EXPERIENCES WITH THE IDA, AND PLANS FOR AN ISDN INFRASTRUCTURE AT UNIVERSITY COLLEGE LONDON

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ABSTRACT

This paper describes the experience at University College London (UCL) with the British Telecom (BT) "IDA" prototype of a basic rate ISDN Service. This experience has been limited to the use of Group IV facsimile, an early experiment in the provision of an X25 gateway to IDA, and its access from workstations via the IDA.

As part of an experimental infrastructure, UCL is putting in much more extensive multivendor facilities which will use the ISDN as soon as it becomes available in the UK. We report our efforts to get approval from the relevant authorities for experimental equipment, and discuss some of the research questions we expect to address in our testbed.

1 INTRODUCTION

The Integrated Services Digital Network (ISDN) has been discussed for more than fifteen years. According to its most enthusiastic advocates, it will provide the panacea for all our communications problems, and will allow a complete mix in services from low speed data (a few Kbps), through voice, high speed data and video. Only one workstation will be needed on the desk, and the communication will be easily affordable by all.

On the way to this very grandiose concept, there are a number of practical shorter term hurdles. This paper concentrates on some of the planning we have been undertaking in the Department of Computer Science of University College London to obtain maximum benefit from the basic rate access to the ISDN which should be available to us towards the end of 1988. It also describes some of our preliminary practical investigations into interworking aspects. Like many others, we do not expect to put in a large investment in switches, gateways, workstations or servers early on. We do not expect easy integration of our voice and data applications or workstations. At the same time we do want to profit from the availability of 64 Kbps switched services without unduly disrupting the infrastructure of the Department. We are also interested in investigating, for research and development purposes, how to benefit further from ISDN potential capabilities in the future.

In Section 2, we describe the communication environment in the Department. It is based heavily on a Local Area Network [LAN] environment, though there are also a Private Automatic Data Exchange [PADX] and Packet Data Switch [X25S]. It is into this whole environment that the ISDN access must fit. Some of the salient points of the network, and some of the software considerations and procedural aspects that affect our planning for the network are described. In Section 3 we describe our research interests relating to ISDN, and in Sections 4 and 5 we give details of our experience so far and our specific plans for the future.

We expect to have more information to report at the conference. This paper is being written before we have had delivery of any of the real ISDN equipment; only that for the British Telecom (BT) prototype ISDN service, IDA (Integrated Digital Access), is in use at present.

2 THE COMPONENTS OF THE INFRASTRUCTURE

2.1 Introduction

The popular conception of the use of the ISDN is that individual workstations will be put in to access the network, and that larger premises will put in voice/data PABXs onto the network. At least initially, in many sites this will not occur. In Section 2.2 we discuss the current configuration in the Department of Computer

Science, and in Section 2.3 our view of the status of the ISDN in the UK. In Section 2.4 we deduce the sort of infrastructure we would like to see in the Department, and in Section 2.5 the additional protocols and software needed for this infrastructure.

2.2 *The Current Scene*

Figure 1 shows a simplified picture of the components of communications in University College London. There are currently a number of Local Area Networks [LAN], which are mainly 10 Mpbs Ethernets; these are either self-standing, or are connected to other LANs. We are just putting in a backbone Spine [S] using FDDI technology. Multi-user systems [MS] are now mainly on a LAN or self-standing; some will be put directly on the Spine. The multi-user systems are partly general purpose computing engines, partly file servers, and partly specialised services (e.g. array processors, back-up servers, high performance and quality printers). TCP/IP is the dominant protocol suite on the LANs, though we have started experimental use of both X.25/LLC2 and TP4/CLNP.

Besides the LANs, there are many types of lower speed communication networks. The College has access to the Public Switched Telephone Network [PSTN], various Packet-Switched Data Networks [PSDN], some higher speed leased facilities [HSN], IDA, and we hope soon, real ISDN. While it is intended by the Carriers that the ISDN will eventually subsume all the other networks, we do not expect this to occur within the next decade - though some of our switches will, we hope, become redundant.

At present many of our services are provided on multi-user systems [MS] accessed from relatively simple terminals [T] or single-user workstations [WS]; the MS can be accessed either via LANs or RS-232 ports at speeds up to 64 Kbps. We therefore have provided a digital low-speed circuit-switched network [PADX] with some 2000 ports in the College. Some of the ports terminate directly on MSs, some on LAN terminal concentrators [LAN-TC], and some go on to the PSTN; we expect to terminate some on the ISDN - initially at basic rate, but eventually at higher rates. In some parts of the College, but not in the Computer Science Department, T or WS can be connected to an X25 PAD (not shown). Some of the WS, particularly most of the more powerful ones, are attached directly to a LAN. We expect to attach some directly to the ISDN eventually. We have several PADXs, which are connected into a single circuit-switched data network. Although we have a digital voice switch [PABX] which can be configured for voice/data, this has not yet been done; the reason is mainly the cost per termination of that PABX, and the fact that its data software was not available at the time of installation. Clearly, all the devices shown in Figure 1 terminating on the PADX could also terminate on the PABX; we have no immediate intention of having more than a few data connections to the PABX for cost reasons.

