A Research Framework to Study how Digital Service Innovation Transforms Value Networks

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Abstract. This paper reports from preparations in an ongoing research study concerning how digital service innovation transforms value networks in manufacturing industries. The research study is in the context of the vehicle industry and concerns digital e-maintenance services based on remote diagnostics systems. This digital service innovation in particular is of great importance since manufacturing industries have great potential to expand their business and found new and extended boundaries and relationships with other stakeholder in a network they are attached to. Core challenges and opportunities for digital service innovation will lead us to the study of its influence on the business and innovation environment i.e. the value network. This paper presents a framework to study how digital service innovation transforms value networks based on literature reviews on value network, digital innovation and transformation of value networks.

Keywords: value network, digital innovation, digital service innovation, remote diagnostics system

1 Introduction

Innovations in the digital age are rapidly transforming the landscape for contemporary business and the ways to represent these through related networks. Advancements in digital computing, web 2.0, digital convergence and other digital technologies are modifying business and organizations, and disrupting their traditional boundaries and models associated with them [1][2][3][4]. For example, in innovation such as global broadband, mobile infrastructures, electronic patient record system, YouTube videos, e-newspaper, and pervasive use of RFID chips, digital technology is the chief source of innovations. Such digital innovation is transforming the traditional business to e-business, for example, it gives rise to e-maintenance from traditional maintenance, e-manufacturing from traditional manufacturing [5]. In other words, trends of digital service innovation based on digitalized products and the associated opportunities and challenges open new areas of research [6].

As a result of this development, traditional production business such as manufacturing, the physical artifacts are now being intertwined with digital components that provide them digital capabilities. Inspired by this digital convergence of applications, devices, networks and artifacts present both challenges and opportunities for industries [6][2]. The digitalization of equipment is transforming industries from manufacturing to service industries. One example is the transformation of the vehicle industry where new opportunities for digital innovation such as e-maintenance based on remote diagnostics systems are emerging [7].

Digital innovation includes not only a shift in technology but also change in existing relationships within industrial business and with markets. This ultimately forces businesses into new competition which depends upon how it adds value and challenges present market know-how [8]. The addition of value (both digital and non-digital) of is perceived through value network which is then realized through a business model [9]. The value in network is shown with the help of network of relationship which has key role in the innovation process for outsourcing of technology, knowledge etc. [10]. For example, network of external stakeholders is important source of innovation [11].

Digital service innovation triggered by advancement in digital technology or potential service innovation such as e-maintenance services cause change in structures of value network overtime. It may cause migration of innovation to new networks, and new technological paradigms may cause the emergence of new value networks [9]. For example, digital service innovations may be adopted with the result of new emergent but still interconnected value networks [12]. A single innovation may trigger wakes of overlapped and interacted innovations, hence may play the part of as the initial conditions of another innovation process [10]. For example, in digital services innovation remote diagnostics system is one of the pre or initial conditions for providing e-maintenance services. However, the individual business interest and technological frame with different meanings and conflicting interests of different actors leads to distributed digital innovation which is characterized by uncertainty and ambiguity [13][14].

This transformation of modern economy to service economy is mostly enabled and dependant on digitalization of products. The topic has not a long history in Information System research but it is gaining much attention. For example, IFIP working Group 8.2 conference was dedicated to 'IT in service economy', ECIS (2011)[1] conference is dedicated to ICT and Sustainable Service Development, DESRIST (2011)[2] will focus on Service-oriented perspectives in Design Science Research, MIS Quarterly (2011)[3] will publish a special issue on 'Service Innovation in the Digital Age' and The Journal of Strategic Information Systems (2011) will also publish a special issue on 'Service Management & Engineering: Aligning Business & IT Services'. Moreover, recent research work has shown that digital innovation transform value network. For example, Åkesson [12] studied the influence of digital innovation on value network in Newspaper industry and showed the multi-layered, dynamic, dialectic and diametrical character of value network in digital innovation; Yoo et al., [2][3] have studied the characteristics, dimensions etc. of digital innovation while working on AEC[4] and camera evolution case; Selander et al. [15] extend existing innovation theory and propose a process model for transforming ecosystem relationships in digital innovation. Moreover, Kuschel [7] explains a general trend in vehicle industry which addresses extended equipment functionalities instead of consumers' use of vehicle. However, service innovation in the digital age or IT services are broad terms and capturing variety of services in different areas. The vehicle industry constitutes an area where digitization contributes to an increase in services as opposed to traditional product focus. Thus, a research challenge is to understand the process by which existing value networks in manufacturing industries transform in digital service innovation by attending to their individual characteristics which will be the specific interest for this research.

