MODELLING RESOURCE CONFIGURATIONS IN ICT-ENABLED SERVICE SYSTEMS

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Abstract

Telehealth, the use of information and communications technologies (ICTs) to support care delivery at a distance, is increasingly used in health systems worldwide. A service system is defined as a configuration of people, technologies, and other resources that interact with other service systems to create mutual value. Adopting a service system perspective thus allows understanding a telehealth service as an ICT-enabled service system.

Adequately configuring resources, both tangible (e.g., hardware) and intangible (e.g., knowledge), is key to co-creating value through service systems. However, existing service system engineering methods and tools are not yet able to comprehensively capture the nature, role, and status of resources within service systems. In particular, while conceptual modelling is recognized as an excellent tool of understanding, designing, and monitoring for service engineering, existing conceptual modelling notations have limited abilities to express configurations of resources.

In order to address this gap, the following research objectives are proposed: 1) Develop a conceptual framework of resource configurations as the basis for further developing a metamodel of resource configurations; 2) Develop a metamodel of resource configurations in ICT-enabled service systems that can formally express the constructs, relationships, and constraints within the domain of resource configurations; 3) Demonstrate and evaluate the metamodel by conducting a multiple-case study in the field of telehealth. This study will focus on telehealth as a representative instance of ICT-enabled service systems.

The research design is guided by the Design Science Research Methodology (DSRM). DSRM provides a well-structured process for developing and evaluating information systems artifacts, such as the proposed metamodel, that can solve practical problems while contributing to a knowledge base. A multiple-case study of telehealth services at a Canadian hospital will support the evaluation and refinement of the metamodel.

The results of this research project include both conceptual and practical contributions. The metamodel of resource configurations derived from the reviewed literature and conceptual framework will provide a formal understanding of resource configurations in ICT-enabled service systems. The metamodel may also be adopted as a tool for professionals to capture and analyze resource configurations in the domain of ICT-enabled services such as telehealth.

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1. Introduction

Telehealth is a promising and efficient delivery model in health care. By adopting the service systems perspective, telehealth services are considered representative instances of ICT-enabled service systems. Although the existing research implies that successfully configuring resources is a key factor for realizing value co-creation in service systems, the concept of resource configuration has not been formally defined or expressed in a conceptual manner. This thesis attempts to address the two issues, and this chapter highlights the research background, research gap, research question and objectives, research methodology, and research contributions.

1.1 Research background

Services, whether understood to be sectors or activities, have enormous economic importance and are the fundamental basis of economic exchange (Vargo and Lusch 2004). Services contribute significantly to economic growth worldwide. For instance, services represent approximately 80 percent of the U.S. GDP and a growing percentage of the GDPs of countries around the world (Bitner, Ostrom et al. 2008). Management consulting, IT outsourcing, and health care are some typical service sectors which heavily rely on service activities to provide their final offerings (Muller and Doloreux 2009). Introducing new types of services to extant service sectors or non-service sectors can improve the productivities of those sectors (Strambach 2001). For instance, telehealth as a new health care service delivery model has enhanced the capacities and competitiveness of health care by innovatively combining knowledge, technologies and other resources as high-value unified solutions to fulfill the patients' needs (Cason, Hartmann et al. 2013, Youssef 2014, Tuckson, Edmunds et al. 2017).

A reassessment of concepts such as value, value creation, and resources, has led to a significant interpretation of the concept of service as the application of competences such as knowledge and skills by one entity for the benefit of another (Vargo and Lusch 2004, Vargo and Lusch 2008). This definition implies that service providers can only offer value propositions to service beneficiaries within service activities, and that value can only be co-created after value propositions are accepted by the service beneficiaries within service activities (Vargo, Maglio, & Akaka, 2008). Thus, service involves at least two entities that co-create value and determine benefit (Maglio, Vargo et al. 2009).

These interacting entities can be considered service systems by adopting a system perspective (Maglio, Vargo et al. 2009, Böhmann, Leimeister et al. 2014). A service system is defined as "a configuration of people, technologies, and other resources that interact with other service systems to create mutual value." (Maglio et al., 2009, p. 395). Service systems provide a useful abstraction from which we can better view, understand, analyze and design a service.

Along with the development and application of Information and communication technologies (ICTs), ICTs play an important role in conducting some new types of services, such as telehealth. A particular arrangement of ICTs and other resources is crucial form realizing value co-creation. For instance, when a doctor provides mental health counselling through video conferencing, the conducted service can be viewed as an arrangement of resources (e.g. psychological knowledge, ICTs, and assessment questionnaires) connected to a patient by value propositions to co-improve the patient's condition (Spohrer, Maglio et al. 2007, Spohrer and Maglio 2008). Thus, by adopting the service system perspective, a service, in which the interactions among service actors heavily rely on ICTs, can be viewed as ICT-enabled service systems. ICT-enabled service systems emphasize utilizing information and communication technologies to facilitate value co-creation in service systems (Tuunanen, Myers et al. 2010). Telehealth can be viewed as a representative example of ICT-enabled service systems. The traditional requirements engineering for ICT systems mainly focus on modelling and analyzing the composition and interaction of hardware and software components (Bryl, Giorgini et al. 2009). However, ICT-enabled service systems are socio-technical systems, and thus require an approach that emphasizes the composition and interaction of technical components with human and organizational actors (Bryl, Giorgini et al. 2009). From a socio-technical system perspective, more system elements, such as the architecture and operation organizational rules, business processes, external laws and regulations, new technologies are required to be taken into account in ICT-enabled service system (Davidson and Garagnani, Davidson and Garagnani 2002).

The ultimate goal of an ICT-enabled service is to co-create context-specific value within service interactions conducted by service stakeholders (Vargo and Lusch 2004, Vargo and Lusch 2016). Thus, telehealth services, as ICT-enabled service systems, can only be successful if value is co-created for their stakeholders. From the perspective of Service-Dominant (S-D) Logic, value co-creation is only complete if actors successfully integrate resources in the service exchange (Lusch and Nambisan 2015). S-D Logic views all service actors as service resource integrators. The resources obtained by service actors can not be utilized in isolation, and they have to be combined or bundled with other resources from other service actors to co-create value (Lusch and Nambisan 2015). The combination and bundle (integration) of resources are, therefore, critical for service systems (including ICT-enabled service systems) being viable (Spohrer, Maglio et al. 2007, Spohrer and Maglio 2008). The resource integration process is a process of establishing context-valuable resource configurations. This is achieved through service actors attempting to match, access and adapt resources effectively with their needs at a specific time and place to create value from their perspectives (Vargo and Akaka 2012). In the example provided earlier, a certain resource configuration of both technical and human components is required (e.g. the improvement of the patient's health condition only happens if both the doctor and the patient integrate the necessary resources, such as medical knowledge, remote monitoring devices, the patient's knowledge of using those monitoring devices and network infrastructure). Thus, understanding, expressing and analyzing service resource configurations among service actors can help professionals develop a well-designed ICT-enabled service system (Vargo and Akaka 2012).

ICTs have introduced new scenarios for resource configurations. For example, information-intensive interactions, such as the ones utilizing wearable sensors and audio-visual communication technologies, occur in ICT-enabled service systems, which enhances the need for contextualization and collaboration in service activities (Kieliszewski, Maglio et al. 2012). Another example is that ICT-enabled services extend the access to and the variety of service resources (Böhmann, Leimeister et al. 2014), such as user data collected by ICT devices (Leimeister, Huber et al. 2009) and remote services provided through web portals (Böhmann, Leimeister et al. 2014). Addressing these new scenarios requires a comprehensive understanding and analysis tool for engineering resource configurations, which is important for designing a viable ICT-enable service system. Modelling resource configurations is a powerful manner to improve the design of resource configurations in service systems (Mylopoulos 1998, Böhmann, Leimeister et al. 2014).

1.2 Research gap

Existing research emphasizes that value co-creation, which is the ultimate goal of a service system, requires successful resource configurations (Vargo and Lusch 2008, Vargo, Maglio et al. 2008, Vargo and Lusch 2016). However, existing service system engineering methods and tools are not yet able to capture the comprehensive roles of resources within service systems (Böhmann, Leimeister et al. 2014). In particular, while conceptual modelling is recognized as an excellent tool for understanding, designing, and monitoring services for the purpose of service engineering (Amyot and Mussbacher 2011), existing conceptual modelling notations have few constructs able to express resource configurations. For example, Service Blueprinting, which was specifically developed for modelling service encounters, does not contain a "resource" construct (Bitner, Ostrom et al. 2008). *i** (pronounced "i star"), which is an agent-oriented modelling notation that has frequently been used in the domain of service, offers a "resource" construct, but can only represent a configuration as the addition of individual resources (Yu 2009). Yet, new resource configuration scenarios in ICT-enabled service systems as telehealth require the ability to capture and analyze the interconnection among resources within resource configurations.

1.3 Research question and objectives

In order to address this research gap, this research aims at answering the following research question:

- **"What are the concepts and relationships among concepts that are required to model resource configurations in ICT-enabled service systems?"**

Configuring resources in an appropriate manner in a specific service context is a prerequisite for co-creating value, which is the ultimate goal of a service system (Lusch and Nambisan 2015). In this research, a resource configuration is defined as sets of combined resources interconnected by enacting a practice in a manner that creates contextual value for beneficiaries. This research attempts to identify the conceptual foundations required for understanding and analyzing resource configurations. The resulting framework, anchored in literature, provides a conceptual basis for modelling resource configurations in ICT-enabled service systems. A conceptual model is a representation of a system and is formed after a conceptualization or generalization process (Tatomir, McDermott et al. 2018). Conceptually modelling resource configurations hereby refers to developing a metamodel of resource configurations using the Unified Modeling Language (UML) (Seidl, Scholz et al. 2015). Such a metamodel of resource configurations provides the basis for developing practical tools supporting resource planning in ICT-enabled service systems.

The following research objectives aim to answer the research question:

RO1. **Develop a conceptual framework of resource configurations as the basis for further developing the above-mentioned metamodel.**

Reviewing the existing literature on resource configurations provides a better understanding of nature, core components and relationships among resource configurations. The literature concerning service, service systems, service resources and other related concepts will be also reviewed in order to comprehensively understand resource configurations in ICT-enabled service systems. A conceptual framework of resource configurations is derived from the literature review. The conceptual framework illustrates the process by which a resource configuration can be generated. A resource taxonomy is also developed within the conceptual framework. This conceptual framework further serves as the basis for developing a metamodel.

RO2. **Develop a metamodel of resource configurations in ICT-enabled service systems.**
A metamodel can be regarded as a model of a model, which provides guidance for generating domain models. Through metamodeling, we can express and analyze the constructs, relationships and constraints which are applicable and useful for modelling a predefined class of problems (Mohanty 2015). In other words, a metamodel can help us to replace concepts coming from a specific scenario in a practical domain with conceptual abstractions (Amyot, Becha et al. 2008). Also, a metamodel is often expressed by using a certain kind of conceptual modelling notation. Thus, developing a metamodel could help us to express the constructs, relationships, and constraints among resource configurations in ICT-enabled service systems in a conceptualized and generalized manner. This metamodel could further be adopted as a method or tool for achieving a better service system design.

RO3. **Demonstrate and evaluate the metamodel by conducting a multiple-case study in the field of telehealth.**
Since the metamodel of resource configurations developed in RO2 can be understood as an artifact in design science research, the validity of the artifact to solve a proposed problem needs to be demonstrated and evaluated (Peffers, Tuunanen et al. 2007). Firstly, demonstrating the use of the artifact to solve one or more instances of the problem could prove that the idea of the artifact works. Secondly, a more formal evaluation of the artifact could be achieved through observing and measuring how well the artifact supports a solution to the problem. Since telehealth can be regarded as a representative of ICT-enabled service systems, multiple telehealth cases are selected at a Canadian hospital (hereinafter referred to as “the Hospital”) to serve as the instances of ICT-enabled services. Applying the metamodel to the selected telehealth cases demonstrates its capacity to adequately capture resource configurations. The evaluation of the resource taxonomy within the metamodel against the selected telehealth cases allow comparison and increase the validity of the results.

1.4 Research methodology

Since this research focuses on developing and evaluating the metamodel (information systems artifacts) that can solve practical problems while contributing to a knowledge base, it belongs to Design science research (DSR) in nature (Peffers, Tuunanen et al. 2007). Design science research methodology (DSRM) is a well-recognized methodology for DSR (Peffers, Tuunanen et al. 2007). Hence it is adopted for this research. The DSRM provides a well-structured research process model to guide the research design of a DSR project (Peffers, Tuunanen et al. 2007).

Each research step defined in this research is guided by this model and is described in detail in the methodology and research design chapter.

1.5 Research contributions

The results of this research include both conceptual and practical contributions. The conceptual framework derived from the literature review establishes a comprehensive understanding of the resource configuration concept. The metamodel of resource configurations derived from the conceptual framework provides a formal way to express and analyze resource configurations in ICT-enabled service systems. The metamodel will also allow the development of domain-specific modelling notations that can be used by professionals to model resource configurations in a specific domain.

1.6 Thesis outline

The thesis is organized as follows:

- Chapter 2 presents the research design adopted for this thesis. It is guided by the Design Science Research Methodology (DSRM).
- Chapter 3 presents the literature review providing the conceptual foundations for developing an integrated conceptual framework of resource configurations in ICT-enabled service systems.
- Chapter 4 presents a metamodel of resource configurations in ICT-enabled service systems derived from the framework. It is expressed as a UML class diagram. The constructs, relationships, and constraints of the metamodel are described in this chapter.
- Chapter 5 describes the case study conducted in order to demonstrate and evaluate the capacity of the proposed metamodel to adequately capture the resource configurations in selected telehealth service cases. It concludes with a refined version of the metamodel.
- Chapter 6 discusses the results of this research and its limitations.
- Finally, Chapter 7 concludes the thesis and recommends future work items.

2. Methodology

Design science research (DSR) focuses on connecting knowledge to practice by demonstrating that scientific knowledge can be produced through designing useful artifacts (Wieringa 2009). Thus, the purpose of design science is to create artifacts that meet human needs (Simon 1981, March and Smith 1995). However, when design science researchers identify practical problems with knowledge questions, the research may face the problem of methodologically unsound research designs (Wieringa 2009). DSR provides a methodological context for design science in which practical domain needs motivate the creation of validated artifacts. The justified knowledge derived from these assessed artifacts can be added to the shared knowledge base of the academic domain (Hevner, March et al. 2004). This framework clarifies the interface of design science with its practical environment and the scientific knowledge base, which justifies that design and research are closely related activities, and they can contribute to each other (Wieringa 2009). Based on this perspective, both practical problems and knowledge problems are identified in DSR (Wieringa 2009). The practical problems are solved or improved through creating artifacts in two design processes: "build" and "evaluate" (March and Smith 1995). The artifacts are designed and developed in the 'build' phase and are evaluated against their utility for solving the practical domain problems in the "evaluate" phase. Typically, there are four types of artifacts in DSR, which include constructs, models, methods, and instantiations (Hevner, March et al. 2004). Design science research (DSR) is a research approach increasingly adopted by researchers in the information systems and engineering field (Hevner, March et al. 2004).

2.1 Research design

The ultimate purpose of this research is to develop a metamodel of resource configurations in ICT-enabled service systems. This metamodel should have the ability to express the constructs of ICT-enabled service systems, as well as the relationships and constraints among these constructs. Metamodels are thus one of the core artifacts whose development can be guided by DSR. DSR provides a rigorous process to design artifacts to solve observed problems, to make research contributions, to evaluate the designs, and to communicate the results to appropriate audiences (Hevner, March et al. 2004). As such, it provides an appropriate framework for this research.

Although the utility of an artifact can be evaluated in a practical domain, how to relate and justify its contribution to the scientific knowledge base still requires a methodological framework. A widely recognized methodology for DSR is the design science research methodology (DSRM) (Peffers, Tuunanen et al. 2007). The DSRM provides a well-structured research process model that focuses on developing and evaluating information systems artifacts that can solve practical problems while contributing to a knowledge base (Peffers, Tuunanen et al. 2007). In this model, six phases make up a complete design science study: "Problem identification and motivation," "Define the objectives for a solution," "Design and development," "Demonstration," "Evaluation" and "Communication" (Peffers, Tuunanen et al. 2007). Guided by DSRM, each step of this research is described below:

Problem identification and motivation. DSRM requires us firstly define a specific research problem and justify the value of a proposed solution. Justifying the value of a solution promotes the pursuance and acceptance of the solution and helps the research audience to understand why this research is desired. In this phase, we need to acquire knowledge of the current state of the problem and the importance of its solution (Peffers, Tuunanen et al. 2007). Extant literature (Angus 2003, Canada Health Infostructure Partnerships 2003, Barker 2011, Cason, Hartmann et al. 2013, Youssef 2014, Eibl, Daiter et al. 2015, Tuckson, Edmunds et al. 2017) and informal conversations professionals in the health care field, show that telehealth is becoming an important component of health care systems (Tuckson, Edmunds et al. 2017). Since telehealth is a representative of ICT-enabled service systems (Kleinschmidt, Peters et al. 2016, Tuckson, Edmunds et al. 2017), the design of telehealth systems can be improved through relevant methods and tools for service systems engineering. Resource configurations are critical for a viable service system (Vargo, Maglio et al. 2008, Vargo and Akaka 2012), but there is limited research on the engineering of service resource configurations. Providing a better understanding of resource configurations within ICT-enabled service systems and expressing this understanding as a metamodel can provide the basis for improved tools for planning and orchestrating the resources needed for their successful operation. This, in turn, can support health professionals in their planning and management of telehealth resources.

Define the objectives for a solution. DSRM requires us to infer a solution from the problem definition. The solution may comprise several objectives which are based on the knowledge of what is possible and feasible (Peffers, Tuunanen et al. 2007). The objectives can be quantitative, which means that a newly proposed solution would be better than currently existing ones or they can be qualitative, which means that the newly proposed solution can solve problems that have not been addressed (Peffers, Tuunanen et al. 2007). We define the metamodel of resource configurations in ICT-enabled service systems as our desired solution. The objective of this solution is qualitative. The metamodel provides professionals a formal solution to express and analyze resource configurations in ICT enabled services, which has had very limited attention in extant research (Spohrer and Maglio 2008, Maglio, Vargo et al. 2009, Lusch and Nambisan 2015).

Design and development. In this research phase, DSRM requires us to design and develop the artifacts. Since the artifact, we attempt to create is a metamodel of resource configurations in ICT-enabled service systems, we need first to establish a solid understanding of the nature, role, and status of resources in ICT-enabled services, which is later reflected in the proposed conceptual framework. For creating this conceptual framework, existing literature on resource configurations in ICT-enabled service systems was reviewed. The literature concerning service, Service-dominant (S-D) Logic, service systems, service resources and other related concepts was included to ensure a comprehensive understanding of the concept of resource configuration. A framework of resource configurations was firstly proposed as the basis for developing a metamodel. A metamodel will then be derived from the conceptual framework, providing a set of conceptual constructs and relationships among these constructs for this domain (Vaishnavi and Kuechler 2004). Those constructs can formalize the definition and communication of the desirable artifact (metamodel) (Schön 2017).

Demonstration & Evaluation. This phase contains two parts. The first part is to demonstrate the newly developed artifact, which requires us to apply the artifact to a specific domain to solve instances of the problem (Peffers, Tuunanen et al. 2007). The second part is to evaluate the artifact through observing and measuring if the artifact adequately supports a solution to the problem (Peffers, Tuunanen et al. 2007). Demonstration and evaluation can be conducted in many different forms depending on the nature of the problem and the artifact, which means that any appropriate empirical evidence or logical proof could be included as a part of demonstration and evaluation (Peffers, Tuunanen et al. 2007). The metamodel (expressed by using the Unified Modeling Language (UML) class diagrams) and associated constraints (specified in UML's Object Constraint Language (OCL) rules) were formalized in USE, an application for the specification and validation of information systems expressed in the UML and OCL rules (see Appendix D). This allows ascertaining that the metamodel in internally coherent and respects UML's well-formedness rules. Besides, the effectiveness of the metamodel was demonstrated and evaluated according to the extent to which it could identify more comprehensive and detailed resource requirements for the selected telehealth cases.

To conduct this assessment, a multiple-case study at a Canadian Hospital was conducted. Adopting a combination of different data sources can limit interpretation bias and strengthen results by allowing us to verify if the same conclusions can be drawn from several sources of information (Runeson and Höst 2008), thereby three different data sources (interviews, documentations, and system demonstrations) were included to strengthen the results of the evaluation (Yin 2017). Data collected within each case (interview transcripts, system demonstrations' notes and documentation, as relevant) was be analyzed in two phases. The first phase served to evaluate if the developed resource taxonomy could adequately and comprehensively identify resources in the selected telehealth cases. The second phase served to demonstrate the capacity of the developed metamodel to identify the resource configurations within the selected cases. We define the detailed case selection criteria, participant recruitment plan, data collection method, data analysis processes and coding schemes in the appended case study protocol (see Appendix A – Case Study Protocol). The results of the demonstration and evaluation phase were used to refine the initial metamodel.

Communication. In this research phase, we are required to communicate with the research audience to clarify the following items: the importance of the proposed problem; the utility and novelty of the artifact; the rigour of the design process; the effectiveness for both academic and practical worlds. The report for this research will be structured based on the project report components guided by DSRM (Peffers, Tuunanen et al. 2007). Also, the results of this research may be communicated through relevant conferences and journals in the fields of service science, information systems and requirements engineering.

Figure 1 shows the research phases we defined based on DSRM, the methods that were used within each phase, and the output(s) of each phase.

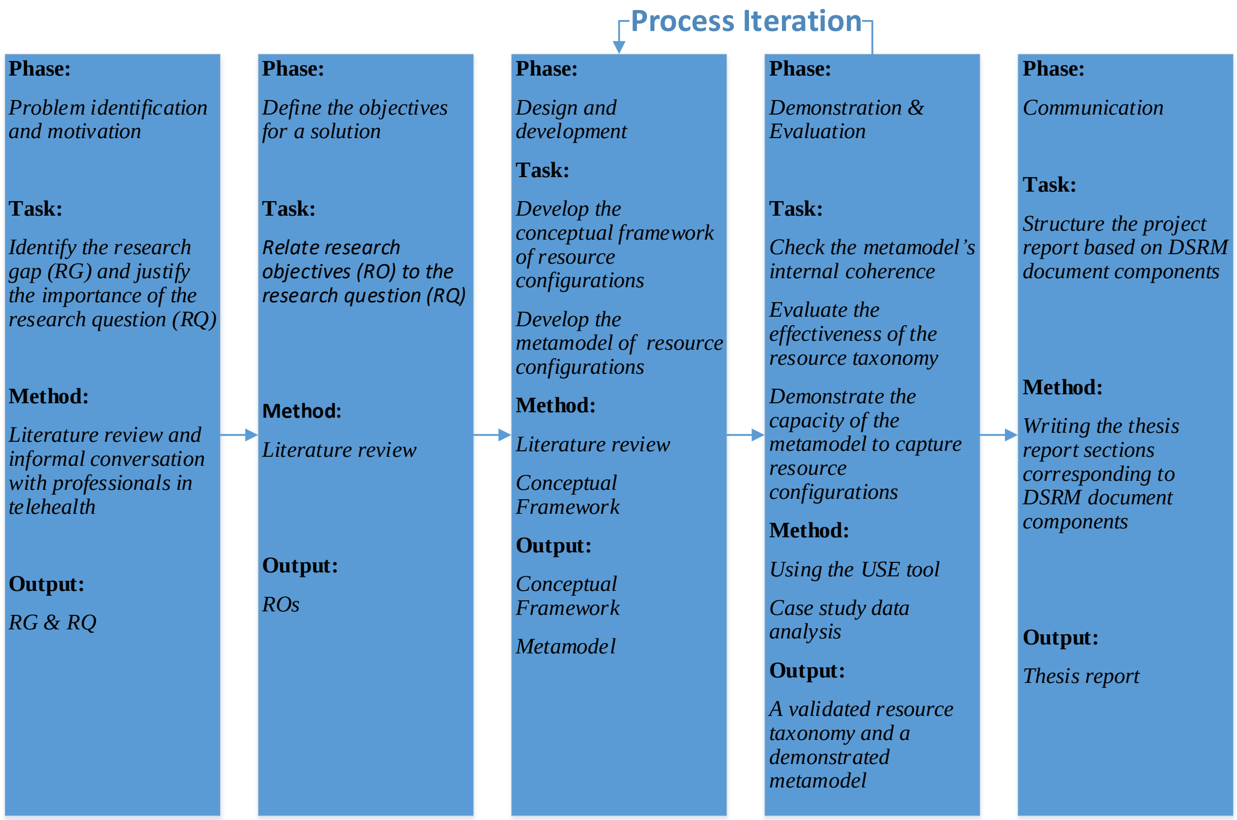

Figure 1 The research design

2.2 Criteria for assessing the quality of the case study

The evaluation of the metamodel developed in this research was mainly conducted through a case study, thus empirically. The quality of an empirical study can be judged through four different criteria: confirmability, reliability, credibility and transferability (Miles 1994). The remaining part of this section explains how each criterion was addressed for the case study.

2.2.1 Confirmability

Confirmability refers to the identification of the explicit biases that exist for the phenomenon being studied to ensure that the conclusions are based on the subjects and the settings rather than the researcher's perspective (Miles 1994). Several steps have been taken to address confirmability. First, detailed descriptions of the data collection and analysis techniques have been provided, so that they can be replicated to verify conclusions. Second, evidence supporting the results has been provided in the forms of coding results and quotes from participant interviews. Finally, the data presented in coding results tables allow others to reanalyze the data.