Many of our external services are of a packet-switched type via the Public Packet Switched Data Network or one of several private PSDNs. To ease our switching problem, we have X25 Switches [X25S] providing access to these packet-switched services. Line speeds of up to 64 Kbps are used at present, though these may be increased. Again we would have some interest in having outside access to the ISDN from these X25Ss at least at basic rates, and possibly at higher rates. Inside the College, the X25Ss are not all of one type, mainly for historic reasons, but are all connected. We have other more specialised external network connections [HSN] at speeds up to full video, but are not expecting to interconnect these with the current generation of emerging ISDN services.

2.3 *The ISDN Network in the UK*

Clearly the ISDN in the UK will evolve over many years. At present there is an Integrated Digital Access [IDA] service in place. This was planned before the current generation of standards had been agreed, and is a (64 + 8 + 8) Kbps service, with the 8 Kbps D-channel behaving significantly differently from the ISDN standard, and not being available to the customer. British Telecom provides Network Terminating Units to this network, which approximate to R-interfaces; we have three such devices in the College. Their use is limited, because little terminal equipment exists to connect to the R-Interfaces in a way which can exploit circuit switching, and IDA access is not widely available either.

The basic rate ISDN in the UK is expected to be introduced towards the end of 1988 as a service. Vendor trials are expected to start in the third quarter of 1988. We have requested that we be included in the Vendor trials, but it is not clear whether this will be permissible. The ISDN service will be introduced in accordance with the NET-3 standards of the European Commission. These will involve not only technical standards, but strict rules about testing the equipment for conformance. The testing cycle may well be considered a reasonable business expense for a manufacturer producing equipment for sale in sizable quantities; it is not yet clear whether it would be in any way affordable for a research institute like ours for research equipment. Most of the types of ISDN equipment implied in Figure 1 will not be available initially; even if

the hardware is, there will be considerable difficulty in integrating the protocol structures into a system like that in our Department. All our activities are in conjunction with various manufacturers, or the development portions of PTTs; it is not clear, however, whether our partnerships will be allowed to ease the approvals process.

There will be no international standards for primary rate access before the 1992 CCITT Plenary. For this reason there will be no NETs for primary rate access before that date. As a result, it is likely that the rules for such access may require only national, not European regulations, and that the facilities to be provided will be decided nationally. There are many different facilities that could be provided under Primary Rate access. The French already provide switched 2.048 Mbps channels over the Telecom I satellite. The UK Unison project [1], provides facilities so that a variable number of basic rate channels are set up on an end-to-end basis dynamically; this requires collaboration between the two end points to mutiplex, demultiplex and synchronise the data between the channels. The UK Admiral project [2] (in which UCL participates) aggregated groups of basic rate channels across links at up to 896 Kbps. These can be used in a fairly straightforward way. Finally, the official British Telecom Multiline IDA allows single basic rate channels to be set up between the two end points - but provides no facilities for dividing data between blocks of these. All the above come under the banner of primary rate access. In addition to the above, British Telecom has adopted the national DASS-2 [3] standards for signalling to set up a basic rate channel. In the absence of international standards, there will be only limited terminal and bridge equipment available. We have not completely formulated our policy at UCL on attempting to provide primary rate switched service; this subject is discussed further in Section 5.

2.4 The UCL ISDN Infrastructure Needs

We mentioned in Section 2.2 the potential problems in getting experimental equipment approved for connection to the ISDN. Much of the equipment we will use is experimental in nature, and comes from US manufacturers who may not be prepared to obtain UK approval. Our concerns with the availability of primary rate and basic rate ISDN, the cost of primary rate access lines, and our worry about regulatory difficulties in obtaining approvals (discussed in Section 2.3), have made us decide that it is imperative that we have ISDN Network Simulation facilities as well as terminal equipment in the Department.

We clearly will not need, nor be able to afford, a large number of basic rate channels to the outside world; those we do have must be shared between the different applications; hence we will need relaying facilities with the existing local networks. We must distinguish between application relays and network relays. In the first, ISDN access is given to a box which contains all the layers of protocol up to the application; in the second, only the lower three layers are present.

For external terminal access to our MSs, or remote log-in to outside resources, the basic rate DTE access, with an application relay, between ISDN and either the PADX or the LAN Terminal Concentrator [LAN-TC] would be important facilities. The first would allow basic rate access to any terminal port in the Department; the second would provide (terminal) access to any multi-user Host [MS] on a LAN. (See Figure 2.)