The aim of this paper is to suggest an framework to address this research challenge based on a literature review of value networks, digital service innovation and e-maintenance. This framework will be applied in a research project endeavoring digital service innovation for e-maintenance based on remote diagnostics system within vehicle industry. Remote diagnostics system refers to a system that is used to provide different types of digital services such as preventive as well as predictive or condition-based maintenance. The system associated with this project will offer these types of services by identifying and detecting (diagnosis) faults and errors. The vehicle firm has ambitions to expand their business with services which will require transformation of their value network and the associated relationships, value creating process and exchanges.

This introduction section is followed by a literature review. This literature review includes description about value network, innovation of services in the digital age and transformation trends due to technology in the networks. This is followed by a research framework to study the transformation process which is coupled with the concluding remarks and future work in the end.

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[1] http://project.hkkk.fi/ecis2011/

[2] http://desrist.org/

[3] http://www.misq.org/

[4] AEC = Architecture, Engineering and Construction

2 Literature Review

The section brings about a review of literature on value networks, digital service innovation and transformation of value networks driven by digital innovation. This will provide the basis to study the transformation of such innovation on value networks. The digital innovation literature serves as a background to establish and describe digital service innovation and its impact on value networks through the lens of digital service innovation based on remote diagnostics systems.
The literature review is done by looking for the material about a value network in general and the elements that constitute it. Further study was aimed at the literature related to service innovation enabled by digitization of the physical products. Finally, the material about 'how transformation occurs in such an environment' is studied.

2.1 Value Network

A Value network in general is "Any set of roles and interactions in which people engage in both tangible and intangible exchanges to achieve economic or social good" [16]. It is categorized as internal-facing value networks, that is, within organizations and external-facing, that is, value networks among organizations and its suppliers, investors etc. [16]. Value networks have been recognized as having a key role in innovation process which spans from the practice of inventing to the process of realizing value, and adoption by the community [12]. This practice of inventing is visualized by an innovation network and, realization and adoption by community is effectuated by a value network [17].
A *value network* creates value through complex and dynamic exchanges of three entities called value currencies: goods, services, and revenue; knowledge; and intangible benefits [18][19]. Knowledge values, now, are also considered as a part of intangible values instead of a separate currency value [16]. According to Allee [16][18][19] roles/actors are the main focus for dynamicity and innovation rather than processes in a value network and intangible values are of equal importance as revenue exchanges. For instance, a vehicle company itself can be understood as a value network and it may offer knowledge about the health status of a particular vehicle to its customers as an intangible value currency in the value network.
The relationships are the medium or mechanisms to exchange values. The relations in the value network are linked by the business model defining the value creation process from which the different actors capture value [11]. The business model is the architectural configuration of the components of transactions needed to realized business value and related to a focal actor – an actor who organizes and has the strongest incentive [20]. From the focal actor's point of view links among organizations, customers, suppliers etc. are known. This includes identification of customer segments and structures for value creation and value capture [17] meaning that different organizations have different business models within the same value network. For example, a service providing company will have one business model for providing health status for an individual vehicle while a parts/vehicle manufacturing company will have another although they co-create value within the same value network. Even referring to a particular focal actor, its impact spans organizational

boundaries [20] showing the tight coupling behaviour of digitized products as mentioned in [2]. These business models align network members to realized value targeting a defined customer base [17]. The value networks shapes the roles in the value creating process [9] and thus value is dependant on how the value network is designed and vice versa [17].
The nature of a value network consists of: value network interrelationships [12]; being multilayered and interconnected system of networks [9]; and innovation paths [21]. For example, vehicle related company may be the part of the value network containing vehicle manufacturing, of the vehicle service providers, vehicle parts manufacturing etc. companies. The value networks surrounding these businesses are not the same since they are built on different relations, exchanges and business models yet they are interwoven and interconnected on different levels and hence innovation paths within each have influence on the others.
In Table 1 below the concepts of value networks is summarized with guidance to the literature references.

