Integrating Users Logic into Requirements Engineering for Connected Healthcare co-Design

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Abstract: The ongoing transformation in healthcare requires the creation of agile systems to meet the growing needs of patients. An approach to develop such systems requires the elicitation of end-users' perspectives to software development life circle. The current requirements development process does not emphasis on the importance of end-users' participation in the requirements elicitation phase. The present study proposes an approach utilizing Service-Dominant (S-D) logic framework to contribute to the co-design of connected health services. Value co-creation practices when combined with requirements engineering best practices can contribute towards the development of usable software for connected healthcare systems.

1 INTRODUCTION

Population age distribution is shifting towards an increase of the elderly. World Health Organization (WHO) has announced that between 2015 and 2050 the population aged over 60 years will surpass the children younger than 5 years (Organization, 2015). The increasingly aging population worldwide arises various challenges to healthcare systems, among others pertinent to support costs and service provision (Chouvarda et al., 2015). Future healthcare systems will have to deliver services to a larger number of patients with chronic conditions and multimorbidities. Therefore, they have to accommodate the needs of a population with interrelated and complex health conditions from different backgrounds, while sustaining cost effective services (Ouhbi et al., 2017).

These challenges have sparked innovation in healthcare management models shifting traditional management approaches towards more agile solutions. Connected health model revolves around patients' needs, utilizing the latest technological advancements to facilitate efficient management of diseases (Ouhbi et al., 2018). Patients and health data are in the spotlight of the healthcare model, that uses information technology to enable active participation of all actors (citizens, patients, healthcare professionals, and policy makers) to decision-making (Caulfield and Donnelly, 2013; Karampela et al., 2019). Effective utilization of health data means that "the correct information" is available "to the correct person at the correct time" (Chouvarda et al., 2015). Connected health paradigm encompasses a range of technologies such as e-Health, m-Health and remote patient monitoring solutions (Caulfield and Donnelly, 2013).

User involvement in the healthcare management paradigm is only an aspect of users' participation in healthcare provision. Propositions of active involvement of users' on the design of health devices supports further the argument that users' contribution can improve not only services but also products (Harte et al., 2014; Hardyman et al., 2015). But what is the difference between services and products? According to Vargo and Lusch services and products have more similarities or commonalities than differences (Vargo and Lusch, 2004b). They argue that "goods are distribution mechanisms for service provision" and that "economic exchange is fundamentally about service provision" (Vargo and Lusch, 2004b), p.326. In the same vein, Gummesson suggested that "customers do not buy goods or services: they buy offerings, which render services, which create value" (Gummesson, 1993).

Service-Dominant (S-D) logic, proposed by Vargo and Lurch, places service as the core value of both services and products. Value co-creation has been the centre of the S-D logic literature. According to Vargo et al. (2008) "The customer is always a co-creator of value", while the value has been defined as the value-in-use (Vargo et al., 2008), p.148. In

this context customers are co-creators of value (Vargo and Lusch, 2004a; Vargo and Lusch, 2017), while companies "cannot deliver value, but only offer value propositions" (Vargo et al., 2008), p.148. Reflecting upon this, companies can co-create value through users' involvement (Vargo and Lusch, 2004a; Vargo and Lusch, 2017; Lusch et al., 2008).

Requirements engineering (RE) is the first step of the software lifecycle and plays a critical role towards delivering quality and reliable software. This paper relies on the requirements development process presented in RE body of knowledge (REBOK) (Nilsson, 2013) and software engineering body of knowledge (SWEBOK) (Bourque et al., 2014) which are widely accepted and established work in the field of software engineering (Ambreen et al., 2018).