There are usually severe limitations on the software which is supported in a multi-user system over its terminal ports; for this reason it is also important to have access directly to their more general communications services. This can be achieved by means of a relay in the network layer which will be invisible to transport and higher layer software. To obtain wide connectivity to systems in the Department, an ISDN DTE interface on the X25 switch [X25S] would be desirable. Figure 1 also shows an ISDN gateway directly on the Ethernet; such a device would be needed to access Multi-user Systems with no terminal or X25 access ports. Eventually this gateway should have a capability of handling multiple basic rate ISDN calls, primary rate ISDN, or higher speeds circuits. It could either be connectionless - layer three being IP (ISO or DARPA), or connection oriented - with layer three being X25 1984.

At UCL, we have not planned to install any equipment which makes novel use of voice facilities. Such workstations will come, and would be able to exploit integrated facilities. For this reason, we plan eventual ISDN access to the UCL voice/data PABX, and plan to upgrade it to handle local data also. Initially this access will only be at basic rate; we expect eventually to provide the Multi-line ISDN access also - where we have 30B+D channels, and can set them up individually. Our present voice/data PABX has some ISDN-like capabilities; there is a special combined digital phone and terminal that it supports. We have not yet investigated how standard that interface is; if it is a normal S-interface, it would meet many of our internal needs.

While access to local communications ports are important, it is also necessary to have terminals [T], worksta-

tions [WS] and multiuser systems [MS] which can access the ISDN directly at basic rate. The T can only so access through an R-interface, or one of the switches mentioned above. However we must provide facilities also for WS and MS to access the ISDN via the S-interface. This is so that we can investigate the operational problems in using the ISDN directly for our various applications.

For primary rate access, we would like more sophisticated facilities than merely a number of basic rate channels as provided by Multiline IDA. Through the current X25S and the PADX, this is all that could be handled. Through the Ethernet Gateway, we would like to provide N x 64 Kbps; this would also be desirable for some video communications over the Livenet [4] fibreoptic network of the University. For the former, we are clear how we would use it. For the video, we have not yet worked out how we would integrate it into the communications fabric; it should go into the local video switch, but this may be difficult technically. For this reason, we must either find ways of using single basic rate calls - providing the end-to-end signalling information to combine the data, or use ISDN-like switches - but provide block switching as in Admiral or Unison.

2.5 *Component Software*

We are concerned here mainly with the protocols needed for the B-channels or some of the gateways. Some basic software is needed to handle the D-channel. Facilities for outgoing and incoming call set up, maintenance and close down are essential also.

Addressing and routing will be a key problem. The ISDN operators will model their addressing on the telephone network; this usually is limited to addressing ISDN terminations. The users will require to route calls via the various ISDN front-ends and switches shown in Figure 1 through to the eventual hosts or workstations; this requires particular care in network addressing. At the same time, the considerations of the bodies studying systems of interconnected LANs and wide area networks start from different premises, and are looking at somewhat different solutions. We believe it will be essential to look very carefully into this area and to ensure that, even with the ISDN, the network addressing is carried out through Nameserver name look-up procedures. Even with comparatively small X25 switches, we have found Network and Configuration management raises difficult problems. With the more complex and sophisticated facilities indicated in Figure 1, and the substantial rate of change of WS and MS on LANs, a consistent use of Nameserver tables by all switches and Hosts is essential. It is probable that the use of Directory Services, to complement the use of the Nameservers, will also be needed.

Initially the service aspects of the ISDN need be little different from remote data use of the current switches. Automatic dialling is clearly both easier and faster with the ISDN. For this reason we can expect more short transaction based applications to be developed. Initially, however, these will be ignored in the UCL infrastructure. We have developed such an infrastructure, using Remote Procedure Calls, in the LAN environment; we believe we know how this could be extended straightforwardly to the ISDN world. Performance and tariff issues will limit the viability of such extensions.

In order to have an integrated structure for local and remote services, which can integrate with current wide-area practice, we expect that we will initially make minimal changes to the higher level software on the MS or the WS. We will also wish to make minimal changes of the software and facilities between the switches and the WS or MS. This implies that we must model the functionality of the ISDN switches and gateways to LANs on the functionality we have in the pre-ISDN era. The meaning of this in the individual cases will be discussed in Section 5.

3 SPECIFIC RESEARCH INTERESTS

3.1 *Introduction*

The infrastructure described above, once established, will provide a platform for several strands of research. The two to which our initial interest will be directed are described below.

