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Conceptual design framework for digital technology assisted service system

Kentaro Watanabe
kentaro.watanabe@aist.go.jp
National Institute of Advanced Industrial Science and Technology, 6-2-3 Kashiwanoha, Kashiwa, Chiba, 277-0882, JAPAN

Yusuke Kishita, Kaito Tsunetomo
kishita@pe.t.u-tokyo.ac.jp, tsunetomo@susdesign.t.u-tokyo.ac.jp
The University of Tokyo, 7-3-1, Hongo, Bunkyo-Ku, Tokyo 113-8656, JAPAN

Abstract

Digitalization is a strong enabler to increase the productivity of existing services and develop innovative services. Meanwhile, the ethical and societal concerns about the negative impact of digital technologies are also growing. In addition to the principles and guidelines for development and use of digital technologies, there is a need for a design methodology to integrate them in services in a harmonized manner.

In this study, we suggest a conceptual design framework for digital technology assisted service systems (DSS). This framework is based on several theoretical foundations including service system design, scenario design, value sensitive design and institutional theory. Our framework illustrates DSS with four layers (value, actor, digital and institution) and its transition in order to clarify required design elements for socially-conscious development and integration of digital technologies.

Keywords: digitalization, service system design, social and ethical concern

Introduction

Digitalization has become a global phenomenon. Recent digital technologies such as Internet of Things (IoT), bigdata analysis and social robotics are becoming more applicable to various types of services compared to traditional ICT. There have already been a number of application cases of digital technologies in the field of mobility, healthcare, tourism and hospitality services. They are expected to increase service productivity and create new types of services.

Meanwhile, the ethical and societal concerns about the application of digital technologies are also growing (Winfield & Jirotka, 2018). Issues such as human autonomy, privacy and bias are being discussed by policy makers, nonprofit organizations (NPOs) and scholars from multiple perspectives such as technology ethics, sociology, psychology and informatics. Various principles and guidelines for the development and use of digital technologies, especially machine-learning based Artificial Intelligence (AI), big data and social robots are proposed (Whittlestone et al., 2019).

Compared to the aforementioned research communities, there are fewer discussions from design research on this matter. While general principles and guidelines regulating the development and use of digital technologies are important, these technologies need to be embodied in a specific context, which requires a methodological investigation on how to harmonize digital technologies in the context (Morley et al., 2019). In particular, the impact of digital technologies can reach multiple stakeholders. The multi-actor consideration is an issue which is often addressed in the research on service system design (Spohrer & Kwan, 2009). Some researchers of service science and service system design have already discussed how to implement digital technologies in service systems (Medina-Borja, 2015; Pekkala & Spohrer, 2019). However, the consideration of social and ethical impact of digital technologies therein is still an emerging issue.

In this study, we propose a conceptual framework for designing digital technology-assisted service system (DSS) in a socially-conscious manner. This framework includes four layers, specifically focusing on the wide and long-term impact of digital technologies implemented in a service system.

In the next section, we overview the discussion on the social impact of digital technologies. Then we illustrate the research challenges in DSS design and theoretical foundation to tackle them. Based on this, we propose a framework and discuss its potential for future study.

Social and Ethical Concerns toward Digital Technology

Rapidly evolving digital technologies, especially machine learning-based AI and social robotics, are attracting more attention about its potential usages and threats. Filter bubbles (Pariser, 2011) and data biases in machine learning are concrete examples of concerned issues in Internet services. The malicious use of robots, such as killer robots is another example. AI ethicists specifically warn about the threat of autonomous intelligent agents, which might become harmful beyond the human control (Dignum, 2017).

In response to the growing needs for actions toward evolving technologies, active discussion is being conducted about how to guide and regulate the development and use of such technologies. Various types of principles and guidelines for development and use of digital technologies have already been proposed. One of the most famous principles is the Asilomar principles for AI (Future of Life Institute, 2019). National governments, international organizations like UNESCO, NGOs and academic societies such as IEEE and JSAI have already announced their own principles and guidelines. In addition to the aforementioned principles, concrete methods and mechanisms for regulation and governance are also being proposed. For example, the check list to clarify the trustworthiness of AI services has been proposed (Arnold et al., 2019). A third party certification to verify the trustworthiness is another idea being considered (Davenport, 2018). Several policies for the social implementation of digital technologies have also been discussed (Winfield & Jirotka, 2018).

Design Challenge and Theoretical Foundation

When we consider actual development and integration of digital technologies, most of the discussion about AI principles is highly conceptual (Whittlestone et al. 2019), and rarely takes care of actual situations of technology use. While we consider general principles and

guidelines important, it is necessary to investigate how to contextualize digital technologies in an actual use setting. We consider that this is an issue worth tackling in the field of design research.