Previous literature focusing on users' involvement into the system development cycle, points out that their inclusion can have a positive impact on the creation of more effective services (Kujala, 2003; Kujala et al., 2005; Wagner and Piccoli, 2007; Pekkola et al., 2006; Bano and Zowghi, 2013). Nevertheless, standardisation of users participation to the phases of the requirements development process has been seen as a challenge that can have an impact on the system design process (Damodaran, 1996). According to a recent systematic mapping study about personal health data (Karampela et al., 2018), the majority of the proposed solutions in healthcare services are developed without any empirical validation on patients' data. The aim of the present study is to employ the S-D logic framework to propose an approach to increase the understanding of the value co-creation in connected health by considering end-users' involvement in the requirements development process.

The following section will introduce the requirements development process, the core ideas of S-D logic and two examples of challenges related to users exclusion from the design process. Section 3 will discuss the approach of integrating S-D logic into RE. Finally, the conclusion section presents future directions outlining S-D logic contribution to RE.

2 BACKGROUND

2.1 Requirements development process

The requirements development process includes the four following phases: requirements elicitation, requirements analysis, requirements specification, and requirements validation. Fig. 1 presents an overview of the requirements development process.

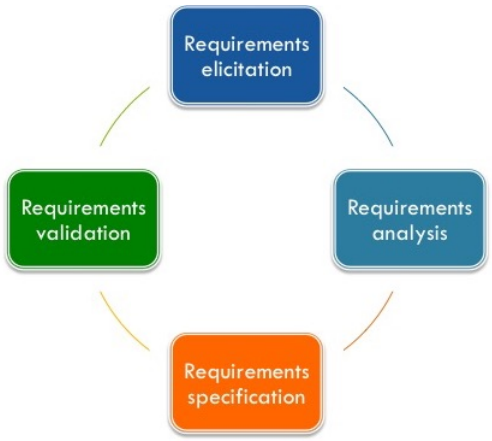

Figure 1: Requirements development process

Requirements elicitation is a complex problem formulation phase in which business requirements, needs and information are gathered and identified.

In the **requirements analysis** phase, the identified customers' needs are translated and transformed into requirements that are traceable, so that can be measured and tested, and will be the core elements of the design process.

Requirements specification results in the specification of the users and system requirements which can establish the system requirements specification (SyRS) document and the software requirements specification (SRS) document (IEE, 2011).

Requirements validation is the last phase of the requirements development process and it is crucial as mirrors the elicitation of requirements phase. This phase validates whether the requirements of the customers have been met or not, so that it gives a reply to the question "did we create the right product?" (Bourque et al., 2014).

This study focuses on the four aforementioned phases proposing an approach to incorporate the S-D logic into the requirements development process.

2.2 S-D logic

S-D logic is a dynamic framework that continues evolving as economic and social factors change over time. The core idea of this framework relies upon the notion that services are exchange of competences between actors underlined by common interests. Services considered to be not just associations of individuals to products, but dynamic relations ("service-for-service exchange") underpinned by commonalities. Services include not only business and customers, but a service ecosystem. This ecosystem of interactions includes all the possible interrelated economic and social actors of an exchange network. Service design

networks are complex and built up in three levels: macro, meso and micro. Zooming in or out in these levels one can examine ecosystems of services from different perspectives, including thus various levels of interactions. So, service ecosystems enable services representations as networks of "holistic experiences". Fig 2 presents the core narrative and processes of the S-D logic.

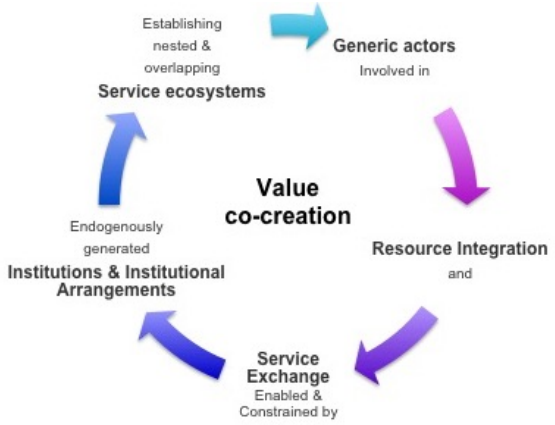

Figure 2: The core narrative and processes of S-D logic

The essence of core values of the S-D logic framework has been formulated into axioms. Table 1 presents the eleven foundational premises (FPs). Five of these FPs have been considered to be the core axioms from which the other FPs can be derived. The five axioms of the S-D logic are presented below.