3.2 *ISDN Workstations*

At present the majority of wide-area data communications falls into one of two classes:

a) Communication via dedicated data networks leased from a PTT at speeds ranging from 2.4Kbps to 64Kbps.

b) Communication over dial-up voice-grade circuits at speeds ranging from 300bps to 2400bps.

The tariffing arrangements for these two classes are very different; a) being comparatively expensive and based on data volume, b) being comparatively cheap and based on time and distance. These arrangements have a profound effect on the modes of usage of workstations and PCs. Attachment via a data network

can only be justified if the utilisation is high. For intermittent use - such as would be required for a home-worker - use of dial-up lines is often more appropriate. The nature of the service provided by dial-up lines is such that it is not worth integrating the communications service very closely into the local system. The commonest form of interaction with a remote system being terminal emulation and some crude form of file-transfer. This falls far short of the level of integration which is usual on a LAN for example.

The tariffing arrangements for ISDN are not yet clear. In the France and Germany, the initial national usage tariffs will be comparable with those for voice, with a 25% to 50% surcharge; there will be higher fixed charges than for voice, but lower ones than for comparable speed data lines. No international tariffs have yet been announced; however these can, presumably, only cover the usage charges. These levels of charge open up a range of possibilities for the design of the isolated ISDN workstation which would make heavy use of communications. The use of proper data communications protocols and relays to LANs and WANs would allow such workstations to participate in peer-to-peer communications. The message store of an electronic mail system could be on the workstation rather than on some remote host. This would allow message transfer to take place independently from creation and reading, and could thus take advantage of off-peak tariffs. Transfer of large multi-media documents would be feasible, as would the full integration of teleservices such as G3 and G4 facsimile. File access rather than transfer would be a possibility.

The study of the design of such workstations and their integration into existing communications environments are important motivations for our work.

3.3 LAN Gateways

Early versions of the gateways described in Section 2.4 will be pragmatic solutions based as far as possible on existing hardware and software components. However the design and efficient management of these gateways, operating as they do between the packet-switching and circuit-switching worlds, itself presents some interesting problems. Thus we will be looking at the issues associated with LAN/ISDN relays.

Whilst the ISDN has many characteristics in common with existing WANs, some important differences arise from tariffs and from the ISDN's circuit-switched nature. A LAN provided with primary rate ISDN access has available a series of variable bandwidth channels which can be switched between remote sites in response to demand, priority etc.. The management of these channels may be affected by tariffs, the required quality of service, perceived traffic patterns, and the quality of service offered in terms of circuit set-up times and end-to-end delays. The management strategy chosen may have effects on the higher-level protocols operating across the end-to-end link.

We will study the management of such relays and will look at the problem particularly in the context of OSI, and the model that provides for network relays. Both the connection oriented and connectionless cases are of interest as is the integration of the relay with directory and other management services.

4 EXPERIENCE WITH THE IDA

The Department has started to get experience with the ISDN precursor, IDA. We have concentrated on a few simple activities. We have been running Group IV facsimile over the IDA; we have also acquired IDA links to PCs. Use of these facilities has helped us understand the limitations of the service, and the difficulties in keeping the links operational. Our early experiences were very unsatisfactory. There were problems with the BT supplied NTEs (NTE3), with line maintenance, with the PC interfaces, and with the diagnostic facilities in many of the subsystems. These impeded the identification of the location of faults in the different failing subsystems; the mean-time-to-repair was often measured in weeks - while new faults were uncovered in days! Newer NTEs (NTE4), better operational organisation by British Telecom, and clearer provision of diagnostic facilities in our equipment has contributed to making these systems quite usable.

Group 4 facsimile is being used in document delivery experiments as part of a project in collaboration with the British Library's Document Supply Centre (BL DSC) at Boston Spa near York. The network is based on a BT "Megastream" (2 Mbps) link which runs between DSC and the London British Library site in Soho, and a connection from there to IDA. The Bloomsbury Science Library (BSL) at University College has IDA access through a standard NTE4.

In the original experiments, two NEC D35 Group 4 facsimile machines were connected between BSL and DSC for the transmission of journal articles requested from Boston Spa. The objectives were to determine the feasibility of connecting between Megastream and IDA, the reliability of the network, speed of delivery and print quality of output. After some initial difficulties in setting up the links and problems of reliability with the NTE, the system worked well, and for some

months delivered documents at the rate of a few hundred pages per week. Print quality was very good and the speed of delivery was high. In previous experiments, Group 3 facsimile had proved inadequate on both factors for this application.

