ([http://oaspub.epa.gov/edr/EPASTD\\$.startup](http://oaspub.epa.gov/edr/EPASTD$.startup)).

<sup>16</sup> BSR is an official ISO data register for use by designers, implementers and users of information systems. It focuses on the naming of data elements widely used in the industry, in order to facilitate transactions among systems, namely for electronic commerce. It helps the sharing of internationally registered multilingual data concepts and their semantic units. BSR is a public facility available online, managed by a consortium (see <http://www.ubsr.org/>). ISO/TC154 (Processes, data elements and documents in commerce, industry and administration) WG1 is the entity responsible for defining rules and guidelines for BSR. See the history of BSR project developments at <http://www.icaris.net/icaris/bsr.html>.

<sup>17</sup> Busse, et al. (1999) provided a good overview of terminology, concepts and issues related to federated information systems, a concept which evolved from that of database federation. For the authors, a federated system is “a set of distinct and autonomous information system components, the participants of the federation” that, besides being heterogeneous and distributed, “in first place operate independently, but have possibly given up some autonomy in order to participate in the federation”. The concept of federation focuses on architectures that are aimed at providing integrated access to the content of multiple databases, through the creation of a third instance where heterogeneities in access are overcome, usually by one of the following methods: by the creation of a federated schema (a third schema is built that integrates schemas totally or partially); or by offering a uniform query language (MDBQL – multidatabase query language) which hides heterogeneities at the language level only. The levels of integration vary and they are said to be forms of more or less ‘tight’ or ‘loose’ integration.

<sup>18</sup> Many of these research directions result from projects developed at the Massachusetts Institute of Technology (MIT) and the Department of Computer Science of the Stanford University. Gio Wiederhold page on Mediation (<http://www-db.stanford.edu/LIC/mediator.html>) includes resources on commercial products implementing middleware technologies based on intelligent mediators.

<sup>19</sup> CORBA – *Common Object Request Broker Architecture* is a set of middleware standards developed and maintained by the OMG – Object management Group (<http://www.omg.org/>) that provides a development environment for distributed object-oriented applications. CORBA is based on the *OMA – Object Management Architecture*, whose main component is

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the ORB (object request broker). The ORB is the programming piece that enables a client to request services from a server without having to know where it is or the characteristics of its interface.

<sup>20</sup> The distinction between ‘logical’ and ‘physical’ levels has been used by several authors to separate broad areas of concern, although not always in the same perspective. For example, from a database system point of view, Goh, Madnick and Siegel (1994) use the terms ‘physical’ and ‘logical’ connectivity in approaching the problem of sharing data among ‘distributed databases’; from a broader computational viewpoint, Wegner (1995) distinguishes the levels of ‘physical’ and ‘logical’ distribution of software components in distributed systems, when dealing with the concept of ‘distributed interaction’; Manola (1995) uses the term ‘physical level’ to refer to data-representations as distinct from the object-model level, which is of a logical nature.

<sup>21</sup> The transparencies referred in the ODP-RM are ‘access’, ‘location’, ‘relocation’, ‘migration’, ‘persistence’, ‘failure’, ‘replication’ and ‘transaction’. They concern the use of a complex distributed system either by humans or programs pertaining to the same or to other systems.

<sup>22</sup> Stephanidis (2003) refers to the ‘disappearing computer environment’, a new paradigm characterised by invisible computer devices embedded in general-purpose appliances and personal gadgets. This future environment not only subsumes totally new forms of interaction with IT but also enhanced forms of systems transparency. An EC supported initiative – *Disappearing Computer* (<http://www.disappearing-computer.net/>) is addressing the topic, in the framework of the FEP – *Future and Emerging Technologies Programme* (<http://www.cordis.lu/ist/fet/home.html>).

<sup>23</sup> An example of the political issues a reference model can raise is included in Day, J. (1995) on the topic of the OSI Reference Model, providing the different points of view of governments and industries.

<sup>24</sup> According to Stallings (1998), the model originated much earlier from the work of Mark Canepa and Charlie Bachman, at Honeywell Information Systems. They produced in 1977 the *Distributed Systems Architecture* (DSA) model, and this was the only proposal presented in 1978 at the ISO group charged to develop such a model. For Stallings, the resulting OSI model is essentially the same as the DSA.

<sup>25</sup> In the OSI model, the ‘lower levels’ (physical, data link, network protocol and transport protocol layers) provide for the more primitive networking functions like routing and addressing, while at the ‘upper level’ (comprising session, presentation and application layers) the software performs application-specific functions, such as formatting, connection management, encryption, etc.

<sup>26</sup> ISO/IEC 10746: 1996-1998. Part 1 - *Overview* - explains the motivations, goals and key concepts of the architecture. Part 2 – *Foundations* - defines the concepts required to specify ODP systems. Part 3 – *Architecture* - contains the framework of concepts, structures, rules and functions. Part 4 - *Architectural semantics* - specifies how the ODP concepts can be formally represented using a number of standardized formal specification languages.

## **CHAPTER FIVE**

### **PARADIGM SHIFTS IN COMPUTING**

#### **5.1 Introduction**

The present Chapter continues the investigation started in Chapter 4 in order to address the second research question of the thesis, particularly the second part of its formulation, namely, is the evolution of computing/IT providing a set of integrative concepts that can serve a durable and extensible common conceptual basis?

The concepts and trends summarized in the previous chapter are rooted in some major paradigm shifts that have occurred in computing since the 70s. These developments provide an important knowledge framework for a deeper understanding of how distributed and interoperable systems came into being, and a basis for exploring further the potential of IT constructs as sources of conceptual alignment between LIS and IT.

This Chapter offers an informal and qualitative account of two major shifts that have emerged in computing/IT. One is a shift in the nature of IT concerns, from computation to interaction and communication (Wegner, 1995; Winograd, 1997). The other is the development of frameworks for system architectures and design methodologies to support the evolution from distributed to open distributed systems (Crowcroft, 1995; Bernus, Mertins & Schmidt, eds., 1998).

The objective of this Chapter is twofold: to discover whether these shifts can give further support to the general conclusions reached in Chapter 4; and to investigate whether IT constructs, in areas such as software engineering and middleware, have been providing a set of concepts that have potential as building blocks for enhancing IT knowledge in LIS. The selection of concepts and their assessment for such an objective follow the criteria of:

- being foundational, i.e., having significant and long lasting influence on the development of a variety of mainstream technologies;
- being abstract and independent, i.e., capable of application to reasoning about information systems and their components independently of the technologies used;
- being analytical, i.e., capable of providing methods for identifying elemental parts or basic principles of information systems;



- being reusable, i.e., capable of application to different parts and components of information systems and their contexts, e.g., from data structures to organizational processes or application services.

## 5.2 From computation to interaction and communication

This Section presents several turning points in IT that have laid major foundations or development paths for distributed interoperable systems. These are the evolution towards interactive models of computing, the growing importance of object-oriented approaches and the enhanced role of interfaces and communication.

### 5.2.1 Evolution towards interactive models

The evolution towards interactive models of computation is reflected in the gradual change of programming languages and models that led to the development of the so called ‘interaction machines’, defined by Wegner (1995: 5) as Turing machines <sup>1</sup> “extended to be interactive by adding input actions, supporting external inputs during computation”. He described the evolution of programming paradigms underlining two distinct phases. The first covers from machine language programming in the 50s to procedure-oriented programming in the 60s. The second, since the 80s, was marked by the introduction of object-based programming (Fig. III-14).

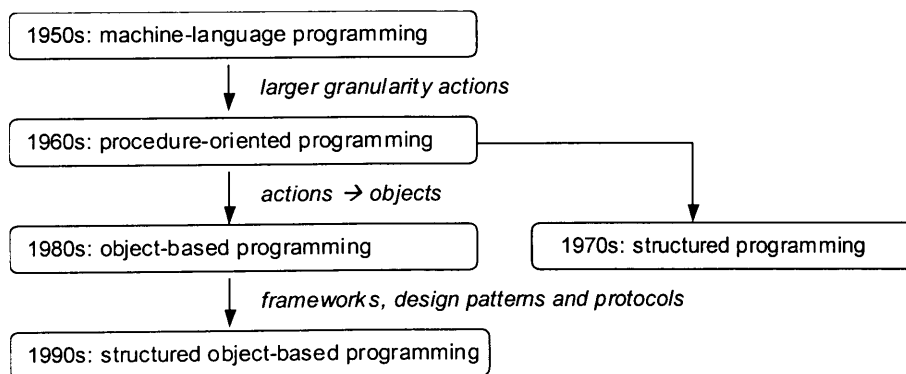


Fig. III-14 *The evolution of programming models* (from Wegner, 1995: 4)

According to Wegner,

“The transition from machine to procedure-oriented programming involves a quantitative change in the granularity of actions while retaining

an algorithmic (action-based) programming model. The transition from procedure-oriented to object-based programming is a more radical qualitative change from programs as algorithms that transform data to programs as systems of persistent, interacting objects” (Ibid.: 4).

The concept of interaction is the key to understanding the advantage of object-oriented over procedural (algorithmic) programming.<sup>2</sup> In this, “functions compute their output from an initially specified input without any external interaction, while objects permit interaction during a computation” (Ibid.:5). The interactive model of computation extends the power of Turing machines, transforming closed systems, governed by algorithms based on mathematical models and complete formal specifications, into ‘open systems’ (Fig. III-15).

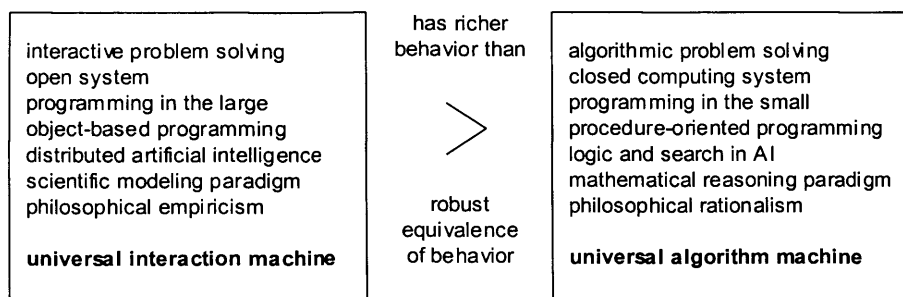


Fig. III-15 *Parallel robustness of interaction and Turing machines* (from Wegner, 1995: 24)

Because “algorithms compute by a finite sequence of inner actions”, they are closed and have less computing power than ‘objects’, which are open to interaction. “Objects compute by a pattern (interaction history) of externally initiated interactions not under the control of the object”, therefore “their observable behaviour more accurately models software applications, distributed systems and actual computers” (Ibid.: 3-4). Interaction machines are, thus, based on empirical models and bear the incompleteness that can accommodate the behaviour of ‘objects’, which is richer than the behaviour of algorithms. ‘Incompleteness’ and ‘empirical approaches’ are two important turning points in computation.

This is a conceptual shift from rationalism to empiricism that is important for a more realistic and productive conception of the computing field. As explained by Wegner & Goldin (2003) and Wegner & Eberbach (2004), the theoretical background based on the Turing Machine concept has been central to computer science educational programmes since the 60s, providing a view that is essentially

‘algorithmic’, hence deterministic. For these authors, it alone, as a complete model, shows important limitations for problem solving, notably for many of actual ‘non-computable’ problems that current IT-based systems address. As put by Wegner (1997),

“The paradigm shift from algorithms to interaction captures the technology shift from mainframes to workstations and networks, from number-crunching to embedded systems and graphical user interfaces, and from procedure-oriented to object-based and distributed programming. The radical notion that interactive systems are more powerful problem-solving engines than algorithms is the basis for a new paradigm for computing technology built around the unifying concept of interaction”.

Understanding this paradigm shift is important for a comprehension of the nature of IT systems and of the current problems they are designed for. In the same way as the algorithmic view of computing is still prevalent in the computing field, so are the conceptions of IT by non-technologists, this being an inhibiting factor for cross-fertilization between the IT and other fields, either in theoretical or practice terms. Therefore, acknowledging the paradigm shift is relevant for both the computing/IT field and for any other field for which IT is an important component or enabler.

### **5.2.2 The significance of object-oriented approaches**

The evolution of programming models according to the interaction paradigm led to the development of object-oriented (OO) approaches

“in a succession of ever-increasing facilities for expressing complex functionalities. [...] The 1960s were the decade of the subroutine. The 1970s saw a concern with the structuring of programs to achieve qualities beyond correct function. Data-flow analysis, entity-relationship diagrams, information hiding, and other principles or techniques formed the bases of myriad design methodologies, each of which led to the creation of subroutines or collections of subroutines whose functionality could be rationalized in terms of developmental qualities. These components were usually called modules. [...]. Abstractions embedded in these components became more sophisticated and substantial and for the first time reusable components were packaged in a way that their inner workings could theoretically be ignored. The 70s were the decade of the module. In the 80s, module-based programming languages, information hiding, and associated methodologies crystallized into the concept of objects” (Bass, Clements & Kazman, 1998: 417-418).

While first object-oriented ideas can be traced back to the 70s, it was the need to address both the issues of open modelling – the modelling of systems that can share or reuse code, or interwork with minimum effort - and the demands for easing the use of computers by non experts that led to developments decisive for OO technology, in the late 80s, and to the consolidation of OO methodologies in the 90s (Graham, 1991: 2-7; Henderson-Sellers, 1998; Emmerich, 2000: 30-33).<sup>3</sup>

The major innovation brought about by OO methodologies is that programming is developed around ‘objects’ (representations of real-world entities) and not ‘actions’ (processes). Among other aspects, this emphasises the importance of data, i.e., the logic of a given process is not defined independently of the data to which it will apply. OO methodologies start by identifying the kind of objects to be processed (the world objects), generalise ‘classes’ of ‘objects’ (define data) and then define logical sequences (called ‘methods’) to manipulate (i.e., to perform ‘operations’ on) them. Operations are performed on objects through messages they receive from other elements of the same or different systems.

The main components of the OO paradigm are thus ‘classes’, ‘objects’ and ‘messages’. What follows is a very informal description of these and related concepts (for more complete overviews see, for example, Ambler, 2001: Chap. 2).

### **5.2.2.1 Major OO concepts**

Objects and classes are related entities. They convey hierarchies of representations of real world entities for which data attributes and behaviour are defined. A ‘class’ is

“an abstraction specifying common static and behavioural characteristics of a set of objects [...] a template from which object instances are created” (Graham, 1991: 368).

Classes can be subdivided as necessary so that each class contains only the data and methods needed. Therefore the concept of ‘class hierarchy’ is fundamental to object-orientation. As noted by Britton (2001: 45-46) the clear reasoning behind the construction of class hierarchies is as difficult as it is critical, being often the point of failure in OO, either in applications or in systems design. This happens because the “classification thinking” involved can follow rules that are more or less strict and in more or less consistent ways.<sup>4</sup>

‘Objects’ are class instances, in which all essential characteristics – both abstract data attributes and the defined procedures to perform on these attributes - are encapsulated. ‘Encapsulation’

“or equivalently ‘information hiding’ refers to the practice of including within an object everything it needs, and furthermore doing this in such a way that no other object need ever be aware of [its] internal structure” (Graham, 1991: 13).

Therefore an object has two major aspects: its ‘interface’, which is its external aspect, and ‘implementation’, which is the internal one (Fig. III-16).

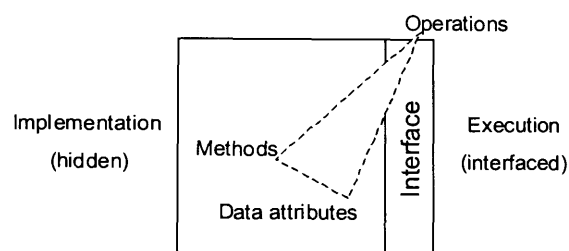


Fig. III-16 *Main characteristics of the concept of ‘object’*

While the implementation is hidden, the ‘interface’ is the object’s visible part, exposing the ‘methods’ for the operations possible with the object. An object can change its ‘state’, i.e., its collection of data attributes and references to other objects, only through the operations/methods defined in its implementation.

‘Methods’ are the implementations of the objects’ possible operations. They are like ‘functions’ and provide the ways to interact with a class or object, determining their accessibility and behaviour. In order to carry out an operation an object has to receive a message calling up the respective method.

‘Message-passing’ is the philosophy behind objects interaction: an object receives a call that requests an operation for which it provides the method. According to the operation carried out, the ‘object state’ may change and the object may have to provide a response message. The set of messages to which an object can respond is also called its ‘protocol’ (Graham, 1991: 14). Other important features of OO that are relevant to note from the conceptual point of view are inheritance, persistence and polymorphism.

‘Inheritance’ is the ability to reuse common data and methods throughout different classes: objects share attributes and procedures from one or more parent classes. For example, “it is possible to define a new class by adding to an existing

class, rather than starting from scratch” (Britton, 2001: 43). This allows for extensibility, because an object can be incrementally specialized, without having to recode the attributes and procedures that are common to the class. This benefits both programming activities – as a code reuse mechanism – and data management, as a mechanism for avoiding redundancies and therefore to make data consistency easier.

‘Persistence’ is the ability of the object to store itself and preserve its state. This means “the property of objects to persist in terms of identity, state and description through time regardless of the computer session which creates or uses them” (Graham, 1991: 371).

Polymorphism “means, literally, many-formedness” (Ibid.). It is the possibility to perform differently the same methods of an object if the call includes specific parameters for that method or function. This means also that one can “add a new method in a subclass for an operation that has already been declared in the superclass” (Britton, 2001: 44). Again, this is another form of reusability and provides for flexibility.

Parsons & Wand (1997) summarized the characteristics of the object model from the perspectives of implementation and representation and its implications for systems analysis (Table III-3, next page). For them, representation in OO is paramount and ontological and cognitive theories of representation are an important background.

“The object-oriented approach emerged as an implementation paradigm, motivated by the objective of building better software more efficiently. However, the use of objects in systems analysis should be driven by the objective of effectively representing a domain” (Ibid.).

#### **5.2.2.2 Application**

Graham (1991) summarized the benefits of OO for applications design, data modelling and programming with the following formula: “reusability + extensibility + semantic richness” (Ibid.: 50). He also synthesized the advantages to manage complexity.

“The problems modelled by computer systems [...] are all inherently complex processes. An abstraction of key elements of the problem domain and a decomposition into objects and inheritance (or classification), assembly (or composition) and use (or client/server) structures based on real world objects and concepts helps with the

Table III-3 *Implementation and representation perspectives of object characteristics and implications for analysis* (from Parsons & Wand, 1997)

Characteristic	Implementation perspective	Representation perspective	Observations and Implications
<b>OBJECTS AS DISTINCT UNITS</b>			
Identity	Objects exist as identifiable entities independent of properties	Existence is separate from properties: no two things possess exactly same properties	Objects can be identified independent of properties: identification of keys is not part of modeling a domain
Encapsulation	Separation of implementation and interface; Information hiding; behavior 'abstraction'	State and behavior of objects cannot be separated	State definition and behavior of objects should be analyzed and modeled together
Persistence	Existence of an object transcends time/space (an object can exist independent of its "creator")	a thing can acquire and lose properties without becoming a different thing	Properties of an object might not be fixed
Homogeneity	Provides a uniform implementation where everything is described in terms of communicating objects	No homogeneity, three main constructs: Objects, properties, classes	Classes are not objects, hence – no class variables and class methods; Methods, state variables, relationships, events are not objects
<b>CLASSIFICATION OF OBJECTS</b>			
Classification/ Instantiation	Classes provide mould for creating instances; Classes contain code	Categorization of objects on the basis of common properties; Objects are fundamental, classes are formed as needed	Classes can be identified properly only on the basis of object properties; No predetermined classes; set of classes does not have to be fixed
Specialization/ Inheritance	Code reusability and sharing	Object classes reflect taxonomical organization of knowledge	A subclass should include properties in addition to parent classes
<b>ASSOCIATION AND INTERACTION OF OBJECTS</b>			
Composition	Efficient retrieval of objects that are likely to be used together; supports database integrity	Objects may be composed of other objects and possess emergent properties	Emergent properties of aggregate objects have to be identified
Communication /Interaction	Supports object independence	Objects have joint properties and interact; no support beyond this	Message passing might not be appropriate to model a domain
Relationships	<i>Not implementation-related</i>	Relationships do not appear as an independent construct, they are <i>implied</i> by mutual (relational) properties	Identify properties that are joint to several objects
<b>OBJECT BEHAVIOR</b>			
Polymorphism	Supports specialization	Reflects precedence of properties	A preceded property may be a specialization of a preceding property
Dynamic Binding	Supports polymorphism	No <i>meaning</i>	Strictly a software issue
Concurrency	Several objects active at same time	No explicit support or contradiction	Not contradicted

management of complexity in several ways. Firstly, the system and the problem are in close correspondence, so that the cognitive wisdom of everyday life can be mapped onto the solution. Secondly, encapsulation divides the problem up into coherent chunks small and simple enough for us to understand them as a whole. Thirdly, object-orientation provides several ways to model structure and meaning [...]. Lastly, the reusability and extensibility of object-oriented systems mean that complex systems may be assembled from simple ones, and that complex systems can evolve incrementally in simple steps into even more complex ones. [...]. Interoperability, modularity, extensibility, simple interfaces and information hiding are intimately related in the contribution they make to the development of truly open systems” (Ibid: 44-45).

Despite its widely recognized advantages and potential, OO analysis and design have not yet become a common practice. Sim (2000) analyzed the reasons for this by comparing the OO and the dominant approach (structured analysis). Using a set of diffusion of innovation factors - relative advantage, compatibility, complexity, trialability and observability - he concluded that OO analysis ranks lower on most attributes necessary for a fast rate of adoption, due chiefly to the organizational and individual efforts needed in the initial shifts to the new methodology, which represent a considerable investment.

According to Sim (2000) the field of programming languages is one of the first and major contributors to OO application. Here, the goal “is to enable programmers to use constructs that model the real world as closely as possible” (Ibid.), supporting complexity. Beyond largely used programming languages, such as C++, current operating systems like Windows or Mac also make extensive use of object-orientation, not only on HCI design but also by supporting dynamic information exchange between applications based on object message passing protocols. In the area of artificial intelligence, Sim (Ibid.) noted conceptual developments similar to OO in the so-called ‘frames’ which are constructs for organizing and representing knowledge that also include both declarative and procedural data.

The area of databases, however, has been the most resistant one and relational databases are still dominant. Developments in this respect have been slow, and few commercial OO products are available so far. The major trend is, according to Britton (2001: 48), to provide relational database systems with object-oriented extensions (see, for example, Rokitskii, 2000). Although identifying several technical reasons for that resistance <sup>5</sup> Britton concludes that the most significant reasons have



nothing to do with the differences in the data model, but are rather inertia motivated by the volume of data existing in relational databases, and the lack of maturity of OO technologies (Britton, 2001: 48).

In fact, from the data viewpoint, the 'object model' and the 'ER (Entity-Relationship) model' <sup>6</sup> are of a different nature but they do not conflict: entities or even attributes in the relational data model can be understood as 'objects'. Besides, entities in the ER model have many characteristics similar to objects in OO, and the difficulties of conceptual data modelling are not so different from one methodology to the other, because decisions on how to capture and express semantics are of an ontological nature (see Wand, Storey & Weber, 1999). The relevant differences rely on the fact that data structures modelled according to ER are separated from behaviour or code (the 'methods' in OO objects) and are not constructed in ways that directly support 'inheritance' (Kilov & Ross, 1994: 47-51; Sim, 2000; Britton, 2001: 46-49).

More significant than technological implementations is the OO potential as a methodology for analysis and design in software development processes (Cockburn, 1993; Henderson-Sellers, 1998; Goldberg, 1999; Britton, 2001: Chap. 10; Sircar, Nerur & Mahapatra, 2001). A methodology or product can be said to be object-oriented if it follows the set of concepts in any aspect, even if it does not lead to an object-oriented technological implementation. Cockburn, for example, distinguished three possible levels of 'object-oriented-ness' in a system: object-based, class-based and object-oriented (Ibid. 428-429).

It is generally agreed that the OO set of concepts offers a method for identifying and managing representations of the world reality that is a far more accurate and natural method than the traditional structured approach.<sup>7</sup> For Sim (2000), while the structured analysis is top-down, by successive levels of process decomposition, the OO approach "organizes the problem statement around objects that exist in the user's view of the world" and starts by identifying "what is to be done, not how". In other words, this is essentially a functional approach, which is different from a process approach as explained by Britton (2001: 175). Besides, an OO methodology facilitates incremental and iterative development, i.e., including stages of rework and redesign of portions of the system (Cockburn, 1993; Henderson-Sellers, 1998).

Another aspect that contrasts with the traditional methods, is the much advocated use in OO of a single notation to define and express the whole process, both analysis and design, built around the same conceptual unit (the object).<sup>8</sup> A single notation, such as UML, reduces complexity, provides more flexibility and an iterative approach that is not easy in traditional methods which require, for example, translations between data flow diagrams into structured charts (Sim, 2000).

The most important and concluding remark about the ‘object model’ of thinking is its contribution for ‘distribution’ and ‘openness’. The principle that “concepts, ideas, processes, or data, or combinations of these, are grouped together into a capsule called an object” and that objects support in themselves the “interfaces to communicate with other objects” (Crowcroft, 1995: x-xii, 17-22) is especially important in this respect. As a concept, and a method of analysis, it is useful even when the subject is not specifically about object-oriented technologies.<sup>9</sup>

Henderson-Sellers (1998) suggested lifecycle seamlessness in software development processes, defending the need to address the transitions of the usually separated functions of ‘analysis’ and ‘design’, because the overall process has three dimensions: i) methodology, ii) people and organizational influences, directly related to management of human activities; and iii) technology (Fig. III-17).

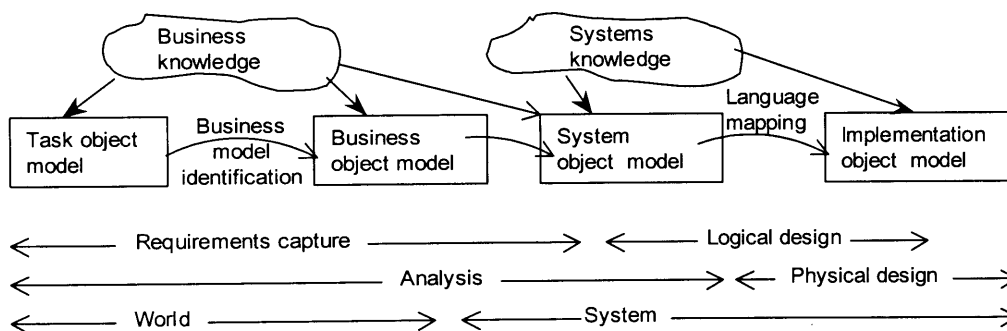


Fig. III-17 *Seamlessness and the various object models* (from Henderson-Sellers, 1998)

If the transitions are correctly managed, the OO concepts can offer a “seamless link from mission down to code” (Ibid.: 433). Because OO concepts can serve different levels of abstraction, for different purposes, in a congruent way, one may think that their usefulness can extend to the management of complexity in other aspects of organizations’ activities that may not have a direct expression in information systems.

### 5.2.3 Primacy of interfaces and communication

The evolution of programming languages and interaction has dramatically changed the way in which computers have been progressively integrated into the current life and activities of non-programmers. As noted by Allen (1999), one of the turning points in this evolution is about ‘interfaces’. “Program to an interface, not an implementation” (Gamma, et al., 1995: 18) became a principle in engineering reusable OO software. In a general sense, interfaces are devices that hide the complexities of a given interaction while ensuring all the information needed to support it.

More specifically, the term can refer to two different things. First, are interfaces for HCI which since the 80s have opened a multidisciplinary approach to advance usability of computers by people (Karat & Karat, 2003; Rogers, 2004). Second, is the interfacing between systems, or systems components which developed with networking and distributed computing. This is the aspect to be highlighted in this Section. Toenniessen (1998) sketched the relationship of these various levels of interfacing (Fig. III-18).

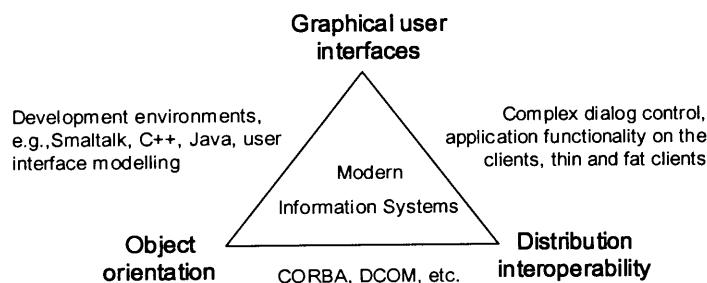


Fig. III-18 *A characteristic triangle of modern information systems*  
(from Toenniessen, 1998)

As noted earlier, the ‘object model’ itself involves the notion of interface as a central one. Interfaces represent at the same time both the mechanism of the object’s external availability and communication and the device that hides the private or externally unnecessary aspects of it.

Programming interfaces are thus the elements that allow a given program, running on one computer, to call a process in another computer (or in the same computer but in another program) i.e., to cause the code to be executed elsewhere. This is carried out by sending messages. Providing these messaging services is a

function of the so-called middleware, a general term that designates programs that mediate between two existing programs or databases.<sup>10</sup>

From the early days of middleware, since the 80s, there have been several kinds of technologies and standards to allow a program to execute procedures remotely, by enabling program-to-program or program-to-database communication. Basically they are messaging systems that provide location transparency, e.g., applications being connected do not have to know each other's network addresses; integrity of the messages transmitted and language transparency, i.e., programs can communicate despite differences in their programming languages (Britton, 2001: 23-24). Typical client-server middleware solutions are RPC (remote procedure call),<sup>11</sup> RDBA (remote database access)<sup>12</sup> or DTP (distributed transaction processing).<sup>13</sup> All these are technologies that have been used to build interfaces for distributed applications in the client/server environment.<sup>14</sup>

As noted by Britton (2001), programmatic interfaces can be of two kinds: i) based on APIs (application programming interface), consisting of "a fixed set of procedure calls for using the middleware"; and ii) based on IDLs (interface definition languages) i.e., using an independent language to translate calls between systems in different languages. In each case there can be many styles, and in some cases there can be a mixture of the two approaches (Ibid.: 83-84). IDLs are languages which provide for interpreting and converting the messages into forms suited to the recipient. With IDLs the semantics of the operations provided by the component being called (its purpose, functionality, usage and restrictions) can be understood by a community of implementers and users.

Since the 90s, technologies such as DCOM<sup>15</sup> and CORBA<sup>16</sup> (Emmerich, 2000: Sec. 4.1, 4.2) introduced the object model into middleware standards. They are, therefore, also called object middleware. There are aspects similar to earlier middleware. For example, as in RPC, object middleware uses IDLs to translate parameters. But there are also major differences. Instead of 'client/server' the relationship is 'client/object' and objects are referenced in an interface repository, i.e., interfaces are found at a point that is independent from the network space where the object resides. When a client needs to call an operation on an object it has first to get its reference.

The advantages are that there is more independence of the object from the calling client. This extends the flexibility already existing in OO programming languages to a distributed space. In this sense, OO middleware is more than just discrete technologies to connect different systems and applications in a static, pre-defined way. Rather it introduces the possibility of building distributed applications in a dynamic manner such that, for example, clients and objects may be relocated transparently because the interfaces are brought to an independent network space (Kramer, 1998; Thompson, D., et al., 1998; Britton, 2001: 49-59).

For these reasons, OO middleware can be considered as standard development environments for distributed applications. Generally speaking, these ‘environments’, sometimes also called ‘platforms’, are based on common agreements about reference architectures and standard interfaces (this aspect will be further addressed in Section 5.3.1 - *Trends in composition and reusability*). All systems that agree to make use of these architectures and standards create themselves a space that enables transparency and reusability, thus favouring interoperability while maintaining autonomy.

‘Communication’ is a concept inherent in interfaces and it is central to the process of gluing programs together, but not simply because this is done by messaging. The interface consists of a collection of operations that are used to specify a service. If such a specification is written in a way that is system/program independent, the service can be more easily used by a variety of other systems and programs. Standard protocol specifications and service definitions have this role.

When compared with the earlier models of typical client-server middleware, the object-oriented standards such as DCOM and CORBA correspond better to the needs of open distributed systems, as they implement a philosophy of independent components (objects) with interfaces that are declared to a network environment (they use interface repositories). This means that communication and interfacing mechanisms tend to be built for an environment of multiple systems, and not just as pieces for solving bilateral (system-to-system) implementations.

Middleware was mentioned here as a significant and structural example of what is meant by the primacy of interfaces and communication. Interfaces become central as they convey all that is needed – technically and conceptually – effectively to bridge flows of information activity that are no longer shaped just by individual systems needs, in a discrete way, but are rather modelled by and for an open environment. Communication becomes a primary factor in computing, because it

highlights the growing importance of placing parts of a system's code in a shared network space, or of making a piece of code perform automatically given functions in a network environment. These aspects are evident, for example, in the notions of 'code mobility' and 'agent technology'.

'Code mobility' was defined by Fuggetta, Picco & Vigna (1998) as "the capability to dynamically change the bindings between code fragments and the location where they are executed". While code mobility is not considered a new concept, as it is already found in many solutions for distributed computing, its importance has been growing with the global network environment where it can be explored on a large scale, with practical applications that improve systems scalability, flexibility and extensibility. A very popular application of mobile code is Java integrated with the WWW technology (see Section 5.3.1).

The concept of 'agent technology' is closely related to that of code mobility. It is quite recent and has no single or stabilized definition (Franklin & Graesser, 1996; Sundsted, 1998). Agents are usually small pieces of software that "do not constitute a complete application" but "instead, they form one by working in conjunction with an agent host and other agents" (Sundsted, 1998). A client can send an agent handling a transaction or query into the network on its behalf, and the necessary operations are handled by the agent on its own, in a manner that is independent of the client being or not being connected. Agent applications are especially suitable to address problems that require "both distribution and intelligence", i.e., clearly independent processes that also "involve explicit reasoning about behaviour" (Aylett, et al., 1998).

Beyond the productivity and flexibility advantages, agent technology also allows network bandwidth problems to be overcome, because they reduce the load created by traditional client-server architectures (Ibid.). The significance of agents in distributed computing has increased in the Internet environment <sup>17</sup> where their characteristics - being autonomous, mobile, adaptive/learning, goal-oriented and flexible - show an increasing potential in enhancing the flexibility of OO approaches, in improving productivity and in facilitating the management of complexity of distributed systems (Jennings, 2001).

#### 5.2.4 Concluding remarks

The analysis provided so far highlighted some of the conceptual changes and trends that can be found in general reflections about the future of computing by authors from the field. In Winograd (1997), for example, the primacy of communication and interfaces is clearly articulated in the three major trajectories that he identified as continuing directions of change in the future of computing:

- “from computation to communication”, meaning a shift in importance from what the computer does towards what it allows by communication;
- “from machinery to habitat”, highlighting the growing distance from strict computing as self-sufficient and self-contained;
- “from aliens to agents”, a trajectory that focuses on the evolution “from intelligence to knowledge”, meaning the trend in support of technology with effective capabilities to support knowledge sharing, either across systems, communities of systems, organizations and people.

These trends were also underlined by Dertouzos (1997: 10), in his understanding of the information market as

“the collection of people, computers, communications, software, and services that will be engaged in the intra-organizational and interpersonal informational transactions of the future”.

For him, the growing importance of information as an activity, i.e., beyond its passive forms (as text, images, videos, i.e., representations with a carrier) embraces all human and computer activities that take and transform information. Clearly, the network environment is blurring the separation and frontiers between the different types of agents (either human or computer processing tools) performing information activities. This is evident in the trend towards new tools – for example those that can perform automated tasks that usually would require (at least much more) human-machine interaction.<sup>18</sup>

New concepts, requirements and constraints emerge, almost all with interoperability in focus. Computing activities evolve from discrete systems to new complex ‘spaces’ in the network environment. This has focused attention on the design of systems and systems components, extending the implications of coherence and functionality beyond their traditional boundaries, i.e., to the environment.

### 5.3 Shifts in software engineering

In the same line of evolution pointed out by Wegner (1995), although in a much less technical view, Winograd (1997) also identified ‘design’ as a major trend for the next decades of computing: the ascendancy – and independence – of interactive, independent design. For him, this focus on design will be mostly connected to pragmatic human and systems needs in a distributed environment of information resources, information processing and information agents. Hence, the notions of ‘habitat’ or ‘environment’, as infra-structural context influencing systems and of ‘information marketplace’ as a set of diversified forces fundamental to shape new solutions for systems in a distributed environment. This focus on design is discussed in the present Section, concerning the trends in software engineering.

#### 5.3.1 Trends in composition and reusability

‘Composition’, meaning the building of software systems based on independent components, is one of the most important trends in systems development. As a research and methodological trend, it represents an approach that shifts from “thinking of the software task as merely programming” (Shaw, Garland & Wing, 1997) to a richer notion where, for example, connectors – elements such as protocols – are raised as first-class entities in a system, instead of being add-ons.

Thus, software composition or compositional software mean more than just composite developments. It means that software development of any component or connector should address system-level properties. From the perspective of interoperability, the consideration of the system or architectural level, is of utmost importance (Putman, 1998). Therefore, software composition implies more than just assemblage, and requires new methodologies, models and principles for making design decisions at the system level and not on an *ad hoc* or partial basis (Wileden & Kaplan, 1998).

Composition has already existed in practice since the end of the 80s as the concept of ‘component’ is inherent to distributed computing. In this sense, composition can be seen behind the concepts of ‘multi-tier architectures’ (where each tier corresponds to a logically distinct and independent component, separating levels for interface, processing components and data) and ‘middleware’ – a layer of usually



independent and flexible software that provides services in layers between the operating system level and applications, overcoming heterogeneities through standard interfaces and protocols.

The trends in systems composition have been strongly influenced by the object model. Although a software component is not necessarily an 'object', as noted by Kiziltan, Jonsson & Hnich (2000), componentization is closely related to object-oriented methodologies, as components hide and protect their data and behaviour with abstract descriptions in a common language at the interface level (Schmidt, H-W., 1998). The standardization of computing environments <sup>19</sup> for middleware development can be seen as a significant example of the trend towards composition as it contributes to the enhancement of the portability of new applications to a variety of end-user client systems, as well as disclosing access to legacy applications (Emmerich, 2002).

Standard development environments for distributed computing, such as the Distributed Computing Environment (DCE)<sup>20</sup> and CORBA are essential to facilitate the building of middleware (Bernstein, 1996; Bond, Duddy & Raymond, 1998; Kramer, 1998; Thompson, D., et al., 1998; Emmerich, 2000a, 2001, 2002). Beyond DCE and CORBA, which represent important industry agreements, other market products, such as Microsoft DCOM, Java <sup>21</sup> or, more recently, development platforms for 'Web services',<sup>22</sup> have appeared to support the development of components for distributed applications.

These standard development environments for middleware show different strengths and emerged from various contexts (Emmerich, 2002) with slightly different purposes, but they all contribute to software composition and interoperability with no major conflicts, and the responsible agencies have been evolving specifications for mappings between them (Raj, 1998).<sup>23</sup> According to Bond, Duddy & Raymond (1998) DCE being the oldest is the most mature and offers a high degree of interoperability in its common code base, as well as a high level of security, but it lacks support for object-orientation and is less adequate than CORBA, or Java, for fine-grained objects.

The concept of composition is closely related to componentization, whose central idea is that of 'reuse'. The advantages of reuse in software development are both technical and economic. It not only allows economies of scale and simplifies development work, but also enhances compatibility, and extends the reach of

distribution and interoperability, either in scale or granularity. These are important aspects for interoperability because finer granularity of components helps to deal with the complexity of information systems and with their growing heterogeneity and dynamism in the global network environment (Bashir, 2003).

Compositional software can thus be defined as software solutions that make use, for a given functionality or set of functionalities, of third-party developed software units which are context-independent, in technical and conceptual terms, and designed to be able to ‘plug and play’ with other components (Kiziltan, Jonsson & Hnich, 2000).<sup>24</sup> As explained by Kain (1998), a component is a defined and discrete unit that can be directly used in development, thereby being separable from its original context and usable in other contexts. Also, in terms of communication with other components, a component can implement more than one interface (export interfaces) for the services it provides; in turn, it can also make use of interfaces from other components (import interfaces) when it needs to get other components in order to execute its own services (Kiziltan, Jonsson, & Hnich, 2000).

Reusability of components at a fine level of granularity is a major trend that can be seen as a form of “industrialization” of software development, where independent components are intended to be assembled in different systems without side effects or unaffordable costs. The trend toward more granularity and independence of software components is most evident in middleware and in agent technologies.

The cost-effectiveness of software development based on components has many perspectives. They range from concerns about standards for managing the processes and quality of software development (Cugola & Ghezzi, 1998, Emmerich, 1998, 2002; Goldberg, 1999), to concerns about the pressure for new design methods, forms, and techniques and formalizations to make software design and implementation simpler because “many content providers become ‘untrained’ programmers in the WWW environment” (Lea, 1996).

### **5.3.2 Software architecture and design: patterns and frameworks**

The maturation of distributed computing and software composition and reuse have had a strong impact on software engineering methods, whose literature is

flourishing. The development of methods and theories about software design matured the area of software architecture that, for Clements (n.d.),

“can be seen as attempting to codify the commonality among members of a program family, so that the high-level design decisions inherent in each member of a program family need not be re-invented, re-validated, and re-described” (Ibid.).

The idea of architecture became important with object-orientation (Lea, 1993) expanded with that of component models (Shaw, 2001), and raised other related concepts like patterns (Appleton, 1998-2000; Coplien, 2000) and frameworks (Wegner, 1995: 56; 1996; Appleton, 1998-2000; Roock, Wolf & Züllighoven, 1998). Software architecture can be defined in various ways (see SEI, 2005). According to Bass, Clements & Kazman (1998: 23),

“The software architecture of a program or computing system is the structure or structures of the system, which comprise components, the externally visible properties of those components, and the relationships among them”.

The same authors clarify other concepts that should not be confused with ‘the’ architecture of a software system (Fig. III-19): architectural styles (description of component types and a pattern for their behaviour); reference models (a representation of the functionality and data flow) and reference architectures (the mapping of the reference model onto software components). All these are results of decisions at different stages and levels (Ibid.: 25).

