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CYBER-PHYSICAL SYSTEMS AS A PLATFORM FOR VALUE CO-CREATION

CASE: INTELLIGENT EQUIPMENT IN MINING AND CONSTRUCTION INDUSTRY

JYVÄSKYLÄN YLIOPISTO
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ABSTRACT

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This thesis focuses on value co-creation in the context of Cyber-Physical Systems (CPSs) in a networked business environment. The object is to investigate how value is co-created in one particular networked environment, in the mining and construction industry, where the intelligent equipment are examples of CPSs. The research is interpretive case study, including one case company, which is a global organization preparing tools and equipment for the mining and construction industry. The framework for value co-creation in Consumer Information Systems (CIS) is used as a framework for value co-creation to study how the different actors from the case company and their customers (=20) perceive value co-creation and what are the system value propositions enabling the value co-creation and the value drivers driving the actors to co-create value in the context of intelligent equipment. The data collection was done using the laddering technique and for the analysis a thematic approach was adopted to turn the data into meaningful graphical presentations.

The results indicate that the use and service experience related to intelligent equipment is the most important value driver in this context. Also the sharing and receiving information related to intelligent equipment and the use and operating environment of intelligent equipment are important from the value co-creation perspective. The core values that emerged were support customer's process, efficiency and reliability. Based on the findings the service-centered perspective offers a broader view to value co-creation in the context of CPSs. This research integrates the cyber and physical world of CPSs but further research is required to form more comprehensive and broader understanding of the value co-creation in the field of CPSs in industrial context, since they are reaching the point of being technical systems and are more of socio-technical combinations including various different actors contributing to the value co-creation.

Keywords: Cyber-Physical Systems, value co-creation, Service-Dominant logic (S-D logic), Service logic, networked business environment, intelligent equipment, mining and construction industry

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Tämä tutkielma keskittyy arvon yhteisluontiin, jonka kyberfyysiset järjestelmät mahdollistavat verkostoituneessa liiketoimintaympäristössä. Tavoitteena on tutkia, miten arvon yhteisluonti tapahtuu kaivosalalla, jossa älykkäät laitteet ovat esimerkki kyberfyysisestä järjestelmästä. Tutkimus on tulkitseva case-tutkimus, jossa case-yrityksenä on maailmanlaajuinen kaivoalan laitteita valmistava yritys. Viitekehyksenä tässä työssä käytetään arvon yhteysluonnin mallia (CIS), jonka avulla voidaan kartoittaa, miten eri toimijat case-yrityksestä ja heidän asiakkaansa (=20) kokevat arvon yhteisluonnin, ja mitkä ovat älykkäisiin laitteisiin liittyvät arvo-odotukset ja toimijoita arvon yhteisluontiin ajavat tekijät kyseisessä verkostoituneessa ympäristössä. Aineisto kerättiin Laddering-haastattelumenetelmällä ja muutettiin graafisiksi malleiksi teema-analyysin tuloksena.

Tulokset osoittavat, että käyttö- ja palvelukokemus ovat tärkeimmät arvoajurit tässä ympäristössä. Myös mahdollisuus jakaa ja saada älykkäisiin laitteisiin liittyvää tietoa ja käyttö- ja operointiympäristö ovat tärkeitä arvon yhteisluonnin näkökulmasta. Keskeisimmät arvot, jotka nousivat esiin tässä tutkimuksessa, olivat asiakkaan prosessin tukeminen, tehokkuus ja luotettavuus. Tutkimuksen tuloksena voidaan sanoa, että palvelusuuntautunut näkökulma mahdollistaa laajemman arvon yhteisluonnin tarkastelun kyberfyysisissä järjestelmissä. Tässä tutkimuksessa kyber- ja fyysinen maailma käsiteltiin yhdessä, mutta lisää tutkimusta tarvitaan, jotta kyberfyysisten järjestelmien mahdollistama arvon yhteisluonti voitaisiin ymmärtää kattavammin teollisuuden toimialalla. Kyseiset järjestelmät tulisi nähdä enemminkin sosiaalis-teknisinä yhdistelminä, kuin vain teknisinä laitteina, sillä ne sisältävät monia eri toimijoita, jotka osallistuvat arvon yhteisluontiin.

Avainsanat: Kyberfyysiset järjestelmät, arvon yhteisluonti, palvelulogiikka (S-D logic, Service logic), verkostoitunut liiketoimintaympäristö, älykkäät laitteet, kaivosala

PREFACE

I would like to thank my supervisor Professor Tuure Tuunanen for all the guidance that you have provided me during this journey. I would also like to thank the people in Case Company for their interest and all the participants for their willingness to give their time to help me in carrying out this thesis. In addition, I wish to thank the many others who have been assisting me in this thesis. Furthermore, I would also like to thank my friends for encouraging me to complete this thesis. The biggest thanks for the support through my studies goes to my family: My father, brother and especially to my mother and grandmother for always believing in me, and Juhamatti for your patience and support in every aspect of life. Thank you.

FIGURES

TABLES

TABLE OF CONTENTS

1 Introduction

The physical environment is increasingly becoming saturated with different entities capable of interaction with other entities and with people (Baheti & Gill, 2011). The information from the physical world collected through different sensors is transformed as inputs to the cyber world, which as a response then can modify and adapt different applications and services to the physical world's need and as an output modify the physical world. Cyber-physical systems (CPSs) represent such systems capable of supporting the continuous interactions between the cyber world and the physical world by bridging them. (Conti, Das, Bisdikian, Kumar, Ni, Passarella, Roussos, Tröster, Tsudik & Zambonelli, 2012.) The integration of the cyber and physical world enables new capabilities for physical elements, such as machines, equipment and structures, and transforms them into smart or intelligent elements, which are able to operate in changing environments, often with humans in the loop. Integrated networking, information processing, sensing and actuation capabilities are outcomes of tightly integrated and coordinated processes between the cyber and the physical world. (Sztipanovits & Ying, 2013.) According to Hovárth (2014) CPSs are reaching the point were they cease to be just technical systems as they are constructed by various components, such as humans, equipment and other items, and are strongly interacting with the human domain and the embedded environment.

A parallel evolution with the CPSs is the shift of marketing and business perspective from the goods-dominant (G-D) logic towards the service-dominant (S-D) logic by Vargo & Lusch (2004), which emphasizes the role of service as the facilitator of value co-creation. The S-D logic offers a complete and structured framework for exploring the service related phenomena, which cannot be explained with the G-D logic (Vargo & Lusch, 2008). The nature of service exchange has gained attention due to the development of information technology (IT), which has increased the amount of information and expanded the opportunities to exchange it. The new business models and service opportunities enabled by the IT cannot be explained from the goods-centered perspective since the service is the object of exchange instead of products and the value perceived is not the value-in-exchange but rather value-in-use. (Vargo, Lusch & Akaka, 2010.)

For the traditionally product-oriented manufacturer, adopting the service-centered perspective on business is challenging as it changes the traditional view of value chain and the linear value flow from the raw material provider to manufacturer to supplier to customer (Basole & Rouse, 2008). The S-D logic views that the value is created through the network of resource integration and includes various different actors (Vargo et al., 2010a). The actors all contribute to the value co-creation based on their core competences (Gebauer, Paiola and Saccani, 2013) indicating that the service provider cannot determine the value. Instead the value creating networks are constantly changing, requiring adaptability from organizations to serve the value network and integrate resources (Vargo, Lusch & Tanniru, 2010). Furthermore adopting the service-centered perspective to business requires fundamental change from the manufacturing company, since instead of classifying services as a separate function the company should focus on supporting the customer's processes and see the service as a way to meet the customer's corresponding activities and processes to form an integrated stream of actions that enable the value co-creation (Grönroos & Helle, 2010).

In manufacturing industry the adoption of the S-D logic offers a broader view to the new service innovations and value co-creation opportunities, which the evolvement of IT enables. Increasingly the IT is integrated with the traditional manufacturing processes and products, creating a new formation of digitalized processes and products (Xion & Yin, 2006). This has changed the role of IT from being a supporting element to an enabling technology (Mathiassen & Sørensen, 2008). The concept called "Industry 4.0" is used to describe the movement towards the increased digitalization of products and processes and the establishment of intelligent product and production processes in manufacturing. The key enablers of this development are CPSs (Brettel, Friederichsen, Keller & Rosenberg, 2014).

Even CPSs are such systems capable of facilitating the value co-creation network due to the adaptation capability, the understanding of the CPSs as a phenomena and the nature of such systems is still in its infancy (Horváth, 2014). The opportunities enabled by CPSs are not completely recognized yet, even though the demand is starting to grow in various industries. The technological capability is already there, but for deploying the full potentiality of CPSs the service-centered perspective could offer a much broader view on emerging service and value co-creation opportunities than the product-centered perspective. The observation of Laine, Paranko and Suomala (2007), however, demonstrates the challenge to view the whole business from a service-centered perspective as the service revenues have stayed at a marginal level since the benefits of service-centered strategy for the manufacturer itself can be easily envisioned, but without the understanding of what the service phenomena is causes difficulties when describing the benefits for the customer, thus decreasing the customers willingness to buy. (Laine, Paranko & Suomala, 2007.) Salonen (2011) also noticed that in maturing markets instead of reorientation around the customer's processes for forming better understanding, the manufacturing companies tend to add more features to the products (Salonen, 2011).

The networked environment with various actors challenges the designing of CPSs. The design and development of CPSs is in many cases lacking of models, methods and tools since the CPSs research has concentrated on short-term results in the early phases of the development. The research of CPSs consists of various subdisciplines, such as sensors, communication engineering, computer science, control theories and human-computer interaction. The models from these disciplines represent either the cyber or the physical process not the integrated world. (Baheti & Gill, 2011.) Horváth (2014) argues that there exists a huge gap related to designing and engineering principles of realizing the CPSs, which is not linear like traditional systems. Also the awareness of the CPSs impact to the surrounding networked environment is relatively low (Horváth, 2014.)

1.1 Research question

The ability of the CPSs to facilitate continuous value co-creation is recognized (Conti et al., 2012). However being able to understand how the CPSs can facilitate the value co-creation process requires the deeper understanding of the interactions between the cyber and the physical world. The object of this study is to investigate how the value is co-created in the context of CPSs in networked business environments, where the different actors and components contribute to the value co-creation. The main research question is:

1. *How is the value co-created in the context of CPSs in networked business environments?*

For understanding the co-creation of value in the context of CPSs in networked business environments it is also important to understand how the different actors of the network perceive value co-creation, what are the value propositions and what are the value drivers. In this thesis, the focus is on understanding value co-creation in one specific domain, in the mining and construction industry, where the intelligent equipment are examples of CPSs. The sub question is:

1a. *What are the value propositions and the value drivers in the context of intelligent equipment?*

This thesis is conducted as a case study, as it enables to investigate the phenomena in its environment, which is important in the context of CPSs as they include the cyber and the physical world with various actors and embedded environment. This study focuses on intelligent equipment in the mining and construction industry, where the intelligent equipment are examples of CPSs by integrating the cyber world and the physical world. In this research the case company is a global organization preparing tools and equipment for the mining and construction industry.