2.2.2 Credibility

Credibility refers to identifying if the study makes sense by verifying if the results of the study are credible to the people being studied as well as the readers (Miles 1994). Credibility for this study was addressed by including detailed descriptions of the cases in the results chapter. Also, the credibility of the study is further strengthened by linking the findings to prior theory in the discussion chapter (Miles 1994).

2.2.3 Transferability

The transferability of the study refers to identifying the extent to which the conclusions of the study can be generalized to other contexts (Miles 1994). Rich descriptions of the findings in the results chapter enable readers to assess the potential transferability to their own settings. The transferability of this study was moreover increased by explaining the possible threats to generalizability in the limitations section. Finally, the different types of telehealth cases selected for this study encourage theoretical replication of the findings (Yin, 2011). The results of the study may only apply to contexts similar to the Hospital. However, the selected cases are common types of telehealth services, and they rely on the infrastructure available throughout Ontario, which means the study results could be potentially transferable to the telehealth services offered by other Ontario and Canadian health organizations.

2.2.4 Reliability

The reliability of the study refers to consistency in the process of the study so that it remains stable over time and across researchers (Miles 1994), ensuring the ability to obtain similar results by repeating the same approach. The reliability for this study was improved by providing detailed descriptions and explanations in the case study protocol (see Appendix A) and the interview protocol (see Appendix B) to remove confusion. Also, the interview questionnaire, data collection method, coding schemes, and data analysis steps were discussed in detail and piloted by both the principal researcher and a co-researcher to enhance reliability (Miles 1994).

3. Literature review and conceptual framework

This chapter is in line with the second research objective (RO1), which is to develop a conceptual framework of resource configurations as the basis for developing the metamodel. This chapter is divided into two subsections: 3.1 Conceptual Foundations and 3.2 Conceptual Framework. The literature on the fields of services, resources, and related concepts is reviewed to generate the conceptual foundations from which the conceptual framework of resource configurations is then derived.

3.1 Conceptual foundations

This section reviews the literature on the evolving understanding of services and the evolution of perspectives on resources and related fields such as Good-dominant (G-D) Logic, Service-dominant (S-D) Logic, service systems and service ecosystem.

3.1.1 From services to service

There are two commonly used paradigms to understand and study services, namely, Good-dominant (G-D) Logic and Service-dominant (S-D) Logic. In this section, the literature on G-D Logic and S-D Logic and related concepts are reviewed to explain how these two paradigms differ, and why S-D Logic is the most relevant paradigm for ICT-enabled services such as telehealth.

3.1.1.1 Services as goods

For many years, various definitions or characterizations of services have been proposed by researchers. The traditional conceptualizations of services often view them as non-material or non-storable, or as products delivered at the very time they are produced. The (plural) term "services" is adopted here since it emphasizes that they are "units of output" (Vargo and Lusch 2016). Thus, services are viewed as a residual, which is not a tangible good; an affiliate that is offered to enhance a good. This view is reflected in the classification of service industries, such as software outsourcing and health care (Vargo and Lusch 2004).

These conceptualizations of services are rooted in Good-dominant (G-D) Logic in which tangible output and discrete transactions were central (Vargo and Lusch 2004). The philosophy of G-D Logic is rooted in the discussion of value creation and economic exchange introduced by Adam Smith (1776) in economics (Vargo and Lusch 2004). The G-D Logic perspective postulates the following: 1) the purpose of economic activity is to produce and distribute goods that can be sold to customers; 2) utility and value are embedded in goods during production and distribution, which are later delivered into the market for completing trade transactions; 3) producers do their best to maximize the profit from goods sale; 4) goods are often standardized and produced away from the market for maximizing production control efficiency; 5) goods are often inventoried until it is sold to customers for profit. Based on these five postulations, several insights are derived from G-D Logic: 1) value is only created by producers and measured by the amount of nominal value (price) received in market exchange (value-in-exchange); 2) customers later "used up" or "destroy" or "consume" the value created by producers, which means customers' actions bring no effect on value creation; 3) the unit of exchange is primarily goods in which producers embed value; 4) no matter which type goods belong to (a tangible or intangible or mixed one), market exchange is the only point for value measurement (value determination); 5) only operand resources (materials and goods) are considered as primary in production, distribution and market exchange (Ramírez 1999, Vargo and Lusch 2004, Vargo, Maglio et al. 2008)

The concept of "services" may refer to pure services provided for customers such as financial consulting, software development and medical diagnosis (an intangible type); it can also refer to services provided in conjunction with goods such as electronic map service offered by a combination with an online map software and a GPS device (a mixed type) (Bitner, Ostrom et al. 2008). From the G-D Logic perspective, both forms are viewed as (intangible) goods or affiliates of goods. This view emphasizes the transaction of selling service offerings rather than the process of offering a service; thereby it emphasizes the nominal value measured in market exchange (value-in-exchange) rather than the utility value created in a service process (value-in-use). Since services are viewed as a special form of goods, the value embedded in them is consumed (or destroyed) later by customers. The effect of customers' involvement in the process of providing a service is generally ignored.

For example, an IT company provides software outsourcing services through its final service offering, which may be a software solution. The software company creates utility and value and embed them into the service offering (as a special form of goods). The embedded utility in the software solution which will eventually be exchanged in the marketplace for money. Thus, once the company delivers the software system to its customer and the purchase transaction is completed, the value is measured (determined) immediately. In this description, software outsourcing service is viewed as a sequential, unidirectionally, and transitive process (Ramírez 1999). The activities such as client requirements analysis, solution design and testing, which often highly rely on the interactions between the software company and customers, are ignored for discussion. The software company is the only creator of value, and the software solution is viewed as an operand resource in development, exchange and use stages (Vargo and Lusch 2004).

Since the primary interest of economic analysis was the manufacturing sector in the Industrial Revolution era, G-D Logic served reasonably well as a feasible theoretical foundation (Vargo and Lusch 2004). Although G-D Logic is not necessarily incompatible with the process nature of a service, this traditional perspective views a service process as a black box and only focuses on the exchange of service offerings (Vargo and Lusch 2004). Thus, it cannot be relied on as a conceptual foundation to comprehensively capture the dynamic, bidirectional nature of a service (Vargo and Lusch 2004).

3.1.1.2 Service as a process of applying resources

Rather than viewing services as (a special form of) goods, another understanding emphasizes the process nature of service. The (singular) term of "service" is adopted here intentionally since emphasizes viewing service as a process rather than goods that can be counted (Vargo and Lusch 2016). This perspective specifies service as the "basis," rather than the "unit" of exchange (Vargo and Lusch 2016). Thus, a service is deeds, processes, and performances (Lovelock 1991, Zeithaml 2000); a service refers to activities and processes rather than an object (Solomon, Surprenant et al. 1985); a service may be defined as a change in the conditions of a person or a good belonging to some economic unit, which is brought about as the result of the activity of some other economic unit with the prior agreement of the former person or economic unit (Hill 1977). This conceptualization considers a service as a process and distinguishes between the economic units involved in the process, thereby offering a more suitable lens to understand the complexity of a service.

S-D Logic has been recognized as a revised conceptual foundation for rethinking a service (Vargo and Lusch 2004, Vargo and Lusch 2008, Vargo and Lusch 2016). Also, it has been considered as an important theoretical framework for the development of service science and the study of service systems (Maglio and Spohrer 2008, Vargo and Lusch 2010). S-D Logic provides a more comprehensive and inclusive approach than G-D Logic to view and understand a service and market exchange (Vargo and Lusch 2010). There are two different views about what is exchanged in a market. The first view involves "the output from the performance of specialized knowledge and skills" (goods), which corresponds to G-D Logic; the second view involves "the performance of specialized knowledge and skills" (service) (Vargo and Lusch 2004). While G-D Logic focuses on operand resources (goods), S-D Logic emphasizes operant resources as primary. In other words, the different perspectives on what is exchanged (goods vs a service, operand vs operant resources) distinguish the G-D and S-D Logic (Vargo and Lusch 2004).

From the perspective of S-D Logic, a service is defined as the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself (Vargo and Lusch 2004). Since competences, such as knowledge and skills, are typical examples of operant resources, which are usually intangible, dynamic resources that act on other (operant or operand) resources, the definition of a service can also be expressed as a process of applying one's (operant and operand) resources for the benefit of another entity (Vargo and Lusch 2004, Lusch and Vargo 2014).

3.1.1.3 Reconceptualize service form S-D Logic

Since S-D Logic offers an updated perspective to understand the concept of service, we need to review its foundational premises in detail to derive some key insights for establishing a revised conceptual foundation for understanding service. The following Table 1 shows the foundational premises of S-D Logic.

Table 1 Foundational premises (FPs) of S-D Logic Adapted from (Vargo and Lusch 2016)

Foundational premises (FPs) of S-D Logic	
FP1 (axiom status)	Service is the fundamental basis of exchange.
FP2	Indirect exchange masks the fundamental basis of exchange.
FP3	Goods are distribution mechanisms for service provision.
FP4	Operant resources are the fundamental source of strategic benefit.
FP5	All economies are service economies.
FP6 (axiom status)	Value is co-created by multiple actors, always including the beneficiary.
FP7	Actors cannot deliver value but can participate in the creation and offering of value propositions.
FP8	A service-centred view is inherently beneficiary oriented and relational.

FP9 (axiom status)	All social and economic actors are resource integrators.
FP10 (axiom status)	Value is always uniquely and phenomenologically determined by the beneficiary.
FP11 (axiom status)	Value co-creation is coordinated through actor-generated institutions and institutional arrangements.

Applying resources (service) is the fundamental basis of exchange: from the S-D Logic perspective, the performance of specialized activities, rather than the output from the performance of specialized activities, is exchanged in the market (Vargo and Lusch 2004). This notion emphasizes that service, rather than goods, is the basis of exchange (FP1). Since service (performance of specialized activities) results from applying (operant) resources (e.g., knowledge and skills), service can be viewed as a process in which necessary resources are applied by one party for another beneficiary (Vargo and Lusch 2004, Lusch and Vargo 2014).

At the fundamental level, all economic activity pertains to applying resources (e.g., knowledge and skills, technologies, materials) by one party to create benefit for another one. Thereby they can be all considered as service (Vargo and Lusch 2008). All phenomena involved in value co-creation through applying resources are included in the S-D Logic's conceptualization of service.

Although goods are involved in many economic activities, they are transmitters of operant resources (embedded knowledge). Goods are intermediate "things" that are used by other operant resources (beneficiary) as appliances in value creation processes (Vargo and Lusch 2004). They can be considered as vehicles for delivering the applied resources (namely, a service) (Vargo, Maglio et al. 2008). They are distribution mechanisms for applied resources (a service) (PF3).

Thus, all economic activities are fundamentally a service (PF5). S-D Logic, as a positive, rather than normative, theoretical foundation, is universally applicable for all social and economic activities (Vargo and Lusch 2004). From this notion, applying resources (service) is the fundamental basis of exchange (Vargo and Lusch 2004, Vargo and Lusch 2008, Vargo, Maglio et al. 2008).

Value is co-created through resource-to-resource (R2R) networks: the concept of value co-creation is central for understanding service and to the study of service science and service systems (Maglio, Kieliszewski et al. 2010). The divergences between S-D Logic and G-D Logic are rooted in the different perceptions of the concept of value. How people interpret the concept of value will determine how people interpret the process of value creation. The concepts of Value-in-Exchange and Value-in-Use are the cognitive basis for understanding the differences between G-D Logic and S-D Logic. From G-D Logic, utility or value is deemed to be embedded into goods, and firms are the only creators of value. Value-in-Exchange is the focus in G-D Logic, which is later measured by nominal value (price) in completed transactions (Vargo and Lusch 2004). However, S-D Logic focuses on utility value, namely Value-in-Use, which is created by the application of operant resources transmitted through operand resources by one party with and for another one (Vargo and Lusch 2004). The utility of the particular service offering is subjectively assessed by personal judgment and cannot be determined only by one party (Ramírez 1999). Hence Value-in-Use is subjective and even contingent, which means that it cannot be determined only by providers without customers' judgement in a particular context

(Ramírez 1999). Thus, Value-in-Use is cocreated within a service process rather than embedded in goods (Vargo and Lusch 2016). This notion implies that one actor can only offer value propositions to another actor and the value can only be co-created after the value propositions are accepted by another actor (FP7). All service actors including service providers and service customers reciprocally benefit from each other (FP6). Since all involved service actors co-create value, the roles of service providers and service customers are not distinct (Vargo and Lusch 2004). This notion leads to moving from a dyadic orientation toward a network orientation to view service (Vargo, Maglio et al. 2008, Lusch and Vargo 2014). The term of "actor" is adopted intentionally here, since S-D Logic requires a move from a single-minded concern with restricted, pre-designated roles of "producers"/" consumers," "firms"/" customers," to more generic actors. In other words, the concept of value co-creation leads to an actor-to-actor (A2A) orientation (Vargo and Lusch 2016).

As noted, S-D Logic, as a positive foundation, is a generalizable mindset from which a general theory of economic activity can be developed. It provides the foundation for the theory of service systems (Vargo and Lusch 2008). A service system has been defined as a collection of resources (including people, information, and technology) organized in a manner that enables the collaborative creation of value with other service systems (Spohrer, Maglio et al. 2007, Maglio and Spohrer 2008). From the service systems perspective, the concept of value cocreation articulates the idea that value is created through interaction and mutually beneficial relationships within and among service systems. In other words, service systems are connected through value propositions and ultimately interact through service-for-service exchange (Spohrer, Maglio et al. 2007, Vargo, Maglio et al. 2008). In service-for-service exchange, actors integrate and apply resources for and with other actors (Vargo, Maglio et al. 2008). Value co-creation is not confined to the activities or resources of any individual encounter. Value co-creation is also influenced by the context, or environment, as well as the resources of others (Vargo, Maglio et al. 2008). As noted in FP9, The A2A orientation suggests that a part of the resources used in a service provision normally contributed by other actors (Vargo and Lusch 2016). A service then can be viewed as a collaborative process cocreating context-specific value (Value-in-Context) by applying and integrating resources (Vargo and Lusch 2016). Thus, value is cocreated through a resource-to-resource (R2R) network.

All service actors are resource integrators: resource integration is a central component to value co-creation in S-D Logic (Vargo and Lusch 2010). Since all social-economic actors are recognized as resource integrators (FP9), the labels of service providers and service consumers are no longer necessary and an actor-to-actor approach is more suitable for studying service exchange and value co-creation (Vargo and Lusch 2011).

Since services can be defined as an application of (both operant and operand) resources, resources have been regarded as a critical component for value co-creation. Operant resources, which can act on other resources to provide benefit, are recognized as the underlying driver of service exchange and value co-creation. Thus, operant resources, rather than operand resources, are argued as primacy in services (Vargo and Akaka 2012). Since each integration or application of resources (i.e., service) changes the nature of the related A2A network in some way, resources are not only the important but also dynamic component to the network (Vargo and Lusch 2016). This notion implies that a network approach alone is not adequate, and a more dynamic systems orientation should be necessarily adopted (Vargo and Lusch 2016). In other words, not only the network of value co-creation but also the mechanisms of facilitating resource integration and service exchange through the actors' coordination should be taken into account (Vargo and Lusch 2016). This notion and the primacy of operant resources services point toward the critical role of social resources, which are emphasized in FP11 (e.g. institutions) (Vargo and Akaka 2012).

Value is always uniquely and phenomenologically determined by the beneficiary: the emphasis of value is co-created by all service actors in S-D Logic emphasizes the notion, which is that value is uniquely and phenomenologically derived and determined through a particular use of service offering from a particular perspective (individual viewpoint) in a specific context (e.g., time, place, and social setting) (PF10) (Vargo and Akaka 2012). Value-in-Context was introduced to articulate better the idea that value is co-created in a particular context (Vargo and Lusch 2008). Value-in-Context is always determined through the use of a set of particular resources in a particular context (Vargo and Lusch 2008). People do not buy objects (service offerings), instead buy performances (a contextual use of service offerings) (Arnould 2007). In fact, not only the value of service offerings is determined contextually, but also the value of used resources in the service process is contextually determined.

From the service systems perspective, value (Value-in-Context) can also be defined as improvement in system well-being, and it can be measured in terms of a system's adaptiveness or ability to fit in its environment (context) (Vargo and Lusch 2008). In other words, value is an increase in viability (survivability, well-being) of the system. Determining value is not limited to the evaluation of an individual actor, but it is based on the ability of an actor or service systems, to adapt and thrive in its social environment (Barile and Polese 2010). Thus, value is largely contextual determined based on various perspectives within an ecosystem (Chandler and Vargo 2011).

The service ecosystem perspective: as noted in PF8, A service-centred view is inherently beneficiary oriented and relational, value co-creation is assumed inherently relational. However, value co-creation is not the "repeat transaction" conceptualization argued by G-D Logic (Vargo and Lusch 2016). Importantly, value co-creation is reciprocal exchange that is facilitated by the existence of shared institutions (social resources) (Vargo and Lusch 2016). Namely, a service, as a service system, are shaped by social values and forces (e.g. institutions) in social systems (Edvardsson, Tronvoll et al. 2011). The FP6 and FP9 of S-D Logic and the numerous other publications (Vargo and Lusch 2008, Vargo 2008, Chandler and Vargo 2011, Vargo and Lusch 2011) encourage zooming out to wider perspective than "firm"-"customer" exchange for viewing economic activities, which has resulted in a major turn toward a systems orientation (Vargo and Lusch 2016). The term of service ecosystem has been introduced to identify mutual service provision (Lusch and Vargo 2014). A service ecosystem is defined as a relatively self-contained, self-adjusting system of resource integrating actors connected by shared institutional arrangements and mutual value creation through service exchange (Vargo and Lusch 2016).

The concept of service ecosystems is considerably similar to the concept of service systems in service science since both of them are grounded in S-D Logic (Vargo and Lusch 2016). In Maglio's literature, service systems are defined as a configuration of people, technologies, and other resources that interact with other service systems to create mutual value (Maglio, Vargo et al. 2009). However, unlike emphasizing the role of technologies in the definition of service systems, the service ecosystem definition emphasizes the more general role of institutions (Vargo and Lusch 2016).

3.1.2 Evolution of perspectives on resources

The shift in paradigms from services as goods to a service as a process of applying resources have an important impact on the understanding of resources (e.g., as shown by FP4 and 9). In this section, we revisit G-D Logic and S-D Logic as they pertain to the understanding of resources.

3.1.2.1 Resources as tangible, static and operand

The traditional understanding of resources can be expressed through Thomas Malthus's analysis of resources. He concluded that along with the continued geometric population growth, the society finally would face a resource shortage (Malthus 1798). From his perspective, resources basically mean natural resources that humans draw on for support. In Malthus's time, one of the primary political and economic activities for people, organizations, and nations was fighting over the acquisition of natural resources. Thus, resources were seen to be static and physical "things" in nature playing an operand role. Operand resources are defined as resources on which an operation or act is performed to produce an effect, which means they could be acted on by people for economic advantage (Constantin and Lusch 1994). Through people's operation on resources, value becomes embedded in them, which is a notion in line with G-D Logic (Vargo and Lusch 2004).

3.1.2.2 Resources as intangible, dynamic and operant

The understanding of resources has been extended and updated over the past 60 years through many related studies and literature. Madhavaram and Hunt developed the resource-advantage theory in which resources are defined as the tangible and intangible entities available to a firm for value creation (Madhavaram and Hunt 2008). Resources have come to be regarded not only as "stuff" but also as intangible and dynamic functions of human ingenuity and appraisal (Vargo and Lusch 2004). From this perspective, resources can be intangible and dynamic rather than only being static and fixed in nature. Also, they can play an operant role. Operant resources can be defined as resources employed to act on other (operand or operant) resources to produce effects (Constantin and Lusch 1994).

Since three groups of adjectives (Tangible vs Intangible; Operand vs Operant; Static vs Dynamic) have been adopted to describe resources in the above two paragraphs, the differences within each group and the relationship among these groups may seem to be fuzzy and confusing. The following three subsections are dedicated to addressing this issue.

3.1.2.3 Understanding the nature, role, and status of resources

As noted, resources can be described by three groups of adjectives (Tangible vs Intangible; Operand vs Operant; Static vs Dynamic). These adjectives describe the nature, role, and status of resources respectively. G-D Logic and S-D Logic underlie their contrasting understanding. Viewing resources as being tangible, operand, and static is a traditional perspective that is in line with G-D Logic. In contrast, S-D Logic emphasizes that a resource should be considered as having an intangible nature, an operant role, and a dynamic status.

Viewing a resource from its nature, role and status can be illustrated through a three-dimensional manner, in which the first dimension is about the physical form of the resource (nature). The second dimension is then about the relationship between the resource and its related actions (role), and the last dimension is related to the status of utilization. This three-dimensional view can be expressed by the following figure (Figure 2).

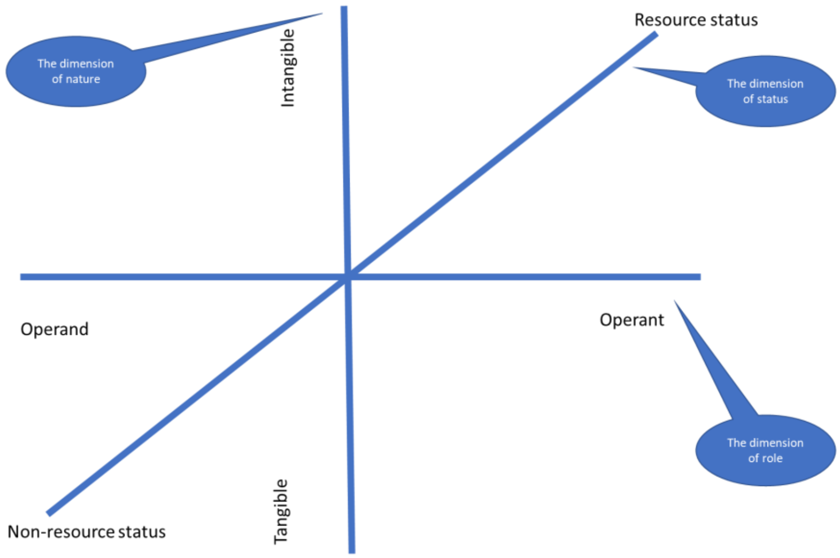

Figure 2 A three-dimensional manner for viewing a resource

3.1.2.3.1 The nature of resources: Tangible vs Intangible

In general, the difference between tangible and intangible resources is obvious since it is based on determining whether a particular resource can be visually observed by people. As discussed in Thomas Malthus's analysis of resources, since natural resources, as the only recognized category of resources in his time, are physical existence, most of them are tangible (Malthus 1798). However, there are some exceptions, such as wind and solar energy. On the other hand, human knowledge and skills, as typical instances of operant resources, are intangible resources. However, there is still disagreement in this classification. For example, data are often considered to be intangible resources. However, if people regard a piece of paper containing statistical tables as data, they somewhat can be viewed as tangible resources.

Although there is disagreement in identifying a particular resource to be tangible or intangible, this classification points out that people can classify resources based on their nature. Thus, some resource classifications based on existence form have been proposed in related literature (Zimmermann 1951, Hunt and Morgan 2005, Barney, Ketchen Jr et al. 2011). These classifications can serve to create an integrated resource taxonomy for the domain of ICT-enabled services (e.g., telehealth), which will be discussed in the service resource taxonomy section.

3.1.2.3.2 The role of resources: Operand vs Operant

Contrary to the dominant role of operand resources (e.g. natural resources) in Thomas Malthus's time, the relative role of operant resources became more crucial in the late twentieth century since people realized that resources, like knowledge and skills, were the most important category of resources (Vargo and Lusch 2004). Operant resources are often intangible and are likely to be infinite rather than being finite, which is usually the case of operand resources (Vargo and Lusch 2004). Since operant resources produce effects, they enable humans both to multiply the value of natural resources and to create additional operant resources. Because they are the producers of effects, S-D Logic perceives operant resources as primary resources in economic activities (Vargo and Lusch 2004).

Although operand resources are often tangible (e.g. materials) and operant resources are often intangible (e.g. knowledge and skills), these two sets of concepts should not be considered as being equivalent. The idea of identifying a resource to be tangible or intangible leads to a discussion on the taxonomy of resources based on their nature or existence form. However, based on the definitions of operant and operand resources, being an operant and operand resource is determined by the role which the resource is playing. In other words, a resource as the objective or subjective of the action will determine the role of the resource to be operant or operand. Thus, theoretically, no resources are inherently operant or operand. Being operant or operand resources are temporarily determined in a particular service activity and can be changed in another one. For example, knowledge and skills are often considered operant resources that perform an action on operand resources (e.g. equipment). However, they also can be influenced by regulation (institution or social resources) when they are no longer compatible with or legitimate under regulation revise. The detailed relationship between the resource roles and resource categories will be discussed in the section presenting the conceptual framework.

3.1.2.3.3 The status of resources: Static vs Dynamic

Since the initial analysis of resources mainly focuses on natural resources (Malthus 1798), people traditionally view (natural) resources as static entities that contain economic value. In other words, if an entity is a resource, it holds the status of being a resource constantly, and value is objectively embedded in the resource. The description of economic activity from the G-D Logic perspective is that people draw on the resource to produce products for economic advantages (monetary value), which are realized through the transaction (value-in-exchange) of these products (in a market). From this point of view, the static nature of a resource means that being a resource is a constant status and consequently it constantly contains values measured by transactions (Vargo and Lusch 2004). Also, since people need to act on a physical entity (a resource) for deriving economic advantages, the static perspective of resources usually correspond to viewing them as being tangible and operand (Vargo and Lusch 2004).