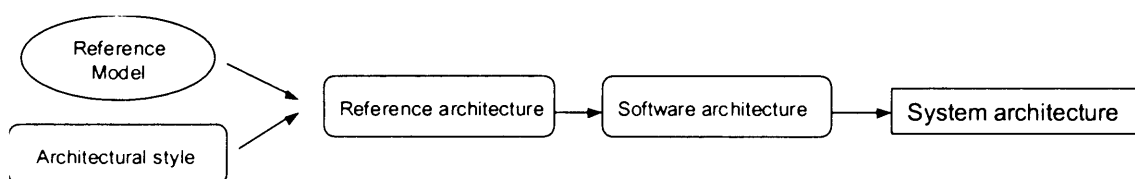


Fig. III-19 *The relationship between reference models, architectural styles, reference architectures and implemented software architectures* (from Bass, Clements & Kazman, 1998: 26)

As abstractions of a system, software architectures are important vehicles for communication. Decisions at each stage assume a given representation. Malan & Bredemeyer (2004) explained the various levels of architectural decisions with a decision framework (Fig. III-20, next page) in which the resulting architecture shows three different views: conceptual (corresponding to the identification of components

and their relationships), logical (design of component interactions and related mechanisms, etc.) and execution architectures (processes and how to implement them with physical resources).

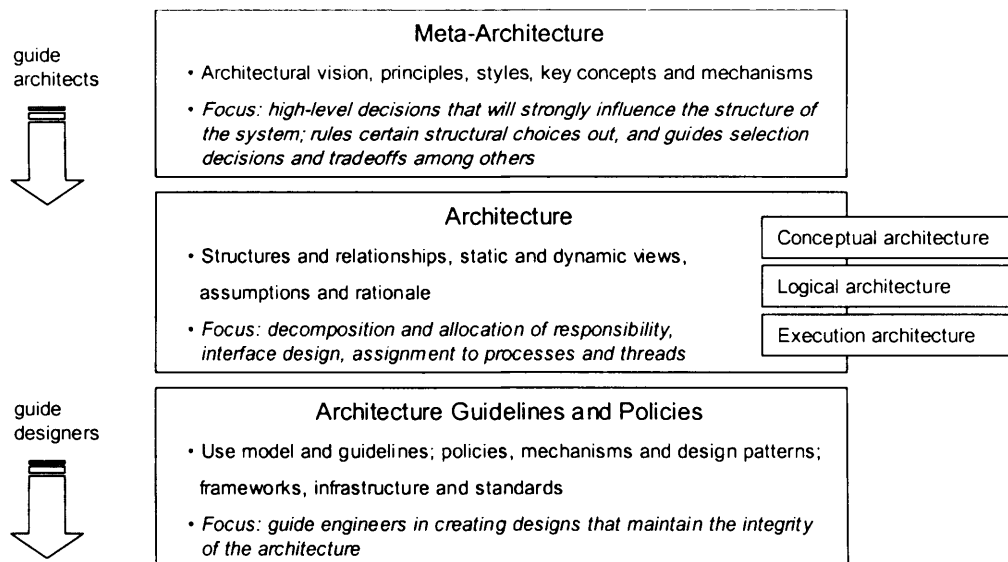


Fig. III-20 *Architecture views* (from Malan & Bredemeyer , 2004)

‘Patterns’ became a frequent topic in the 90s, especially after Gamma, et al. (1995), in software development methodologies. Patterns focus on reusing solutions and best practices and highlight the usefulness of having available explicit knowledge, i.e., documentation, about the principles and the methods followed from the definition of requirements to the detailed design and implementation.

Software patterns are usually described as “a recurring solution to a recurring problem” (Kiziltan, Jonsson & Hnich, 2000). They reflect proved or established practices and are ways of conveying high-level abstract knowledge in context. In software design, patterns convey information about key aspects of the design structures underlying the software in which they were applied, for example to key business patterns commonly found in enterprises (Arlow & Neustadt, 2004). This is important because such knowledge is needed to facilitate reusability and it is not easily deductible from the software itself.

The notion of ‘pattern’ does not apply to software design only but can be used in other levels of abstraction. At a higher level, there are ‘architectural patterns’, which document the fundamental roles assigned to, and the rules and guidelines underlying relationships of a given set of software subsystems. At a lower level,

there are 'idiom patterns', which refer specifically to a programming language, describing how to implement particular aspects of components with such a language (Appleton, 1998-2000). The frontiers among these concepts are not always clear; for example, as noted by Beck & Johnson (1994), developing patterns can help to generate software architectures.<sup>25</sup>

'Frameworks' are related to patterns but they are not confined to formalized abstractions. As explained by Roock, Wolf & Züllighoven (1998), framework is a term used in different senses in software engineering. Conceptual frameworks are used to identify items of relevance in a given application domain; construction (design) frameworks mean a technical design of a software system; and, finally, software frameworks are software products that provide mini-architectures with a given generic structure and behaviour provided for reuse by extension, i.e., an executable product, prompted for practical implementation.<sup>26</sup>

Most of the research motivations and achievements in these areas are related to distributed applications, middleware and solutions for the Internet environment. The matter is far more complex than the general idea provided here, and is still undergoing clarification of concepts and terminology. Beyond contributing to dealing with the complexity of distributed software systems, these developments are also very significant for interoperability because they highlight the need for explicit knowledge sharing about software components and compositional systems.

Such needs for knowledge sharing have been raising new requirements of formality in the representations of models, patterns, architectures or frameworks, as well as tools for building and maintaining such documentation support (Thuraisingham & Mowbray, 1998).

### **5.3.3 Concluding remarks**

Sharing knowledge about architectures, patterns and frameworks is sharing representations of abstractions. Trends in composability and reusability of software systems have been stressing the need for different levels of systems abstractions. Concepts such as models, patterns, and architectures became important for communication about systems. They are all used to convey reductions of real world, or projected, things, but they are reductions of different types, according to their purpose and scope.

In the literature of information systems and software engineering there is a multitude of slightly different definitions and usages of these term/concepts, and often some terms are used interchangeably causing confusion (Appleton, 1998-2000). Yet, in most cases, the meanings are not far from their general understanding or original contexts, the disciplines of design and architecture. Having understood generally the applicability and usefulness of these concepts in software development one can, therefore, adopt context independent understandings, having essentially in mind the different characteristics and purposes of each level of abstraction.

‘Models’ are reductions to convey the whole concept or shape of something, like a miniature that shows at least the essential elements and properties, in due proportion. Models can be used i) to identify or define (analyse, discover or formulate) the essentials of a given real world thing (i.e., an archetype of the thing); and/or ii) to guide and control (by imitation, or through comparison) the creation of similar things. In this case the model can be said to imply patterns, because it subsumes recurrent characteristics of a class of things. A reference model is one that represents a thing or a class of things with no intention of providing a fully detailed representation of its characteristics.

‘Patterns’ are reductions which convey (identify or define) recurring aspects or properties (regularities) of something, which can be particular to a thing or common to a class of things. Patterns can constitute models if they are intended for prospective repetition (imitation, comparison) of the ‘regularities’ of a given thing or class of things.

‘Frameworks’ are reductions to convey (identify or define) the supporting structure (frame) of a thing or of a class of things. When applied to a class of things, frameworks usually imply i) some commonalities within the class that can be seen as models (if commonalities convey the whole) or at least patterns (if commonalities are just about some recurring aspects or properties); and also, often ii) some common relationship of the class with the supporting structures of other classes.

Besides being used as representations of something, the concepts discussed in this Section also mean activities. Design and architecture, for example, are more strongly connected with activities, i.e., designing (defining the functional characteristics of something) and architecting (sketching the plans for the whole thing, encompassing but not detailing structural, functional and final shape aspects). Yet such activities work by making representations, therefore we have ‘the

architecture' or 'the design' of something; or 'architectural or 'design' models of a group of things.

Both activities and representations are interdependent and sharing knowledge about them means not only common understanding of a representation language but also of principles and strategies used in constructing what is represented. For both the activity and the representations there is a need for formalizing techniques and languages. This is the aspect addressed in the following section.

#### **5.4 The emergence of meta-modelling**

Models have been important for both software (Kozaczynski, 1998) and data and information processes (Finkelstein, C., 1998 ). In either field there are no unique methods and techniques. The analysis, specification, design, implementation and documentation of any part of an information system is a modelling activity that requires adequate methods, supported by languages that convey the methods and provide for the representation of models.

Being used in computing since the 70s (Mylopoulos, 1998), modelling methods have been the object of increased attention and research since the 90s. Several reasons have contributed to that. On the theoretical side, the rise of object-oriented methodologies appeared to improve the processes of software development and data modelling. In this context, however, the meaning of 'methodology' has not been linear, and has evolved in different ways: from methods as conceptual orientation, to methods as technique guidelines for design and documentation, to applied methods specific to particular contexts or domains (Henderson-Sellers, 1998).<sup>27</sup>

The formalization of methodologies raises the need for 'metamodels', i.e., "models that describe effectively the rules underlying the methodology itself" (Ibid.), a set of conventions for representation, or formal language, to convey the methodology and the results of its application. That is, for example, to express

"how class, type and instance are related; when certain relationships are valid and when invalid – essentially the semantics as well as the syntax of the methodology" (ibid: 443).

Many other factors have contributed to the growing interest in meta-modelling: the expansion of networks and the maturing of distributed systems, the need to realise business process and data integration across different systems, the growing

need for and usage of software packages for computer aided-design (CAD), particularly in computer software-aided engineering (CASE) tools, the increasing availability of technologies and standards that are model-driven.

All this has contributed to the expansion of interest in modelling activities, methods, standards and tools. In general, the activities related to modelling methodologies and languages are twofold: i) they make use of systematic and effective ways to deal with complexity, by abstracting formal representations of the problems; and ii) they provide coherent and unambiguous representations of systems analysis, specifications, design and implementations.

#### **5.4.1 Models and meta-modelling**

Meta-modelling is a term used to refer to the subject of and activities related to modelling languages. As these are of interest to a wide variety of fields, there is a wealth of literature with many different views and variations of terminology. Meta-modelling refers to the activity of producing meta-models. Meta-models are models that can produce other models, therefore a modelling language is itself a meta-model because it implies the concepts, constructs and rules to model something. But the term meta-model can also be applied to a model – as an instance application of a given modelling language – if that model is further used to model other things, at a different level of abstraction granularity.

Differences in terminology among different communities should be noted among the fields of object-oriented methodologies, artificial intelligence, the WWW semantic activities and the standards for particular industry activities.<sup>28</sup> The most important terminological differences are between two major groups of communities. One is the field of information systems and software engineering, where the terms ‘model’, ‘modelling activity’ and ‘modelling language’ are used often associated with, or implied in, the concept/term of ‘method’, meaning a methodology and a language (e.g., as in Henderson-Sellers, 1998; Kozaczynski, 1998). The other group relates to fields closer to artificial intelligence, that deal with knowledge representation theories in logic or knowledge representation (see Sowa, 2000) for computing purposes in expert systems. In these, the term most commonly used is ‘ontologies’, used also largely in the context of the semantic Web (Fikes, 1996; Devedžić, 2002).



Nevertheless, the terms ‘modelling languages’ and ‘ontologies’ refer basically to activities, constructs and tools that have the same kind of objectives in mind. Although the term ‘ontologies’ underlines more clearly the main objective of declaring explicitly the semantics of a given construct, building and using modelling languages is not so different (Bézivin, 1998). Both are about declaring a semantically controlled model – a meta-model – about a given reality. Research in the field is led in both groups. See, for example, Geoffrion (1996-1999), Paige, Ostroff & Brooke (2000), Sprinkle, et al. (2001) for approaches within software engineering; and Noy & Hafner (1997), Cranefield (2001, 2001a), Pan & Horrocks (2001) for approaches in AI and the WWW.

The motivations and applications, as well as the kind of tools and projects differ for each group. On the side of AI and the WWW, the efforts are more prospective and focus on automating aspects of information processing that are not new but have been exposed to a completely new scale with the Internet and the WWW. As noted in the survey by Noy & Hafner (1997) these are projects that address principally natural language processing and information retrieval. The recognition of the importance of clarifying the field and improving collaboration among different research and practitioner’s communities led to the establishment of some public funded projects such as *OntoWeb* and *On-To-Knowledge*.<sup>29</sup>

On the side of systems and software engineering, the motivations have a longer tradition and are mostly about optimization, business or industrial process management and product quality. In this case, standards and tools for meta-modelling already have a real play on the market. They are about systems, software components, enterprises and their business domains.

#### **5.4.2 Modelling languages**

As explained by Schmidt & Bernus (1998),

“A modelling language is a set of constructs for building models of systems [...] at any stage of the system life-cycle (e.g., specification, design, implementation), and from various viewpoints (e.g., information, function, resources)”.

There are multiple, sometimes competing, modelling languages, with different capabilities and strengths, for different levels of abstraction, different domains and

goals. Levels of abstraction can range from microscopic to comprehensive aspects of a system; therefore the language can be more or less adequate to a given level of analysis. Modelling languages have usually a primary domain of problems in focus, or are built with a particular paradigm in mind, which constrains their applicability. Finally, modelling languages can be targeted at a given audience, to produce models for human consumption or for both human and computer usage.

Therefore, modelling languages are not equally suitable for all different modelling and description needs of information systems. Some are defined together with a given modelling method or technique, providing guidance on how best to apply the method in building models with such a language. When diverse modelling languages are used for different aspects of a system, the support of formal interoperability among them is important, namely logic-based approaches. An area of current research is that of formal methods, i.e., mathematically based techniques, for the specification, development and verification of software in distributed systems (Meseguer & Talcott, 1998).<sup>30</sup>

Modelling languages can be standards, de jure or industry agreed. They can be publicly available for implementation in modelling tools, or they can have more or less proprietary status. Schmidt & Bernus (1998) categorized modelling languages in three major groups, according to the type of concerns that they address. These categories are next used to provide general descriptions and examples of modelling languages.

Data and object modelling languages are one category. According to Schmidt & Bernus (1998), these are languages

“intended for the modelling of the information view, i.e., information that is stored and processed by the information system at various phases of the system life-cycle”.

An example is EXPRESS, a formal modelling language used in many CAD tools. Models produced with this language can be algorithmically transformed into a computer accessible representation, e.g., a database schema (see Anderl, John & Pütter, 1998).<sup>31</sup> Another example is ORM – *Object-Role Modeling*, also known as NIAM (*Natural Language Information Analysis Method*). This method provides both graphic and textual languages for data modelling, thus expressing models in a form that is more natural and easier to understand than other methods and representations (see Halpin, 1998-1999).<sup>32</sup>

Activity and process modelling languages form another category. These are languages “intended for the specification, design and implementation modelling of the function of the information system” (Schmidt & Bernus, 1998). An example is Petri Nets <sup>33</sup>, a language with a long tradition that provides a graphic representation of events (see Proth, 1998).

Multi-view languages fall into a third category. These are languages

“suitable for the representation of multiple views of the information system, possibly serving the modelling needs of multiple levels of the system life-cycle” (Schmidt & Bernus, 1998).

Examples of languages that address several levels are the family of IDEF languages <sup>34</sup> (Menzel & Mayer, 1998); and CIMOSA,<sup>35</sup> an open system architecture for enterprise integration that provides modelling languages for functional, information, resource and organization aspects of the enterprise (Vernadat, 1998).

Another kind of language for defining the logic and providing visual representation of knowledge is ‘conceptual graphs’. Their purpose is to express meaning in a form that is logically precise, human-readable and that can also be processed by computer. They provide graphic representation of first-order logic and can be used for design and specification in many application areas such as database projects, information retrieval, natural language processing and expert systems (Sowa, 1998, 2000: 476-489).<sup>36</sup>

### **5.4.3 Unification and formal interoperability**

Modelling with the support of established modelling languages became important both for software engineering and data modelling, and it also represents an indirect support for interoperability, as it provides for disclosing precise knowledge about systems. But the proliferation of different methodologies and languages creates interoperability problems, i.e., makes more difficult the reuse of the information and data that models contain by another system.

As pointed out by Henderson-Sellers (1998), the evolution of OO methodologies led to the proliferation of methods and languages, with different features and strengths because they have different targets. According to him, simple standardization, by aggregating all features from all methods in a single methodology, would not be the answer because it would be extremely time-

consuming and complex. Instead, he suggests the creation of convergence, by compatibility, i.e., the definition of a set of core features for all methodologies, allowing at the same time for each to be able to extend to the needs of particular domains and contexts (Ibid.: 440-443).

Several initiatives under the auspices of the OMG have been addressing these concerns, and UML is an industry standard that appeared in this context.<sup>37</sup> Defined as a standard “for specifying, visualizing, constructing, and documenting the artifacts of software systems”, UML is a language that applies the object-oriented paradigm and contains the features needed for modelling in a general-purpose perspective, i.e., independent of types of systems, domains, methods and processes. It is extensible in the sense that it can be added for specialized purposes without changing the core concepts and notation. Due to its characteristics and general-purpose nature, it is expected that UML will increase the practical use of OO modelling in formal ways, and thus facilitate the automated processing and the sharing of data concerning models of different systems.

UML is not a methodology, but rather a notation and a metamodel (Henderson-Sellers, 1998; Halpin, 1998-1999). It is relevant for the broad modelling methods discussion but it does not eliminate the usefulness and role of other existing methods and modelling languages, notably those that have specific goals or are domain specific. Most likely, these will tend to have UML mappings, or to be transformed into UML specific profiles, and will also contribute to elicit UML enhancements. Halpin pointed out some of these issues, in a comparison of ORM and UML (Halpin, 1998-1999).

Another aspect is the relationship of UML with markup languages, notably SGML and XML, because these can be understood and used for ‘modelling’ purposes, as they embody data structures. On this subject, Cover (2001-2003) stressed the need to distinguish between the primary syntax role of markup languages and the “(quint)essence of interoperability problem being semantics, not syntax”. The potentials of UML appear also interesting to projects in the context of the semantic Web, especially for ontologies (Cranefield, 2001a) or for XML data interchange in general (Skogan, 1999) as UML provides the means to define data structures from where document type definitions (DTDs) or schemas can be derived.

UML is quickly being adopted by software tool vendors and is currently one of the central pieces of the MDA (Model Driven Architecture)<sup>38</sup> launched by the OMG in 2001. Other core standards of MDA (Miller,J. & Mukerji, eds, 2003) are:

a) *MOF - Meta-Object Facility* - a common meta-model for all of OMG's modelling specifications, allowing derived specifications to work together; it also includes definition of a standard repository for meta-models and models. MOF provides the constructs through which models are analyzed in XMI, and defines programmatic interfaces for manipulating models and their instances. Such interfaces are defined in IDL and are also being extended to Java;

b) *XMI - Metadata Interchange*, a standard that defines an XML-based interchange format for UML metamodels and models. It is the interchange mechanism used between various tools, repositories and middleware. XMI can be used to derive XML DTDs and schema from UML and MOF models, thereby providing XML serialization for these artefacts, not only software models but also data warehouse and database models (from CWM, see below), as well as CORBA and Java interfaces; and

c) *CWM - Common Warehouse Meta-model*, a comprehensive meta-model that enables the design, building and managing of data warehouse applications. Its definition in UML leverages the power of data mining across databases and allows the definition of mappings for database schemas. CWM is a kind of UML profile, intended for the data in the same way as software models do for software. CWM is a result of a co-operative effort between OMG and the Meta-Data Coalition (MDC).<sup>39</sup>

All these standards take advantage of UML as the common representational component. One characteristic of UML is that it is methodology-independent, therefore regardless of the methodology used, UML can express the results. The MDA philosophy is based on this concept and this provides portability to the level of the design specification. With this strategy MDA expands the earlier OMG architecture (the Object Management Architecture – OMA) beyond the objective of integration of disparate systems, where CORBA, the standard central to OMA, has been the major piece. MDA still includes CORBA but provides for a more comprehensive and structured solution for application interoperability.

Every application adhering to MDA will be based on a normative, platform-independent UML model and will interoperate more naturally across a broad range of systems of all kinds that will also conform to MDA. As the base specification of

every service, facility and application is a platform-independent model, architects can specify links from an application to needed services and facilities, and to other applications, as part of its model. In this structure of linked models, MDA tools can automatically build bridges that connect implementations on their various middleware platforms. This includes the possibility to encompass particular platforms that are currently supporting the new generation of Web middleware, such as Microsoft.NET and Sun's ONE (see note 22), and Java/EJB (see note 21), provided that a platform-specific profile is defined for them in MDA.

Achieving interoperability by sharing and linking standardized, machine-processable models of systems and of systems components is a totally new concept. The interoperability requirements are best met at this higher level, where they can more easily be interpreted, validated, mapped and then transformed automatically to the implementation level. The concept combines the power of a standardized and platform, system and method independent modelling language (UML) with facilities that transform systems definitions (models) into machine executable form (using MOF and XMI). Finally, it should be noted that XMI constitutes a crucial element in establishing the link between the world of MDA and Web technology.

## **5.5 Conclusions**

In the framework of the second research question of the thesis, this Chapter has provided a selection of aspects that explain major shifts in computing/IT that are behind the emergence of distributed systems and interoperability and that provide the main traits of their conceptual background, from areas such as software engineering and middleware.

The objectives were to discover whether these shifts provide further support to conclusions reached in Chapter 4 and to investigate the existence of IT constructs providing concepts that can be potential building blocks for enhancing IT knowledge in LIS, according to a set of criteria defined (see page 215).

The outcomes are positive and point to two levels of findings, explained and discussed in the Sections to follow:

- The matters analysed confirm the existence of new, more open dimensions of IT systems, i.e., whose understanding tends to be less constrained by the lack of an IT background; and

- The existence of high-level concepts and languages, derived from technical IT constructs but amenable to wider understanding and application, thus having the potential to foster the conceptual alignment between IT and non-IT communities.

### **5.5.1 New open dimensions for IT systems understanding**

The first objective was to investigate further evidence of the general conclusions of Chapter 4, that the lack of a common technical background in computing/IT is not a persistent barrier to knowledge sharing with LIS. This is because the evolving nature of interoperability and distribution is both demanding of the participation of a variety of non-IT professionals and has also elicited a general abstract vocabulary about the main properties and components of IT-based information systems that is meaningful without having to assume detailed knowledge of the underlying IT technical matters.

The analysis carried out in the sections 5.2 and 5.3 of the present Chapter provided further evidence of these findings, lending support to the main argument of the thesis. The evolution towards interactive models of computing added new empirical approaches to the traditional ‘algorithmic’ conception of computing, thus allowing ‘open’ approaches that are closer to the real world problems and to the ontologies and vocabularies of their stakeholders. Linked to this, OO programming and methodologies have provided abstract vocabularies and methods that can be applied by different stakeholders to different viewpoints, layers and concerns of information systems and their contexts, for varied purposes yet in manner congruent with IT.

The importance of OO is twofold. It offers a new approach to the conception of software systems that ‘packages’ complexity while offering more flexibility. OO also represents a model of reasoning about information systems in general, i.e., a method of analysis that can be applied to different levels of things related to information systems, e.g., business models, organizational processes, data structures and functionalities. The conceptual shift of OO towards interfaces, environments and reuse has enabled another major change explained in this Chapter, the trend towards compositional systems and reusable components. This trend is first of all a conceptual instantiation of the open systems philosophy, of the emergence of the

distributed paradigm, reiterating the rise in importance of communication mechanisms (e.g., interfaces and middleware).

The trend is not restricted to executables, but also extends to systems modelling methodologies. That is to say, the need to share systems formalizations starts in methods of analysis and practices of systems development, which is rather more than just sharing programming languages. In the form of reference architectures, software patterns and frameworks, there is a variety of different levels of reuse which means instances of agreement and compatibility that promote interoperability and understanding among wide communities of systems and people.

The major concepts implied in this synthesis are depicted in Fig. III-21.

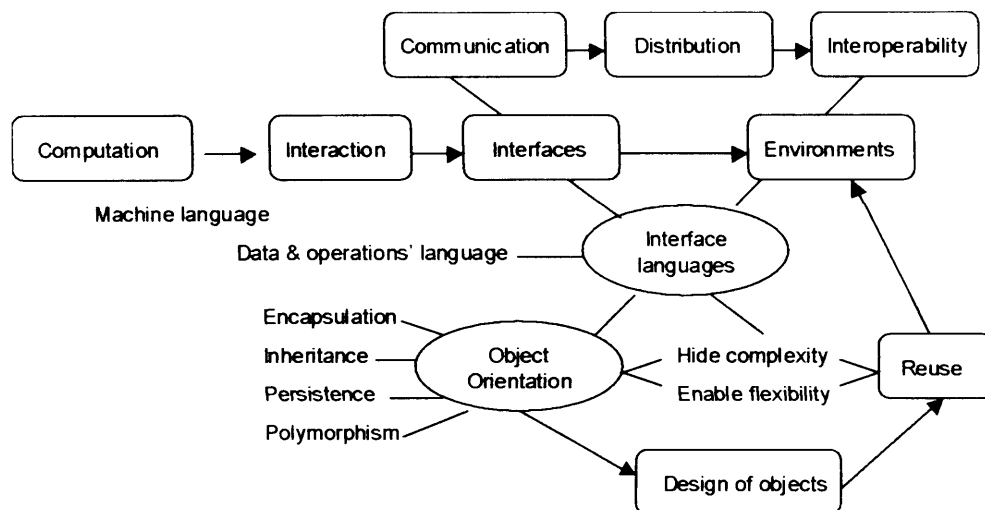


Fig. III-21 *Object-orientation concepts and the development directions of information systems*

Overall, the development and primacy of programming interfaces and middleware, and of composition and reusability in software development, have shown the growing prominence and sophistication of transparency mechanisms between independent functions or systems. This underlines the architectural orientation of IT-based information systems, which creates levels of decision/specification and communication that are higher and independent of programming or engineering knowledge.



### 5.5.2 Concepts and languages for IT knowledge sharing

The second objective of this Chapter was to investigate whether IT constructs have provided concepts that have potential as building blocks for enhancing IT knowledge in LIS, according to a set of criteria that includes: long-lasting influence on IT developments; abstraction and independence of particular technologies; analytical power and reusability regarding any part of information systems or their contexts.

In this respect, the present Chapter carries a positive answer to the research question. While the concepts pertaining to object-orientation provide the most eloquent case regarding the criteria referred to above, the methods and theories of software architecture can also be held to make a relevant contribution to knowledge sharing, as explained in Section 5.3, as they achieve the building of abstract models, i.e., the codification of knowledge about information systems for purposes of communication within and beyond the craft of systems engineering.

The emergence of meta-modelling and the development of modelling languages, explained in Section 5.4, provide the ultimate evidence of the trend towards common languages for conveying descriptions and specifications of systems, in standard ways, i.e., agreed for a technical community or communities of systems. Fig. III-22 shows the relationships between the design and architecture of compositional systems and distribution and interoperability, through modelling.

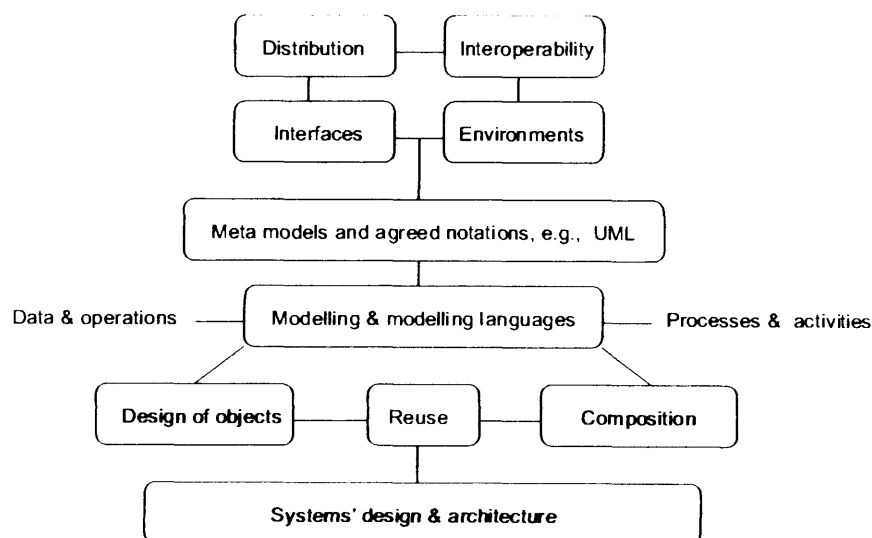


Fig. III-22 *Modelling and modelling languages in systems design and architecture to support distribution and interoperability*

Modelling languages, of which the ultimate example is UML, are the constructs that project into the future the trend towards higher levels of abstraction and improved means of communication needed to stitch together both the variety of stakeholders of and interveners in information systems and the results of their activities.

While the knowledge and ability to use modelling languages exists principally in software engineering, its significance is not limited to software systems and the trend to encompass (i.e., improve communication with) other stakeholders is clear: the means to develop information systems and to communicate about them are even less confined to a given professional community (e.g., programmers) and more open to a wide variety of fields. The relevance of this is even greater in the cases where the modelling languages are bound to formal processes in such a way that they are understandable by both humans and machines.

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## Notes to Chapter 5:

<sup>1</sup> Introduced by Alan Turing (see Hodges, 1983; 1995-2004) in 1936, a Turing machine (TM) is a basic abstraction of a machine whose procedures (algorithms) are defined mathematically in a precise way. Beyond theoretical studies in computer science (see Barwise & Etchemendy, 1993; Agar, 2001) the concept of Turing machines has also been influential in philosophy (see Barker-Plummer, 2005). TM has been central to computer science educational programmes since the 60s, providing a theoretical background that is essentially ‘algorithmic’, hence deterministic. It alone, i.e., as a complete model, shows important limitations for problem solving, notably for many of actual ‘non-computable’ problems (Wegner, 1997; Wegner & Goldin, 2003; Wegner & Eberbach, 2004).

<sup>2</sup> Procedural programming consists of sets of instructions – also called function, routine, subroutine or method, depending on the programming language - that are followed by a computer from start to finish.

<sup>3</sup> Graham (1991) described three phases in the development of object-oriented methods. First is the phase of advent, with the introduction of simulation and contributions from artificial intelligence languages, namely LISP, producing the first experiences of interaction machines, such as Dynabook with Smaltalk language. The second phase, in the 80s, concentrated in the user interface and consolidated the GUI, with first examples in Lisa and Macintosh, and saw the appearance of programming languages such as C++ and toolkit libraries, introducing the reusability of components in software engineering. The importance of GUI for object-orientation in computing was twofold: while the development of GUI was supported by object-oriented programming, the WIMP (Windows, Icons, Mice and Pointer paradigm) style in turn became decisive for the later developments in object-oriented programming. The third phase, in the 90s, is marked by a consolidation of the object-oriented approach toward open systems. It is focused on design by object-oriented analysis, and on the development of end-user applications, notably for office automation (Graham, 1991: 2-8).

<sup>4</sup> Britton compares these difficulties to those that can be found in library classification activities. Determining class attributes implies not allowing class members to bear exceptions regarding common attributes, in which case different classes and possibly a common super-class should be established. When this strict discipline is not followed in the design phase, problems will arise only in practice and the reusability of a class – its set of attributes and procedures – is affected as well as the correct relationship with other classes. Such reusability is essential for the processing of data organized in class hierarchies, as they should allow for “single points of change”. This means, for example, that inconsistent rules when building the hierarchies may lead to later disruptions requiring a cascade of changes throughout the system. These aspects are of utmost importance for the realization of ‘inheritance’, one of the most powerful features of object-oriented methods (Britton, 2001: 45-46).

<sup>5</sup> Notably, Britton pointed out the fact that relational databases rely on simple tabular structures and powerful query languages which presuppose data being visible. This contradicts the spirit of encapsulation (instead, databases use ‘views’ to restrict data visibility) and encapsulation also forces all updates through each object’s method code (Britton, 2001: 48).

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<sup>6</sup> The ER model is a conceptual data model that represents the real world as entities and relationships. It was introduced in 1976 by Chen (1976) and its basic component is the Entity-Relationship diagram, which graphically represents data about entities (and its properties or attributes) and their associations. ER diagramming is used to design relational tables, thus having a close relationship in the practice with RDBMS. ER remains the most widely used model for data modelling. Because of its simplicity, it is also recognized that ways of enhancing the expressive power of the model would better support the increase in complexity of databases and applications (Badia, 2004).

<sup>7</sup> The structured approach to systems analysis and design evolved from structured programming introduced in the late 60s, adopting its underlying principles and characteristics. Foundational works in structured analysis are DeMarco (1978) and Yourdon & Constantine (1979). While the variations in terminology and meaning have been many, the main ideas and characteristics are the same. They are based on principles of top down analysis and development and of hierarchical decomposition (e.g., the software waterfall lifecycle), and consist in methods and tools to guide the analysis and the design while providing representations of models and specifications that are also aimed at mediating communication with the users, e.g., by data flow diagrams. The emphasis is usually put on the data flow and process programming around events. These reflect some limitations as approaches are dominated by “closed world assumptions”, linear and not very flexible for open development processes to adapt to organizational dynamics (see, for example, Bansler & Bødker, 1993; Cugola & Ghezzi, 1998).

<sup>8</sup> Beyond notation, different OO methodologies and respective tools may cover different portions of software analysis and design. Henderson-Sellers (1998) refers to between 20-80 of these, and discusses the needs for some eventual standardization, or harmonization, of such tools.

<sup>9</sup> For example, Crowcroft (1995) used the object-oriented approach to explain open distributed systems, on the basis of the usefulness of this conceptual view, not because all open distributed systems are or should be built with object-oriented technologies, e.g., object-oriented databases (Ibid.: X).

<sup>10</sup> A more formal definition of middleware is, e.g., the one provided in FOLDOC: “Software that mediates between an application program and a network. It manages the interaction between disparate applications across the heterogeneous computing platforms. The Object Request Broker (ORB), software that manages communication between objects, is an example of a middleware program” Howe, ed. (2003-2005). However, as noted by Bishop & Karne (2003) a wide range of software can be included in middleware so that it is not simple to be precise in the terminology or to establish a taxonomy of its different types. See also Britton (2001: 75-87).

<sup>11</sup> RPC is a protocol that allows a client to send a request for a procedure to be executed on a remote server, through a message with the name and parameters of the procedure. The main feature of RPC is its use of an interface definition language (IDL) to intermediate representation of the content transmitted. This language allows the conversion of the parameters to and from a simple stream of bits to pass the network. There are many variations of RPC, but the best known is the standard provided by the OSF – *Open Software Foundation*, currently *The Open Group* (see Note 20).

<sup>12</sup> RDBA are standards or programming interfaces to access, read and write on databases that are remote, i.e., on a machine other than the client. Most database vendors provide RDBA. The Microsoft ODBC (Open Database Connectivity) is an example. Instead of an IDL,

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RDBA uses SQL (Structured Query Language). Developments in this field led to DRDA - Distributed Relational Database Architecture, a set of industry standards for remote database access prepared by The Database Interoperability (DBIOP) Consortium (<http://www.opengroup.org/dbiop/>), of The Open Group. The aim is to standardize database protocols for multi-vendor interoperability overcoming inconsistencies and SQL dialects (Gualtieri, 1996).

<sup>13</sup> DTP refers to sequences of information exchange and updates among different databases that have to be treated as a single unit of work, i.e., have to be fully completed (committed) otherwise partial changes have to be rolled back. The sequence of events of a transaction is controlled by a program called a transaction monitor. DTP is very important in the business environment, notably in electronic commerce. DTP was standardized by the *X/Open Consortium*, in the *X/Open DTP Model* and the *XA Specification* (<http://www.opengroup.org/dbiop/s423.pdf>), now also managed by the DBIOP, within The Open Group.

<sup>14</sup> An alternative to these client /server solutions is message-queuing, a peer-to-peer communication, i.e., a communication where there is no distinction between client and server. In this case the messages do not connect programs directly but are put in and got from message queues. Queuing systems are program-independent, being named, managed and having a memory space of its own. As explained by Britton (2001) there are pros and cons in choosing, for example, between DTP and message queuing solutions (Ibid.: 34-37).

<sup>15</sup> DCOM – *Distributed Component Object Model* (<http://www.microsoft.com/com/tech/DCOM.asp>) is the Microsoft technology for distributed object integration. DCOM evolved from OLE (Object Linking and Embedding) and COM (Common Object Model) technologies and was made available in 1996. The DCOM protocol (Object Remote Procedure Call) is based on DCE RPC (see Notes 11 and 20). It is particularly adequate for Windows-based tools and applications. It can be generally considered as an alternative to CORBA, although it is more restricted in terms of programming languages (Thompson, et al., 1998).

<sup>16</sup> See Chapter 4, note 19. In CORBA the object request broker (ORB) is the middleware responsible for locating the object, preparing it to receive the request, passing the data for the request to the object, and for communicating back the result after the operation is executed. CORBA includes specifications for the interface language definition and the ORB services, such as security transactions and messaging. CORBA is designated CORBA/IIOP since the version 2.0 (1995); IIOP - *Internet Inter-ORB Protocol* is the OMG standard protocol enabling CORBA network interoperability (Kramer, 1998).

<sup>17</sup> The importance of agent technology is recognized, for example, in AgentLink (<http://www.agentlink.org/>), a Co-ordination Action for Agent Based Computing supported by the European Union; and in FIPA – The Foundation for Intelligent Physical Agents (<http://www.fipa.org/>), a non-profit organization created in 1996 and aimed at producing standards and specifications for heterogeneous and interacting agents and agent-based systems.

<sup>18</sup> This is the field of the so called bots, knowbots, agents or intelligent agents that are a promise in the new networked environment for information discovery and all sorts of complex electronic commerce transactions (Dertouzos, 1997: Chap. 4).

<sup>19</sup> A ‘development environment’ is usually understood as a suite of standards and/or tools to aid software development for a particular function, or in a particular language.

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But the terminology is not consistent. ‘Development platform’ is also a term used in this sense, but refers mostly to the computing infrastructure and programming tools rather than to standards. When the development environment includes a given architecture for reuse with a corresponding toolkit it can be also named a ‘framework’.

<sup>20</sup> DCE is a set of standards issued by *The Open Group*, formed by the merging of the *OSF - Open Software Foundation* and the *X/Open Consortium* in 1996 (<http://www.opengroup.org/index.htm>).

DCE (<http://www.osf.org/dce/index.html>) standards are intended for the development, use and maintenance of distributed applications based on the client-server model, and are agreed by major stockholders of the software industry. DCE was formed from their formerly separated technologies, integrated into a single toolset, freely available as source code ([http://www.opengroup.org/dce/mall/free\\_dce.htm#top](http://www.opengroup.org/dce/mall/free_dce.htm#top)), so that DCE based products from different vendors are highly interoperable. It is a standardized development environment based on a layered architecture of services above the operating system and network services. DCE provides normalization of services such RPC (remote procedure calls) and specifications for IDL (interface definition language), as well as for security, directory and naming services.

<sup>21</sup> Java is not a distributed processing technology but an object-oriented programming language, from Sun, that can be executed remotely, using Web browsers. The Java environment consists of two components, a Java pre-compiler, which produces an intermediate form of Java called ‘bytecodes’ and a Java interpreter. Java language defines a Java Virtual Machine (JVM) which provides a platform independent software to execute Java applications. The ‘bytecodes’ are JVM instructions that can be executed by any Java interpreter, irrespective of the platform where execution takes place. During execution it may find reference to additional Java classes that can be loaded as needed and executed. Most of the current Web browsers include Java interpreters therefore support distributed Java applications, namely in the form of Java applets, which is a restricted form of Java applications. Java applets are thus a mechanism to execute remotely stored programs in a local computer. Java applications can invoke other Java applications through Java RMI (remote method invocation) whose function is similar to RPC calls (see Emmerich, 2000: sec. 4.3).

<sup>22</sup> ‘Web services’ are an example of component technology especially adequate for building distributed applications on the Internet. The ‘service’ is a unit of application logic that provides data and services to other applications over the Internet, using protocols and data formats such as HTTP, XML, and SOAP (Simple Object Access Protocol). The architecture of Web services has two major components: a service which is described in a standard language (Web services Description Language - WSDL) and a Web services registry built according to standard specifications (Universal Description, Discovery and Integration - UDDI), where the service descriptions are published and from which they can be discovered at run-time. Several companies are offering tools for the construction of Web services: Microsoft (in the context of .NET Framework, <http://msdn.microsoft.com/netframework/>), IBM (<http://www-3.ibm.com/services/uddi/>) and SUN (<http://java.sun.com/webservices/>). See developed information about Web services in Section 6.4.

<sup>23</sup> See a comparison between DCOM, CORBA and Java/RMI with practical examples in Raj (1998).

<sup>24</sup> This definition of compositional software components gathers the main characteristics of reusable software components taken from the definitions collected and commented by (Kiziltan, Jonsson & Hnich, 2000).

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<sup>25</sup> Beck & Johnson (1994) provided a practical example with the case of HotDraw, a graphic editor.

<sup>26</sup> An example of this is the Microsoft .Net Framework SDK (software development kit), for the development of Web services.

<sup>27</sup> Henderson-Sellers discriminates among teaching methodologies, smaller than the current ones and not complete but useful for learning; public domain methodologies, complete duly published and supported, constituting the backbone of the methodology industry; and sophisticated yet proprietary methodologies, although strongly linked to those in the public domain (Henderson-Sellers, 1998).

<sup>28</sup> *MetaModel.Com* (<http://www.metamodel.com/>) by R-Objects, Inc. (<http://www.r-objects.com/>) provides an introduction to these concepts and a compared glossary for some of the terms used by different communities.

<sup>29</sup> These are projects supported by the EU, under the *IST Program*.  
*OntoWeb – Ontology-based information exchange for knowledge management and electronic commerce* (<http://www.ontoweb.org/index.htm>) aimed at promoting ontologies and associated technologies by helping to bridge the diverse and dispersed research communities, commercial agents and funding bodies. The objectives of *On-To-Knowledge – Content-driven knowledge management tools through evolving ontologies* (<http://www.ontoknowledge.org/>) are to develop a methodology and tools for intelligent access to large volumes of semi-structured and textual information sources in large distributed environments taking full power of ontologies and agent technologies in supporting knowledge management.

<sup>30</sup> This area of research originated the conference series FMOODS - *Formal Methods for Open Object-Based Distributed Systems*, being held since 1996 (<http://trese.cs.utwente.nl/fmoods2002/>).

<sup>31</sup> The EXPRESS language is an ISO standard (ISO 10303-11: 2004). It is part of a set of standards (ISO 10303) called *STEP - Standard for the Exchange of Product Model Data*. STEP is the international data description standard which will provide a complete unambiguous, computer-interpretable definition of the physical and functional characteristics of a product throughout its life. Official information on the standard is provided by the ISO TC 184 SC4, at the National Institute of Standards and Technology (NIST - <http://www.nist.gov/sc4/>). A resource page on STEP is provided by the *UK Council for Electronic Business* (UKCeB) at : <http://www.ukceb.org/step/>.

<sup>32</sup> The official site of ORM is at <http://www.orm.net/index.html>.

<sup>33</sup> *Petri Nets* is ISO/IEC 15909-1: 2004. More information about Petri Nets can be found at PetriNets World (<http://www.daimi.au.dk/PetriNets/>).