As a framework for value co-creation the CIS framework is adopted, as it enables to investigate the value co-creation from the perspective of different actors and to answer to the sub question by including the value propositions and the value drivers. The data collection is conducted utilizing interviews and the interviews are done using the laddering technique of Reynolds and Gutman (1988), afterwards outlined by Peffers, Gengler and Tuunanen (2003) more specifically from the perspective of information systems (IS) research for understanding the reasoning why people prefer certain IS features. The case participants are from the networked environment surrounding the case company's intelligent equipment including members of the case company from different operational areas and representatives of their customers. In this research for the analysis a two-step thematic approach is adopted for turning the data into meaningful graphical presentations and also the Critical Success Chain model is used for creating chains of attributes, consequences and values. The analysis follows similar studies (Vartiainen & Tuunanen, 2013, Tuunanen, Peffers, Gengler, Hui & Virtanen, 2006, Peffers et al., 2003) and offers an appropriate model for answering to the research questions to understand the value co-creation when using the CIS framework.

1.2 Thesis outline

The first chapter is an introduction to the research area in this thesis, which also states the motivation for this study. The introduction includes the objectives and questions of this research and outlines the design of this study**.** The literature preview begins in chapter two, which includes two alternative perspectives to service: The Service-Dominant logic and Service logic. This chapter aims to provide an overall understanding of the service-centered perspective compared to the traditional product-centered perspective. The chapter also introduces the value co-creation approach more deeply and the theories behind the CIS framework. The third chapter is a literature review introducing the adoption of service-centered perspective on manufacturing industry in networked business environment. It includes also a brief overlook of how the role of IT has evolved in manufacturing industry and in organizational environment. This chapter also introduces the Cyber-physical systems (CPSs).

In the fourth chapter the choice of methodology and the case study agenda, including the profiles of the participants, are introduced in more detail. The CIS framework based stimuli list, which is used in data collection, is also introduced. The fifth chapter represents the findings and the theme maps, which aims to provide a quick understanding on how the value is co-created in this context. The chapter six discusses the findings in more detail and aims to answer the research questions. This chapter also links the findings of this study to the previous research and gives implications for research and practice. The final chapter summarizes this thesis. The contributions to research and practice will be stated as also the limitations and suggestions for future research.

2 Adopting service-centered perspective on business

Adopting service as a perspective on business and to value creation has been the target of growing interest. However the understanding of service and the service research field are affected by the lack of cohesion and the impact of traditional product-centered perspective. This chapter aims to form a unified understanding of the service as a perspective on business by first introducing the background of the service-centered perspective and contrasting it with the traditional product-centered perspective. The leading approaches to service, called the S-D logic and the Service logic, will be introduced and the key issues of these logics investigated to form a deeper understanding of the service-centered perspective on business and value creation. This chapter also presents the framework for value co-creation by Tuunanen et al. (2010), which includes the system value proposals and the user value drivers.

2.1 Service definition

The understanding of service and the service research field has been strongly affected by the exchange model that marketing inherited from economics (Vargo & Lusch, 2004). When the focus was on production and distribution of tangible products embedded with utility, the marketing field largely ignored the intangible output, service. Service was considered to be a value-adding activity such as distribution or sales, in other words an intangible add-on to the tangible core. Within services it came common to identify and categorize them by the characteristics that separated them from goods, classified as intangibility, heterogeneity, inseparability and perishability characteristics (IHIP). (Vargo et al., 2010a.) In generally these were considered as undesirable qualities of products, since services can not be stored, are not standardized, must be produced and consumed simultaneously and are difficult to realize (Edvardsson, Gustafsson & Roos, 2005).

Since 1970s the three schools of service marketing, the French, the American and the Nordic, intensified the service related research and the amount of publications grew rapidly (Grönroos & Ravald, 2011, Fisk, Brown & Bitner, 1993). The scholars were aware that the competitive advantage could be enhanced through service and Shostack (1977) inquired after an equally descriptive definition for service as there is for goods and questioned the distinction of tangible and intangible since the market entity can be partly both. The need for service related language, concepts and faster evolution of service marketing in general emerged with vigor. (Shostack, 1977.) The new service-centered perspective started to emerge emphasizing that service rather than goods are the fundamental basis of exchange.

Edvardsson et al. (2005) describe that the new perspective towards service challenged the traditional role of the customer being the target of marketing. From the service-centered perspective, the customer's perspective on value creation is more relevant than the provider's since the customer describes the characteristics that are important for them and ignores the ones that are not creating value. From the value creation perspective it is difficult to provide some accurate characteristics for service that could be used to define all services and the traditional IHIP characteristics are too narrow and incapable of explaining the exchange and value creation related to service. Furthermore the development of information technology revolutionized the business models related to services. (Edvardsson et al., 2005.) Vargo and Lusch, (2004) referring to Prahaland and Ramaswamy (2004), argue that the market had evolved as a venue for proactive customer involvement indicating that the customer is rather a co-producer of value and always involved to the value creation process (Vargo & Lusch, 2004).

The service has been defined in various ways due to the subordinate position in relation to products. Vargo et al. (2010a) demonstrate this by stating that the term *services* (plural) as intangible unit of output is referring to the residual category of marketing offerings, value adding services or services in the service industry. The term *service* (singular) refers to the perspective on value creation as doing something for or with another entity and is applicable also to those marketing offerings that involve goods in the process of providing services. (Vargo et al., 2010a.) Table 1 summarizes, according to Edvardsson et al. (2005), the different definitions for service when viewing it from the value creation perspective:

TABLE 1 Definitions for service (Summarized from Edvardsson et al., 2005)

Author (s)	Service definition
Grönroos, 2001	"Service is an activity or series of activities of a more or less intangible nature that normally, but not necessarily, take place in the interaction between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to customer problems"
Gustafsson & Johnson, 2003	"Service is a seamless system of linked activities that solves customer problems or provides unique experiences"
Vargo & Lusch, 2004	"Service is an applications of specialized competences (knowledge & skills) through, deeds, processes, and performances for the benefit of another entity or the entity itself."

Grönroos (2010) states that there is a difference whether to define service activities or offerings as business activities and study service as a separate business activity or view the entire business from a service perspective as an integrated business (Grönroos, 2010). Vargo et al. (2010a) suggest a broader view beyond the activities, which traditionally focus on specifications and operational processes rather than consider the service as the broader scope of the value co-creation space (Vargo et al., 2010a). In this research service is adopted as a perspective on value creation as suggested by Edvardsson et al. (2005) and define it according to Vargo & Lusch (2004) as an applications of specialized competences (knowledge & skills) through deeds, processes and performances for the benefit of another entity or the entity itself. This enables to understand the service as a perspective to business rather than a category of marketing offerings or value adding services.

2.2 Towards service-centered perspective

The understanding of service and the development of the service research field have been strongly influenced by the traditional product and production oriented perspective of marketing called the goods-dominant (G-D) logic. Vargo & Lusch (2004) challenged the G-D logic by introducing the service-dominant (S-D) logic, which is considered to be the first comprehensive structured service-centered approach to marketing. (Vargo et al., 2010a, Vargo & Lusch, 2004.)

The traditional G-D logic is grounded in the development of economic philosophy and science. It focuses on production and distribution of tangible products, which are embedded with utility. The products are measurable and exportable and exchanged for money, when the ownership transfers to the buyer and the value emerges as the value-in-exchange. The value is created during the production and destroyed by customers. (Vargo et al., 2010a, Vargo & Lusch 2004.) At this stage the marketing field largely ignored the intangible output, service. Service was considered to be a value-adding activity such as distribution or sales, an intangible add-on to the tangible core. Service did not fit in the goods-based model of exchange, which made it difficult to study services. (Vargo et al., 2010a.)

The S-D logic is considered to be a more comprehensive logic for marketing by integrating goods with services and considering that service, whether it includes goods or services or both, is the basis of exchange. S-D logic considers service as the process of doing things for and with other entities and stresses the process nature of service. It also questions the G-D logic's view of value and value creation by grounding its understanding of value to the value-in-use and to the approach of value co-creation. (Vargo & Lusch, 2004.) The purpose of the S-D logic is to capture the fundamental function of all businesses and offer a mindset and lens to see the social and economic exchange phenomena more clearly. Furthermore, the S-D logic offers a complete and structured framework with service related lexicon, which enables to explore service related phenomena. (Vargo & Lusch, 2008.)

The original S-D logic has been complemented by Vargo and Lusch several times and by increasing the interest towards the service related phenomena several other scholars have continued the research in the service field and suggested refining and enhancing some topics of S-D logic (Vargo & Lusch, 2008). The S-D logic is also considered to be a philosophical foundation for service science, which aims to combine the earlier, relatively little integrated research fields, such as management, operations, marketing and information technology, by positioning the service as the central concept (Ifm & IBM, 2008). The service science focuses on service systems, which are defined as value co-creation configurations of people, organizations and technology, or dynamic configurations of resources, which interact. These interacting service systems can form large networks, which are changing knowledge to create value. (Maglio, Vargo, Caswell & Spohrer, 2009.) However the lack of cohesiveness in the service related research field has not created a solid theoretical foundation for true science of service. Also the service science is still lacking of an in-depth service perspective since it is influenced by the assumptions of G-D logic, for example the distinction between goods and services is still visible. (Vargo et al., 2010a.)

The influence of the G-D logic is also evident when following the recent debate about economic activity. It has been suggested that we have entered to a new service economy era (Wang, Ming, Wu, Zheng & Xu, 2013, Spohrer & Maglio, 2008). Vargo et al. (2010a) argue that from the G-D logic's perspective it may seem like there is a new service economy as companies have increased the share of services in their total provision and in modern economies the share of service sector is increasing. However the services are not only recently becoming important, rather it is development IT that has changed the way of doing business (Vargo et al., 2010a). These actions demonstrate attempts to understand and identify the growing number of offerings that cannot be categorized as goods from the perspective of G-D logic (Gebauer et al., 2013). However the S-D logic is not aiming to replace the G-D logic, rather it broadens the ability to study service-related phenomena.

2.3 Alternative logics: The service-dominant logic and the service logic

The increasing importance of service was recognised by alternative schools of marketing: The Nordic, French and North American. The S-D logic was the first approach that could compile the prior service research and combine it into an organized structure and create a service-oriented logic for marketing, which the other researchers had not achieved. (Grönroos & Ravald, 2011.) While the S-D logic is an upper-level perspective on service and described on a general level, the Service logic by Grönroos representing the Nordic school described the service related aspect in more detail and contrasted some of the fundamental premises of the S-D logic. The fundamental similarity between the S-D logic and the Service logic comes from the quite similar perspective on the definition of service as a process that applies one's resources for the benefit of another and is central to value creation and exchange. The categories or distinctions between goods and service are not relevant, only the service that they provide is meaningful. Both of the logics are customer-centered implying that the value is defined and experienced by the customer, not determined by the service provider.

The S-D logic is rooted originally in eight (Vargo & Lusch, 2004) and afterwards in ten (Vargo & Lusch, 2008) foundational premises, which are introduced in table 2. The premises are not invented for S-D logic rather they shed the right mindset for considering service and service marketing as the facilitator of the process based exchange through applications of resources enabling value creation among the actors.