As part of the upgrading of the British Library's own telecommunications network, new digital PBXs were installed earlier this year at both the London and Boston Spa sites, using the Megastream link to connect them. Unlike the UCL PBXs (from the same manufacturer), these were configured to carry both voice and data. Current experiments involve building an internal facsimile network of NEC D35's linked directly to the PBXs, with one D35 in London acting as a relay to IDA. This latter will provide a connection to UCL and other trial sites for document delivery. On the UCL side, the D35 will be used as a relay to a network of Group 3 machines linked to the campus PBX system (or via PSTN in the case of remote sites). In particular, this will provide document delivery services to a number of outlying libraries attached to medical institutes of the University. Eventually it is hoped to replace this Group 3 network with a Group 4 system, to mirror that of the British Library, but for cost reasons this may not be possible in the short term. The configuration is shown in the Figure 3.

Although the characteristics of IDA (and ISDN) favour facsimile as a primary application area for data transfer, we have also been experimenting with other applications. Although PC to PC file transfer over IDA has been demonstrated for several years, it has not been possible until recently to exploit other kinds of connection: LAN to LAN links, for example, or PC to host for remote logon. We have developed a simple-minded relay between an X25 Switch and the IDA. The purpose of this relay was to extend IDA access to as wide a range of local hosts as possible. About a dozen of our hosts have access to the local X.25 switch, and several of these have interfaces capable of operating at the full 64Kbps. The relay is built from an IBM PC/AT with two X.25 cards, one being enhanced by the addition of a full X.21 circuit-switching interface as required by IDA. This relay will be enable us to undertake a series of experiments and demonstrations on the use of ISDN workstations in advance of the availability of a full ISDN service.

The first to be demonstrated is remote logon from a PC to a mainframe (Pyramid) via IDA and an X25 switch. This is currently operational in prototype form and is being used to develop high-speed interfaces to electronic mail services and database systems. The gateway itself is based on two X25 cards hosted on a standard PC, with one linking to IDA and the other to the X25 switch.

5 CURRENT PROGRESS

5.1 Introduction

The Department has started to put in a complete infrastructure for basic rate on the ISDN. We cannot obtain access to the real ISDN before the summer of 1988 - and fear we may have similar operational problems to those we experienced with the IDA. Moreover, we are not yet clear how we will obtain operating approval. For this reason we are concentrating on having a complete in-house facility. A schematic of the components is shown in Figure 4.

The first requirement for this is an ISDN simulator, various WS and MS attachable to the ISDN, and various gateways. The steps we are taking to achieve these are discussed in this Section. In Section 5.2 we mention the interface boards we are acquiring. In Section 5.3 we consider the switch and gateway interfaces we can construct using these, and in Section 5.4 the Hosts and Workstations we will attach. The steps being taken to achieve an ISDN Simulator are considered in Section 5.5. In Section 5.6 our moves towards primary rate access are considered.

2 foo

5.2 The Boards

We are acquiring the following boards. We cannot really know how well they will meet our needs until we have examined them thoroughly.

i) A board which will accept two RS232 or RS422 channels on one side, and connect to the ISDN as a basic rate DTE at the S-interface on the other; any two of the input channels and a telephone jack can be switched remotely onto the two B-channels. Calls are controlled over a separate RS232 channel; this provides acess to the D-channel. We have several systems which could utilise this board.

ii) A board which will plug into a PC bus, and connect to the ISDN as a DTE.

iii) A board which will plug into a VME-bus, and connect to the ISDN as a DTE or DCE; Calls are controlled over a separate RS232 channel.

iv) A solution with three types of board which can fit a number of roles. One board will fit into a Q-bus on a Microvax, and will allow us to attach four synchronous, and two asynchronous, channels to each board. A second board interfaces to the first, and provides basic rate access to the two B-Channels and a D-Channel. The third type also interfaces to the first, and assigns specific B-Channels on a primary access group to the input channels. Both the last two boards can be configured to be either DCE or DTE.

v) A board which will attach to an in-house CASE X25 switch, and which will also provide DTE access to the ISDN (or its simulator). For the present, the addressing and other facilities will be somewhat elementary.

vi) A board which will fit into a Microvax, and will act as an Ethernet Terminal Concentrator; its interface to the ISDN is a primary rate ISDN channel.

While several of the above boards should support primary rate access, it is not clear how many basic rate channels they can support simultaneously.

5.3 Switch and Gateway Interfaces

Figure 1 shows that we are interested in basic rate access to the following gateways: a PABX, a PADX, an X25 Switch [X25S], and an Ethernet gateway.

For the PABX, we have not yet determined whether it will be possible to so equip the main voice digital PABX of the College.

For the PADX, we have discussed with the manufacturer of our PADX; he may provide the appropriate boards, but does not yet have a schedule for their availability. If he does, it will be as DTE not as DCE.

For the X25S, Board iv) of Section 5.2 will provide the facilities we require.