<sup>34</sup> IDEF (standing for ‘integrated definition’) is a suite of modelling languages for various aspects of enterprise modelling, including the modelling of: actions and activities, functions, data (for either relational and object-oriented methods), processes and also a language to built ontologies, i.e., domain vocabularies. More information about IDEF is provided at <http://www.idef.com/default.html>. The parts of the IDEF languages most used in the industry are IDEF1X, for relational databases, and IDEF3 for process modelling.

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<sup>35</sup> *CIMOSA - Computer Integrated Manufacturing-Open System Architecture*, was originally developed for computer integrated manufacturing (CIM) with funding from the European Commission under the Esprit projects between 1986 and 1994. Current information about CIMOSA can be found at the *CIMOSA Association* ( <http://cimosa.cnt.pl/>).

<sup>36</sup> There is a draft ISO/IEC standard for Conceptual Graphs proposed by the ISO/JTC1/SC 32/WG2. The draft standard and other current information related to Conceptual Graphs can be found at <http://users.bestweb.net/~sowa/cg/>.

<sup>37</sup> UML (<http://www.uml.org/>) resulted from the convergence of three separate leading OO methods: *Booch Method*, by Grady Booch ; *OOSE – Object-Oriented Software Engineering*, by I. Jackbson, and *OMT – Object Modelling Technique*, by James Rumbaugh. Their joint efforts, carried out during 1994-1996, were later enhanced by a consortium with other partners, including industry leaders. UML was proposed to OMG in January 1997 and officially adopted as an OMG standard in November the same year. UML specifications consist of four parts:

*UML semantics*, which is the core for all the standard definitions of the UML elements (in terms of semantics, syntax, rules);

*UML Notation Guide*, containing the visual representations, with examples and guidelines;

*UML Extension* documents, for two pre-defined process-specific extensions (one for software engineering and the other for business modelling, both derived from previous work by Jacobson).

<sup>38</sup> See a brief description of MDA in Section 4.3.3 c).

<sup>39</sup> The MDC (formerly the *Metadata Coalition*) was a group of several major IT vendors that worked together towards solving the problem of multiple incompatible metadata repositories. In 1999 the MDC merged with the Object Management Group (see notes 16 and 37).



## **CHAPTER SIX**

### **INTEROPERABILITY AND THE WWW**

#### **6.1 Introduction**

The present Chapter continues the investigation developed through chapters 4 and 5, to address the second research question of the thesis, is the technical background of computing/IT a persistent barrier to knowledge sharing with LIS, or is the evolution of computing/IT providing a set of integrative concepts that can serve as a durable and extensible common conceptual basis?

Chapters 4 and 5 have already provided part of the answer by identifying, from the evolution of IT since the rise of distributed systems, long-standing trends and concepts derived from IT constructs that are amenable to audiences, and applicable to management situations wider than those of the computing professions.

The dramatic changes brought about by the WWW justify a separate chapter to analyse IT developments in this domain. As in the previous chapters, the analysis is conducted principally around the perspective of interoperability. However, other socio-technical perspectives are also included as they form important elements of the Web technology context. The criteria for the selection of IT constructs and identification of integrative concepts are the same as those explained in Chapter 5.

The objective is twofold: to identify major aspects proper to the WWW that influence the requirements and models of access to information and interoperation; and to verify whether or not the trends and concepts underlying Web technologies provide further evidence to complement the conclusions reached in the previous chapters of this Part.

The Chapter provides a selection of the main changes brought about by Web technology and the issues and prospects it raises for access and interoperability. Because the WWW emerged as an actual information environment affecting information provision and management in all areas, some aspects are included that are not of a strictly technical nature. For the same reason, the literature used includes more authors and points of view from the library field. However, as in the previous chapters of this Part, most of the supporting literature pertains to technical areas of IT.

## 6.2 The WWW as a distributed information environment

With the growth of the Internet, connectivity between systems became largely facilitated (Holm, 1994): the TCP/IP suite of protocols simplified the communication transactions pertaining to several layers of the OSI model, at the data transport level, while the HTTP/HTML introduced fundamental changes in network publishing, as they are open, widely applicable and very undemanding standards. The WWW grew out of a simple infrastructure for distributed documents, offering some properties of distributed systems, such as location, concurrency and replication transparencies.

According to Wegner (1995: 58),

“The World-Wide Web is probably the most successful example of interoperation, due to its simple architecture and to HTML which supports communication through universal resource locators and typeless links. Markup languages like SGML for literary texts, HTML for World-Wide Web documents and VRML for virtual reality multimedia documents are much simpler than programming languages but achieve a high degree of interoperation for documents. Interoperation of object-oriented programs at the object level, supported by systems like CORBA and COM/OLE, is a much harder problem than interoperation of documents since interfaces consisting of operation signatures are more intricate than interfaces that are untyped links”.

However, as explained by Tanenbaum & van Steen (2002: 4), the WWW does not appear to users as a single “gigantic, centralized document system”, so it cannot qualify as a distributed system. While the basic WWW standards, HTTP/HTML, pertain to the upper levels of the OSI model they do not address interoperability in the same manner as database systems. They are at the application level, yet HTML syntax is much simpler than programming languages and database structures, as it is limited to describing “both an intradocument structure (the layout and format of the text) and an interdocument structure (references to other documents through hyperlinks)” (Abiteboul, Buneman & Suciu, 2000: 3). This is usually called semi-structured data and is qualified as “schemaless” or “self-describing” (Ibid.: 11). This is also why the HTTP protocol is said to be typeless, i.e., the data transmitted is not encoded according to type specifications, i.e., has no reference to any data schema.

With respect to databases, the initial Web standards brought some changes, very attractive from the user’s point of view but limited to presentation improvements. Many systems were provided with an HTML interface, thereby

becoming usable with a browser. The visibility of such databases in the network environment, principally those that are intended for public free use, was augmented, as they became associated with Web pages that announce them. Beyond this, interoperability and functional integration only exists if other mechanisms are implemented, such as the Z39.50 search and retrieve protocol used in bibliographic systems (Hammer & Favaro, 1996; Lahary, 1997).

Without underlying mechanisms of this kind, which imply agreement on data attributes and structures and specific protocols with standard messaging, systems continue to be available individually, i.e., the user has to use one system at a time, each with functionalities and interface features of their own, for which the browser environment is just a surface (see, for example, Lopez Sosoaga Torija (1998) regarding the issue of Web interfaces versus Z39.50 in bibliographic databases).

Therefore, the distributed environment created by the WWW can be considered, first of all, as an open environment for publishing documents. The support for integrated access to structured resources held in databases requires more than the basic HTML/HTTP standards. As a matter of fact, it was the lack of such solutions that generated the concept of the so-called ‘hidden’, ‘deep’ or ‘invisible’ Web (Sherman & Price, 2001; Pedley, 2001), i.e., the recognition of the existence “of material that general-purpose search engines either can not, or perhaps more importantly, will not include in their collections of Web pages (called indexes or indices)” (Sherman & Price, 2001: 1).<sup>1</sup>

This is because Web pages generated from a database only exist when (and while) they are dynamically created as the result of a specific search, executed by the search engine of that database. As they are dynamically generated they cannot be crawled. According to Bergman (2001),

“The deep Web is about 500 times larger than the surface Web, with, on average, about three times higher quality based on our document scoring methods on a per-document basis. On an absolute basis, total deep Web quality exceeds that of the surface Web by thousands of times. Total number of deep Web sites likely exceeds 200,000 today and is growing rapidly.[...] The deep Web also appears to be the fastest growing information component of the Web” (Ibid.).

In the context of the WWW, the problem of access has been a strong motivator not only of new IT developments but also of other changes in economic, social and legal aspects of software and information which intertwine with IT.

### 6.2.1 A new culture of access

Fostered by the Internet and the WWW some socioeconomic trends have been changing the way information and software resources are viewed as public goods, i.e., as “something that is regarded as beneficial and can be provided to everyone who seeks it without their use of it diminishing its value” (Willinsky, 2006: 9), that should be openly accessible.

The so-called open source software (OSS)<sup>2</sup> and open access (OA)<sup>3</sup> movements have gained dramatic prominence<sup>4</sup> as general phenomena based upon collaboration (Ghosh, 2005) and ‘collaborative ownership’ (Kelty, 2005). They focus on alternatives to traditional business models of scholarly publishing (Freeman, 1996; Willinsky, 2002, 2006; Ginsparg, 2004; Lamb, 2004) and of the software industry (Raymond, E., 2001; Behlendorf, 1999; Messerschmitt & Szyperski, 2003: 78-81; Benkler, 2005).

Although the history of both OSS (see DiBona, Ockman & Stone, eds., 1999; Raymond, E., 2001:1-18; Weber, S., 2004: Chap. 2; Benussi, 2005) and OA (see Suber, 2002-2006) can be traced to a much earlier date, these alternatives have emerged as reactions to the growing number of economical, legal and technical barriers to the potential of the peer-to-peer and uncontrolled nature of the Internet (Minar & Hedlund, 2001; Vaidhyanathan, 2004) as a public domain of knowledge and ideas (Lessig, 1999, 2002, 2004; Weber, S., 2004; Willinsky, 2006). In this context, OSS and OA are viewed as a “renaissance of the commons”, i.e., “a social regime for managing shared resources and forging a community of shared values and purpose” which constitutes “insurgencies” regarding the premises of the traditional free market doctrine (Clippinger & Bollier, 2005).

While they have different objects of attention, motivations and stakeholders, OSS and OA evolve around two major key points of the new culture of access: i) regulatory aspects, expressed in copyright terms and access licences; and ii) the technological infrastructure, tools and standards which support and populate the open digital information environment of the Internet.

Copyright/licensing is paramount to access issues because it frames the economics of both scholarly publishing (Willinsky, 2006: Chap. 5)<sup>5</sup> and software production/distribution (Smith, B., 2005).<sup>6</sup> New arrangements have emerged for copyright formulations of intellectual property rights as an alternative to the

traditional ones whose laws, e.g., the Digital Millenium Copyright Act, have expanded increasingly restrictive rules for control over resources in ways that unbalance the interests of both authors and public. Organizations such as the Creative Commons<sup>7</sup> and the Free Software Foundation<sup>8</sup> represent social structures of a copyright thinking that diverges from the conventional ideas about work and compensation. They provide licensing schemes that grant open access to resources while protecting author's rights to recognized authorship and integrity of their works, either software (Webbink, 2003; Fitzgerald & Bassett, 2003; Weber, S., 2004: Chap. 7) or other creative works (Willinsky, 2006: Chap. 3).<sup>9</sup>

The second key point common to OA and OSS is IT, i.e., the technological infrastructure provided by the Internet/WWW and collaborative software. For OSS, they are the enablers (Weber, S., 2004: 83-84) of new modes of production and distribution of software, largely based upon peer-to-peer networking among a loosely knit community of developers and making use of repositories such as SourceForge.<sup>10</sup>

Distinctive features of OSS development approaches are

“Unencumbered access to the source code [...] and development processes and procedures [that] do not follow organizationally mandated models [...]. Indeed [...] open source analysts explicitly contrast regularized management and oversight (what is called the ‘cathedral’ approach) with the more informal and ad hoc arrangements of open source projects (the ‘bazaar’)” (Souza, Froehlich & Dourish, 2005).

But, as noted by Weber, S. (2004: Chap. 3), while the ‘bazaar’

“does capture the feeling of an ideal type [...] it is analytically misleading. *The key element of the open source process, as an ideal type, is voluntary participation and voluntary selection of tasks* [...] which] is not just a free market in labour. There is no consciously organized or enforced division of labour [...]. Labour is *distributed* [...] but it is not really divided in the industrial sense of that term”(Ibid.: 62).

Distribution and loose co-operation are not synonymous with anarchy. In large scale projects such as Linux, Apache or Perl (Ibid.: 63, 92), developing and maintaining code is not anarchic. There are hierarchical and methodical procedures to review submissions and to decide upon changes for incorporation into the code. Here, beyond free open code, the access principle is “to lower the barriers to entry for individuals to join the debugging and development process” (Ibid.: 63);<sup>11</sup> that is to say, architectural principles and coordinating structures that are needed for

complex systems such as software are not absent even if they are not apparent a priori. They usually emerge from the structure of the work itself.

Weber, S. (2004: 71) described the community of participants in Linux as “an image of several hundreds of central members who do most of the coding, and several thousands of comparatively peripheral participants who contribute in more indirect and sporadic fashion”. Souza, Froehlich & Dourish (2005) analysed structures of OSS projects to show that they have patterns of interaction and participation inscribed into them, i.e., they demonstrate how module dependencies (the dependencies in structure of source code) can disclose participation dependencies and changes of authorship; and that such patterns can vary, in different moments of a collaborative project, including shifts between core and periphery.<sup>12</sup>

When the prevalent pattern, i.e., code structure and its corresponding coordinating structure, is not suitable to a participant, e.g., because his/her code patch is not accepted, a new project (a variation) may become a spin-off: the participant has the alternative, and the right, to take the core code, incorporate the patch and start a new OSS project. This is called “forking”, and for many this possibility is considered an essential part of the freedom in OSS (Weber, S., 2004: 64). This independence and freedom also underpin the “distributed innovation” which Weber, S. (2004: 232-233) sees in OSS because it is organized in networks that do not enforce a central control. As with the basic architecture of the Internet, “which does not know what it is carrying” because the intelligence is not at its centre, the innovation lies in the edges i.e., “functionally dispersed”.

“Innovation is incentivized and emerges at the edges; it enters the network independently; and it gets incorporated into more complex systems when and if it improves the performance of the whole” (Ibid.: 233).

With a rather different object, OA shares several of the OSS fundamental concepts and operational strategies described above, many of which derive from the technological infrastructure provided by the Internet/WWW and collaborative software. They have been essential for the emergence of the movement and for reaching practicable goals, i.e., the feasibility of OA main publishing mechanisms, open access journals and repositories/archives (Lamb, C., 2004; Prosser, 2004, 2004a). IT solutions to reduce costs through automating the publication processes, among other aspects by incorporating direct collaboration with authors, are enablers of OA business models that do not charge the reader.<sup>13</sup>

Accompanying the spread of the OA movement, is an increase in the offer of free open source solutions for the management of electronic journals and, especially, repositories/archives (Crow, 2004).<sup>14</sup> This is a particularly relevant point of connection between OSS and OA, as both emerge from ‘bottom up’ and are based upon communities of interest that are not market-oriented and that can contribute to one another’s objectives. The connection extends further to open standards for interoperability (Dewatripont, et al., 2006: Chap. 9) such as the OAI-MPH,<sup>15</sup> a protocol that features in most OSS institutional repository systems (see Crow, 2004), aimed at exposing/collecting metadata from different data sources, either repositories or journals, open or not. This, like OSS or freely available tools for reference linking based on open standards<sup>16</sup> that may be added to any system containing bibliographic metadata, extends the notion and practicability of enhancing access to literature by interlinking content from different publishing sources, whether open access or not.

The nature of OSS, as sketched above, shows some conceptual links with the trends highlighted in Chapter 5, e.g., composition and reusability of software systems. These features bring to distributed systems the agility, adaptability and mobility that OSS projects seek in their processes by having an open distributed community of developers. On the other hand, OSS also introduces social features that are common to processes underlying the generation of Web standards (see Section 6.3) such as those of the W3C, and technologies such as Web services (see Section 6.4.4). They combine dynamic processes based on voluntary participation with open access to results on the global network, and feature the possibility of points of innovation that are not dependent upon an unique central control. These are also aspects underlying OA, as a voluntary, distributed, non-restrictive and flexible strategy for sharing content which is heavily intertwined with the generation/deployment of the technologies it uses.

In both functional and conceptual terms OSS and OA are relevant to the second research question of this thesis and support the claim for enhancing IT knowledge in LIS. Combined, they provide an example of the growing intermeshing between IT and content, blurring the frontiers between the interests, needs, values and ‘knowledges’ of the corresponding stakeholders. This blur, also underlying other aspects analysed in the remainder of this Chapter, consists of “productive rearrangements” that are “fundamentally creative [...] not simply unintended consequences of the inevitable march of technology” (Kelty, 2005).

### 6.2.2 A space with two content and technical realities

The changes introduced with the Web environment are both about content and technologies. According to Ojala (1999), the world of online information went through a second generation with the Internet and a third, “dynamic” era with the WWW. A number of issues emerged for LIS and information management in general, as this dynamic era is

“characterised by a multiplicity of sources, various channels of communication, mutability both of information and of access to that information, and constantly changing definitions of even the most basic building blocks of information. What’s a journal? What’s a newspaper? When an electronic version differs from its printed counterpart, which is the ‘right’ one? [...] What’s a document? XML coding can change something information professionals wouldn’t consider as a document into a document. What’s an answer? Data mining, and its close cousin text mining, analyses data and suggests relationships. In the Dynamic generation of online, answers are not of the straightforward ‘two plus two equals four’ variety” (Ibid.)

Another aspect, noted by Abiteboul, Buneman & Suciu (2000), is that the Web became a space of two different worlds, with two distinct technical realities and cultures: the database culture and the culture of the WWW technology. They do not conflict but they are conceptually and technically different, and they represent information universes usually diverse. Even when they appear combined, as is the case with a database with a Web interface, they show clearly their differences, in terms of structure, scope, accessibility and permanence.

Database resources are limited in scope and content, and are highly structured, at all levels necessary for information management purposes: data syntax and semantics, relations, separation of layout from content, etc. There is a clear distinction between logical and physical levels in information structures. Information on the Web, namely in HTML, comprises unlimited sets of resources with very poor data structures mostly intended for layout and hyperlinks. A distinction between physical and logical levels hardly exists. Databases have mechanisms for maintaining integrity and consistency, as well as effective techniques for data storage and preservation, while on the Web resources have no structural relations, only hyperlinks, so there is no guarantee of information integrity and permanence.

Databases have efficient internal search services, optimized for their content, but database content is out of the reach of general-purpose Web search engines.



Accessibility of Web resources depends on search services that are external to them. These services vary between those that provide wide coverage and good recall, but bad quality and poor precision of the results provided (usually search engine fully automated services) and those that provide, organized and relevant results but are limited to restricted coverage (usually services based on human selection and indexing, or mixed solutions).

The trend in applying database concepts and techniques for tasks related to the management of information on the WWW was surveyed by Florescu, Levy & Mendelzon (1998), confirming the different nature of the two fields but also the usefulness of their convergence. For Abiteboul, Buneman & Suciu (2000), the convergence of the two cultures is needed, implying some shift in the paradigm of distributed systems, by which the simple client/server model is even more replaced by multitier architectures (Ibid.:4-5). But, above all, this convergence relies on improving the structure of information available on the Web, or through the Web, i.e., by overcoming the typeless nature of HTML/HTTP (Ibid.: 6-7).

Data types are a central issue for interoperability, because they convey knowledge about the data being dealt with and thus allow for querying and meaningful interpretations of results. Abiteboul, Buneman & Suciu (2000) provided six reasons for improving the structure of Web data: a) to optimise query evaluation; b) to facilitate the task of integrating several data sources; c) to improve storage; d) to construct indexes; e) to describe the database content to users and facilitate query formulation; and f) to proscribe certain updates (Ibid.: 122).

### **6.2.3 Intermediation services: separate approaches to integration**

Although hyperlinks can link between individual documents and information units of a database, neither the HTML nor the database worlds are served by a common technical basis which encompasses sound solutions for integration. Therefore, solutions for integrated access are still structurally separated. They are usually provided by third party services that use broker architectures for information database gateways and search engines or directory services for Web documents.

The Web integration of different databases or repositories of digital objects requires the construction of automated mediation services (Arms, W. 2000a: 155-156) that change the traditional client-server configuration into multitier

architectures. Intermediary solutions are added that have the function of transforming the data structures existing at the data sources into the structures needed at the client level, for example, HTML. In cases where a mediation exists to access several data sources with different data structures and functionalities, the service has to perform all necessary translations of the queries and of the results in order to 'integrate' them according to a single data model, the one that is rendered to the client, in a single search interface (Day, M., et al., 2000).<sup>17</sup>

While these kinds of service structures were not new, their number increased dramatically with the advent of the Web, especially to increase the availability of the so-called 'legacy' information assets, with particular impact on the government, cultural and educational information areas. Nevertheless, what they provide are solutions for integrating database resources that are structurally independent of the world of Web publishing, both in technical requirements and content coverage. On the other hand, the integration of any other types of resources available directly on the Web remains difficult because of the lack of common representation structures to be used by automated independent agents.

The capabilities of Web search engines have been continuously improved, with different methodologies and devices, from document information extraction (Adams, 2001) to automatically gathered context elements, e.g., from user queries, or by identifying categories of web documents or web communities (Lawrence, 2000), as in the case of link analysis (Henzinger, 2000). Various techniques have been developed towards reducing the randomness of resource discovery by search engines, and to minimize the lack of sources for consistent identification and description of Web resources (Kobayashi & Takeda, 2000; Cohen, W., McCallum & Quass, 2000).<sup>18</sup> However, all of them still face severe limitations that cannot be overcome by technology alone, if the resources themselves do not provide better conditions for more sophisticated automated processing (Callan, 2000), namely in terms of logical structure and semantic value.

The need emerged for solutions to enhance Web publishing with open standards capable of improving the architecture, the forms of data representation and even the data content about and within individual information objects (Berners-Lee, 1997-2000; 1998). Originally, the development of standards such as XML, metadata schemes for Web resources and specifications such as RDF emerged to address these needs. But the potentials of XML-related technologies and the value of the Web-

related market rapidly involved the industry and progressively gained ground in the traditional computer environment, i.e., the market of database supported information systems (see, for example, Abiteboul, Buneman & Suciu, 2000; Bourret, 2000-2005; Chaudhri, Rashid & Zicari, 2003).

### **6.3 Web standard developments to raise interoperability**

The most important, and comprehensive context of the new Web standards and related IT developments is that of the so-called ‘semantic Web’. The semantic Web is a vision where data on the Web - documents, their parts, and data held in databases - are defined, expressed and interlinked in a such a way as to enable automated processing not only for information presentation but also for other purposes such as functional integration and data re-utilization by different software applications. Thus, the semantic Web addresses the structure and meaning of data on the Web and its audience encompasses not only people but also computers (W3C, 2001-2004; Fensel, 2001; Dumbill, 2001; Berners-Lee, Hendler & Lassila, 2001; Ding, et al., 2002).

XML and metadata initiatives are the two major components of a large spectrum of technical specifications and collaborative efforts that have been raised in recent years to build the semantic Web, i.e., a Web that is thought to evolve by means of information architectures that should be expansible, flexible and conceived to enable interoperability. It is a new Web age that follows what has been designated as the “HTML cycle” (Berners-Lee, 1998-2000). According to Ding, et al. (2002), the semantic Web is in its early stages and encompasses a variety of different developments:

“We need languages for representing meta data, we need ontologies that link formal with real world semantics, and we need various tools and convincing application areas to keep the ball rolling” (Ibid.).

#### **6.3.1 XML: an open and neutral language to structure data**

Basically, XML appeared to overcome limitations of HTML in terms of structuring the data that constitutes Web documents. Such limitations derive from the restricted and non-expandable number of tagged elements defined and from the fact that HTML is mostly focused on the layout characteristics of documents (Bray, et al., eds., 2001-2004). Being essentially a publishing language, HTML has little to offer

for other purposes of automated processing, namely for search and retrieval of data in context, as it hardly allows the specific identification and description of documents (Connolly, Khare & Rifkin, 1997). First issued in 1998, XML rapidly became popular although its practical usage in WWW documents has not yet achieved intensive and generalized usage, as noted by Mignet, Barbosa & Veltri (2003), who presented the first study of the characteristics of the XML Web, i.e., the subset of the WWW that is formed by XML documents.

XML is usually presented as a cut-down version of the first markup language, Standard Generalised Markup Language (SGML) (ISO 8879: 1986), yet not so simple as HTML. Unlike these, XML refers not to a single standard but constitutes the core of a set of specifications, still under development, that address several aspects of functionality intended for Web documents and for the management of Web data in general. As a markup language XML is a textual representation of data defined by tagged elements in a more sophisticated and flexible way than HTML, but less demanding for program applications than SGML. While retaining the architectural principles of SGML, XML provides the basis for richer functionality, promising to fulfil what had been the SGML vision (Burnard, 1999).

From SGML it inherits the representation of detailed and meaningful document structures, making it possible for the document to describe itself within its content. As its name reveals, XML is extensible, meaning that tags can be specified as needed, and elements can be further developed into sub-elements and attributes, nested to arbitrary depth. Optionally, XML documents may contain, or be associated with, a description of their grammar (tags, sub-elements, attributes, etc.) declared in a DTD or in an XML schema.<sup>19</sup>

DTD and XML Schema definitions allow the same grammar to be applied to several documents or to be agreed within a publishing community with special interests or purposes. Thus, XML, is suitable for profiling without constraints. Furthermore, the availability of such grammars allows for document syntax validation, thereby preventing later unexpected document behaviour, as well as increasing the potential for automated processing of documents for many other purposes besides presentation (Bosak, 1997).

In respect to presentation, other XML constructs address another fundamental change regarding HTML: layout definition becomes independent of document structure. Layout can be defined in a separate file, formulated according to a set of

rules provided by other specifications, Cascading Style Sheet (CSS) (Lie & Bos, eds., 1996-1999; Bos, et al., eds., 2004) and Extensible Stylesheet Language (XSL) (Adler, et al., 2001). This reintroduces an important feature of SGML, the formal separation of style from content. It makes style interchangeable, which is again an issue of improvement for automated processing and flexibility, because the same document may be provided with more than one layout without affecting the document content itself, and the same layout rules may be applied to sets of documents.

Another component of the XML constructs important for interoperability is the Extensible Stylesheet Language Transformations (XSLT) (Clark, ed., 1999), which enables the writing of translation rules to and from XML. Because portability of data is a major concern for interoperability, XSLT became a very important tool for the transformation of structured documents into different formats, not only among specific XML formats but also in relation to other file structures. XSLT has been used, for example, as a tool more powerful than DTD for defining and processing MARC data in XML (Hough, Bull & Young, 2000; Carvalho, et al., 2004; Keith, 2004).

Other XML specifications have been developed for new capabilities in “addressing a resource, describing the linked resources and the relationship between them, processing and presenting the link resource” (Hemrich & Shafer, 1999). These are Xlink (DeRose, Maler & Orchard, 2001), Xpointer (Grosso, et al., eds., 2003, 2003a; DeRose, Maler & Daniel Jr, eds., 2002; DeRose, et al., eds., 2003) and Xpath (Clark & DeRose, eds., 1999). These are standards that support the generation and processing of typed links.<sup>20</sup>

Fundamental for XML data processing is the possibility to query XML data by means of a common language of the kind of SQL<sup>21</sup> used in databases. The advantages of this kind of tool for convenient and expressive access to data led to the development of XML query languages since 1998<sup>22</sup> (Abiteboul & Widom, 1998; Maier, 1998; Marchiori, 2001). XQuery is the query language being developed by the World Wide Web Consortium (W3C) (Boag, et al., eds., 2003). Formulated in XML, XQuery is aimed at expressing queries across many kinds of structured data, “stored in XML or viewed as XML via middleware” (Ibid.).

This brief overview of XML specifications is sufficient to reveal some of its potential advantages for automating operations on Web data and for bridging

between Web and non-Web data, notably between the WWW and databases (Bosak, 1997, Emmott, 1998; Abiteboul, Buneman & Suciu, 2000). The fact that XML consists of a language/format capable of representing complex structures in a non-proprietary and self-explanatory way, thereby being independent of platforms and applications, is important in many respects, from portability to preservation. Overviews of existing XML database products are provided by Bourret (2000-2004) and Chaudhri, Rashid & Zicari (2003).

The evolution of Web technology towards object-orientation is particularly important for the integration between the Web and database cultures (Manola, 1998). Beyond overcoming the typeless nature of HTML, XML and XML Schema provide for a representation of objects that is much richer and dynamic: it is possible to create data structures that can represent object behaviour (i.e., an ‘object state’ and the associated ‘object methods’). This means adding functionality to Web documents, with structured data that consists of programs to process them. Making such objects and methods available in a distributed way, by messaging mechanisms that can convey data types and object methods, dramatically increases the interoperability potentials of the Web environment (Sommers, 2002).

In this perspective, it is important to note the rise of XML specifications for programming. The Document Object Model (DOM) is a standard and neutral API to the structure of documents, allowing accessing and processing their content in a non-sequential way (W3C, 1997-2004). In particular, the development of SOAP and WSDL has introduced major innovations in automated network services called Web services (see Section 6.4). SOAP is an XML-based protocol for application-to-application messaging (Mitra, ed., 2003; Gudgin, et al., eds., 2003; Haas, et al., eds., 2003). WSDL is an XML format for describing network services (Chinnici, et al., eds., 2004; Gudgin, Lewis & Schlimmer, eds., 2004).

Changes in the architecture of distributed computing brought by these tools are highly significant for data and systems interoperability. Bray (2001) considered these changes the great potential of the so-called “generation X” in terms of distributed application architectures. Through XML tools it is possible to aggregate, transform and send portions of code from servers to Web clients to enable interaction with XML objects in a manner that is much more open and independent than the classic client-server solutions.<sup>23</sup>

### 6.3.2 Metadata structures

Metadata is an area that since the mid 90s has been attracting considerable interest. The relationship of metadata with the WWW is twofold. First, metadata is elicited by the need to cope with the discovery, identification and control of information objects in the heterogeneous and unbound network environment (Thomas, C. & Griffin, 1998). Second, new metadata standards devised for these functions are intended to be applied using Web languages and technology, notably XML (Dillon, M., 2000; Day, M., 2000).

Until it was highlighted by the Web environment, the term metadata was without great ambiguity in the field of database management, its original practical field (Jeffery, 1998; see also Section 4.2.3.3 Data interoperability). The most common definition of metadata being ‘data about data’ is rather poor and vague in the information management field at large, taking into account that what is usually meant is a set of information elements that identify and/or describe the resources they refer to for a variety of purposes. In the new context, metadata can be for many different functions, so there can be many different types of metadata.

In library and information related projects the three most commonly mentioned categories are referred by Caplan (2003: 3-5):<sup>24</sup> ‘administrative metadata’, which can cover many different purposes related to the life-cycle of the object (Hansen & Andresen, 2003; Medeiros, 2003; Cordeiro, 2004; Cundiff, 2004); descriptive metadata, for search and retrieval mostly, encompassing old and new metadata schemes, such as MARC, EAD, TEI, DCMES; and structural metadata, to represent the structure (parts, components) of a resource, be they hierarchical, linear or composite. In addition to these, Gilliland-Swetland (1998) presented other used qualifications of metadata: ‘preservation metadata’, i.e., administrative and technical metadata about state and actions concerning permanency; ‘technical metadata’, usually associated with behaviour of objects, namely digital objects, concerning formats and technical devices; and ‘use metadata’, i.e., use and user tracking, notably for rights management. A comprehensive definition of metadata was presented by Dempsey & Heery (1998):

“metadata is data associated with objects which relieves their potential users of having to have full advance knowledge of their existence or characteristics. It supports a variety of operations. A user might be a program or a person”.

Applied to the management, organization and retrieval of discrete information objects, metadata bears some overlapping with concepts of the bibliographic field. For most of the new metadata initiatives concerned with resource discovery, descriptive metadata is, in concept and objective, nothing very new: bibliographic and archival descriptions are essentially the same. This has made the concept fuzzy and the relationship between the traditional bibliographic community and the new metadata environment a complex matter, sometimes problematic (Heery, 1996; Gradmann, 1998; Brisson, 1998; Milstead & Feldman, 1999; Dovey 2000a; Younger, 2002; Campbell, 2004).

In general, what is problematic is the lack of a common understanding at a conceptual level, because of three major aspects: i) the concept of metadata is loose and often used with different and even contradictory scope; ii) the popularization of metadata comes associated with changes in the information environment that call for a re-analysis of traditional library goals and standards (see, e.g., Jones, Ahronnheim & Crawford, eds., 2002); and, finally, iii) metadata is used by a variety of professional communities with different perspectives and in different contexts (Dorner, 2004a).

Indeed, it is the context and functional purpose of the new metadata that is different from the forms and functional environment of traditional document descriptions, and this is the main reason that justifies the new terminology. In the digital publishing environment, 'metadata' means having information that describes a document or aspects of its management, inserted in, or simultaneously presented with, the document itself. The fact that both are in electronic form gave passage to the term 'data' over 'information' (as in 'reference information'). The goal is to enhance the electronic resource with data that enables better functionality in its interactions with external agents, human or automated. This is an essential aspect, whether for descriptive metadata or for other types of metadata, e.g., for rights management and control of use, or for document management and preservation.

#### **6.3.2.1 Descriptive metadata**

Unlike what is sometimes argued, what distinguishes metadata for the WWW from library cataloguing and archival descriptions, is not the extent, organization and accuracy of the information elements. Although these aspects are important, the



major distinction is functional (Berners-Lee, 1997-2000). Besides being machine-readable, descriptive metadata is information intended to be i) an integral part of the resource itself, from its origin; ii) supplied by the author, publisher or any other agent that makes the resource available online; and iii) it should also be machine-understandable by automated agents, for purposes of resource discovery, selection, search and retrieval, and management.

These three aspects of descriptive metadata for electronic online resources enable control functions that are synchronic with their online publication, in a way that is technically suitable for the Web context and for addressing the WWW information space in general. Access and control functions provided by third party information services such as libraries, are mostly diachronic regarding publication, as well as being selective, system-contained and aimed at a specific context that does not encompass the whole WWW or just the WWW.

Descriptive metadata initiatives were developed mostly since 1994 to address that problem of information discovery on the Web (Woodward, 1996; Cathro, 1997; Vellucci, 1998; Milstead & Feldman, 1999; Arms, C., 2000; Caplan, 2000) notably those issues identified with the so-called “engine crisis” (Arnold, S., 2000), i.e., the lack of logical and meaningful mechanisms to access information on the WWW. The resource discovery concept itself originated in the need to retrieve information from a pool of heterogeneous and distributed resources, i.e., an environment that is not an organized and bounded system (Lagoze, 1997; Proper & Bruza, 1999). But while there is the need to address the question of resource discovery in general, it seems unlikely that a single model or solution is feasible and able to address all needs of the different subject areas and Web communities.

In practice, there has been a proliferation of metadata models and specifications (see Gorman, G., ed., 2004) designed with different motivations and for different projects or domains. The Schemas Project (Schemas, 2000-2002) provided a European forum for guidance in all these new developments, with metadata watch reports, workshops and a metadata registry. Among the new developments Dublin Core <sup>25</sup> is noted for its role in international consensus and intended wide application. It was conceived to be domain independent, and to serve as an exchange element set among different metadata schemes (Weibel, 1997). DC is a set of 15 basic elements, plus qualifiers (DCMI, 2000, 2003-2004) most of them matching in very general terms the main elements of bibliographic description,

although in some aspects using a slightly different terminology, intended to be better understood by the layman i.e., the non-professional.

The main features of DC reveal the objectives of the element set: i) to be easy to use by anybody making resources available on the Internet; ii) to be flexible enough, as its elements are not prescriptive; iii) to be expansible, as it allows for the qualification of basic elements, therefore open to record more detailed information. In this sense, DC is suitable for profiling, i.e., for specific development and further definition for special communities (see, for example, CIMI, 2000),<sup>26</sup> without losing the compatibility with its basic version, thus ensuring a minimum of conditions for interoperability at the WWW global level (Weibel, 2000). Profiling, and documenting profiles is an important aspect of metadata (Baker, T., et al., 2001).

The basic consensus that DC represents was not, however, easily reached and discussions highlighted two opposite approaches (Weibel, Iannella & Cathro, 1997, Lagoze, 2000, 2001). One is the minimalist approach, or “search engine approach” (Miller, P., 1996), more focused on the need to improve the service of all kinds of fully automated Web search systems, seeking to maintain the original simplicity in order feasibly to generate a considerable critical mass of usage from the general Web publishing environment. The other is the structuralist, or “expert approach” (Ibid.), which is more professional, working with hand-crafted or semi-automated strategies, focused on more than just discovery and wanting to cope with other qualitative aspects of the management of information objects.

To each of the two approaches correspond tools for different levels of deployment, for example protocols such as the OAI-PMH<sup>27</sup> and Z39.50 respectively (this matter will be addressed in Chapter 7). Dempsey & Heery (1997; 1998) categorized metadata in three bands of different types of metadata schemes in terms of structure, fullness, domain specificity, professional requirements, associated search tools and status (Table. III-4, next page).

Both minimalist and structuralist approaches co-exist in metadata discussions and application, and not only concerning the DCMES. Besides the diversity of schemes and their flavours for resource description already existing before the Web, and even when these are not ignored as a possible source of inspiration, the fact is that the need to solve the problems of heterogeneity and specificity, by subject or other criteria, tend to multiply the number of standards, specifications or usage interpretations.

Table III-4 *Typology and characteristics of metadata formats* (from Dempsey & Heery, 1998)

	Band one	Band two	Band three
	(full text indexes)	(simple structured generic formats)	(more complex structure, domain specific)
	Proprietary formats	Proprietary formats	(part of a larger semantic framework)
		Dublin Core IAFA/WHOIS++ RFC1807	FGDC MARC GILS ... TEI headers ICPSR EAD CIMI ...
<b>Environment of use</b>	Global Internet search services Web indexing services Location	Selective Internet search services	Descriptions of scholarly collections; other important repositories
<b>Function</b>		Discovery; location; selection	Location; selection; evaluation; analysis; documentation
<b>Creation</b>	Robot generated	Robot plus manual input	Intellectual expertise required, often involving dedicated information staff
<b>Designation</b>	unstructured	Attribute value pairs; limited structure	Subfields; qualifiers; structured markup
<b>Associated search protocols</b>	HTTP with CGI form interface	HTTP with CGI form interface; directory service protocols (WHOIS++, LDAP) with query routing (Common Indexing Protocol)	Z39.50 SGML browsers and querying
<b>Status</b>	Proprietary	Emerging Internet standards	Domain specific standardization

In this context, ideas and efforts have been spreading in order to allow for metadata interoperability (Xu, A., 1997; Iannella, 1998; Borgman, 2000: 149) either among new or old metadata records, professional or non professional, and concerning both metadata for electronic and non-electronic information objects.

Consequently, activities to create conditions for data interoperability and portability, by means of mapping between formats and by data format/semantics registries, became also the order of the day.

### 6.3.2.2 Crosswalks and registries

Mapping among different metadata schemes produces the so-called 'crosswalks' (see Day, M., 1996-2002), i.e., formalized representations of correspondences between elements of different metadata schemes. Crosswalks became a basic concern for interoperability, undertaken especially by major metadata initiatives and metadata maintenance agencies. The difficulties of mapping show the

lack of common “terminology, properties, organization, and processes used by many of the metadata standards” (St Pierre & Laplant, 1998) and the issues that always arise from data conversion (Woodley, 2000). Mappings provide opportunities to expand knowledge about the portability of data and for seeking solutions for compatibility or compromise where conversion is not straightforward.

It is worth noting that crosswalks are not confined to new metadata formats but are also used for traditional formats such as MARC formats (Library of Congress..., 2001). This also stresses the strategic importance in providing for data conversion for federated services between library information management systems, other systems and/or the data embedded in information objects (Lynch, C., 1998c; Arms, C. 2000).

To enhance awareness of existing metadata schemas, there are also metadata registries (Heery, 1997; Heery, et al., 2000; Baker, T., et al., 2001; Polydoratou & Nicholas, 2001) of which DESIRE, ROADS and SCHEMAS <sup>28</sup> are examples. Registries are aimed at declaring the syntax and semantics of metadata schemes by making publicly available authoritative descriptions of their objectives, structures, rules of application, maintenance agencies, relationships with other metadata schemes, etc. Therefore registries can play an important role towards interoperability, as they contribute to the dissemination of existing standards, preventing useless duplication of effort and promoting inter-relationship among different metadata communities.

Metadata registries fit in the larger framework of promoting public and authoritative registries for ‘data languages’ and ‘data vocabularies’ that have been fostered internationally by ISO, notably through standards such as ISO/IEC 11179: 1995-2005 <sup>29</sup> (Newton, 1996; Nell, 2000; Bargmeyer & Gillman, 2000).

### **6.3.2.3 Concluding remarks**

With the WWW, the field of metadata structures was suddenly widened and new issues emerged, dealing with a greater heterogeneity of sources and underlying standards. The field of descriptive metadata is the one that has generated more impact in LIS because it relates to library core functions. The new issues relate to cross-domain search services and data interoperability in general. Possible solutions demand requirements that are not confined to a system, group of systems or domain,

as previously, and their feasibility depends on the interests and technical and economic motivations of a diversity of stakeholders (Thomas & Griffin, 1998).

However, unlike in the past, the interests and motivations are diverse and not always well defined. Essentially, metadata deals with the management of data, which is a field that lives upon standards. But in the case of metadata for the WWW context, the traditional standard approach (one solution for all) is not feasible, and useful standardization balance or harmonization is difficult to achieve (Caplan, 2000a).

The field has matured but continues to be fuzzy, complex and dominated by barriers of “obfuscation and specialist language” (Miller, P., 2004) that do not facilitate sharing and reuse of metadata among different domains and disciplines. This is true even for LIS, a field devoted to information management whatever the domain or discipline. For example, Polydoratou & Nicholas (2001) conducted a survey to assess the understanding of metadata standards and metadata registries and concluded that while metadata terminology was still diffuse, and the most frequent metadata schemes mentioned were MARC and DCMES, metadata registries were less familiar and relatively unknown in the LIS environment.

As pointed out by Gilliland-Swetland (2004), the trend in metadata standards is still towards diversity, and this stresses the sociological and political aspects of it, meaning, first of all, that there will continue to be tension and compromise between wide-scale solutions and the actual needs of particular domains. Particular domains (or any domain that is managed by a professional community) have strong motivations for requirements that are usually much more demanding than those defended for wide scale, cross-domain solutions. The practicability of the latter is therefore weaker, and only can show some return in the long term. For many in the professional realm, wide scale easy-to-use solutions like DCMES, do not live up to their promise and are seen as of very limited utility (see Dillon, M., 2003; Beall, 2004).<sup>30</sup>

As a wide scale solution for WWW discovery, there is as yet no sign of significant adherence to DCMES, despite its apparent simplicity. There are indications from recent studies that many search engines do not ignore DC metadata and that resources with DC elements may get higher visibility in search result lists (Zhang & Dimittroff, 2004, 2005). But, according to the study carried out by O'Neill, E., Lavoie & Bennett (2003) while the use of meta tags in Web pages is

growing (around 70% in 2002) there seems to be a “reluctance of content creators to adopt formal metadata schemes”.