Table 1. Summary of value network concepts

Concepts	References
Roles/Actors	Allee (2000a; b; 2008); Åkesson (2009); Biem and Caswell (2008)
Relationships/Medium or mechanism of exchange	Allee (2000a; b; 2008); Chesbrough and Rosenbloom (2002); Biem and Caswell (2008); Amit and Zott 2001, Chesbrough et al., 2006
Values (Tangibles and Intangibles)	Allee (2000a; b; 2008); Christensen and Rosenbloom (1995); Chesbrough and Rosenbloom (2002); Chesbrough et al., 2006; Biem and Caswell (2008);
Exchanges/Transactions/Activities	Allee (2000a; b; 2008); Åkesson (2009); Biem and Caswell (2008)
Nature of value network	Åkesson (2009); Henfridsson et al. (2009); Christensen and Rosenbloom (1995)

These concepts in Table 1 are useful in describing and modeling value networks. For example, e3 value modeling, c3 value modeling, Verna Allee's value network modeling and network-based value modeling [22]. Among these, some present value network as activity-oriented (e.g. Parolini's model) while others as actor/role-oriented (e.g. Allee's model). Moreover, some describe these networks as unmanageable (like ARA model) whereas others (like Gulati) assert that networks are manageable [22]. Describing and modeling the existing value network is a departure point for understanding the transformation process brought by digital service innovation in manufacturing industries.

2.2 Digital Service Innovation

Digital innovation is defined as the realization of new combinations of digital and physical components to produce novel products, while the services enabled by such digitalization are called digital services and innovation in services is called digital service innovation [4]. Driven by advanced development of digital technology digital services differ from conventional services and inherit properties from digitalized products as well as from services in addition to some additional unknown properties, hence it posses the hybrid nature [1][3]. Drawing on this point, it is necessary to pipeline the underlying properties and concepts' discussion regarding digital innovation in order to study digital service innovation.

An important stimulus of digital innovation is the digitalization of previously non-digital artifacts (e.g. embedded system such as remote diagnostics system in vehicles). This digitalization of non-digital artifacts has undergone evolutionary waves. Yoo et al. [2][3] have identified three waves of digitalization and discussed them while studying digital innovation in case of AEC and camera evolution. According to them, the first wave of digitalization includes simply the technical digitization of analog contents and service into digital format without any basic changes in the industry. So the digital technology provides the same function as non-digital counterparts, with some additions and intelligence advantaging the reduction in cost. The distinct feature of second wave is the separation of digital devices, networks, services, and contents that were tightly coupled. This provides the shift in traditional boundaries across product categories and industries. In the final wave of digitalization, there is possibility to use mesh-up services that can be further re-combined creating incessant stream of new innovation possibilities for products, services, technologies etc. as can be seen in Google digital earth service. As digitalization continues, digital products are being equipped with increasingly diverse set of capabilities. Furthermore, small and powerful computing devices such as RFID chips now can be embedded into previously non-digital artifacts such as trucks, buses and other automobiles. Moreover, these digital capabilities allow digital artifacts to capture and transmit different types of information, and interact with other digital artifacts and services. This may lead to new business opportunities and models that may include information provider, information broker and service provider [23] which can then be shared in the value network [2][4].

The digitalization of non-digital products leads to an emergence of a generic model of digital technology architecture with four layers: devices, networks, services and contents [4]. The device layer is the bottom layer and deals with hardware and operating systems. Network layer manages logical transmission and physical transport while service layer provides application functionality that directly serves users during storage, manipulation, creation and consumption of contents. The top layer is called content layer and it contains data [2]. Because of continuous digitalization of earlier non-digital products and services, this four-layered architecture of digital technology has become more expansively applicable for all types of digitalized products [3]. Before digitalization, these four layers were tightly coupled together with a particular product boundary and in case of some purely mechanical products such as an automotive, these layers did not exist [3]. As a consequence of the digitalization, these four layers will be decoupled or loosely coupled to a greater extent [3].

These digitalized artifacts have different materiality properties that differentiate from their non-digital equivalents [24]. Yoo et al. [2] describe such seven properties as follows: First is programmability which means the ability to accept new set of instructions in order to modify its behavior, so digital artifacts become malleable. Second, addressability means the ability of each digitalized artifact to be identified uniquely within their context. The first two features together make digital products Internet of Things. Third, the senseability relates to the ability to sense and respond to its environment and makes them context-aware. Next is communicability which relates to the ability of sending and receiving any type of digitized message. Another property is memorizeability meaning the ability to record and store information. Then, the property of traceability refers the ability to chronologically identify, memorize and inter-relate events and entities in time. The last one is associability which is concerned with the ability of digitalized artifacts to be related to and identified as something along with other entities and inferring some future states and conditions.