On the contrary, the S-D Logic provides a revised perspective to view the status of a resource in economic activity, which emphasizes the dynamic status of resources. From this perspective, every resource entity is economically neutral (if not even a resistance) until people learn what to do with it (Zimmermann 1951). Resources are frequently the subject of discussion in the interaction between individual actors but may also be the objects that are modified and activated by their interaction with other resources (Håkansson, Ford et al. 2009). This means that the value of a resource depends on its relation to other resources; resources may change and develop over time; they are embedded in a multidimensional context (Peters, Löbler et al. 2014). Thus, resources are highly dynamic functional entities, which firstly means that no entity is inherently a resource (resources are not, they become). Resources evolve out of the interaction of nature, people, and culture, in which nature typically sets outer limits, however, people and culture largely determine a specific use of an entity (a specific portion of physical totality) for humans (Zimmermann 1951, Vargo and Lusch 2004, Vargo and Lusch 2011). Other than viewing resources as a specific portion of physical totality (Zimmermann 1951), the notion of non-physical entities was also introduced to the discussion on resource integration (Vargo, Lusch et al. 2010). For example, resources such as time, weather and laws, which are traditionally considered exogenous and uncontrollable by individuals and organizations, are often integrated into the value creation process by all service systems (Vargo, Lusch et al. 2010). Thus, resources are not only become but also can cease to perform as resources when they are no longer utilized in value-creating processes (Löbler 2013). In other words, resources are not necessarily contributor, but sometimes even resistance in value creation. Also, the value of a resource is determined contextually by actors for a specific use of it (value-in-context). Thirdly, actors draw on operant resources, such as knowledge and skills to perform resource integrating activities, so operant resources play a crucial role within these activities (Vargo and Lusch 2004, Berghman, Matthyssens et al. 2006, Golfetto and Gibbert 2006, Vargo and Lusch 2008, Ngo and O'Cass 2009, Vargo and Lusch 2011).

3.2 Conceptual framework of resource configurations

The above-reviewed literature provides an in-depth understanding of the concepts related to service and resource (Vargo and Lusch 2016), the conceptualization of how resources are configured to fulfill the value cocreation in a service remains unarticulated. A resource configuration is a set of highly interconnected resources that could provide a promise of offering value. Although the three-dimensional manner proposed in the previous section could help people examine a resource from its different aspects (i.e., resource nature, role or status), it is not sufficiently detailed for describing and designing resource configurations. Several approaches have been developed in the existing literature for understanding the process of utilizing resources (e.g. resource-based view, organization ecology, cluster theory, interpersonal resource exchange theory and the development of social and cultural capital) (Peters, Löbler et al. 2014). In this section, we firstly review the literature grouped into four different perspectives, which contributes to understanding the concept of resource configuration; Then, we propose a conceptual framework of resource configurations in ICT-enabled service systems by integrating these perspectives.

3.2.1 The categorization perspective

Only labelling a resource as tangible-operand-static or intangible-operant-dynamic does not have the adequate capacity of classifying the variety of resources that are used in an ICT-enabled service. To address this issue, we need to develop an integrated resource taxonomy that is appropriate for the domain of ICT-enabled service systems. This integrated resource taxonomy is part of the conceptual framework described in Section 3.2.4. A number of bodies of literature have been reviewed to identify varied resource types that could contribute to forming the integrated resource taxonomy.

3.2.1.1 Categories of resources in service systems (SS)

People, technology, organizations, and shared information are considered as four categories of resources in value co-creation of service systems (Maglio and Spohrer 2008). These four categories include resources with rights (i.e., people and organizations), resources as property (i.e., technology and shared information), physical resources (i.e., people and technology), and socially constructed resources (i.e., organizations and shared information). In addition, researchers identified three subcategories of shared information, language, laws, and measures (Spohrer, Maglio et al. 2007). Importantly, if actors lack common languages or shared encoding of information, they may face coordination issues, which lead to unsuccessful value creation. Laws and contracts are necessary for offering sophisticated services and maintaining the continuance of the services. Also, there are various measures involved in providing a service. For example, price can be used to monetarily measure the value of a service. Standardizing the measures of a service can often improve productivity of a service system (Spohrer, Maglio et al. 2007). The categories of resources identified in the service system literature can be visually expressed by the following Figure 3.

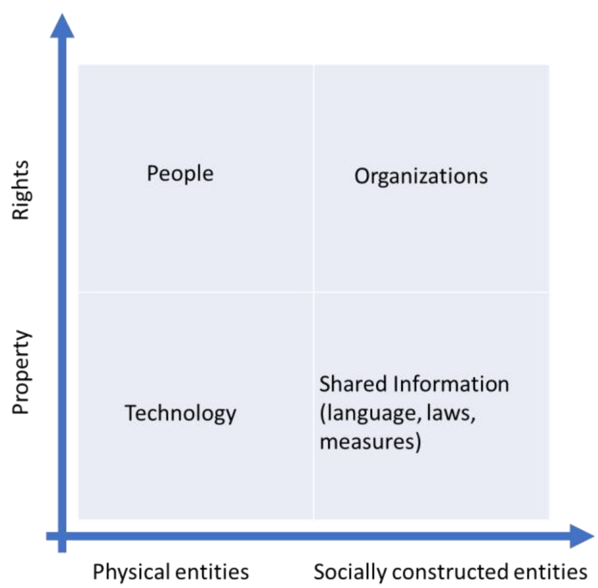

Figure 3 Categories of resources in service systems (SS), Adapted from (Maglio and Spohrer 2008)

3.2.1.2 Categories of resources in resource-based view (RBV) and resource-based theory (RBT)

The resource-based view of the firm (RBV) and the resultant resource-based theory (RBT) are proposed as an important framework for explaining and predicting the basis of a firm's competitive advantage and performance (Slotegraaf, Moorman et al. 2003, Vorhies and Morgan 2005, Barney, Ketchen Jr et al. 2011). Since a firm can be viewed as a service system or a set of service systems (Maglio and Spohrer 2008, Maglio, Vargo et al. 2009), this body of literature can be relied on to identify resource categories for service. From the RBV and RBT perspective, resources in a firm can be classified into four broad categories: financial resources, physical resources, human resources, and organizational resources (Barney and Hesterly 2009).

Financial resources include all the available money from whatever source which actors utilize to conceive of and implement strategies (Barney and Hesterly 2009). The typical examples of financial resources are cash, equity holders, bondholders, and banks. Retained earnings, previously made profit and invests are also important types of financial resources (Barney and Hesterly 2009).

Physical resources include all the used physical technology. The typical examples of physical resources are equipment, geographic location, and raw materials. Specifically, the used hardware and software of ICTs are categorized into typical physical resources (Barney and Hesterly 2009).

Human resources are an attribute of single individuals, which include training, experience, judgment, intelligence, relationships, and insight of individuals (Barney and Hesterly 2009). Human resources are not limited to just entrepreneurs or senior managers, in fact, all employees at a firm are part of human resources that enables a firm to gain competitive advantage (Barney and Hesterly 2009).

Organizational resources are the attribute of groups of individuals, which include formal reporting structure, formal/informal planning, controlling and coordinating systems, culture and reputation, and informal relations among groups within a firm or between a firm and those in its environment (Barney and Hesterly 2009). Thus, the resource categories proposed in RBV can be presented as following Figure 4.

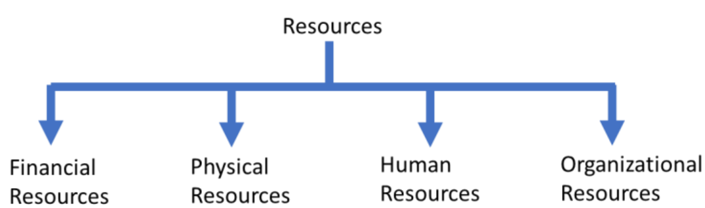

Figure 4 Categories of resources in RBV and RBT, Adapted from (Barney and Hesterly 2009)

Specifically, one existing research focusing on resource contributions in value cocreation adapted the categories of resources proposed in RBV, and further proposed the classification of various resources contributed by customer and firm (Agrawal and Rahman 2015). Based on this research, resources can be classified into financial resources, physical resources, legal resources, human cultural resources, organizational cultural resources, informational resources, and relational social resources (Agrawal and Rahman 2015). The following Figure 5 provides some typical examples under each category of this resource taxonomy.

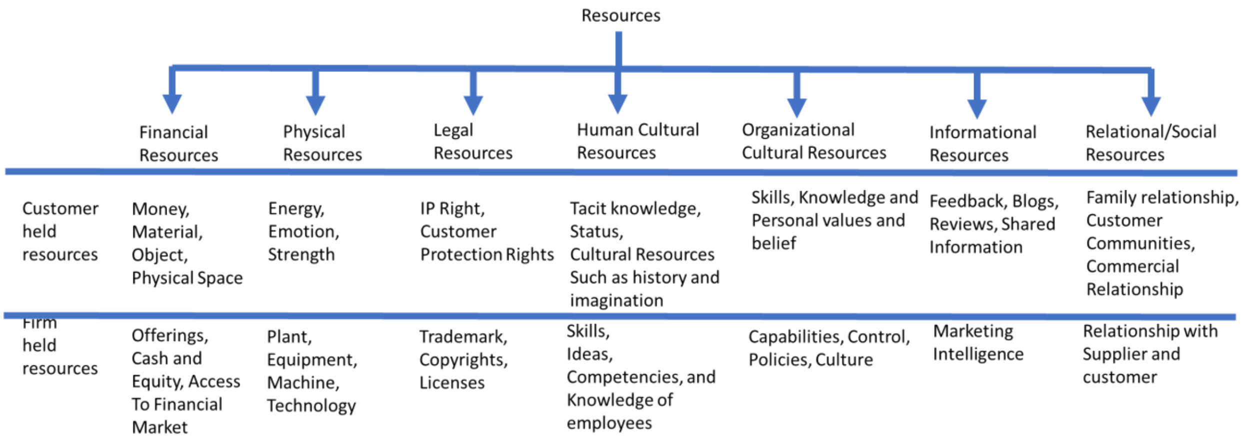

Figure 5 the extended categories of resources based on RBV, Adapted from (Agrawal and Rahman 2015)

3.2.1.3 Categories of resources in resource-advantage theory (RA)

Resource-advantage theory (RA), which is built upon RBV, is a theory focusing on competition (Hunt 1997, Hunt 2000, Hunt and Morgan 2005). The resource-advantage theory classifies resources into physical (e.g., raw materials), human resources (e.g., knowledge and skills), organizational resources (e.g., controls, routines, cultures, competences), informational resources (e.g., information of market segments, competitors, and technology), and relational resources (e.g., relationships with competitors, suppliers, and customers) (Hunt 2004). The resource categories proposed in RA can be presented as following Figure 6.

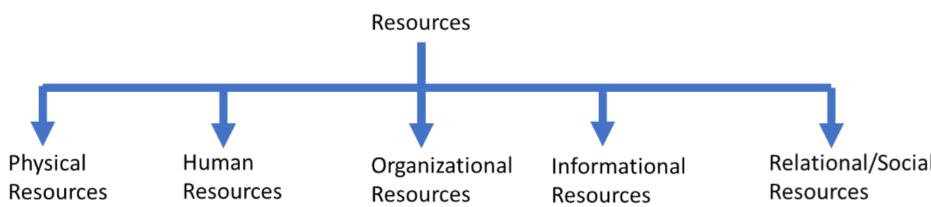

Figure 6 Categories of resources in RA, Adapted from (Hunt 2004)

3.2.1.4 Categories of resources in project management (PM)

A project can be defined as a temporary endeavour undertaken to create a unique product or service (2001). A project is temporary, which means it has a defined beginning and end in time, and therefore defined scope and resources. Also, a project is unique which means it is not a routine operation, but a specific set of operations designed to accomplish a singular goal. Normally, projects are regarded as a means to respond to the request that cannot be addressed within an organization's routine operational limits (2001). Although services are not necessarily equivalent to a project by its definition, it is suitable to include the resource categories used in project management since both concepts share some similarities in terms of fulfilling a predefined goal, and resource management is one of the key tasks in project management (2001).

The resource categories in PM classify resources into labour, tools & equipment, and materials & supplies (2001). For larger projects, the following resources can also be used: organization/administration, subcontractors, facilities, financing costs, contingencies, and overtime pay (2001). In addition, the type of project influences required resource types. For example, in a construction project, on-site facilities, services & systems, and transportation arrangements may be considered as necessary resources (Ritz 1994). Moreover, since a project can be defined as a set of temporary tasks which dedicate to achieve a predefined goal, time management is a crucial task for completing a project (Ritz 1994), the availability of a particular entity is an important resource needs to be included. Thus, the resource categories proposed in PM can be presented as following Figure 7.

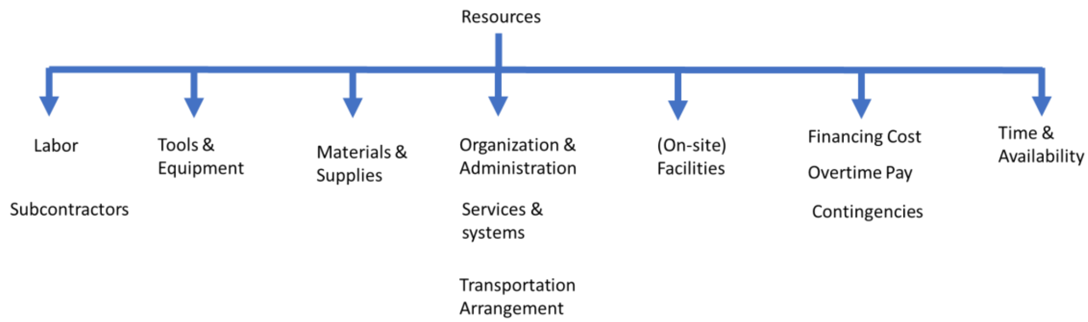

Figure 7 Categories of resources in PM, Adapted from (Ritz 1994, 2001)

3.2.1.5 Institutions and institutional arrangements as resources

One important insight we can derive from the above-mentioned resources categories is that all of them contain some resource categories which have the capacity of guiding, regulating, and even restricting an actor’s activities (e.g., shared information, reporting structure, formal/informal planning, and controlling/coordinating systems) (Maglio and Spohrer 2008, Barney and Hesterly 2009). This insight leads to the discussion on institutions as an important category of resources.

Institutions can be defined as a set of rules governing interpersonal governance (North 1990). Institutions are the “rules of the game” rather than organizations in which the game takes place. They can come in many forms including formal codified laws, informal social norms, conventions, or any other routinized rubric. The typical examples of institutions are rules, norms, and beliefs humanly devised which enable and constrain action and make social life predictable and meaningful (Scott 1995). Based on the nature of institutions, they can be categorized into three subcategories: regulative, normative, or cognitive (Scott 2008). Regulative institutions include all formal rules which enabling or constraining the behaviour of actors. Regulation, observation and sanctioning are three subcategories of regulative institutions, which ensure actors’ behaviours to meet certain standards. Normative institutions consist of norms and values. Norms here means how a particular task should be conducted; while value determines the expectation and evaluation standards of the outcome of the task. Cognitive institutions are related to the actors' perceptions of reality, which is usually influenced by the actors' cultural context (Scott 2008). The institutional resource categories can be presented as following Figure 8.

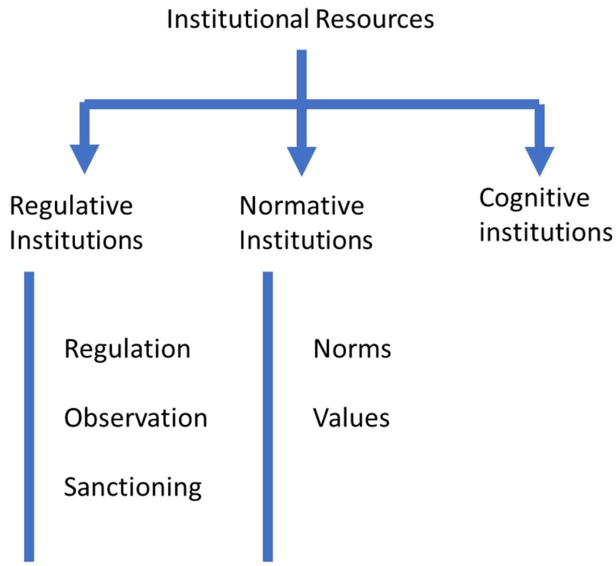

Figure 8 Categories of institutional resources, Adapted from (Scott 2008)

In addition, high-order institutional arrangements (sets of interrelated institutions) and the process and role of institutionalization are the keys to understanding the structure and functioning of service ecosystems (Vargo and Lusch 2016). This further means that they are arguably the keys to understanding value cocreation in general (Vargo and Lusch 2016). The different forms of institutions provide a shortcut to cognition, communication, and judgement. In practice, they typically exist as part of more comprehensive, interrelated institutional arrangements (Vargo and Lusch 2016). In economic activities, human cognitive ability is a limited resource, which means that the central issue is not so much whether or not actors are rational but rather how they efficiently rationalize, given limited abilities. This issue is solved through diffused and shared institutions among actors (Vargo and Lusch 2016). Institutions enable actors to accomplish an ever-increasing level of service exchange and value cocreation under time and cognitive constraints (Vargo and Lusch 2016). The shared institutions among actors result in a network effect with increasing returns. In other words, the more actors share institutions, the greater the potential coordination benefits to all actors. Thus, institutions and institutional arrangements, as an important type of resources, play a central role in value cocreation and service exchange (Vargo and Lusch 2016).

3.2.1.6 An integrated resource taxonomy

The resource categories reviewed in the previous sections provide useful insights for identifying varied types of resources that can be found in ICT-enabled service systems. Also, telehealth, as a representative of ICT-enabled services, provides us with a specific context for choosing, combining, and revising these existing resource categories for generating an appropriate resource taxonomy for ICT-enabled service systems.

The above-reviewed resource categories can be integrated for the purpose of ICT-enabled service systems. This entailed to make choices among these resource categories and merge overlapping concepts. The following logic underlies the integrated taxonomy shown in Figure 9. Firstly, since the concept of service system provides a useful abstraction for describing a service, its resource categories are drawn on as an initial basis for generating the resource taxonomy of ICT-enabled service systems. Secondly, since the application of technology is a precondition for implementing ICT-enabled services, such as telehealth, ICT and its related subtypes, as an independent resource category, are determined to be separated from the physical resource categories found in RBV, RBT, RA. ICT resource candidates are classified into hardware, software, and network, which cover every element constituting the whole network circle. Thirdly, information, as an important resource type, emphasized in the domains of SS, RBV and RA, which is included in the proposed resource taxonomy. Fourthly, all of above-mentioned resource categories, especially the one derived from the field of service ecosystems, consider institutions an important category of resources (Maglio and Spohrer 2008, Barney and Hesterly 2009), which are included in the proposed taxonomy. However, since cognitive institutional resources, such as the service actors' perceptions of reality, are generally related to taken-for-granted behaviours of an actor, they thus are not the focus of this research as well as the domain of telehealth service planning, which are excluded from the integrated taxonomy. Fifthly, human resources are emphasized by introducing the three subtypes: knowledge & skills, experience, obtained training since ICT-enabled services, such as telehealth, highly relies on the expertise of service actors. Lastly, time or resource availability brings a significant impact on capacity and efficiency in terms of conducting a service. Thereby it is included as a separate category in the taxonomy. The resource taxonomy for ICT-enabled service systems is expressed as following Figure 9.

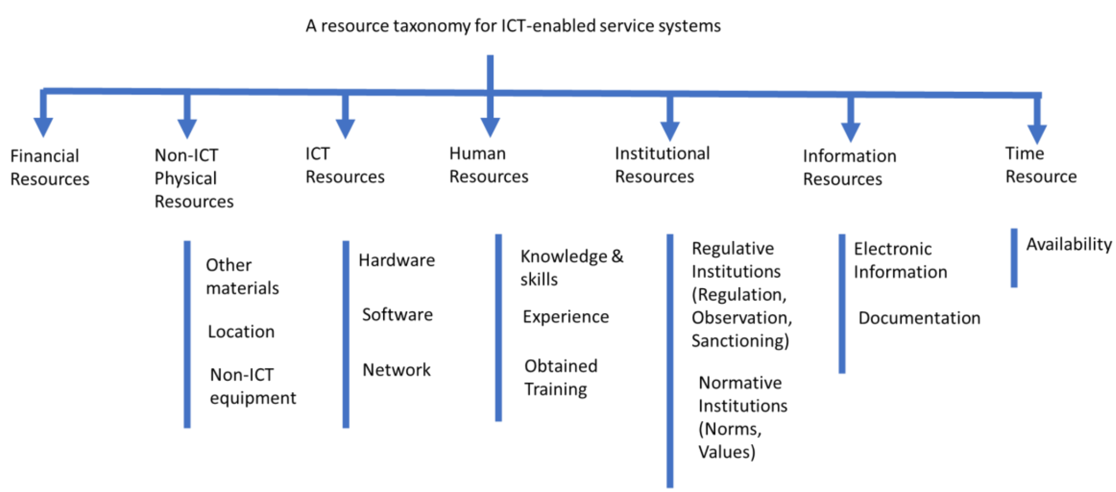

Figure 9 An integrated resource taxonomy for ICT-enabled service systems

3.2.2 The emergence perspective

The particular usefulness of a resource could be changed or activated through the interaction between one resource and another in a resource utilization process (Håkansson, Ford et al. 2009). From this point of view, the value of a resource is determined in a particular social context; also, the value or usefulness of a resource can be changed and developed over time (Peters, Löbler et al. 2014). Thus, the term of resource is a highly functional concept, which means that resources are not, they become.

3.2.2.1 Resources are not, they become

A resource cannot be characterized without considering the specific purpose related to its intended deployment (Peters, Löbler et al. 2014). In other words, a (tangible or intangible) resource candidate cannot be viewed as a resource directly by its own rights. In fact, a resource is a property of an entity (a resource candidate), which can be understood as a result of human capability (De Gregori 1987). This means that when a resource is used, it essentially is a carrier of actors' capabilities for enabling a particular intention (Fischer, Gebauer et al. 2010). Thus, a resource candidate becomes a resource only when it is deployed for a specific intention and its value is derived from its specific use complying with this intention (Löbler 2013). For example, a car is a car, and it only becomes a resource (e.g., a taxi) when it is used for a specific intended application (e.g., transporting guests) offering a level of perceived value to its user (e.g., a traveller). However, if a car is integrated with other resources (e.g., first-aid equipment, a nurse, and a driver) for a different purpose (e.g., emergency service), it becomes a different resource (e.g., an ambulance) offering a different value to its user (e.g., a patient). Also, while these two examples emphasize the specific function of a car's mobility, other potential users of a car may focus on the functions of the car's social capital aspect (e.g., the hedonic, status and prestige derived from the car). Thus, a resource candidate's intended purposes may vary across actors and contexts, and a specific intended purpose (a specific use) is determined by specific actors in a specific context (Voss, Spangenberg et al. 2003). Furthermore, when the useful life of a resource for a specific intention ends, it reverts to simply being a relevant resource candidate again (e.g., a car) and it can only reacquire its resource status again by extending its useful lifecycle. Consequently, the transition from a resource candidate to a resource or vice versa depends on whether the desired capacity of a resource candidate could be derived from a resource integration process. Namely, resource integration is the process in which a specific capacity of the integrated resource candidates is subjectively and contextually determined by users. Thus, any resource that has not been utilized can only be viewed as a resource candidate; it only acquires its resource status through the process of resource integration.

3.2.2.2 Resource integration

Resource integration can be defined as a continuous process in which a series of activities of utilizing resources is performed by an actor for the benefit of another actor (Payne, Storbacka et al. 2008). This definition is conceptually aligned with the definition of service based on S-D Logic, which is an application of resources through deeds, processes, and performances for the benefit of another party (Vargo and Lusch 2004, Vargo and Lusch 2008, Vargo and Lusch 2016). Thus, a process of conducting a service is fundamentally a process of integrating resource candidates.

The understanding of the mechanism of resource integration is rooted in the understanding of the distinction between dispositional and categorical properties of a resource candidate (Groff 2013). While the categorical properties depend on what the resource candidates are (e.g., resource taxonomy), the dispositional properties depend on what they can be used for by actors (Groff

2013). In this sense, gaining a resource status (a specific use of a resource candidate) is barely determined by any inherent properties of the resource candidate, but rather a capacity derived and utilized for a specific intended purpose (Peters, Löbler et al. 2014). Hence, the resource status of a resource candidate is dynamic in nature, which depends on whether it is used, how it is used, and whether it is appraised as being potentially useful (Peters, Löbler et al. 2014). More importantly, new dispositional properties (a new capacity) can be generated from integrating a resource candidate with other resource candidates in a particular resource integration process. Thus, resource integration can also be regarded as a process in which a set of resource candidates are configured in a particular way, and then a novel capacity emerges.

Thus, from the emergence perspective, value is not inherently contained by a resource. A capacity rather emerges from the process of resource integration, which further requires being accepted by its user. In addition, this concept of emergent capacity is in line with the concept of value proposition in S-D Logic. The process of a capacity emerging from resource integration could be illustrated by the following Figure 10.

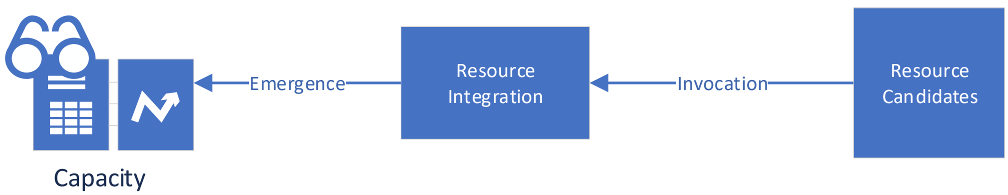

Figure 10 Emergent capacity

3.2.2.3 Resource configuration as the result of an emergence

Since novel dispositional properties (new capacities) may emerge from resource integration, we can view the result of resource integration as emergence (Clayton 2006). In academia, there are two distinct theoretical perspectives to understand the concept of emergence: the epistemological emergence perspective and the ontological emergence perspective (Silberstein and McGeever 1999, Smith 2011). From the epistemological perspective, a property of an entity can be reduced to or determined by the properties of the entity's components (Silberstein and McGeever 1999). This point of view aligns with the view that is usually found in systems theory, which is that the components themselves produce the system of which they are a part. Namely, emergence is autopoietic (Maturana and Varela 1987). The ontological emergence perspective differs from the epistemological emergence perspective, mainly in the relationship between components and the system to which the components belong. From the ontological emergence perspective, an emergent property of a system cannot be reduced to the system's components, and the property is novel and unique (Silberstein and McGeever 1999).