“For example, Dublin Core metadata appeared on only 0.5 percent of public Web site home pages in 1998; that figure increased almost imperceptibly to 0.7 percent in 2002. The vast majority of metadata provided on the public Web is *ad hoc* in its creation, unstructured by any formal metadata scheme” (Ibid.).

On the other hand, DCMES is widely used to federate access to distributed resources in managed repositories or databases using different metadata schemes. This has been fostered by protocols such as OAI-PMH. But, as a cross-domain scheme with intermediate functions, DC lacks data portability, i.e., it is hard to convey data beyond the minimal (Andresen, 2004); otherwise it would require local extensions for specific data for which there is usually already a given domain scheme. Along with these disadvantages for domains requiring more specific data, other aspects have been criticised in DC that have contributed to discourage its implementations or make them inconsistent, such as imprecision of data elements definition and lack of application guidance (Caplan, 2003: 78-79, 86; Dillon, M. 2003).

### **6.3.3 RDF: an independent architecture for metadata**

As ‘reference information’, descriptive metadata may raise complex issues but they are not essentially different from those that are dealt with in bibliographic systems. Yet, there are novel aspects to metadata representation when it is not handled in a database but is part of, or associated with, the electronic resource, for availability on the Web. In this case metadata should be expressed in HTML or XML.

Descriptive metadata sets such as Dublin Core were originally developed to be expressed in HTML, using the ‘Meta’ element of the HTML version 2.0. In version 4.0, HTML was provided with additional attributes for the META element in order to allow for the representation of more specific meta-information, as the earlier versions were very simplistic (see Miller, E., 1996).

Nevertheless, several limitations of HTML remain with regard to identifying clearly different metadata schemas, relations among metadata elements, authoritative metadata element sources, etc., that do not facilitate the full

understanding and usage of metadata. On the other hand, simply embedding metadata as part of a general and variable structure in XML cannot support all the requisites for efficient metadata deployment (Berners-Lee, 1998a; Bray, 2001a).

The Resource Description Framework (RDF) (Beckett, ed., 2004; Manola & Miller, 2004)<sup>31</sup> was designed to answer these needs. It is a specific application of XML that establishes a data model and syntax for the accommodation of metadata that is independent of any particular metadata syntax and semantics (Miller, E., 1998; Brickley, 1999-2001). RDF consists of a set of specifications which encompasses two major layers: a data layer, which is mostly a generic data model and syntax (RDF); and a schema layer (RDF Schema), which extends further the basic modelling features of RDF in order to express all needed features of vocabularies (Broekstra, et al., 2000).

The first layer, data model and syntax, is the RDF itself (Klyne & Carroll, eds., 2004; Beckett, ed., 2004) and provides a generic mechanism for expressing machine-readable metadata in a syntactically standardized way. It is a neutral mechanism that ‘simplifies’ the architecture of metadata, as it functions as a purpose-built metadata container,<sup>32</sup> distinguishing metadata from the data that forms the resource itself. In this respect, RDF provides for ‘accommodation’ of any kind of metadata – in a very rough way somewhat comparable to the function of ISO 2709<sup>33</sup> for the transport and readability of records in different MARC formats, thus facilitating their co-existence and automated processing.

RDF provides not only the syntax for metadata elements and their attributes, at different levels of granularity, but also the linkages of these with external sources that authorize or give additional information about them. RDF can be applied to any type of metadata, for any purpose, appearing to be particularly suitable in what concerns the descriptive metadata, which can be quite complex. The data portability provided by RDF, as a common syntactic model, will enable the reuse of differently structured metadata about the same object, among different communities for different purposes. An example could be the interoperation between the traditional model of bibliographic information, Dublin Core and those of the publishing industry (Bearman, et al., 1999).

The second level, provided by the RDF Schema (RDFS) specification (Brickley & Guha, eds, 2004) is a semantic extension of RDF designed to allow representation of the structures and constraints of actual vocabularies used in

metadata statements. The language uses a class and property system that, although showing some differences,<sup>34</sup> can be considered to be of the same kind of object-oriented programming languages such as Java. RDFS is thus the mechanism whose features allow the declaration of vocabularies, i.e.,

“the sets of semantics property-types defined by a particular community [...] as well as any characteristics or restrictions of the property-type values themselves” (Miller, E., 1998).

In other words, “RDF Schema provides a *type system* for RDF” that applications can use to interpret and process data (Manola & Miller, eds., 2004: 5.3). Thus, RDFS features open the possibility to convey more ‘intelligence’ about metadata than RDF alone. The enrichment of RDFS with further capabilities, e.g., defining cardinality constraints, is a future target. This level of specification is usually addressed by the so-called ontology languages, most of them closely related to the developments of RDF and part of the projects that concur to the semantic Web movement (Manola, & Miller, eds., 2004: 5.5; see also Broekstra, et al., 2000).

Manola, & Miller, eds., (2004: 6) provide an overview of RDF actual applications. Among other, these include: encoding of Dublin Core metadata in Web resources, the PRISM (Publishing Requirements for Industry Standard Metadata) specification (IdeAlliance, 2001-2005) developed for the serial publishing industry to meet requirements of resource discovery; rights tracking and reuse of metadata along the pipeline of publishing production; the XPackage specification (Wilson, G., ed., 2003), a framework to define structured groups of resources (e.g., an XML document and its images); and the RDF Site Summary (RSS) specification, a “lightweight multipurpose extensible metadata description and syndication format” for news feed (Bege-Dov, et al., 2000-2001).

The cases cited above show how RDF can deliver advantages for usage by agent technologies, i.e., applications that interact with different distributed sources “to perform tasks autonomously without constant communication with the user” (Lassila, 1998). The advantages of RDF for automation, portability and reuse of metadata, dealing at the same time with two fundamental aspects of the semantic Web, vocabularies and technology, have been recognized in specific domains such as that of learning environments (Nilsson, 2001).



#### **6.3.4 Beyond structure and syntax: issues about metadata content**

In theory, the usefulness of metadata provided as part of, or closely associated with the electronic resources on the Web, is undeniable. In practice, much ground has yet to be covered before there is sufficient critical mass of available metadata in order to assess the effects of its application, at the level of a community or of the whole WWW.

XML, metadata element sets and RDF are fundamental pieces of the gearing of semantic interoperability, by adding value to the bulk of poorly structured Web resources. They are technical architectural elements very important to the feasibility of the semantic Web, yet they alone cannot solve the issues of adequacy, quality or interoperability of metadata content. These are aspects that depend upon the policies, methodologies and practices that are built and consolidated by different communities according to their objectives and requirements.

For example, MARC formats, although they reflect in their structures general needs expressed in information models such as the International Standard Bibliographic Description (ISBD) and the Anglo-American Cataloguing Rules (AACR), do not ensure by themselves much more than ‘mechanical’ interoperability – the syntax part of the data language. This is either because different policies for data content may be adopted within the framework of the same information model, or simply because policies and rules of a given information data set are subject to interpretation and many decisions depend on human discrimination.

The development of qualifiers for Dublin Core (DCMI, 2000) and its further specifications, or profiles for particular communities, are examples that highlight the fact that agreements on models of information are not easy, that they permeate the data modelling but are not confined to it. And that a data model that is simple and not supported by further intellectual and organizational factors will provide only for simple functionalities and will only fill simple interoperability requirements. The profiling activities upon general standards themselves make the case that simple functionalities and simple requirements are not always sufficient.

While the agreement on the data structures is the essential point to enable data interoperability, it is its articulation with data content that can – or cannot – realize it. The overall success of cross-domain metadata initiatives depends on a wide variety of metadata producers, with a wide variety of motivations, concerns and skills that

will be reflected in the variety and quality of the metadata content they provide (Vellucci, 2000). The range of problems that this raises in the WWW environment is not different from or less difficult than those already well known concerning semantic interoperability in the world of database systems. On the contrary, such problems are scaled up to unknown dimensions, more diverse and complex, because they are not confined to known technical and organizational frameworks.

So far, most attention in metadata initiatives has been focused on information models and data structures, old and new, on establishing crosswalks among them, and on providing authoritative sources for their use and maintenance. Although more difficult, the level of data content should follow the same path. That is to say, there is need for common conceptual models that can apply to the understanding and structuring of different content (i.e., metadata values), and a common means to enable systems to use their different representations interchangeably. These desiderata should be addressed by trusted and maintained metadata sources.

In this respect, there is a growing need for available, accredited and shared representation tools, notably vocabularies. This is an area which encompasses assets such as library authority files, subject indexing languages, classification systems and other kind of tools aiming at intellectually unified and organized representations of real world entities, concrete and abstract, like ontologies, taxonomies, nomenclatures, etc. The needs raised by the WWW environment and the development of digital libraries, have suddenly expanded this field from professional information management to many other areas of academic and professional activity, in a way that is not without lack of professional communication and understanding (Soergel, 1999).

While a lot is expected from libraries in this respect (Hodge, 2000), the library field itself still has a long way to go to achieve considerable internationalization of their metadata content tools despite the experience and relevance of existing online library cooperative programmes and projects in this area (Cordeiro, 2003, 2003a). In general, the communication and transfer of professional content metadata tools from their original professional communities to the wider communities interested in them is not easy for different kinds of reason.

One is the difficulty of transferring the conceptual knowledge underpinning those tools, which is often not explicit and, when it is, uses particular domain languages that are usually unfamiliar to a widespread audience. The other is the slow

pace in coping with new technological possibilities and trends from the part of the systems supporting such tools (see, e.g., Cordeiro & Slavic, 2002; Slavic & Cordeiro, 2004, 2005).

All these questions contribute to the overall sense that the practicability and the balance between the desirable quality and functionality of general-purpose metadata structures such as Dublin Core are, at the level of the whole WWW, very difficult to devise and foresee (Caplan, 2000). The tension between “tailoring vs. interoperability” (Borgman, 2000: 152) will remain and is one of the current challenges for open distributed systems. The challenge is how to cope with open-ended objectives, because “where limits are not set, objectives cannot be measured, and if they cannot be measured they are unrealistic” (Svenonius, 2000: 23).

This stresses the acknowledgement that, unlike a library, an information gateway or a digital library, distributed or not, the Internet and the WWW are not designed and managed as ‘a’ system, i.e., they do not fit into the classic paradigm of information management. However, the evolving components of Web technology show that interoperability issues in the WWW are not so different from the technical point of view. Thus, in the architecture thought for the WWW (Berners-Lee, 2000), one can find the progressive development of layers of formalization (Fig. III-23) that also exist in a bounded information system. Notably, beyond the base technical standards that makes the Web operational, there is need for ontology support, knowledge representation constraints, data authorities and rules, all aspects that, by definition, are context-dependent.

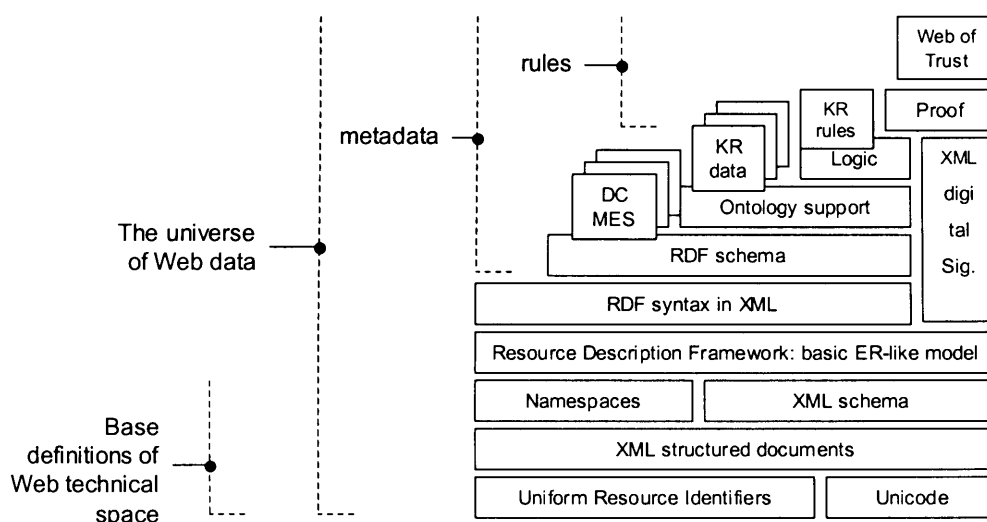


Fig. III-23 *The growing formalization of the Web architecture*  
(adapted from Berners-Lee, 2000)

## **6.4 Changing models of interoperation: Web services**

Among the numerous developments of the WWW technology, Web services are of special significance for bringing new ways to build interoperability solutions and for contributing to the blurring of frontiers between the WWW and the world of databases. ‘Web services’ are a set of technologies and standards for interoperability that especially address the characteristics and potentials of the Web environment, making it possible to share code, data and services among different systems on the basis of an independent platform, i.e., based on Web standards.

### **6.4.1 Major characteristics of Web services**

Web services emerged among many other Web technological developments in a cloud of vague definitions and some confusion. One reason is because of Web services being “poorly named” (Bloomberg & Schmeltzer, 2002), as the term can be used equally to refer to any service a provider makes available on the Web, from simple Web pages to Web accessible databases or code. Actually, in the more general sense, all of such services use the very same base Web standards, such as HTTP and XML. But Web services have a particular and distinctive nature: they are application-oriented services, i.e. they serve application-to-application processes (W3C, 2001-2004a). The notion of ‘service’ is of special importance in this context as it refers to the task (a functionality or a set of functionalities) that is provided by a network addressable software component, on behalf of another system, application or component that sends a call to it.

#### **6.4.1.1 Application-oriented services, based on mainstream Internet standards**

A Web service can be defined <sup>35</sup> as an application-oriented service available on the Internet using a standardized messaging system that is not tied to any particular operating system or programming language, since it is conveyed using XML and a Web protocol such as HTTP. Such messaging systems make portions of code needed to exchange information between applications easily readable and reusable by any other system, as they are transmitted in a universally standardized and independent language.

Being application-oriented is, thus, the first characteristic that defines Web services. From this perspective, Web services add to an application-centric view of the Web, as opposed to the most common human-centric view, where requests are primarily initiated by humans using Web browsers (Cerami, 2002: 5-6) thereby contributing to facilitate Web automation, one aspect fundamental to the semantic Web movement (Berners-Lee, Hendler & Lassila, 2001; W3C, 2001-2004).

Being based on Internet mainstream standards is what makes the difference and the potential of Web services, when compared to earlier interoperability frameworks (Bloomberg, 2001; Ogbuji, 2002; Stal, 2002). This aspect highlights the idea of the Internet as a computing platform in itself rather than simply a data transport mechanism (Carpenter, 2003). As a computing platform, the Internet offers a truly open environment: Web services build on standards that are platform independent, vendor neutral and make use of lightweight communication technologies (XML, SOAP<sup>36</sup>, WSDL<sup>37</sup>, HTTP) (Fig. III-24). Therefore, it becomes easier to cope with a large world of systems heterogeneities. Furthermore, compared with earlier computing environments, the Internet offers increased ubiquity: Web services can be wherever the Internet is.

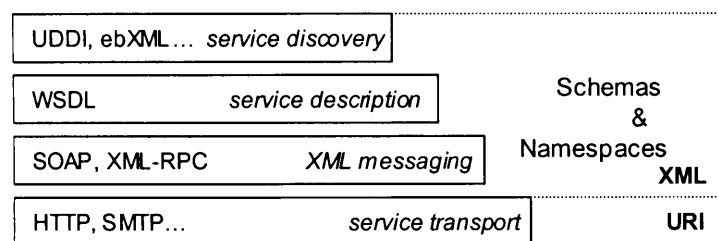


Fig. III-24 Major components of the Web services stack

The standards specific to Web services convey other fundamental characteristics. These are: i) 'self-description', i.e., Web services are described in an XML standardized language (WSDL) used to specify the public interface of a service (information about functions available, data types, binding information concerning the protocols to be used and address of the service); and ii) 'dynamic discovery', meaning that Web services are published in publicly available registries (UDDI<sup>38</sup>, ebXML<sup>39</sup>), so they can be found and used at any time.

Altogether these characteristics and constituents of Web services can lower the barriers to application integration, by making it easier to discover, access and use

remote applications and data, in ways that overcome some important costs and limitations usually implied in building interoperability services. They are not constrained by agreements about a particular technological environment for interoperations, characterized by distinct functionalities and different address spaces, as it has been to date with, e.g., DCE-RPC, CORBA, DCOM and RMI technologies (Bloomberg, 2001) which are based on standards that create proprietary environments (see further information on this aspect under 6.4.2.1).

#### 6.4.1.2 Main properties, model and advantages

In terms of main properties, Web services are usually defined (Bloomberg, 2001; Bloomberg & Schmeltzer, 2002; Cerami, 2002) as encapsulated, loosely coupled and contracted. Because Web services are encapsulated, loosely-coupled and contracted, they allow the circumvention of a lot of the expensive a priori knowledge and fine-tuning work among peers, needed to put different application systems to work together. These properties, along with the above-mentioned standards, define the agents, roles and operations that make the Web services basic model, depicted in Fig. III-25.

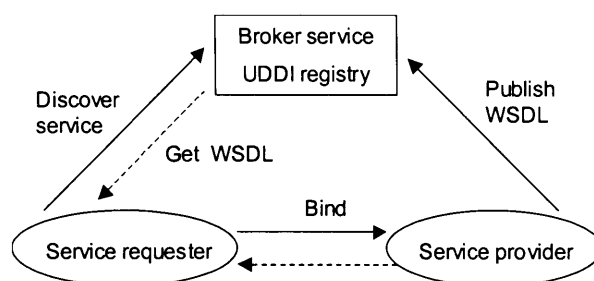


Fig. III-25 *The Web services model*

‘Encapsulation’ is a property inherited from object-oriented architectures, meaning that a Web service implementation is hidden from the outside and known only from its interface. Thus, the technology underlying the functionality provided is separated from, independent of, and can be ignored by, any system consuming the service. Being ‘loosely-coupled’ means that the interoperation mechanisms are such that Web services can be changed without requiring changes on the part of consumer services; the invoking services (consumers) can be independently changed as well. This is a major advantage in terms of flexibility for distributed applications, because interoperability can exist in an ‘unmanaged’ environment. Finally, being ‘contracted’

signifies that the service is described with all that is needed, i.e., is made available ready-to-use by any consumer system that get access to it. Access rights to the service can be controlled by the service provider.

All these characteristics bring advantages for interoperability, as they open the way for greater flexibility and reusability, meeting the objectives defined by the *Web Services Architecture Working Group*: a modular architecture based on XML, platform independent, simple, decentralized and extensible, i.e., providing for interoperability without a central authority and supporting a combination of several services without the need for third party agreements and a priori knowledge of each other (W3C, 2002). Examples of Web services applications are provided by He, Haas & Orchard (2002-2004).

A high degree of flexibility is possible by having the possibility of building integration at runtime, whenever providers/consumers do not want to, or cannot, control the technological environment of each other. As the code to access and use a given Web service is written and maintained by the service provider, it can be reused at any point by any other system requesting it, without the need for consumer systems to take it into account at its design stage. This is also true of the business environment: a given Web service provided from a system within a given business domain can be invoked and used by a system in any other domain, in ways easier than the traditional solutions.

The advantages of reusability come not only from the fact that code is produced once and used many times. There are other important benefits in terms of IT management and costs. One is that the technical expertise underlying the functionality of a given Web service is not a concern of the consumers, thereby allowing people with less expertise to assemble software solutions; another is that providers can continue to make use of whatever prior technologies they have without being isolated, as they can provide them with a front end of Web services.

Furthermore, the advantage of reusability is not only about software development. As data and information can more easily be exchanged across a growing number of independent and disparate information systems, one practical benefit of Web services is the possibility to combine more easily data from various sources. This increases the value of data assets, and is especially relevant in the case of the so-called legacy databases; or of databases pertaining to a specialist domain

for which a considerable technical detail about their data structures has to be known as with bibliographic databases, for instance.

## 6.4.2 Major changes introduced by Web services

Two main aspects should be noted in terms of changes introduced by Web services: technical issues that really make interoperability much easier and less costly; and a new model for distributed applications interaction.

### 6.4.2.1 Technical background and innovative aspects

Web services are essentially a new generation of distributed computing that build upon previous technologies, notably on the experience of electronic data interchange (EDI), DCE RPC, and more recently, on object-oriented middleware frameworks such as CORBA and DCOM. Some concepts fundamental to Web services, such as message-passing, encapsulation and interface definition language, came from these technologies. Ogbuji (2002) provided a timeline for this evolution, shown in Fig. III-26.

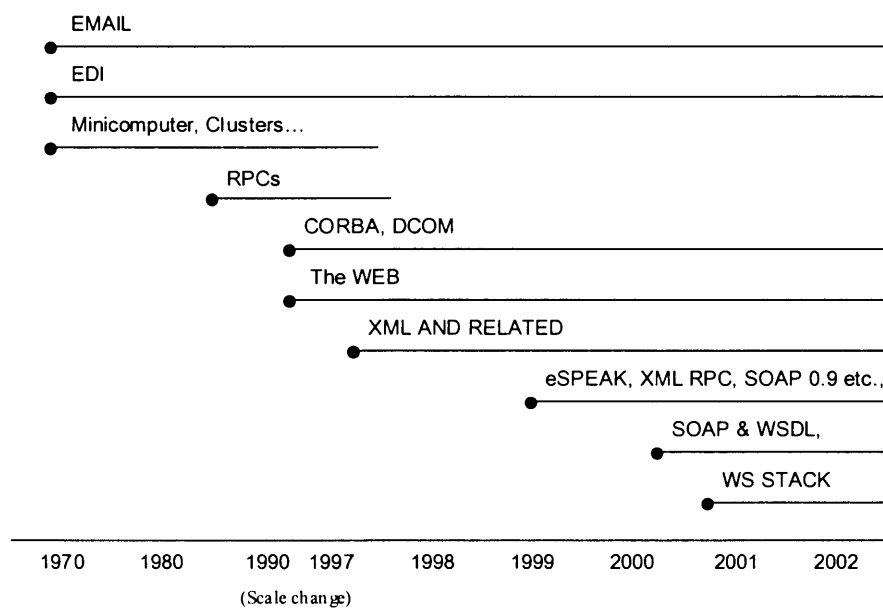


Fig. III-26 *Web services in the evolution of distributed computing* (from Ogbuji, 2002)



EDI provided earlier experiences with using Internet protocols and XML for application interoperability, taking advantage of already existing mechanisms and standards for business interchange, and leading to ebXML. XML-RPC, SOAP and WSDL specifications started as initiatives of individual companies that later merged their efforts in the context of the W3C (Ogbuji, 2002). On the technical side, Bloomberg (2001) compared earlier middleware systems with Web services, as follows (Table III-5):

Table III-5 *Web services: a comparison with prior technologies* (from Bloomberg, 2001)

RPC Architecture	Payload parameter value format	Endpoint naming	Wired protocol	Interfaces
CORBA	CDR (Common Data Representation)	IOR (Interperable Object Reference)	IIOP (binary)	IDL (Interface Definition Language) Inherited from COM
DCOM	NDR (Network Data Representation)	OBJREF	DCOM (binary)	
RMI	Serializable Java Objects	URL	JRMP (Java Remote Method Protocol)	Java Interfaces
Web services	XML	URL	SOAP (text-based)	WSDL

Technical advantages of Web services highlighted by Bloomberg (2001) are: i) being text-based, universally understood standards (the value brought by XML) while any other RPC architectures use specific formats of their own, sometimes not easy to translate to other environments; ii) the use of URLs for naming communication endpoints, which greatly simplifies the process, this being also the case with Java RMI, but not of CORBA and DCOM that use different endpoint naming conventions; iii) while prior technologies use binary protocols, which are less Web friendly, SOAP being text based is easier to debug and less problematic with firewalls; iv) Web services are not connection-oriented and tightly-coupled like prior technologies, and can interact either via synchronous request/response patterns or, more frequently, using asynchronous mode.

#### 6.4.2.2 A new model for distributed applications interaction

With Web services the design of distributed applications is not constrained by temporal decisions. There is a range of different integration options, from binding

Web services at the design stage to discovering and binding at runtime, i.e., the so-called ‘just-in-time’ integration that, as noted by Bloomberg (2001) was never feasible before. This means a transformation from the

“client/server-based applications to the delivery of more precise application logic exposed as modularized Web Services that can be created, published, discovered, and invoked on the fly” (Eisenberg, 2001).

According to Carpenter (2003), there is an increasing distribution of processing and a decrease of the client-server star-like topology of current systems. This transformation is represented in Fig. III-27.

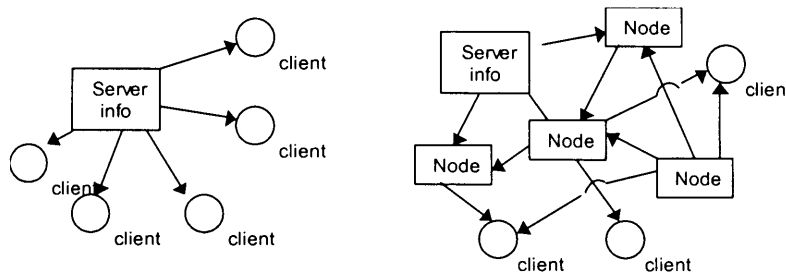


Fig. III-27 *The shifting model of computer interaction*

The changing model of network interactions also modifies the roles among peers, which become diversified and more interchangeable. In the new model, clients and servers can be on the same machine and a node can be just an integration instance that combines paths to information from various sources. Web services fit partially in the concept of ‘recombinant computing’ – a concept supporting a kind of ‘serenpeditous’ interoperability, where devices and services can be arbitrarily combined with, and used by, each other with only very restricted prior knowledge (Edwards, W., et al., 2002).

As an integration technology, Web services can function as ‘adapters’, i.e., as solutions to access, transform and transfer data among heterogeneous systems that have to process it in different stages of a flow. Therefore, they can be considered part of the so called “flow technology” (Leymann & Roller, 2002). Information processing becomes more widely distributed and interoperability also becomes decentralized (Layman, 2001), multi-party and multi-domain, in an essentially dynamic mode of collaboration (Sedukhin, 2001).

### **6.4.3 A new philosophy for distributed applications**

Beyond transforming the current client-server model this trend can also have a significant impact on application systems architecture. The possibilities for building nodes for dynamic aggregation of Web services not only reduce development costs but also facilitate interoperability by simplifying the assemblage of distributed software components. Other complexities, e.g., at the level of modelling and semantics are, however, stressed by this different philosophy for the design of distributed applications.

#### **6.4.3.1 The emphasis on service-oriented architectures**

The trends identified above have particularly emphasized the importance of service-oriented architectures (SOA): software architectures based on the principles of encapsulation and composability, i.e., increasing in modularity and containing smaller and more focused distributed and reusable, service components (Burbeck, 2000; Stevens, 2002). Service-orientation, based on encapsulation and composability, was already present in object-oriented middleware, using frameworks such as CORBA and DCOM, but it was essentially in a static, purpose-oriented and complementary approach. With Web services, taken in their dynamic nature, the notion of SOA becomes more central in applications' design. From this perspective, Web services can support "demand-driven dynamic business processes" which allow the increase in systems and businesses adaptability (Sedukhin, 2001).

Adaptability is closely connected with business systems agility, i.e., according to Bloomberg, the ability to manage change and changing businesses environments, in a proactive manner. Business agility depends on efficient integration and SOA responds to these needs. In this context, a service-oriented architecture and management will need to compose fine-grained atomic Web services into coarse-grained business services, in order to manage instances of simple and complex services as well as ensure different aspects of the quality of service they provide (Bloomberg, 2002, 2002a).

In practice, this means that Web services should not be taken in just a 'mechanical' approach, i.e., simply applied to whatever functional objects at any level of granularity they can be as discrete objects. This would only increase network

traffic, and possibly would disaggregate business logic, whenever a given function is made of many pieces of fine-grained functionality (Frankel & Parodi, 2002).

In order for Web services not to remain islands, they should serve a holistic approach to integration similar to that which enterprise application integration (EAI) products envisage, though reaching further in adaptability than these proprietary solutions (Stal, 2002). In sum, Web services potentials should not be considered just in a tactic “band aid” approach (Fisher, 2001)<sup>40</sup> but with a long-term goal. This demands an analytical framework where the consistency of a given business function, or its transformations, is to be retained in a coherent, robust and scalable manner.

#### **6.4.3.2 The importance of modelling**

Web services allow the compositions of primitive functionality, thereby asking for design and architecture at a higher level. This is essentially about modelling rather than programming: if processes of a given business function can be improved with Web services, they should be redesigned. Hence the need to underline the importance of modelling: modelling businesses with Web services, and modelling Web services themselves, as building blocks used to rethink an existing information architecture, to transform or expand it (Bloomberg & Schmeltzer, 2002).

Moreover, if some kind of formal approach and tools, e.g., UML, are used for modelling Web services, coherence is not only more easily attained but it also can be easier to generate and manage complex implementations (Frankel & Parodi, 2002). This modelling requires more than UDDI, WSDL and SOAP, because there is the need to cope with the automated sharing of business processes’ definitions and their underlying semantics. These should be formalized in ways understandable by a variety of systems.

In this context Fensel & Bussler proposed an analytical framework named *Web services modeling framework* (WSMF).<sup>41</sup> It is a conceptual model for developing and describing Web services’ compositions, aiming at forms of automated support for finding and comparing vendors and their offers, and for dealing with numerous and heterogeneous data formats and business logics. Two complementary principles are defined for the framework: “maximal de-coupling” of

the various components that realize an application, and a “strong mediation service”, enabling any system to speak to another system in a scalable manner.

The main elements of WSMF are: “ontologies”, to provide formal semantics; “goal repositories”, to define objectives that a client may have for using the service; “Web service descriptions” and “mediators”. The last introduce the need for modelling various mediation services that may be used by a given service in responding to a given request before it can provide its functionality, i.e., translation of data structures, business logics, message exchange protocols and also dynamic invocation of other Web services (Fensel & Bussler, 2002).

### 6.4.3.3 The increased need of explicit, standardized definitions

The rationale of WSMF includes the recognition of eight different layers of issues that need to be addressed in order to achieve automatic Web service discovery, selection, mediation and composition into complex services (Table III-6).

Table III-6 *Type of issues in Web services composition* (adapted from Fensel & Bussler, 2002)

Document types	description of document contents, exchanged in a given interaction
Semantics	ontologies and vocabularies that support correct understanding of the content of document types
Transport binding	definitions of the layout of the message, according to the transport mechanism used
Exchange sequence definition	definition of a sequence of acknowledgement messages, to ensure that a given message is transmitted only once
Process definition	the business logic in terms of the business message exchange sequence
Security	methods of encryption and signing needed to provide integrity, privacy and authenticity of messages
Syntax	the syntax in which documents are exchanged
Trading partner specific configuration	adjustments needed before any cooperation takes place, when requestors and providers implement their business logic differently

For Fensel & Bussler (2002),

“current Web service technology scores rather low compared to these requirements. Neither UDDI nor WSDL add any support to in the terms enumerated above”.

In addition to the basic Web services' standards many other have been developed to cope with some of the above aspects. Examples of languages for process and exchange sequence definitions include WSFL, XLANG, ebXml BPSS, BPML and WSCL (Fensel & Bussler, 2002; Fletcher & Waterhouse, eds., 2002: Chap. 10).<sup>42</sup> Especially since 2000, a vast multiplicity of new XML specifications has been developed to support many different levels of formalization that Web services demand to support actual and useful implementations, in a given domain or business environment, with the necessary level of automation.<sup>43</sup>

Such specifications emerge at a rapid pace and exist in various states of completion, in many cases showing overlapping efforts, dispersal and contradictory effects. They have also a great variety of sources, fueled by many different motivations: individual software companies, company joint-ventures and industry groups, researchers and standards organizations. They range from the most simple syntax aspects to the semantic level, including architectures, distribution and management features, orchestration of complex aggregations of Web services, and identity and security.

All this ongoing movement of specifications development underlines three important aspects: i) the Web services model is perceived, and pursued, as having a strong potential for driving the future of IT and for enabling important business changes; ii) the public standards-based approach is the cornerstone of Web services and has laid the foundation; but, iii) a lot of standardization has yet to be developed to fill the actual needs of interoperation, beyond the basic Web services stack.

The field of EDI <sup>44</sup> is perhaps the best to illustrate the range of problems that are not solved just by the basic Web services standards. According to Kotok (2002), it is this sharing of business processes definitions and terminology, relying on more than twenty years of experience that explains the fact that previous EDI standards will not simply disappear in face of Web services. They not only define the syntax for exchanging data but also the business semantics, in the sets of messages exchanged between trading partners. Besides, each industry uses terminology codified for its own purpose, which makes merging information between two different industries using EDI difficult. While in its early days XML held a promise of more flexibility for exchange of different EDI terminologies, it also became a curse, with a proliferation of industry-specific and incompatible business semantics.

ebXML<sup>45</sup> brought some solution to these problems: common cross-industry business processes were identified and a Business Process Specification Schema (BPSS) was defined. At a more detailed level, ebXML defines core components addressing semantic interoperability for data items, so as to overcome different data items naming used by different companies; i.e., core components are a way to bridge individual terminologies.<sup>46</sup> In between these two levels a framework for assembling data items into messages was needed, in order to provide e-business exchanges with a predictable structure. Such a framework was developed by the ANSI Accredited Standards Committee (ASC) X12; it is a reference model (ANSI ASC X12, 2002) built on ebXML core components and mapped to the current EDI X12 standards (Kotok, 2002).

#### **6.4.4 Web services: an enabling technology for business changes**

It is generally acknowledged that Web services are in their early stages and real wide scale deployment has been slow (CBDi Forum, 2002; McKendrick, 2002), in part due to the lack of features for security essential for business-to-business (B2B) transactions, with the market growing especially in training and consulting on architectures (Mayo, 2004). On the other hand, there is already a large share of open, non-proprietary, Web friendly and freely available standards on which to base Web services, as well as sophisticated and easy to use tools such as *VisualStudio.NET* and various other SOAP/WSDL toolkits to make it easy to turn Web services into practice.

As noted by Fletcher & Waterhouse, eds. (2002: 2-5) Web services are not a strategy in their own right. While it is recognized that they can drive integration costs down (Duden, 2002) they also raise strategic and structural imperatives, because they elicit new roles, functions and opportunities. This is true not only for networked businesses in general (Aoyama, et al., 2002; Bloomberg & Schmeltzer, 2002; Fletcher & Waterhouse, eds., 2002) but also for the management of institutional information environments (Dovey, 2001; Jacobson, 2002; Lorenzo, 2002).

Web services technology will probably have a significant impact on information integration within large organizations that still hold a range of diverse application systems running independently. Beyond application integration, Web services can provide ways of unlocking legacy data, without the heavy cost of having

to change legacy code and data structures. This is especially important in cases where major investments, in the style of EAI solutions, are not possible. EAI solutions themselves will eventually become Web services enabled (Samtani & Sadwani, 2001; Bloomberg & Schmeltzer, 2002; McKendrick, 2002; Stal, 2002).

Furthermore, Web services technology will be especially important in functions that need to expand the information integration capabilities beyond the internal boundaries of organizations and across the Internet. Web services are a new trend in data federation and distribution (Jhingran, Mattos & Pirahesh, 2002) that can enhance the value of existing data assets along with the growing market for third party automated information services. Federation of Web services can integrate functions executed externally with functions of internal database systems, all pertaining to the same business process (Haas, Tin & Roth, 2002).

Most often, new business opportunities enabled by Web services are exemplified with B2B integration, such as retail services and transactional intermediaries that handle the movement of payments, especially attractive for companies that do not use already classic EDI solutions. But while these areas still await Web services maturity that can ensure the quality of service and security, other areas of activity can benefit from early experience with Web services without major risk. This is the case with information services provided by the public cultural sector in which libraries play a major role.

In the field of LIS, the topic of Web services has been advancing slowly. The LIS literature on Web services is still scarce, mostly introductory of the technology and its component standards (Burridge, 2001; Dovey, 2001; Gardner, T., 2001; LU, et al., 2002), or prospective in terms of its potential for the integration of institutional services, academic networks (Jacobson, 2002; Lorenzo, 2002; Powell & Lyon, 2002) and libraries (Carvalho & Cordeiro, 2003; Cordeiro & Carvalho, 2002, 2003), with few references to applications in specific services such as portals (Dolphin, Miller & Sherratt (2002) or e-print repositories (Martin, R., 2003).

Web services technology may represent an important shift in the way library systems functionality is composed and data interchanged with other systems. The main developments so far have been the application of Web services in relation to Z39.50, in order to overcome some of the drawbacks of this protocol especially for reuse of library data outside the world of library systems. This topic will be addressed in Chapter 7.



## 6.5 Conclusions

This Chapter has provided an overview of the changes that the WWW has brought to the environments of networked information publishing, retrieval and management, and of underlying technologies, explored around the topics of access to information and interoperability.

The aim was to extend to the domain of the WWW the same analysis that was carried out in the previous chapters of Part III, in order to address the second research question of the thesis, i.e., is the technical background of computing/IT a persistent barrier to knowledge sharing with LIS; or is the evolution of computing/IT providing a set of integrative concepts that can serve a durable and extensible common conceptual basis? The objectives were to identify major aspects proper to the WWW and Web technologies that influence the requirements and modes of interoperability; and to verify whether they provide trends and concepts that convey further evidence to complement the conclusions reached in the previous chapters of this Part. Overall, the representation given in this Chapter provided evidence that:

- The Web IT developments show trends that are congruent with and extend those already identified in previous chapters: i) they expand to the realm of the open environment notions fundamental to distribution and interoperability by means of a base technical system that is simple to understand and in actual general use; and ii) they exhibit an architectural logic whose understanding and reuse does not necessarily demand high expertise in computing.
- IT constructs proper to the WWW environment also tend to provide concepts that have a potential as building blocks for enhancing IT knowledge in LIS: they have generated vocabularies for discourse about information systems and their contexts, and abstract languages for information representation, featuring the criteria defined in Section 5.1, thus being usable and reusable by a wide variety of information systems stakeholders, for a variety of management purposes.

The remainder of this Section provides a synthesis and discussion of the aspects contributing to the findings summarized above.

The impacts of the WWW on access and interoperability issues derive from its characteristics as a distributed environment which are different from those of bounded, and managed, distributed systems. As seen in OSS and OA, this has consequences for both the models of software production and information distribution and frameworks and patterns of activity of their stakeholders.

The WWW emerged as a space with two different realities both in terms of content and in technical issues. As a network system, it is based upon a light, unmanaged and unbound distribution model whose standards, representing little cost of adoption, became of universal usage. This system has effected major changes in the online information environment, especially in network publishing, motivating changes in the market forces and successive developments with important implications for the management of information and information services.

New search and retrieval services emerged for a new niche of services not covered by the traditional information services held in databases; and for the latter integration with the new network environment became an emergent need. Both aspects have elicited a plethora of new standards on top of the basic ones that made the Internet and WWW operational. As a whole, these standards have been addressing problems that overlap in kind the various levels of information systems interoperability explained in the preceding chapters.

But the problems are now extended to unstructured data resources and to the relationship between them and traditional structured systems. Furthermore, as a simple, powerful and global environment with new possibilities of communication and interoperation, the Web has been changing business models and the architecture and design of underlying systems. Therefore, the overall changes brought about by the Web reach much further than the effect of data networks in previous stages.

As a consequence, the issues become more complex and diversified, and so are the possible solutions/standards. The general trends in the interoperability focus are the same already noted for traditional database-supported information systems: i) the evolving attention from infrastructure to syntax to semantics; ii) higher levels of abstraction, stressing the importance of design and architecture; and iii) a growing need for formalization devices intended to even larger audiences, i.e., of conventions that provide 'languages', or support to 'conversations' between a multiplicity of systems, systems components and a wide variety of stakeholders.

The Web with all its technical developments has reinforced the paradigm of computing founded on the object model, of open distributed systems based on composition and reuse, and of an information environment relying strongly on the qualities of interfaces and communication. Two major conclusions can be drawn from this.

First, there is a clear movement in the convergence between the Web and the traditional environment of computing and IT, not only in technological but, more importantly, in conceptual terms. If we transpose this convergence trend to the socio-technical environments, we can also expect a gradual dissipation of the tensions and disruptions in understanding that novel concepts/undertakings generated with the WWW (e.g., metadata and digital libraries) have caused between diverse professional and organizational communities. This is not to say that technical problems become less complex, but rather that different intervening 'cultures' may be starting to be more prepared to interact about them. Second, the Web technology has brought the concept of 'distributed systems' to a level of realization that has been shaking many of the assumptions about the objectives, principles, languages and standards of traditionally established domains of information systems, such as the bibliographic one. Thus, any tension around a novel topic has extrapolating effects on many other aspects. Overall, these tensions reveal two main interrelated problems that give support to the claim of this thesis for enhanced IT knowledge in LIS.

One is the difficulty of understanding and acting purposively in an environment that is unbound to specific purposes and open ended. This is a novel aspect in information management that impacts on the strategy, design and conceptions of particular (purposeful, managed and controlled) information systems. New models are not yet clear but the indications are that loose aggregations of systems and communities will evolve. This prospect can be extrapolated from the fact, being reinforced by the WWW, that interoperability has actually evolved from being a characteristic of tightly-coupled groups of systems and communities to become a characteristic native to the environment.

The other problem is the difficulty of establishing conversations among multiple stakeholders that still come together with many different requirements, views, concepts and languages. It is this unavoidable situation that justifies the need for conceptual and strategic understanding on a level that should be high above the details of standards and technicalities, but not completely ignorant of them.

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## Notes to Chapter 6:

<sup>1</sup> Sherman & Price (2001: Chap. 4) consider 4 levels of invisibility: the “opaque Web” (files such as PDF and Word, which are not indexed by search engines); the “private Web” (password protected or intentionally excluded resources); the “proprietary Web” (resources only accessible by agreement to terms for viewing pages); and the truly “invisible Web” (resources that cannot be seen by search engines by technical reasons, notably dynamically created Web pages from databases).

<sup>2</sup> There are several definitions of OSS and other common designations such as OSS/FS (see Wheeler, 2005: App. A1). In strictly technical terms, open source software is software for which the source code is open to inspection and in most cases to manipulation. Because this situation is not typical of commercial software, but rather of free software, the two aspects appear most often associated and thus OSS assumes the ‘free’ aspect. For Weber, S. (2004: 5), there are three essential features to OSS: “Source code must be distributed with the software or otherwise made available for no more than the cost of distribution; anyone may redistribute the software for free, without royalties or licensing fees to the author; anyone may modify the software or derive other software from it, and then distribute the modified software under the same terms”. See also the complete definitions by the GNU Project (<http://www.gnu.org/philosophy/free-sw.html>) and the Open Source Initiative (<http://www.opensource.org/docs/definition.php>).

