DIGITAL TWIN-BASED SERVICES: A TAXONOMY (Extended Abstract)

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Keywords: DIGITAL TWINS, SERVICE INNOVATION, DIGITAL ECONOMY, TAXONOMY, DIGITAL SERVICES

Abstract

We are witnessing an increased interest and advanced developments of Digital Twins (DT) across different industries; manufacturing, construction, oil and gas, aerospace, energy or healthcare among others. Some actors are already realising that the power of DTs goes beyond efficiency gains and cost savings for internal processes, and recognise the potential of DT to enable the design of new service offerings. Uncovering the potential of DT in the development of new value propositions may lead firms to business model transformations, particularly to the expansion of servitization strategies. Thus, there is a need for more research exploring DT as a service enabler, and shedding light on the typologies and characteristics of these innovative digital services. To address the need for a more comprehensive understanding of DT-based services, we develop a taxonomy able to classify and characterise services enabled by DT. To develop this novel DT-based services taxonomy, we drew upon literature review and use cases. In our ongoing research, four main dimensions emerged to configure a taxonomy of digital twin-based services: service recipient, target operand resource, service content and service pricing model. The proposed taxonomy is intended to be useful in the understanding of the current DT-based service offerings and design principles. In addition, the taxonomy has potential to be used as a practical tool for service providers in the development of new DT-based services.

1 Introduction

The new generation of information technologies (Internet of Things [IoT], Artificial Intelligence [AI], Cloud Computing [CC], Digital Twin [DT], Blockchain [BC], etc.) is driving to rapid advances in the digitalisation of society [1]. Consequently, more items, physical assets, processes and people are being digitized [2]. This phenomenon enables the emergence of new tools and perspectives to understand more comprehensively the complex systems that rule our reality, and facilitates the emergence of a new service-oriented era.

The service industry continues expanding rapidly and comprises a significant portion of both gross domestic product and employment in developed economies [3]. This increasing growth of services is empowered by the servitization phenomenon, that has given rise to good-oriented companies offering services [4,5]. Nonetheless, this transition is not always successful, leading to a situation known as the "service paradox", where the investment in the creation of new services does not bring the expected benefits [6]. Although this "paradox" also applies to digital services [7], some scholars defend that those services enabled by simulations, as it is the case of DT-based services, can deal better with service variability, which is one of the challenges of servitization [8,9].

In the service research field, the coming of digital services in the first decade of the 2000s demanded research around service design processes and the more suitable modes to be offered to users [11]. Nowadays, the arrival of new and more complex services enabled by this new generation of information technologies is requiring an additional research effort in this area [12]. In particular, questions around how to integrate physical, digital and social elements in the design of new service offerings [13], or how to identify the value models and pricing these new services. Beside these questions, there is also a gap in the understanding of the potential of DT as an enabler for new services offerings, as well as the factors that modulate the design and development of services enabled by DT [14].

Therefore, it is noteworthy that more research in DT-based services is needed to better understand and guide the use of DT in service propositions. As a result, this research in progress intends to accomplish a double objective. First, to portray emergent DT-based services that are already being offered and identify key dimensions and characteristics to understand and classify them. Second, to contribute to the better design and development of new services enabled by DTs.

In achieving these objectives, we review the literature and use cases to configure a taxonomy of DT-based services where service offerings can be classified and differentiated. Classification in emergent research areas is frequently seen as a requirement for the scientific process [15]. Due to the dynamic nature of these new services, we try to identify

https://doi.org/10.1049/icp.2023.2578

components that transcend specific cases and capture the core characteristics of these new services.

The rest of the paper is organised as follows. In order to contextualise the research topic, a theoretical background covering the resource integration process in DT-based services, the role of DTs as a service enabler, and the current role of these services is presented. Later, the methodology is described, justifying the steps being taken in this research work. Finally, some preliminary findings are reported, and brief conclusion is drawn.

2. Theoretical Background

DT-based services and resource integration processes
Service-dominant logic (SDL) conceptualises a multi-actor value creation process where the integration of resources plays a crucial role [16, 17]. This integration of resources comprises interaction, cooperation and collaboration among the actors involved in the creation of value and organisations coordinate how resources are integrated [18].

Technology has been understood as both operand (tangible enabler) and operant (intangible skill) resource [19]. Digitalisation is transforming equipment and assets traditionally seen as operand into operant resources that allow actors to increase new ways of resource integration [16]. However, this phenomenon also increases the complexity of resource integration, particularly in ecosystems [20]. In this context, a DT, understood as a digital replica of an object in the physical world created by combining data from different sources to replicate processes in and collect data to predict how they will perform across different scenarios [21], can be seen as a combination of operand resource (physical-digital enabler) and operant resource (data-driven knowledge) [22]. Hence, sophistication in service offerings based on DTs increases.

DT as a service enabler
Due to the servitization phenomenon, there is an increasing trend, particularly among manufacturers, to provide *advanced services* that are performance-based.[23]. These cutting-edge services illustrate how products evolve into a vehicle for delivering value via services. In this shift, the service provider, who is also the owner of the physical asset, bears the production costs and risks. This makes the service provider's product evaluation and operations very delicate [22]. In this context, DT emerges as a very beneficial technology for servitized companies.

Therefore, DT can be used to improve and optimise the performance of physical assets being used to provide a performance-based service. And on the other hand, firms can use DT to improve their value propositions and better understand the demands of other actors in the service ecosystem [22,24].

DT-based service offerings
Nowadays, DT is mainly focused on operational efficiency and, consequently, academic research mostly shows DT as a technology to enhance productivity, reduce costs, and improve the services that are currently offered. Nevertheless, DT could be a cornerstone on how different actors (companies, operators, clients, users, etc) co-create value in a service ecosystem generated by the integration of DTs [25] and the creation of an ecosystem of 'connected DTs' [26].