Several scholars on service systems (Watanabe & Mochimaru, 2017; Barile et al., 2019) emphasize a human-centered view in the design of digital technology, the role of which is assistive for value creation among actors, irrespective of whether the technology is autonomous or not. Based on the concept of technology-assisted service system (Watanabe & Mochimaru, 2017), we study a design methodology of digital technology-assisted service system (DSS) (Watanabe et al., 2020). In order to better understand the positive and negative impacts of introducing digital technologies to the service system, DSS contains four aspects to be considered in design, which are: 1) multi-actor interaction; 2) diverse value; 3) long-term influence and 4) institutional difference as shown in Figure 1. Below, we introduce corresponding theoretical foundations to tackle these ideas.

1) Multi-actor interaction

Unlike the traditional Human-Computer Interaction, the impact of current digital technology is not limited to dyadic relations. The interactions with technology occur among multiple actors, directly with physical interactions or indirectly through data transactions. Therefore, multi-actor perspective is a key. The concept of service system, in which multiple stakeholders interact to create value is a suitable framework to capture the role of digital technology in multi-stakeholder interactions (Spohrer & Kwan, 2009; Watanabe & Mochimaru, 2017). The development and use of digital technologies is also an important topic in service system design as emphasized in the research on smart service systems (Medina-Borja, 2015) and concrete design methods have been also proposed (Pekkala & Spohrer, 2019). This can be an effective approach to illustrate the adequate role of digital technology among stakeholders.

2) Diverse values

The social impact of digital technologies has not been widely discussed in the existing service system design research. However, concerning the assessment of service systems, there have been several methods. For example, Shimomura et al. (2003) proposed a modelling scheme to

represent the influence of services with parameters of the service receiver's state. Using this method, diverse influences of multiple actors are represented, though it does not focus on digital technologies and their impacts. In the innovation research, multi-actor, multi-criteria framework is effective for multi-faceted assessment of service systems (Hyytinen, 2017). However, this has not been directly connected to design processes. The other relevant study is Value Sensitive Design (VSD) (Friedman et al., 2013). This approach focuses on stakeholders' values, especially social values in ICT design. This approach is considered as an effective approach in the research on AI and ethics (Stahl & Wright, 2018). This will also be the basis of this study.

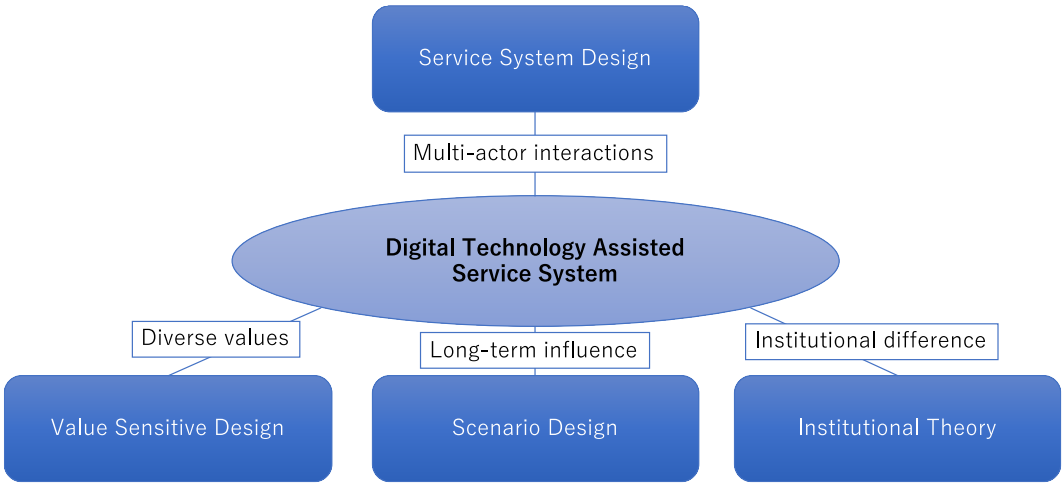

Figure 1: Theoretical foundations for the design of DSS

3) Long-term influence

Another aspect to be considered is the long-term influence of digital technology and its evolution. Service system evolves through the continuous use and dissemination of digital technology (Watanabe & Mochimaru, 2017), and its impact also changes. The design approach needs to adapt to this evolution process, which has not been tackled by existing studies. Scenario design is a relevant approach to this issue (Kishita et al., 2017). For example, a forecasting approach is effective to understand how digital technology will be accepted in the service system

of the future. By integrating such an approach, the development and integration of digital technology can be adaptable to the evolution process.