<sup>3</sup> According to the Budapest Open Access Initiative, OA resources imply “free availability on the public internet, permitting any users to read, download, copy, distribute, print, search, or link to the full texts of these articles, crawl them for indexing, pass them as data to software, or use them for any other lawful purpose, without financial, legal, or technical barriers other than those inseparable from gaining access to the internet itself. The only constraint [...] should be to give authors control over the integrity of their work and the right to be properly acknowledged and cited” (Budapest..., 2001). This definition was further extended by the Bethesda Statement to include as a second criterion “the deposit of a complete version [...] immediately upon initial publication in at least one online repository that is supported by an academic institution, scholarly society, government agency, or other well-established organization that seeks to enable open access, unrestricted distribution, interoperability, and long-term archiving” (Bethesda..., 2003). The Berlin Declaration (2003) adopted the Bethesda definition to advocate “measures which research policy makers, research institutions, funding agencies, libraries, archives and museums need to consider” (Berlin..., 2003).

<sup>4</sup> Evidence of this prominence is the proliferation of literature on OSS (see, e.g., Waliszewski, ed., 2002) and OA (Bailey, 2005) since 1999-2000. This coincides with a growing interest on both subjects from the part of governmental agencies and not for profit organisations (see, for example, Wheeler, 2005: Sec. 12, regarding OSS; and Bailey, 2005: Sec. X). The timeline for the OA movement provided by Suber (2002-2006) exhibits a dramatic increase in the variety of OA initiatives since 2002 and their widespread institutional and governmental support in many countries. For a summary of these, and the recommendations of the European Commission, see Dewatripont, et al. (2006: 16-19; 69-75; 87-89).

<sup>5</sup> In scholarly publishing, OA has been driven principally by the increasing volume of research and the consequences of the economics of commercial publishing channels, i.e., the rise in print publishing costs and journal prices together with reduced competition brought about by the growing concentration of business by mergers and takeovers (Wellcome Trust,

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2003; White & Creaser, 2004; Dewatripont, et al., 2006: 21-45). Price became the main barrier to access literature published in print or digital form by traditional publishing channels, seriously affecting the affordability to libraries (ARL, 2005, 2005a; Dewatripont, et al., 2006: 48-53) and the general public. This barrier is especially unbearable for royalty-free academic literature, i.e., whose authors are usually not paid and which, in many cases, comes out of publicly-funded research (see, e.g., NIH, 2005). Through open access strategies, academic communities and institutions providing information services, such as libraries, seek to lower the price barrier while fostering the availability of non-published research (Suber, 2004). For an example of how policies on OSS combine with publicly funded projects for information services see Yeates, S. & Rahtz (2004).

<sup>6</sup> Creativity and innovation (Von Hippel, 2005: 97-98, 115-116), and other individual motivations such as “art and beauty [in writing elegant code], job as vocation, the joint enemy, ego boosting, reputation and identity and belief systems” (Weber, S., 2004: 135-149), have been considered the driving forces of OSS, with innovation being the reason why important software companies have started to integrate open source in their business models (DiBona, Ockman & Stone, 1999). But there are also economic reasons, from both production and demand (Fink, 2002; Goldman & Gabriel, 2005). In terms of adoption, the advocates of open source underline the growing market share of OSS and argue that its total cost of ownership is lower than conventional proprietary systems; other arguments are technical reasons such as reliability, performance, scalability, security; and strategic reasons, e.g., avoiding single source proprietary solutions which provide, among other aspects, greater flexibility and innovation (see Wheeler, 2005).

<sup>7</sup> Founded in 2001, The Creative Commons (<http://creativecommons.org/>) provides a set of copyright licences for creative works of various kinds other than software. Under these licences authors can retain their copyright while licensing them as free for certain uses or under certain conditions. Another organization with similar goals in advocating and convening efforts towards OA is Public Knowledge (<http://www.publicknowledge.org/>).

<sup>8</sup> The Free Software Foundation (<http://www.fsf.org/>), established in 1985, promotes OSS and provides the most widely used licence in this context, the GNU General Public License (GPL). Anyone is free to do anything with source code available under GPL except restrict further that freedom to others, i.e., for the sake of continuous access, a product derived from GPL code must also be released, with its source code, under another GPL.

<sup>9</sup> The Creative Commons and the GNU GPL are just the best known open licences. For a comprehensive overview and comparison of the open content licences available, see Liang (2004).

<sup>10</sup> SourceForge (<http://sourceforge.net/>), founded in 1999 by the Open Source Technology Group (<http://www.ostg.com/index.htm>), is the largest repository of open source code and applications available on the Internet.

<sup>11</sup> See Weber, S. (2004: Chap. 4) for a detailed description of the history of Linux decision making system.

<sup>12</sup> They range from centralized patterns, where the developers' code is called by the architect's code, the one integrating the whole project; to 'densely networked' projects, with no central 'architect' but a group of highly interdependent modules/developers sharing the integrating responsibility with no distinction of participation (but usually a set of primary developers emerge); to a variation of the previous structures where there is a clear core and periphery distinction “between forms of participation as characterized by the

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interdependencies of the work". They also showed that in the evolution of a project there can be shifts between the core and its periphery, if the analysis is carried out on a dynamic structure, e.g., at different times during the same project (Souza, Froehlich & Dourish, 2005).

<sup>13</sup> The aim of OA repositories and journals is not to recover the production and maintenance costs from readers, so alternatives to funding are several (see Willinsky, 2006: App. A). In journals, they range from complete support by the publishing institutions (many can be found in the Directory of Open Access Journals, at <http://www.doaj.org/>), to total or partial funding from external grants and subsidies (e.g., D-Lib Magazine), to collecting, from authors or their institutions, upfront processing fees on received papers (as in the Public Library of Science and BioMed Central), or a mix of the above. For guidelines on OA journals' business models, see Crow & Goldstein (2003, 2003a, 2004), PLoS (2004) and Velterop (2005).

<sup>14</sup> Examples of OSS for journal management are Open Journal Systems from the Public Knowledge Project at Simon Fraser University (<http://pkp.sfu.ca/ojs/>) and DPUBS, from Cornell University (<http://dpubs.org/>). See also the resource lists available from SPARC (<http://www.arl.org/sparc/resources/pubres.html>) and the Public Knowledge Project ([http://pkp.sfu.ca/ojs/other\\_OJS.html](http://pkp.sfu.ca/ojs/other_OJS.html)). Examples of OSS for e-print repositories/archives are EPrints, from the University of Southampton, UK. ( <http://www.eprints.org/>), DSpace (<http://dspace.org/index.html>) from Massachusetts Institute of Technology, and CDSWare, from CERN (<http://cdsware.cern.ch/cdsware/overview.html>).

<sup>15</sup> See Chapter 2, note 27.

<sup>16</sup> Examples of this are the CrossRef OpenURL Resolver ([http://www.crossref.org/02publishers/openurl\\_info.html](http://www.crossref.org/02publishers/openurl_info.html)) and LinkOpenly (<http://www.openly.com/link.openly/>).

<sup>17</sup> Day, M., et al. (2000) provided a report about different architectures and protocols used in broker architectures for gateways confirming that classical database protocols (such as Z39.50), which are not of the Web generation, continue to play a fundamental role.

<sup>18</sup> In their varied types, Web search engines are constantly evolving. Leighton & Srivastava (1999) reported a comparison study. A literature survey on the topic was provided by Jansen & Pooch (2001) including comparison with library OPACs. A regularly updated source about search engine characteristics, coverage and functionalities is provided by Notess (1999-2005).

<sup>19</sup> The main difference between a DTD and an XML schema is that the latter uses XML syntax, thus not implying knowledge of any other syntax and bearing other XML advantages such as extensibility. The standard, XML Schema (Fallside & Walmsley, eds., 2004) defines how to express structure, attributes, data-typing, etc. of XML documents.

<sup>20</sup> Typed links designate a type of hyperlinks more sophisticated than the initial hyperlink model of the Web. Instead of simple, unidirectional and static links from a single source to a single destination, typed links contain a syntax and semantics that express relationships between resources and exhibit processable data according to the behaviour intended for the resources. Typed links are usually dynamically generated from structured resources like databases (Lowe & Wilde, 2001).

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<sup>21</sup> SQL - *Structured Query Language* is the most widely used query language to access data in relational databases. It has been an ANSI standard (ANSI INCITS 135: 1992) since 1986 and an ISO standard (ISO/IEC 9075:1999-2003) since 1987.

<sup>22</sup> In 1998 the W3C organized a Workshop on the subject, The Query Languages Workshop (QL98) whose position papers are available at <http://www.w3.org.TandS/QL/QL98/pp.html>. They include a paper related to the library experience (Denenberg, 1998).

<sup>23</sup> Bray (2001) considered “generation 1” the mainframe model, with all the code, data and processing activities centralized in a server; “generation 2” the pure client-server data-centric model of the 80s, which distributes code to clients enhancing interactivity and client autonomy; “generation 3” the multi-tier model where part of the applications run not at the client but at the server; and “generation X” the Web generation evolving from the 1990s. For Bray the initial “generation x” was somewhat like “generation 1”, with all code and logic at the server side, and clients subject to waiting according to constraints of network capacity and traffic; the possibility to transfer – on the fly – the necessary code to the client for a needed transaction makes the difference.

<sup>24</sup> Sometimes the distinction is not clear, among other reasons because some metadata schemes are not confined to just one of these categories.

<sup>25</sup> See Chap. 2, note 24.

<sup>26</sup> CIMI (2000) provides special guidance on the use of DC for the museum community.

<sup>27</sup> See Chapter 2, note 27.

<sup>28</sup> DESIRE - *Development of a European Service for Information on Research and Education*, was an European collaboration project that ran from 1998-2000, focused on tools for building Internet search services including caching, resource discovery, content rating and directory services. Among the outcomes is the DESIRE demonstrator of a metadata registry (<http://desire.ukoln.ac.uk/registry/>).

ROADS - *Resource Organisation And Discovery in Subject-based services* (<http://www.ukoln.ac.uk/metadata/roads/what/>) was a project developed under the UK eLib Programme to provide a set of software tools to enable the set up and maintenance of Web based subject gateways. The metadata format used for resource description was ROADS templates, developed upon the Internet Anonymous FTP Archive (IAFA) templates. ROADS provided a registry for those templates at <http://www.ukoln.ac.uk/metadata/roads/templates/>.

The SCHEMAS Registry (<http://www.schemas-forum.org/registry/desire/index.php3>) is a prototype based on the DESIRE Registry.

<sup>29</sup> See also under Section 4.2.3.3 *Data interoperability*.

<sup>30</sup> In both cases the authors argue in favour of MODS (Metadata Object Description Schema) (Guenther, 2003), the alternative to DCMES provided by the Library of Congress, which has a structure more compatible with MARC, while being lighter and particularly adapted for digital library objects.

<sup>31</sup> RDF was developed in the context of the W3 Consortium since 1997 and became a W3C Recommendation in 1999. The suite of RDF specifications is available at <http://www.w3.org/RDF/>. A resource page on RDF is provided by Beckett (1998-2004).

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<sup>32</sup> The general model of RDF as a ‘container architecture’ evolved from the Warwick Framework, a result of the Metadata Workshop II, in 1996 (Lagoze, 1996). In its internal structure RDF includes features for different types of containers to group things (see Manola & Miller, eds., 2004: 4.1).

<sup>33</sup> ISO 2709 is the common format for exchange underlying all MARC formats. It is a generalized format for communication, not for processing within systems. It consists of a record label, a directory, data fields, separators and record separators (ISO 2709:1996).

<sup>34</sup> The differences and how they allow for more extensibility compared to classical object-oriented systems are explained by Brickley & Guha, eds. (2004: Introd.) and Manola & Miller, eds. (2004: 5.3).

<sup>35</sup> The W3C provides the following definition: “A Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format (specifically WSDL). Other systems interact with the Web service in a manner prescribed by its description using SOAP messages, typically conveyed using HTTP with an XML serialization in conjunction with other Web-related standards” (Booth, et al., eds., 2004: 1.4).

<sup>36</sup> Basically, SOAP is a format specifying the messaging layout characteristics for requesting services from remote applications through XML. It is a Candidate Recommendation of the W3C and is maintained by the W3C XML Protocol Group. *SOAP* acronym stood originally for *Simple Object Access Protocol*, but the word is now used as the full name of the protocol, since the last revision of the standard (Gudgin, et al., eds., 2003). A comparison with other XML protocols is provided at <http://www.w3.org/2000/03/29-XML-protocol-matrix>.

<sup>37</sup> WSDL - *Web Services Description Language* (Gudgin, Lewis & Schlimmer, eds., 2004) is an XML format for describing network services as a set of endpoints operating on messages containing either document-oriented or procedure-oriented information. The idea behind WSDL is to make Web services self documented for client applications. WSDL is targeted at software development tools, not humans. A tool should be able to read a WSDL description of a service and automatically produce most of the client application code needed to access the described service.

<sup>38</sup> UDDI - *Universal Description, Discovery and Integration* (Clement, et al., eds., 2004) is a technical specification creating directories of Web services, i. e., for publishing and finding businesses and Web services online. It includes a data model expressed in an XML schema and an API for searching and publishing UDDI data. Beyond the specifications, UDDI also includes an actual registry service (UDDI Cloud Services, at <http://www.uddi.org/register.html>) that was launched in 2001.

<sup>39</sup> See Note 46.

<sup>40</sup> Fisher emphasises the negative aspects of such an approach in the context of EAI solutions, not specifically about Web services. Yet, the main points to consider from this perspective of leveraging legacy assets by extension are fully pertinent to Web services strategies. For more information about EAI and how it relates to Web services see Samtani & Sadhwani (2001), Fletcher & Waterhouse, eds. (2002) and Ambrosio (2002).



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<sup>41</sup> WSMF is part of the IST Project *Semantic Web Enabled Web Services* (SWWS), running from 2002 to 2005 with the goal of providing an integrated software environment for the objectives underlying WSMF. More information at:  
[http://swws.semanticweb.org/swws?cmd=show\\_entity&entity=Home+English](http://swws.semanticweb.org/swws?cmd=show_entity&entity=Home+English).

<sup>42</sup> All these are XML specifications that have similar goals, although they show different levels of detail. All are XML schemas and/or DTD that convey a model and a language to describe, on top of WSDL, business processes, including types of documents and sequencing of activities involved in a collaboration through a Web service.

WSFL - *Web Service Flow Language* (Leymann, 2001), developed by IBM, is an XML language for the description of Web service compositions, allowing the definition of business rules and sequencing.

XLANG - *Web Services for Business Process Design*. was developed by Microsoft (Thatte, 2001).

ebXML BPSS - *Business Process Specification Schema* (Levine, et al., eds., 2001) is a specification to define business transactions and the choreography of business transactions into business collaborations.

BPML - *Business Process Modeling Language* (Arkin, 2002) was developed by BPMI (Business Process Management Initiative), a non-profit corporation devoted to the promotion and use of business process management.

WSCL - *Web Services Conversation Language* (Banerji, et al., 2002) was developed by Hewlett Packard and submitted to the W3C. It allows to specify the XML documents being exchanged when using a Web service as well as its sequence.

<sup>43</sup> Major organizations involved in Web services standards, beyond the W3C, are the WSI - *Web Services Interoperability Organisation* (<http://www.ws-i.org/>) and OASIS - *Organization for the Advancement of Structured Information Standards* (<http://www.oasis-open.org/home/index.php>).

<sup>44</sup> EDI designates an extensive group of standards for electronic business transactions. The most relevant and widely accepted EDI standards are those produced by the UN/EDIFACT EDIFACT (United Nations Electronic Data Interchange for Administration, Commerce and Transport), established in 1996, and the ASCX12 Committee (ANSI Accredited Standards Committee X12 (<http://www.x12.org/>), created in 1979. Although sharing many of the UN/EDIFACT features, and the same syntax principles, X12 standards differ in various aspects of structure and syntax. X12 standards are primarily connected with the North American marketplace, while UN/EDIFACT is more international.

EDIFACT syntax rules are published as ISO 9735: 2002.

<sup>45</sup> ebXML - *Electronic Business using eXtensible Markup Language* (<http://www.ebxml.org/>) is an initiative established in 1999 by the UN/CEFACT - *United Nations Centre for Trade Facilitation and Electronic Business* (<http://www.unece.org/cefact/>) and OASIS (<http://www.oasis-open.org/>) aimed at making EDI semantics available in XML. It consists of a modular suite of specifications especially designed for EDI using Web services, including a directory of services similar to UDDI. For more detailed information about the e-business evolution with XML technologies and the goals of ebXML see Webber & Kotok (2001).

<sup>46</sup> For a detailed overview see Eisenberg & Nickull, eds. (2001).

## **PART IV**

### **TOWARDS EMBEDDING IT CONCEPTS IN LIS**

#### **Introduction**

The aim of Part IV is to conclude the research project and summarizing the findings of the thesis from the focus of LIS. It comprises two chapters, 7 and 8, corresponding to two different objectives.

One objective is to consolidate the answer to the first research question provided in the findings of Part II, with a case study which can exemplify the poor absorption of IT concepts in libraries/LIS and the difficulties in communication with the mainstream IT communities.

The second objective is to synthesise the major findings of Part III, regarding the potential of IT constructs to provide a set of integrative concepts that can foster a common conceptual basis between LIS and IT, and elaborate a general reflection on the issues of knowledge sharing between the two domains.

Chapter 7 presents the case of Z39.50, a technological standard which specifically addresses interoperability and has particular importance for libraries in terms of its origin, developments and applications. The case study aims to illustrate with practical evidence the lack of embeddedness of IT knowledge in libraries and the consequences of this situation.

Chapter 8 concludes the thesis with a synthesis of issues concerning knowledge sharing between the two fields, contrasting aspects typical of the past of the relationship between libraries/LIS and IT together with prospective directions supported by the conceptual exploration of IT constructs. Major findings from the various parts of the study are combined here, discussing the reasons why the nature and content of the relationship should change and noting the potential and benefits of incorporating IT concepts in LIS, in the light of a more systemic, i.e., integrated, view of technology.

## **CHAPTER SEVEN**

### **BIBLIOGRAPHIC SYSTEMS AND INTEROPERABILITY: THE CASE OF Z39.50**

#### **7.1 Introduction**

This Chapter presents the case study of Z39.50, a search and retrieval protocol aimed at the remote access to sets of independently managed library catalogues through a system providing a single point of access/interface. As a case study, the objective of the Chapter is to analyse the advances and drawbacks of the standard, its successes and failures, in order to illustrate the general findings of Part II, thus giving more support to the need to find ways to improve IT knowledge in LIS, claimed in this thesis.

The relevance of the case derives from three aspects: i) the centrality of the function envisaged with Z39.50 for library services, of a nature that is also of interest to wider domains; ii) the fact that Z39.50 went through critical periods of change in network technology and information environment, thus providing a privileged focus for understanding the relationship between libraries and IT; and iii) the significance of what can be learned from the expectations about and practical experiences with it, in the library field. Because the last aspect is the most important in gathering evidence for the purpose of this research, the Chapter concentrates on the issues arising since Z39.50 started to have practical implementations. A general background on the history, nature and constituencies of the standard is provided in Annex 1.

Since the late 80s interoperability has been a target of library management systems aimed at covering two major functions: search and retrieval (SR), with the Z39.50 protocol (ISO 23950: 1998; ANSI/NISO Z39.50: 2003); and the flow management of library transactions concerning interlibrary loans (ILL) management<sup>1</sup> between different institutions' systems, and EDI<sup>2</sup> solutions for the integration of library acquisitions processes with book suppliers' systems.<sup>3</sup> While acquisitions, ILL and document delivery address mostly administrative workflow processes (see Larbey, 1997), by integrating library systems processes with systems of third parties involved in the supply of goods or services, the SR area is of a more fundamental nature. It is directly connected to the primary function of access and it is also a

prerequisite of other functions that build on search results, such as the processing of an ILL request or the exchange of MARC data between systems.

SR function is central to library systems, as it is to any information system, yet the specific contexts, standards and technical particularities make library SR particularly complex. Z39.50 relies upon the core data of library systems, i.e., bibliographic, thus representing, alongside MARC, a milestone in the history of library automation (Cooper, 1996: 621) and a requirement for bibliographic systems since the mid-90s (Hagler, 1997: 165; Healy, 1998: 14).

## **7.2 Z39.50 in the field: overview of an evolution**

The long history of Z39.50 development (see Annex 1, Sections 2-4) only began to deliver industry applications in library systems since what Moen called the “fourth stage” of the standard, that of “implementers and implementation (1992-1995)”, when the standard really evolved from theory to practice (Moen, 1998b: Chap. 5). From a different perspective, Lynch distinguished two phases: while during the eighties the community’s view of the goals for Z39.50 was focused mainly in providing professional access to a “handful of major bibliographic utilities”, in the 90s the end-user perspective grew out of the global network expansion, and the “provision for uniform, consistent access to a range of networked servers hosting content resources” became dominant (Lynch, C., 1997b).

This change in perspective derived principally from the expanding functional requirements that the “wired campus” brought to library automated systems, “historically insular” and “often based on specialized hardware and/or operating systems lacking industry-standard networking capabilities” (Lynch, C., 1989). Users’ expectations were widening from ideas such as the “scholar’s workstation” (see Phillips, 1992). For several years such expectations collided with difficulties in terms of the evolution the network standards and changes needed for library systems to operate in the network environment as “information servers” (Lynch, C., 1990).

As noted by Dempsey (1992: 146), the “integrated library system unconnected to any network [had] been the pattern” and there was a general lack of network experience on the part of library vendors, whilst libraries were still “faced with confusing choices” derived from the lack of consensus about the OSI versus TCP/IP networks (Ibid.: 32).

For Heseltine (1993),

“integration of the standard into real systems and networks, and the determination of the place of the traditional library system in the resultant framework of communication [...] remains difficult to envision with consistency and a real sense of practicability”.

Despite the growing support to the client server model, only in 1993 did some interoperating services begin to be put in place. There was lack of implementation experience for assessing SR/Z39.50 in actual services and to provide feedback into the standardization process. More awareness and funding was needed (Dempsey, Mumford & Tuck, 1993) and, in 1994, Leeves, ed. (1994: 11, 24) reported that SR/Z39.50 was still cited as a future development by library systems suppliers in Europe. Up to 1995, most of the literature on Z39.50 or SR was principally focused on either the standard development process or on network technical issues such as the controversy between OSI and TCP/IP (e.g., Lynch, C., 1990, 1991, 1994; McCallum, 1990, 1993; Dempsey, 1992; Turner, Tallim & Zeeman, 1992; Dempsey, 1994; Holm, 1994).

Only after 1995, when Version 3 of the standard was approved, did Z39.50 become a topic of a wider professional interest. From the professional literature since 1995 it is possible to identify three major phases, explained below, in the library understanding and deployment of Z39.50. They are important to illustrate the evolution of library information management views and concerns related to interoperability. These phases, rather than delimitation lines, are a generalization from the main traits of such a literature (topics, contents and audiences).

A first phase, of exploratory applications, is characterized by awareness of the standard and random perception of the range of interoperability problems raised by the emerging practical usage of the protocol. A second phase, designated below as ‘evaluation and assessment’, was marked by systematic analyses of actual implementations and their problems. A third phase shows trends in strengthening of the external components that support Z39.50 information services architecture, through advancements in profile specifications and policy and technical community agreements.

### 7.2.1 Exploratory applications

Chronologically, this first phase is mainly situated in the period 1984-1998. This section provides the evolution of the market of Z39.50 solutions and covers most of the problems found in projects and in production services. In the mid-90s, some library systems suppliers were already claiming to have incorporated the standard or to plan to do so over the next year (KPMG, 1994: Supplier Survey). But, according to Dempsey (1994),

“Most implementors are still in prototype or test phases. Some production servers do exist: OCLC and RLG, for example [...]. It is possible to buy both server and client products in various configurations from a number of suppliers, and several public domain versions exist”.

By 1996 the protocol was already considered as a standard requirement in library systems outside the US (Russell, 1996) and a considerable number of vendors could be found in the *Z39.50 Register of Implementors* (Dempsey, Russell & Kirriemuir, 1996). There was a growing offer of client software, part of it available in the public domain (DSTC, 1996). But there was concern about the lack of servers available, meaning that software client was demanded by libraries more than the ability or willingness to offer a server. This called for cooperation in order to “avoid a situation of a multitude of clients with no place to go” (Russell, 1996).

With a growing number of projects going on, a period of intense diffusion about Z39.50 started in the professional community. Beyond general overviews of the protocol (Iltis, 1995; Kunze & Rodgers, 1995; Moen, 1995, 1995a; Sévigny, 1995; Turner, 1995; Dempsey, Russell & Kirriemuir, 1996) some other fundamental aspects which are not just technological began to be discussed, such as the content semantics of the protocol (St. Pierre, 1996; Lynch, C., 1997b) and the role and organizational demands of profiles (Denenberg, 1996a). But the literature introducing the protocol to a non-technologist professional audience continued to flourish alongside more technical and critical views (e.g., Finnigan & Ward, 1997; Wells, et al., 1998; Baldacci & Parmeggiani, 1998; Turner, 1998; Miller, P., 1999a; Hartman, 2000), showing that the standard continued to be somewhat unabsorbed and not well understood in library information management.

From the mid 90s onwards, the expansion of the WWW and its popularity in improving the network visibility of library OPACs contributed to misguide the

professional understanding of interoperability issues, stressing the need to clarify Z39.50's unique and distinctive role regarding HTTP (Dempsey, Russell & Kirriemuir, 1996; Joy & Murray, 1995; Scolari, 1996; López de Sosoaga Torija, 1998, 1999). But, on the other hand, the popularity of the WWW motivated greater attention to the advantages of Z39.50 as a technology for resource discovery over other information retrieval protocols (Ward & Wood, 1995; Hakala, 1996). The synergetic potential of the relationship between Z39.50 and the WWW was emphasized and Z39.50 /WWW gateways became common (Hammer & Favaro, 1995, 1996; Sévigny, 1995; Cervone, 1997; Greenstein & Murray, 1997; Czaplinsky & Moret, 1997; Lahary, 1997).

A critical mass of experiences started to be available, especially with the growing number of EU funded international library projects involving the application of Z39.50 (Dempsey, Russell & Kirrimuir, 1996; Russell, 1996; Pedersen, 1997). Initially, such projects were aimed at testing the feasibility of the protocol in different technical environments,<sup>4</sup> but after 1995 they expanded in number and objectives, from providing free solutions for Z39.50 software<sup>5</sup> to implementing ILL and document delivery services,<sup>6</sup> or to support specialist services such as those for image retrieval and sound archives.<sup>7</sup> Project reports and experiences from commercial implementers began to reach wider audiences (e.g., Over, et al., eds., 1995; Favaro & Catoni, 1997; Ludwig, Becker & Güntzer, 1997; Wesseling, 1997; Yeates, 1997; Murray, R. & Pettman, 1997; Clissman, et al., 1997; Larbey, 1997a).

Many projects built on top of previous ones, enriching the exploitation of the protocol in prototypes that successively applied more of the functionalities enabled by the protocol. The project UNiVerse (see Annex 2) exemplifies the delivery of a fairly complete use of Z39.50, by implementing services less commonly available, such as 'Resource control' and 'Explain' (see Annex 1: Sec. 5.1), by addressing many of the technical interoperability issues that are implied in a virtual union catalogue (e.g., character set conversions, deduplication of records, thesaurus multilingual access) and by integration of the ILL protocol and the Ariel<sup>8</sup> system for document delivery (Murray, R., Smith & Pettman, 1999). An overview of several projects of this phase that integrated Z39.50, ILL and document delivery standards was provided by Braid (2000). But the most common implementations of Z39.50 in production services continued to be very limited, far behind its technical possibilities and showing a number of practical problems that contradicted the expectations.

### **7.2.2 Issues and problems arising from practice**

A number of practical problems began to be reported and became common in the literature of Z39.50 once it started to be used in production services. Most of them arose in the Z39.50 exploratory stage but have remained, so this Section includes also literature from later stages. The general sense is that of a poor deployment of the protocol capabilities because viable implementations have been limited to the lowest common denominator of attribute definitions among servers. While this is the aspect most commonly recognized, there are other issues to be mentioned. The following is a summary of the most typical problems that have limited the Z39.50 take up in both library management systems (Akeroyd & Cox, 1999) and in personal bibliographic software (East, 2003).

#### **a) Differences in implementation of the standard**

Differences in the implementation of both clients and servers have been often acknowledged and attributed to the complexity and flexibility of the standard, i.e., its wide range of optional functionalities (Lynch, C., 1997b). In the first phase most existing implementations were partial and the standard was used in ways that would not prevent clients from interpreting Z39.50 associations differently from server to server (Iltis, 1995). There was also the perception that the ATS profile (see Annex 1: Sec. 5.4) was not robust enough, and the lack of multilingual facilities was noted (Kolman, 1996). Poor practical results began to raise some doubts about the feasibility of a virtual union catalogue composed of Z39.50 servers (Manojlovich, 1996).

Even within a given domain referring to the same profile, it has been common that databases and servers each support a different subset of Z39.50 attributes and attribute combinations, and the mapping of these attributes to database indexes may also vary and be too broad (Lunau, 1997). While there is a common basis in the composition of MARC bibliographic records which has supported the electronic exchange and reuse of records, the database indexes produced in each system can show many variations. This makes the online retrieval of data from several servers difficult (Fattahi, 1997; Moen 2000a).



Another aspect is the set of functionalities supported by each local system (support for truncation, relation, etc). Not only do these vary from system to system but they are also often misunderstood or not defined in Z39.50 implementations. With *Use Attributes* (see Annex 1: Sec. 5.2) being the most important for the mapping of search terms, frequently the other five types of attributes pertaining to *Attribute Set Bib-1* were set incorrectly or inconsistently among servers (Miller, P., 1999a).

All these problems of different interpretations of the standard and of the incomplete and inaccurate configuration of attributes have remained largely unsolved in the world of library Z39.50 servers (Needleman, 2000; Moen, 2001; Gatenby, 2002; East, 2003).

#### **b) Lack of alignment with mainstream IT interests and technologies**

Because Z39.50 is strongly connected to the library domain, to its technicalities and specific standardization, the use of the protocol has been virtually restricted to libraries. It has not attracted substantial interest from commercial vendors <sup>9</sup> other than those providing library-oriented products or products designed with library users in mind, such as personal bibliographic management systems. There are a few exceptions for some other domains which are also public//non-profit sector, such as governmental information, museums and archives (see Annex 1: Sec. 5.4). These areas have demonstrated the wider potential of the protocol, yet Z39.50 remained unattractive to the industry at large (Needleman, 2000).

Several factors have contributed to this situation. The first was the late deployment of the standard regarding the original technological environment for which it was designed (Lynch, C., 1997b). Actual implementations came at a time when the context for Z39.50 models of deployment was already changing with the WWW (Jones, N., 1998; Moen, 2000b) and constraints and drawbacks of the technology underlying the protocol were felt. As noted by Jones, N. (1998), Z39.50 as a client/server mechanism lacks requirements for navigation between different servers of information resources that characterize the Web environment.

Furthermore, other features of Z39.50 are especially unsuitable or in disagreement with the Web technology. Being a binary protocol, strongly connection-oriented, stateful, and making use of syntaxes, such as ASN.1/BER (see

Annex 1: Sec. 5.1) that are not commonly used, are among the most negative features of Z39.50 (Gatenby, 2000, 2002; Needleman, 2000; Wake, 2000; Zagalo, Martins & Pinto, 2001; Taylor, M., 2002). These aspects contrast with the simpler technology underlying the Web: HTTP is stateless, i.e., the server treats each request independently, does not need to deal with storage of an ongoing conversation, and uses a simple and widely known syntax.

Other negative aspects are the complexity of the standard itself, and the very specialized knowledge that is required about the functionalities and data structures of systems involved in interoperation. In the case of bibliographic systems, when such knowledge is absent, implementations are difficult and the results can be very deceptive (Lynch, C., 1997b; Moen, 2001; Gatenby, 2002).

#### **c) Lack of sources about actual servers and their configurations**

Directories of Z39.50 servers have been scarce <sup>10</sup> and, for a long time, individual publication by Z39.50 providers of technical details such as the attributes and functionalities supported was not a systematic practice. On the other hand, the *Explain* facility (see Annex 1: Sec. 5.1) by which Z39.50 clients can get technical parameters and other information about servers has rarely been implemented (Lunau & Turner, 1997, 1997a; Jones, N., 1998; Dempsey, Russell & Murray, 1999; Zagalo, Martins & Pinto, 2001; Denenberg, et al., 2002; East, 2003).

#### **d) Unresponsiveness to multinational and multilingual requirements**

Z39.50 support of multi-national and multilingual requirements, “not always obvious in the US implementers group” (Dekkers, 1995), became highlighted with the expansion of the Web. These relate to incompatibilities that are “external” to the protocol but have important repercussions at the end-user level: different languages and scripts, with different support for character sets and transcription rules, different sorting criteria, the variety of MARC formats and the lack of conversion facilities and finally, differences in data content motivated by different rules and traditions underlying cataloguing. While this set of issues is common to Western countries, there are added complications for systems also handling oriental language/script materials (Tam, 1999).

While the character set issues can in theory be dealt with by the ‘negotiation’ mechanisms between client and server defined in the version 3 of the protocol, the remaining problems cannot. These are aspects that clearly point to complementary approaches to standardize implementations of the protocol. For Dekkers (1995),

“It should be clear that a standard like Z39.50 is just a vehicle for communication and will never be capable of solving all the problems that exist; neither should it try to do this”.

#### **e) Quality and usability of service**

Because Z39.50 is a standard for computer to computer interaction, for a long time it was seen as principally a matter for implementers. A consequence of this was the lack of attention to the level of end-user services. By the time the protocol started to be used in production services, Z39.50 client software had received little attention with respect to usability, resulting in disparity in quality and adequacy of interfaces (Iltis, 1995; DSTC, 1996).

Besides, there are also aspects of awareness of user preferences in respect to service architecture and functionality. For example, in theory the benefits of mounting multiple database search services seem obvious. However, in practice it emerged that this implies issues subject to choice that cannot be overlooked. First, the implementation of a common interface though Z39.50 may imply the sacrifice of special features and advanced functionality found in native database systems. This means that decisions have to be taken on whether or not to maintain provision for both choices (single or multidatabase search).

Secondly, simultaneous database searching can either make use, or not, of options to query different databases either in a simultaneous and/or a sequential way. Simultaneous database searching, which seems the most attractive, poses problems of response time (Tam, 1999; Hammer & Andresen 2002) and requires client facilities to handle multiple result sets coming from different servers. In all these aspects the user perspective is critical for identifying barriers to effective implementations (Payette & Rieger, 1997; Cousins, 1999).

All the above-mentioned issues of mismatch of configurations, resulting in a situation where the same query through Z39.50 may produce different results from those of the native systems, plus the problems of response time in parallel searches and the varied ways in which different clients handle results sets (e.g., having or not

de-duplication facilities) have caused frustration and mistrust on Z39.50 technology (Hodges, D. & Lunau, 1999).

### **7.2.3 Evaluation and assessment**

The idea of virtual, or distributed, catalogues is among the original expectations of Z39.50 and most of the projects already mentioned addressed, in some way, this objective. The results of such projects, the increasing availability of Z39.50 software and the growing installed base of Z39.50 servers motivated a series of studies to analyse and clarify recurring interoperability problems within actual communities of systems.

From 1998 to 2000 several such studies provided the first published empirical investigations of the problems (Blue Angel Technologies, 1998; Hinnebusch, 1998; Lunau, 1998; Williams, J.F., 1999; Coyle, 2000; Stubbley, Bull & Kidd, 2001). In different ways, they provided assessments of existing Z39.50 services by surveying server and client software installed in libraries, vendor products and services (protocol version, functionalities supported, quality of documentation and support, etc.), characteristics of the underlying MARC databases and users' difficulties and expectations.

Blue Angel Technologies (1998) evaluated the use of Z39.50 in twenty-two Iowa State libraries, assessing the ease of setting up Z39.50 services on the Internet; the strengths and weaknesses of the services, the status of vendor applications (eight commercial systems were evaluated in terms of Z39.50 features and attributes supported), and the usefulness of the Iowa State Library's Z39.50 Gateway. Weaknesses reported include inconsistencies among systems in vendor implementations, in MARC mappings to Use Attributes, lack of support for holdings, poor search capability and slow performance.

Hinnebusch (1998) surveyed the libraries and related library systems of the CIC (Committee on Institutional Cooperation, a consortium of major American universities in the Midwest), focusing on Z39.50 attribute support, both at the level of servers and clients. The survey was complemented by a "Z39.50 query robot" run by Index Data on the servers concerned. Major findings include inconsistencies and omissions in attributes as well as mismatches in configuration between clients and servers, leading to the "lowest common denominator" situation for searching;

different indexing strategies in the local databases; Z39.50 software generally pertaining to the first generation, i.e., lack of support for the functionalities introduced by the Z39.50: 1995 version, such as Scan and Explain.

Lunau (1998a) provided the final report of the Virtual Canadian Union Catalogue (vCuc) project. The study, started in 1996, included a series of test phases carried out in 1997 and 1998 to assess a representative sample of Z39.50 services, covering eighteen Z39.50 servers on ten different platforms. The results provided figures on Z39.50 experience in libraries (with only 33% of significant experience) and uses of Z39.50 (highlighting ILL and copy cataloguing functions). The study identified specific search problems related to different interpretations of Attributes, and recommended the “adoption of a common Z39.50 attribute profile” which should be “international in scope” (Ibid.: 12).

Williams, J. F. (1999) carried out an extensive and detailed survey of the situation in California State libraries. Starting from Z39.50 as the standard central to the California Linked Systems Project, the study identified twenty components of a proposed Library of California Technology Infrastructure, covering much more than Z39.50 specific issues (Ibid.: 33-40) and policy recommendations for each of them. Most of the problems respecting Z39.50 were due to variations in vendor implementations of the protocol and to differences in local choices about database indexing.

Coyle (2000) described a test implementation of a virtual union catalogue for the University of California libraries comparing it to the existing centralized (physical) union catalogue (Melvyl). The test highlighted different database indexing policies in the participating systems. Many discrepancies (without a pattern) were found for the same searches run on each system and on the virtual union catalogue, showing that some of the features of a traditional union catalogue were absent and in need of further organization agreements and software capabilities. This includes features such as sorting, merging and de-duplication of result sets. It was found that few systems supported some of these features (such as Sort) included in version 3 of the protocol, and that other aspects, such as merging and de-duplication, were technologically challenging in the case of large result sets.

Stubley, Bull & Kidd (2001) developed a similar analysis in the framework of a feasibility study for a UK national union catalogue. Seven vendor systems were analyzed in working catalogues and the results showed a significant proportion of

installations with outdated versions of the protocol, lack of Scan and Sort facilities and essentially a general lack of consistency in Attributes leading to poor search services.

Most of the critical problems reported in these studies not only confirm many issues already present in earlier professional literature, but they also helped to shed a new light on the nature of the problems and on possible strategies to face them. One general confirmation was that in fact many of the problematic heterogeneities among Z39.50 services are beyond the scope of the protocol itself, as a standard and as a coding mechanism. Other general aspects underlined were the insufficient understanding of the protocol and its components by both libraries and software vendors. This is a consequence of another, more important aspect: the need for clear definition of goals and requirements behind a given implementation.

### 7.2.3.1 Synthesis of Z39.50 interoperability problems

Despite the positive perspectives that are in general present in the assessment studies referred to above, the range of problems encountered came to confirm the essentially complex and irreducible nature of information interoperability.

As noted by Moen (2001) the problems expand in complexity when the case is not just the configuration of a given client to communicate with and search in a given server. While this may be time-consuming, solutions are relatively straightforward. For Moen (2001) searching multiple systems has “an associated multiplier effect on the interoperability crisis points” that are depicted in Fig. IV-1.

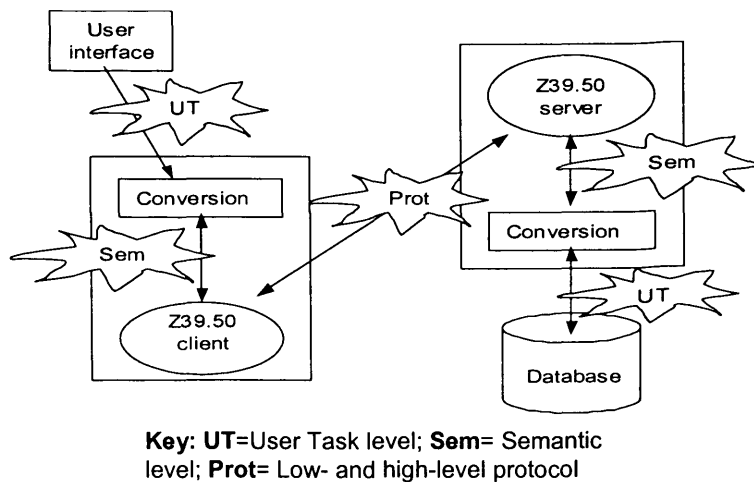


Fig. IV-1 *Crisis points in Z39.59 interoperability* (from Moen, 2001)

Moen (2001) summarized the problems relating to these crisis points at different levels of interoperability:

- a) *Low-level protocol interoperability* (syntactic), i.e., the degree to which two implementations interchange protocol messages according to specifications of the standard. At this level problems are less frequent and easier to solve;
- b) *High-level protocol interoperability* (functional), i.e., the degree to which two implementations support common services/functions. This depends not only on the functionality provided by the Z39.50 client and server software (functions/services supported), but also on commonalities in IR systems functionalities (for example, even configured accordingly at the protocol level, no Z39.50 system can force a local system to perform a given type of truncation that it does not itself support);
- c) *Semantic level interoperability*, i.e., the degree to which two implementations preserve and act on the meaning of information retrieval tasks. The range of factors at this level is far more diversified than at any other level (it encompasses issues of local IR systems, for example, database indexing policies; consistency of data structures, of mapping of such data structures to protocol Attributes, types and values; and also issues about data granularity and of consistency of data content/meaning, notably in controlled access points);
- d) *User tasks interoperability*, i.e., the degree to which two systems support the information retrieval tasks needed for one or more user groups; this relates to user expectations about interoperability and is the less informed aspect so far; many factors can affect the user perception of an interoperability service, from the quality of the underlying databases to the system's response time.

Low-level (syntactical) protocol interoperability is usually the less problematic, but high-level (functional) is more critical due to the extensive optional functionality provided in the standard. Problems at any of these points will prevent interoperability at the other levels, even if the conditions on which such levels

depend are perfect. Conversely, if all is smooth in terms of syntactical and functional interoperability but there are, for example, incompatibilities at the level of local IR systems (indexes, data structures, behaviour of search terms, etc.) interoperability can still be hampered.