For the Ethernet Gateway, we have several routes - but will have to build up the gateway ourselves. Boards iii), iv) and vi) of Section 5.2 all form a possible base for such a gateway. We will be getting all three, and will then see which will provide the most expedient route. Several of our current Ethernet relays could be adapted.

At present all our Ethernet relays are connectionless. Most run the US DOD Internet protocols, but some are being modified to run the connectionless network protocol (DIS 8473), the connectionless link protocol (DIS 8802-2 Class 1), over CSMA/CD (IS 8802.3). For the ISDN basic rate purposes, this will have one side changed to have the Physical Level run the I.431 Physical layer - where the numbers refer to the relevant ISO or CCITT standards. Alternately we can change analogously to the way we currently are modifying the relays to run over the PSDN. This would require changing the whole stack below the connectionless network protocol to the X25 stack namely the X25 PLP Network layer (DIS 8208), over the LAB-B Link layer (DIS 7776), and then the I.431 Physical layer. We will probably start with the former, and then see how the international standards develop in this area. Details of our plans in this area are given in [5].

5.4 Host and Workstation Interfaces

Based on Boards i) and ii) of Section 5.2, we will configure PCs to be the WS of Figure 1. Based on Board iii), we will configure Suns to be either WS or MS. Based on boards iv) and vi), we will configure Microvaxes to be the MS of Figure 1. In practice, we do not expect all these boards to work in quite the way promised, and doubt whether we will carry through the integration of all of them into our operational systems.

5.5 The ISDN Simulator

Several of the manufacturers with whom we are collaborating have developed in-house ISDN simulators; unfortunately most have developed facilities to allow them to test their equipment (particularly the operation of the D-Channel) - not necessarily to run data through it. The natural way to acquire an ISDN simulator, would be to put ISDN DCE interfaces on an existing circuit switch. We have discussed this possibility with the manufacturers of our PADX, but not yet of our PABX. So far the manufacturers of the PADX seem to have nothing available. They are aiming to put basic and primary rate access between the PADX switch and the ISDN; they are not yet concerned with supporting ISDN workstations. They do not support proper basic rate access for terminals, and can run only in DTE mode on the line side. For this reason, we have abandoned the use of the PADX for this purpose, but are still pursuing the use of the PABX. If that proves infeasible, there still seems to be the possibility of developing the simulator using any of Boards iii), iv), v) or vi). We are still investigating which would be the most expedient.

5.6 *Primary Rate Access*

We have three requirements for primary rate access. One is to provide a higher rate Ethernet gateway; a second is to provide basic rate Ethernet access for a significant number of workstations; the third is for a specific fibreoptic network we have installed for teaching.

We are investigating the feasibility of providing the primary rate Ethernet gateway by either using Board vi), or one of the bridges to Megastream we have in place. While Board vi) has the appropriate hardware interfaces, it is currently configured as an application level relay, and the software may be difficult to modify. At present this development has lower priority than the basic rate infrastructure. We expect to have two separate Board vi)s. One is designed to test the operation of ISDN switches; as such it can exercise any channels in the channel, but may not be capable of sustained operation. The other is designed for real traffic - but there is some doubt as to how many channels it can drive simultaneously. Much work is still needed on the primary rate applications; most of these still assume a number of basic rate channels, rather than ones in which N basic rate channels are set up and switched together.

We have begun some work on the management of LAN/ISDN relays in advance of the availability of real hardware. Modelling work [6] has already been done elsewhere on strategies for managing queues of different classes of data inside such relays. Obviously such work has to make assumptions about the pattern of the traffic passing through the relay, usually a Poisson distribution is assumed. We are keen to test some of these strategies with real data in both the connectionless and connection oriented cases.

Currently we are building a system which will emulate two Ethernet/ISDN relays connected by a number of primary rate ISDN circuits, the exact number being determined by the processing band-width available. Traffic will be generated through this emulation by logically partitioning our local Ethernet so that a portion of normal traffic is diverted. At present, the emulation runs on a single 68000 system. We expect this to have a rather limited real time performance and it is regarded mainly as a vehicle for software development and for gaining a feel for the design issues involved. Eventually we will split the emulation and run it in two machines connected by a high-speed link. At first this link may use an ad hoc interface, eventually it will use primary rate ISDN.

6 CONCLUSIONS

We hope this paper has shown the complexity of integrating even data applications of the ISDN into an environment which is already rich in communications facilities. At present we are pulling together many isolated boards into existing platforms, and are endeavouring to put together a viable basic rate ISDN access to interwork with our other facilities, and considering also what would be required for a primary rate scenario. We expect to employ the same OSI stacks, above the link layer, that we already use for one set of applications, or the DARPA Internet protocols used for another set.

We expect to have more information to report at the conference. This paper is being written before we have had delivery of any of the real ISDN equipment; only that for IDA is in use at present.