TABLE 2 Foundational premises of S-D logic (Vargo & Lusch, 2004, 2008)

FP (#)	Premise	FP (#)	Premise
FP1	Service is the fundamental basis of exchange	FP 6	The customer is always a co-creator of value
FP2	Indirect exchange masks the fundamental basis of exchange	FP 7	The enterprise cannot deliver value, but only offer value propositions
FP3	Goods are distribution mechanism for service provision	FP 8	A service-centered view is inherently customer oriented and relational
FP 4	Operant resources are the fundamental source of competitive advantage	FP 9	All social and economic actors are resource integrators
FP 5	All economies are service economies	FP10	Value is always uniquely and phenomenologically determined by the beneficiary

The first foundational premise that service is the basis of all exchange (FP1) is the basic premise of S-D logic and related to the premise that all economies are service economies (FP5). This indicates that the shift of focus is not from goods to services but rather viewing the operant resources as the fundamental source of competitive advantage (FP4), which drive the value creation and are therefore not limited to the service provider's resources but include the whole network that contribute to the value creation. According to S-D logic the resources are exchanged to create value (FP9). This indirect exchange and web model often masks the direct service-for-service exchange (FP2) and that also products can be considered as the distribution mechanism for service provision (FP3). Revealing for S-D logic is that the service provider cannot deliver value or determine the value; it can only offer value propositions (FP7) as the beneficiary decides what are meaningful for them (FP10). The customers are therefore considered as the co-creators of value (FP6). This indicates that the service-centered view is strongly customer oriented and relational (FP8). (Vargo et al., 2010a.)

To form a more unified understanding of the service-centered perspective in general, the foundational premises will be divided under the key issues that are resources and exchange, value, value creation and value co-creation and experience. The key ideas of these premises will be challenged and extended with the more specific concepts of Service logic.

2.3.1 Resources & exchange

Resources are the central concept in understanding the S-D logic. The S-D logic focuses on operant resources, such as knowledge and skills, of customers, employees and the environment. These are the opposite of operand resources that are the core of the G-D logic. Traditionally the national wealth was considered as being created with exportable things and depending on operand resources. However as the marketing moved from distribution towards the process of exchange the importance of operant resources increased. Operant resources are employed to act on operand or other operant resources. They produce effects and enable the creation of other operant resources, such as new ideas and knowledge. The S-D logic considers both operant and operand resources as inputs for value creation, but the key idea is that operand resources become valuable only via the application of operant resources. (Vargo et al., 2010a.)

From the service providers perspective the organizations are considered resource integrators, as they transform the employee-level knowledge and skills and other internal and external resources into a service provision. It also involves the customers, users and other beneficiaries as they contribute to the value creation. The value creation is a network of networks as the value is created though the web of resource integration, called the service ecosystem (Vargo & Akaka, 2009). Between the S-D logic and service logic there lays a fundamental consensus that all resources can be used as services, whether it is purely operant resources or operant resources using operand resources. According to Grönroos and Gummerrus (2014) the usage or consumption involving resource integration leads to realization of the service (Grönroos & Gummerrus, 2014).

The exchange model of the S-D logic is service-centered as service is considered to be the fundamental basis of exchange. However the exchange also can include products as the distribution mechanism for service. The S-D logic does not consider the service as a substitute for goods, but rather considers that the G-D logic is nested within S-D logic. This indicates that the S-D logic tries not to replace the importance of products but rather broadens the lens from which the service-related phenomena can be studied. (Vargo et al., 2010a.)

Grönroos (2010) states that the perspective on service business and marketing are fundamentally the same for both the S-D logic and the service logic. However, according to the Service logic, the consideration that service is the basis of exchange is restrictive since the value creation is more fundamental for participating parties than the service, so the basis of business and exchange should be the value creation. According to this view the service can be seen the facilitator of value creation. (Grönroos, 2010.)

2.3.2 Value

The value perceived can be multifaceted as it can be described with many specific characteristics. Kakar (2014) states that the typology of value includes only two types – the utilitarian value and the hedonic value (Kakar, 2014). The concept of value has been challenged as the consumer behaviour has evolved from emphasizing rational choice towards filling irrational needs (Holbrook & Hirschman, 1982). Until the first quarter of the twentieth century, the design and production of commodities focused on high utilitarian aspects. The mass production was devoid of the hedonic consideration and the utilitarian value attributes such as useful, practical, and functional were considered important attributes that helped to achieve a certain goal (Kakar, 2014.) The G-D logic emphasized the meaning of utilitarian value and the functional benefits (Vargo et al., 2010a) and viewed value as something that is embedded in products during manufacturing processes and destroyed when consumed, indicating the value-in-exchange (Grönroos, 2008).

As the functionality and practicality of mass-produced commodities was challenged by the hedonic considerations such as aesthetic, emotional or affective preferences of consumers, the need to consider the hedonic value was fostered (Kakar, 2014). Holbrook, Chestnut, Oliva and Greenleaf (1984) paid attention to the experimental aspects of consumption and came to the conclusion that it is motivated by hedonic enjoyment. The consumer's behaviour includes hedonic elements such as fantasies, feelings and fun. (Holbrook, Chestnut, Oliva & Greenleaf, 1984.) The hedonic attributes could be described as pleasant, fun, enjoyable or appealing to the senses (Kakar, 2014). As the perspective of marketing turned towards service, the locus of value creation for the customer became the target of increasing interest. The value-in-exchange was challenged by value-in-use that considered value emerging customers' during value generating processes and not created by the provider. (Grönroos, 2008.)

The S-D logic emphasizes the phenomenological and experimental value as the beneficiary determines the value. The idea of value in G-D logic is highly reliant on the monetary value and the sort of value that the customer receives is secondary. According to the S-D logic firms can only make value propositions and the beneficiary always determines the value. The firms are constantly striving to make better value propositions under the flux of a continuous series of social and economic processes. (Vargo et al., 2010a.) The primary flow in the service-provision chain, also referred as the value chain, is knowledge and service is the provision of information to be used by a customer who desires it. This is quite contrary to the goods-centered perspective that considers the primary flow to be material flow. (Vargo & Lusch, 2004.)

However Grönroos (2008) argues that the value-in-use and the locus of value creation are implicit in S-D logic. The value is difficult to define and measure, even though the value has got the measurable side in financial terms, but the attitudinal components of value, such as trust, affection, comfort and ease of use, are more abstract. The Service logic considers that the use is the key qualifier of value-in-use, not the context or interaction. If the context changes so does the level of value-in-use. Service logic also takes into account that value can be created and destroyed since the value-in-use evolves over time as a cumulative process, which may include destructive stages. (Grönroos & Gummerrus, 2014.)

2.3.3 Value creation & value co-creation

The conception of the value creation process has gone through a significant change. Prahaland and Ramaswamy (2004) conclude that the change challenges Porter's (1980) value chain, which makes a clear distinction between the roles of the firm and the customer as the producer and the consumer. However, as the focus of marketing turned towards services, the interactions between the customer and the firm enabling the co-creation of unique experience and the joint creation of value for both firm and the customer became the key concept. All interaction between the provider and the customer are considered as opportunities for value creation. (Prahaland & Ramaswamy, 2004.)

Both the S-D logic and the Service logic have adopted the value co-creation approach. The S-D logic focuses on creating a fundamental basis for the new way of thinking about the value creation as a contrast to G-D logic. Originally Vargo & Lusch (2004) used the term co-production to describe the customer's participation to the production of value. The aim was to create the distinction and stress the service-centered perspective rather than the goods-centered perspective by highlighting the customer's role as an operant resource acting on operand resources. (Vargo & Lusch, 2004.) However Vargo and Lusch (2008) states that the term co-production in fact relates strongly to the G-D logic lexicon and the production of products. Afterwards the customers have been described as co-creators of value to express the collaborative participating to the value creation. To make it even clearer, they stated that the customer's role in the co-production is optional but that the customer is always the co-creator of value. (Vargo & Lusch, 2008.)

Grönroos and Gummerrus (2014) and Grönroos (2008) also strongly question the S-D logic's value co-creation approach and the statement that the service provider can only make value propositions (Grönroos & Gummerrus, 2014, Grönroos, 2008). The Service logic challenges the key concepts of S-D logic's value creation and claims it to be too implicit and to remain on a metaphorical level. The Service logic offers an analytical concept to describe the role and focus of co-creation, the actors involved and the value co-creation more specifically. The Service logic is clearly led by the idea that the customer as a user is the value creator and the driver of the value creation process. The firm, by preparing skills, knowledge and other resources, is the facilitator by providing potential value-in-use. Even though the value for the customer and the value to the firm are two different sides, there exists reciprocally influence between each other's value creation processes meaning that the customer may offer practical information to the firm that turns the customer to a service provider with the firm as a customer and a value creator. (Grönroos & Gummerrus, 2014.)

Since the service activities only have meaning in terms of the service the Service logic separates the customer perspective and the provider perspective. The customer perspective referred as customer logic indicates that according to Service logic the customers combine resources provided by the firm with other resources in their value creation process and, if the firm adopts the provider perspective referred as provider logic and establishes interactions between the service provider and the customer, then the value can be co-created (Grönroos, 2010). This is a significant difference compared to S-D logic. As Vargo & Lusch (2008) state in the S-D logic interactions appear mainly as a statement that the customer is always a co-creator of value and the interactions are considered to exist in the network environment (Vargo & Lusch, 2008). Vargo et al. (2010a) notice the role of interaction on a relationship and exchange level by stating their role in collaborative communication and learning through exchange. The S-D logic views the interactions related to the market interactions concerning the customer solution and experiences, rather than the transfer of ownership as in G-D logic. (Vargo et al., 2010a.) The link between the interactions and value co-creation stays without any attention in S-D logic.

The Service logic offers a more explicit description of interactions. Grönroos & Gummerrus (2014) emphasize the role of interactions as the foundation for how the service emerges to the customer and, referring to Grönroos & Voima (2013), offer an interaction concept that divide interactions to direct and indirect interactions. Direct interactions refer to a situation where two or more actors act together in one process influencing each other's actions and perceptions. These two processes conjoin in one collaborative interactive process. Every actor that is involved can directly influence the emerging value-in-use of the other actor, creating the platform for value co-creation. On the interactive platform interactions may influence one or all actors value realization or fulfilment, assuming that they are willing to use the value co-creation opportunity. The direct interaction can also appear between one actor and an intelligent non-human resource and by responding to the speech or registering the actions of a person, create a joint dialogical process and the platform for value co-creation. Descriptive for direct interaction is the immediately reaction and learning of both parties. (Grönroos & Gummerrus, 2014.)

However, non-human resources or systems responding in a standardized way to user's actions do not fulfill the criteria of an intelligent non-human resource and direct interaction. From the customer's perspective the interaction still is created with the firm through the use of products or resources, but this sort of indirect interaction does not create the platform for value co-creation. In indirect interaction the firm offers to the customer non-intelligent products or systems as a source of potential value-in-use and it is depending on the customer's actions as to whether value-in-use is created or emerges. (Grönroos & Gummerrus, 2014, Grönroos, 2011.)

Continuing this view the Service logic considers value creation as a customer driven process occurring in three spheres. The provider sphere describes the firm's role in the value generation process as a facilitator of customer's value creation process. The firm develops and provides resources that support the customer's creation of value-in-use. The customer's sphere is the customer's independent value creation or value-in-use sphere. Between these two is the joint sphere that is the value co-creation sphere requiring the direct interactions to create the platform for value co-creation. These views of spheres also strengthen the Service logic's customer perspective since the value creation is customer driven. (Grönroos & Gummerrus, 2014.) This view questions clearly the supposition that the customer always is a co-creator of value, rather it happens in the best scenario depending on the firm's ability to offer the right resources.