Axiom1/ Service is the fundamental basis of exchange. Services are exchange of resources. Resources are applications of knowledge and skills, which are the core for every exchange.

Axiom2/ Value is co-created by multiple actors, always including the beneficiary. The value is created when the beneficiaries use the end-product. So, "the value-in-use" is co-created by producers and consumers in an interactive manner through exchange of resources (knowledge and skills).

Axiom3/ All social and economic actors are resource integrators. All the actors of a service have common objectives. Traditionally the term "producer" was used for the actors who created value and the term "customers" for the ones who destroyed value. This notion had restricted interaction between businesses and customers assuming that they had different goals. Nevertheless, all actors (businesses, customers. etc.) that are involved in a service, as a product of economic exchange, are "resource-integrating, service providing enterprises" and have a common objective to (co)-create value (Vargo and Lusch, 2017), (p.48). What joints this network of actors is the "collective wellbeing", in an individual and common level as an act for achieving or maintaining well-being.

Axiom4/ Value is always uniquely and phenomenologically determined by the beneficiary. The value is determined by beneficiaries when they use the end-services. But the value is subjective, is based on the experiences and is dependent on the context of services. The perceived value of services is unique and related on the direct experiences of beneficiaries (Kujala and Väänänen-Vainio-Mattila, 2009).

Axiom5/ Value co-creation is coordinated through actor-generated institutions and institutional arrangements. In S-D logic framework the terms institutions does not concern organizations, but "are the humanly devised rules, norms, and beliefs that enable and constrain action and make social life at least somewhat predictable and meaningful" (Vargo and Lusch, 2017), (p.49).

The S-D logic framework has been applied to various disciplines such as branding, logistics and supply chain management (Ballantyne and Aitken, 2007; Flint and Mentzer, 2006; Tokman and Beitelspacher, 2011), consumer culture theory (Arnould, 2007), public management (Osborne et al., 2013) and information systems (Alter, 2010). Studies have also been discussing applications of S-D logic to healthcare information systems (Hardyman et al., 2015; Rehman et al., 2012).

2.3 Examples of design challenges due to poor requirements

The Chaos Report series conducted by the Standish Group demonstrated that the major software project impaired factors are incomplete requirements and lack of user involvement (Sta, 2009).

A typical example of software failure due to exclusion of users to the requirements development process is the HealthCare.gov health insurance exchange web service. It launched on October 2013, failed to serve users needs due to various issues such as inaccurate forecasting of user population which resulted to accessibility issues. Various system and software design failures were related to poor user evaluation (BBC-News, 2013). The failure to test scalability and include end-users to the design process resulted among others to user dissatisfaction, delays in the project implementation and growth of expenditures.

A second example concerns the National Programme for IT in the NHS (NPfIT) in the United Kingdom. The NPfIT web service was an effort to offer a centralized electronic health record (EHR) that would be accessible by patients and also would con-

Table 1: Axioms and Foundational Premises (FPs) of S-D Logic (Vargo and Lusch, 2016).

Axiom1	FP1	Service is the fundamental basis of exchange.
	FP2	Indirect exchange masks the fundamental basis of exchange.
	FP3	Goods are a distribution mechanism for service provision.
	FP4	Operant resources are the fundamental source of strategic benefit.
	FP5	All economies are service economies.
Axiom2	FP6	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-centered view is inherently beneficiary oriented and relational.
Axiom3	FP9	All social and economic actors are resource integrators.
Axiom4	FP10	Value is always uniquely and phenomenologically determined by the beneficiary.
Axiom5	FP11	Value co-creation is coordinated through actor-generated institutions and institutional arrangements.

nect general practitioners and hospitals' records. After its implementation the software was scrapped due to several failures such as poor functionality connected to exclusion of end-users and stakeholders in the design process (Justinia, 2017).