4) Institutional difference

The acceptance of technology and values for actors to be cared about depends on institution including norm, rules, regulation, policy and culture. Institution also affects human behavior. Institutional theory clarifies the features and categorization of institution and its impact in organizational behaviors (Scott, 2013). This has been applied to the service system concept also (Vargo & Lusch, 2011). The existing research exemplifies how the same digital technology is accepted in a different way in other countries (Watanabe & Niemelä, 2019). Institutional difference is an important factor especially when disseminating digital technologies internationally.

Four-Layer Model

In this paper, we propose a four-layer model as a conceptual design framework of DSS. The layers of DSS in Figure 2 include value layer, actor layer, digital layer and institution layer.

1) Value layer

Value layer consists of values for actors. The definition of value here is “what a person or group of people consider important in life” based on VSD research (Friedman et al., 2013).

In this model, social and ethical values are described as comparable with the other types of values, such as functional, psychological and financial values. This does not mean that social values are trivialized, but rather are considered as a directive element in combination with other values. Both positive and negative values are represented in this layer. In the design process, values in the layer are compared to evaluate how the service system affects actors therein. In addition, what kind of values actors have is affected by the institution layer.

2) Actor layer

Actor layer represents multiple actors interacting with each other. Their interactions are also represented in this layer. The interactions are mostly physical, but financial and emotional transactions are also described. Digital technology is represented in two ways in actor layer. One is to represent it as an independent entity interacting with actors. The other is to represent it as a part of an actor cooperating in DSS. Actors are correlated to values in the value layer, describing the influence of interactions. Actors also belong to a certain institution which influences actors' behavior and their values.

3) Digital layer

Digital layer represents data flow and operation among digital technologies allocated in the actor layer. Digital technology is described as a digital entity corresponding to the actor layer. This entity collects data from actor layer, processes data, transacts with another entity, and triggers actions in the actor layer.

4) Institution layer

Institution layer includes institutions affecting actors and their values. As discussed above, different types of institutions such as normative, regulatory, and cultural institutions are included (Scott, 2013). Institutions in DSS are the underlying factors for actors' behavior and their value. With the exception of some of regulatory institutions such as local rules and policies, institutions act as the presumption for DSS design. However, normative and cultural institutions may also change through the transition of DSS, as discussed later. Therefore, the long-term evolution process of DSS needs to be designed in consideration of changing institutions.

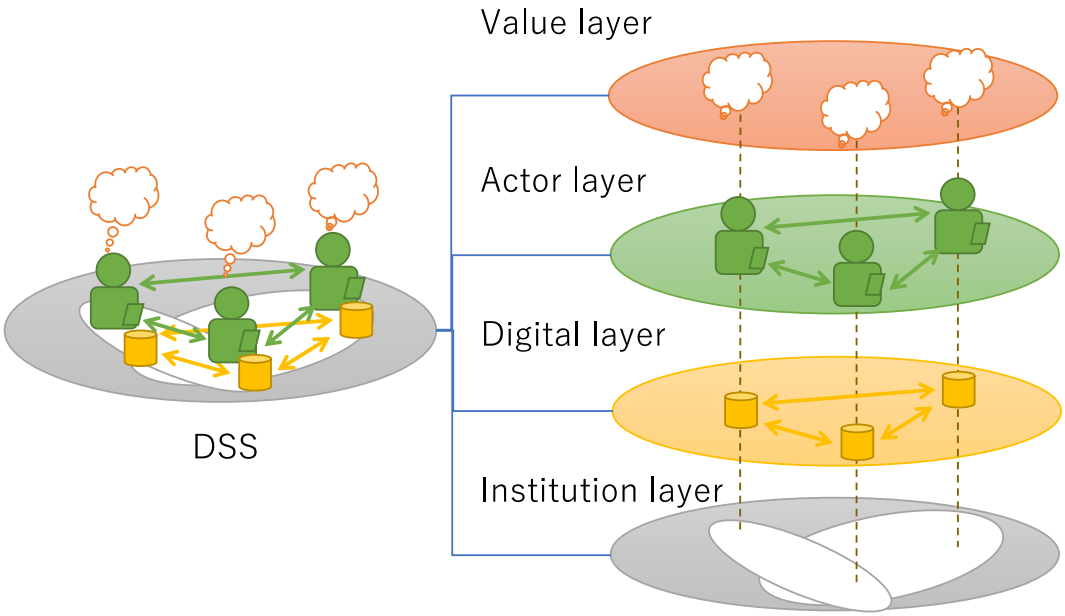

Figure 2: Four-layer model

Layer	Value	Actor	Digital	Institution
Element	Value (functional, social , ethical, financial, psychological, etc.)	Human - Individual - Organization Technology (physical) - Independent - Dependent Interaction - Human-human - Human-technology	Technology (digital) Interaction - Technology-technology (digital)	Institution - Norm - Rule/regulation - Culture/ custom/habit

Figure 3: DSS elements in the model

Moreover, when a certain DSS is applied to a different country for example, DSS should be adapted to its local institution. Institution is specifically important for internationalization of DSS (Watanabe & Niemelä, 2019).