From the ontological perspective, the concept of emergence can be defined as a process in which a new entity is constituted with its own particular characteristics (e.g. structures, qualities, capacities, textures, mechanisms) through interactively combining other different entities that are necessary to create the new entity, but do not contain the original entities' characteristics (Smith 2011). Based on this definition, the interactive combination of entities is the prerequisite for generating dispositional properties. However, a random combination of resource candidates is not necessarily sufficient to produce an expected ontological emergence (Peters, Löbler et al. 2014). In other words, a combination of entities cannot guarantee the emergence of a dispositional property. This means that, from the ontological emergence view, generating a capacity (a dispositional property) requires integrating resources in a certain way rather than a random combination of them. From this view and in line with S-D Logic, the result of resource integration can be viewed as a dispositional property; or a novel capacity; or the result of an emergence; or a value proposition, which all require interactively combine resources in a certain manner. Stated differently, a dispositional property, or a novel capacity, or a value proposition can only be derived from a set of intentionally configured resources (a resource configuration).

The differences between a (particular) resource configuration and a random resource combination are rooted in the intentional intervention and rationality on which actors draw to configure resources. Resource configuration (as a result of an emergence) occurs by design. In other words, resource configuration is the intended outcome of intentional intervention by purposeful actors, and all integrated resources constitute the resource configuration through rationality rather than merely composition (Smith 2011).

For example, a study in the domain of health care which is conducted by McColl-Kennedy et al. (2012) pointed out that health care outcomes were not only influenced by the access to related resources but were largely determined by the way in which they related to the activities that actors undertake, the interactions they engaged in with other in the service network, and the role they played in resource integration (McColl-Kennedy, Vargo et al. 2012). When a health care professional (a resource) had a high performance in conducting activities, had adequate and appropriate interactions with other resources in a service, collaborated with other service actors as a team, the quality of the health care service was found to be considerably improved (McColl-Kennedy, Vargo et al. 2012). This improvement could not be reduced to any above-mentioned particular resource, action or relationship, but to the overall set of configured resources, which allowed novel properties (i.e. the improvement of a health care service) to emerge (McColl-Kennedy, Vargo et al. 2012).

By viewing resource configuration as an emergent result from resource integration, Figure 10 can be updated to Figure 11. This figure illustrates the process in which a resource configuration, containing a novel capacity, is generated from integrating resource candidates. This is the core process that needs to be included in the conceptual framework of resource configurations.

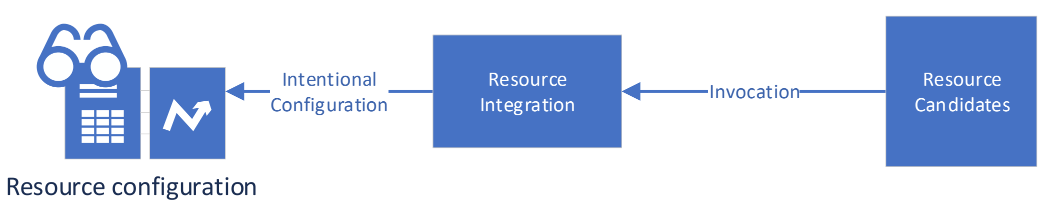

Figure 11 Resource Configuration

3.2.3 The practice perspective

While a resource configuration is often viewed as a whole from the emergence perspective, the interactions that occur among resource candidates are the prerequisite for generating a novel capacity (Peters, Löbler et al. 2014). Resource candidates (e.g., knowledge, skills, equipment, money, and institutions) are rendered within these interactions; also, these resource candidates gain their resource status (being a resource) and specific roles (being operant or operand) in the interactions (Peters, Löbler et al. 2014). Thus, a resource configuration cannot be fully understood without introducing practices through which resources interact with each other. In other words, we need to adopt a practice perspective to understand better the factors (e.g., resource interactions, resource roles), which facilitate forming a resource configuration.

3.2.3.1 Institution matter for resource integration in ICT-enabled service systems

S-D Logic emphasizes that value can only be co-created (FP6) and determined (FP10) through resource integration (FP9) and service-for-service exchange (FP1), it thereby focuses on the cooperation and coordination as well as reconciliation of conflict between service actors in a service ecosystem (Vargo and Lusch 2016). Institutions are instrumental in these cooperation and coordination activities by providing the building blocks for resource integration and service exchange activities in nested and overlapping ecosystems (Ostrom 2009, Vargo and Lusch 2016). In other words, institutions can be regarded as the human-devised (Simon 1996), integrable resources that are continually assembled and reassembled to provide social context (structural properties) for economic activities (Chandler and Vargo 2011, Edvardsson, Tronvoll et al. 2011).

Since value is a contextually contingent concept (Vargo and Lusch 2008), understanding context is essential for understanding the cocreation and determination of value. Institutions perform as building blocks for contributing to form and reform the context of a service. Thereby they are essential for us to understand value cocreation processes (Vargo and Lusch 2016). While the term of institutions refers to a relatively isolatable, individual rule (e.g. norm, meaning, symbol, law), institutional arrangements refer to interrelated sets of institutions that together constitute a relatively coherent assemblage that facilitates coordination of activity in value-cocreation (Vargo and Lusch 2016). Single, unrelated institutions cannot be active, instead, a set of specific nested institutions affecting each other in various but coherent ways with respect to their effectiveness in a service (Edvardsson, Kleinaltenkamp et al. 2014). The essential role of institutions and institutional arrangements in value co-creation is reflected by an additional foundational premise (FP11) in S-D Logic: value co-creation is coordinated through institutions and institutional arrangements (Vargo and Lusch 2016). Since value cocreation requires resource integration, the process of resource integration is enabled as well as constrained by institutions and institutional arrangements (Vargo and Lusch 2016). Thus, the coordinating role of institutions and institutional arrangements is essential for a deeper understanding of resource integration in ICT-enabled service systems (Vargo and Lusch 2016). This institutional perspective of S-D Logic is arguably a precursor to making better strategic decisions in resource integration, and thereby it allows resource integration to be viewed and understood in a more complete, realistic, and robust manner (Vargo and Lusch 2016). In other words, institutions contribute to form the context of an ICT-enabled service system and affect the involved actors' behaviour (Edvardsson, Kleinaltenkamp et al. 2014). In addition, the institutional perspective of S-D Logic also reframes the purposes and processes of economic exchange and provides a zoomed-out perspective by which actors can envision new ways to integrate and beneficially apply potential resources (multiple possible resource configurations or service innovation) (Vargo and Lusch 2016).

The activities within resource integration are executed by actors who conduct their behaviour according to their own interests, which are not always harmonious with each other. This means that potential conflicts may emerge in the process of resource integration, and further may obstruct an expected resource configuration (Edvardsson, Kleinaltenkamp et al. 2014). Thus, the collaborative processes of resource integration should be regulated or solved by the joint efforts of all involved actors (Haase and Kleinaltenkamp 2011). Institutions become prerequisites for resource integration since they play a key role when actors operate on resources in service systems because they introduce broader belief and regulations which shape cognition and behaviour of a service actor (Edvardsson, Kleinaltenkamp et al. 2014).

Although resources may be invoked as an enabling/supporting or constraining/restricting factor in a service, institutions provide a consistent force that synchronizes service actors in their resource integration behaviour. In this sense, institutions can improve the efficiency of a service system (Edvardsson, Kleinaltenkamp et al. 2014). In addition, institutions, such as contracts, regulations, legal agreements, sanctions, trust, and credible commitments, reduce the uncertainties obstructing, or caused by resource integration (Edvardsson, Kleinaltenkamp et al. 2014). Moreover, on one hand, knowledge, skills, intentions, and motivation, as well as actions taken by actors, are influenced by institutions for resulting a resource configuration in a service system; on the other hand, new resource configurations (service innovation) may lead to changing existing institutions as well (Edvardsson, Kleinaltenkamp et al. 2014). Furthermore, institutions not only regulate and guide the actors' resource integration behaviour but also their value expectation and evaluation (Edvardsson, Kleinaltenkamp et al. 2014).

3.2.3.2 Resource role in ICT-enabled services

As noted, the interactions between different types of resources affected and guided by institutions and institutional arrangements, the relationship among institutional resources, other resources, and the activities performed by actors remain unarticulated. Structuration theory (Giddens 1984) provides a practice approach for studying value cocreation and value-in-context, which suggests that as actors enact practises, which are routing activities, they continually reproduce social structures as well as systems (Akaka and Vargo 2014). The core idea of structuration theory is based on the duality of structure. Social structures can be composed of two interrelated layers: structure and systems (Akaka and Vargo 2014). The structure is defined as recursively organized sets of rules and resources that exist out of time and space; meanwhile, systems are defined as reproduced and situated activities enacted by actors across time and space (Giddens 1984). Structuration is considered the condition that connects structures and systems; meanwhile, it enables reproducing both of them (Giddens 1984). In other words, enacting practices (actor's routine actions) influence and are influenced by the social norms and standards (institutions) associated with a particular social system (e.g. service systems) (Vargo and Akaka 2012).

Orlikowski applied structuration theory to study the field of development and use of technology (Orlikowski 1992). She proposed a structurational model of technology, in which she argues that institutions are important factors in the development phase and use phase of technology; however, the use of technology can vary depending on context. While technology may appear to have an objective form and function at one point, it may do vary by different users, by different contexts of use, and by the same user over time (Orlikowski 1992). In other words, technology can be viewed as an operand resource that requires action taken upon in it to be useful, but it also can be regarded as operant resource which is capable of influencing other resources (e.g. institutions) (Vargo and Akaka 2012). Based on the duality of technology and the structurational model proposed by Orlikowski (1992), Akaka and Vargo proposed a framework that illustrates the relationships among institutions, technologies, and resource integration practices in a service system (Akaka and Vargo 2014). In this framework, the interactions among institutions, technologies and practices are bidirectional, which provides an important implication that is all resources (institutions, technology and practices) enact the role of being operant or operand (Akaka and Vargo 2014). In other words, without considering a particular interaction within resource integration, the role a resource enacts cannot be specified. From another angle of view, all resource candidates are neutral in terms of role.

ICT, as an important type of technology, is a precondition for implementing ICT-enabled service systems. For example, ICT can be an operand resource in the case of a computerized patient record system logged in by a doctor; it also can enact the role of operant resources in the case of a self-service provided by a telehealth system in which blood test results are stored. In the first case, a system user guideline (institution) enacts as an operant resource to regulate the system operating behaviour; in the latter case, introducing that telehealth system may force professionals to revise or update the existing medical service procedures of blood test. Additionally, by adopting the perspective suggested by Akaka and Vargo's framework (Akaka and Vargo 2014), we could consider that the role of a given resource candidate (rather than only ICT) stays uncertain until it is invoked in resource integration for a particular service scenario. For instance, a newly invented medicine for curing cancer could be prescribed to a patient by a doctor (new medicine being operand); it also requires the potential updates for the existing therapeutic guideline of that kind of cancer (new medicine being operant). Thus, based on this view, we argue that the technology construct in the framework proposed by Akaka and Vargo (2014) can be extended to describe any resources. Figure 12 illustrates the framework of the relationships among institutional resources, any other resources, and practices.

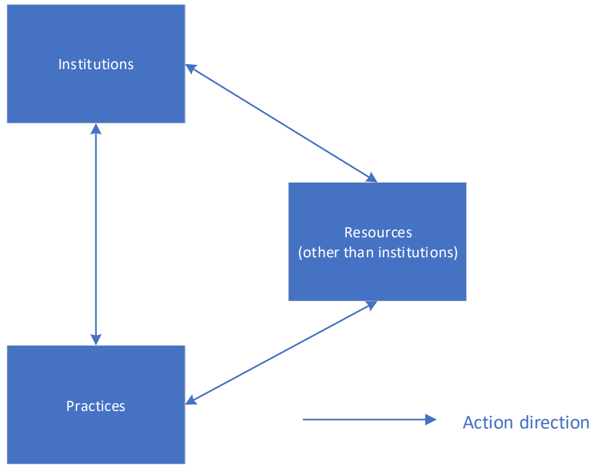

Figure 12 The relationships between institutional resources, other resources, and practices

3.2.3.3 Resource Integration as practices

Integrating resources, including shared institutions, drives value cocreation within a service (eco)system (Vargo and Lusch 2011, Vargo and Lusch 2016). Institutions can be viewed as common rules or norms for the governance of social interaction between resources. Since institutions are capable of influencing and guiding action, they can be considered as operant resources. The importance of operant resources is emphasized by S-D Logic, which implies that institutions could be viewed as necessary and primary resources for value cocreation to occur in a service (Vargo and Akaka 2012). The social interactions and related governance have been the focus of the research domain of practices. Practices are the central social phenomenon by reference to which all other social entities, such as actions, institutions, and structures, are to be understood (Schatzki and Schatzki 1996). Since they recur and often are regularized features of everyday life, they are considered foundational to understanding all social activity (e.g. resource integration) (Lofland 2006). Thus, a discussion of practices is needed to better conceptually understand resource integration since resource integration, value cocreation and the network of service exchange are essentially sociotechnical activities in ICT-enabled service systems (Vargo and Akaka 2012). In addition, although resource candidates could be classified by adopting the proposed resource taxonomy for ICT-enabled service systems and the role that the resources enact can be specified to be operant and operand, capturing the detailed interactions that occur among the integrated resources are still needed for representing and analyzing resource integration. In other words, both a taxonomy of resource candidates and a taxonomy of resource integration practices are needed.

A practice is considered as the routine activity and sensemaking framework that actors conduct in a particular context. Practices are enacted by actors (human resources) in order to act and often to make sense of other actors' actions (Schatzki and Schatzki 1996, Reckwitz 2002). They can be adopted to capture the actions that occur among resource candidates. In this sense, resources are building blocks (e.g. telemedicine system, doctor, nurse, network) of social activities and practices integrate them into a service (e.g. telemonitoring service) (Ballantyne, Frow et al. 2011, Edvardsson, Tronvoll et al. 2011, Grönroos 2011). Resource integration is the central aspect of these practices (Korkman, Storbacka et al. 2010). In other words, as practices are enacted, resources are integrated (Vargo and Akaka 2012). Resource integration can be conceptualized as a central practice in value co-creation (Vargo and Akaka 2012). This point of view indicates that a resource integration process may consist of a set of enacted sub practices that invoke appropriate resources under a context that is constrained by institutions and influenced by actors. In addition, resources are integrated into the configurations that one service actor offers the network of service exchange in the form of value propositions (Svensson and Grönroos 2008, Vargo and Lusch 2008). In other words, resources are integrated to make up value propositions; however, the more precise anatomy of value propositions remains unclear (Skålén, Gummerus et al. 2015). Some existing research suggests that value propositions are configurations of several different practices and resources (Skålén, Gummerus et al. 2015). This implies that what a service actor really offers is a configuration in which resources are integrated by different practices.

There are three broad categories of practices recognized in the domain of the relationship between practices and a market (viewed as an exchange system), which are 1) exchange practices, 2) normalizing practices, and 3) representational practices (Kjellberg and Helgesson 2007). However, these three practice categories are proposed for market analysis, and they thereby are more appropriate for macro-level analysis. A more suitable classification of practices for the context of micro-level (i.e. a service) was proposed based on an empirical study in which the eight cases of the companies from a variety of industries were studied (Skålén, Gummerus et al. 2015). In this study, the researchers identified ten common practices organized in three main categories: provision practices; representational practices; management and organizational practices (Skålén, Gummerus et al. 2015). Since provision practices are the practices supporting other actors' value creation, they lie at the heart of a value proposition (see Table 2). Provision practices enable the value proposition by supporting other actors' value creation. Provision practice category contains three subcategories: operating practice (e.g., collecting information), problem-finding practice (e.g., investigation, assessment), and problem-solving practice (e.g., integrating IT systems). Representational practices involve articulating the value proposition by giving its meaning and structure. They are used to communicate the value proposition both externally and internally. Representational practice category contains three subcategories as well, which are naming and labelling practice (e.g., compiling lists, defining), modelling practice (e.g., business models), and interacting practice (e.g., calls with customers). Management and organizational practices support the above-mentioned two aggregates of practices. Management and organizational practices intend to fulfill the value proposition by aligning, organizing, and managing the above-mentioned two aggregates of practices. This category further has four subcategories: organizing practice (e.g., meeting), staffing and team-building practice (e.g., team building, teamwork), networking practice (similar to organizing practices such as meeting or workshops, but they are shared via a network), and knowledge-sharing practice (e.g., sharing best practices). Also, each main aggregate contains several subtype practices (Skålén, Gummerus et al. 2015). Since these practices normally overlap rather than being mutually exclusive, they are often bundled to integrate resources in a service system (Araujo, Kjellberg et al. 2008). From this view, resource integration is continually performed through enacting multiple practices (Vargo and Akaka 2012). In addition, since the concepts of value proposition and resource configuration are conceptually in line with each other, the anatomy of practices for a value proposition could be adopted as a taxonomy to comprehensively capture the interactions that occurred in resource configuration.

Table 2 A practice anatomy for resource configurations adapted from (Skålén, Gummerus et al. 2015)

Category	Subcategory
Provision Practice	Operating practice
	Problem-fining practice
	Problem-solving practice
Representational practice	Naming and labelling practice
	Modelling practice
	Interaction practice
Management and organizational practice	Organizing practice
	Staffing and team-building practice
	Networking practice
	Knowledge-sharing practice

3.2.4 The phase perspective

As noted, resource integration can be understood as a continuous and dynamic process in which a series of interactions are taken place among a set of resources to generate novel capacities for other beneficiaries. Although the process of resource integration is dynamic and may change across time and space, its phases can be conceptually illuminated.

Madhavaram and Hunt (2008) proposed a hierarchy of operant resources based on Resource-Advantage theory and S-D Logic (Madhavaram and Hunt 2008), which can be adopted to understand the phases of the resource integration process. In this hierarchy, they proposed that the process of integrating operant resources could be described in three phases: 1) Basic, Operant Resources (BORs); 2) Composite, Operant Resources (CORs); 3) Interconnected, Operant Resources (IORs). From this point of view, resources generated from late phases of resource integration are combinations of basic (operant) resources. As resource integration progresses up the hierarchy, the resource combinations become more interconnected, and they are more difficult to be developed (Madhavaram and Hunt 2008).

In this hierarchy, Basic, Operant Resources (BORs), such as specific knowledge and skills, are regarded as underlying, lower-level resources that form the building blocks of higher-order operant resources (Madhavaram and Hunt 2008). For example, if there are three basic operant resources in a context waiting for combination, they can be expressed by (A, B, C). Composite, Operant Resources (CORs) are defined as combinations of two or more distinct, basic resources with few interactions, which can enable producing service offering with value (Madhavaram and Hunt 2008). In other words, it is basically a collection of basic operant resources from which a more interconnected operant resource can be further derived. It is important to be noted that whether viewing a combination of resources as CORs does not have absolute criteria, it is determined by analytical schema (Madhavaram and Hunt 2008). For instance, one particular combination of resources may be viewed as CORs in one analysis; however, it may be considered BORs in another analysis. A CORs consisting three BORs: A, B, C can be expressed by (A+B+C). Interconnected, Operant Resources (IORs) consists of lower-level resources or resource combinations, but these lower-level resources or resources combinations have significant interactions by which reinforces each other in enabling a firm or an actor to produce efficient, effective, and valued service offerings (Madhavaram and Hunt 2008). An IORs consisting of resources: A, B, C can be expressed by A*B*C.

Although this hierarchy initially focused on describing the phases of operant resources integration (Madhavaram and Hunt 2008), it can reasonably be extended to include operand resources since 1) operand resources are necessary for resource integration and value cocreation; and, 2) all resource candidates are initially neutral in terms of resource roles (being operant or operand). In addition, this hierarchy of operant resources is conceptually in line with above-discussed emergence perspective on resource integration. That is, all resources are initially neutral in terms of status, namely resource candidates (Basic Resources (BRs)), before being invoked in resource integration; then they are collectively combined (Composite Resources (CRs)) and wait to be further intentionally interconnected; finally, a novel capacity is derived from significantly interconnecting resource combinations, and that capacity is actually an emergent resource configuration (Interconnected Resources (IRs)). From this notion, we can adapt this hierarchy to express the phases of resource integration (see Figure 13). The size of the boxes in the figure indicates the potential number of resources in each phase. Compared with the number of resource candidates in the initial phase, the number of resource configurations or composite resources generated from late phases is relatively small. The arrows of "combine" and "interconnect" indicate that resources in higher phases are generated from resources in lower phases through enacting "combination" or "interconnection" activities. The arrows come back to the boxes of previous phases since the resources (i.e. resource configurations) generated in higher phases in one service context could be viewed as lower or basic resources in the analysis of another service context.

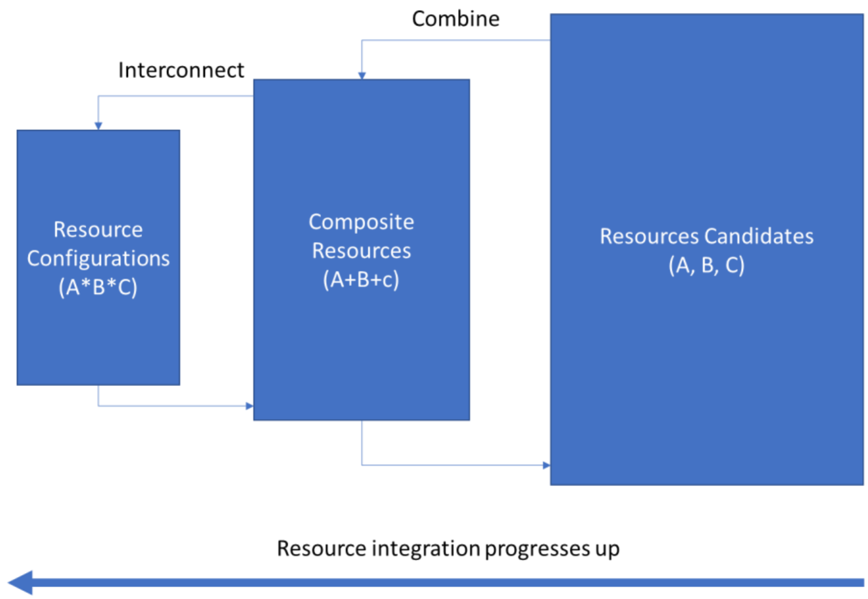

Figure 13 The phase of resource integration, adapted from (Madhavaram and Hunt 2008)

3.2.5 An integrated framework of resource configurations

Understanding service resources from the categorization, emergence, practice, and phase perspectives provides a comprehensive conceptualization of resource configurations in ICT-enabled service systems.

From the emergence perspective, a resource candidate only becomes a resource once it is invoked into a resource integration process. Acquiring a resource status for a resource candidate actually means that a certain dispositional property of this resource will be used by a service beneficiary; more importantly, a novel or unique dispositional property may be generated from integrating this resource with other resources. In fact, the intentionally generated dispositional property is a novel or unique capacity which can be offered to potential service beneficiary. By taking the S-D Logic view, this novel or unique capacity, as a result of emergence from resource integration, is a value proposition that waits for a potentially contextual acceptance from other service actors. In other words, a result of emergence from resource integration is a capacity of promising a value-in-context to other service actors.

The capacity mentioned above, as a value proposition, cannot be reduced to its various constitutive resources by adopting the emergence perspective. A value proposition is defined as a configuration of several different practices and resources (Skålén, Gummerus et al. 2015). This definition corresponds to the notion we derived from the practice perspective, in which multiple practices are enacted to integrate resources (Vargo and Akaka 2012). In this sense, practices are resource integrators (Korkman, Storbacka et al. 2010). The emergence perspective and the practice perspective help us to conceptually dissect the generated capacity which is normally viewed as a whole. Since the central aspect of practices in service systems is to integrate resources, the interactions among integrated resources can be expressed by identifying the enacted practices (Vargo and Akaka 2012). The novelty or uniqueness of the generated capacity is rooted in the uncertainty of which role a set of resources may perform and which action a set of resources may enact in a particular context. In addition, the process of resource integration can be conceptually understood with three phases (BRs, CRs, and IRs) (Madhavaram and Hunt 2008).

Based on the interpretation on all these interrelated concepts (dispositional property of a resource candidate, novel or unique capacity, value proposition, resource integration as emergence, resource integration as practices, and a hierarchy of resource integration), we define *a resource configuration as a set of resource combinations interconnected by enacting a practice, as a whole, to propose contextual value for beneficiaries.*

By integrating the proposed resource taxonomy, the adopted practice anatomy (Skålén, Gummerus et al. 2015), and the adapted hierarchy of resource integration, we propose the conceptual framework of resource configurations in ICT-enabled service systems as following Figure 14. This conceptual framework integrates the understanding of resource candidates that can be categorized, the capacity that intentionally emerges from resource combinations interconnected by enacting practices as well as three phases of resource integration. In the case of telehealth, a doctor, a nurse, an IT technician, an X-ray machine, a computer, internet, and a telemedicine system are some typical instances of resource candidates. When a telehealth service is conducted, a workflow is performed. These resource candidates are then invoked into each step of the workflow. A doctor, a telemedicine system, and internet as resources may be combined in a workflow step of "system login". An IT technician, internet, a computer may be combined in another workflow step of "network troubleshooting". These two resource combinations could further be interconnected by enacting the practice of "knowledge sharing" (under management and operational practice aggregate) to generate an (intentional and contextual) resource configuration by which the IT technician could provide a user training of that telemedicine system for the doctor. However, a resource candidate, or resource combination, or resource configuration should be defined based on the analytical purpose of a specific case. For example, a computer may be considered as a hardware under the ICT resource category in one context (e.g., a professional uses a computer as a tool to offer a service offering); meanwhile, in an analysis for a different context (an IT technician updates the operating system on a computer), the computer could be conceptually divided into a resource combination of hardware and software. Also, a resource configuration (a service offering) in one service lifecycle could potentially be viewed as a resource combination or even a resource candidate in another different service lifecycle. These possible iterative processes are captured through the relationship of "be part of" in the framework.