3 Integrating the users logic into RE

Healthcare transformation underpinned by connected health aims to empower patients by creating services that will "connect" all the stakeholders' needs in an effective manner (Caulfield and Donnelly, 2013). The challenge for requirements development process is that it should respond to these needs by enabling stakeholders participation to the life cycle of software development.

Fig. 3 presents where value co-creation can be generated in the requirements development process. Drawing from S-D logic paradigm software can be seen as a "service". This means that software engineers hold the responsibility to design complex healthcare services encapsulating social and relational norms and interactions into services. However, transforming knowledge, business and users' needs into software components is a challenge by itself. Our proposed framework based on S-D logic can contribute on that in different ways.

Considering software in the lens of service means that the focus of the requirements development process should be shifted to the design of exchange of resources, so to the design of knowledge and skills (Axiom1, FP1) (Vargo and Lusch, 2017). In case of healthcare services it is essential to involve patients into the design process as their needs are often complex and unique, requiring thus solutions that are sensitive on that (Axiom4, FP10).

The idea of value-in-use is a notion that requirements development process can benefit from. According to this notion, value is created by the beneficiaries of a service while using the services. Moreover, the value is co-created by multiple actors including always the end-users (Axiom2, FP6). Based on that, a suggestion would be to involve beneficiaries, patients in this case, along the requirements development process. Their knowledge in each step of the requirements development process could lead to the creation of more agile and effective solutions that will be aligned with their needs.

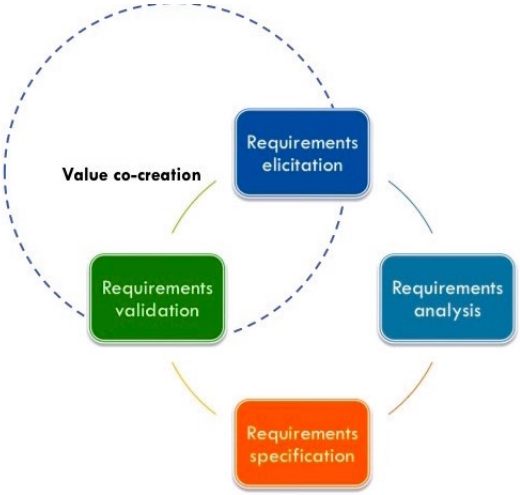

Figure 3: Value co-creation in requirements development process

The idea of a common objective for "collective wellbeing" amplifies the argument that stakeholders involvement in the requirements development process can have positive impact (Axiom 3, FP9). The contribution of this axiom is the notion that service ecosystems are environments that connect actors under a common goal. So, more attention should be given to the commonalities of the stakeholders of a services than to the differences (Axiom5, FP11).

The relation of actors in a service ecology environment is complex and develops in different levels. One can argue that the complexity of such networks can pose a challenge to engineers, designers or business analysts. The S-D logic suggests a frame to cluster these relations into different levels (micro, meso, macro). On this way software engineers could gain

a better understanding of this complex network of actors focusing on different perspectives within the same network. Mapping the actions and stakeholders could contribute to better understanding of service ecology leading to the development of more agile solutions.

Although the S-D logic framework could contribute towards better understanding of service ecology and network of users, the education of the future software engineers can also facilitate them to better understand and reflect upon citizens' needs. Designing multidisciplinary education programs that will focus not only on the technical perspectives, but also on the self-reflection of students has been suggested as an innovation that can make a difference (Graham, 2018).