The S-D logic is strongly guided by the idea that the firm can only make value propositions, contrary to the G-D logic's view that the firm is able to create the value. In a general level it can be understood this way, but as Grönroos & Gummerrus (2014) state, the value proposition is a firm oriented one-sided concept and is not designed for a service context supporting direct interaction and the platform for value co-creation. What the value proposal needs in the service context is to act to ensure the realization of the proposed value. This may only exist in the interaction between the firm and the customer. In the platform for value co-creation the activities are interactive, mutual and reciprocal, and the service provider can, instead of only offer value proposals, also actively and directly influence customer's experiences and the determination of the value-in-use. (Grönroos & Gummerrus, 2014.)

2.3.4 Experience

The growing interest towards the customer experience is linked to the co-creation of value, as the customer experience is co-created through customer interactions with the elements of the service. The holistic nature of the service experience challenges the interdisciplinary methods and tools of service design (Teixeira, Patricio, Nunes, Nóbrega, Fisk & Constantine, 2012).

The S-D logic views the experience to be closely linked to the value co-creation, as there is no value until the offering is used and therefore stresses the essentiality of experience and perception for the value determination. The S-D logic also emphasizes the importance to understand how the customer uniquely integrates and experiences the service related resources for creating the competitive advantage (Lusch, Vargo & O'Brien, 2007). Grönroos and Voima (2012) referring to Strandvik et al. (2012) contrast the S-D logic's view that service must be experienced by the customer arguing that the current marketing terminology with terms such as solution, service offering and value proposition implies the firm's dominant position for value creation. The Service logic emphasizes the firm's ability to influence the customer's experience, but recognizes the lack of conceptualization. (Grönroos & Voima, 2012.)

Teixeira et al. (2012) referring to Berry et al (2002) suggest that for enabling the desired experience the customer journey must include coherent elements, which enable the experience to take place and the customers to co-create unique experiences though their interactions with the different touch points. Jüttner, Schaffner, Windler and Maklan (2013) referring to Berry et al. (2002) suggest that the experience can be conceptualized as a subjective response to the holistic and indirect encounter with the company. The customers' service experience can be seen as the sum of all cognitive and emotional responses to a company's experience stimuli indicating that the experience should be designing as a series of stimuli, which in ideal situations trigger the positive cognitive and emotional responses from the customer. (Jüttner, Schaffner, Windler & Maklan, 2013.)

Always, the experience is also a response to other elements, which the service provider cannot control, such as the social environment, indicating that the experience does not follow the predicted outcomes and that the customer experience cannot be designed; rather the service can be designed to support the customer experience. (Teixeira et al., 2012.) The customers' experience behaviour can be seen as purposeful and goal-oriented and related to the customers' personal values. The causal links between the experience stimuli and the personal values indicates that the importance of stimuli may vary between different customers. Exploring the links between the company stimuli and the customers different hierarchical levels are essential because they affect the customer's purchase decisions and the experience evaluation. (Jüttner et al., 2013.)

Due to the development of the IT and the changed nature of service, the experience has become increasingly important and the service design as an approach has become more evident. When considering the service as perspective on value co-creation rather than action, the outcome of the service is not the result of a single encounter or trade-off. Even though there might be a so-called "moment of truth" when the quality or the service experience becomes apparent to the customer that is enabled by the entire service process. (Glushko & Tabas, 2008.)

Glushko and Tabas (2008) offer a service system related model for understanding the experience, which includes the front stage and the back stage. The experience that is created depends on how the back stage supports the front stages actions. The front stage usually focuses on techniques and tools from human-computer interactions and the user-centered design approaches for creating the desired experience. For capturing and communicating the service from their perspective they use tools such as scenarios, blueprints and interactive prototypes. On the contrary the back stage focuses on different goals and techniques that lead the efficiency, robustness, scalability and standardization of the system, seeing people as abstract actors in this process. The back-stage analyzes information requirements, flows and feedback loops using techniques from information architecture, process modelling and software development to produce class diagrams, simulation models and software. (Glushko & Tabas, 2008.)

The service experience needs a multidisciplinary approach to recognize how the experience is created from the customer's perspective. Also in order to design the service to support the customer experience it is essential to understand the service from the perspective of value creation and not as a marketing offering for obtaining the broader perspective of the environment affecting the experience.

2.4 A framework for consumer information systems (CIS)

Understanding the factors of value co-creation has been the central issue in information systems (IS) research and service science since adopting the service-centered perspective. However the S-D logic or the Service logic have not offered specific frameworks or models for value co-creation. Tuunanen, Myers and Cassab (2010) proposed a framework for value co-creation for digitized services called the framework for value co-creation in consumer information systems (CIS). In this thesis the CIS framework is used as a framework for value co-creation.

The purpose of CIS framework is to offer a framework for value co-creation to support the developing of digitized services. Tuunanen et al. (2010) view that like the recent consumer psychology, behavioural psychology and marketing research indicate, consumption is increasingly driven by the utilitarian and hedonic value instead of functionality or effectiveness. This requires realigning the focus towards the service experience since the enjoyment of using the product or service reflects on the need of considering the customer as an active participant in the production of these systems. Thus, insights from IS and the service marketing literature can be combined to discover and define requirements for IS systems from the value co-creation point of view. (Tuunanen et al., 2010.)

CIS views the value co-creation from the customer's perspective by emphasizing the system's role as the facilitator or platform for the value co-creation. Tuunanen et al. (2010) define CIS as:

> ”Systems that enable consumer value co-creation through the development and implementation of information technology enabled processes that integrate system value propositions with customer value drivers.”

As the value co-creation is seen as an outcome of joint processes between the service provider and the consumer, the CIS framework integrates the system value propositions and the consumer value drivers as seen in the figure 1. The CIS framework is divided into two sections. The left side is formed by system value propositions and the right side from customer value drivers. The system value propositions are the social nature of use, construction of identities and context of use, which represent features of the system that enable the value co-creation. The customer value drivers are participation in service production, service process experience and goals and outcomes indicating the values that are driving the user to co-create value. These six factors affecting value co-creation are rooted in IS, marketing and service research literature offering theoretical approaches to enable the handling of these factors in the designing and development.

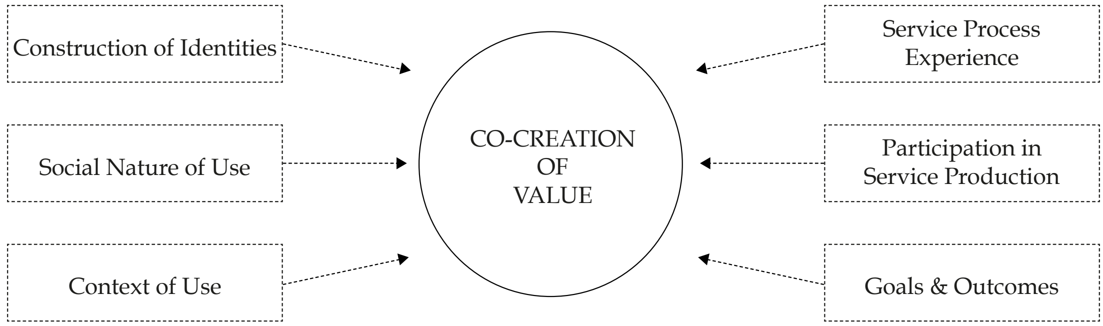

FIGURE 1 Framework for value co-creation in consumer information system (Tuunanen et al., 2010)

2.4.1 System value propositions

Consumer motivation and reasoning behind consumption are difficult for service developers to predict but also difficult for consumers to explain why certain features of a service or the IT artefact are important. Lamb and King (2003) referring to Goffmann (1974, 1959) suggest the social actor theory an appropriate approach to understanding the use of IT in social settings (Lamb & Kling, 2003). The first system value proposition of CIS is the construction of identities emphasizing the importance to understand the reasoning behind the use of IT artefacts in value co-creation. Lamb and King (2003) view that social actors use IT artefact as a way to construct identities. Especially in organizational settings the social actors use IT artefacts to obtain and exchange information and simultaneously constructs identities for themselves, for the firm, for competitors and for clients. The level of the IT utilization is a signal of the competence level and may be used as an indicator of technology mastery for both the social actor itself and the whole organization. (Lamb & Kling, 2003.) According to Tuunanen et al. (2010) the critical success chain approach and the laddering interview technique can be used to provide information about the preferred features. The laddering will be discussed further in the research methodology chapter later.

As Lamb and Kling (2003) phrase the traditional IS development has been leaded with various requirement elicitation techniques as a way to understand the user of IS. Traditionally the user is considered to be an isolated individual with the ability to define preferences and within certain cognitive limits to use deliberatively selected systems. The social nature of use is the second value proposition. It refers to the argument of Lamb and King (2003) who stated that systems are rarely used in isolation. According to Tuunanen et al. (2010) users rather seek ways to network and interact with other users (Tuunanen et al., 2010). In order to understand how the system can enable the value co-creation it is important to understand how the different actors are linked and how they interact.

The third system value proposition, the context of use, is an important issue according to Tuunanen et al (2010) who argue that the context of use has greater impact on the use of CIS than in organizational settings to the use of IS. Dey and Abowd (2000) define context as information that can be used to characterize the situation of entity, which can be a person, place or physical or computational object, whereas a context-aware application is able to provide task-relevant information or services to the user. In order to design a context-aware application the designer needs to understand the context of use and determine what context-aware behaviour the application needs to support. For application the ability to respond to the changes in their environment leads to better performance and improved ability to support the user. (Dey & Abowd, 2000.)

An important issue related to the context of use is the cultural aspect. Tuunanen et al., (2006) referring to Honold (2000) state that cultural context affect to preferences and reasoning of system use. Factors such as mental models that are based on previous experiences, environment and organizational factors affect the use and these need to be taken into account in order to meet the preferences of location specific customers. (Tuunanen et al., 2006.) CIS suggest that an in-depth laddering interview could be used to provide information about the reasons why users prefer certain features and how the potential new feature connects to the values driving the user (Tuunanen et al., 2010).

To conclude, consumer behaviour and the use of IT artefacts are influenced by several aspects. The user or, as suggested, the actor needs to be viewed in social settings in order to understand the interactions as a part of constructing identities. Also the context of use influences the experience and the preferred features requiring a deep understanding of the different users.

2.4.2 Value drivers

The users have values that drive their behaviour, which also influence the consumer’s acceptance. The first value driver of CIS is the service process experience referring to the challenge to understand the issues influencing the experience. Holbrook et al. (1984) observe that consumption includes experiential aspects of playful like consumption that is motivated by hedonic aspects such as enjoyment, satisfaction and fun. Tuunanen et al. (2010) referring to Kahneman (2003) also emphasize the hedonic utility through the use experience. (Tuunanen et al., 2010.) Also Agarwald and Karahanna (2000) continue with the importance of experience by stating that the individual’s interaction with the technology can offer engaging experiences. The theory of flow can be used to study the flow experience, a state when the individual is in a state of intensive concentration and enjoyment during the interaction, to understand the human-technology interactions and attitudes towards technologies or their functions. Agarwald and Karahanna (2000) also introduce cognitive absorption (CA) to further examine user experiences with technology (Agarwald & Karahanna, 2000).