Yoo et al., [3] have described three key design features of a digital technology that differentiate it from earlier technologies as: the re-programmability that relates to the ability of devices to be re-programmable enable separation of semiotic functional logic of device from physical embodiment; the homogenization of data which refers to the binary representation of data and together with emergence of new media separate the content from medium; and the self-reliance nature of digital technology means it requires the use of digital technology.

Further, Yoo et al., [4] introduced six new dimensions (convergence, digital materiality, heterogeneity, generativity, locus of innovation, pace) to innovation outcomes and processes due to the invasion of digital innovation. Convergence in this context means the combination and re-combination of devices, network, services and contents. Digital materiality refers to what it is that the digital capability does or what is its semiotic logic. Heterogeneity includes the combination of resources and components in wide and unforeseeable ways. Generativity is related to the direct quality of digital technology to allow indirect actors to create new forms of products, services, contents etc. while Locus of Innovation refers to make participation of distributed and previously non-connected actors into the innovation process affordable. Finally, pace means the rate at which change to ‘new’ is enabled within the digitized forms.

As described above, digital services are produced as the result of digitization of products. These services, in general, are characterized by remoteness, heterogeneity, on-going exchange of tangibles, seamless computing capabilities and materiality properties as described above [2][3] [4][25]. These characteristics are embedded due to the involvement of information and communication technologies, databases, and digitized products and so on.

The characteristics of digitization influence the quality and characteristics of digital services. For instance, digital services may take on the characteristics of products, such as storability and separation of production and consumption of services [25]. The use of digital technologies enables services to be automated the same way as the production of goods [7]. Yoo et al. [1] have presented a modular layered architecture to discuss the architecture of digital technology. They have discussed the involvement of heterogeneous actors for the design and production of novel components on layers

outside a firm's digital product platform i.e. outsourcing the part or complete layers to take competitors advantage. In the following instances, IT has either reduced or eliminated the direct involvement of service provider: self-services such as internet banking, remote customer order entry and follow-on customer service systems (e.g. operator surveillance system). Mobile products such as contemporary vehicles are embedded with sophisticated computing capabilities [21] which serve to optimize the uptime of the vehicle.
The advantage of using digitalized artifacts include new dimensions to service relationship as embedded sensors can become eye and ear of remote service provider [25][2] who can access real-time data and in turn can provide seamless services to customers.
In the Table 2 below the concepts relating to digital service innovation are summarized with reference to the literature:

Table 2. Summary of digital service innovation concepts

Concepts	**References**
Materiality properties of digital products (programmability, addressability, senseability, communicability, memorizability, traceability, associability)	Yoo et al., 2010a; c
Key features of digital innovation (re-programmability, homogenization of data, self-referential nature)	Yoo et al. (2010a;b;c)
Dimensions of digital innovation (convergence, digital materiality, generativity, heterogeneity, locus of innovation, pace)	Jonsson (2010); Yoo et al. (2010 c)

The three concepts i.e. characteristics, dimensions, and materiality properties of digital innovation form the departure point for understanding the driving force of value network transformation inherent in digital innovation.

2.3 Transformation of Value Network Driven by Digital Service Innovation

It is recognized in innovation literature that value networks are not static; they dynamically change over time [9]. With the advent in technology, digital service innovation may influence different processes such as supportive processes, relationship with stakeholders (e.g. customers, suppliers, and partners). Selander et al. [15] showed how relationship transformations are driven by tensions between collaborations and competing values in the telecom industry. As a result, value networks need to be reorganized to show changed relationships, value and exchanges that occur due to addition, deletion or modification of stakeholder roles. On a business level, this also offers several benefits like cost reduction, time efficient and high quality maintenance, increased in sales and new and challenging business opportunities which eventually lead to new revenue-generating business [25]. For

instance, digital services (i.e. services independent of time and place) effect business in manufacturing industry based on remote diagnostics systems. Some other advantages of digital innovation such as creating media-rich channel between companies and their customers have been illustrated in [18]. Allee [18] showed how a value network transforms by providing competitive advantage to customers through the introduction of internet technology. Change in number, type and relationship of actors is another example where digitization influences business and is related to change in value creation structure. However these changes are not one-directional. Åkesson [12] demonstrated in the Newspaper industry how value networks in digital innovation are in constant changing and parallel configurations. Digital innovation drives value networks in to divergent structures whereas stabilization in business drives value networks to convergent structures. This dialectical pattern has also been recognized in the telecom industry [15].