Another suggestion has been to reconsider the education of engineers (Ouhbi et al., 2015), drawing lines towards societal and environmental challenges that the world is facing. In addition, project-based education and internships have been seen as a way to shift the focus of engineers from the laboratories to real-world challenges leading thus to better understanding of human nature (Graham, 2018). Software engineers hold an essential role and an ethical responsibility to serve society by contributing towards the creation of welfare services.

4 CONCLUSION AND FUTURE WORK

This paper presents a preliminary discussion of S-D logic integration into the requirements development process. It has discussed how the five core axioms of the S-D logic, the service ecology and reformation on education of engineers could contribute on the redesign of the requirements development process.

Our future work will focus on the refinement of the proposed approach and the development of a model to support software engineers to improve the requirements development process for connected health systems. We intend also to conduct empirical evaluation to validate our proposed approach.

REFERENCES

(2009). Standish-Group, CHAOS summary 2009.

(2011). IEEE Std 29148-2011, ISO/IEC/IEEE International standard - systems and software engineering – life cycle processes – requirements engineering.

Alter, S. (2010). Viewing systems as services: a fresh approach in the IS field. *Communications of the association for information systems*, 26(1):11.

Ambreen, T., Ikram, N., Usman, M., and Niazi, M. (2018). Empirical research in requirements engineering: trends and opportunities. *Requirements Engineering*, 23(1):63–95.

Arnould, E. J. (2007). Service-dominant logic and consumer culture theory: Natural allies in an emerging paradigm. In *Consumer culture theory*, pages 57–76. Emerald Group Publishing Limited.

Ballantyne, D. and Aitken, R. (2007). Branding in B2B markets: insights from the service-dominant logic of marketing. *Journal of Business & Industrial Marketing*, 22(6):363–371.

Bano, M. and Zowghi, D. (2013). User involvement in software development and system success: a systematic literature review. In *Proceedings of the 17th International Conference on Evaluation and Assessment in Software Engineering*, pages 125–130. ACM.

BBCNews (2013). Obama addresses healthcare website glitches.

Bourque, P., Fairley, R. E., et al. (2014). *Guide to the Software Engineering Body of Knowledge (SWEBOK (R)): Version 3.0*. IEEE Computer Society Press.

Caulfield, B. and Donnelly, S. (2013). What is connected health and why will it change your practice? *QJM: An International Journal of Medicine*, 106(8):703–707.

Chouvarda, I. G., Goulis, D. G., Lambrinoudaki, I., and Maglaveras, N. (2015). Connected health and integrated care: Toward new models for chronic disease management. *Maturitas*, 82(1):22–27.

Damodaran, L. (1996). User involvement in the systems design process-a practical guide for users. *Behaviour & information technology*, 15(6):363–377.

Flint, D. J. and Mentzer, J. T. (2006). Striving for integrated value chain management given a service-dominant. *The service-dominant logic of marketing: dialog, debate, and directions*, 139.

Graham, R. (2018). The global state of the art in engineering education. Technical report, Massachusetts Institute of Technology (MIT), Massachusetts, USA2018.

Gummesson, E. (1993). Quality management in service organizations. *ISQA, New York, NY*, 487.

Hardyman, W., Daunt, K. L., and Kitchener, M. (2015). Value co-creation through patient en-

gagement in health care: a micro-level approach and research agenda. *Public Management Review*, 17(1):90–107.

Harte, R. P., Glynn, L. G., Broderick, B. J., Rodriguez-Molinero, A., Baker, P., McGuiness, B., O'Sullivan, L., Diaz, M., Quinlan, L. R., and ÓLaighin, G. (2014). Human centred design considerations for connected health devices for the older adult. *Journal of personalized medicine*, 4(2):245–281.

Justinia, T. (2017). The UK's national programme for IT: Why was it dismantled? *Health services management research*, 30(1):2–9.

Karampela, M., Ouhbi, S., and Isomursu, M. (2018). Personal health data: A systematic mapping study. *International journal of medical informatics*, 118:86–98.