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(6) *Kraimeche B., Schwartz M., "A Channel Access Structure for Wideband ISDN", Proc IEEE Infocom '87 Conf., San Francisco, (Mar 31 - Apr 2 1987)*

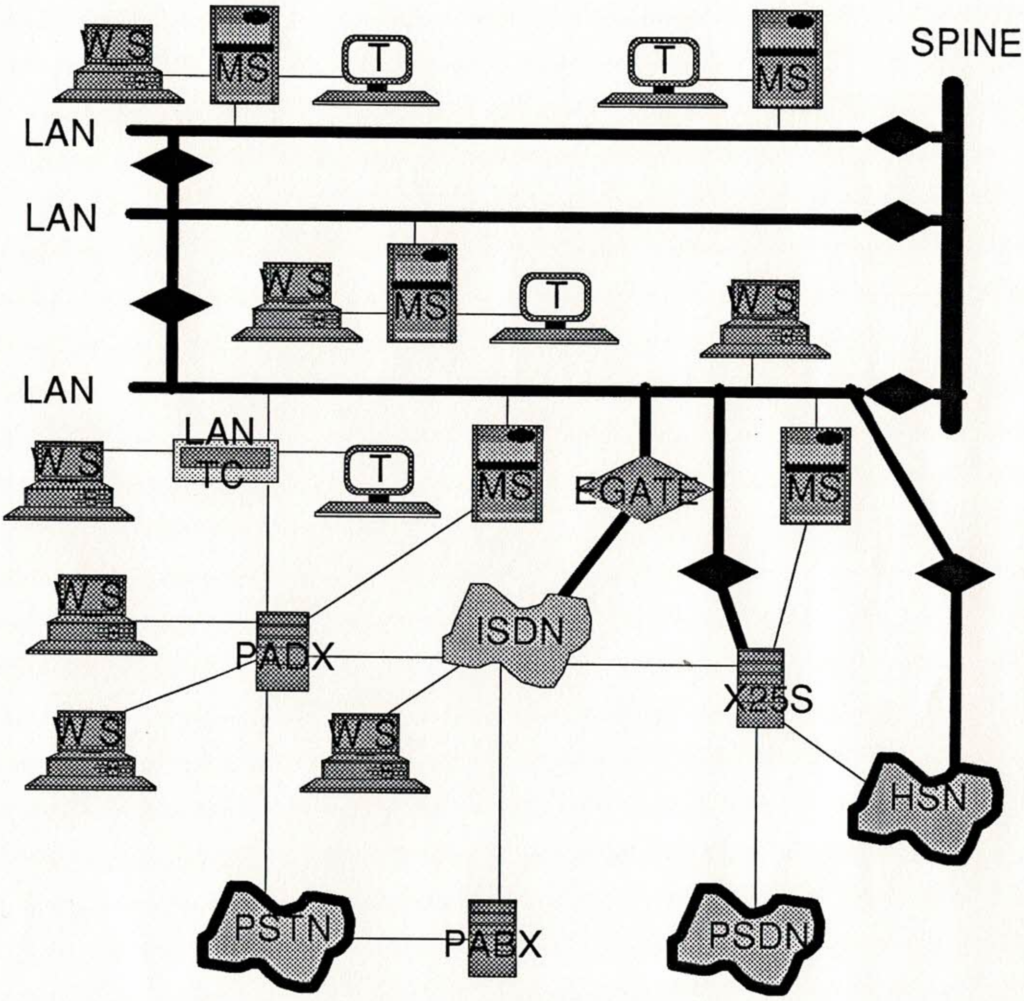