This transformation opens new area of research such as redesigning customer-service processes and redesign of existing value proposals [25]. Hence, more research is required on the impact of digital computing on value creation structures, value proposals and customer relations [25]. In particular, there is relatively little research in Information Systems contributing with an understanding of the process by which value networks are transformed in manufacturing industries expanding their businesses with service economy enabled by digital service innovation [26].

3 A Research Framework for Studying the Transformation Process of Value Networks

As mentioned in introduction section, this research framework will be applied in a three year research project in the vehicle industry. The partnering vehicle company is exploring the challenges and opportunities of digital service innovation based on disruptive digital artifacts. Moreover, they are interested in how it will transform the traditional business approach and existing value networks. To probe into the situation a framework is suggested with guiding research questions based on the literature review.

A preliminary perception about the influence is that the characteristics of digital service platform will influence value network, for example, digital service innovation in the manufacturing industry such as the vehicle industry expand the value network rather than squeezing it, introduce new customer bases, new collaboration and more co-operation. However, it is not known exactly today how this transformation process unfolds. The purposed framework will serve the dual-purpose *(i)* how digital service innovation transforms the value network's roles, relationships, value creation, value perception etc. and, *(ii)* the other way around, i.e. how value network helps to contribute in digital service innovation, as it is established fact that current value networks have already expanded the vision e.g. exchanges by considering both tangibles and intangibles. In Fig. 1 this relationship is described drawing on the concepts identified in the literature review.

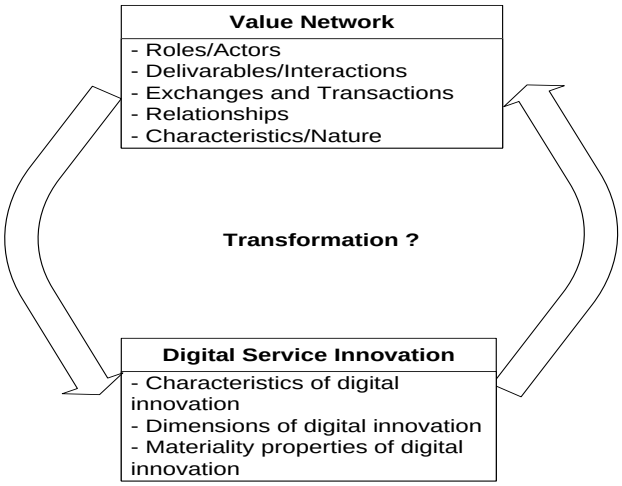

Fig. 1. Relationship between value network, digital innovation and transformation

This model serves an underlying assumption of the relationship in the transformation process addressed within the research. It shows the exploration between related main areas – value networks and digital service innovation based on remote diagnostics system.

The main question addressed in this paper is: what is the process by which existing value networks in manufacturing industries transform in digital service innovation? This research framework will serve as a frame for embarking a three year study. The research will start with describing the starting value network before the digital service innovation is initiated. In collaboration with the partnering vehicle company and its customers, a service innovation process will be initiated in exploring and co-creating services based on remote diagnostics technology under current development in the project. The process will be cantered on customer needs and how the technology can be adapted to enable value creating services addressing these needs. Potential value creating services will be implemented, tested and evaluated in real-life settings in large scale. During this process, the transformations of the value network will be observed. After implantation, the transformed value network will be described and analyzed against the starting point and the process observations. In addition, the configuration of the starting value network's influence on the digital innovation will be analyzed. The aim is to provide a process model that explains how digital innovation transforms value networks in manufacturing industries.

4 Concluding Remarks and Future Work

The research framework presented in this paper is a response to recent calls for research on the increased service oriented economy. We concur with [3] that the transformative power of digital technology accelerates and that one of the new centres of interest in IS research will relate to the role of digital innovation in future economy

and human enterprise. Therefore, we hope that the presented research framework can inspire researchers doing similar inquiries in other areas.
The context where the study is being applied provides possible limitations in the research context i.e. it will study the influences in particular to vehicle industry. Even so, our aim is that the results will be of value to understand the process of how digital innovation transforms value networks in manufacturing industries in general.

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