Karampela, M., Ouhbi, S., and Isomursu, M. (2019). Accessing and sharing electronic personal health data. In *12th International Conference on Health Informatics*, HealthInf, page in Press.

Kujala, S. (2003). User involvement: a review of the benefits and challenges. *Behaviour & information technology*, 22(1):1–16.

Kujala, S., Kauppinen, M., Lehtola, L., and Kojo, T. (2005). The role of user involvement in requirements quality and project success. In *Proceedings. 13th IEEE International Conference on Requirements Engineering*, pages 75–84. IEEE.

Kujala, S. and Väänänen-Vainio-Mattila, K. (2009). Value of information systems and products: Understanding the users' perspective and values. *Journal of Information Technology Theory and Application (JITTA)*, 9(4):4.

Lusch, R. F., Vargo, S. L., and Wessels, G. (2008). Toward a conceptual foundation for service science: Contributions from service-dominant logic. *IBM systems journal*, 47(1):5–14.

Nilsson, F. (2013). Introduction to requirements engineering REBOK requirements engineering body of knowledge. *REQB® Certified Professional for Requirements Engineering*, 1:59.

Organization, W. H. (2015). *World report on ageing and health*. World Health Organization.

Osborne, S. P., Radnor, Z., and Nasi, G. (2013). A new theory for public service management? toward a (public) service-dominant approach. *The American Review of Public Administration*, 43(2):135–158.

Ouhbi, S., Fernández-Alemán, J. L., Carrillo-de Gea, J. M., Toval, A., and Idri, A. (2017). E-health internationalization requirements for audit purposes. *Computer Methods and Programs in Biomedicine*, 144:49–60.

Ouhbi, S., Fernández-Alemán, J. L., Toval, A., Rivera Pozo, J., and Idri, A. (2018). Sustainability requirements for connected health applications. *Journal of Software: Evolution and Process*, 30(7):e1922.

Ouhbi, S., Idri, A., Fernández-Alemán, J. L., and Toval, A. (2015). Requirements engineering education: a systematic mapping study. *Requirements Engineering*, 20(2):119–138.

Pekkola, S., Kaarilahti, N., and Pohjola, P. (2006). Towards formalised end-user participation in information systems development process: bridging the gap between participatory design and ISD methodologies. In *Proceedings of the ninth conference on Participatory design: Expanding boundaries in design*, volume 1, pages 21–30. ACM.

Rehman, M., Dean, A. M., and Pires, G. D. (2012). A research framework for examining customer participation in value co-creation: Applying the service dominant logic to the provision of living support services to oncology day-care patients. *International Journal of Behavioural and Healthcare Research*, 3(3-4):226–243.

Tokman, M. and Beitelspacher, L. S. (2011). Supply chain networks and service-dominant logic: suggestions for future research. *International Journal of Physical Distribution & Logistics Management*, 41(7):717–726.

Vargo, S. L. and Lusch, R. F. (2004a). Evolving to a new dominant logic for marketing. *Journal of marketing*, 68(1):1–17.

Vargo, S. L. and Lusch, R. F. (2004b). The four service marketing myths: remnants of a goods-based, manufacturing model. *Journal of service research*, 6(4):324–335.

Vargo, S. L. and Lusch, R. F. (2016). Institutions and axioms: an extension and update of service-dominant logic. *Journal of the Academy of Marketing Science*, 44(1):5–23.

Vargo, S. L. and Lusch, R. F. (2017). Service-dominant logic 2025. *International Journal of Research in Marketing*, 34(1):46–67.

Vargo, S. L., Maglio, P. P., and Akaka, M. A. (2008). On value and value co-creation: A service systems and service logic perspective. *European management journal*, 26(3):145–152.

Wagner, E. L. and Piccoli, G. (2007). Moving beyond user participation to achieve successful IS design. *Communications of the ACM*, 50(12):51–55.