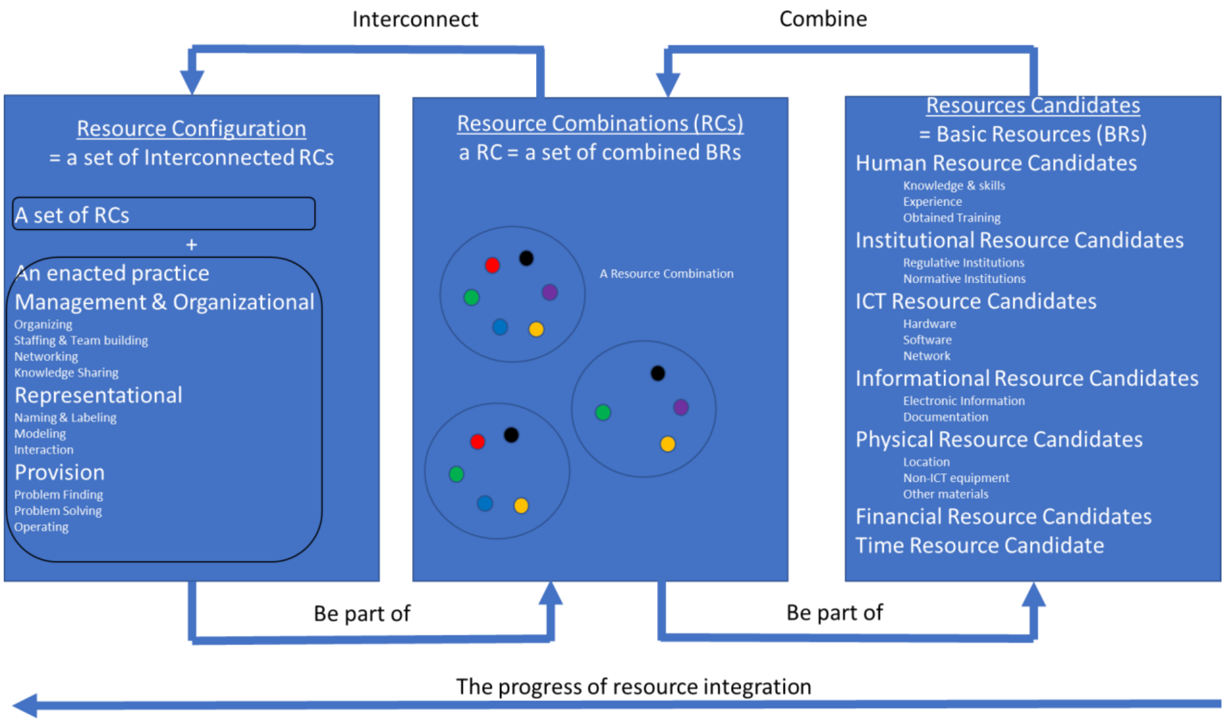

Figure 14 the conceptual framework of resource configuration

4. Metamodel of resource configurations in ICT-enabled service systems

The proposed conceptual framework identifies the core concepts and relationships to form a metamodel of resource configurations in ICT enabled service systems. Since, as noted, a resource configuration conceptually corresponds to a value proposition (namely, a service offering) and ICT-enabled service systems are viewed as the context for this study, thereby forming a more meaningful metamodel requires us to include other concepts and relationships by which a resource configuration and its life cycle are described, specifically value-in-context, value expectation and service exchange. Also, introducing these additional constructs provides the possibility of plugging the metamodel of resource configurations into a larger metamodel of service systems (Lessard, Amyot et al. 2019).

The category of a resource candidate (resource nature) is captured by the attribute of resource taxonomy, such as the resource taxonomy of ICT-enabled service systems we proposed. Although resource candidates (e.g., knowledge and skills, ICT, institutions) are discussed by using different terms in S-D Logic, service systems and related literature (e.g., FP3, FP4 and FP7 in S-D Logic as well as the concept of service system entity in service systems literature) (Maglio, Vargo et al. 2009, Vargo and Lusch 2016), they are abstracted as the construct of "*ResourceCandidates"* in the metamodel. The attributes "category" (enumerated type) and "name" (string type) are added to the construct of "*ResourceCandidates"* to specify the resource category and the name of a specific resource candidate.

As discussed in the conceptual framework, a resource integration process could be understood and described in three phases: resource candidate, resource combination, and resource configuration. The construct of *"ResourceCombinations"* is proposed to reflect the intermediate stage in which resources are collectively combined (reflected by the relationship <Combine…Combined>) in each workflow step in a service.

The construct of *"ResourceConfiguration"* describes the result of the latest phase of resource integration. The resource combinations, which come from each workflow step, are further highly interconnected by an enacted practice (reflected by the relationship <Interconnect…Interconnected>) to generate a novel or unique capacity (Madhavaram and Hunt 2008). The enacted practice is considered an attribute of a resource configuration. The attributes "practice" (enumerated type) and "name" (string type) are added to the construct of *"ResourceConfiguration"* to specify the practice category and the name of a specific resource configuration.

The notion of workflow steps was not included in the initial version of the metamodel. However, the analysis of empirical data showed that an additional unit of analysis, namely workflow steps, was required for identifying resource combinations. Also, a workflow step has a lower level of granularity a practice, which could be viewed as a specific activity conducted within an enacted practice. The attribute "workflow step" (string type) was thus added to the construct of *"ResouceCombinations."*

The metamodel of resource configurations in ICT-enabled service systems presented in Figure 15 captures the core concepts and relationships derived from the proposed conceptual framework and other related literature. However, several additional constraints are needed to be accounted when analyzing the requirements of real cases of ICT-enabled service systems (e.g. telehealth). The constraints are specified in UML's Object Constraint Language (OCL) (OCL 2006). The metamodel and associated OCL rules were formalized in USE, which is an application for the specification and validation of information systems expressed in the Unified Modeling Language (UML) and OCL rules (Richters and Gogolla 2000) (see Appendix D). This allows ascertaining that the metamodel in internally coherent and respects UML's well-formedness rules.

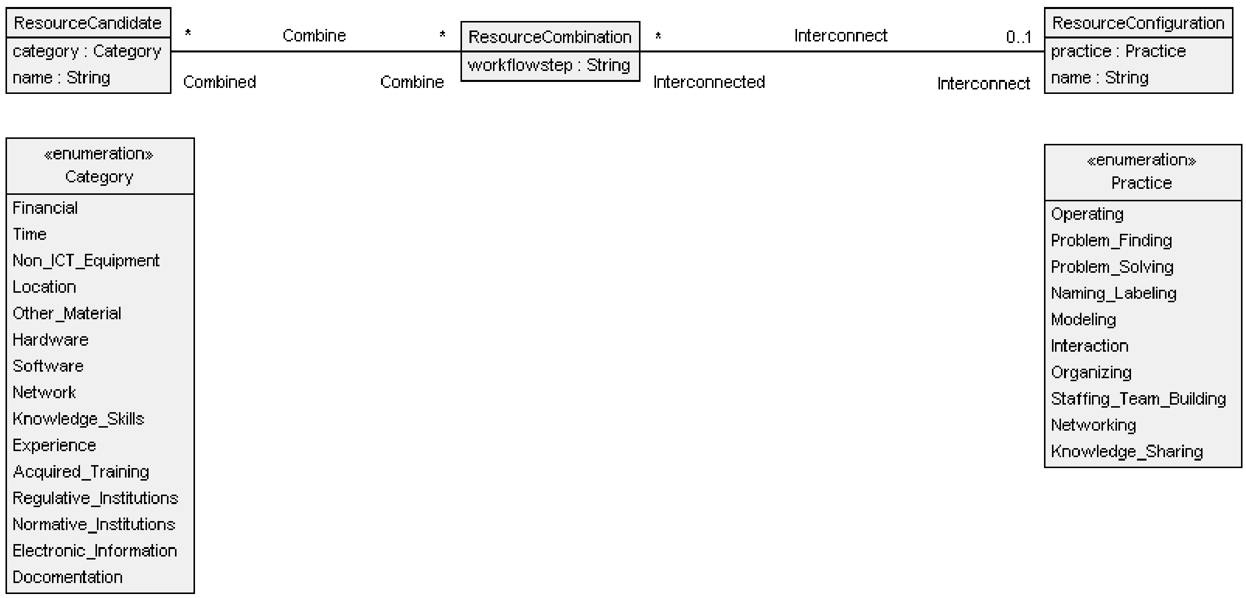

Figure 15 the metamodel of resource configurations in ICT-enabled service systems

5. Demonstration and evaluation

A multiple-case study was conducted to demonstrate and evaluate the proposed metamodel of resource configurations in ICT-enabled service systems. The case study described in this chapter and the related documents attached in Appendix A and B were reviewed and approved by the research ethics boards of both the Hospital and University of Ottawa's Office of Research and Integrity (see Appendix C). In this chapter, we discuss the results of this case study. The following sections present a summary of the case study protocol, a summary of investigated cases, and the results of demonstration and evaluation. A refined metamodel, modified in line with the study results, is presented in Section 6 (Discussion).

5.1 Background to case selection

Telehealth is a relatively new health care delivery model. This term is also interchangeably used with telemedicine (2018). The American Occupational Therapy Association defines telehealth as the application of evaluative, consultative, preventative, and therapeutic services delivered through information and communication technologies (ICTs) (Cason, Hartmann et al. 2013).

Telehealth is becoming an indispensable component of health care systems. In an official 2016 report, the United States Department of Health and Human Services estimates that more than 60% of all healthcare institutions and 40% to 50% of all hospitals in the United States have already adopted some forms of telehealth (Office of Health Policy, 2016). The adoption of telehealth is motivated by multiple goals, including improving the healthcare experience for patients, increasing the healthcare coverage of populations, and enhancing healthcare services deliverability (Tuckson, Edmunds et al. 2017). A systematic literature review conducted by the Healthcare Research and Quality in the United States also revealed the effectiveness of telehealth adoption in many healthcare service scenarios, such as remote monitoring of a patient's condition, remote counselling for patients with chronic diseases, psychotherapies for behavioural interventions through video conferences, electronic exchange of medical records, and more. (Tuckson, Edmunds et al. 2017). Its widespread adoption and effectiveness show telehealth as an important and promising service delivery model for health care.

The utilization of ICTs is a prerequisite for implementing telehealth. ICTs not only facilitates multiple telehealth care delivery models, it also further influences the service actors' behaviours and actions during service activities (Kleinschmidt, Peters et al. 2016). Those influences can be observed through a variety of telehealth service scenarios, which can be expressed through a classification of telehealth. The following table provides a classification of telehealth in terms of service actors (e.g. Clinician-to-patient or Patient-to-ICT), ICTs (e.g. video conferencing or wearable monitors), and newly developed or improved health care service interactions (e.g. remote monitoring or remote counselling) (Tuckson, Edmunds et al. 2017). It helps to understand that telehealth innovates health care services in multiple aspects and can be understood from multiple points of view including service actors, service activities, service infrastructure, service interactions, and service scenarios.

Table 3 A classification of telehealth, adapted from (Tuckson, Edmunds et al. 2017)

Service actors	ICTs	Telehealth Services

Clinician to Patient	Video, Phone, E-mail, Remote wireless monitoring, Internet	Care for chronic conditions, Medication management, Wound care, Counselling, Post-discharge follow-up, Mental health
Patient to ICT	Wearable monitors, Smartphones, Mobile Apps, Video, E-mail, Web portals, Games	Health education, Monitoring of physical activity, Monitoring of diet, Medication adherence, Cognitive fitness
Clinician-to-Clinician	E-mail, Video, Data exchange	Dermatology, Radiology, Surgical peer mentoring, Emergency trauma, intensive care unit (ICU) care

The classification shown in Table 3 represents varied service scenarios where the development and adoption of telehealth rely heavily on implementing ICTs. For instance, without remote wireless monitoring devices and videoconferencing technologies, doctors cannot remotely monitor patients' chronic conditions and further communicate with patients to provide counselling. Thus, telehealth as an innovation of healthcare services cannot come true without changing the service infrastructure by adding ICTs (Kleinschmidt, Peters et al. 2016). ICTs are one of the most discussed dimensions of service innovation (Breidbach and Maglio 2015, Lusch and Nambisan 2015, Peters 2016). Although the ultimate service objectives in telehealth remain the same as those of traditional healthcare service systems (e.g. improving the patient's physical condition), service value creation activities of healthcare service actors are changed by introducing ICTs, which improves the possibilities and efficiency of service value creation (Kleinschmidt, Peters et al. 2016). Thus, ICTs play a crucial role in realizing telehealth as a health care service innovation. Meanwhile, the service scenarios implied by Table 3 also show that it is more appropriate to consider telehealth as a service innovation of health care rather than as a technical innovation of ICTs. In addition, since traditional healthcare services focus on human interactions and personal services where personal interactions between the different service actors are essential for value creation, they are inherently human-centred service systems. However, ICTs act as an enabler of human interactions in the context of telehealth (Kleinschmidt, Peters et al. 2016). Thus, telehealth can be regarded as a representative of ICT-enabled service systems rather than pure ICT systems (Kleinschmidt, Peters et al. 2016).

5.2 Summary of cases

The research design of this multiple-case study, including the research objective, research questions, data collection methods, case selection criteria, recruitment plan and data analysis procedures are detailed in the case study protocol (see Appendix A). The remainder of Section 5.1 provides a brief description of the case study conducted at the Hospital.

Although we could identify a telehealth service at the Hospital based on the definition of telehealth such as the one provided by the American Occupational Therapy Association (Cason, Hartmann et al. 2013), the case selection of this study was based on the convention of the Hospital. The case selection aimed to reflect a diversity of telehealth services. However, services that only concerned automatic data transmission without the involvement of clinicians at the Hospital were excluded from the case selection. Based on these considerations, three telehealth cases conducted in different health care fields were selected for this study: 1) Mental health videoconferencing consultation; 2) Orthopedic videoconferencing consultation; 3) Hematology videoconferencing consultation.

This section provides a summary of the three cases investigated in the case study. Since telehealth is regarded as a representative of ICT-enabled services, three telehealth service cases were selected. Since these three cases were selected in different health care fields (mental health, orthopedic, and hematology), they vary in terms of required resources and service procedures, etc. Despite the differences between the cases, interviewees with different professional backgrounds and working roles were interviewed to provide valuable insight into resource utilization in each case. Participants played varied roles within each service, allowing the understanding of each case from different situated perspectives.

5.2.1 Case 1: mental health videoconferencing consultation

The first case presents the mental health videoconferencing consultation service at the Hospital. In general, professionals provide consultation sessions via videoconferencing in this service case. There are two different scenarios in this telehealth case: central intake and eVisit. To some extent, these two different scenarios may be considered two different telehealth services. However, those two scenarios share significant similarities in terms of resource utilization, and we view them as a single case. Central intake is the scenario in which a nurse or a social worker uses the videoconferencing functionality provided by hospital's telehealth network (HTN) to triage patients to an appropriate health care treatment. In this scenario, a secretary first receives requests from family doctors. The secretary documents the information of referrals bases on these requests. She then sends the referrals information to the nurse, who is in charge of conducting central intake. The nurse schedules and initiates a videoconferencing session with each of these patients to evaluate their situation using a pre-defined questionnaire Based on the results of the evaluation, the nurse triages the patient to an appropriate health care treatment. The second scenario focuses on eVisit, in which a social worker at the Hospital provides follow-up consultation sessions to outpatients who are far away via an eVisit functionality. eVisit is a piece of software that can be installed in personal computers or smartphones, which also provides videoconferencing functionality. In this scenario, the social worker receives referrals triaged by central intake. The social worker's main role is to make sure that the symptom of a patient is managed well after the patient has been discharged from the Hospital. The social worker typically meets with the patient once a week to provide follow-up psychoeducation sessions and make sure the patient is in good mental health condition.

5.2.2 Case 2: orthopedic videoconferencing consultation

The second case focuses on orthopedic videoconferencing consultation. The service is typically offered when a patient is going to have orthopedic surgery. For example, if the patient needs a prosthesis placement, a nurse with a surgeon or a doctor will provide a consultation session to patients before the surgery to discuss the detail concerns from the patient. This consultation session is also conducted through videoconferencing. The nurse and the surgeon (or the doctor) show the prosthesis to the patient during the videoconferencing session. Also, they adopt a specific questionnaire to gather related information from the patient. In addition, they are basically required to answer all the questions asked by the patient.

5.2.3 Case 3: hematology videoconferencing consultation

The third case concerns a hematology videoconferencing consultation service. This case can be described in two parts. The first part is for initiating the first session with a patient. A physician sends a consultation request in the form of hard copy by fax to the hematology clinic at the Hospital. A doctor there receives the request and assesses it by checking the related forms. The doctor schedules all requested consultation sessions based on assessing the priority of each request. The doctor then sends the schedule of these sessions to the scheduler, who is in charge of contacting patients and setting up appointments. The second part is for recurrent visits. The doctor mentioned above may need to see the patient every certain period, for example, every six months. The doctor informs the arrangement of the recurrent visits during the session with a patient. Also, the doctor creates an appointment card for the follow-up appointments. A nurse keeps track of these appointment cards. The doctor conducts the consultation sessions via video conferencing functionality.

5.3 Participants

Any professional who was knowledgeable about the aims, functioning and evolution of the selected telehealth service cases were considered potential participants for this case study. In each selected case, at least two professionals from different perspectives (the clinical or technical perspective) were interviewed. The “Special Projects Advisor – Telemedicine” (hereinafter referred to as “the Advisor”) at the Hospital was also invited as the collaborator and the key informant for this case study to provide data from the administrative perspective. Interviewing participants from different perspectives could enhance the richness and comprehensiveness of the collected data of this case study. The participants interviewed for each case are presented in Table 4 and described as following.

Table 4 Participants for each case

Participants for each case				
	Mental health videoconferencing consultation		Orthopedic videoconferencing consultation	Hematology videoconferencing consultation
	Central intake	eVisit		

Clinical perspective	P1: Nurse conducting central intake	P2: Social worker conducting eVisits	P3: Nurse responsible for Orthopedic telemedicine service	P4: Nurse responsible for Hematology telemedicine service
Technical perspective	P5: IT technician responsible for HTN systems			
Administrative perspective	P6: The Special Projects Advisor – Telemedicine			

5.3.1 Participants of case 1

Four participants specializing in different areas were recruited for the case. The first participant recruited for this case is the nurse who is in charge of conducting central intake. The second participant interviewed is the social worker who conducts eVisit sessions. The third participant that we interviewed is an IT technician who is in the IT support team at the Hospital. The IT technician is in charge of maintaining the HTN systems at the Hospital. Also, we interviewed the Advisor. Since the Advisor is responsible for telemedicine services in general at the Hospital and can provide insight for the case from the administrative perspective.

5.3.2 Participants of case 2

Three participants with different working roles were recruited for this case. The first participant is the nurse who conducts the service of orthopedic videoconferencing consultation. We interviewed her to collect data from the clinical perspective. The second participant is the IT technician who could provide the information related to resource utilization in this service from the technical perspective. Also, the Advisor who is responsible for managing telemedicine in general was interviewed to provide data from the administrative perspective.

5.3.3 Participants of case 3

Three participants with different working roles were interviewed for this case. The first participant is the nurse who keeps track and attends the sessions of hematology videoconferencing consultation. Also, we collected data on resource utilization from the IT technician as the second participant. In addition, the Advisor, who manages telemedicine systems at the Hospital in general, participated to provide data from the administrative perspective.

5.4 Collected data

Interviews were semi-structured, guided by the questionnaire described in the interview protocol (see Appendix B). The questionnaire created in the interview protocol (see Appendix B) was divided into two sections to facilitate data analysis: the first section (Section 1) aimed to collect data on participants' perception and understanding of the purpose, functioning, workflow, and evolution of the selected cases; the second section (Section 2) directly asked participants to mention the resources currently used within the service from their situated perspectives. The data collected from Section 1 was used to generate List 2 in the data analysis phase (see Section 5.1.5); the data collected from Section 2 was used to generate List 1 in the data analysis phase. Participants were provided with a generic definition of the term "resource" from an English dictionary and the resource taxonomy proposed in the metamodel of ICT-enabled service systems to facilitate data gathering in Section 2 and to ensure consistency among interviews. Data was also collected through demonstrations of selected telehealth systems by the Advisor at the Hospital and through relevant documentation. Collecting data from the three different data sources (interviews, system demonstration, and documentation) strengthens the results of this case study (Yin 2017). Especially, adopting a combination of different data sources can limit interpretation bias by allowing us to verify if the same conclusions can be drawn from several sources of information (Runeson and Höst 2008). The sources of data collected in each case are described in the following Table 5.

Table 5 Data source for each case

<table>
<tr><th colspan="5">Data source for each case</th></tr>
<tr><td></td><td colspan="2">Mental health videoconferencing consultation</td><td>Orthopedic videoconferencing consultation</td><td>Hematology videoconferencing consultation</td></tr>
<tr><td></td><td>Central intake</td><td>eVisit</td><td></td><td></td></tr>
<tr><td>Interview (clinician)</td><td>the interview with P1 (40:36)</td><td>the interview with P2 (41:01)</td><td>the interview with P3 (46:36)</td><td>the interview with P4 (45:51)</td></tr>
<tr><td>Interview (technician)</td><td colspan="4">the interview with P5 (52:01)</td></tr>
<tr><td>System demonstration (administration)</td><td colspan="4">the field note for the system demonstration provided by P6 (40:46)</td></tr>
<tr><td>Documentation</td><td colspan="2">the Hospital’s mental health program form;
the Hospital’s mental health slides;
the Travail social form;
the HTN documentation of mental health.</td><td>the Hospital’s Knee Arthroplasty brochure;
the Knee X-Ray Results form;
the Knee Physical Exam form;
the Knee History form;
the Medical History form;
the HTN documentation of orthopedic</td><td>the HTN documentation of hematology</td></tr>
</table>

5.5 Data analysis

The interview transcripts of each case were coded for data analysis. The system demonstration field notes and relevant documentation were adopted as data sources for background understanding. The data analysis was conducted in two phases: the evaluation phase and the demonstration phase. To reduce the risk of bias, two researchers (the principal investigator and the co-investigator) reviewed, piloted and discussed the coding schemes and each step within the data analysis procedures. Specifically, the co-investigator independently executed each step within each phase for one selected case. Any disagreement on the proposed data analysis procedure and the results derived from the case that was coded separately by each researcher was discussed until consensus was achieved.

In the evaluation phase, the resource taxonomy coding scheme (see Resource taxonomy coding scheme, Table 2 of Appendix A) was applied to each entire interview transcript of a given case. In demonstration phase, two other coding schemes (see Resource Combination coding scheme, Table 3 of Appendix A and Resource Configuration coding scheme, Table 4 of Appendix A) were applied to the interview transcripts of each case to identify the list of resource combinations and resource configurations in each selected cases. The proposed metamodel defines a resource combination as a set of resources used in a particular workflow step within an ICT-enabled service. Based on the definition of resource combination, the resource combination coding scheme was proposed to identify each step within the workflow of a selected case. Since a particular workflow step may logically be identified based on the semantic and grammatical structure of transcripts, adverb, conjunction, punctuation, and word order as three types of clues were included as the coding scheme to help us identify each workflow step in a case (see Resource Combination coding scheme, Table 3 of Appendix A). The resource taxonomy coding scheme was also adopted to identify resources in a particular resource combination. In addition, the adopted ten common practice types (Skålén, Gummerus et al. 2015) were relied on to create the resource configuration coding scheme (see Resource configuration coding scheme, Table 4 of Appendix A) for identifying the practices in each interview transcript in this case study.

5.6 Evaluation results

Two lists were generated from the data analysis of each case in the evaluation phase. The first list of required resources for a given case was generated from the second section of the interview (List 1). The second list of required resources for a given case was generated from the first section of the interview (List 2). The validity of the metamodel was evaluated by comparing List 2 with List 1 to evaluate if the developed resource taxonomy could adequately and comprehensively identify resources in the selected telehealth cases. An evaluation was conducted in six steps:

1. Applied the resource taxonomy coding scheme (see Resource taxonomy coding scheme, Table 2 of Appendix A) to each transcript, including Section 1 and Section2.
2. Generated "List 1" from the coded Section 2 of each transcript. This list includes anything directly mentioned as a resource (e.g., "videoconference software") by a participant during each interview.
3. Since at least two participants per telehealth case were interviewed, a merged "List 1" was created for each case. The merging process entailed the removal of duplicate resources among coded transcripts, and the combination of the remainder of codes so that each identified resource was only listed once in the final "List 1" for each case.
4. Generated "List 2" from each entire transcript.
5. Merged individual "List 2" within each case as described in Step 3. The resulted "List 2" thus contains the resources identified in each case's "List 1", as well as additional

resources indirectly identified by participants (e.g., when describing a typical scenario for their service).