Thus far, companies using DT continue putting emphasis on operational efficiency and internal processes, which points out the presence of business-improvement mindset rather than a business-opportunity approach [27]. Therefore, the research setting outlined above motivates this research that aims to identify traits and characteristics of DT-based services with the ultimate goal to shed light on the opportunities of DT as a service enabler and help organisations in better comprehending the advantages that DT provides in service offering.

3 Methodology

In this research, we are adopting a three-step methodology for the for taxonomy development; literature review, taxonomy development and taxonomy evaluation [28].Taxonomies are classification schemes based on dimensions and characteristics that allow researchers and practitioners to structure, analyse and better comprehend a determined field [29, 30]. Hence, the development of a taxonomy of DT-based services is pertinent research output in the study of a contemporary and modern phenomenon such as the role of DT in service offerings, where little theoretical understanding of it has been published to date.

Building a taxonomy requires observation to realise that a feature of an aspect in an entity differs from the same aspect of another entity. Taxonomies can be seen as a first step to develop rigorous theory [11]. If the dimensions and categories are developed effectively, taxonomies aid researchers and practitioners in differentiating between entities and their properties [11].

As this is an ongoing research, solely the first step of our proposed method has been already completed. In this first phase we conducted a review of the literature that connects DT, services, business models and value creation. In addition to the academic literature review, we increased our database by identifying grey literature and use cases to understand more precisely how DT are used by real organisations in the provision of services.. In a second phase of this research, we will cross-check the initial results of our taxonomy with experts from different industrial sectors with experience in DT implementation with the object to refine and validate our taxonomy.

4 Early Results

To date, as a result of an extensive literature review, our taxonomy of DT-based services comprises 4 dimensions and 20 characteristics (Table 1). In the following, we describe the key dimensions and main characteristics that have been

identified after the iterative process of observation and analysis.

Service recipient
The people or organisations who receive or benefit from a service offered are known as service recipients. The recipient of a service is a critical component in service design as recipient's needs and preferences determine features of the service in order to satisfy and provide the expected value [31]. This dimension leads to service differentiation and customisation processes. In DT-based services, we identified four different types of recipients; Internal customer, who are recipients of services aiming to meet the needs from internal processes and operations; external organisations, the case of service providers operating in the B2B sphere; public authority, when the recipient is the government or any other public organism; and end-users, when service providers operate B2C.

TAXONOMY OF DT-BASED SERVICES	
DIMENSIONS	**CHARACTERISTICS**
I. SERVICE RECIPIENT	▪ Internal Customer ▪ External Business/ Organisations (B2B) ▪ Public Authority ▪ End-users (B2C)
II. SERVICE TARGETED-OPERAND RESOURCE	▪ Physical Asset / Product ▪ Process ▪ System / Network ▪ Event
III. SERVICE VALUE PROPOSITION	▪ DT-based Design ▪ DT-based Planning ▪ DT-based Optimisation ▪ DT-based Resource / Energy reduction ▪ DT-based Monitoring / Control ▪ DT-based Security / Safety / Risk Management ▪ DT-based Research / Insights ▪ DT-based Health care ▪ DT-based Entertainment
IV. SERVICE PRICING MODEL	▪ Subscription-based ▪ Performance-based ▪ Value-based

Table 1: Taxonomy of DT-based services (Self-elaborated)

Service targeted-operand resource
Operand resources in service offerings refer to resources required by a service to operate and produce the expected output [32]. DT-based services use digital replicas as their main operand resource. The targeted-operand resource is a paramount factor in DT-enabled services, as the nature and level of accuracy of the digital replica influence decisively the input data needed for the service operation and determine the ability of the service provider to enhance service performance, increase flexibility, and support future service integration. Four different characteristics of this dimension have been identified, which correspond to the categories of physical entity that the DT represents; physical asset (product, equipment, building, human organ, etc.), process, system or network (supply chain, complex systems, etc.) and event.

Service value proposition
The value proposition defines what makes the service offering valuable and different, and what needs and expectations the service is aiming to meet. The service value proposition is a critical element in the service offering, and it comprises the key benefits the service provides to the target recipients [33]. The nature of value propositions in DT-based services is increasing and broadening the horizon beyond efficiency gains. In our taxonomy, we identified nine main areas where providers of DT-based services enclose their value propositions: design, planning, optimisation, resource / energy reduction, monitoring / control, security / safety / risk management, exploration / research, health care and entertainment.

Service pricing model
The pricing model is identified as an important differentiator in DT-based services. The service pricing framework determines how the service provider charges the service recipients for the use of the service [34]. The selection of the pricing model may depend on the nature of the service, the value proposition, the target customer, and the competitiveness of the market [35]. In DT-based services, pricing models are usually subscription-based, outcome-based, or value-based revenue models [36].

5 Conclusion

For many organisations, unleashing the potential of DT in service offerings remains unclear. Given the context described in our research background, it seems increasingly important to pay more attention to the role that DT may play in the design and deployment of new services. In addressing this gap, this research project is developing a taxonomy of DT-based services to categorise and classify the different DT-enabled service offerings and contribute to an increased understanding of the design principles of DT-based services. The final results of this study should provide a framework for organisations to design better and more efficient DT-based services, and they may also serve as a starting point for the continued refinement of this proposed taxonomy by future researchers.

6 Acknowledgments

This paper is outcome of Eleni Papadonikolaki's Fellowship that was supported by the Royal Academy of Engineering under The Leverhulme Trust Research Fellowships programme 2022-2023 (6642415).

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