The IS literature notices the importance of the user involvement especially in the requirement elicitation and analyze phase, but the best way to involve them remains unclear (Tuunanen et al., 2010). This leads to the second value driver of CIS, which is the participation in service production. The user participation in service production emphasized by CIS is a view coherent with the S-D logic. Also as Vartiainen and Tuunanen (2013) state the customers are expecting more personalized experiences. Von Hippel (1986) suggests that by focusing on users, which are called lead user, whose present strong needs eventually become general in the marketplace is a way to forecast upcoming needs. The lead users usually attempt to fill the need they experience and are able to identify the desired new solution. (von Hippel, 1986.) Tuunanen et al., (2010) referring to Tuunanen and Rossi (2004) suggest rapid prototyping as a way to take the customer participation even further.

The customer goals and outcomes are the last value driver. They are a challenge for CIS since the information system should be able to create hedonic utility through the use experience and the measurement of that is difficult. Tuunanen et al. (2010) observe the lack of models to be used to measure the hedonic utility. The traditional IT models are not valid in the context of CIS with the metrics for perceived usefulness or efficiency. Also the conjoint approach of marketing that is used to measure the consumers association of the utility of product or service isn't offering metrics for hedonic value. The Quality function deployment (QDF) technique developed by Herzwurm, Schockert and Mellis (1997) realizes the customer's role as the determiner of the product's success. The model is based on the idea of developing products or services with characteristics that the customer demands and the development focuses on increasing the customer benefits and satisfaction. (Herzwurm, Schockert & Mellis, 1999.)

3 Cyber-physical system as a platform for value co-creation in industrial context

Understanding service and value in industrial context are strongly guided by the product-centered perspective. This chapter aims to explore how the manufacturing industry could benefit from the service-centered perspective and the value co-creation approach. This chapter also briefly explains the networked value co-creation environment and the changed role of IT in organizational settings. This chapter also introduces Cyber-physical systems (CPSs), which from the service-centered perspective could enable various new service opportunities when considered as the platform for value co-creation.

3.1 Towards service-centered perspective and value co-creation in networked business environment

For manufacturing companies changing the focus of business towards a service-centered perspective requires managing the entire business from the service perspective. Grönroos and Helle (2010) argue that the basic problem of many product manufacturers is that their business logic is traditionally product-oriented and the service-centered approach is considered achievable by focusing on separate service activities. In practical terms adopting the service-centered perspective on business would require that all the activities and processes of the manufacturer that are relevant to its customer's business are coordinated with the customer's corresponding activities and processes to form a stream of actions. (Grönroos & Helle, 2010.) Instead, in the traditionally product-oriented industry the companies tend to add more features to the products or create new supporting services instead of reorientation around the customer's processes (Salonen, 2011).

The literature suggests various service-led competitive concepts such as servitization, product-service systems, lifecycle services and after-sales services, for the manufacturing companies to turn their focus from products towards services. These include services such as acquisition, installation, upgrades, spare parts and maintenance. (Oliva & Kallenberg, 2003.) Vargo et al. (2010a) argue that these concepts emerge from the perspective of G-D logic and indicate the need to fit the service to the product driven world. These concepts are closely linked to the G-D logic and consider service as marketing offerings, not perspective on value creation (Vargo et al., 2010a). For example the success of Rolls Royce's "power by house" service (Gebauer et al., 2013) is an example of service that is difficult to explain with the G-D logic but which demonstrate the stream of actions that support the customer's process. It is an example of the service and value co-creation process that can be understood and explained better within the S-D-logic.

The lack of understanding service and value co-creation in the manufacturing industry is evident even though there can be seen a clear shifting from goods-centered to service-centered strategy. The service revenues, regarding the machinery and spare parts sales, have stayed at a marginal level. The reason for this is that the benefits for the manufacturer itself can be easily envisioned, but without the understanding of what the service phenomena is, it is difficulties to describe the benefits for the customer, which decreases the customer's willingness to buy. (Laine et al., 2007.) Grönroos and Helle (2010) argue that even though the evidence of adopting the service-centered perspective and gaining competitive advantage is clear, the majority of the research in the field of manufacturing studies service as a separate function and only the strategy, management, marketing, innovation and relationships are studied from the service perspective. On the contrary the product management is often studied from the product-centered perspective. (Grönroos & Helle, 2010.)

The value for the customer and the value for the firm are usually understood as separate and non-interactive phenomena in manufacturing companies. However the service-centered perspective involves both the customer and the service provider. The focus should be on the realized value-in-use for the customer, not the value at the point of sale. (Grönroos & Helle, 2010.) Adopting the service-centered perspective challenges the traditional view of value chain and the linear value flow from the raw material provider to manufacturer to supplier to customer (Basole & Rouse, 2008). The S-D logic views the service provision as the outcome of internal and external resources, such as the employee-level knowledge and skills, and also includes the customers and other beneficiaries that contribute to the value co-creation. The value is co-created through the network of resource integration and includes various different actors. (Vargo et al., 2010a.) As the service-centered perspective is more dependent of resources such as knowledge and skills, the organization adopting the service-centered perspective needs to broaden the perspective towards the value creation from the selling services to co-creating value by supporting the customers business. When service is adopted as a perspective on business it is not a separate business function. Instead service is a networked process, includes various actors, both from the service provider's and the customer's side, participating to the value co-creation process.

In the network the value is co-created by different horizontal and vertical actors, such as the original equipment manufacturers, third-party service providers and customers each contributing their core competencies to the value co-creation process. The co-operation in the network requires coordination between different units but still maintaining their autonomy. (Gebauer et al., 2013.) Basole and Rouse (2008) define the complex socioeconomic systems as service value networks. They argue that even as the network includes various actors the consumers drive and determine all activities in the value network. (Basole & Rouse, 2008.)

The networked value creation environment requires adaptability and learning capability from the organization. Since the value creating networks are constantly changing the organization is required to learn how to serve the value network and integrate resources. The complex network requires the participation of all parties and the willingness to share information across internal and external organizational boundaries for the benefit of the network. (Vargo et al., 2010b.) Even the literature suggest various reasons why manufacturing companies should shift towards service-centered perspective and what is the broader value co-creation space including different actors, for companies the service-centered perspective is still a challenge. As Laine et al., (2007) observed that there is a gap between offering more services and the ability to actually coordinate the whole business from the service-centered perspective. More research is needed to provide clear vision on what the service-centered perspective changes and what is the fundamental organization-wide change. Also the value co-creation in network is clear at the level of vision but in practice it needs to be studied more to understand how the value is co-created in the networked business environment and how organizations that previously have considered service as a separate business function along with the other separate business functions can support value co-creation.

3.2 Evolving role of IT in manufacturing industry

The evolvement of IT has significantly changed the industrial landscape, particularly in the manufacturing industry in the developed world. The role of IT has evolved from being a supporting element to an enabling technology (Mathiassen & Sørensen, 2008). Since IT integrated with traditional manufacturing technologies the formation of digital manufacturing processes and products has become the enabler of new innovations. Digital manufacturing clearly enables new opportunities from the production perspective but also from the collaboration perspective. As in the networked environment, it improves the ability to adapt and respond to the changing requirements internally and externally. (Xion & Yin, 2006.) The concept, called "Industry 4.0", is used to describe the movement towards the increased digitalization of products and processes and the establishment of intelligent product and production processes in manufacturing. Industry 4.0 is also used to describe the next industrial revolution, which is triggered by the Internet that allows communication between humans, machines and products in large networks through Cyber-physical systems (CPSs). (Brettel et al., 2014.)

The development of IT has also affected organizational structures and operation models. Nowadays, humans make decisions based on their experience of process adaptation. As the intelligence and complexity of the processes and products increases, these intelligent components become able to self-optimize their performance. The labour work will change, but still remain irreplaceable since the roles of humans evolve towards coordinators and problem-solvers. (Brettel et al., 2014.) The vision of industry 4.0 is strongly focused on the production and process improvements and studied from the G-D logic perspective. However adopting the service-centered perspective in the context of industry 4.0 remains unclear.

Mathiassen & Sørensen (2008) have also recognized that the role of IT in organizations has undergone a change, as it has become common to adopt a service rather than system perspective to understand the contemporary practices and users in organizational environments. They describe information service as configurations of heterogeneous information processing capabilities, which help the organizational actors to execute tasks and enable different configurations to lead to satisfactory outcomes. The need for understanding IT usage from the service perspective is driven by the diffusion of communication and network technologies, improved interfaces and applications that promote the service-oriented mindset. (Mathiassen & Sørensen, 2008.)

In organizational environments the users of information systems are traditionally assumed to be interested in the efficiency and effectiveness of their work performance (Lamb & King, 2003). However, the organizational actors also have individual preferences and a variety of information processing needs that may vary inside the organization and differ from the line that the process oriented organization is offering (Mathiassen & Sørensen, 2008). As the organizational users are accustomed to use different devices and applications in their personal life, they would expect the same facilities in work environment, which challenges the designing of user experience and usability in organizational settings. This phenomenon is called the consumerization of IT. It has led to the situation where the organizational actors desire hedonic attributes from information systems (IS), instead of just the utilitarian value. (Kakar, 2014.)

Finding the balance in the complex relationship between organization and technology is essential in order to provide the required information services in organizational environments. Mathiassen and Sørensen (2008) observe that a greater interaction between the studies of IT and the studies of organizations is required for understanding how the organizational and technological choices influence each other. The socio-technical theories concerning the understanding of IS use and organization are limited. (Mathiassen & Sørensen, 2008.) The process-oriented Enterprise Resource Planning system (ERP) is an example of IS systems for organizational use. It includes systems for knowledge management, customer relationship management and supply chain management. (Caruso, 1999.) The problems with systems like ERP occur when organizations implement systems, which are not flexible and serve the objectives of the organization but do not support the organizational user and hedonic user experience.

The central issue for IS research has been to find an answer to the questions why and how new information technology are adopted at an individual and organizational level. The Innovation Diffusion Theory (IDT) explains the spread of a variety of innovations from agriculture to technology in general and in organizational or individual level. The Theory of Reasoned Action (TRA) is drawn from social psychology focusing on the prediction of behavioural intention. TRA is adapted to other models and theories of individual acceptance such as the Technology Acceptance Model (TAM) and its extension TAM2, measuring individual acceptance of technology. The Theory of Planned Behaviour (TPB) is also adapted from TRA. These models predict intention and usage and inform on those aspects that some users may find difficult to use, but does not offer prescriptive guidance for designers. (Venkatesh, Morris, Davis & Davis, 2003.)

In organizational environments, the planning of new IS is traditionally conducted from a top-down perspective, indicating that the top-level decision-makers ensure that the IS planning is in line with the firm's strategy and achieving strategic objectives. The top-down planning could, however, miss the knowledge from lower levels of the organization or outside the organization, where the needs and expectations emerge. (Peffers et al., 2003.) Since the hedonic utility is becoming a central issue of IS, user participation is promoted by the IS researchers (Tuunanen et al., 2010). In organizational environments in the future, the consumerization of IT increasingly challenges IS planning as the networked environment includes different actors with different and changing requirements, requiring high adaptability to the changing situation. The Cyber-physical systems are able to perform as platforms for service in the networked environment and adapt; they will be introduced next more deeply.