All these levels/crisis points threaten interoperability in ways that are not confined to standard conformity. For Moen (2001), there is “a continuum of interoperability” rather than a definite answer about conformity. Two systems can conform to the standard but not interoperate at all or do it only partially. Most of the more critical and difficult to solve problems are “out of the jurisdiction of the standard” (Ibid.).

“Current interoperability issues typically relate more to Z39.50 implementation and local information retrieval systems functionality rather than the adequacy of the standard” (Ibid).

This clarification has been important to identify the real domain of most of interoperability issues as being information management, encompassing data/information/services’ architectures and policies, and not only technology. It is the inextricable mixture of all these aspects that for a long time has produced misleading or partial understandings of the problems at stake.

“Z39.50 has been the object of criticism because to some it represents an outdated technology since it prescribes semantic level interaction between systems and also low-level protocol encoding mechanisms” (Ibid.).

#### **7.2.3.2 Gateways and union catalogues**

The exploratory stage of Z39.50 generated high expectations about creating ‘virtual libraries’ just by enabling several catalogues with the technology. While at first the goal was simply to search remote databases, one at a time, the idea of building virtual union catalogues expanded rapidly, amplifying the expectations as much as the frustrations. This has brought the topic of collective or union catalogues to the order of the day, especially since the end of the 90s, in a clear sign that information management aspects of Z39.50 finally got the same status of concern than purely technological ones.

Z39.50 can give support to different service levels, from simple gateways to union catalogues. Because the terms are often used interchangeably, some clarification is useful. The concept of a union catalogue is bound to stronger quality



and management requirements for searching and indexing consistency and for data consolidation and scaling (Lynch, C., 1997; Cousins, 1999; Dovey, 2000; Stubley, Bull & Kidd, 2001; Dunsire, 2002; Gatenby, 2002; Sfakakis & Kapidakis, 2003; Hider, 2004), while gateways have a different context and usually provide a less ambitious service.

Gateways are aimed at a unique point of entry to provide seamless access to different systems, usually with no further services beyond search and retrieve, or guarantees about the quality of multiple database result sets. But the concept of a union catalogue has been traditionally more than just an aggregation of information sources and requires goals and policies defined in common. With Z39.50 technology a gateway can be mounted without awareness of the connected systems and that alone is not a union catalogue.

Yet, a community of systems may want to agree to use the technology to constitute a distributed union catalogue. In this case, while the technology is essential, further agreements are needed as to objectives, service levels, etc., with common technical aspects defined accordingly. While in both gateways and distributed union catalogues there are common problems in terms of integrated access, the latter poses additional, more demanding, requirements.

This means that for enhanced sophistication in search and retrieval and support for other functions (like data consolidation, copy cataloguing, ILL, shared responsibilities on collection development, etc.) there has to be either a centralized management system or a distributed, but managed, environment. In general, a good level of quality of service is more attainable in union catalogues as centralized databases, where aspects of data management and consolidation (by batch processing activities on error checking, authority control, de-duplication, etc.) and performance (by not having dependencies on external systems varied conditions, for example, in terms of connectivity, search load and response time) are more controlled.

But circumventing many of these factors that cause degradation of the service at the end-user level by having a centralized system, comes at a high cost. The alternative is the distributed model promised by Z39.50, at a much lower cost and offering also the advantage of higher levels of data currency. But in this case, the results can only theoretically be the same as in centralized databases, because the distributed search model is constrained by “the lowest common denominator” among participating systems, in functional and semantic terms, and “most often

consolidation functions are still completely omitted” while the performance “is paced by the performance of the slowest participating system” (Lynch, C., 1997).

This realistic understanding does not diminish the value of Z39.50 to build federations of distributed systems. But there are changes in concept, requirements and expectations that have evolved around Z39.50, whose original and so far more successful role has been that of

“extending familiar local user interfaces to remote databases outside a local system, particularly if this is done in a crafted implementation rather than just the ad hoc incorporation of random external databases” (Ibid.).

As noted also by Cousins (1999), McLean (2000), Gatenby (2002) and Sfakakis & Kapidakis (2003), Z39.50 was not originally designed for multi-database searching but for point-to-point intersystem communication, notably for interlinking already existing centralized databases. These authors recognize the need for more research into models of database federation and some suggest that a combination of the two approaches – the virtual and the physical – may increase the quality of service for the end-user while taking advantage of the less costly distributed model.

Such a mixed model was suggested, for example, for the EUCAT project (Gatenby, 2002; van der Graff, 2004), for a pan-European catalogue of major bibliographic databases. The model comprises not a central database replicating all data from the participant systems but only a central index so that search is executed in a central service which then links results to the appropriate local database. This is a model that is close to that of OAI,<sup>11</sup> which collects metadata from several sources to provide an integrated index (Lynch, C., 2001b; Gatenby, 2002).

### **7.3 Strengthening components of networked information services’ architecture**

The current stage of Z39.50 deployment is characterized by a clearer perception that Z39.50, as a standard and as a protocol, is only part of the solution for network discovery and information retrieval problems; and by national and international initiatives towards more refined and effective solutions for interoperability. Assessment of Z39.50 implementations is still a major concern (Moen, 2001) because

“There are currently [...] no accepted testing methodologies, formal processes, and interoperability benchmarks by which customers and vendors can assess conformance to profile specifications or demonstrate effective interoperability” (Moen, 2002: Need and justification).

Assessments of actual Z39.50 services have been linked to policy formulations and progress on Z39.50 has been based on intense collaboration among policy bodies and groups of institutions, moved by standardization or strategic purposes. Models for broker systems using Z39.50, as well as with other protocols as middleware components (Dempsey & Heery, 1998) have been maturing and experiences drawn from digital and hybrid library projects have enlarged the field and scope of Z39.50 either as a protocol or as a framework for analyzing different levels of interoperability. The need to cope with higher demands and the evolving technological context have produced two major outcomes: i) an important movement towards the definition of national and international Z39.50 profiles; and ii) an evolution towards specifications to align Z39.50 with current trends in Web technology.

### **7.3.1 Development of more structured and detailed profile specifications**

Until 1997 the ATS-1 profile (Annex 1: Sec. 5.4) was almost the only one used with bibliographic databases. Practical experience revealed its insufficiency, and that it was prone to different interpretations and implementations. In 1997, the projects ONE (OPAC Network in Europe)<sup>12</sup> (Husby, 1997) and MODELS<sup>13</sup> (Murray, R. & Davidson, 1997) and the National Library of Australia<sup>14</sup> (Wells, et al., 1998; Gatenby, 1999) issued new profile specifications on top of the ATS-1. In 1998, the Conference of European National Librarians (CENL) approved the CENL Profile, with “the features that would be supported by all Z39.50 applications used in Europe” (Hakala, 1998). These profiles extended ATS-1, providing more detailed, and better documented, specifications.

Other profiles followed, aiming at standardizing Z39.50 library applications in different countries. The National Library of Canada released the *Virtual Union Catalogue Profile* (Lunau, et al., 1998);<sup>15</sup> the ICCU (Istituto Centrale per il Catalogo Unico delle Biblioteche Italiane) prepared the *SBN Profile* (Baldacci & Parmeggiani, 1998). Other national examples are the *DanZIG Profile* (Andresen & Jørgensen,

2004)<sup>16</sup> and the *Z39.50 Norwegian Profile* (Husby, 1999). All these profiles represent the trend towards standardizing implementations regionally. They are not, however, major deviations from earlier profiles, as they were all built successively on Bib-1 (from the ONE project) and CENL profiles.

Two other profiles emerged that have had greater impact since 1999, the *ZTexas Profile* (TZIG & Moen, 2000; TZIG, 2003) and the *Bath Profile* (Bath Group, 2003). The first is the outcome of a US regional group<sup>17</sup> that produced a profile with different functional areas, for bibliographic and holdings (usually a weak aspect of Z39.50 services, see Moen, 1999), library and cross-domain searches (using DC attributes), authority records and citation databases. Since the first version, this profile documented extensively all implementation aspects including recommendations for database indexing.

The *Bath Profile* (Bath Group, 2003)<sup>18</sup> is the result of an international initiative (see Miller, P., 1999) aimed at an international profile not limited to the traditional 'minimal common denominator' features, i.e., exploring further the potential of the protocol and the functionalities that bibliographic databases can offer (Gethin, 2001). Drawing on the experience of other profiles, notably of *ZTexas*, the *Bath Profile* is modular, with functional areas for different types of searches/functionalities, as well as different levels of conformity (Moen, 2000c).

The *Bath Profile* soon gained international recognition, although most commercial products still lack compliance, despite what is often claimed (Manojlovich, 2001; 2003). According to Lunau (2003), the Bath profile is already implemented in updated versions of the *ZTexas Profile*, of the *ONE2 Project*<sup>19</sup> and The Library and Archives Canada. It has been endorsed by standards bodies, having served as a basis for the development of an US standard profile (ANSI/NISO Z39.89: 2003) and its future support has been announced by major library system vendors and OCLC. A gateway for conversion to and from other bibliographic profiles was developed by the project Gate Z (Bull, 2001; see Annex 1, note 6). However, the implications (costs and impact) of its application in production systems may represent some delay in the generalization of the profile (Nicolaidis, 2003). On the other hand, the impact it may have on commercial library products is not yet clear, while the business/customer environment regarding Z39.50 is not stable (Bull, 2003).

The *Bath Profile* is expected to improve and stabilize the practical applications of Z39.50 in bibliographic applications. Essentially, this new profile builds on previous profile definitions but sets a more clear and rational analysis of requirements, in a modular and comprehensive way, accompanied by specifications in full detail that was not usual in previous profiles.

### **7.3.2 Evolution towards alignment of Z39.50 with Web technologies**

One of the problematic aspects of Z39.50 mentioned earlier has been its lack of alignment with the current technological environment (see Section 7.2.2 b), first with the move from OSI to Internet protocols and later to Web technology.

Awareness of the proliferation of tools for networked information retrieval became an important matter for the Internet community and initially Z39.50 was a relevant subject alongside WAIS, Gopher and the WWW (Tomer, 1992; Foster, ed., 1994; Leon, 1994; Kong, & Gottschalk, 1994). The interest in Z39.50 for application to areas broader than libraries, such as services encompassing non-bibliographic applications in a university campus (Kunze, 1992), WAIS services (St. Pierre, et al., 1994) and access to multiple sources of governmental information (Moen, 1994; Moen & McClure, 1994), date from this early period. WAIS, for example, is usually referred to as the only initiative to implement the first version (ANSI/NISO Z39.50: 1988), beyond the LSP (Lynch, C., 1995a, 1997b).

However, these initial trends did not thrive. Besides libraries, the protocol has been used in government, geospatial and museum information only (see Annex 1: Sec. 5.4) and tried here and there, for instance, in the case of archives. On the other hand, the protocol barely received attention from domain-independent IT stakeholders. This is usually explained by Z39.50 being tightly based in the classic client/server model and making use of technologies not conversant with, or implementable at the level of the Web.<sup>20</sup> Moreover, the development of Web technologies also slowed progress in Z39.50 diffusion in the bibliographic world as other cross-domain solutions for resource discovery and search and retrieval, such as the OAI-PMH and DCMES, based on XML, became in the order of the day.

The lack of synergy between Z39.50 and the Web, as well as the little connection between the respective traditions and players, was patent (Hammer & Favaro, 1996) and started to be addressed by 1998 (Le Van, 1998, 1998a; Ward &

Wood, 1998; Z39.50 Maintenance Agency, 1999), when the potential of XML for libraries became widespread. As an open standard, Z39.50 had been actually very 'library centric' and remained quite 'closed', strongly associated to a whole set of complex and not novel standards, like ASN.1 or MARC, foreign to those interested in global solutions and developments in mainstream Web IT. Some Z39.50 implementers started to work on solutions for encoding the Z39.50 operations in XML, e.g., to replace ASN.1 (Sue, 1999; Christian, 1999a).

The future of the protocol's role and its model in face of the Web environment entered the discussions of ZIG experts (Jørgensen, 2000; ZIG, 2000, 2000b, 2000c, 2000d). The mismatch with the Web had to be overcome (Denenberg, 2000; ZIG, 2000, 2000a) but the matter was contentious because Web requirements, standards and tools appear to be far lower than the sophistication (complex data, complex searches, complex semantics) of bibliographic IR (Taylor, M. 2000).

This mismatch is about IT as much as it is about other information standards and underlying concepts/languages. One example is seen in the controversies about the promise of XML regarding MARC, for a while leading to a popular understanding that MARC inadequacies to current needs can be solved just by translation of it into XML. The problems of MARC disadjustment are far more complex, implying principally conceptual constructs (see Weinstein, 1998; Tennant, 2002; Andresen, 2004) rather than just the syntax used to convey bibliographic data.

But, while the latter is important, as explained by Carvalho & Cordeiro (2002), the advantages, methods and strategies for having MARC records in XML, for exchange purposes instead of plain ISO 2709 files, were not sufficiently clear at the first stage. They analyzed different patterns of using XML for MARC, from very direct and simple but irreversible MARC conversions as in the OAI and DCMES, to semantically rich (but cumbersome) conversions that include all valid combinations of fields, according to the constraining values and rules of MARC.

They concluded that a conceptual model <sup>21</sup> should distinguish three main areas, and the respective requirements, for the use of XML with MARC data: i) records exchange (data transport); ii) record validation (data conformity and management); and iii) sharing of services (for application services like Z39.50). They defended different (although compatible) XML formulations of MARC for each of these areas, and advanced the potential of XML to enable library Web services, i.e., as application code that could be published in WSDL for reuse in solutions that need to

make use of MARC data without the cost of having to know the format details or how to compose the queries in a very specialized language (Cordeiro & Carvalho, 2002, 2003a).

These concerns, applied specifically to the integration of Z39.50 with the Web environment, have been answered by the Z39.50 International Next Generation (ZING),<sup>22</sup> an initiative born within the ZIG in 2001 (ZIG, 2001). Building on prior developments of XML related to bibliographic data, a new set of specifications was released in 2002, named *Search/Retrieve Web Service* (SRW) and *Search and Retrieve URL Service* (SRU) (SRW Editorial Board, 2004).<sup>23</sup>

The main features of SRW/U aim at overcoming most of the technological barriers to a Z39.50 wider deployment. Essentially, they provide lightweight Web services for the main Z39.50 functions. Both SRW and SRU are XML-based and Web-enabled protocols covering the following Z39.50 functions: Explain, Scan, and Search and Retrieve (see Annex 1: Sec. 5.1).

The Web services are based on/combined with Z39.50, which provides for backward compatibility. SRW or SRU gateways to Z39.50 servers enable these systems to provide Web services while maintaining the classic services. The differences between SRW and SRU reside in the mode of operation. While SRW uses SOAP, and therefore encapsulates data (e.g., search requests are formulated in an XML document), SRU defines a simpler system that standardizes the way search parameters are included in a URL syntax in a way similar to OpenURL (ANSI/NISO Z39.88: 2004).<sup>24</sup>

The simplifications provided by SRW/SRU are that, besides using XML instead of ASN.1/BER syntaxes in their messaging system, they also use record syntaxes in XML following several cross-domain record schemas, like DCMES; a more intuitive query language (CQL); and access points statically defined instead of the combination of attributes. A brief explanation is provided in Annex 1: Sec. 6.

The choice between implementing SRW, SRU or both is more a matter of the level of the overhead work required than a choice of different functionality. Both SRW and SRU provide similar functions although implemented in different ways. While SRU is simpler to implement (Morgan, 2004; van Veen & Oldroyd, 2004),

“SRW can [...] provide for more complex search parameters. An advantage of SRW is that it can be integrated into the service framework provided by SOAP Web services. On the other hand, a benefit of SRU is that it is very similar to most web-based search and retrieval applications,

with the exception that those interfaces respond with HTML rather than XML” (van Veen & Oldroyd, 2004).

Being a lightweight version of Z39.50 functions, SRW/U does not cover all the services and functionality of the classic protocol, but it is expected to make it much easier to deploy, thereby enhancing the possibilities of wider usage, especially in non-library environments. There is already available a number of tools for developers and several projects and systems are planning or offering SRW/U services.<sup>25</sup>

Other developments contemporary with SRW/U have taken place towards the same objective of making the protocol easier to implement by hiding its complexities. Two important examples are Zoom (Z39.50 Object Orientation Model) and JAFER (Java Access for Electronic Resources). ZOOM provides an abstract OO API to a subset of the Z39.50 (Taylor, M., 2001-2004) and bindings for concrete programming languages (Taylor, M., 2005). It has been implemented in programmers’ toolkits for the development of Z39.50/SRW/SRU software, such as the YAZ Toolkit (Hammer, et al., 1995-2005). JAFER was a project funded by the JISC under the DNER development programme to build a lightweight Z39.50 toolkit for Internet-based services over the classic Z39.50 protocol. It was developed in Java and is available as open source software <sup>26</sup> (Corfield, et al., 2002, 2002a, 2002b; Dovey, Tatham & Corfield, 2005). The development of gateways to bridge other protocols for resource discovery like OAI PMH is also an important aspect of Z39.50 technological alignment (Habing, 2003; Sanderson, Young & Le Van, 2005).

The role of SRW/U versus Z39.50, and all the bibliographic standards and conventions underlying it, is better understood by making a parallel with what was already explained about EDI versus ebXML (see 6.4.3.3). While Web services enable easier construction of interoperable services, not limited to a given community and more open to the environment, there is still the need for sophisticated agreement on and coordination of functional and semantic parameters if there are specific processes on which to interoperate in a given business area. In the classic Z39.50 not only the most complete functions for library search and retrieve interoperability exist but also the most complete semantic agreements are those defined by Z39.50 profiles and their attribute sets.



This means that the classic Z39.50 will continue to be needed and SRW is more a matter of a technological alignment rather than of simple disruption. What is different with SRW/U are the technological ways to realize some of the services of Z39.50. The specialized functionality that is modelled by the Z39.50 protocol, its profiles and attribute architectures remain valid, and especially useful within the library domain. In fact, most of the Z39.50 problems that are not of a technological nature, i.e., that do not pertain to the low level protocol interoperability characterized by Moen (2000) are not solved by SRW/U. The problems pertaining to the high-level protocol interoperability (functional) and semantic level interoperability (Ibid.) continue to be issues that are upstream of any protocol and beyond its technology, thus SRW/U per se, like Z39.50, will not solve them.

Therefore, all efforts to improve standardized profiles, as mentioned in 7.3.1, continue to be highly pertinent.

## **7.4 Conclusions**

Previous Chapters, in Part III, have provided indication that the understanding of interoperability concepts and their technical realizations have strong implications for the management of information services. The subject is, therefore, an important one to analyse the relationship between IT and information management communities.

In this Chapter, Z39.50 was chosen as a concrete example of such a relationship. The objective was to seek confirmation of the poor absorption of IT concepts into libraries/LIS and of the difficulties in the interchange of libraries with mainstream IT communities.

Overall, the Chapter has provided evidence which gives support to the general findings already achieved in Part II: despite the good rate of IT adoption in libraries, there have been barriers to library adaptivity to the network environment (see p. 119) which have gone from operational to conceptual levels, i.e., affecting the strategic level needed for future strategies regarding IT-supported library services; while, at the same time, the pace of change in the IT environment has increased the difficulty to articulate different orientations and technical languages across the growing variety of professional communities involved (see p. 120).

The overview provided in the Chapter confirms the relevance of the case for illustrating the issues above, for two reasons. First, Z39.50 was started to address technical IT issues derived from libraries needs of a kind that soon became mainstream: the problem was interesting beyond libraries. Second, before Z39.50 could deliver a critical mass of results for the field, the standard went through two important shifts of the technological environment, the Internet and the WWW, which imposed successive new challenges: growing heterogeneity and complexity of the information spaces, blurring with new and more diverse contexts, requirements, standards and stakeholders of interoperability services.

In this evolution, Z39.50 and its protagonists have had difficulty to break several barriers to working on a sound basis within the library field and to get its potentials recognized by wider audiences. Despite the extensive use of the protocol in libraries, the case of Z39.50 exemplifies well the kind of misfit, i.e., of the lack of common understanding and alignment, between libraries/LIS and IT. This is patent in the literature on Z39.50 since the mid-90s: the problematic aspects of Z39.50 are not mainstream topics for the profession, but discussed by just a minority of authors that are from the technologist side of LIS; it is mostly through them only that one get expressions of the contradictions and lack of alignment with the general IT environment. Some examples of these expressions are provided in Annex 3.

This Chapter showed that the evolution of mainstream IT was faster than the standard development of Z39.50, and this hampered its success, being also a sign of misalignment. But it was also shown that in the understanding, implementation and prevision of what to expect from Z39.50, the problems are essentially semantic. This entails mastering the data assets in its conceptual model, data types and the functionality they are intended to support, independently of whatever system is handling them. In the case of Z39.50 application in libraries, this means knowledge of MARC and the functionality of a catalogue. These have been extensively used for decades, without major changes. Even the issues of managing MARC data from different sources are not substantially new at least for all those that have worked in collective databases. The main difference is that data come together, from different sources, on the fly.

What the history of Z39.50 reveals is a lack of mastering the model and semantics of bibliographic data/functionalities of a catalogue, from the various stakeholders. My interpretation is that preconceptions and traditional attitudes have

conditioned progress from both the part of the library and the IT domains. Libraries, as IT customers, have put little demand and in general have just waited, because they believe the issues are beyond their realm. Library vendors, the actual workforce in the IT market that should master the issues, just followed with the least effort the application of data standards and traditional library functional requirements, in whose preparation they had not participated. For example, IT people view MARC standards as arcane, overly complex and not interesting, especially since the relational model of databases became common. And despite MARC data being stored in relational database systems it is most often treated as in flat-file systems, i.e., with all bibliographic data in a single table.

All the above are plausible reasons for the general misfit about Z39.50. The misfit becomes more evident if analyzed from the very same perspectives that could have supported a growing alignment between the fields. The remainder of this Chapter elaborates conclusions on these perspectives, conveying the interpretation of the researcher.

#### **7.4.1 The centrality of Z39.50 application functions**

From the perspective of the general IT market, the IR function is as central to libraries as it is to any information system in other areas. However, Z39.50 evolved as if it were for a market niche only, neither capturing significant interest of wider markets or the IT industry. The protocol was embraced by a few sectors only, mostly not-for-profit. Most of development and diffusion processes of Z39.50 were essentially funded rather than pushed by the market (see Annex 1: Sec. 4). While helping to build and put the technology into practice, this may also have restrained more general competition.

From the perspective of the library sector at large, for most of its long history Z39.50 has been seen principally as a technological matter (in a mechanistic fashion), weakly connected to the mainstream knowledge of information and information services management. This kind of orientation has left much of the substantive matter of interoperability aside from the actual concerns of library professionals and institutions, who just waited (in many cases still wait) for the promises of Z39.50 to appear. Only recently, in the assessment phase mentioned in

7.2.3, did the sector realize that most of the interoperability problems depend on information management issues, the majority all but new.

From a theoretical perspective, Z39.50 could have contributed to a cross fertilization of concepts between fields. Z39.50 is an abstract model for IR combining old and new IR topics that were debated for about 20 years. But there is little reflection of this in the research literature of IR, both in Computing and Information Science. Since the mid-nineties conceptual analyses have been produced in Computing/IT about models of systems interoperability, notably on multi-databases and federated systems, or digital libraries, where there is some mention and exploration of Z39.50 (e.g., EU-NSF, 1998; Larson, 2003). However, in none of these fields did Z39.50 or its underlying model gain the status of an object of research to contribute theories to IR or strengthen the theoretical relationship between LIS and Computing/IT.

#### **7.4.2 Z39.50 and the growing cross-domain demands**

Z39.50 emerged in a context where SR was expanding and much activity was directed to tools for network information discovery. The knowledge and experience derived from Z39.50 would have been logically in a position to attract the interest of the IT and commercial information sectors at large. This was not the case, apparently for two major reasons.

One has been the ‘library centric’ identity of the protocol, that since its early days has been strongly connected to the very specific sector of libraries, whose requirements and technicalities are not easy to understand, or to map conceptually to the new demands for quick and easy demonstrable cross-domain solutions. In most new metadata and protocol development initiatives for cross-domain services the participation of the traditional library domain did not happen until long after they were started.

On the other hand, most of the new developments for cross-domain SR did not come from the IT sector linked to the traditional information management, e.g., that of databases, where Z39.50 developed, but from the novel field of Web technology. As explained in Chapter 6, it took some time for the technical convergence of the database and Web cultures to start. In this context, the delays in Z39.50 alignment

with the Internet and the Web, while understandable, were significant to create the tradition of its common dismissal.

Both reasons – being tightly connected to a sector not very influential in technological matters and disconnected from novel technologies – have elicited the ‘not invented here’ syndrome which, combined with issues of timing, may explain the poor take up of Z39.50 in the general field of cross-domain network information discovery.

### **7.4.3 Z39.50 as an opportunity for knowledge integration**

The demands that led to the development of Z39.50 were first driven by inter-organizational vision and leadership. Initially, they were hand in hand with IT in the (quite uncharted) territory of systems interconnection and the protocol was a topic discussed alongside implications for changing services and for re-evaluation of certain library standards and procedures, like MARC coding, cataloguing practices or authority control (see Annex 1: Sec. 2). However, since its development as a formal standard (see Annex 1: Sec. 3), and despite the regular participation of libraries and library IT vendors, the matter of the protocol passed almost exclusively to the level of IT technicalities whose language and foci have been far from the language and concerns of the traditional LIS field.

During the long stage of the protocol standard definition, the topic passed into a kind of abstract limbo accessible only to the few who could understand the nitty-gritty aspects of the novel network technologies and its language. This is clear from the literature on Z39.50 whose population of technical protagonists is fairly small, and has not varied much throughout the years. For a long period, the average library manager or practitioner saw the protocol as simply a good technological thing that would come, with no apparent implication on the model of services, standards and procedures of library technical work. It would be simply something to add to the existing facilities. This means that the ‘technological viewpoint’, concentrated on the protocol as an IT artefact, was for a long time the prevalent view of Z39.50, rather than the ‘information viewpoint’ which focuses on information management aspects of the distributed systems in which the protocol would work.

This is, of course, a broad generalization but gives some indication to why the development of Z39.50 was a missed opportunity to bridge the conceptual

knowledge and vocabularies between the fields of information management, as it is carried out in libraries, and that of IT. Z39.50 is a meta-architecture that requires abstract formalizations of knowledge from the two fields. The abstract formalizations were there but apparently the common understanding about it was kept to a very ‘aseptic’ (i.e., not mutually contaminated) minimum. For example, it did not help to get the IT side enthusiastic about knowing more of bibliographic data structures like MARC, nor did it help library managers to grasp the extent of (apparently minor) technical decisions such as how to index their databases.

On the side of IT, as explained in Chapter 3 (Section 3.6), the tradition has been that of abstract machines, usually seen as deterministic and not contingent. But the world of information management is that of real people and institutions combined with machines. It is inherently imperfect, prone to error, inconsistent and contingent. Keeping the two aspects apart has contributed to delay the understanding of the actual nature of interoperability problems around Z39.50 until a late stage.

While there is still a lot to be learned in common from the Z39.50 experience, it is difficult for both sides to erase prejudices and ideas that are often subliminal and entrenched for so long. For many in the library field it will be difficult to see Z39.50 failures as not simply technology failures. For many on the IT side, the blame will remain as the complexity of ‘old’ bibliographic data structures or ‘over-weighted’ library functional demands. Each of these quite common understandings about what happened with Z39.50 is not correct or realistic.

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## Notes to Chapter 7

<sup>1</sup> The ILL protocol is a set of standards that specify the services and protocol for interlibrary loan applications. The respective standards (currently ISO 10160: 1997 and ISO 10161: 1997) were approved in 1991 and first published in 1993. Part 2 of the ISO 10161 (ISO 10161-2), concerns the *PICS* (Protocol Implementation Conformance Statement) *Proforma* (for declaring the conformance of a given product) was approved in 1995 and published in 1997. The ILL Application Standards Maintenance Agency is the Library and Archives Canada (<http://www.collectionscanada.ca/iso/ill/>).

<sup>2</sup> Example of this instance are EDI standards such as the US X12 standard and the EDIFACT standards in Europe, to manage activities with the book trade. See also Chapter 6, note 29.

<sup>3</sup> These are business-oriented functions whose processes require the control of a range of transactions between library systems and systems of various providers. ILL and EDI standards are conceptually similar: they establish defined sets of messages according to the business rules that govern the relationship between the system's owners, the data elements needed and a syntax for structuring the messages. Automation of ILL processes was among the first concerns of networking services for major libraries with national and international supply functions such as the national Library of Canada and the British Library (see Dempsey, 1992: Chap. 5; Dempsey, Mumford & Tuck, 1993).

<sup>4</sup> Examples were SOCKER, to develop a Z39.50 client that could work in a CD-ROM workstation, library system and network access point; and EUROPAGATE and ONE, to build Z39.50 solutions that could run either in OSI or TCP/IP technology (see Annex 2).

<sup>5</sup> Projects with Z39.50 software deliverables were ARCA, PARAGON, SOCKER, EUROPAGATE and CASELIBRARY (see Annex 2 and European Commission, 1998).

<sup>6</sup> Examples of such projects are: ION, DALI and DECOMATE (see Annex 2); and IRIS (*Irish Interlending Service*) which started as a project in 1992 (<http://www.iris.ie/IRCO.htm>) and is now a current service (<http://www.iris.ie/>) managed by the *Consortium of Irish University Libraries*.

<sup>7</sup> Respectively, projects ELISE II and PARAGON (see Annex 2).

<sup>8</sup> Ariel® (<http://www.infotrieve.com/ariel/index.html>) is a software for document delivery that uses either FTP or email for document transmission, based on the GEDI standard (ISO 17933: 2000). It was developed and launched in 1991 by the RLG.

<sup>9</sup> Few and scattered examples exist of exploring the protocol for other purposes or combined with other IT standards of general use. These include: an application of an OO Petri Net language (see Chapter 5, note 33) to model the Z39.50 protocol (Lamp, 1994); a comparison with RDA - *Remote Database Access* (ISO/IEC 9579: 2000) was provided by Islam (1999). The project Z+SQL - *Distributed Interoperable Database Searching with Z39.50 and SQL*, produced a profile that expands the capabilities of Z39.50 by adding features of SQL, so that the protocol can be used for complex SQL queries in several databases, of any type (Finnigan, Bird & Colomb, 1999; Goodchild, 2000); a tool to convert Z39.50 queries from RPN to SQL was developed to access data in relational databases whose metadata is not conformant to any profile but is mapped in a metadata clearinghouse (O'Rourke, n. d.);

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an object model of the Z39.50 search system was developed by Wake (2000); an exploration into a mechanism to enable the Mozilla browser to launch queries to Z39.50 servers is available from Brickley (1999-2003).

<sup>10</sup> There are only a few Z39.50 target directories or registries, especially in terms of international coverage. The most comprehensive ones are initiatives of Z39.50 product vendors:

- *Index Data* (<http://www.indexdata.dk/targettest/>) is a consultancy company specializing in networked information retrieval, Z39.50 being one of the technologies deployed. Index Data provides a Directory of Z39.50 with around 800 servers that are periodically checked with 'Z-Spy', a robot-like script that automatically probes to see if the servers are alive and what their configurations are. Based on this Index Data provides not only the directory but also statistics on the characteristics (e.g., most implemented 'use attributes') and geographical distribution of servers (<http://www.indexdata.dk/targettest/stat.php>);
- *Web Clarity* ([http://www.webclarity.info/products/overview\\_registry.html](http://www.webclarity.info/products/overview_registry.html)). WebClarity is a vendor of a Z39.50 client for Windows (BookWhere) and provides a registry (WebClarity, 2001) where any institution can publish information about its server(s) with over 1000 records for Z39.50 servers worldwide.

National directories exist, for example, for the United Kingdom, by UKOLN (<http://www.ukoln.ac.uk/distributed-systems/zdir/>), for Australia, by the National Library of Australia (<http://www.nla.gov.au/libraries/z3950/>).

<sup>11</sup> See Chapter 2, note 27. See also Lynch, C. (2001b) for a clarification between the OAI protocol (PMH) and Z39.50.

<sup>12</sup> This profile is named *Bib1 Profile for ONE*, often referred to as just *Bib1*.

<sup>13</sup> The scope of MODELS was the UK library community in general; it establishes not a single profile but a set of profiles (4 levels) providing "an incremental level of interoperability facilities" Murray, R. & Davidson (1997).

<sup>14</sup> UCP – *Union Catalogue Profile*. One of the particularities of this profile is the provision for implementation of the extended service 'update', which allows a client to update records in a server.

<sup>15</sup> The profile originated in the *Virtual Canadian Union Catalogue project* (vCuc) that ran from 1996-1998 (Lunau, 1998, 1998a).

<sup>16</sup> This profile originated in the DanZIG - *Danish Z39.50 Implementers Group* (<http://www.bs.dk/content.aspx?itemguid={AB84A94F-090C-4436-8AC2-B4AFAFD8B78E}>) and was initially approved in 2001. It defines two levels of requirements.

<sup>17</sup> The *Z Texas Project* (Moen, 1998c; TZIG, 1998), addressing interoperability in a statewide network of libraries, was led by the *Texas Z39.50 Implementors Group* (TZIG). <http://www.tsl.state.tx.us/ld/projects/z3950/>. The current release of the *ZTexas Profile* is 3.0 (TZIG, 2003).

<sup>18</sup> The current version of the Bath Profile is Release 2.0 (2003) available at <http://www.collectionscanada.ca/bath/tp-bath2-e.htm>. The Library and Archives of Canada is the Maintenance Agency for the Profile (<http://www.collectionscanada.ca/bath/tma-bath-admin-e.htm>).



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<sup>19</sup> The ONE 2 Project (<http://www.one-2.org/>), involving the national libraries and/or union catalogue agencies of Finland, Sweden, Norway, Denmark, United Kingdom, Italy, and Hungary, is an extension of the project ONE (*OPAC Network in Europe*) aimed at the implementation of new Z39.50 functionalities, combined with ISO/ILL (ISO 10160/10161) for item ordering, inter-library lending, copy cataloguing and update, and electronic document delivery. The ONE-2 Profile (Jørgensen, 1999) updates the BIB-1 Profile for ONE (see Husby, 1999) according to the Bath Profile and specifically addresses the above functions.

<sup>20</sup> An early initiative to address this was the *Stanford Protocol for Internet Retrieval and Search* (STARTS), developed since 1996 within the Stanford Digital Library Project. The aim was to build a profile for a light version of Z39.50: 1995 using the HTTP protocol, intended for search engines addressing a variety of data sources (Denenberg, 1996; Gravano, et al., 1997; Ward & Wood, 1998). The project produced the ZDRS Profile (ZDSR, 1997).

<sup>21</sup> The model was called TVS – *Transport, Validation and Services* (Carvalho & Cordeiro, 2002).

<sup>22</sup> ZING – *Z39.50 International: Next Generation* (<http://www.loc.gov/z3950/agency/zing/zing-home.html>). Initially announced as ZNG (Z39.50 Next Generation, see at <http://www.loc.gov/z3950/agency/zng.html> ).

<sup>23</sup> The document consolidates all specifications concerning both SRW and SRU.

<sup>24</sup> But, as explained by the SRW Editorial Board (2004a) SRU and OpenURL are different in nature and do not address the same functions. Although both address navigational features of an information distributed environment, the latter is not a distributed search protocol but a context-sensitive linking device (Caplan & Arms, 1999; Grogg, 2002; O'Neil, 2003). The OpenURL standardizes the syntax of the URL used in reference linking systems to carry metadata about a resource from a given system to a target in order to find the relevant copy to customers of the origin system. The metadata contained may vary, usually including a minimum of descriptive metadata for lookup and identifiers, e.g., the DOI (Atkins, et al., 2000; Beit-Arie, et al., 2001). The 'context sensitive' action is performed via a third system which resolves the 'origin' URL into the 'target' URL appropriate in each case. The publishing industry provides repositories of identifiers, e.g. the CrossRef service, which enable the management of the linking to service to be independent of the location of the resource (Van de Sompel, 2000; Brand, 2003).

<sup>25</sup> See SRW implementers at: <http://www.loc.gov/z3950/agency/zing/srw/implementors.html>, for available SRW/U development tools and in production systems. There are several toolkits for developers and the Cheshire II Project (<http://cheshire.berkeley.edu/overview.html>), which has provided an open source free system for digital library services now includes SRW/SRU facilities. Examples of production systems are the Library of Congress SRW/SRU/Z39.50 gateway to the Voyager Z39.50 server for the LoC Online Catalog; the Koninklijke Bibliotheek (Netherlands) uses SRU as the common access mechanism for most of its catalogues (see <http://www.kb.nl/persons/theo/myportal/zngdbs.xml>); there is also a pilot implementation of SRU in the portal for TEL -The European Library (van Veen & Oldroyd, 2004).

<sup>26</sup> See *JAFER ToolKit Project – Development Website* at <http://www.jafer.org/downloads.html>.

## CHAPTER EIGHT

### CONCLUSIONS

#### 8.1 Introduction. Summary of conclusions

This thesis has provided a study on the relationship between libraries/LIS and Computing/IT, motivated by the increasing demands on IT knowledge in libraries due to the rapid pace of change, and the intermeshing and growing complexity of the information and technological environments. The research context was defined with a management perspective, arguing for the need to strengthen forms of ‘business-IT alignment’, for which it is fundamental to enhance congruence of the frames of reference between IT and non-IT communities.

Libraries have at least a triple perspective in their relationship with IT. Firstly, as information services providers, libraries run a ‘business’, i.e., pursue concrete functions through sets of given processes to be sustained, optimized and renewed through IT. Secondly, libraries act as a major player in the information marketplace, but because of their societal goals, models of using or thinking about IT are affected by pressures and factors that are not of a business nature. Thirdly, because they have information as their core object and *raison d’être*, which is increasingly dependent on IT, libraries’ missions, functions, processes and competencies are especially vulnerable to all sorts of technical and philosophical changes in the information environment. In this context, one aspect particularly important to clarify is the status quo of knowledge sharing between the fields, especially of IT knowledge integration in LIS. Despite the long history of IT usage in LIS the relationship appears to be weak, in technical and conceptual terms.

The literature review, covering different perspectives of the relationship between LIS and IT, pointed to the lack of shared conceptual knowledge, the existence of different cultures and the general absence, in the LIS literature, of analyses of IT concepts and languages beyond practical approaches. Stemming from this, the research problem was defined as that of IT knowledge integration in LIS, and two research questions were defined to address it.

The first question - is the relationship between LIS and IT characterized by sharing conceptual foundations that facilitate conveying IT knowledge into LIS; or is

it predominantly confined to the operational needs of IT artefacts consumption – was aimed at investigating whether or not computing/IT has been conceptually embedded into library practices and LIS theoretical thinking. The research carried out in Part II (Chapters 2 and 3) revealed that:

- i) in practice, the relationship has been predominantly limited to operational needs, which have been pragmatic thus not demanding a conceptual IT background;
- ii) in disciplinary and conceptual terms there is little interchange or cross-fertilization between LIS and IT. The case study presented in Chapter 7, on Z39.50, provided further evidence of the misfit between LIS and IT communities, while showing the weak understanding and absorption, in LIS, of matters depending on IT technical constructs.

The second research question - is the technical background of computing/IT a persistent barrier to knowledge sharing with LIS? Or is the evolution of computing/IT providing a set of integrative concepts that can serve as a durable and extensible common conceptual basis – was defined to investigate the hypothetical potential of IT constructs as sources of conceptual alignment, i.e., of contributing to the congruence of frames of reference between IT and non-IT professionals. The investigation carried out in Part III (Chapters 4-6) to answer this question revealed that:

- i) the lack of an IT/computing background is not a persistent barrier to IT knowledge acquisition because the evolution of IT has been marked by trends of high-level formalizations which create an easier and better understanding of IT systems; and
- ii) the existence of high-level concepts and languages, derived from IT constructs but amenable to understanding and application beyond the realm of technical IT systems, gives an indication of their potential as sources of conceptual alignment.

The research questions defined for this study correspond broadly to the two main areas of investigation which are also reflected in the thesis title. The first part, “IT frameworks in LIS”, was focused on understanding the relationship between LIS and IT has been weak in conceptual terms. The outcomes of the study in this area

clarify the existence of a knowledge problem that is counterintuitive due to the long-standing and extensive use of IT in libraries. The second part, “exploring IT constructs as sources of conceptual alignment”, was focused on the understanding of how information technologies came to be as they are, their underlying conceptual trends and constituencies. The outcomes here disclose a level of knowledge that is not visible from just the practical use of or acquaintance with discrete technologies or technical aspects of IT.

The results from both areas provide support for the claim made at the beginning of the study: the need to feed “business-IT alignment” at the knowledge level. Mastering IT trends and their concepts helps to build common communication channels and languages for different expert and management communities, to devise important tactical opportunities, to act upon developments, and to decide on the strategic level. This meets the conceptual framework defined in Chapter 1 (see Fig. I-4, p. 26).

The remainder of this Chapter conveys a more detailed description and discussion of the conclusions summarized above.

## **8.2 On the relationship between LIS and IT**

Chapters 2 and 3 provided the main traits of the past and present of the relationship, for which three major viewpoints were selected: organizations and their patterns of using IT; people, their IT knowledge and forms of its acquisition; and the links between disciplinary/practice fields connecting LIS to IT. From all viewpoints the analysis revealed weaknesses in knowledge sharing perceived as negative for IT management, prospective services and strategy definition in LIS organizations.

Problems of business/IT alignment were identified and different types of barriers to library transformation through IT were perceived, i.e., issues that may prevent LIS organizations from leading or taking full advantage of appropriate technologies for their business redefinition. One of the barriers relates to problems of IT knowledge integration in LIS, derived from a tradition of IT management essentially operational, and of IT education and training based principally on skills. Another barrier identified was a general perception of IT essentially as a tool for pre-determined routines, a black box, an ‘unquestioned given’.

This part of the study showed that the approaches in LIS have been principally confined to practical aspects of consuming IT (introduction, diffusion, and deployment, i.e., the IT ‘application’ to library processes), with little or almost no reflection of technological concepts on the theories and conceptions of the LIS field. This was evident from the analysis of disciplinary fields, revealing that the situation is not peculiar to LIS, but to all fields involved in the relationship. Contrasting with the recognized centrality of IT in these fields, the weak cross-fertilization of ‘knowledges’ among them suggests, above all, a difficult communication.

Issues of communication provide an ultimate locus for synthesizing the problems of the relationship between LIS and IT, because they entail ontological and interaction aspects yet permit the simplification of such a complex subject. From this perspective, three major synthesizing aspects were chosen: the prevalent views of IT, the models of interaction with IT stakeholders and matters and the content, or object, of such interaction.