6. Compared Lists 1 with Lists 2. If a given List 2 could identify additional resources, for example, “knowledge” that might have been implicit in its related List 1. Such results would testify the validity of the resource taxonomy within the metamodel for professionals since it would indicate that potentially important resources are not currently being identified and planned for.

The following sections present the results generated from phase 1 of the data analysis procedure. For each case, the merged List 1 and the merged List 2 are presented. Resources in blue refer to additional resources identified in each merged List 2.

5.6.1 Results of case 1

By comparing List 1 and 2 generated from this case, we identified several additional resources, which shows the validity of the proposed resource taxonomy. These additionally identified resources are from the categories of time, location, hardware, software, knowledge & skills, electronic information, and documentation.

Table 6 Merged list 1 for the mental health videoconferencing consultation case

Merged list 1 for the mental health videoconferencing consultation case		
Classifications / Sub-classifications		
Financial Resource Candidates		Funds for purchasing a webcam, funds for buying the material, funds for being an HTN member
Time Resource Candidate		The availability of webcam for clinicians, the priority of HTN sessions to use the rooms
Non-ICT Physical Resource Candidates		
	Non-ICT equipment	
	Location	Physical infrastructure for clinicians, set-up offices, rooms with HTN systems
	Other materials	Paper, pen
ICT Resource Candidates		
	Hardware	Computer, camera, speaker, screen, webcam, HTN hardware, microphone
	Software	Personal Computer Video Conferencing (PCVC), email, Chrome, HTN hub, MEDITECH
	Network	Internet connection, the Hospital internal network
Human Resource Candidates		
	Knowledge & skills	IT person, nurse or social worker, psychiatrist, archivist
	Experience	Nurse or social worker’s previous experience of conducting this service
	Acquired Training	The license of nurse, the speciality of psychiatrist, the training of how to use HTN for clinicians; the training of how to use webcam for clinician
Institutional Resource Candidates		

	Regulative Institutions	The college of nurses, the Hospital has a big section of regulation described in French (including policies and procedures), general confidentiality
	Normative Institutions	The norms of nurses
Information Resource Candidates		
	Electronic information	The scanned form, which is stored in a computer, documentation in the HTN's website
	Documentation	The assessment questionnaire form

Table 7 Merged list 2 for the mental health videoconferencing consultation case

Merged list 2 for the mental health videoconferencing consultation case		
Classifications / Sub-classifications		
Financial Resource Candidates		Funds for of purchasing a webcam, buying the material, funds for being an HTN member
Time Resource Candidate		The availability of webcam for clinicians, HTN session has priority in those rooms, the availability of the patient, the availability of another site, the time duration of the following treatment for the patient, 1-hour duration of psychiatrist in DEP sessions
Non-ICT Physical Resource Candidates		
	Non-ICT equipment	
	Location	Physical infrastructure for clinicians, set-up offices, the rooms with HTN systems, the location of another site, 30 mins duration of central intake sessions
	Other materials	Paper, pen
ICT Resource Candidates		
	Hardware	Computer, camera, speaker, screen, webcam, HTN hardware, microphone, phone, fax, TV
	Software	PCVC, email, Chrome, HTN hub, MEDITECH, video conferencing
	Network	Internet connection, the Hospital internal network
Human Resource Candidates		
	Knowledge & skills	IT person, nurse or social worker, psychiatrist, archivist, the knowledge and skills of family doctor, the skills of front desk, the knowledge and skills of staff of another site, the skills of secretary for DEP psychiatrist, the skills of clerk, the administrative knowledge and skills of manager
	Experience	Nurse or social worker's previous experience of conducting this service
	Acquired Training	The license of nurse, the speciality of psychiatrist, the training of how to use HTN for clinicians; the training of how to use webcam for clinician

Institutional Resource Candidates		
	Regulative Institutions	The college of nurses, the Hospital has a big section of regulation described in French (including policies and procedures), general confidentiality
	Normative Institutions	The norms of nurses
Information Resource Candidates		
	Electronic information	The scanned form, which is stored in a computer, documentation in HTN's website, every request from the family doctor, the referral sent to nurse by the front desk
	Documentation	The assessment questionnaire form, criteria, gathered info on which service is suitable for the patient, a bunch of pamphlets

5.6.2 Results of case 2

By comparing the list 1 and list 2 generated from this case, we identified several additional resources, which shows the validity of the proposed resource taxonomy. These additionally identified resources are from the categories of hardware, software, knowledge & skills, and documentation.

Table 8 Merged list 1 for the orthopedic video conferencing consultation case

Merged list 1 for the orthopedic video conferencing consultation case		
Classifications / Sub-classifications		
Financial Resource Candidates		Salary of therapist, salary of clerk 1 (call patients and organize everything), salary of clerk 2 (book telemedicine), salary of coordinator, salary of P1, global fixed fee for HTN, fixed funds for the Hospital's internet infrastructure, funds for software's licenses, funds for appointment requests,
Time Resource Candidate		Availability of offices, availability of technologies, availability of HTN systems, availability of computers, availability of nurses
Non-ICT Physical Resource Candidates		
	Non-ICT equipment	X-ray machine
	Location	Office with privacy
	Other materials	Desk, chair, lighting
ICT Resource Candidates		
	Hardware	Computer, camera, speaker, phone, tablet, laptop, fax
	Software	HTN system, PCVC, PACES system (for x-ray images), vmware, Meditech
	Network	
Human Resource Candidates		
	Knowledge & skills	Doctor's knowledge to do telemedicine
	Experience	Doctor's experience to do telemedicine
	Acquired Training	Coordinator or P1's company in first three sessions for a new professional, college of nurse, college of doctor

Institutional Resource Candidates		
	Regulative Institutions	Accreditation of telemedicine in French or English
	Normative Institutions	
Information Resource Candidates		
	Electronic information	Schedule of appointments, code of appointments for statistic and billing, elaborated video in French (about telemedicine), electronic forms, EMR in Meditech for all of the patient information
	Documentation	The Hospital's protocol, paper charts

Table 9 Merged list 2 for the orthopedic video conferencing consultation case

Merged list 2 for the orthopedic video conferencing consultation case		
Classifications / Sub-classifications		
Financial Resource Candidates		Salary of therapist, salary of clerk (call patients and organize everything), salary of clerk (book telemedicine), salary of coordinator, salary of P1, global fixed fee for HTN, fixed funds for the Hospital's internet infrastructure, funds for software's licenses, funds for appointment requests
Time Resource Candidate		Availability of offices, availability of technologies, availability of HTN systems, availability of computers, availability of nurses
Non-ICT Physical Resource Candidates		
	Non-ICT equipment	X-ray machine
	Location	Office with privacy
	Other materials	Desk, chair, lighting
ICT Resource Candidates		
	Hardware	Computer, camera, speaker, phone, tablet, laptop, fax, TV screen
	Software	HTN system, PCVC, PACES system (for x-ray images), VMware, Meditech
	Network	The Hospital network infrastructure
Human Resource Candidates		
	Knowledge & skills	Doctor's knowledge of conducting telemedicine Telemedicine advisor's knowledge of guiding professionals during services, Telemedicine advisor's skill of giving professionals access, Telemedicine advisor's knowledge of supporting professionals during consultation, Telemedicine advisor's knowledge of educating professionals, doctor' knowledge of diagnosing patients, a nurse as a coordinator with coordinating skills, a nurse's knowledge of teaching and elaborating some protocols, a clerk's skill of conducting scheduling in both HTN and Meditech

	Experience	Doctor's experience of conducting telemedicine
	Acquired Training	Coordinator or P1's company in first three sessions for a new professional, college of nurse, college of doctor
Institutional Resource Candidates		
	Regulative Institutions	Accreditation of telemedicine in French or English
	Normative Institutions	
Information Resource Candidates		
	Electronic information	Schedule of appointments, code of appointments for statistic and billing, elaborated video in French (about telemedicine), electronic forms, EMR in Meditech for all of the patient information
	Documentation	The Hospital's protocol, paper charts, a specific questionnaire that is asked during a session, education material for patients, booklet for patients, pamphlet talking about confidentiality

5.6.3 Results of case 3

By comparing the list 1 and list 2 generated from this case, we identified several additional resources, which shows the validity of the proposed resource taxonomy. These additionally identified resources are from the categories of time, location, hardware, software, knowledge & skills, electronic information, and documentation.

Table 10 Merged list 1 for the hematology video conferencing consultation case

Merged list 1 for the hematology video conferencing consultation case		
Classifications / Sub-classifications		
Financial Resource Candidates		Salary of coordinator, salary of scheduler, funds for providing locale, funds for buying IT systems, funds for buying HTN assistance, funds for (long distance) telephone
Time Resource Candidate		
Non-ICT Physical Resource Candidates		
	Non-ICT equipment	
	Location	Room equipped by HTN system
	Other materials	
ICT Resource Candidates		
	Hardware	Computer at the Hospital, computer at another site, faxing machines
	Software	Email system, (long distance) telephone, auto fax system (changing to), HTN system, scheduling system, ENCOMPASS system, eVisit, PCVC, SharePoint system, Meditech system
	Network	Network infrastructure
Human Resource Candidates		
	Knowledge & skills	Skill of faxing a document, skill of emailing a document, skill of receiving a document via fax or email or system, doctor's knowledge of reviewing patient's condition, skill of conducting

		paperwork, skill of auto faxing, knowledge of scheduler, knowledge of clinic clerk, knowledge of IT specialist, knowledge of decision making from higher management, skill of scanning a document
	Experience	Specialist's Experience of HTN and ENCOMPASS (good to have)
	Acquired Training	Training for scheduler, training for clinic clerk, orientation of staff, one-to-one training practice, brainstorm across different telehealth services
Institutional Resource Candidates		
	Regulative Institutions	Policy of sending a prescription (not directly to patient), policy of sending a requisition (to patient), the Hospital's five main strategies
	Normative Institutions	KAIZEN procedure, procedure of scheduling
Information Resource Candidates		
	Electronic information	Fax number of pharmacies, name of pharmacies, protocol as an attachment in HTN, public documentation of HTN, public video clips in HTN website, protocol of orthopedic service, all policies and procedures kept in SharePoint, patient' chart
	Documentation	Bloodwork form, Requisition, worksheet of patient's basic information, prescription

Table 11 Merged list 2 for the hematology video conferencing consultation case

Merged list 2 for the hematology video conferencing consultation case		
Classifications / Sub-classifications		
Financial Resource Candidates		Salary of coordinator, salary of scheduler, funds for providing locale, funds for buying IT systems, funds for buying HTN assistance, funds for (long distance) telephone
Time Resource Candidate		Availability of outside HTN site's system, availability a specific period during a month in a outside HTN site
Non-ICT Physical Resource Candidates		
	Non-ICT equipment	
	Location	Room equipped by HTN system, outside HTN site (family health center, community health center, family physician having HTN system)
	Other materials	
ICT Resource Candidates		
	Hardware	Computer at the Hospital, computer at another site, faxing machines, laptop (changing to eVisit), smartphone (changing to eVisit)
	Software	Email system, (long distance) telephone, auto fax system (changing to), HTN system, scheduling system, ENCOMPASS system, eVisit, PCVC, SharePoint system, Meditech system, auto-fax (changing to)

	Network	Network infrastructure
Human Resource Candidates		
	Knowledge & skills	Skill of faxing a document, skill of emailing a document, skill of receiving a document via fax or email or system, doctor's knowledge of reviewing patient's condition, skill of conducting paperwork, skill of auto faxing, knowledge of scheduler, knowledge of clinic clerk, knowledge of IT specialist, knowledge of decision making from higher management, skill of scanning a document, knowledge of registered nurse, skill of telemedicine coordinator to scheduling appointments and support physician, knowledge of physician, knowledge of a doctor to assess a form, knowledge of a doctor to prioritizes appointments charts, skill of doctor to inform patients recurrent visits (follow-up), skill of nurse to keep tracking follow-up appointments, skill of scheduler to start a process of booking recurrent visits, skill of clerk, knowledge of a nurse to support the doctor during sessions, skill of a doctor to fill up forms, knowledge of outside HTN site's nurse to conduct quick assessment for patients, skill of outside HTN site's nurse to summarize telehealth session for patient
	Experience	Specialist's Experience of HTN and ENCOMPASS (good to have)
	Acquired Training	Training for scheduler, training for clinic clerk, orientation of staff, one-to-one training practice, brainstorm across different telehealth services
Institutional Resource Candidates		
	Regulative Institutions	Policy of sending a prescription (not directly to patient), policy of sending a requisition (to patient), the Hospital's five main strategies
	Normative Institutions	KAIZEN procedure, procedure of scheduling
Information Resource Candidates		
	Electronic information	Fax number of pharmacies, name of pharmacies, protocol as an attachment in HTN, public documentation of HTN, public video clips in HTN website, protocol of orthopedic service, all policies and procedures kept in SharePoint, patient' chart, address of patients
	Documentation	Bloodwork form, Requisition, worksheet of patient's basic information, prescription, hardcopy of consultation request, a list of medication of patient, share the same documentation as in-person visit, marking the visit as telemedicine

The validity of the proposed resource taxonomy in the metamodel can be justified through the evaluation since we identified additional resources in each selected case. Also, the compare results across these three cases reveal some commonalities. Firstly, hardware, software, knowledge & skills, and documentation are the common categories in which we identified the additional resources. This implies that these resource categories need more attention for the telehealth service planning at the Hospital. Secondly, the resource category of knowledge and skills contains the most of additional resources in each case. This finding reflects that human resources, as operant resources, play the most important role in telehealth service planning. Thirdly, clinicians at the Hospital often encounter availability issues related to IT systems and workspaces. These issues occur in another site as well, which often delay offering a service to patients.

5.7 Demonstration results

The capacity of the developed metamodel to identify the resource configurations was demonstrated by the results which were generated from codding the transcripts of each case by applying the resource combination coding scheme (Table 3 of Appendix A) and the resource configuration coding scheme (Table 4 of Appendix A). The resource configurations were captured within two parts: 1) resource combination; 2) resource configuration, which correspond to the constructs of resource combination and resource configuration of the proposed metamodel. Since the metamodel defines a resource configuration as a set of resource combinations interconnected by enacting practices, the capacity of the developed metamodel to capture resource configurations within the selected cases was demonstrated by conducting the following steps.

1. Applied the resource combination coding scheme (see Resource Combination coding scheme, Table 3 of Appendix A) to each transcript.
2. Generated a list of resource combinations from each transcript. This list attributes resources to their relevant workflow step.
3. Since at least two participants per telehealth case were interviewed to generate a list of resource combinations for each case, a merged list of resource combinations was created by merging all generated lists of resource combinations together for each selected case.
4. Applied the resource configuration coding scheme (see Resource Configuration coding scheme, Table 4 of Appendix A) to each transcript.
5. Generated a list of resource configurations (practices) from each transcript. This list includes all enacted practices by which a set of resource combinations were interconnected to provide a telehealth service as described by each participant.
6. Since at least two participants per telehealth case were interviewed to generate a list of resource configurations for each case, a merged list of resource configurations was created by merging all generated lists of resource configurations together for each selected case.

This demonstration of the metamodel shows how to apply the metamodel to a selected telehealth case as well as the relevance of the metamodel to telehealth professionals.

The following sections present the results generated from phase 2 of the data analysis procedure. The "Events" column shows representative quotes that were generated by applying the resources combination coding scheme (Table 3 of Appendix A). Then we identified all resources in each representative quote (the "resource combinations" column), which further formed a resource combination. The actual service workflow step in each quote was marked by using short terms. The interconnected resource combinations eventually formed a resource configuration by enacting a practice, which is presented in the "practices" column. The populated metamodels with the partial contents of each case are presented along with each demonstration list as well.

5.7.1 Results of case 1

Table 12 Demonstration list of the mental health video conferencing consultation service case

Demonstration list of the mental health video conferencing consultation service case			
Events	**Resource combinations**	**Workflow Step**	**Practices**
"now we are receiving every request from the family doctor. It goes through our I don't know it's not a secretary, but she works at the front desk, "	family doctor, request from the family doctor, front desk secretary	Receive request	Collect information (Operating practice)
"she enters this into Excel just so that it's somewhere in, it's working in the computer, so it's stored somewhere in a computer so that we know it's somewhere if someone calls us"	front desk secretary, records, excel form, computer	Store request	
"and after that she send us their referral to us"	front desk secretary, referral information, nurse	Send request	
"So, I'm the first person that the patient usually will see by videoconference. So, I call the patient myself and make an appointment. "	nurse, HTN, phone, appointment scheduling	Set appointment	Call patients and facilities by phone (Interaction practice)
"and then we call a patient with other patient with their availability and if we see that it's a possibility to do a teleconference"	nurse, phone, availability of patients	Check patient's availability	
"we offer them this service and right now what I'm doing is I'm giving them an appointment saying that the appointment is goanna be checked if it's available on the other side in the other clinic. "	nurse, phone, appointment scheduling, availability of another site	Check site's availability	
"we just do a little triage just looking at the paper make sure that if the	nurse, patient information, criteria	Check patients based on the criteria	Assess patient's situation

patient fits into our criteria”			(Problem-finding practice)
"So before starting the intake usually I say okay I'm just goanna ask you some administrative things and I ask his address I ask it you know more like phone number and then I ask where is he right now taking the phone call so I can get this information just in case something goes wrong and is there an emergency phone number like in someone I could call if we have an emergency something like that so at least if something goes wrong I can call that person or something like that but right now no and at the same thing for the psychiatrist consult there's nobody that there's no assistance there that needs to be done. "	nurse, address information of patients, contact information of patients, emergency contact information of patients, nurse, psychiatrist	Collect patient's information	Collect information (Operating practice)
“So after all this is done the appointment is done we meet on the same date, like I come to my computer a register in HTN he where he's at the patient the staff there they register they opened the HTN hub and then the conference comes on we do our intake the intake is a questionnaire”	nurse, computer, HTN at the Hospital, staff at another site, HTN at another site, questionnaire	Login HTN system	Diagnose patient's situation (Operating practice)

“We go through, this is the one questionnaire here, that takes usually about 30 minutes, and after the intake, the objective of this meeting is to gather information make sure that we assign the patient to the right service in our clinic”	nurse, questionnaire, availability of nurse, information of patient	Conduct consultations using the questionnaire	
"so after doing the intake we start discussing what the service we could offer the patient, and then he confirms with us this is what he was seeking for, and then we explained the amount of time and we ask more for specific like this he prefers a man or a woman or young, sometime they have preference, and then we explained the amount of time"	nurse, questionnaire, information of patients, confirmation from patients,	Conclude the consultation's results	Conclude the follow-up service offerings (Interaction practice)
"and we say that he's goanna receive a phone call from a secretary and about the number of months it takes to see if that person okay. "	front desk secretary, phone, information of service	Inform the follow-up call	
"it is just the therapist at the site over there they like to learn on whatever we're teaching so they participate in the group"	therapist, nurse, teaching material	Other sites participate to share the session content	Share knowledge with other sites (Knowledge-sharing practice)

"so whenever we finish the intake usually we discuss pretty much every case and we take a decision together make sure that we triage the patient right and whenever there's more complex cases we have a meeting once every two week with the intake team and the intake team is meet a social worker the psychiatrist in chief of the department and our manager and a clerk and so we can discuss about more complex that we have a hard time a triage"	nurse, information of cases, social worker, psychiatrist, manager, clerk	Meet with colleague to discuss cases	Conduct the team meeting for improving the quality of intake assessment (Organizing practice)
"we do the same thing, sometime if she calls in sick, I can take all her case "	nurse, social worker	Shift between the nurse and the social worker	Arrange teamwork (Staffing and team building practice)
"A clerk and yes IT. Because I have to call them sometime there's a shutdown with the computer "	clerk, IT technician, computer	Request IT support	Solve issues related to IT systems (Problem-solving practice)
"and like I said like my manager to support me into my decisions. "	nurse, manager, decision of case triage	Request decision making support for cases	Obtain best practice from the manager (Knowledge-sharing practice)
"The secretary will call and do the more administrative book the appointments and everything "	the front desk secretary, phone, appointment scheduling,	Set appointments	Telephone call patients and facilities (Operating practice)
"and then the psychiatrists will open their computer and they'll do the	psychiatrists, computer, HTN at the Hospital, room, HTN at another site	Conduct consultation sessions	Diagnose patient's situation

appointments with the patient in the same way."			(Operating practice)
"Usually it takes about an hour to do the consultation and they'll send whenever they're finished, they go they do pretty much they give their recommendation to the patient"	nurse, availability of nurse, recommendation information for patients,	Conclude follow-up service offerings	
"and then they send a fax to the family doctor with the recommendation and the consultation."	nurse, fax machine, family doctor	Send the conclusion of a consultation session	Inform family doctor with consultation recommendation (Interaction practice)
“they get in touch with the therapist there at the clinic over there so that the people that will show up.”	nurse, therapist at another clinic, room at the Hospital, room at another site	Contact clinical professionals at another site	Assess patient's situation (Problem-finding practice)
“for their group will have the right documentation to follow through and then the TV in the room where everybody meets for the group will be open.”	documentation, TV screen, room, HTN system, nurse, therapist	Conduct a consultation session following by the documented procedures	
“and the patient will sit in the clinic over there like in north let's say and will be in front of a TV and the rest of the group that are here will see a TV with a patient and we can collaborate all together.”	clinic room, availability of clinic room, TV screen, nurse	Assess a patient's situation through the collaboration with another site's professionals	

We populated an instance model based on the partially selected data of case 1 (collecting information) (Figure 16). This instance model was created by using UML Object diagrams (Seidl, Scholz et al. 2015) in the USE tool (Gogolla, Büttner et al. 2007). The attributes of the three constructs were assigned with the values based on the data from case 1. The resource candidate “front desk secretary” was combined into more than one resource combination (“receive request” and “store request”). Also, the red links demonstrated the relationships of <Combine…Combined> and <Interconnect…Interconnected>. In addition, the demonstration of this instance model also provides an example of how to apply the proposed metamodel to an ICT-enabled service case.

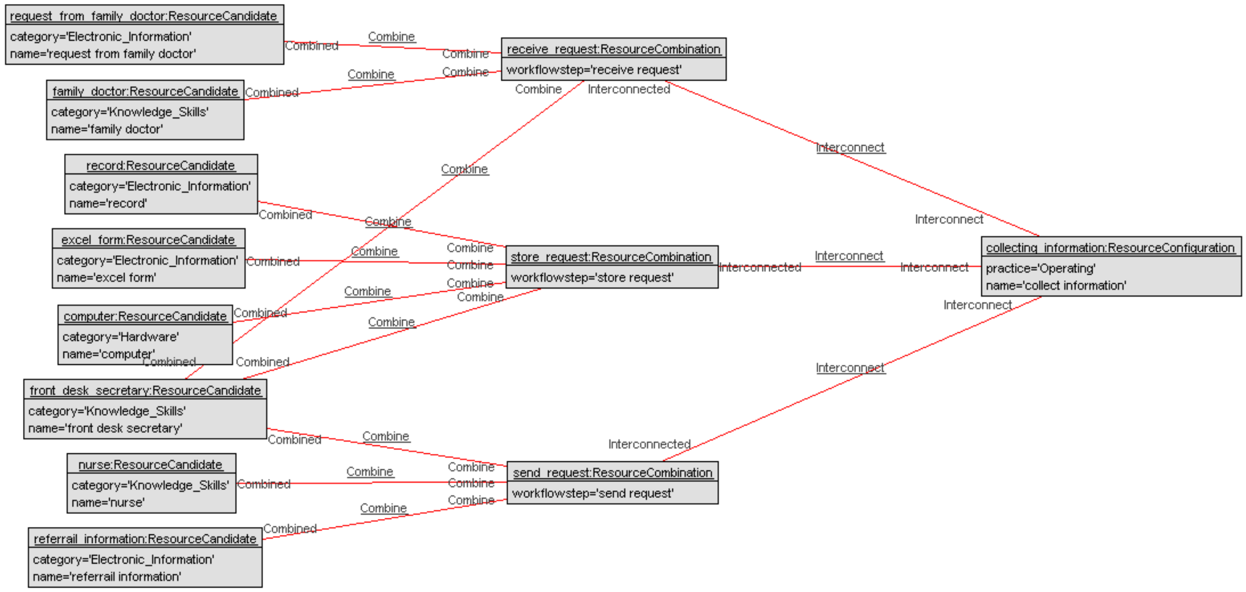

Figure 16 a populated metamodel for case 1

5.7.2 Results of case 2

Table 13 Demonstration list of orthopedic videoconferencing consultation service case

Demonstration list of orthopedic videoconferencing consultation service case			
Events	**Resource combinations**	**Workflow Step**	**Practices**
"this appointment is 15 minutes,"	time availability	check time availability	Check availability (Interaction practice)
"we had a patient where the orthopedic doctor is here at the Hospital, and the patient was let's say in Trenton, the patient had surgery here at the Hospital, and the doctor was seeing the patient maybe six weeks post-op after surgery, "	time availability, doctor	check time availability	
"the clerk will do that the clerk will call the patient to tell them that they have an appointment and will tell them where they have to go because sometimes the patient comes to the Hospital here, but sometimes the patient goes to another site, so the clerk job is that."	clerk, location availability	check location availability	

"we also have a clerk and the clerk does the scheduling into our two system. because whenever we do appointments for those patients, we needed to do into the HTN system, and we need to do it also in our hospital system,"	clerk, HTN, Meditech, appointment information	Maintain appointment information in multiple systems	Maintain schedule in systems (operating practices)
"we answer all of their questions; we have a specific questionnaire that we ask them."		Assess patients by using questionnaire	Assess patients (Problem-finding practice)
"the doctor will ask that the patient have x-ray done before, and the doctor will look at the x-ray, they will be on another screen, and the doctor will discuss that with the patient, "	doctor, patient's x-ray photo, screen	Discuss x-ray results with patients	
"if they need to do something specific, the doctor will ask if the patient has pain, if the patient is comfortable walking and all of those questions."	doctor, instruction	Assess patients by instructions	
"and usually what we do is we try and show them what the prosthesis is going to look like, let's say they're getting a new knee or a new hip, so we show them what its goanna looks like. so, we do have some how would I call it tools, not just pictures, and we show them what is going to look like, so we show that through the camera,"	prosthesis, camera, doctor, nurse	Show prosthesis through camera	Educate clinical related content (Interaction practice)
" and after that we answer the questions that they might still have remaining. there they do get education material, so there's books that we give	questionnaire, doctor, nurse, booklet, books, educational material	Educate patients about the surgery	

them, and it tells the whole process of when they're goanna have their surgery, prior to surgery, when they have surgery, and after surgery so everything is in a booklet that is available on our site, "			
"she's here to explain to them how the telemedicine will work, what they have to do that it is the same as if they would be in front of the doctor, so education is done to the patient that way. "	professionals of another site, educational content of telemedicine systems	Educate patients about the use of telemedicine system	Educate telemedicine system related content (Interaction practice)
"they do explain to the patient about the volume, about who they goanna see on the screen. "	professionals of another site, educational content of telemedicine systems	Educate patients about the use of telemedicine system	
"she will give them the little pamphlet we have that talks about confidentiality. so that the patient feels secure that he can talked with is his doctor or whoever he's talking with and do that is not scared that somebody is goanna get into the TV or whatever pirate or anything that. "	professionals of another site, pamphlet, educational content of telemedicine systems	Educate patients about the use of telemedicine system	

We populated an instance model (Figure 17) with the partially collected data of case 2 (assess a patient's situation). The resource candidates, "physician" and "doctor" were combined into more than one resource combination.