3.3 Towards cyber-physical systems in industrial context

Increasingly objects of the physical world are able to sense, communicate and interact with the physical environment (Baheti & Gill, 2011) extending the intelligent capabilities of systems that previously were limited and pre-designed. The fundamental economical and technological trends created an environment requiring a variety of new capabilities and characteristics such as safety, efficiency, adaptive behaviour, communication, self-optimization, monitoring and automation (Sanislav & Miclea, 2012). Geisberger, Gengarle, Keil, Niehaus, Thiel and Thonnißen-Fries (2011) referring to Moore's law about the exponential growth of processing power of digital systems states that the close interplay of technological innovations, economic dynamics and social changes have stimulated the emergence of the new discipline called Cyber-physical systems (CPSs), which integrate the cyber world and the physical world (Geisberger, Gengarle, Keil, Niehaus, Thiel & Thonnißen-Fries, 2011).

CPSs are networks of interacting appliances with physical inputs and outputs when compared to standalone devices (Lin, Zeadally, Chen & Chang, 2012). Figure 2 summarizes the visualization of CPSs by Conti et al. (2012) and

Lin et al. (2012). Typically the CPSs connect the objects from the physical world called actuators, which are embedded with sensor nodes. The sensor nodes convert the various measurement metrics into digital format and send those as inputs to cyber world. The cyber world as the decision-making system makes decisions based on the inputs and as outputs the network of actuators in the physical world act correspondingly to the computational process in a coordinated way. (Lin et al., 2012.) In CPSs, the interactions between the cyber and physical world are seamless and the cyber world is able to continuously monitor and perform intelligent actions by adapting the applications and services to the physical world's needs (Conti et al., 2012).

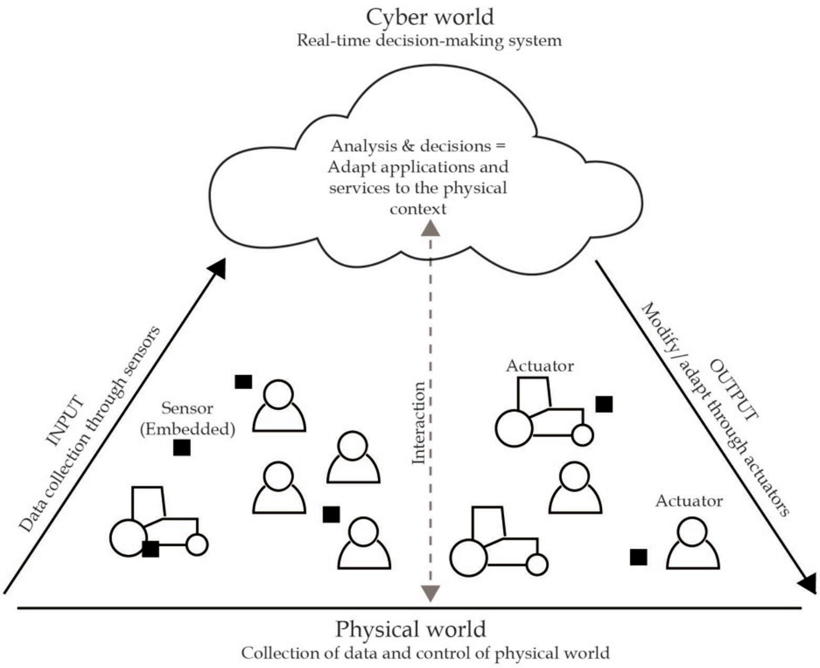

FIGURE 2 Cyber world and physical world (adapted from Conti & al., 2012, & Lin et al., 2012)

As the above figure 2 indicates CPSs have various specific defining characteristics, from which some may also be the characteristics of traditional systems. Horváth (2014) aggregated a comprehensive set of characteristic, which as a whole can only belong to CPSs:

- Open systems – Self-organizing, functionally decentralized and geographically distributed
- Dynamically changing – Able to reconfigure, change boundaries and reorganize functionality or behaviour

- Constructed of components – Components are heterogeneous (humans, equipment, buildings) and have predefined, emergent or ad-hoc functional connections
- Knowledge intensive – Obtained by sensors and generated by reasoning and learning mechanism
- Distributed decision making – Based on reflexive interactions among components
- Real-time requirement – Need to operate and communicate in real-time and in a synchronized manner
- Context awareness – flexibly adapt to the environment and users and their personal and social context, optimal symbiosis
- Managed by sophisticated strategies – High requirements for security, integrity, reliability, accessibility and maintainability

The ability to perform in real-time is a defining characteristic for CPSs, as it can provide emergent intelligence for the components, and with the capability of memorizing and learning from history and situations, the components are able to adapt to unpredictable or emergent environmental circumstances, execute non-planned functional interactions and act proactively (Horváth, 2014). Wan et al. (2013) define more specifically that the cyber capability is in every physical component and resource constraints enabling the closed-loop control and high degrees of automation (Wan, Yan, Suo & Li, 2013). The closed-loop control is essential in order to achieve the real-time requirements.

The emergence of CPSs is a result of development in various areas, which enable the high-performance capability. Low-power electronic components with increased communication capabilities and processing power enabled heterogeneous systems and devices to integrate and improved the ability to provide platform independence, real-time requirements, robustness, security and scalability (Colombo & al., 2014). Furthermore CPSs are not completely new systems; rather they are extending the capabilities of previous systems in unprecedented way. Cengarle, Bensalem, McDermid, Sangiovanni-Vincentelli and Törngre (2013) describe that the research and industrial agenda for the past 10 years have been characterized by the combination of the evolvement of the networked embedded systems and wireless system networks. In the beginning of 2000s the academics in United States recognized the increasing role of physical aspects of embedded systems, which eventually turned from closed systems and devices into open CPSs. (Cengarle, Bensalem, McDermid, Sangiovanni-Vincentelli and Törngre, 2013.)

The emergence of CPSs has correlations to other parallel domains such as wireless sensor networks (WSNs), machine-to-machine (M2M) communications and Internet of things (IoT). Wan et al. (2013) classify that from the architecture perspective all these previous mentioned belong to IoT, which includes components such as sensing, heterogeneous access, information processing and applications and services. WSNs are a basic scenario of IoT, since the information is collected through various sensor nodes, preceded by the evolution of low-cost and increased sensor capability and the revolution of wireless communication.

WSNs are regarded as the foundation of CPSs and the supplement of M2M communications. M2M communication is based on the idea that networked machines are more valuable than standalone ones with the capabilities of decision-making and autonomous control with limited or no human intervention included. The CPSs can be seen the upgrade of M2M communications as it includes clear human intervention and enables distributed and real-time control. (Wan et al., 2013.)

The increasing academic and industrial interest in CPSs is reflected in the various definitions for the term. Lee (2008) describes CPSs as integrations of computation with physical processes where as Rajkumar, Lee, Sha and Stankovic (2008) define CPSs as physical and engineered systems, in which operations are monitored, coordinated, and controlled through computing and communication core (Rajkumar, Lee, Sha and Stankovic, 2010). Lin et al., (2012) define CPSs as the integration of abstract computations and physical processes, where sensors, actuators and embedded devices are networked to sense, monitor and control the physical world (Lin et al., 2012). Conti et al. (2012) see the opportunities that CPSs enable from the physical world's perspective stating that CPSs enable better services with the ability to understand and interact with the physical world and its social activities through the augmented sensing and interacting capabilities. They also state that the pervasive infrastructure of CPSs is able to support the continuous value co-creation process that is essential for user contribution. (Conti et al., 2012.) Also the definition of Broy, Cengarle and Geisberger (2012) describes CPSs from different a perspective by seeing them as open socio-technical systems providing a range of new functionalities, services and features (Broy, Cengarle & Geisberger, 2012). In this thesis CPSs are studied from the service-centered perspective and follow the definitions of Conti et al. (2012) and Broy et al. (2012) defined in this thesis in the following way:

> CPSs are open socio-technical systems that are able to understand and interact with the physical world while supporting the continuous value co-creation through the cyber worlds adapting capabilities.

The opportunities that CPSs enable are not completely recognized yet but the demand is starting to grow in various industries. Geisberger et al. (2011) envisioned that services based on CPSs are going to revolutionize markets and change the market structures and business models significantly (Geisberger et al., 2011). Rajkumar et al. (2010) describe that CPSs are pushed by recent trends such as low-cost and increased-capability sensors, the availability of small form computing devices, wireless communication and improvements in energy capacity (Rajkumar et al., 2010). Geisberger et al. (2011) state that from the push perspective the possibility to interact and extend the capabilities of the physical world through computation, communication and control is the driver of future innovations. The push is occurring in integration with the demand side pull, indicating that the challenge is to fulfil the end users' and market's requirements (Geisberger et al., 2011). Increasingly the need for CPSs is pulled by sectors such as aerospace, factory automation, process and environmental control

(Rajkumar et al., 2010). The future CPSs will improve safety, efficiency and solve key challenges in numerous fields. (Geisberger et al., 2011.)

The design and development of CPSs is in many cases lacking of models, methods and tools since the CPSs research has concentrated to short-term and quick results. The research of CPSs consists of various subdisciplines, such as sensors, communication engineering, computer science, control theories and human-computer interaction. The models from these disciplines represent either the cyber or the physical process not the integrated world. (Baheti & Gill, 2011.) Lee (2008) mentions more specifically that methods such as object-oriented design and service-oriented architectures built on abstractions better meet the requirements of software than physical systems as CPSs are not only concentrating to computation (Lee, 2008). Geisberger et al. (2011) stress that in order to achieve sustainable acceptance the key fields of human-machine interaction such as research, training and practical implementation needs to be further developed. Also from the user-specific perspective the human factors such as mental models of the users, usability, ergonomic issues and situational adequacy are also essential for the users ability to understand the provided information, solutions and implications. (Geisberger et al., 2011.)

Brazell (2014) describes CPSs as platforms or engines of the development in the twenty first century and Conti et al. (2012) envision that the interactions between cyber and physical worlds and the human social activities opens various service innovation opportunities. The research in manufacturing industry has concentrated on CPSs ability to improve the processes and products from the technological perspective (Conti et al., 2012). For example Colombo et al. (2014) see the CPSs as the drivers of "Industry 4.0" or the 4th industrial revolution, as they provide platforms for service sales (Colombo et al., 2014). The cyber world and physical world will be explored next from the service-centered perspective to better understand the environment and the actors participating to the value co-creation.

3.3.1 Cyber world's capabilities

The cyber world is the enabler of the physical world's increasing intelligence. That is enabled by dynamically and opportunistically connecting and interacting components of the cyber world's infrastructure, which are able to adapt themselves to the rapidly changing physical world's needs (Lee, 2008). Due to this capability the cyber world is considered as a decision-making system, which, with the ability to manage, monitor, measure and control the physical world and to determine the appropriate actions by real-time decisions, enables the objects of the physical world to perform more intelligently (Lin et al., 2012).

In order to be able to adapt to the changing physical world, the cyber world needs to be logic-based and event oriented. The wireless sensor network is the cyber world's contact point to the physical environment (Erdelj, Mitton & Natalizio, 2013). The single wireless sensor node is a device that measures various metrics such as physical, chemical and biomass quantities and converts the information from the physical world into a digital format that can be used in the decision-making system. The monitoring quality and the network connectivity are key requirements for the decision-making system to receive the available inputs from the physical environment. In order to achieve this the area of interest is required to be covered by sensors. The coverage can be ensured by a certain number of sensors, with the mobility capability ensuring the information even from dangerous and unreachable regions. Since the decisions are based on certain locations, the location information is important. (Lin et al., 2012.)