Figure 1. UCL Configuration

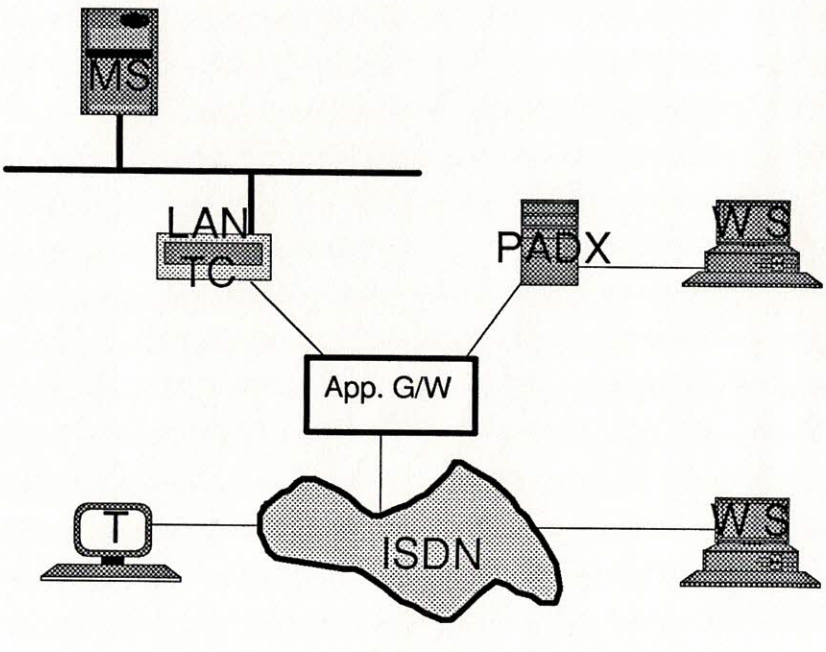

Figure 2. Application Level Gateway

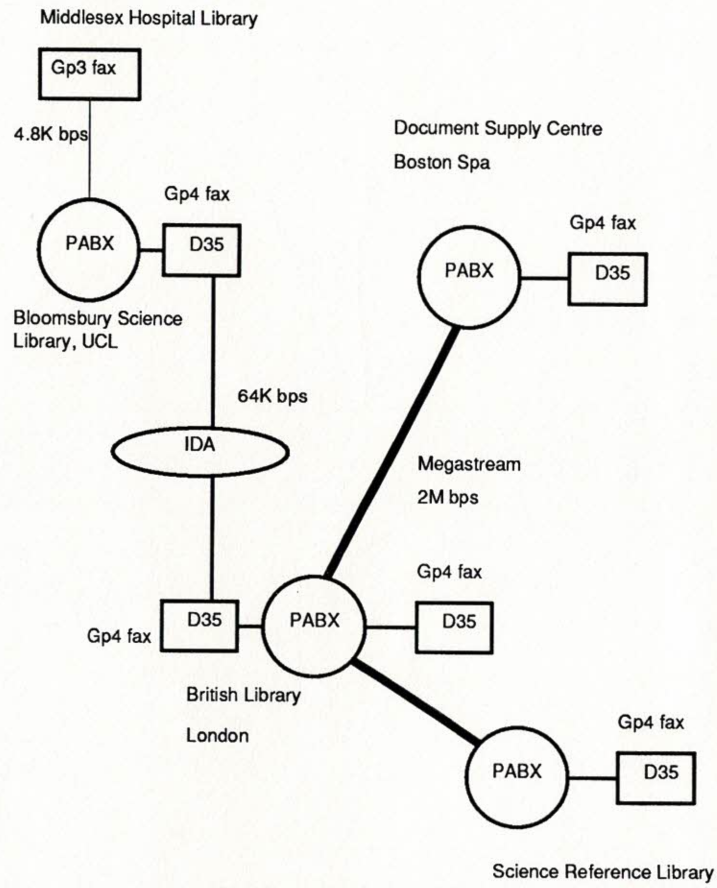

Figure 3. Telefax for document delivery

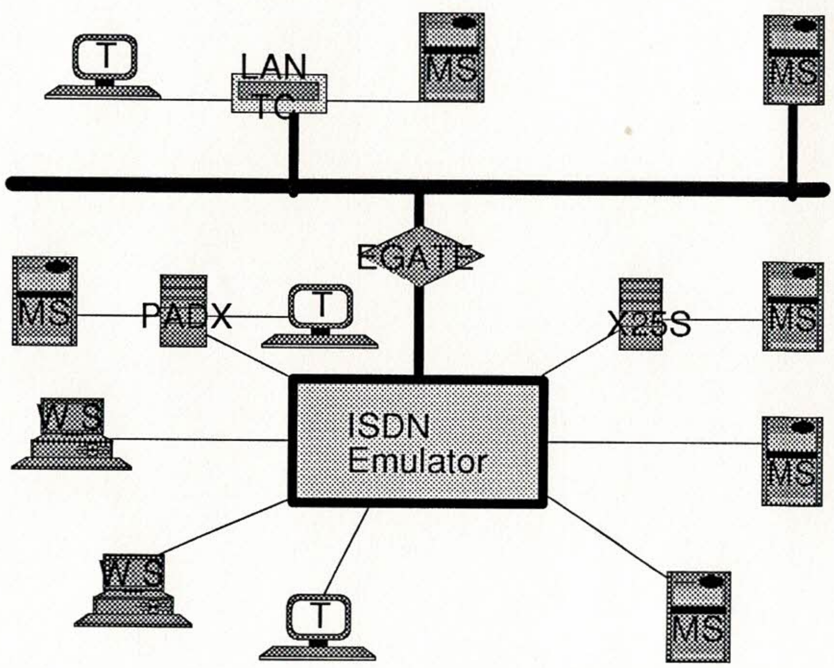

Figure 4. ISDN Emulation