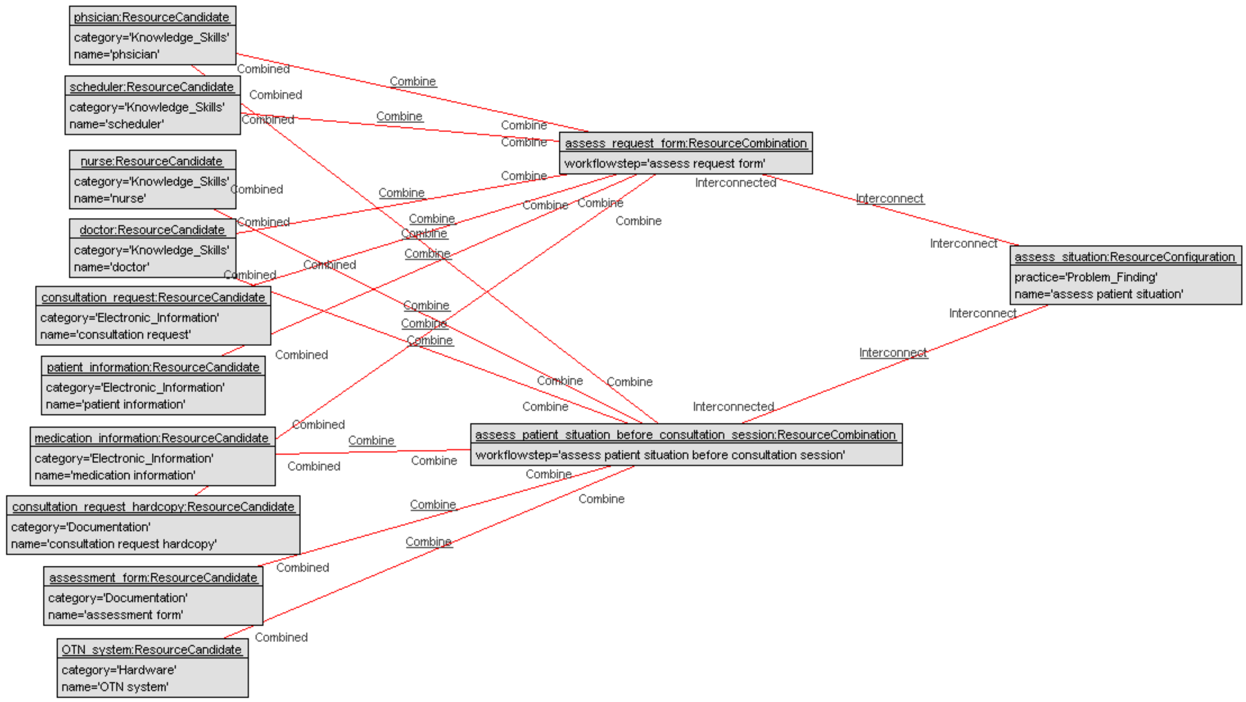

Figure 17 a populated metamodel for case 2

5.7.3 Results of case 3

Table 14 Demonstration list of the hematology videoconferencing consultation service case

Demonstration list of the hematology videoconferencing consultation service case			
Events	**Resource combinations**	**Workflow Step**	**Practices**
"so, the patients are, there's two methods. first method is physicians who request a consultation with the doctor for one of their patients, so a consultation is sent. Initially, it was sent as a hardcopy by mail, by fax, I should say to the hematology clinic. "	physicians, consultation requests, doctor, a hardcopy of consultation request	Receive request forms	Collecting information (Operating practice)
"then those forms are assessed by the doctor. The doctor assesses those consultation, and then prioritizes them into you know which ones have to be seen sooner than later. when she reviews the consultations, she assesses the address of the patient, and if she sees that it's a patient that lives a distance from the Ottawa, then she will write telemedicine, once done	the forms of consultation request, doctor, the information of patients, scheduler	Assess request forms	Assess patient's situation (Problem-finding practice)

she gives the consultations to her scheduler,"			
"absolutely, most, in the Hospital's HTN systems are accompanied by a nurse. the patient has a nurse that perceives them, that does their vitals, that does a quick assessment, a list of their medication and so on, and that form actually is beneficial they send it to us prior to the visit. So, the doctor who actually sees what the patient's taking as for medication and so on, or if there's any major health issues. "	HTN systems, nurse, an assessment form, doctor, medication information of patients	Assess patient's situation before consultation sessions	
"so that is done, and then she gives those consultations to the scheduler, and the scheduler is a person in the medical date unit that takes care of scheduling these patients. "	the information of each consultation session, scheduler	Send the consultation information to the scheduler	Send session information (Interaction practice)
"so that the scheduler again starts a process of booking the patients, these patients for their follow-ups. "	scheduler, the schedule of booked follow-ups	Check the availability of patients	Check availability (Interaction practice)
some sites if you want to group a three four patient in a specific site, then you have to initially contact the site by email to ask their availability of their system.	schedule, the availability of HTN systems at other sites	Check the availability of other sites	
so sometimes they're not available, so you have to juggle your clinic around to be able to get these patients seen in time,	clinic with HTN systems	Arrange another site for patients	
"and the scheduler prioritizes the charts, and then books telemedicine appointments as requested by the doctor."	appointment chart, scheduler, booked appointments' information	Prioritize the appointment charts	Assess the priority of sessions (Problem-finding practice)

"the second part is then during the visits as well; some patients need to be seen on my recurrent visit. So, every six months or so she decides that after the during the visit when she wants to see the patient yet again. she informs the patient during the visit, and also, we keep track when the patient will be seen. "	doctor, recurrent visit schedule, nurse	Inform recurrent visit schedule	Inform patients with schedules (Interaction practice)
“during, she will tell the patient always, she will say I'd like to see you again in so much time. so the patient is aware of when she wants to or if there is a next visit or you know, she will tell the patient herself, you know, we'll see you I'm goanna send you such-and-such of requisitions, and we'll see you in a few months for them to review these blood tests.”	doctor, the schedule of follow-up sessions	Inform patients follow-up session's schedule	
"so, it's she basically writes on an appointment card, follow-up in so much time, and these cards are given back to the scheduler at the end of the clinic. "	doctor, appointment card, scheduler	Specify the information of follow-up sessions	Input appointment information (Operating practice)
"telemedicine schedulers will be the Clerk. it's a clerk that does the all be scheduling in the HTN site, the encompass site, and also schedules the patient in our hospital scheduling system as well, and calls the patient to remind it to ask them if they are willing to participate the visit by telemedicine. "	scheduler (clerk), HTN system, encompass system, scheduling information, phone	Input scheduling information in multiple telemedicine systems	
“well the patients once they're scheduled, they're also scheduled in the Hospital's system called Meditech. So, a patient is entered and scheduled in the HTN system and that visit is also entered in the Meditech system. “	Meditech system, the schedule of appointments, schedule	Input schedule into Meditech system	

"so, at the end of the visit, then can give a quick overview of what's said, because a lot of the patients are elderly patients, so…"	an overview of the session	Provide a conclusion of the session for patients	Summarize a session's conclusion (Operating practice)
"because we all know that sometimes patients don't understand you know the instructions given, so we find it very helpful if there is a person with the patient there"	instructions given during a session, nurse	Assist patients to understand the content of the session	

We populated an instance model (Figure 18) with the partially collected data of case 3 (inform patients about schedules). The resource candidate, "doctor," was combined twice into two different resource combinations.

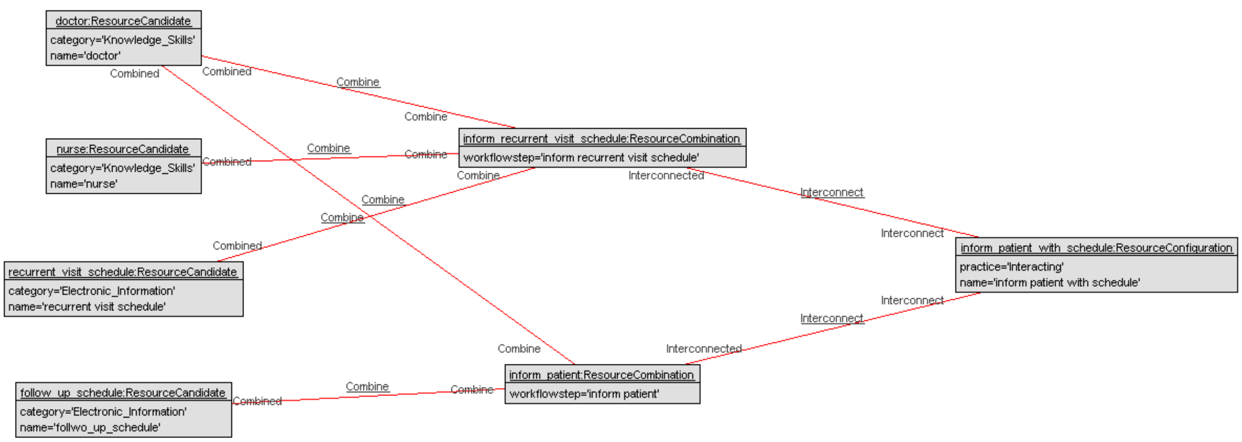

Figure 18 a populated metamodel for case 3

6. Discussion

This chapter first discusses the results of the multiple-case study. The case study results are discussed in two parts, which correspond to the evaluation and the demonstration of the metamodel. A refined version of the metamodel based on the implication of the case study results is then presented.

6.1 Implication of the evaluation

By applying the resource taxonomy, we identified a number of resources that were ignored by the participants' situated perspectives in the selected telehealth cases. In general, the capacity of the resource taxonomy to adequately capture required resource candidates for achieving a successful service plan is validated based on the results of the case study. However, the results also provide some implications from different aspects of planning a service.

Firstly, operant resources, such as professional's knowledge and skills, play a significant role in generating a resource configuration (Ngo and O'Cass 2009). This finding could be reflected both by the number of operant resources mentioned and ignored in the investigated telehealth cases from the participants' situated perspectives.

Secondly, ICTs also play a crucial role in a telehealth service (Akaka and Vargo 2014). On the one hand, implementing ICTs, such as introducing HTN systems, could increase the patients' access to health care services; on the other hand, multiple unsynchronized telemedicine systems (e.g. the inconsistent data between HTN and Meditech) could lead to data duplication (e.g., storing scheduling information in multiple systems). In other words, introducing ICTs only brings the possibility of enhancing access to health care, rather than guarantee the fluency of conducting the activities within a telehealth service.

Thirdly, based on the results of the selected cases, service actors at the Hospital frequently encountered availability issues for planning a telehealth service, especially in terms of ICTs and workspaces. For example, almost every participant emphasized that checking the availability of HTN systems, conference rooms, and offices at the Hospital or other sites is the most time-consuming task for setting up a telehealth appointment.

Finally, evaluating the capacity of the proposed resource taxonomy by comparing the generated List 1(s) and List 2(s) not only helps us to identify the resources that are often ignored but also provides a systematic way to rethink any possible issues among the identified resources in a service (e.g., the synchronized data in two telemedicine systems).

6.2 Implication of the demonstration

We demonstrated the capacity of the metamodel to capture a resource configuration by generating an instance model with the partial data from a given telehealth case. The instance models demonstrate the usefulness of the metamodel, as a conceptual tool, for service planning. Although, as noted, a resource configuration is an emergent capacity (as a whole) (Peters, Löbler et al. 2014), it could be described as a set of configured resources with an enacted practice (e.g., the populated metamodels in section 5.6). Operating practices (e.g., collecting information), interaction practices (e.g., calling patients) and problem-finding practices (e.g., assessing patients' situation) play a significant role in forming a resource configuration in the telehealth cases at the Hospital. In addition, we used a short term to describe a workflow step that contains a resource combination. However, these workflow steps could be potentially standardized in an organization or industry (e.g., a hospital or health care industry). A standardized workflow step with its resource combination could be viewed as an atomized service component, which is no longer ambiguous for service planning and training (compared with the complexity of the entire process of a service). Meanwhile, a standardized workflow step with its resource combination could also potentially be reused for generating novel service offerings (service innovation) (Peters, Löbler et al. 2014). In other words, service innovation could be understood as a reconfiguration of (existing) basic service components (a standardized workflow step with its resource combination) (Peters, Löbler et al. 2014).

7. Conclusion

This chapter first presents the conceptual contributions made by this research. Then practical implication brought by this research is described. Finally, it points out the limitations of the research and concludes with the directions for future work.

7.1 Conceptual contribution

Existing literature in various domains contributes to the discussion on the different aspects of resource utilization in a service (e.g., the discussion on the classifications of resources in the domains of RBV, RBT, RA, PM, SS, and service ecosystems (Hunt 2000, Hunt and Morgan 2005, Barney, Ketchen Jr et al. 2011, Vargo and Lusch 2016)). Also, existing literature discusses the process of resource integration, value co-creation as well as the constituent components of a service offering (Vargo and Akaka 2012, Edvardsson, Kleinaltenkamp et al. 2014, Peters, Löbler et al. 2014) (Skålén, Gummerus et al. 2015). However, this body of literature does not offer an integrated manner to understand the processes from which a resource configuration could be generated. The proposed conceptual framework and its related metamodel address this gap by capturing the constituent components of a resource configuration. In addition, the metamodel expresses the phases (resource candidate, resource combination, and resource configuration) that occur in the process of resource integration (Skålén, Gummerus et al. 2015). Although the similar concepts such as basic resources, composite resources, and interconnected resources, were discussed in the existing literature (Skålén, Gummerus et al. 2015), the proposed metamodel illustrates the relationships among the three evolving phases as well as the components within each phase. Understanding and describing resource integration through these three phases conceptually reflect the process of how a resource configuration could be generated or innovated. Moreover, the proposed framework comprehensively reflects the change of a resource candidate in terms of its nature, status, and role in a given service process. Different aspects of resources have been discussed from different perspectives in the existing literature. For example, the nature or categorization of resources was often emphasized in the literature from the G-D Logic perspective (Vargo and Lusch 2004); the role or status of resources was often emphasized in the literature from the S-D Logic perspective (Vargo and Lusch 2016). However, successfully configuring resources in a service requires a multi-perspective manner to view a resource, which the proposed framework attempts to address. Hence, this research provides the conceptual foundation for better understanding a service from a resource-based perspective. Its results could be adopted as a basis for developing a more comprehensive model of service systems in the field of service system engineering (Spohrer, Maglio et al. 2007, Maglio, Vargo et al. 2009, Lessard, Amyot et al. 2019).

7.2 Practical contribution

The metamodel points out that a resource configuration is essentially a set of configured resource combinations and a related practice (Skålén, Gummerus et al. 2015). Resource combinations with related workflow steps reflect the intermediate stage between the input (resource candidates) and output (a resource configuration) of a resource integration process. Thus, introducing the concept of resource combination reduces the ambiguousness of the process from which a resource configuration is derived. In practice, the methods we used for demonstrating and evaluating the framework and the metamodel could be adopted as a structural tool for professionals to plan a service offering, especially in terms of resource utilization. Generating instance models based on real cases could help professionals to analyze the resource requirements of a specific service. Also, instance models could be considered as a formal manner to document resource requirements for service system design.

7.3 Limitations

Despite the contributions of this research, a number of limitations affect its results. Three types of limitations are of particular interest: conceptual, practical and methodological limitations. They are briefly described in this section, alongside the ways in which they could be addressed.

In terms of conceptual limitations, although the proposed framework and metamodel are the first attempt to conceptually describe the connotation and process of generating a resource configuration in a service, the metamodel could be further improved. Firstly, additional perspectives on resources could be included within the metamodel, such as the perspectives of quality and dependency. By considering the concept of resource quality, the specifications of a resource for a specific service context could be described in detail (e.g., the speed, colour, or texture of a specific resource). Dependencies among multiple resources are other important factors that could be taken into account to arrive at a more comprehensive metamodel of resource configurations; indeed, dependencies among resources help to clarify the preconditions for integrating a specific resource. For example, conducting a videoconferencing session requires a conference room to be available and equipped with necessary ICT systems in a given period; IT support should stand by to eliminate any possible IT issues clinicians may encounter during the session. Also, dependencies among multiple resource combinations could be further taken into account to clarify the sequences of the workflow steps in a service. Resource properties such as quantity and availability could also be captured for a comprehensive description of resource dependencies. Secondly, the proposed metamodel does not capture the fact that a resource configuration in one context can be a resource candidate in another context. This issue is caused by the inability of the metamodel to express changes through time; one way to address this issue would integrate the resource configuration metamodel within a larger metamodel of service systems that addresses the concept of lifecycle in service systems (Lessard, Amyot et al. 2019).

The practical limitations of this research relate to the use of the metamodel in professional settings. For example, detailed procedures for using the resource configuration metamodel would need to be developed. This would require additional empirical studies for developing and validating these procedures. Moreover, the metamodel should be expressed in a known modelling language supported by accessible information technology tools. Existing tools and procedures for automatically creating conceptual models from text could be leveraged in that regard (Landhäußer, Körner et al. 2014). While these practical limitations result from the conceptual nature of this research and are thus in line with its intended scope, addressing them would be important for better supporting resource planning for ICT-enabled service systems.

The methodological limitations of this research are related to the demonstration and evaluation phases of this study. A first limitation is the small number of cases used to evaluate the metamodel. While a larger number of cases may have yielded additional insights, the selection of multiple telehealth cases theoretically enhances the generalization of results in multiple-case studies (Yin 2009, Yin 2017). Moreover, selected cases represent some of the most frequently conducted telehealth services in Ontario, which enhances the applicability of the results of this research across this province and in other regions or countries where similar telehealth services are offered in health care facilities. A second limitation concerns the use of qualitative data, which have been criticized for their potential lack of rigour in data analysis. This limitation was mitigated by using a structured and transparent process of collecting and analyzing data. The use of a case study protocol helped to ensure the consistency of data collection and analysis across the selected cases. A third limitation is related to focusing on telehealth as a representative example of ICT-enabled service systems to conduct the evaluation. Other domains where ICT-enabled service systems can be found (e.g., E-commerce) may have different characteristics, which limits the generalizability of the proposed metamodel.

7.4 Future research

The results of this research provide the basis for future research aiming to further understand, model and analyze resource configurations. A number of future research opportunities are identified based on the results and limitations of this research.

Firstly, the proposed framework and metamodel could be evaluated by adopting a larger sample of cases of different ICT-enabled service types (e.g., E-commerce and E-marketing). Doing so could enhance the generalizability of the proposed metamodel in the context of other ICT-enabled services (Yin 2009, Yin 2017). In addition, the procedures or methods for service resource planning could be derived from demonstrating and evaluating the metamodel based on a larger sample of cases of different ICT-enabled service types. These procedures or methods formalize the practical use of the metamodel.

Secondly, a standardized terminology or taxonomy of workflow steps in a specific ICT-enabled service domain, such as telehealth, could be developed. The workflow taxonomy of a specific domain could normalize the terms we used to define a workflow. Also, it helps us to determine the granularity of a workflow (how to determine the scope of a workflow) for a specific service context. This standardization could be achieved by conducting an empirical study. Also, practices that are specific to telehealth or other representatives of ICT-enabled services (practice styles for a specific service field) could be further refined. This means that we could develop domain-specific taxonomies of practices, or a high-level practice taxonomy of ICT-enabled service systems could be first developed and then inherited for populating a domain-specific practice taxonomy in an instance model.

Lastly, the proposed three-dimensional manner of viewing a resource candidate could be further specified. For example, being operant/operand could be specified with a set of actions for a given resource candidate. Also, more perspectives on resources could be potentially studied and included to enhance the comprehensiveness of the metamodel. For example, dependency, quality, and quantity could be potentially included as additional dimensions. Doing so may lead to a method by which we could algebraically label and store the change of a resource in a service process for further possible optimizations. Furthermore, the proposed metamodel could be potentially integrated with the metamodel of service systems (Lessard, Amyot et al. 2019).

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Appendix A. Case study protocol

Principal Investigator: Daoyang Xiao, MSc student, E-Business Technologies program, University of Ottawa

Co-Investigator: Lysanne Lessard, Assistant Professor, Telfer School of Management, University of Ottawa

Abstract

The study is part of a master's thesis research aiming to create a model of the resources needed within information and communication technologies (ICT)-enabled services in order to better support their design. Also, ICT-enabled service is a service where ICTs play a key role in the process of offering the service and creating value from it. Telehealth services are a representative type of ICT-enabled services. Moreover, telehealth services require the use of both tangible (e.g., hardware) and intangible (e.g., knowledge) resources. Selecting and combining these resources in a way that creates value for all stakeholders can thus be challenging for professionals who have to make such decisions. As part of this research, a model of the resources used in ICT-enabled services systems is being developed from literature. The present study aims to validate this model using real-world cases of telehealth services. The model will be applied to three to six cases of telehealth services offered by a Canadian hospital (hereinafter referred to as "the Hospital") in order to assess if it can correctly and comprehensively identify the resources needed to operate each service. This process could lead to the refinement of model or its underlying concepts. The validated model could facilitate the planning of resources for future telehealth services and ICT-enabled services more generally.

Research Background

Telehealth is a relatively new health care delivery model that has emerged with the introduction of information and communication technologies (ICT) in healthcare. The widespread adoption and recognized effectiveness of telehealth services show them to be a promising service delivery model for health care (Tuckson, Edmunds et al. 2017).

Although changing the service infrastructure by adding ICT is a prerequisite for implementing telehealth, telehealth should be considered as service innovation rather than ICT innovation (Kleinschmidt, Peters et al. 2016). Service is a configuration of people, technologies, and other resources that interact with other service systems to create mutual value; this understanding provides a useful abstraction from which we can better view, understand, analyze and design service activities (Maglio, Vargo et al. 2009, Böhmann, Leimeister et al. 2014). Innovating services means that new or considerably changed service concept, client interaction channel, service delivery model, which most likely rely on the introducing new service functions and new technological, human or organizational capacities of the service organization (Van Ark, Broersma et al. 2003).

Given the socio-technical nature of telehealth as well as how innovates health care delivery, telehealth services can be understood as ICT-enabled services. ICT-enabled services are socio-technical services where information technologies and other types of resources such as human knowledge and organizational capacities are organized in a manner that creates value.

Research Gap

Adequately configuring resources, both tangible (e.g., hardware) and intangible (e.g., knowledge) is key to co-creating value in services (Vargo and Lusch 2008, Vargo, Maglio et al. 2008, Vargo and Lusch 2016). Resource configuration can be defined as a set of resources (e.g. people, organization, technology, information, etc.) integrated by actors and a certain institutional arrangement (sets of interrelated institutions) that enable and constrain integrating these resources in a particular service. Institutions refer to humanly devised rules, norms, procedures, and beliefs that enable and constrain the interactions of an actor in a service. Configuring resources thus means identifying a set of needed resources as well as how they can be organized given existing constraints (e.g., both technical and clinical knowledge are required to use a virtual stethoscope, and the data transfer from the stethoscope must comply with PIPEDA). However, existing service system engineering methods and tools are not yet able to capture the dynamic role of resources within services. In particular, while conceptual modelling is recognized as an excellent tool of understanding, designing, and monitoring for service engineering (Amyot and Mussbacher 2011), existing conceptual modelling notations have limited abilities to express resource configurations. The proposed model of resource configurations in ICT-enabled services ("the model" as follows) aims at addressing this limitation. However, the ability of this model to adequately capture the detailed requirements of resource configurations in ICT-enabled services has not been officially validated.

Research Question

The evaluation of the model of resource configurations in ICT-enabled services can be achieved through its application to varied cases of telehealth services. Therefore, we propose the following research question in order to achieve the objective of this study:

"Can the application of the model to cases of telehealth services correctly and comprehensively capture their resource configurations, which are the set of resources needed for services and the interactions among these resources, in these services?"