### **8.2.1 Prevalent views of IT**

The views of technology that can be extrapolated from the literature and practice of a field are fundamental for an understanding of its position and stage regarding IT. They provide the essential ideas that, consciously or not, have dominated the frame of reference for IT matters. Analysing the full set of articles of ten years of a leading research journal in Information Systems, Orlikowski & Iacono (2001) found a range of different conceptualisations of IT which they grouped into five broad meta-categories (Table IV-1, next page).

Using this taxonomy against the representation given in this thesis of the relationship between LIS and IT, my interpretation is that the dominant views of IT have been principally centred on the ‘tool view of technology’ in terms of practice and on the ‘nominal view of technology’ in terms of research. The limitations of these views are evident when compared to the ‘ensemble view of technology’: they promote a rather ‘static’ attitude vis-à-vis IT which, socially and technically speaking, is contrary to the very nature of IT evolution, essentially dynamic and engaged with many fields.

Inconveniences of the ‘tool’ and ‘nominal’ views of IT are twofold: they do not promote, or they reduce to the minimum, common understandings of different

technical areas, i.e., they mostly delegate to each other what are seen as separate competencies and trust the combination to work in a mechanistic fashion; and, consequently, they reduce the opportunities for convening contributions towards IT advancements.

Table IV-1 *Different conceptualizations of IT* (based on Orlikowski & Iacono, 2001)

IEWS OF TECHNOLOGY	FOCI OF ATTENTION
<b>I. <i>Tool View of Technology</i></b>	The engineered artifact
IT as labour substitution tool	Mechanization and automation
IT as productivity tool	Labour augmentation
IT as information processing tool	New ways to process information
<b>II. <i>Proxy View of Technology</i></b>	Proxy logics, IT captured through surrogate measures
IT as perception	Measures of users' perceptions of the technology
IT as diffusion	Measures of diffusion and penetration
IT as capital	Value of IT resource or investment
<b>III. <i>Ensemble View of Technology</i></b>	Dynamic interactions between people & technology in all stages
IT as production network	The supply side of technology
IT as embedded system	IT is enmeshed with the conditions of its use
IT as structure	Technology is seen to embody social structures
<b>IV. <i>Computational View of Technology</i></b>	Computational power of IT
IT as algorithm	Algorithmic endeavours of computational systems
IT as model	Data and programming models
<b>V. <i>Nominal View of Technology</i></b>	Technology invoked in "name only, but not in fact". IT artifacts are not described, conceptualised or theorized
IT as absent	

One can hypothesize that the continuing prevalence of the 'tool' and 'nominal' conceptions may be explained by a long-standing preconception about the intrinsic nature of IT as being essentially computational, i.e., algorithmic, rooted in mathematics, therefore out of the reach to the majority of the LIS population with a humanities/social sciences background. But, as the second area of this research has shown, and will be synthesized later on, the evolution of IT has for a long time been distant from the algorithmic model, showing growing levels of conceptualisations that are even less mechanistic and more social in nature, thus less 'closed', i.e., less dependent on strict computer expertise for understanding. As noted by Kling & McKim (2000), changing the views of technology is "not just a matter of time", because there are

"social forces – centered around disciplinary constructions of trust and of legitimate communication – that pull against convergence. [...] The range of technological possibilities may change rapidly, while the worldviews that dominate specific scientific communities are likely to change much more slowly" (Ibid.).

### 8.2.2 Models of communication regarding IT

Interactions regarding IT may assume different forms according to the nature of the interacting entities. They can connect diverse parts of an organization, different people or the broad components that define a field of study or activity. The place of interactions/position of actors defines the orientation and reach of the communication channels.

LIS interactions regarding IT matters have been essentially of a practice nature involving the profession horizontally as an end-user population of IT products and services. But in terms of strategy and management, it cannot be said that IT, despite its centrality, has occupied a vertical position, crossing all the levels of the organizations' hierarchy, still the most commonly recognised pattern of communication. The prevalent model of communication involving IT concepts, concerns, strategies, choices and implementations has been predominantly peripheral to most of the structure of organizations in LIS.

In terms of the network of knowledge for IT management aspects, the actors are principally practitioners who constitute a small, localized and floating population that communicates quite informally (Fig. IV-2). Contrasting with the still prevailing chain communication model of organizations, the communicating model regarding IT has been usually more flexible and informal, linking peers that are both internal and external to the organization.

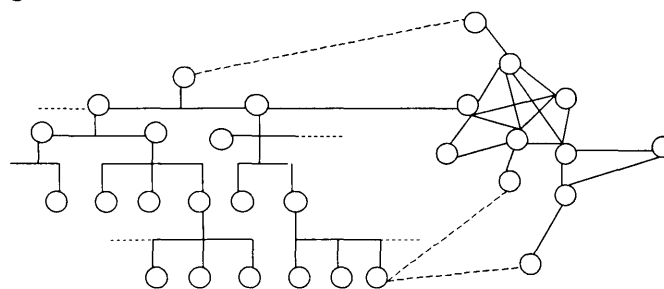


Fig. IV-2 Relationship between LIS and IT: dominant model of communication

This informal, multiple-channel model of communication is largely decentralised and problem-solving oriented, providing faster circulation of information to satisfy members needs. But it is also more contingent, saturated and volatile than the chain model of organizations. Furthermore, because of IT management functions being less institutionalized (in the sense that they have existed in many transient forms and flavours, differing from institution to institution, in

forms added to the core structure) there have been few (usually just sufficient for operational purposes) points of regular connection with the traditional structure.

All these characteristics have not helped the embedding of technological matters in organizations in a more stable and continuing manner. The communication model of IT in LIS configures broadly that of ‘communities of practice’, a strategy to solve knowledge management problems that are not solvable by regular organizations. The term ‘communities of practice’ is chosen to underline three aspects. The first is that it highlights situated learning, i.e., learning in situ and by doing (Lave & Wenger, 1991: 31), as opposed to formal knowledge acquisition. The second aspect is the fact that it expresses a kind of knowledge generation and sharing that is non-canonical, loosely structured, and collaborative. Finally, the term entails a “set of relations among persons, activity, and world, over time and in relation with other tangential and overlapping communities of practice” (Ibid.: 98).

In this context the term ‘community’ implies three dimensions: mutual engagement, joint enterprise and a shared repertoire (Ibid.: 73). Community does not, however, mean agreement, coherence or homogeneity. For Wenger (1998), community implies diversity and negotiation of meaning and the

“communities of practice are not intrinsically beneficial or harmful. They are not privileged in terms of positive or negative effects. Yet they are a force to be reckoned with, for better or for worse” (Ibid.: 85).

Practice, on the other hand, is a concept that includes

“both the explicit and the tacit. It includes what is said and what is left unsaid; what is represented and what is assumed. It includes the language, tools, documents, images, symbols, well-defined roles, specified criteria, codified procedures, regulations, and contracts that various practices make explicit for a variety of purposes” (Ibid.: 47).

Practice is, thus, more than just professional practice, i.e., the practice reified in all kinds of activities (in library, educational and project settings) where LIS and the computing/IT communities come together. All that comes out in practice settings has more extensive and profound implications than situational problem-solving activities. It includes the kind of demands that practice puts on educational and scientific endeavours. Pressures and contingencies in creating disciplinary identities while aiming at coping with the rapid pace of IT change leave little space for durable exchanges between the fields. From the conclusions produced in Chapter 3, a parallel of the above communication model can apply to the interchanges between



disciplines, i.e., they have been mostly tangential, not structural, with few and irregular points of interconnection.

### **8.2.3 The content of interactions**

The content of interactions refers to what runs in the communication channels. In practice, there are three major aspects in a system for information management: data, information processing resources (software applications) and services, i.e., the functionality that is provided by the articulation of both data and applications. What follows is a characterisation of the content of interactions in these aspects, referring to the space of the hierarchical chain of the model above (Fig.IV-2) which is the most typical. Interactions in the informal, multiple-channel space (e.g., between systems librarians and vendors, application developers, etc.), because they are situational and less institutionalized, do not show typical expressions that may be considered embedded forms of IT in organizations.

Data capturing, production and management have been the most concrete aspects of systems activities performed by library professionals. Their activities deal with data at a high level, which is that of information usually lacking a close relationship with “raw data”, i.e., data as composed of database low-level elements. For example, MARC is understood as mostly a translation of a set of information rules for input (e.g., cataloguing codes) closely determined by a given set of outputs. Because the conceptual frameworks behind MARC are not explicitly formulated in terms of a data model and use a special bibliographic language from which a model is not easy to grasp, the most common implementations of MARC in current systems are not far from flat file systems, i.e., they are made to correspond to a set of given outputs (information rendering) making poor usage of the relational facilities of RDBMS for the management of relationships among data elements internal to MARC.

Software applications are the most visible side of IT, at both the production and the exploitation levels of a system. For the library professional they have been principally tools to operate with information in confined and pre-defined ways, notably for IR and information rendering services. The definition, development or composition of software applications have not been a usual concern of LIS, and the closest approach has normally been the definition of sets of functionalities at the

level of user requirements, either professional or end-user. This is usually aimed at ranking existing ‘off-the-shelf’ products essentially for selection purposes. While library management systems nowadays offer some flexibility in the customization of applications, the relationship with IT is still mostly at the user level.

Therefore, information management activities remain highly focused on data input activities for static models of output, and barely have incorporated, or adjusted to some of the paradigm shifts that have been taking place at the technological levels. One aspect that has characterized library management systems is their a priori, and often monolithic, nature. This means that systems have been viewed and consumed as products essentially, ‘as they are’, with some levels of customization but intended to be mostly static in their structures.

However, in the current information network and distributed computing environment, information management systems should be able to cope with dynamic changes. Requirements for the construction, management and ongoing maintenance of both data assets and software solutions are interrelated, and should reflect environmental changes during the whole lifecycle of the system. In this perspective, the term ‘maintenance’ itself becomes much richer in meaning than its traditional, literal, sense. In fact, the concepts and methodologies behind data assets management and software solutions have not been static in the IT market, either because the object and needs of information management have evolved or because the available technology may offer new possibilities.

Many of the barriers to reconfiguring library systems for alignment with the demands of the current information environment derive from the fact that the practices of the relationship between LIS and IT have shared only a small part of their respective contents. Fig. IV-3 represents the broad components of such a content showing the dominant zone of communication.

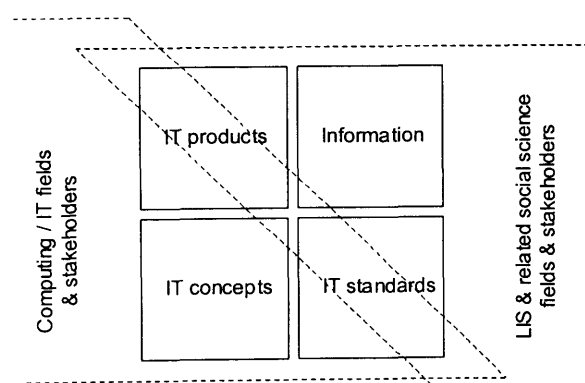


Fig. IV-3 *Predominant zones of content interaction between LIS and IT*

The interactions have been largely about practical application standards and products (see the overlaps), leaving most of the conceptual underpinnings of IT away from LIS knowledge. The same may be said about the knowledge transfer from LIS to IT. This suggests a lack of permeation of forms of knowledge transfer that are not simply declarative (e.g., standards to implement) or procedural (processes to automate). Forms of structural, or conceptual, knowledge of each side (the quadrants of IT concepts and of LIS information concepts and structures) have been largely out of the overlapping band, especially since the 80s.

One argument implied in the second area of this thesis is that the exchanges in both directions will flow more easily if the LIS field seeks actively to embed structural IT knowledge and thus enable itself to entertain conversations that otherwise, because of the general purpose nature of IT, are difficult to motivate.

### **8.3 On the integrative potential of IT concepts**

The first area of the thesis highlighted the fact that enhancing IT knowledge in LIS has been difficult for two reasons. First, the long period of library automation based on the so-called turnkey systems entrenched a limited view of IT, ending up by creating a quite monotonous and low-demanding market in which companies were not pressured to innovate. To cope with the challenges of IT change since the beginning of the 90s, policies of public funding for alignment and innovation have been the prevalent strategy. The fact that they still continue confirms that renovation with and through IT has not been a natural process of, or an easy to lead transformation from within the existing markets, organizations and disciplines.

The predominance of IT short-term pragmatic objectives in current management has prevailed since automation, later accompanied by a project orientation in terms of innovation (e.g., building pilots), since the rise of networked systems. In either case the embedding of IT systems in general professional library knowledge was limited to the practicalities of intended outcomes. For a long time it was apparently sufficient for both the library and IT sides to run by and large on parallel lines of professional knowledge borrowing from each side at a few points only. This was only possible while the advances of IT were not such as to change substantially the models of the information market/environment as happened with the WWW.

### **8.3.1 The importance of a longitudinal view of IT evolution**

The expansion of the WWW opened many new areas of discussion and development in IT and information matters, such as those of metadata and digital libraries, that suddenly elicited a wide intermeshing of professional communities including LIS. The phenomenon emerged not only because the Web technology created a global environment, but also because it first appeared somewhat disconnected from the preceding IT evolution. The disconnection has been evident in the objects (concerns) and subjects (communities) of such developments, which appeared diverse from traditional IT, focused on databases and distributed systems for which bound environments were created.

Yet, many of the issues brought about by the WWW are in fact extensions, or new realisations of issues and trends that can be traced as having their roots much earlier. In technical terms, the reconnection of these diverse worlds has been patent in the path of development of the Web technology itself. But history as such is also relevant to understand IT and is emerging as a concern in Computing/IT educational programmes (see, e.g., Akera & Aspray, eds., 2004). The evolution described in Chapters 4 to 6, around the topic of interoperability, provided a high-level overview of the directions of change in IT which are summarised in Table IV-2 (next page).

Overall, the changes reveal a trend from systems-to environment-centred technologies. Commencing with discrete solutions for systems interconnection and interoperability which used to be fringe or added aspects to an IT system, the changes evolved by a growing prominence of building the means for controlled environments for groups of systems and later by bringing issues of open environment to the centre of attention in systems constituencies and design. Aspects that were once peripheral become central altering the notions of systems' boundaries and autonomy and changing also the models of businesses and organizations supported by IT.

All conceptual trends summarized above point to the primacy of communication, interaction, design and architecture of larger, more complex and more dynamic information spaces, technical systems and underlying knowledge structures. Design and architecture, copiously present in the literature of any field related to IT, are above all expressions of the prevalence of socio-technical contexts,

Table IV-2 *Major conceptual milestones in IT since the 80s*

	Driving factors	Sample of IT concepts	Example IT constructs	Emphasis / focus
Networked systems	Connectivity	Connection & communication; hierarchy & interdependence of communication levels	Data network protocols, e.g., X25, TCP/IP, HTTP	Interconnection; recognition of different communication layers; focus on channels
	Early middleware needs	Remote procedures and programmatic interfaces for client/server systems	RDBA; RPC; IDLs; APIs;	Overcoming programming languages and databases heterogeneities; focus on program-to-program and database-to-database communication
	Interactive problem-solving; increased demand on IT systems' functionality	From procedure to object-based programming & design	OO programming languages	From static, pre-defined 'actions' on data to to 'objects'; focus on larger granularities
Distributed systems		Encapsulation & interfaces, inheritance, persistence, polymorphism	OO methodologies	Hide complexity, enable flexibility; focus on data and behaviour combined, on self-controlled, transparent, communicable and reusable units
	Composition & reusability	Patterns & frameworks	Software development methodologies and kits	Context-independent solutions & components; focus on efficiency and reuse
	Building & communicating architectures	Modelling languages	IDEF, CIMOSA, UML	Modelling IT systems from modelling businesses knowledge; ontologies; focus on formalizing domain knowledge
Interoperable systems	Sharing of computing and information resources	Distributed computing	Viewpoints	Increased complexity, specialization & separation of concerns; focus on articulation between specialities
		Development environments	DCE, DCE RPC	Common basic industry specifications; focus on technical environments
		Scalability, transparency & openness	Reference models, e.g., OSI, ODP, MDA	Integrative articulation of groups of standards / their communities
	Sharing application services; information integration	Application protocols	EDI; ILL; Z39.50	Sharing processes or services in controlled or uncontrolled environments; focus on systems' syntax and semantics (processes and data)
		Object middleware	CORBA, DCOM	Sharing independent application components in agreed, controlled environments (e.g., in EAI). Focus on integration architectures
		Mobile code, agent technology	Java, Internet bots	Shipping code to a different location for execution; decoupling and executing pieces of software on their own in an open, uncontrolled environment; focus on finer modularity, functions' independence, flexibility and customisability
		Web services	UDDI, ebXML, WSDL, SOAP, XML, SRW	Sharing functionalities and data in ready-to-use services, platform independent, simple, decentralised and extensible; focus on dynamic integration and on the Internet as an open computing environment

of the growing confluence of many fields and the need for higher levels of abstraction and communication that are far away from the computational view of technology. Models and modelling languages represent the ultimate aspect of the trend. Significantly, the evolution of interoperability concerns and the corresponding directions of technology give a clear indication of the changing nature of IT.

The change is patent in the expanding heterogeneities that have to be managed in information systems (Fig. IV-4). They are even more dependent on social aspects of information interaction, revealing a growing approach, or resemblance, to issues such as those of linguistic systems. This exemplifies a categorization of key issues that may help congruence of technological frames among diverse groups of professionals and articulation of the respective sources of codified knowledge.

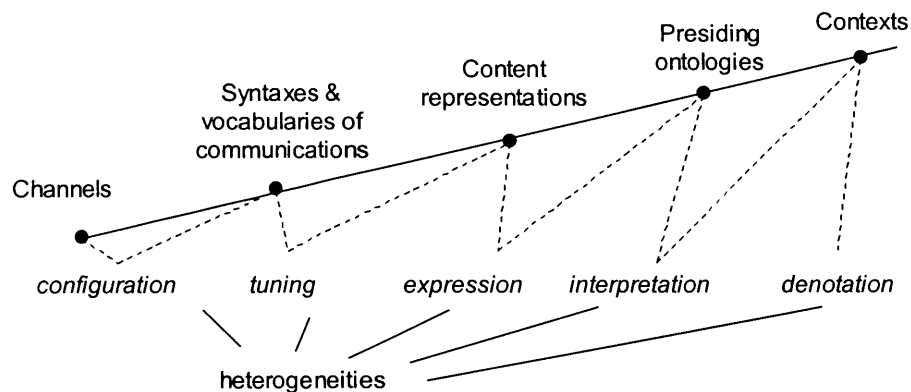


Fig. IV-4 *The expanding field of heterogeneities to be managed in information systems*

The observation above is relevant for the attitudes regarding discussions about the content and functions of IT systems, as well as for collaborations on the building of the systems themselves. Most of the IT constructs selected above to summarize the trends have contributed to making it possible for wider and more diversified groups of IT and non-IT persons to use, master or manage IT resources of various kinds. But the naïve or simply operational use of current technologies may induce elusive or incomplete visions of the nature of the changes going on, with implications for the future of IT itself. From the work carried out to answer the second research question of this thesis, I argue that a longitudinal view of IT, founded on its technical constructs rather than just on the appreciation of its reach and effects, is currently of utmost importance for professional fields like LIS because of present and future implications of IT in all information management related functions. The knowledge of IT constructs and how they came to be as they are is what can enable one to distinguish the new from the novel and thus gain a better comprehension of the nature and forces of IT and IT-enabled changes. Such a knowledge provides forms of integration beyond the literal sense (adoption and diffusion) because it also enhances the possibilities to act upon IT developments and trends.

### 8.3.2 IT integration and structures of signification

From the perspective of knowledge, IT integration implies the notion of IT as not simply a 'tool', a 'given', or a unified thing but as a variety of structures generated, reproduced and modified over time by a multiplicity of human and social agents. It follows from this that general directions of IT development that can be parsed from the myriad discrete (and often apparently unstructured and dispersed) IT constructs are reflections of the types of concerns, modes of organization and models of activity of a variety of groups and businesses rather than just being a matter of purely technical invention. Integration is thus a matter of entering the varied flows that concur to shape and reshape IT, sometimes in unintentional ways, through forms of deep (conceptual) structures used in the interactions regarding IT.

For Orlikowski & Iacono (2001) the approaches comprehended in the 'ensemble' view of technology (see Table IV-1) are the most productive in terms of understanding integration of IT and how it is socially produced and reproduced. Following Giddens' structuration theory, IT can be seen as 'structure', i.e., "rules and resources, or sets of transformation relations organized as properties of social systems" the latter being "reproduced relations between actors and collectivities, organized as regular social practices" (Giddens, 1984: 25). As explained by Poole & DeSanctis (2004),

"Structuration occurs as actors move to invoke existing structures or to create new ones, producing and reproducing the structures and the associated social systems. Structures include resources (command over people and material resources) and rules (recipes for action), which operate to provide a social system with power (structures of domination), norms/routines (structures of legitimation) and meaning (structures of signification)".

As noted by Giddens (Ibid.: 28-29) the three types of structure are interlaced, and are separable for analytical purposes only. As this thesis has not addressed issues of power and legitimation, structures of signification are the focus of our attention. Structures of signification (constitution of meaning) are created through "interpretive schemes", i.e., "the modes of typification incorporated within the actors' stocks of knowledge applied reflexively in the sustaining of communication" (Giddens, 1984: 29). They can be traced in descriptive (e.g., accounts), prescriptive (e.g., standards) or interpretative expressions of a field and constitute part of its 'institutions'.

From what has been conveyed in this study, it seems clear that, in general, the LIS field exhibits poor expressions of interactions with computing/IT structures of signification developed since the mid-eighties. Only concepts that are far too general or prone to many different interpretations and realisations, such as interoperability, have entered the field, but usually without the understanding of the underlying technical issues that would sediment common structural knowledge. Many of the developments that became part of mainstream IT, e.g., in object-orientation, middleware and componentization of software applications or modelling methodologies and languages, have been largely absent from LIS. For a variety of reasons they have had little presence in the realm of systems supporting common library operations, but neither have they been captured for systems aspects that are not primarily technological but conceptual, like information and data modelling, which have been always central to LIS (e.g., for cataloguing and data standards).

The few exceptions mentioned in 1.4.1.1 are exemplificative of the conceptual richness that can be drawn from IT to rethink library information structures and the respective standards. But, being quite recent, they also expose the conceptual gap that has been growing between LIS and Computing/IT since the 80s. In addition, with the exception of FRBR, these incursions into appropriating IT concepts have consisted principally of individual explorations with as yet no significant impact on LIS as a field. The majority of LIS principles and standards, and the professional language(s) they have created, have seen little change since the 80s compared to the dramatic changes in IT and in the information environment.

My interpretation is that many contentious issues that have emerged for the information management communities in the Web age (of which the cases of metadata and digital libraries were highlighted) result from this misalignment of languages representing different structures of signification combined with diverse technological frameworks. The case study of Z39.50 illustrated many of the issues in this respect with the advantage of showing, throughout several stages of technological development, misalignments with the general IT field and also within the LIS field itself.

Structures of signification stabilized upon widespread and long-standing active standards and languages of a field may give a measure of its maturity and strength, especially in a context in which the rapid pace of change around it is the norm. This is especially true of LIS. But such stabilised structures may also hamper exchanges



with other fields and, above all, they may prevent dialogue for a concerted perception of major reconfigurations of the whole environment. Furthermore, when the environmental changes are such that elicit new solutions and standards, emergent structures of signification tend to take space from existing ones and even contribute to their apparent dismissal before the new phenomena or issues are well clarified. This only augments, at least temporarily, any existing gaps in the communication between fields.

### **8.3.3 IT constructs as integration elements**

The evolution of IT expressed above in Table IV-2 consists of just a broad selection of concepts/constructs from a large spectrum of technical knowledge increasing in complexity for which there exists a vast body of representations that can be found in many different levels of detail and for varied purposes and audiences. Augmented functionality and dependence on communication and distribution, increasing complexity in the management of heterogeneities and, at the same time, support for autonomies and customizability at fine-grained levels, all are trends that have generated increasing levels of formalization in IT and more diversified and specialised technical languages. This becomes even more complex as another tendency emerges in forms of distribution that do not use central points of control, but rely on operations controlled in a decentralised, multi-device manner.

To be able to use IT effectively and to influence its development directions, means understanding, selecting and interacting with the variety of available technologies and their underlying concepts in a purposeful manner which implies levels of absorption that are deeper, and therefore of a higher level than the functional use characteristic of a 'tool view' of technology. Yet, it is difficult to convey/acquire usable knowledge about given technologies just on the basis of general traits, e.g., of the kind highlighted in the first and last columns of Table IV-2. Usable knowledge, even at the conceptual level, entails some technical approaches at the level of concepts and constructs exemplified in the inner columns. However, trying to master all kinds of IT constructs at the detailed, functional level is unrealistic because of the vast array of specialities involved and the rapid pace of change in all sorts of technological developments.

It is this impracticability, often overlooked by the pressure to provide ready-to-use practical IT knowledge, that tends to produce random, surface-levelled and short-lived IT knowledge acquisition strategies by individuals, organizations or educational structures. Within IT the problems of knowledge transfer between many different technologies and their respective specialists would be the same. But what one can observe in IT is that the barriers to knowledge transfer caused by complexity have been overcome by the successive development of technical devices for the separation of concerns, componentization and complexity hiding, and a wide variety of 'systems of translation' (Leydesdorff, 2003: 199-203), for use by both systems and people, which feature prominently in the technologies themselves.

In the IT developments studied around the topic of interoperability, we have seen that such 'systems of translation' recursively elicit levels of a next-higher order of communication about and IT matters. That is, the creation of new technologies/specialities is accompanied by forms of expert knowledge codification that ensure their integration into the existing environment without disruptive demands on other technologies or stakeholders. An example of this, at a high level, is the emergence of reference models, which have been used in IT to bridge knowledge of diverse technological levels and respective communities. Averill (1994) explained the articulating function of reference models in a systems view of organizations, as depicted in Fig. IV-5.

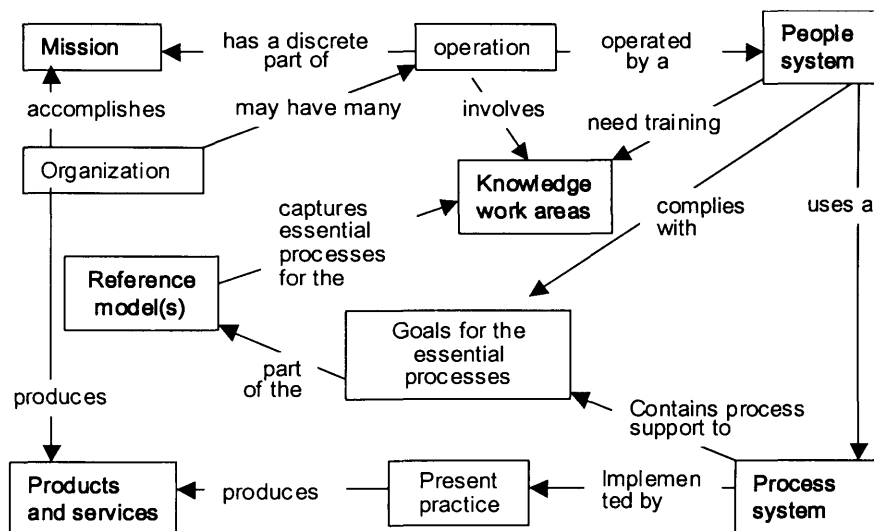


Fig. IV-5 An entity-relationship diagram of reference models, knowledge areas and people and process systems in organizations (from Averill, 1994)

The figure highlights two major components in organizations: 'people systems' (interactions between people, organizations or organization's units) and

‘process systems’ (the processes that occur within such interactions and that facilitate their alignment and synergy, encompassing IT). ‘People systems’ are “usually engaged in more than one knowledge area” and reference models can help to lever cultural change in people, according to the needs underlying the evolution of organizational missions and processes (Ibid.). Standards, or other types of equivalent instances of codified expert knowledge of specific areas (e.g., foundational principles and concepts, and technical languages) are the essential loci for building systems of translation. Reference models document them in a synthesized, top-down manner, contributing to expand the usability and benefit of standards to other audiences thus facilitating the continuous improvement of processes that depend on collective, heterogeneous people systems.

Between LIS and IT, the lack of common elements for shared codifications at the level of reference models means that their ontologies and technical languages have remained structurally apart, with only superficial, or occasional, incursions into each other field. This may explain why, in turn, the panoply of codified sources of LIS expert knowledge is not easily ‘read’ by IT communities. Towards changing this situation, the major argument of this thesis has been that IT itself can disclose for LIS levels of knowledge that are essential for building a new common ground. The argument can be synthesized in three major aspects.

First, if IT is central to the object of LIS activities and organizations, it should be appropriated in forms deeper than the adoption and diffusion levels. This entails absorption of concepts, i.e., consistent and structured technical knowledge acquisition that can be abstracted and generalized to be applied to different situations. This is a necessary condition for LIS participation in stages of IT ‘scanning’ and new ‘knowledge creation’, comprehended in the model for organizational learning by Merali (2001) (Fig. IV-6).

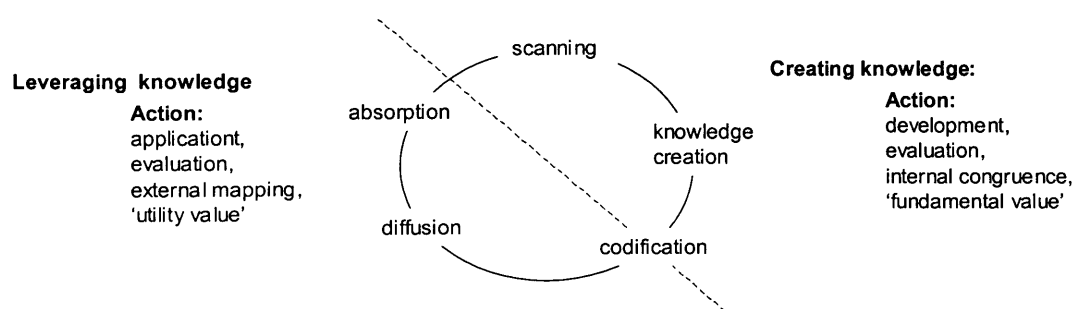


Fig. IV-6 *The leveraging of capabilities in the context of the learning cycle*  
(from Merali, 2001)

The second aspect follows from the assumption of IT centrality as not deterministic, i.e., founded in the understanding that IT is socially constructed and that its directions are not alien to what happens in the application fields. Thus, ‘reading’ and ‘interpreting’ the evolution of IT provides more than knowledge of the history of computing, because it can illuminate changes in paradigms and socio-technical trends at large. This kind of knowledge adds to the functional (technical) knowledge the substrate that can feed the insights needed for the strategic alignment argued in Chapter 1. Notably, it enables the competencies of ‘scanning’ and ‘abstraction’ mentioned above and included in the ‘social learning cycle” (SLC) defined by Boisot & Griffiths (2001).

“Scanning [is] identifying threats and opportunities in generally available but often fuzzy data, i.e. weak signals. [It] may be rapid when the data is well codified and abstract and very slow and random when the data is uncoded and context-specific. [...] Abstraction [is] generalising the application of newly codified insights to a wider range of situations. This involves reducing them to most essential features – i.e., conceptualising them” (Ibid.).

The third aspect is a corollary of the above. The technological evolution reviewed in this thesis shows the growing tendency of IT to enmesh with the socio-technical environments of application areas, i.e., other fields, and to produce concepts and codifications that can be reused in contexts wider than strictly technical IT systems. Since the advent of the object model and distributed systems IT languages have kept a growing distance from algorithms, exhibiting expressions amenable to a wide range of viewpoints and technical and social components of an information system. Thus the philosophy of the object model, the properties of a distributed system, the principles underlying methodologies of software engineering or the decentralised model of integration patent in the latest Web technologies are available to the broad field of information management populated by non-technologists, and can be usefully explored in the design of the conceptual and organizational systems within which the technical IT systems operate.

As explained throughout the chapters of Part III, many of the IT constructs mentioned in Table IV-2 can be applied beyond their original purpose: as methodologies of analysis, as strategies for identifying, defining and conceptually assembling components and behaviours of organizational and information systems,

as well as language elements for articulating the various knowledges required to make it all work with IT systems in an aligned way.

Recognition of the theoretical value of IT constructs to understand or give insights about the redesign of human and social realities is present in social sciences, for example, in sociology (e.g., Leydesdorff, 2003) and business management (e.g., Evans & Wurster, 2000). IT constructs are not only suggestive, as good metaphors; they also convey forms of dealing with complexity that emerge in technological systems from their human and social endeavours.

In the same way, IT has integrated conceptual elements from other fields, as with the prevalent orientation by design and architecture (e.g., Coyne, 1995: Chap. 6; McCullough, 2004) which, beyond metaphor, is founded in the reuse of principles elaborated by architects (Alexander, et al., 1977). Information architecture has been also highlighted as an integrative concept for the realm of information management combined with the management of IT. To be more than vague metaphor or just one more new branding of old activities, it implies the inclusion of and conversation with working concepts from actual IT, encompassing a structural view not confined to the subset of latest Web realities or technologist activities.

This thesis has argued why this structural view and integration of IT knowledge is important for LIS. In its functional (literal) sense, IT knowledge is more fundamental than ever for those in charge of managing technologies used by libraries. But beyond the operational, fundamental IT constructs should be conveyed across other LIS activities and organizational spaces in order to leverage conceptual knowledge aligned with IT. They are useful to help changing the prevalent limited views of technology, clarify aspects of the LIS field dynamics and reconfiguration, contribute to strengthen a variety of technical matters which have received poor attention in IT terms, and inform organizational management and strategies.

#### **8.4 Major contributions and limitations of this study. Further research**

This research has investigated a subject of utmost importance for the present and future of information services: its relationship to IT, focusing especially on knowledge sharing. Although the topics of IT in LIS have been extensively treated in the literature, the perspectives taken in this thesis have not been systematically addressed in previous research. The thesis presents two major contributions to the LIS field.

Firstly, by means of an overview and interpretation of the relationship between LIS and IT, the study provides a synthesis of the state of affairs which is not easily perceived from the discrete expressions of its multifaceted and varied reality. In this regard, the usefulness of the study follows from the fact that the main traits of this relationship, and their constraints, are counterintuitive. This is not only because IT has been for long years and extensively used in LIS, but also because the history of the field exhibits recognized moments of early adoption of IT, and even participation in innovative IT developments (see, e.g., Malinconico, 1997).

The second major contribution consists in showing the potential of a non-nominal view of IT, i.e., that the conceptual underpinnings of IT evolution and constructs can provide levels of understanding with the potential to bridge IT topics throughout many different areas of LIS, between management and operations, to inform conceptually many organizational strategies and to improve exchanges with the technological communities.

The nature of the research questions required a longitudinal view of the subjects, covering a considerable time span, and the articulation of different perspectives of analysis, and this imposed limitations on the depth of the variety of topics treated. In many respects the representations given are by necessity broadly painted. However, while this may appear as a weak aspect if one considers the subtopics individually, the overall purpose of the research was to identify major lines of evolution, milestones and conceptual threads that can shed new light on the socio-technical phenomena or the significance of the technologies analysed.

The study provides a comprehensive coverage of topics but there is no claim of completeness and the selections were based on criteria of relevance, or illustrative potential, for the questions under research. For example, there was no special attention to the description and analysis of usage and trends of the most recent

technologies being explored in library services (e.g., solutions developed for digital libraries, metasearch tools, integration of courseware, digital preservation, authentication and authorisation systems and rights management) as the focus was not on describing the emerging issues and trends but rather on aspects that for their long-standing nature are part of typical, long-standing characterisations.

The same is valid for the selections and level of approach in the study of the evolution of IT. Particular technologies of the past are included as they provide a kind of historical record of trends and the predecessors of more current forms of technology. The study includes a more detailed overview of the constituents and trends of IT concerning distributed systems, middleware and Web technology, yet the selections and perspectives have been essentially at the conceptual level, relating to the analysis of issues at stake, rather than being concerned with exhaustive and detailed functional descriptions.

In sum, a considerable part of the thesis content consists, by necessity, of IT introductions and descriptions, but it is not intended as a study of technologies and it is not aimed at any kind of technical appreciation, guidance or prescriptive orientation. These can be very relevant objectives for current research in the broad field that relates IT and LIS. However, in the present thesis IT is taken as general reflections of realities that are beyond functional technology and that can disclose patterns of thought and directions of development regarding the social realities that make use of, emerge from, are reconfigured by or influence IT.

The results of this study are essentially interpretative of the past and exploratory of future forms of improving the relationship between LIS and IT. These are essentially conceptual and represent the first stage of a suggested direction, not conveying results of concrete, immediate applicability for problem-solving. Thus, there is a wide variety of topics that could constitute extensions or in depth analysis of the issues discussed in this thesis.

They can range from trying IT strategies, methodologies and techniques for the conceptual redesign of specific library data assets, such as authority files and terminologies; for the building of reference models to structure conceptually the most relevant library standards and map them to relevant IT standards; or the study of forms of library organizational strategies inspired by most influential IT conceptual models.

## ANNEX 1

### Z39.50 BACKGROUND: HISTORY, NATURE AND CONSTITUENCIES OF THE STANDARD

#### 1 Z39.50 scope and model

'Z39.50' is the identification code of an American standard. In practice, it has been used to refer to a network application protocol that was already a de facto international standard before ISO adopted it, in 1998, with the same title and content, although with a different code designation, ISO 23950. Unless otherwise specified, the term 'Z39.50' will be used to refer to the protocol as such, irrespective of the ANSI/NISO or ISO publications.

In a simple and general definition, Z39.50 is a protocol for SR of information from remote systems, based on the client-server model, allowing interactions to take place at the application level in order to overcome differences between systems. The standard itself provides a model, i.e., an abstract structure upon which Z39.50 systems can be built, and specifies the type of interactions that are possible, as well as the data structures and interchange rules to be followed.

Z39.50 allows a given client to search and retrieve information from a given server <sup>1</sup> using its own interface and query language, irrespective of the interface, query language and internal data structure of the server, or of any other aspects of its IT platform. The information received from the server is rendered according to criteria defined at the client level (Fig. A-1).

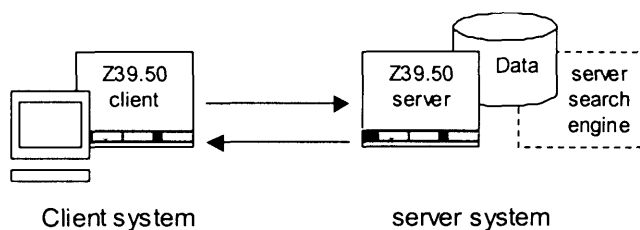


Fig. A-1 *Basic model of a Z39.50 system*

A common configuration in library services is to have an WWW/Z39.50 gateway, i.e., a piece of software that encompasses the Z39.50 client and provides the conversion of Z39.50 messages to and from HTML so that the end-user works only with a browser (Fig. A-2, next page).



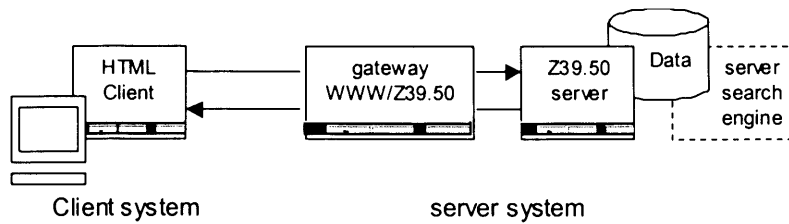


Fig. A-2 A common implementation of Z39.50 enabling Web user interface

The major point of the protocol is, thus, to provide transparency of access to information in different systems by separating the interface from data, i.e., the virtual integration needed for activities that require the online sharing of disparate data sources. This virtual integration can be operated by a client with respect to several servers simultaneously, while the same server is reachable by a variety of clients (Fig. A-3). ‘Clients’ and ‘servers’ designate the actual function of a system at a given moment, as the same system may act in both capacities, in different sessions.

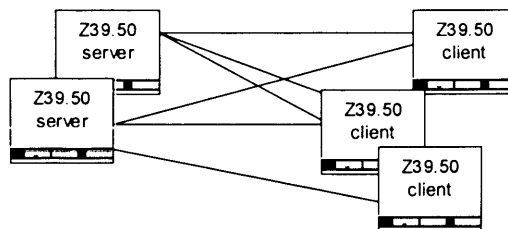


Fig. A-3 Virtual integration of multiple Z39.50 servers and clients

The transparency provided by the protocol represents the following advantages: i) added-value for the data assets available through the protocol, as data become ‘system independent’ in exploitation terms; ii) increase in productivity of online activities, by end-users or information professionals, as they can make use of remote systems in addition to their local one; and iii) online transfer of selected machine-readable data for reuse in different systems. The last aspect was the major motivation of the initial efforts towards a standard for the SR application protocol.

## **2 Origin and evolution of the standard**

Linking and sharing vast repositories of structured bibliographic information fostered, in the 80s, the development of a standard for an SR protocol in order to overcome the costs and limitations of interoperability solutions designed case by case, i.e., constrained by the characteristics of hardware and software of each system.

The formal development of Z39.50 took place from 1979 only, but earlier developments had occurred in the library field since the 60s towards an SR protocol. These are next synthesized, under three main aspects: i) standard and technical advances in library automation, ii) development of organizational leaderships, visions and policies and iii) early initiatives towards an inter-systems communicating protocol.

### **2.1 Background. Early technical and organizational efforts**

Advances brought about by library automation are principally related to MARC (Avram, 1975). Developed since the early 60s, MARC was successfully tested in 1966 and its base structure was approved as a national standard in 1971 (see ANSI/NISO Z39.2: 1994), the equivalent to the later ISO 2709. Beyond being a bibliographic production standard, MARC was explicitly envisaged as a standardized format for communicating bibliographic information. This perspective of data interchange was essential and in a very short time MARC enabled the electronic distribution of records on tape, thus modernizing the service that the Library of Congress had already been providing, in paper form, since the beginning of the century. While helping to foster automation in the library community, MARC also introduced the practice of shared electronic cataloguing leading to the creation of consortia like OCLC, founded in 1967.

With technological support it was possible to maintain “a regular flow of up-to-date bibliographic information among libraries” (Avram, 1970). The potential benefits of bibliographic networks led to engagement in technological research for systems interconnection and raised awareness of other technical and organizational issues. MARC was not perceived as the whole solution for building a collaborative professional environment. Other levels of standardization and agreement were recognized relating to the rules and practices underlying data content, as in the

production of descriptive cataloguing and subject analysis, or the formulation of access points, decisions about systems indexes, etc.

For all these aspects reassessment was needed, if the future of the production and exploitation of catalogue data was not any longer confined to the model of single catalogues (Avram, 1970, 1977, 1978). Furthermore, a coherent programme in support of a national bibliographic network should be a decentralized effort and encompass the participation of publishers, learned societies, abstracting and indexing services, etc. (Wigington & Wood, 1970).