With the ability to sense and collect information of the environments that are not controllable or easily accessible, sensors may prevent accidents. The sensors can also be used to monitor parameters such as energy usage or pollution. The ability to monitor conditions increases the self-monitoring that improves the failure prediction and real-time problem diagnostics. The products entire life cycle can be utilized with the process monitoring ability, and monitor from an industrial perspective the activity, or from the user's perspective, the performance or quality of the specific service provision. (Erdelj et al., 2013.)

The cyber world as a decision-making system is depending on heterogeneous information and cross-domain sensor cooperation (Wu, Kao & Tseng, 2011). The ability to adapt to the rapidly changing physical and social context and the comprehensive situation awareness are well-recognized issues in the field of pervasive computing in general. These issues are no longer related to the inquiry of the necessary data to support the context-awareness, rather it is the handling of overwhelming amount of the data. The components of the cyber world are required to access and digest the information that the complex multi-faceted situations require for adaptation decisions. The overwhelming amount of data requires more comprehensive levels of awareness and infrastructure for multi-faced situations that drive the activity of the components in a coordinated manner. The situation awareness supports the collectiveness and autonomous adaptation to the physical world's requirements. (Conti et al., 2012.) This high-performance requirement challenges the development, deployment and management of cloud-based infrastructures and services. Cloud computing is transformed by the new requirements including the heterogeneity of resources and devices, security, better quality of user experience and the faster respond. (LEIT, 2013.)

The networked environment of CPSs also sheds some special challenges to the cyber world's infrastructure since it is not possible to test the system under all possible conditions (Lee, 2008). As the amount of users, devices and data items increase, the requirements of autonomous adaptation and context-awareness increases also. The ability to serve the diversity of requirements from a variety of actors requires suitable measures to evaluate the behaviour of the system. The increasing diversity of the components and their evolution supports the user's contributions and personalization. However the collective adaptation and intelligence requires a shift of perspective from current forms to more social ones that support the value co-creation. The autonomous and opportunistic networking requires mechanisms to support effective interaction among components, as all the components must be able to support the collective service. (Conti et al., 2012.)

Fischer (2012) suggests that the overall focus of the cyber world should be targeted to humans and, as Conti et al. (2012) state, the current approaches of CPSs emphasize the technical infrastructure and have paid little attention to the fact that users are also integral components of the overall infrastructure by contributing via human sensing and actuating (Conti et al., 2012). The challenge is not to deliver more information but to deliver the right information, in the right place, to the right person. Due to close human intervention CPSs can be seen as context-aware socio-technical systems, resulting from a requirement of awareness and understanding of the tasks that the users are performing and the objectives of the interactions. The cyber world needs to understand how the tasks in the physical world should be carried out and the time and place where the interactions occur, ensuring that the user gets the information that is relevant for them, even they don't know it exist (Fischer, 2012).

One key challenge for the decision-making system is to receive enough specific details from the environment to support the decisions. Kuang, Hu and Zhang (2013) stress that the ability to reach the human perception becomes the key challenge, as the interpretation of the environment needs to be similar to what it would be with human vision, hearing and feelings (Kuang, Hu & Zhang, 2013).

3.3.2 Increased intelligence in physical world

The physical world is continuously changing and difficult to predict. Whereas the cyber world's architecture operates in a logic-based way in order to follow the physical world, the physical world incorporates natural and human-made components with different objectives governed by the laws of physics (Horváth, 2014).

With the cyber world the physical world can become more intelligent as the complex processes that are not amenable to human intervention can be handled in the cyber world (Sztipanovits & Ying, 2013). The fast closed-loop control enabled by the cyber world is a significant element as it can reduce the possibility of human error and improve safety. However the cyber world should perceive humans and the environment from the human perspective, as the humans are a meaningful part of the control loop and the reasonable decision makers. The cyber world should collect information about the environment and human behaviour and transform the information for building knowledge and deep understanding of the environment and humans. Better understanding of the people's decision making and the reasoning behind it ensures the closer to human decision-making processes in the cyber world. (Kuang et al., 2013.)

Sztipanovits and Ying (2013) emphasize that in order to build a seamless human and CPSs interactions, it is essential to form better models to link the human strengths and weaknesses with the corresponding machine strengths and weaknesses. Human-machine interactions (HMIs) are increasingly participatory, which requires cognitive models to couple the unpredictable human behaviour with the predictable behaviour of machines and physical systems.

(Sztipanovits & Ying, 2013.) As the CPSs can impact on human behaviour the HMI is a significant element of CPSs and influences the acceptance and the experience (Cengarle et al., 2013). The ability to enrich the interactions of human-to-human, human-to-object and object-to-object are one of the most significant factors that the CPSs enable from the physical world's perspective (Lin et al., 2012).

The physical world is becoming saturated with computing and communication entities. Humans have access to various devices through which they are able to interact with the cyber world. The human social structures control the way information spreads in the cyber world and, thus, how the applications and services are arranged increases challenges in locating and navigating different place, device and time scales. Since the raw data is collected through sensors and is a complex combination of multidimensional time series' with spatial attributes, it needs to be evaluated and provided in a meaningful format before it is valuable for the humans. (Conti et al., 2012.)

From the collaboration perspective the changes that CPSs cause must be understood in order to ensure effective collaboration in the network surrounding the CPSs. The CPSs span across multiple domains and in order to work collaboratively the knowledge needs to be shared and be accessible across product lines and operational areas. The collaboratively work among different stakeholders over different domains and disciplines would benefit from an actively used and clear terminology for CPSs. (Campetelli, Irlbeck, Bytschkow, Gengarle & Schorp, 2014.) When there are humans involved the requirements for intuitive and multimodal support with broader space and time perception and capacity to act are important. CPSs should also be able to interpret the state and context of the human and be able to learn based on the previous interpretations. (Geisberger et al., 2001.)

The roles and competence requirements of humans are changing as the CPSs progresses and evolves (Sztipanovits & Ying, 2013). As the decision-making capability is transferred to the cyber world, it enables the decreased need of human actions and increased autonomous control. This is one of the future visions of CPSs as it could enable unmanned equipment that are able to perform their tasks with relatively little human competence required, increasing the need of remote control. These can increase the efficiency, lower costs and reduce errors significantly. (Wan et al., 2013.) Geisberger et al. (2011) argue that in the context of CPSs the human-machine interaction needs to be further studied in areas such as research, training and practical implementation. Especially the focus should be on human factors, such as the logic of workflow, situational adequacy and usability of equipment and ergonomics. (Geisberger et al., 2011.) Even though the need for humans to take over actions might be less important in the future, the humans are still in the centre of CPSs. The technological development might enable the unmanned equipment and therefore change the roles of humans but the humans are still needed in the process to make, for example, interpretations on data and make rationale decisions.

In industrial settings the opportunities of CPSs are well recognized in the product and production environments, but as the research of CPSs has focused on the utilitarian aspects with a strong product-centric perspective, the possible value co-creation opportunities from the service-oriented perspective have remained of less interest. From the service provider's perspective CPSs challenge the constraints of R&D budgets, the mission-centric focus, technical silos and the disciplinary focus, requiring more open and multidisciplinary approaches. (Sztipanovits & Ying, 2013.)

The need for context-aware socio-technical systems (Fischer, 2012), the computing for human experience (Sheth, Anantharam & Henson, 2013) and the hedonic attributes enhancing the ease of use of business users of IS products (Kakar, 2014) are examples of important issues that needs to be taken into account in the future when developing CPSs and seeking potential value co-creation opportunities that are facilitated by CPSs. For generating the transdisciplinary theoretical framework for CPSs, the overall understanding is needed of how the CPSs should work in general. The awareness of the possible impacts of CPSs to the environment, society and people is still relatively low, which challenges the ability of designing self-learning, self-adaptable and self-evolving CPSs. (Horváth, 2014.)

4 Methodology

The object of this study is to understand how value is co-created in the context of CPSs in a networked business environment. The focus is on intelligent equipment in the mining and construction industry, which are examples of CPSs. The purpose of this chapter is to introduce the philosophical approach that guides this research towards answering the research questions and specify the chosen methods for collecting and analysing the data to justify that they are in alignment with the research problem.

4.1 Research approach

In order to answer the research questions Planing (2014) suggests that the starting point should be the selection of the philosophical approach that guides the methodological decisions and clarifies what kind of evidence is required and how it is to be gathered for to the purpose of answering the research questions. The philosophical approach is rooted in the researcher's assumptions about how the knowledge can be generated. (Planing, 2014). Myers (1997), referring to Orlikowski and Baroudi (1991), states that knowledge can be obtained with positivist, interpretive or critical research. The positivist research assumes that the reality is objectively given and attempts to test theory to increase the predictive understanding and the ability to describe the reality by measurable properties. Interpretive research attempts to understand the phenomena through the meanings that people have and sees that the reality can only be accessed through social constructions such as language, consciousness and shared meanings. It also tries to produce understanding of the phenomena's context and its influence to the phenomena without defining dependent or independent variables and instead focuses on the human senses in the emerging situation. The critical research considers that the social reality is historically constituted and focuses on oppositions, conflicts and contradictions to eliminate the causes of alienation and domination. (Myers, 1997.)

The object of this research is to understand how value is co-created in the context of CPSs in a networked business environment. The focus is on value co-creation in one specific area, in the mining and construction industry, where the intelligent equipment are examples of CPSs. The aim is to explore what are the value propositions and value drivers related to the value co-creation in this context. From this premise the interpretive approach supports this objective. In IS research the interpretive approach has emerged as an important enabler in understanding human thoughts and action in social and organizational contexts and produces deep insights concerning the information systems (Klein & Myers, 1999).

After deciding the philosophical approach Planing (2014) suggest that the next step is to identify the appropriate methodologies that supports the aim of finding the answer to the research question. The most common distinction is the quantitative and qualitative methodologies. Quantitative research makes approximations or hypotheses about the reality and uses measures to fit the divergent views into predetermined response categories. On the contrary, qualitative research views the reality from the people's perspective and tries to develop understanding through observation. (Planing, 2014.) Gordon (2005) notes that qualitative approaches allow the observation of emerging themes in situations where relatively little is known about the area of interest (Gordon, 2005). Myers (1997) considers that since the focus among IS researchers started to shift from technological to social issues, the interest towards qualitative research increased as it enables an understanding of people in their own social and cultural context. (Myers, 1997.) Following the selection of interpretive approach and the aim of this research, the qualitative approach is chosen in this research to form the understanding about the area of which relatively little is previously known.

4.2 Research strategy

As the object of this research is to understand how value is co-created in the context of CPSs in a networked business environment. The case study method is an appropriate research strategy for this thesis, as it enables to investigate the value co-creation in its own environment. Myers (1997), referring to Yin (2002), describes that a case study focuses on contemporary phenomenon in its real-life context and is appropriate especially when there does not exist clear boundaries between the phenomenon and its context. The research method is a strategy regarding the philosophical assumptions that can be positivist, interpretive or critical and leads towards research design and data collection. (Myers, 1997.) In this thesis, the focus is on understanding value co-creation in one specific domain, in the mining and construction industry, where the intelligent equipment, examples of CPSs, are able to integrate the cyber world and the physical world. In the mining and construction industry the operating environment plays a significant role to understand value co-creation and therefore the case study is appropriate method for this study.