Figure 3 shows the structural relations among elements in the four-layer model. Elements are mutually correlated not only within each layer but

also across layers. How to rearrange correlated elements, especially in alignment with values and institutions, is a fundamental challenge in DSS design. A home-monitoring service using a social robot is a good illustrative example. A social robot brings comfort for its user through affective interactions. However, when implementing a monitoring function, an ethical dilemma among values such as safety and privacy could arise. This also relates to family culture such as the social expectation for children to take care of their older parents. The balance between values needs to be considered, taking such an institution into account, and then the composition of actors and digital devices should be configured.

Transition of DSS

In describing the evolutionary process of DSS, we adopt the concept of ‘transition’ between DSS models as shown in Figure 4. DSS is dynamic in nature and unintentionally changes. However, our intention is to plan and guide the transition of DSS towards a desirable future by the design approach. Drivers and inhibitors which are derived from the change in DSS affect the transition and its speed. For example, if the value for a certain actor may become worse through the transition, it will be an inhibitor of the transition. Big change in actors’ interactions can also become an inhibitor because of actors’ status quo bias. Institution is another factor affecting transitions. Based on these factors, the transition process should be designed to increase drivers and decrease inhibitors for a desirable DSS. A scenario design approach will be applicable. For example, a backcasting approach to create future vision will be applicable to design DSS after transition. It is important to develop a transition plan based on the scenario.

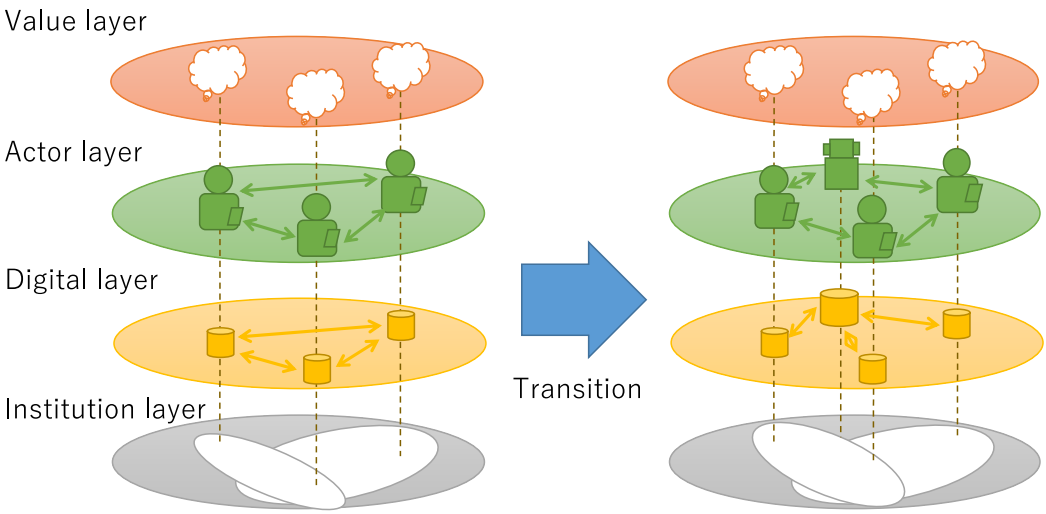

Figure 4: Transition of DSS

Concluding Remarks toward the Design of DSS

In this paper, we proposed a conceptual design framework for DSS aiming at the socially-conscious development and integration of digital technologies for value creation. Considering the characteristics of digital technology and its evolution, we illustrate the features of design for DSS including multi-actor interaction, diverse value, long-term influence and institutional difference. The proposed framework with four layers and transition covers these features based on the corresponding theoretical foundations. This framework provides a basic structure to develop a concrete design methodology for DSS.

Based on the proposed framework, several research topics are being studied (Watanabe et al., 2020). Firstly, a modelling method of DSS is under development. This method represents elements and relations of DSS to analyze and develop it. In addition to the four layers, the transition plan also needs to be formalized. Secondly, the design process is being developed as an iterative process specifically focusing on values of actors. This process should correlate to the modelling method to clarify required information for DSS design. In addition, the design process should be continuously applied to promote the evolution of DSS. Finally, the assessment method should also be concretized based on the proposed framework. Value is an important factor for the assessment of DSS. The

comparison of DSSs before and after transition will be a basic approach. How to assess the transition process should also be considered.

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