## **2.2 Development of organizational leaderships, visions and policies**

Besides the Library of Congress two other organizations, the NCLIS (National Commission on Libraries and Information Science) and the CLR, developed activities towards the vision of a national bibliographic network. These organizations issued reports on the matter and, until 1979, they collaborated in several endeavours such as the CCNBC Committee for the Coordination of National Bibliographic Control (CCNBC), promoted by NCLIS, and the Bibliographic Service Development Program (BSDP) Committee, promoted by the CLR. While they addressed principally policy issues, other aspects that would be on the technical agenda for the interconnection of different systems were already being approached by groups with a more technical focus: the Network Advisory Group (NAG), later NAC, and the Network Technical Advisory Group (NTAG), both promoted by the Library of Congress (Malinconico, 1997; Moen, 1998b: Chap. 4).<sup>2</sup>

## **2.3 Early initiatives towards an inter-systems communicating protocol**

The very first initiatives towards specifying general requirements for transmission of bibliographic data, including the recognition of the need for bi-directionality, date from 1975 and were carried out by the Information Science and Automation Division (ISAD) Telecommunication Committee, of the American Library Association (ALA) (Moen, 1998b: Chap. 4: 13). This work was followed, in a more systematic way, by the NCLIS/NBS (National Bureau of Standards) Task Force on Computer Network Protocol, established in 1976 which, besides libraries and library authorities, involved representatives of other government agencies,

professional societies and private corporations from the publishing and IT industries. In 1977 this Task Force issued a model for the protocol based on five layers, with bi-directional communication processes composed by pairs of request/response messages. This was further continued by the above-mentioned NTAG, who developed in 1978 the message type system for the communication protocol (Ibid.: Chap. 4: 14-18).

According to Moen (1998b), the years 1977-79 saw some overlap of activities among these groups that, despite having some members in common, showed some discrepancy of concepts, terminology and work-plans. By 1979, with the CLR's BSDP Program in place, the developments moved to two different streams of activity. The formal standard development was pursued under the umbrella of ANSI/NISO and the actual experimentations were carried out by the Linked Systems Project (LSP), funded by the CLR (Ibid.: Chap. 4: 21; Denenberg, 1996a), whose services became operational in 1985.

The LSP was launched in 1980 with the objective of interlinking the systems of the Library of Congress, Research Libraries Group (RLG), Western Libraries Network (WLN) and, from 1984 onwards, of OCLC. Its major focus was the transfer of records, notably authorities, in the context of the National Coordinated Cataloguing Program (NCCP). The Project produced two different levels of protocols, within the OSI framework: Record Transfer (RT) and Information Retrieval (IR) (Buckland & Lynch, C., 1987; McCallum, 1987; Dempsey, 1992: Chap. 4).

Both protocols were submitted to ANSI in 1983. The attempts to reach the standard status for RT were declined and this protocol was later replaced by FTP. The IR protocol, however, became the basis of the future Z39.50 standard (Lynch, C. & Preston, 1990; Denenberg, 1996a; Lynch, C., 1997b; Moen, 1998b: Chap. 4).

### **3 Development of the standard**

Within ANSI, the work started in 1979 with the establishment of the *Subcommittee D* of the ANSI/NISO Z39 Committee. A first standard project, based on the LSP Information Retrieval protocol, failed the ballot in 1984 but a second attempt produced the first version of Z39.50, officially approved and published in 1988 (ANSI/NISO Z39.50: 1988). Independently, ISO, through its Technical

Committee 46, Sub-committee 4, had begun work on an international standard for a search and retrieve protocol, called SR, with objectives similar to Z39.50. The ISO SR standard was approved in 1991, in two parts (ISO 10162: 1993; ISO 10163: 1993). There was US input in this international standard but “as difficult as it was to achieve consensus on Z39.50 in the US, it was more difficult to achieve international consensus” (Denenberg, 1996a) and this resulted in differences and incompatibilities between the two standards.

The next stage of Z39.50 was towards compatibility with ISO SR, in a phase marked by the beginning of a different approach and methodology. In 1989, NISO had appointed the Library of Congress as the Maintenance Agency of Z39.50 and a group of implementers (ZIG) was established. The role and action of ZIG at this stage notably influenced the inclusion of sufficient functionality to make implementations commercially attractive and broaden the potential interest in Z39.50 into areas of application other than libraries. Version 2 of Z39.50 was prepared in this context, being formally approved in 1992, as a compatible superset of ISO SR.

At this point, both Z39.50 and ISO SR were aligned as OSI standards. The technological environment, however, was changing. The lack of maturity, completeness, stability and of a sufficiently large base of systems implementing the OSI standards was felt as a serious disadvantage for Z39.50, especially when Internet protocols were gaining ground (Denenberg, 1990; Denenberg & Reusser, 1990). By the beginning of the 90s it was already apparent that a large market could be gained for the Z39.50 protocol if used over TCP/IP. In order to explore this possibility the CNI sponsored in 1992-1993 a test-bed program called Z39.50 Interoperability Test-bed, open to participation by any kind of system and organization (Lynch, C., 1992).

The success of the test-bed contributed decisively to the credibility of Z39.50, making it easily demonstrable and encouraging the interest of library systems vendors and users (Moen, 1998b: Chap. 4: 73-74). More importantly, Z39.50 was re-positioned in the network environment, with an Internet Request For Comments (RFC) explaining how to run the protocol directly over TCP/IP (Lynch, C., 1994), i.e., without using the more complex OSI layers (Holm, ed., 1994: Sec.13; Corey, 1994).

In this phase ZIG, whose primary activity had evolved from the initial idea of developing profiles to that of assisting in the maintenance of the standard,<sup>3</sup> was

already preparing a new version of Z39.50. This was later approved as Version 3, in 1995, with an important number of incremental changes and also new functionalities, in order to accommodate the requirements of a more diversified community of implementers. Z39.50 became more flexible, with the majority of features optional, but the extended functionalities increased the complexity of the standard.

For Lynch, C. (1997b), other aspects contributed to the “bulk and apparent complexity” of version 3. One was the inclusion of Version 2, i.e., the ability to accommodate backward compatibility with earlier implementations. Another was the maintenance of the standard within the OSI framework, with its particular vocabulary, not widely used. Yet, the possibility of running the protocol over TCP/IP was mentioned in the standard. But this information was omitted from the main content and included in an Appendix, along with information about registered profiles (ANSI/NISO Z39.50 : 1995: App. 15).

The ANSI/NISO Z39.50: 1995 became a superset of ISO SR, exceeding it in adjustments and functionality. At this stage ISO’s strategy was changed. Instead of continuing a process of alignment that would be burdensome, ISO decided to adopt the integral text of the ANSI/NISO Z39.50: 1995 and discontinue both ISO 10162 and 10163. The new ISO standard was balloted in 1996 and published in 1998 (ISO 23950: 1998).

#### **4 Mobilizing efforts in support of Z39.50**

While in the US important library agencies had been directly involved in the standard development, at the international level systems interconnection was greatly fostered by organizations like IFLA, especially during the eighties, in the framework of promoting OSI standards. These were deemed increasingly important to the objectives of some IFLA Core Programmes, particularly the Universal Bibliographic Control and International MARC (UBCIM), the Universal Availability of Publications (UAP) and the Universal Dataflow and Telecommunications (UDT) programmes (see, e.g., Smith, C., ed, 1988; Turner, Tallim & Zeeman, 1992; Holm, ed., 1994; McCallum, 2003).

Other groups were established to explore the potential of open systems networking for libraries, such as the Expert Group for Libraries of the European Workshop for Open Systems (EWOS EG-LIB) and the European Forum for

Implementers of Library Automation (EFILA), at the international level; and the UK Z39.50/SR Pre-Implementers Group (PIG), later renamed UK ZIG, in the UK. Active in the beginning of the 90s, EWOS-EG LIB was a formal standardization body devoted to specifying profiles for ILL and SR protocols and it acted as the focal point for European implementers of library applications. It led to the establishment of EFILA in 1995, launched with support of the European Libraries Programme (mentioned below) to act as the European counterpart of ZIG (Holm, 1996; Pedersen, 1998).

PIG started in 1992 and had an active role in awareness about experiments and issues related to Z39.50, notably over the question of OSI versus TCP/IP at a stage when the OSI orientation was still dominant in Europe (Holm, 1996). In 1995, PIG was renamed UK ZIG (United Kingdom Z39.50 Implementers Group), reflecting the fact that a number of UK implementations were already in place (Dempsey, Russell & Kirriemuir, 1996; Krivine, 1996).

But the most important support came from policy bodies and their funding programmes. Launched in 1990, the EC *Action Plan for Libraries*, later renamed *Telematics for Libraries Programme*,<sup>4</sup> specifically included action lines towards the development of technical standards, pilots and test-beds for establishing links between systems across national boundaries (Turner, Tallim & Zeeman, 1992: Chap. 8). Early projects in this programme dealing with the OSI SR protocol were the Nordic SR-NET, the German project STN (to link the databases of the Scientific and Technical Information Network) and the project ION (Interlending OSI Network), (Dempsey, Russell & Kirriemuir, 1996).

An extensive set of international library projects funded by EU programmes (see 2.2.2.2 and Annex 2) would follow and prove decisive to explore Z39.50 technology (Russell, 1996; Pedersen, 1997), delivering prototypes for a range of library services. Many of them had development companies as partners and some produced software (projects SOCKER, EUROPAGATE, PARAGON, ARCA and CASELIBRARY, see Annex 2) reused in other projects or made publicly available.

At a national level, the UK eLib Programme, established in 1994 by the JISC, after the *Follett Report* (Follett, et al., 1993) and the recommendations of the Follett Implementation Group for IT (FIGIT) (JISC, 1994, 1994a), funded a number of projects related to Z39.50. These include the important framework studies of MODELS,<sup>5</sup> developed since 1995 to address strategic and architectural issues of

distributed environments. One of the eLib main areas during its third phase, from 1997 onwards, was large-scale resource discovery “to kick-start a critical mass of use of Z39.50” (JISC, 1997) for the integration of scattered bibliographic resources.<sup>6</sup> Related to this objective was the establishment of the *UKOLN Interoperability Focus*, in 1999, aimed at “exploring, publicising and mobilizing the benefits and practice of effective interoperability across diverse information sectors” (Guy, 2005).

## 5 How Z39.50 works

Z39.50 addresses systems that provide information retrieval services: databases containing records and a set of access points (indexes). A Z39.50 server can be for one or more databases in the same system. A Z39.50 client is independent of any servers and can reach one or several Z39.50 servers simultaneously. Although the protocol establishes a connection between two machines only, Z39.50 client applications can use multiple (parallel) Z39.50 connections to reach several machines concurrently.

When a Z39.50 association is established (basically an association is a session, opened at the request of the client, i.e., the initializing machine) the Z39.50 server offers its services through the interface of the Z39.50 client. Therefore, the client does not have to deal with the differences of interface, menus, commands, etc., or the differences in internal and presentation data structures, that exist at the server system side (Fig. A-4).

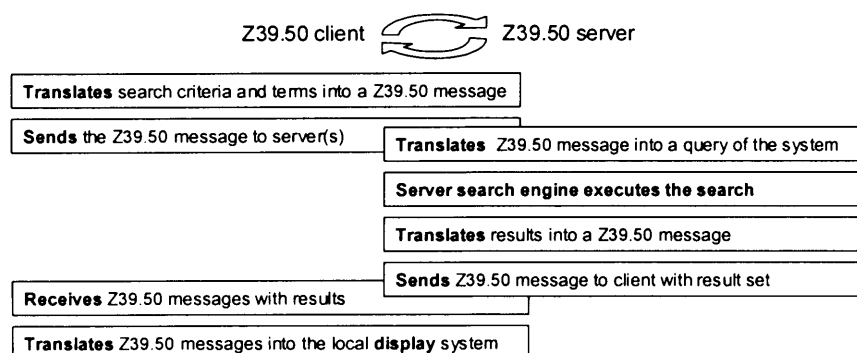


Fig. A-4 *Interaction between Z39.59 client and server*



This interfacing function is structural and bi-directional. In the interaction process the client software is responsible for the dialogue with the end-user: search interface, formatting and display of search results and management of additional operations over the result set received; for the translation of search queries into Z39.50 messages and for sending them to the server; and for the reception and translation of Z39.50 responses received from the server into the client's formats and display parameters.

## **5.1 Services and messaging system**

The role of the server software is to recognize and translate Z39.50 messages received from clients into the queries to be performed by its own search engine; to perform searches and convert result sets into Z39.50 response messages and send them to the client.

To support these processes the standard defines the types of operations that a client can request from the server, the facilities (the main services or a logical groups of services), as well as the specific services possible in each facility. The facilities of the IR service (ANSI/NISO Z39.50: 2003: Sec. 3.2; App. 7) are presented in Table A1 (next page).

The standard pairs of messages that are exchanged (APDUs – application protocol data units) in the communication between client and server are defined in terms of content, sequence and syntax. The syntax is the ASN.1 - *Abstract Syntax Notation One* (ANSI/NISO Z39.50: 2003: App. 18). ASN.1 is a standard pertaining to the OSI framework (ISO/IEC 8824: 1990) which defines the ways for encoding structured data to be transmitted on a network. In the context of Z39.50 it is also referred to as ASN.1/BER, where BER stands for *Basic Encoding Rules*. This is the set of rules (encoding scheme) that allows the encoding of values in a self-identifying and self-delimiting way (each data unit consists of three parts: a tag identifying the data, its length and the data itself) so that data values can be identified, extracted and decoded individually (Cooper, 1996: 617; Howe, ed., 1993-2005).

Table A-1 *Facilities of the Information Retrieval service in Z39.50*

Initialization	Init service	the client can initiate the association with the server and negotiate all necessary parameters
Search	Search service	the client requests a query, the server creates a result set
Retrieval	Present/segment service	the client requests the response records
Result-set-delete	Delete service	the client requests the server to delete the result set(s)
Browse	Scan service	the client specifies a term list to scan and a starting term
Sort	Sort service Duplicate detection service	the client can request the server to sort the result(s) set the client can request the server to effect duplicate detection in the result(s) set
Access control	Access control service	the server can request the client a given control action (e.g. authentication)
Accounting/Resource control	Resource control service Trigger resource control service Resource report service	the server can notify a client about some kind of resource consumption, and subsequent actions can take place; the client may decide to stop or continue a given search or the receiving of a given result set of records; it also permits the production of reports about the number of searches executed, or of records retrieved
Explain		the client can obtain details of the server implementation, such as databases available, attribute sets implemented, record syntaxes supported, etc. The Explain facility uses the services of Search and Retrieval
Extended services	Extended services service  Database update  Persistent result set/ persistent queries  Periodic query schedule  Item order  Export Specification/ Export invocation	these services define tasks for a set of new functionalities added in the version 3 of the protocol and include the following: this service allows a client to execute updates in the server's database the client can request the server to save search result sets for later access or refinement / a client can request the server to save a query for later use the client to request the server to activate a given schedule for a given query the client can request a copy of a given document referenced in the database the client to can define an export specification, e.g., destination / a client can invoke an export specification
Termination		both the client and the server can request the close service to end the session

## 5.2 Queries and attribute sets

The search facility is at the core of the protocol and is supported by a series of parameter definitions, e.g., the type of query and the notation used. The standard defines six query types, but the query type-1, using RPN (Reverse Polish Notation) must be supported by all Z39.50 conforming servers (ANSI/NISO Z39.50-2003: 23-24, 95). This kind of notation specifies the operators (symbols used as functions) and operands (the values) to be used in the query. RPN is especially suitable for Boolean queries, although it is up to each server to define which operators to

implement. The type and position of elements in the RPN expression completely define the operations to be performed (Iltis, 1995).

The query itself specifies search term(s) and their attributes, referring to one or more access points in the server database. Attributes are of special importance for the semantics of the search term and for the behaviour of the server in executing the search. Attributes are standardized in attribute sets, i.e., a group of attribute types plus the list of possible values for each type, expressing the needs and semantics of a given community of systems. Attribute sets are, thus, the formalization of standard understandings concerning data types. Attribute sets are fundamental to and a precondition of any Z39.50 implementation.

For example, the most common attribute set used by libraries has been *Bib-1* (Attribute Set Bib-1, 1995-1997; Bib-1 Attribute, 1995-2003). It consists of six types (*Use, Relation, Position, Structure, Truncation and Completeness*).

The *use attribute* and its defined values specify, for example, if the search term is used as 'author' (value 1003), as 'author personal name' (value 1004), as 'title' (value 4) or as 'title parallel' (value 35), etc. The remaining attributes define other important qualifications for the processing of the search term, e.g., 'less than' or 'equal', in the case of relation attribute; 'first in field' or 'any position' in the case of position attribute; 'word', 'phrase' or 'date' in the case of structure attributes; 'right' or 'left' truncation, in the case of truncation attribute; 'complete' or 'incomplete subfield', in the case of completeness attribute.

*Attribute set Bib-1* was the first and, until version 3 of the standard, the only attribute set established. Originally created for use with bibliographic resources, it was over the initial years supplemented by new *Use attributes* required for a variety of other non-bibliographic communities, among other reasons because version 2 of the standard did not allow the same query to include attributes from more than a single attribute set. Therefore, not only *Bib-1* grew out of rigour but also, as Z39.50 implementations became more common and more profiles were created, problems emerged over multiple attribute sets, including duplication of attributes across different sets. This generated ambiguities and lack of clear guidance in the semantics of attributes, hampering interoperability (Lynch, C., 1996; Miller, P., 1999a; ANSI/NISO Z39.50: 2003: 203-204).

### 5.2.1 New architecture for Z39.50 attribute sets

This situation led to the development of a new architecture for attribute sets based on classes, according to which commonly used attributes are collected together in core attribute sets, i.e., sets that can be used by all applications regardless of the domain, while local and domain-specific attribute sets are defined separately. Different classes and different attribute sets within the same class can be related, built on each other and be used together.

The new *Z39.50 Attribute Architecture*, was prepared since 1996 and first published in 1999, with developer guidelines (Z39.50 Attribute, 1999, 1999a; ANSI/NISO Z39.50: 2003: App. 17). It is a framework for constructing attribute sets in a modular way, i.e., in an independent but co-ordinated and more flexible manner. Not only a given attribute set may use attributes from other established sets, namely basic sets that are intended for general use, but it also makes use of semantic qualifiers and content authorities to provide additional refinement and control.

*Z39.50 Attribute Architecture* comprises the definition of *Attribute Set Class 1*, a class intended to cover “all known, existing requirements, at the time”, a kind of “universal attribute class” that can be used as a “template for developers of attribute sets” (ANSI/NISO Z39.50: 2003: App. 17, p. 206), and two complementary sets to deal with two kinds of attributes of general use (Ibid.: pp. 215-216):

- *Utility Attribute Set* (Z39.50 Utility attribute, 1999-2003), which defines commonly used values (i.e., applicable to dissimilar domains) for the attribute types defined for *Class 1*. They concern metadata access points for the database records (e.g., record date and time, record language, record syntax, etc.) which may need to be distinguished from the metadata access points for the resources themselves (e.g., language of a MARC record versus language of the resource it describes);
- *Cross Domain (XD) Attribute Set* (Z39.50 Cross-domain, 1999), which specifies a set of attributes that allows simple non-domain specific searches to be performed across domain specific applications. It defines values for the *Access Point Attribute Type* based on DCMES, intended as a core set for cross domain search from which developers can expand new sets or against which new sets should fit.

The *XD Attribute Set* draws on the experience of *Attribute Set Bib-1*, as a de facto cross-domain attribute set, and is a ‘compromise’ solution with no pretensions of sophistication, “anything in between complete understanding and complete ignorance” which can produce searches that are semantically fuzzy (Z39.50 Cross-Domain, 1999a). It is provided with mappings for the existing Attribute Set Bib-1. The mapping with Dublin Core differs with regard to the element ‘Name’ which the Z39.50 Implementors Group has chosen to create from an aggregation of the DC Creator, Editor and Publisher elements.

Within this architecture a new attribute set for searching bibliographic databases, typically using MARC formats, was developed: *Bib-2 Attribute Set*. This set is intended to supersede *Attribute Set Bib-1* and builds on the attribute types defined for *Attribute Set Class-1*, *Cross Domain (XD) Attribute Set* and *Utility Attribute Set*, adding at each of these levels the necessary bibliographic attributes: types, qualifiers, content authorities, values and meanings (Bib-2 Attribute, 2002).

Attribute sets are at the core of the Z39.50 semantics and most of the richness and quality of service provided by a given implementation derives from two major factors, in establishing attributes: the richness of the attribute sets implemented and the degree of coverage and coherence that the same attribute sets show in other Z39.50 implementations. The first aspect strongly depends on the accuracy of the search functional requirements defined for a domain of application. The second, on the quality of the data structure’s analysis carried out in the same domain. Finally, the documentation of the attribute set, with all its rules and semantics, is fundamental for its correct interpretation and implementation. These aspects are stressed in the accompanying *Guide of the new Attribute Architecture* (Z39.50 Attribute, 1999a).

The Z39.50 Attribute Architecture is likely to ease the consistency in attribute sets development, implementation and interpretation, either among systems that share the same attributes or systems that relate to different attribute sets. This is a long-term perspective as, at the time of writing, little is known about Z39.50 implementations based on attribute sets following the new architecture (a mapping to the Bath profile is available from Stovel & Shuh (2001-2002).

The new Architecture introduces some very important points concerning the way metadata for search and retrieval is viewed and managed. It provides a more structured methodology that evolved from a kind of ‘flat’ definition of data types and values to a more analytical approach to these sets of meta-metadata, either from the

functional or content perspectives. This is important for the efficiency in managing attribute sets and for attaining more consistent services from different implementations of the protocol. Additionally, it can also inspire methodologies for the re-analysis of data element sets and their respective data structures.

A final aspect of this new architecture is the clarification between what pertains to the level of the protocol as a standard and as a mechanism for systems interconnection and what pertains to the field of information and data management. Clearly, attribute sets are not part of the protocol. In this respect the Maintenance Agency (the Library of Congress) has a role as the Registration Authority and the Z39.50 Implementors Group (ZIG) is responsible for the basic architecture and core attribute sets only. Therefore, the definition and management of any domain specific set is the concern of the standardization groups or bodies of the respective communities (Z39.50 Attribute, 1999a).

### **5.3 Record syntaxes**

Z39.50 can be used to handle data in different record syntaxes (e.g., UNIMARC, MARC21), specified at the server side. Optionally, the client can also specify the preferred record syntax in which records are transmitted if supported by the server. While in the first two versions the standard only included syntaxes for MARC records, version 3 introduced the definition of other syntaxes and a Generic Record Syntax (GRS-1) (ANSI/NISO Z39.50: 2003: App. 4) enabling the retrieval of arbitrarily structured data, thereby making the protocol more robust to support interoperation between MARC and non-MARC databases (Moen, 2001).

### **5.4 Profiles**

As an open standard, and despite its origins being strongly related to the universe of bibliographic databases, Z39.50 can be applied in any domain and for any type of database. Any implementation requires a profile, i.e., specifications for certain aspects of the Z39.50 standard that aggregate common technical options and semantics of the systems involved. This includes a variety of aspects from the declaration of the version and features of the protocol that should be supported, to externally defined semantics and syntaxes such as attribute sets and record syntaxes.

Profiles are documented agreements that reflect a minimum of functionalities and of data structures and semantics capable of being mapped into a common set of characteristics for search and retrieval purposes (ANSI/NISO Z39.50: 2003: App. 16).

Profiles of Z39.50 for bibliographic databases have been the most common and the most widely used. The first and most basic profile was ATS-1 (ZIG, 1997) using a simple subset of use attributes. ATS stands for Author-Title-Subject, the core attributes of the profile. It ceased to be updated in 1997, when other richer profiles started to be defined in several projects. A variety of bibliographic profiles emerged during the years 1997-2000 under the initiative of several projects, (Husby, 1997; Murray, R. & Davidson, 1997) or major bibliographic agencies concerned with nationwide standardization of Z39.50 services (Wells, et al., 1998; Gatenby, 1999; Hakala, 1998; Lunau, et al., 1998; Baldacci & Parmeggiani, 1998; Husby, 1999; TZIG & Moen, 2000; TZIG, 2003; Andresen & Jørgensen, 2004), many of them aiming at building virtual union catalogues. The *Bath Profile* (Bath Group, 2003) emerged as an international effort to encompass the needs already specified in earlier profiles and to provide all the guidance and documentation needed to improve the efficacy of implementations. It is currently the most important profile for bibliographic services, though as yet at the stage of being diffused more than being widely implemented (see more about the evolution of profiles in Section 7.4.3.1).

Other types of profiles show the range of applications using Z39.50 in other fields: the Global Information Locator Service (*GILS*) profile (GILS, 1997), developed to access databases of US governmental services, but now used also in other countries (Christian, 1996, 1996a; 1999; 2001); the *CIP* (CEOS, 1998) and *GEO* (Nebert, 2000) profiles for systems focusing on geospatial data; the *CIMI* (Bearman, 1992; Finnigan & Bird, 1998) profile for museum information (Perkins & Moen, 1997; Finnigan & Bird, 1998; Moen, 1998, 1998a); and the *Zthes* profile (Taylor, M., 2000a; 2004) for representing and searching thesauri. In the area of archives there has been also some interest in Z39.50 (FDI, 1996; Joy, 1996; Watry, 2001) although there is not a specific registered profile.

Essentially, profiles correspond to the needs of a given community, according to its objectives and stage of standardization. Thus, in some cases a profile may imply the definition of an abstract model for a specific kind of application, as in *Zthes*; or the development of schemas, element sets, and abstract record structures, if

they are not pre-existent, as happened in *GILS* and *CIMI*. In fields where these structures already exist, a profile prescribes choices on the options available in the protocol standard and criteria for the use of associated existing objects (e.g., data standards). This is mostly the case with bibliographic profiles (ANSI/NISO Z39.50: 2003: 199).

## 5.5 Registries

An important aspect of Z39.50 is its extensive use of registries for object identifiers (OIDs). This means referring to certain data objects by an identifier registered by a competent authority. Many parameters of the Z39.50 APDUs (the units of information transferred between client and server) require the use of identifiers to designate an object, e.g., an attribute set or a record syntax.

An OID is an “unambiguous, globally-recognized, registered identifier for a data object, assigned by a registration authority” (ANSI/NISO Z39.50: 2003: 6). OIDs are numerical strings assigned to objects that have to be uniquely identified in order to be easily processed by computers, notably in protocols. The establishment of OIDs is regulated by an ISO standard (ISO/IEC 9834-1: 1993). OIDs are managed in a hierarchy whose top is the OID for ISO. By assigning OIDs to organizations, ISO delegates to them the authority to register other OIDs under theirs. The OID for Z39.50 is ‘1.2.840.10003’ (where ‘1.2.840’ designates NISO and ‘10003’ designates Z39.50, assigned by NISO) and this is the root for all the specific OIDs registered under Z39.50.

The Z39.50 standard defines 14 classes for Z39.50 objects under which other specific objects are numbered. These are listed in an appendix of the standard (see ANSI/NISO Z39.50-2003: App. 1) but more can be assigned as necessary, under request to the standard’s Maintenance Agency.

Appointed by the NISO, the Library of Congress has been responsible since 1989 for the Z39.50 Maintenance Agency. Currently, it is *Z39.50 International Standard Maintenance Agency*, encompassing the functions of maintenance and registration authority for both the ANSI/NISO Z39.50 and the ISO 23950 standards.<sup>7</sup>

The use of registries highlights the rationale of an open environment: distributed concerns and responsibilities and the need to formalize any objects that may be used across actual systems, in terms that reduce complexity. Behind the



establishment of an OID are definitions and descriptions of data and systems behaviour that have to be explicitly available, often in the form of specific standards.

## **6 Characteristics of the SRW/SRU: a summary**

The following is an informal summary of the major characteristics of SRW/SRU in respect to the differences and advances regarding Z39.50.

The messaging system is based on XML. In the case of SRW both requests and responses are in XML. In SRU requests are embedded in an URL and responses are obtained in XML. This feature overcomes the inconvenience of the less known and less intuitive abstract syntax of ASN1/BER used in Z39.50.

Record syntaxes are based on XML, using record schemas such as Dublin Core, Online Information Exchange (ONIX), Metadata Object Description Schema (MODS) and MARC21 XML Schema (MARCXML). Record schemas available to SRW should have an SRW URI.<sup>8</sup>

Queries in Search or Scan requests are formulated in CQL, a Common Query Language, based on Common Command Language, whose goal is “to combine simplicity and intuitiveness of expression with the richness of Z39.50’s type-1 query” (Sanderson, 2004: Sec. 32). The language is simpler than other query languages such as SQL and XQuery, and allows the expression of Boolean operators, proximity, search context (the Use attribute that in Z39.50 specifies the indexes, here named Context Set), relations (to search ‘all’, ‘any’ or ‘exact’ terms in a search), relation modifiers to indicate truncation or term format (e.g., to specify that a given term is a date); and wildcards (Ibid.).

Access points are flat, i.e., statically defined in terms of Z39.50 attributes, instead of the attributes themselves. This means that Context Sets, which specify the indexes provided by the servers are defined and published. CQL has a published Context Set<sup>9</sup> for indexes that are ‘utilities’, i.e., broadly applied with no relation to the type of data content to be searched. Other published Context Sets are defined to express specific semantics of data indexes. They exist for data element sets like Dublin Core, or Z39.50 profiles like Bath Profile or Zthes.<sup>10</sup>

The Explain function allows clients to obtain knowledge about the features of the protocol and of CQL that servers support. This is a very light implementation of the corresponding Explain service of Z39.50. Both clients and servers should support

this operation. The request from a client can be as simple as 'explainRequest' pointed to an URL, and the response can return more or less complete information according to the 'Explain record' existing in the server. The structure of Explain records is defined in a DTD, containing six sections to accommodate all details necessary, e.g., basic information on how to connect to the server and the URL for the WSDL file of the service; database description, indexes and record formats available, etc. (SRW Editorial Board, 2004: Sec. 40-47).

Registered object types are defined to facilitate implementation. As in Z39.50 OIDs, there are URI for the object types to be used in SRW/U. These are specified by a common base address and a specific identifier for each type, as well as the values for each delegated authority.<sup>11</sup>

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## Notes to Annex 1

<sup>1</sup> Until the 2003 version (ANSI/NISO Z39.50: 2003) the text of the standard used “origin” and “target” to designate the client and server respectively. Those terms, remaining from the context of OSI, were abandoned (Ibid.: 265).

<sup>2</sup> The creation of NAG followed the establishment of the Network Department Office (NDO) at the Library of Congress, in 1976, with the aim of bringing representatives of other external organizations. In 1977 the NAG became NAC (Network Advisory Committee), a consultative committee of the Librarian of Congress.

<sup>3</sup> As stated in the *Foreword* of Z39.50 (ANSI/NISO Z39.50: 1995), the “protocol was originally proposed in 1984 for use with bibliographic information. Interest in Z39.50 broadened and in 1990 the [...] ZIG was established. [...] ZIG membership is open to all interested parties”.

<sup>4</sup> Since 1999, starting with the Fifth Framework, libraries’ support is included in the *IST Programme* (see Chap. 2, note 9).

<sup>5</sup> See Chapter 2, note 29.

<sup>6</sup> Results include several Z39.50 services currently operational:

CAIRNS - *Co-operative Academic Information Retrieval Network for Scotland*, a gateway to Scottish HE library catalogues (<http://cairns.lib.gla.ac.uk/>)

RIDING - *Z39.50 Gateway to Yorkshire Libraries* (<http://www.shef.ac.uk/~riding/>)

M25 Link - *Z39.50 Gateway for 140 HE library catalogues in the London area* (<http://www.m25lib.ac.uk/Link/>)

Projects involving Z39.50 under later JISC programmes:

Xgrain - *Cross-searching Specialist Databases for Learning and Teaching* (2000-2003), which developed a broker system to offer cross-searching of A&I databases and ToC services across the DNER (Shaw, S., 2003); in a second phase focused on providing broker services for portals, it became the *GetRef Service* (<http://edina.ac.uk/getref/>) and includes provision of OpenURL links.

Gate Z - *A protocol gateway to support use of the Bath profile* (<http://www.rdn.ac.uk/projects/gate-z/>) which developed a Z39.50 to Z39.50 gateway to interface Bath-Profile clients to non-Bath Profile targets (Bull, 2001).

Other UK search and retrieval services based on Z39.50:

AHDS - *Arts and Humanities Data Service* (<http://ahds.ac.uk/index.html>);

BOPAC - *Bradford OPAC*, University of Bradford (<http://www.bopac2.comp.brad.ac.uk/~bopac2/>), a gateway to several UK and foreign catalogues based on the EUROPAGATE software.

<sup>7</sup> See the (<http://www.loc.gov/z3950/agency/>). The *Registry for Z39.50 Object Identifiers* is available at: <http://lcweb.loc.gov/z3950/agency/defns/oids.html>.

<sup>8</sup> The list of record schemas with an SRW URI is available at <http://www.loc.gov/z3950/agency/zing/srw/record-schemas.html>.

<sup>9</sup> See at <http://www.loc.gov/z3950/agency/zing/cql/context-sets/cql.html>.

<sup>10</sup> See the published SRW Context Sets at <http://www.loc.gov/z3950/agency/zing/cql/context-sets.html>.

<sup>11</sup> See the SRW URIs at <http://www.loc.gov/z3950/agency/zing/srw/infoURI.html>.

## ANNEX 2

### PROJECTS FUNDED BY THE EUROPEAN COMMISSION RELATED TO SR/Z39.50

ION - *OSI pilot/demonstration project between library networks in Europe for interlending services* (1990-1995) - <http://www.cordis.lu/libraries/en/projects/ion.html>

SOCKER - *SR Origin Communication Kernel* (1992-1996)  
<http://www.cordis.lu/libraries/en/projects/socker.html>

EUROPAGATE - *European SR-Z39.50 Gateway* (1994-1996)  
<http://www.cordis.lu/libraries/en/projects/europaga.html>

EURILIA - *European Initiative in Library and Information in Aerospace* (1994-1997)  
<http://www.cordis.lu/libraries/en/projects/eurilia.html>

DALI - *Document and Library Integration* (1995-1996)  
<http://www.cordis.lu/libraries/en/projects/dali.html>

PARAGON - *SR Target Development as a paragon for Catalogue Systems* (1995-1996)  
<http://www.cordis.lu/libraries/en/projects/srtarget.html>

ARCA - *Access to Remote Catalogues by implementing SR target functions* (1995-1997)  
<http://www.cordis.lu/libraries/en/projects/arca.html>

CASELIBRARY - *Library services interface toolset* (1995-1997); produced ZNavigator client and software tools - <http://www.cordis.lu/libraries/en/projects/caselib.html>

ONE - *OPAC Network in Europe* (1995-1997)  
<http://www.cordis.lu/libraries/en/projects/one.html>

SESAM - *System for Electronic Support of Academic Material* (1995-1997)  
<http://www.cordis.lu/libraries/en/projects/sesam.html>

UNIVERSE - *Large Scale Demonstrators for Global, Open Distributed Library Services* (1996- 1999) - <http://www.cordis.lu/libraries/en/projects/universe.html>

CASA - *Cooperative Archive of Serials and Articles* (1997-2000)  
<http://www.cordis.lu/libraries/en/projects/casa.html>

CANDLE - *Controlled Access to Digital Libraries in Europe* (1998-2000)  
<http://www.cordis.lu/libraries/en/projects/candle.html>

DEMOMATE II - *Developing the European digital library for economics* (1998-2000)  
<http://www.cordis.lu/libraries/en/projects/decomat2.html>

ONE II - *Opac Network in Europe- II* (1998-2000)  
<http://www.cordis.lu/libraries/en/projects/one2.html>

EULER - *European Libraries and Electronic Resources in Mathematical Sciences* (1998-2000) - <http://www.cordis.lu/libraries/en/projects/euler.html>

### ANNEX 3

#### VIEWS AND COMMENTARIES ON Z39.50 SINCE 1997: A SAMPLE

**John Kirriemuir, *Ariadne*, 1997**

“Z39.50 has been around for a long time, now - why do you think it has not been assimilated into networked retrieval applications and technologies to the extent of e.g. CD-ROMs, the Web?” (question to C. Lynch in Lynch, C., 1997a).

**Clifford Lynch, *Director, Library Automation, University of California*, 1997**

“The development process for the Z39.50 standard is also of interest in its own right. Its history, dating back to the 1970s, spans a period that saw the eclipse of formal standards-making agencies by groups such as the Internet Engineering Task Force (IETF) and informal standards development consortia. Moreover, in order to achieve meaningful implementation, Z39.50 had to move beyond its origins in the OSI debacle of the 1980s. Z39.50 has also been, to some extent, a victim of its own success -- or at least promise. Recent versions of the standard are highly extensible, and the consensus process of standards development has made it hospitable to an ever-growing set of new communities and requirements. As this process of extension has proceeded, it has become ever less clear what the appropriate scope and boundaries of the protocol should be, and what expectations one should have of practical interoperability among implementations of the standard. Z39.50 thus offers an excellent case study of the problems involved in managing the evolution of a standard over time. It may well offer useful lessons for the future of other standards such as HTTP and HTML, which seem to be facing some of the same issues” (Lynch, C., 1997b).

**Andrew Wells, *National Library of Australia*, et al., 1998**

“While everyone has heard about Z39.50, there is still a lot of uncertainty about its relevance to the library community. ‘It’s still under development,’ you may have read on lists or heard people say. ‘It’s too complex to implement.’ ‘It doesn’t work.’ ‘It’s not needed now we have the Web.’ In fact, Z39.50 is a mature standard, widely implemented in the library community. It is beginning to solve real problems, not just for libraries [...]” (Wells, et al., 1998).

**Paul Miller, *Interoperability Focus, UKOLN*, 1999**

“New technologies such as XML and RDF certainly fulfil aspects of the information discovery and retrieval process better than basic Z39.50, but work is underway to capitalize upon this, and to tie such technologies more closely to Z39.50. It appears for the moment that, whatever its limitations, Z39.50

remains the only effective means of enabling simultaneous queries upon distributed heterogeneous databases, and this remains something that the broader user community wants to be able to do. Z39.50 is often attacked on a variety of levels by those who see it as overly complex, old fashioned, not sufficiently web-like, or simply no match for the latest 'great idea' (currently, this 'great idea' is usually cited as being some combination of XML and RDF). It is undoubtedly true that Z39.50 has quirks and limitations, some of which have been outlined in this paper. This is true, though, of most standards, and the very fact that Z39.50 has been extensively used for long enough to be criticized as old fashioned is surely a testament both to its robustness and to the lack of any viable alternative” (Miller, P., 1999a).

**Mike Taylor**, *software engineer, ZIG member, 2000*

“it's a continual failure of bright people coming into new situations that they tend to discount everything that's come before them, with all its accumulated wisdom. I found it ironic that in DC, it was John Kunze - a founding father of the ZIG - who wanted to throw everything away and start again; while I - a relative newcomer - want to keep more or less what we have now. [...] We know that we need an editorial reworking of [the] standard. We also need to make and promote more and better tools that work with more fashionable languages and development environments. However, we won't win the web people over by watering down what we have, because there are plenty of simple mechanisms out there already - not least the web itself, which is just perfect for simple searching and retrieval. If the web is like a Volkswagen Beetle - small, cheap, easy to use - then Z39.50 is like a Harrier Jump Jet - big and powerful, and necessarily somewhat harder to use. For many purposes - nipping down the road to do some shopping, taking the kids to school - a Beetle is an excellent solution and a Harrier would be ridiculous overkill; likewise, the web is an excellent solution to many information needs. However, for people who need to fly, a Beetle with aero-engines attached with string is a dangerous hack. These people need Harriers” (Taylor, M., 2000).

**Sebastian Hammer**, *co-founder of Index Data, 2000*

“Does Z39.50 have the potential to become a universal standard for searching the Web? Most likely; but it probably won't, because some people consider it too comprehensive and too complex for general Web applications. [...] For what it does, it is unsurpassed by any other standard” (Hammer, 2000).

**Peter Gethin**, *Sirsi Corporation, 2001*

“There are some implementations of Z39.50 that are so basic that the combination of attributes that they are capable of supporting is so small, that almost all queries are rejected and return an error diagnostic. With those systems you only get a response if you submit one of the few combinations that are supported. These implementations are at least within the letter of the standard, albeit that they return no information most of the time (Gethin, 2001).

**Sandy Shaw, *EDINA XGrain project*, 2001**

“A number of problems have arisen in the practical use of Z39.50 services for various reasons: weakness in implementation, vendor ignorance, and unrealistic expectations. Rightly or wrongly, a substantial number of negative perceptions are also commonly held: commercially irrelevant; overweight and expensive; resistant to integration” (Shaw, S., 2001).

**Karen Schneider, *Director of Technology, Shenendehowa Public Library, NY*, 2001**

“Things that haven’t quite caught on the way I thought they would include community networks, Z39.50, and cataloging the Internet. Nothing crashed and burned, and these ideas are in use, not dead; but overall these are excellent concepts with more baggage than airlift” (Schneider, K., 2001)

**Dynix, *library systems producer*, 2003**

“The standard is very flexible, offers many ways of accomplishing a task and tries to accommodate any type of search and retrieval task. Therein also lies its weakness: on the one hand it is huge and feels overwhelming and on the other hand it is often not specific enough because it tries to be everything to everybody. [...] [Never implemented features, like character set negotiation] “are often due to a chicken and egg problem: vendors don’t bother adding a feature in their client software because no server will be able to actually use the feature, and features don’t get added in servers because clients don’t support it either. The resulting situation is that not a single implementation ever implemented the full standard” (Dynix, 2003).

**John East, *Librarian, University of Queensland, Brisbane*, 2003**

“There seems to be a feeling in the profession that Z39.50 is a technology which has promised great things, but has yet delivered little in practical terms. [...] it seems to have had little impact on the day-to-day work of most librarians. However, those of us involved in providing training and support for researchers using personal bibliographic management programs are conscious of the existence of a very large group of Z39.50 users unknown to most librarians. Even Z39.50 experts seem to know little about this application of the protocol [...]. All this presents a depressing picture, and it is little wonder that many librarians mistrust the Z39.50 protocol and advise their clients to avoid it. [...] [Problems are] familiar to librarians involved in Z39.50 implementation. However, there is little detailed knowledge of these issues in the wider library community, let alone the large number of researchers who are accessing Z39.50 servers. [...] Many vendors provide no information on their [...] Z39.50 server, or else the information they provide is incomplete and inaccurate. [...] But libraries themselves are at fault here, as few of them provide suitable documentation concerning their own Z39.50 implementation” (East, 2003).

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