Objective

This case study research is part of a larger Design Science Research (DSR) project in which the research team models resource configurations to further support the design of information and communications technology (ICT)-enabled services. DSR focuses on connecting knowledge to practice by demonstrating that scientific knowledge can be produced by designing useful artifacts (Wieringa 2009). Design Science Research Methodology (DSRM) is a widely used methodology that guides the design of information system artifacts (models, methods, or instantiations of systems), ensuring that artifacts are well-anchored in theory and produce knowledge for the design of future artifacts. A key step in this methodology is the validation of the artifact. In this DSR project, a model of resource configurations in ICT-enabled services is developed from the literature. However, the validity of this model needs to be evaluated. This multiple-case study is part of the evaluation phase of the DSR project, and the objective of this case study research is to validate the ability of the model to capture correctly and comprehensively the resource configurations of given ICT-enabled services. Since the telehealth services offered by the Hospital can be regarded as representative types of ICT-enabled services, they are an appropriate context for this case study.

Research team Expertise

Daoyang Xiao, as the principal investigator reviewed two bodies of academic literature before conducting this case study research: one is related to the domain of resource configurations in ICT-enabled services; the other one is related to the domain of conceptual modelling notations. Reviewing these bodies of literature provided him with the knowledge required to create conceptual models for ICT-enabled service scenarios.

Professor Lysanne Lessard, as the co-investigator will supervise Daoyang Xiao throughout this case study. Professor Lessard's research centers on service design. In particular, her research focuses on producing new models and methods for the design, transformation, and evaluation of services such as healthcare services. She also has a strong background in conducting case study research and conducted similar research projects before.

In addition to these two investigators, the "Special Projects Advisor – Telemedicine" (hereinafter referred to as "the Advisor") at the Hospital, will act as a key informant and facilitate participant recruitment for the case study. The Advisor will coordinate the arrangement of the study activities, including the interview schedule, the system demonstration meeting schedule and the documentation collection plan. The Advisor also will provide an overall picture of the telehealth services conducted routinely in the Hospital. Moreover, the Advisor may provide her suggestions to facilitate the research team selecting telehealth cases.

Methodology

Case studies are commonly used in areas like psychology, sociology, political science, social work, business, and community planning (Yin 2009). Case studies are conducted to increase knowledge about individuals, groups, and organizations, and about social, political, and related phenomena in these fields (Runeson and Höst 2008). They are particularly relevant when investigating contemporary phenomena in their context (Runeson and Höst 2008). The boundary between the phenomenon and its context is usually unclear in case studies. Also, within design science research, case studies are a recommended method to demonstrate the use of the artifact to solve instances of a problem and to evaluate how well the artifact supports a solution to the problem (Peffers, Tuunanen et al. 2007). Since the resource configuration model developed as part of the larger thesis can be understood as an artifact in the service system engineering domain, this study adopts a multiple-case study approach to allow comparison and increase the validity of the results.

Case study research is relatively flexible compared to other types of research designs, such as experiments. However, good planning for a case study is still crucial to its success (Runeson and Höst 2008). Following a clear protocol is also a recommended tactic to increase the reliability of a case study, which ensures the ability to obtain the same results if repeating the study's operations since doing so ensures consistency in fieldwork, (Yin, 2009). The following sections thus present the key points of the protocol developed for this case study.

a. Case Selection Criteria

Multiple cases will be studied to ensure the robustness of the resource configuration model evaluation. While the number of cases is not pre-defined, it is expected that between three and ten cases will be selected. The number of selected cases will depend on the ability of the selected cases to comprehensively support the demonstration and evaluation of the constructs within the resource configuration model.

In case study research, a case is generally anything that is a contemporary phenomenon in its real-life context (Yin 2009). Since we use telehealth services as a representative type of ICT-enabled services, a case in this research can be any existing telehealth services in the Hospital. However, in this case study we will define the scope of a particular telehealth service based on the convention of the Hospital. For example, telemedicine service and distance psychological counselling are two typical telehealth services at the Hospital. Furthermore, a selected telehealth service may contain several different service interventions. For example, home monitoring and one-on-one counselling are two service interventions within a service of distance psychological counselling. The unit of analysis of each case will be at the intervention level.

There are inclusion/exclusion criteria for each of case selection, and the criteria are listed below:

<u>Inclusion Criteria</u>

The first inclusion criterion is that a case should comply with the definition of telehealth. The American Occupational Therapy Association defines telehealth as the application of evaluative, consultative, preventative, and therapeutic services delivered through information and communication technologies (Cason, Hartmann et al. 2013). The terms "telehealth" and "telemedicine" mean different types of services at the Hospital. Telemedicine normally refers to the use of systems such as hospital's telehealth network (HTN) or Meditech, while telehealth means the use of the health help phone system. However, since those two terms are interchangeably used in many academic and professional articles ("Telehealth FAQs," n.d.), and both of them comply with the definition of telehealth services, we consider both of them as telehealth services in this research. Table 15 shows typical categories of telehealth services (it is not an exhaustive list, however, and other categories of telehealth services will also be considered).

The second criterion relates to diversity. While no case will be rejected unless it meets the exclusion criteria stated below, we will strive to select cases that represent the diversity of the existing telehealth services in the Hospital. Also, we will seek to include both telehealth services that are deemed satisfactory by the Hospital's professionals, as well as those that may be perceived as being less satisfactory. Indeed, the latter indicates that the value co-creation has not been realized smoothly in these cases, which points to the need to improve existing resource configurations.

Table 15 Categories of telehealth (Adapted from (Tuckson, Edmunds et al. 2017))

Service actors	**ICT**	**Telehealth Services**
Clinician to Patient	Video, Phone, E-mail, Remote wireless monitoring, Internet	Care for chronic conditions, Medication management, Wound care, Counselling, Postdischarge follow-up, Mental health
Patient to ICT	Wearable monitors, Smartphones, Mobile Apps, Video, E-mail, Web portals, Games	Health education, Monitoring of physical activity, Monitoring of diet, Medication adherence, Cognitive fitness
Clinician-to-Clinician	E-mail, Video, Data exchange	Dermatology, Radiology, Surgical peer mentoring, Emergency trauma,

		intensive care unit (ICU) care

Exclusion Criterion

Telehealth services that only pertain to automatic data transmission and with which professionals at the Hospital do not interact will be excluded from the study, such as sharing the electronic medical history of patients among the Hospital and other health care institutions.

b. Recruitment Plan and Study Design

i. Participant Criteria

Participants for interviews related to this study are clinicians, nurses and related technicians, who are knowledgeable about the aims, functioning and evolution of the selected cases. Due to the time limitation of this case study research, the patients' opinions and thoughts about those selected telehealth services will be indirectly collected through the medical and technical staff in the Hospital. A key informant for this study is the Advisor at the Hospital. The Advisor possesses administrative and clinical knowledge about the Hospital's telehealth services and will be recruited for interviews on the Hospital's telehealth services in general and, possibly for interviews related to selected cases.

ii. Participant Recruitment

The Advisor has agreed to facilitate case selection and the recruitment of study participants. Following the selection of cases for the study, the Advisor will send an introductory email to selected case stakeholders for this purpose. The study's P.I. will follow-up individually with potential participants using variations of a standard recruitment email.

Ethical considerations. The subjects' participation is not a requirement of the Hospital, the University of Ottawa or any other department of government, and it will not be reported to anyone.

iii. Data Collection Methods

Several different sources of information can be used in a case study (Runeson and Höst 2008). Indeed, the use of different sources of evidence strengthens the results of a case study (Yin 2017). Adopting a combination of different data sources can limit interpretation bias and strengthen results by allowing us to verify if the same conclusions can be drawn from several sources of information (Runeson and Höst 2008). Three categories of methods are thus recommended to conduct data collection in case studies: direct (e.g. interviews); indirect (e.g. data collection through video recording); and, independent (e.g. documentation analysis) (Lethbridge, Sim et al. 2005). We will rely on two of these categories based on the purpose of this study.

For direct methods, we will conduct semi-structured interviews and telehealth system demonstrations. Semi-structured interviews will rely on an interview protocol that lists questions of interest, but may not always be asked in the same order; moreover, questions can be followed up by clarification questions, which are not included in the interview protocol, in response to the interviewee's descriptions and accounts (Roulston 2010) (see Interview Protocol, Appendix B). For each telehealth case, two or more interviewees will be sought to allow an understanding of the service from multiple perspectives.

The questionnaire created in the interview protocol is divided into two sections: the first section is to collect data on participants' perception and understanding of the purpose, functioning, workflow, and evolution of the selected cases. The data collected from the section 1 are to generate List 2 in data analysis of this study; the second section is to directly ask participants to mention the resources currently used within the service from participants' situated perspectives. The data collected from the section 2 are to generate List 1 in data analysis of this study.

Participants will be provided with a generic definition of the word "resource" from an English dictionary and the resource taxonomy created in the metamodel of ICT-enabled service systems to ensure consistency; however, the term "resource" is widely used in everyday language, and it is anticipated that participants will easily identify the list of resources that are needed to operate the telehealth service for which they are being interviewed.

Demonstrations of the selected telehealth systems will also be sought. These demonstrations could be given by the Hospital's technicians, clinicians or other staff members knowledgeable about the service's operations. Observations of demonstrations will provide detailed information on the functions and features of the existing telehealth systems in the Hospital. During the system demo, the research team may ask related questions to the technicians to obtain a full picture of the components and functions of the telehealth systems. Interviews and system demonstrations will be audiotaped upon the consent of participants; if consent is not given, structured field notes will be taken instead.

The third method of data collection belongs to independent methods. Documentation about telehealth services at the Hospital, as well as documentation specific to selected cases (e.g., the standard operating procedure (SOP) of a selected telehealth service or the system architecture diagram of a selected telehealth system), will be sought.

Ethical considerations. The focus of data collection will be to gather information related to the resources used in selected telehealth services, rather than any clinical information such as the state of an illness or cure rate.

Ethical considerations - Method of Consent
The informed consent form will be sent to each participant via email before interviews and system demonstrations. Two copies of the informed form will be given to the participants to read and sign before the interviews or system demonstration started. Participants and the research team will keep one signed copy respectively.

After the first interview or system demonstration, the research team will provide an addendum to consent, authorizing the research team to re-contact the participant for follow-up questions. If the participant refuses to do so, the research team will not contact the participant again. The purpose of follow-up questions is to obtain further detailed information (related to goals, functioning, procedures, etc.) about telehealth services for clarification. The follow-up questions can be asked via emails, phone calls, video chat, or real meetings.

Ethical considerations - Compensation
Participants will not receive any compensation as a result of taking part in this research project.

Ethical considerations - *Participant Withdrawal*
Participants will be allowed to withdraw from the study at any time. The participants will be free to stop an interview or system demonstration and withdraw from the study if they feel uncomfortable. Any data collected from participants who have withdrawn from this study will be destroyed permanently and not used as part of the study. There should not be any negative consequences for the participants if they decide to withdraw. The research team will protect their confidentiality as if they had completed the study.

iv. Data analysis

Data collected within each case (interview transcripts, system demonstrations' notes and documentation, as relevant) will be analyzed in two phases. To reduce the risk of bias, the two researchers (the principal investigator and the co-investigator) established a complete agreement on the coding schemes as well as each step within the data analysis procedure created in this case study. Also, the co-investigator independently executed each step within each phase for one selected case. Any disagreement on the proposed data analysis procedure and the results derived from that double-checked case was discussed until consensus was achieved.

Phase 1:
The first phase serves to compare List 2 with List 1 to evaluate if the developed resource taxonomy can adequately and comprehensively identify resources in the selected telehealth cases. This phase contains six steps:

1. Apply the resource taxonomy coding scheme (see Resource taxonomy coding scheme, Table 16) to each transcript.

2. Generate “List 1” from the coded Section 2 of each transcript. This list will include anything directly mentioned as a resource (e.g., “videoconference software”) by a participant during each interview.

3. Since at least two participants per telehealth case will be interviewed to generate a “List 1” for each case to ensure comprehensiveness, a merged “List 1” will be created eventually by merging all generated “List 1” together for each selected case. During the list 1 merging process, any reduplicative resources will be only listed once in the final “List 1” for each case. “List 1” contains anything that is considered resources from a participant situated perspectives.

4. Generate “List 2” from each entire transcript and any other relevant data sources (e.g., system demonstration notes and documentation).

5. Adopt the similar merging process mentioned in Step 3 to create a merged “List 2” for each case. “List 2” contains all identified resources by applying the developed resource taxonomy of the metamodel of resource configurations in ICT-enabled service systems.

6. Compare Lists 1 with Lists 2. Lists 2 should identify at least all of the resources identified in Lists 1 to be considered valid. Moreover, the metamodel could identify additional resources, for example because they were implicit in Lists 1 (e.g., knowledge). Such results would demonstrate the relevance of the resource taxonomy within the metamodel for professionals since it would indicate that potentially important resources are not currently being identified and planned for.

Table 16 Resource taxonomy coding scheme

Coding category	**Description**
Classifications / Sub-classifications	
Financial Resource Candidates	Financial resources include all the available money from whatever source which actors utilize to conceive of and implement services. The typical examples of financial resources are

	cash, equity holders, bondholders, and banks. Retained earnings, previously made profit and invests are also important types of financial resources (Barney and Hesterly 2009).
Time Resource Candidate	Anything related to the availability of other resources
Non-ICT Physical Resource Candidates	Physical resources include all the used physical entities except ICT and information related entities. The typical examples of physical resources are equipment, geographic location, and raw materials (Barney and Hesterly 2009).
Non-ICT equipment	Any machinery entities.
Location	Any needed spaces, such as conference rooms.
Other materials	Any raw materials or consumable items.
ICT Resource Candidates	Specifically, the used hardware and software of ICTs are categorized into typical physical resources.
Hardware	Any ICT hardware even it may contain some sorts of software, such as firmware.
Software	Any pure software systems, such as the HTN platform or apps.
Network	Internet / intranet connections or capacities
Human Resource Candidates	Human resources are an attribute of single individuals, which include training, experience, judgment, intelligence, relationships, and insight of individuals (Barney and Hesterly 2009). (I ignored judgment, intelligence, insight since I think they are not the focus of our analytical purpose in telehealth)
Knowledge & skills	Any professional or common knowledge and skills.
Experience	Any professional experience requirements.
Acquired Training	Any profession certificates; any internal or external training.
Institutional Resource Candidates	Institutions can be defined as a set of rules governing interpersonal governance (North, 1990). The typical examples of institutions are rules, norms, and beliefs humanly devised, which enable and constrain action and make social life predictable and meaningful (R. Scott, 1995). Based on the nature of institutions, they can be categorized into three subcategories: regulative, normative, or cognitive (W. R. Scott, 2008). Since cognitive institutions are related to the actors’ perceptions of reality,

		which is usually influenced by the actors' cultural context (W. R. Scott, 2008), it's more related to the intelligence of an actor, I ignore this classification in this taxonomy.
	Regulative Institutions	Regulative institutions include all formal rules which enabling or constraining the behaviour of actors. The typical examples: Regulation, observation and sanctioning ensure actors' behaviour to meet certain standards.
	Normative Institutions	Norms here means how a particular task should be conducted; while value determines the expectation and evaluation standards of the outcome of the task. The typical examples: norms, values.
Information Resource Candidates		Information resources are any piece of information that is needed in offering a service. The medium of an information resource can be either paper or electronic files.
	Electronic information	Any electronic files which are saved in a computer system, such as a scanned questionnaire.
	Documentation	Any paper files.

Any incorrect or missing resource identified through the application of the resource taxonomy within the metamodel will lead to refinements in the resource taxonomy or its underlying categories. These steps of assessment will be repeated for each selected case until the resource taxonomy can correctly and comprehensively identify all resources. This iterative approach will result in a validated resource taxonomy.

Phase 2:
The second phase serves to demonstrate the capacity of the developed metamodel to identify the resource configurations within the selected cases. The resource configurations will be captured within two parts: 1) resource combinations; 2) resource configurations, which correspond to the constructs of resource combination and resource configuration of the proposed metamodel. Thus, two other coding schemes will be applied to all collected data in each case (interview transcripts, system demonstrations' notes, documentation, if relevant) to identify the list of resource combinations (see Resource Combination coding scheme, Table 17) and resource configurations (see Resource Configuration coding scheme, Table 18) in each selected cases.

The proposed metamodel defines a resource combination as a set of resources identified in a particular workflow step within an ICT-enabled service. Based on the definition of resource combination, the resource combination coding scheme is proposed to identify each step within the workflow of a selected case. Since a particular workflow step may logically be identified based on the semantic and grammatical structure of transcripts, the following three types of clues are included as the coding scheme to help us identify each workflow step in a case. The resource taxonomy coding scheme is also adopted to identify resources in a particular resource combination.

Table 17 Resource combination coding scheme

Adverb, conjunction	Punctuation	Word order
So, so that, after, and, then,	Comma, period, other punctuations	Word order, sentence order

The metamodel defines a resource configuration as a set of resource combinations interconnected by enacting practices. An existing empirical study across eight firms, conducted from the service-dominant logic perspective, made a knowledge contribution regarding the anatomy of a value proposition (Skålén, Gummerus et al. 2015). This study suggested that a value proposition is a configuration of several different practices and resources (Skålén, Gummerus et al. 2015). The study further found that then common practices organized in three aggregates (i.e. provision practices, representational practices, and management and organizational practices), which constitute and fulfill a value proposition (Skålén, Gummerus et al. 2015). Since a value proposition corresponds to and could be expressed by a resource configuration from the perspective of the proposed metamodel, the ten common practices which were identified in that existing empirical study can be relied on to create a coding scheme (see Table 18) for identifying the practices in the data collected in this case study.

Table 18 Resource configuration coding scheme

Aggregate	Type	Definition
Provision Practices	**Operating practices**, such as best practices, diagnosis schemes, work packages, collecting information, documenting	Aimed at supporting the core customer value creation, as stated in the value proposition.
	Problem-fining practices, such as technical audits, customer surveys, brainstorming, investigation, assessment, pilot studies	Identifies (a) problems with customer value creation and (b) customer needs for new forms of creating value.

	Problem-solving practices, such as integrating IT systems, getting rid of the bug in data coding, implementing software, and aiding users	Solves customer problems.
Representational practices	**Naming and labelling practices**, such as standardizing language, compiling lists, mapping, defining concepts, branding and producing presentations	Describes the activities of the value proposition and their fulfillment.
	Modelling practices, such as business models, maps, matrixes, schemes, designs, concepts	Creates the structure of the value proposition.
	Interaction practices, such as telephone calls with customers and dialogues with fellow employees, offering and reports	Enables the communication of value propositions to customers or the co-creation of value propositions with customers.
Management and organizational practices	**Organizing practices**, such as meetings, workshops, forming cross-disciplinary teams, budgeting, conferencing, reference group meeting	Organizes the work of providing and representing value propositions.
	Staffing and team-building practices, such as creation of a “dream team”,	Used to hire staff and build teams that can provide and communicate service.

	competence mapping, teamwork, employee involvement, recruiting	
	Networking practices, similar to those under organizing practices, e.g., meeting, committees, workshops, but they are shared via a network	Of their network to create, deliver or negotiate value propositions.
	Knowledge-sharing practices, such as training, sharing best practices, establishing consensus across groups and human interaction	Practices used to share knowledge and skills in order to realize the value proposition.

The capacity of the developed metamodel to capture resource configurations within the selected cases is demonstrated by conducting the following steps.

1. Apply the resource combination coding scheme (see Table 17) to each transcript.

2. Generate a list of resource combinations from each transcript. This list will distribute resources to each workflow step they belong to.

3. Since at least two participants per telehealth case will be interviewed to generate a list of resource combinations for each case to ensure comprehensiveness, a merged list of resource combinations will be created eventually by merging all generated lists of resource combinations for each selected case.

4. Apply the resource configuration coding scheme (see Table 18) to each transcript.

5. Generate a list of resource configurations (practices) from each transcript. This list will include all enacted practices by which a set of resource combinations are interconnected to provide a telehealth service in each transcript.

6. Since at least two participants per telehealth case will be interviewed to generate a list of resource configurations for each case to ensure comprehensiveness, a merged list of resource configurations will be created eventually by merging all generated lists of resource configurations together for each selected case.

This demonstration of the metamodel shows how to apply the metamodel to a selected telehealth case as well as the relevance of the metamodel to telehealth professionals.

c. Data Retention and/or Data Destruction Plan

Data collected will be retained for a maximum of five years after the study is completed and will then be destroyed.

Risks & Benefits

Potential Risks

The main risk for participants is the time consumption of the study. This potential risk will be mitigated by optimizing the arrangement of interviews and system demonstrations. Firstly, the research team will limit the duration of each interview to about 45 minutes, and the duration of system demonstrations to about 30 minutes. Secondly, the research team will arrange meetings at a time and place that is convenient for participants (e.g., the participant's office or a coffee shop).

Another potential risk is related to information security. The information a participant shares with the research team will be recorded on a digital recorder if they consent to do so. To ensure that recorded information is secure, the research team will transfer recorded audio files to RedCap, and the secure online research platform provided by the Hospital. Files on the digital recorder will be destroyed as soon as a copy has been placed in RedCap. Interview transcripts will also be stored in RedCap. A master list containing the names of the participants that correspond to each Participant number will also be stored in RedCap.

The research team will ensure that in any interview transcripts or other electronic or printed documents referring to participants is anonymized before being used for coding purposes; specifically, transcripts or other documents will only refer to participants by numbers (e.g. Participant 1, 2, etc.) to ensure their anonymity.

Potential Benefits

- If the ability of the resource configuration model to adequately capture the resource configuration requirements is successfully demonstrated through this case study, the resource configuration model can be adopted by the participants to facilitate designing new telehealth services.
- A short report outlining the results of this case study will be sent to participants if they express interest. The report will provide a complete picture of the resource configuration of each selected telehealth service, which may provide managerial insights related to resource planning.

Appendix B. Interview protocol

The main goal of the interview is to collect rich data on participants' perception and understanding of the purpose, the functioning and the required resources of the selected telehealth cases. The questions written below should thus be considered as a general guide to be used to stimulate the conversation with the participants, but not to direct the conversation. If the participant wishes to orient the discussion on other topics than those covered by these questions, he or she should be free to do so. However, the person conducting the interview should ensure that answers to the questions written below have been answered in one form or another.

The following list of questions aims to collect the required data for the study. They may be asked as written, but they can also be accompanied by explanations if the participant asks for clarifications. Additionally, a question can be omitted if the participant provides the answer spontaneously or in the context of answering another question.

The following questions aim to gather information about the context and purpose of the telehealth service, as well as some basic information about the participant in relation to the service:

- How do you name or refer to the telehealth service?
- What is your role and responsibilities in the telehealth service?
- What is the purpose of the telehealth service?
- How does the telehealth service function?
    - Are there any routine procedures or plans for conducting the telehealth service?
- Could you describe a typical scenario of using the service?
- Can you describe one or more occasions, which were different from the occasion we just discussed, when you conduct the service?
- Who else is involved in conducting the telehealth service?
- Are there any documents that describe or guide the telehealth service?
    - May I have access to them?
- To your knowledge, has the telehealth service changed over time? If so, what changed? Do you know why?

The following questions focus on the resources used in the telehealth service:

- In your opinion, what resources are used in this telehealth service scenario?
    - (The interviewer may provide a dictionary definition of "resources" if the participant is not sure how to respond, e.g., "A stock or supply of money, materials, staff, and other assets that can be drawn on by a person or organization in order to function effectively.")
- What kind of technical system or system components do you need to operate the telehealth service?

- How do you use the resources you just mentioned?
    - Did you ever face any difficulties in using them?
- Are there any issues or complaints with this telehealth service?
    - If there are complaints, do they originate from clinicians, patients, other?
- In your opinion, is there anything missing in the telehealth service?
- Is there anything that can be improved in the telehealth service?
- Are there additional resources that you think would improve the telehealth service? Which resources? How would they improve it?”

Appendix C. Ethics approval certificate

27/03/2019

Université d'Ottawa
Bureau d'éthique et d'intégrité de la recherche

University of Ottawa
Office of Research Ethics and Integrity

Lettre d'approbation administrative | Letter of administrative approval

Numéro de dossier / Ethics File Number	S-03-19-3711
Titre du projet / Project Title	Case Study - Modeling resource configurations in ICT-enabled services
Type de projet / Project Type	Thèse de maîtrise / Master's thesis
CÉR primaire / Primary REB	Hôpital Montfort / Hôpital Montfort
Statut du projet / Project Status	Approuvé / Approved
Date d'approbation (jj/mm/aaaa) / Approval Date (dd/mm/yyyy)	27/03/2019
Date d'expiration (jj/mm/aaaa) / Expiry Date (dd/mm/yyyy)	20/03/2020

Équipe de recherche / Research Team

Chercheur / Researcher	Affiliation	Role
Daoyang XIAO	École de gestion Telfer / Telfer School of Management	Chercheur Principal / Principal Investigator
Lysanne LESSARD	École de gestion Telfer / Telfer School of Management	Superviseur / Supervisor

Conditions spéciales ou commentaires / Special conditions or comments:

Montfort REB # 18-19-03-044

Appendix D. USE file of the metamodel

---start of the USE file---

```
model RC

-- enumerated types

enum Category {Financial, Time, Non_ICT_Equipment, Location, Other_Material, Hardware, Software, Network, Knowledge_Skills, Experience, Acquired_Training, Regulative_Institutions, Normative_Institutions, Electronic_Information, Docomentation}

enum Practice {Operating, Problem_Finding, Problem_Solving, Naming_Labeling, Modeling, Interaction, Organizing, Staffing_Team_Building, Networking, Knowledge_Sharing}

-- classes

class ResourceCandidate
attributes
  category : Category
  name : String
end -- resource candidate

class ResourceCombination
attributes
  workflowstep : String
end -- resource combination

class ResourceConfiguration
attributes
  practice : Practice
  name : String
end -- resource configuration


-- associations

association Combine between
 ResourceCombination[0..*] role Combine ResourceCandidate[0..*] role Combined end

association Interconnect between
 ResourceConfiguration[0..1] role Interconnect ResourceCombination[0..*] role Interconnected end
```

--end of the USE file--