Baheti and Gill (2011) argue that the research of CPSs is divided into isolated subdisciplines such as sensors, communication or networking, which represents either the cyber world's or the physical world's processes, but not integrated. Darke, Shanks and Broadbent (1998) note that the case study method is an appropriate method for understanding the interactions between the IT-related innovations and the organizational context. It is considered particularly useful when the theory and research are at their early phase in understanding why and how processes or phenomena occur or the experience or context of actions. (Darke, Shanks & Broadbent, 1998.) Walsham (1995) considers that the interpretive case study has increased its popularity among IS researches as the need to understand the social issues such as human actions and interpretations surrounding the systems usage, and development became more important than the technical issue (Walsham, 1995). By adopting the interpretive case study as the research method enables to investigate the value co-creation process in the environment that integrates the cyber and the physical worlds. It also enables to understand the value propositions and value drivers in that context.

The case study research can adopt either the single case or multiple-case designs. According to Walsham (1995) the single case study allows the in-depth investigation of a phenomenon, providing rich description and deep understanding (Walsham, 1995). According to Darke et al. (1998), Yin (1994) describes more specifically that a single case study is appropriate when it represents a critical case for testing theory, it is extremely unique or it is revelatory by nature, and multiple case studies are appropriate when the aim is to contrast results (Darke et al., 1998). In this research the interpretive case study is expected to improve the ability to understand how the value is co-created in the context of CPSs in networked business environments and the single case study is deemed an appropriate way to investigate it since the object is not to contrast results.

There are several ways how the generalization based on the single case study can be guaranteed. Walsham (1995) suggest four ways how to tackle the critique that the single case study has received concerning the generalisation issue based on a single case. The generalization can be done with the development of concepts, the generation of theory, the drawing of specific implications and the contribution of rich insight (Walsham, 1995). Runeson and Höst (2009), following the list of characteristics by Yin (2003), suggest that the generalization can be ensured by collecting the evidence in a planned and consisted manner from multiple sources and by being based on previously published theory (Runeson & Höst, 2009). For the design and scope of the case study, literature analysis is essential for understanding the existing literature within the research area and how the research questions can be positioned. In this thesis the existing literature and the CIS framework are introduced first for creating the theoretical background, which indicates the relationship of this research to the previous research.

4.2.1 Introduction to the case organization

The design of case study research requires the identification of the actual case and the unit of analysis (Darke et al., 1998). In this research the object is to understand how the value is co-created in the context of CPSs in a networked business environment. This study investigates one particular context of CPSs: Intelligent equipment in the mining and construction industry. The case company in this thesis is a part of a global engineering group specializing in high-technology equipment. They provide tools, equipment and components, such as drills and crushers, for the mining and construction industry. The case company is shifting towards intelligent equipment since their product development has evolved from the direct operated hydraulic control systems into intelligent ones that enable distributed automation. Intelligent equipment, as examples of CPSs, are integrating the cyber world and the physical world, controlling the processes and facilitating continuous interactions between these worlds in multiple levels in the networked environment, where various actors are operating. However, even the case company is at a very early stage of development in intelligent equipment, and the intelligence in this thesis is mainly concerning the drills, while the progress has also been made in other product lines.

According to Darke et al. (1998) the unit of analysis may be an individual, a group, an entire organization or some event. In this research the focus is on individuals from the case company and from the customer side, providing rich insights and knowledge for understanding the value co-creation in this context. When designing the case study it is important to consider the case study research also from the perspective of the participating organization. In order to obtain the interest of the potential participating organization, the research questions need to be interesting. An organization is more likely to provide access inside the organization and to their people whereby the research area is particularly relevant or the research outcome could provide clear benefit to the participating organization. Before the fieldwork it is essential to agree to the confidentiality requirements related to the case study and the findings. (Darke et al., 1998.)

The manufactured equipment and tools of the case company represent high technology and are industry-specific and targeted to the mining and construction industry. From the perspective of the equipment manufacturer, the network surrounding the intelligent equipment includes various internal and external actors participating to the value co-creation process. The case company is a traditional manufacturing organization with different functional silos, including functional areas such as research and development, maintenance, spare parts, sales and services. The case company has got product specialists, such as drillers, who instruct the customers about the usage of the equipment. The customer side includes actors from the mine or site organization and from the contractor's organization, indicating that the relationships between the equipment manufacturer, the contractor and the mine owner are relatively close, as, for example, in Finland the amount of mines is limited.

The case company represents a company and industry, which could benefit significantly from adopting the service-centered perspective to value co-creation in the networked environment. The mining and construction industry and the case company as the manufacturer of intelligent equipment, was considered as an interesting setup for investigating how value is co-created in the context of CPSs in a networked business environment. The case company's representatives informed about the current situation of the case company with the newest equipment line and their future vision. An agreement was made on how the case study and the data collection would be conducted within the lines of the Non-Disclosure Agreement.

The case company and the industry in general, are still at a very early phase in exploiting the intelligence and the perspective towards service, considering the product related after sales services such as spare parts, maintenance and maintenance agreements. Sun, Yu, He and Ding (2012) in their research of coal mining, argue that in the mining industry the research focusing on CPSs has been relatively limited when compared to the more fully investigated areas such as the distributed energy systems, transportation and healthcare systems. The reasoning for the lack of CPSs research in the mining industry might be that the CPSs as an approach is still in its infancy and the working environment is so particular that the attention is rarely focusing on other fields even though the other application domains could offer promising solutions for common problems. (Sun Yu, He &Ding, 2012.)

Deloitte (2014) reported that even though the mining industry has evidently grown bigger in the size of plants, trucks and blasts, the only thing that has not evolved much is the industry itself. The possible innovations and the full value of technologies cannot be realized by layering new technologies over the existing operation models. Although the market swings reflect as pressure on price and demand for cost-efficiency for both the mining companies and the equipment manufacturers, the shift that the industry requires can be only achieved by moving the focus from incremental performance improvements towards the broader theme of innovations. These might exist beyond automation and remote operations in improved visibility over the actual performance and conditions, enabling the re-planning, identification of inefficiencies, tracking pollution levels and streamlining processes. The real-time information on the activity and the state of the equipment and the on-demand reports collected from disparate sources could improve the decision-making, assets utilization, efficiency and reliability. That could minimize the downtime and improve the mine planning. The richer insights about the performance metrics could benefit from the operational perspective and also from the health, safety and talent management perspective. (Deloitte, 2014.)

As IBM's (2009) report suggests, the focus of mining professionals should not be in the mining itself and on how to dig more, which can be held in equal important from both perspectives of the mine owner and the equipment manufacturer. The focus, rather, should be on a wider perspective of the overall business model innovations, the operational improvements via the usage of technology and the improved sustainability. As information can be collected from various sources, the ability to monitor and make insight-driven real-time decision increases. For supporting the rapid-decision making in general the multi-layered organizations should be transformed supporting proactive and pervasive knowledge delivery. The in-house development would benefit from a "meeting of the minds" improving the share of knowledge. As the mines can be dangerous working places the safety issues are central for the development of technologies, which can improve the prevention and prediction of such situations, as well as from the environmentally aware perspective supporting the clean mining operations. The technology can also improve the ability to manage and analyze from different dimensions the equipment's health through its lifecycle and prevent sudden downtime. The integration of the business functions and systems in general improve the ability to create a centralized asset management system. (IBM, 2009.)

The context of CPSs and the interactions between the cyber world and the physical world in the mining and construction industry provide a promising environment to investigate value co-creation. As the service in this research is defined following the definition of S-D logic, the value co-creation can be investigated from service-centered perspective and the understanding of service is not restricted with the traditional product related services, such as the after sales services.

4.2.2 Case study participants & recruiting

When considering that the intelligent equipment in the case company and in the mining industry in general are still in their infancy, recruiting participants for this research and the required characteristics of the participants were merely defined by the fact that the participant should have a close link to the case company's intelligent equipment and be well-aware of them. This research focuses mainly on drills even though there exists also various other equipment that were mentioned during the interviews. And though the case company operates globally, the research focused on Finland, where the potentiality to gather the participants in terms of reasonable schedule could be optimized. As the case company is a broad organization with various functional and operational lines and the knowledge related to intelligent equipment is scattered around the organization, the access to the organization was arranged through the representatives with whom the research was agreed. They also provided an access to the customers' side, which is two-fold, including both the contractor and the mine owner.

The recruiting of the participants started in the end of March 2014 as an internal inquiry. For supporting the internal recruiting a short brief was made about the interview and a private online calendar was opened for ensuring that participants could easily make a reservation for the interview according to their own schedules and, if needed, change the reservation easily. The brief included general information about the interview and explained the context for setting the participant to the right mood. Due to the distances and distributed locations the interviews were preferred to be conducted via phone to ensure that the required time for the interview could be more easily arranged.

As a result of the internal inquiry the contact information of 10 members of the case company was received. They had tentatively agreed to participate.

In addition to the internal inquiry the Goodman's (1960) snowball sampling technique was adopted for recruiting the participants. The snowball sampling technique is based on the process were the individuals from the first stage of the sample group are asked to name other individuals that would meet the given requirements, then the second stage can enable the recruiting of a third stage, and the procedure is continued until the required amount of individuals is received. (Goodman, 1960) The amount of individuals grows like a rolling snowball. The snowballing method can be used to search for "lead users" able to quickly become aware of new features (Tuunanen, Peffers & Hebler, 2011), and in this research the snowballing method was used to recruit participants, who would be considered as experts and are having the needed experience and ability to see how the wholeness could enable the co-creation of value in the context of intelligent equipment.

In this research the snowball method was used at the data collection phase and asked in the end of the interview for the interviewee to name potential colleagues who could be the expert on this field and have rich insights, best knowledge and integral vision as the object of this research was now familiar to them. All participants could name one or more contacts that they considered as experts in the field of intelligent equipment, which then were contacted. Also three representatives of the case company's customers were contacted to receive their opinions when trying to understand the value co-creation process as a whole. The access in this direction was received from the members of the case company. They first contacted the potential customer side's representatives and made the first inquiry whether they would agree to an interview. After the agreement the participants were contacted and suggested a time for the interview.

The area of interest was considerably new in the case company, but by using the snowballing technique the experts with the knowledge of intelligent equipment were easily found. Moreover, they were experts for describing how they would expect the intelligent equipment to perform and what would be driving them to co-create value, since they could define the improvements that the increasing intelligence could enable when compared to the traditional equipment. It was known that the members of the organization are busy and partly unavailable due to commuting abroad for work, which was taken into consideration when forming the preliminary schedule for the recruiting and for the interviews. The aim was to recruit 20 to 25 participants and 31 potential participants were contacted for the interview and eventually scheduled interviews with 20 participants. After starting to use the snowballing method, the potential persons were contacted by phone or email to reserve the time for the interview. All together 12 participants were recruited with the snowballing technique.

To understand how value is co-created in the context of CPSs in a networked business environment, the rich data collected through the different perspectives improved the ability to understand how the value is co-created in the context of intelligent equipment and what elements of the CIS model are relevant for the participants representing different perspectives. The participants had been working with traditional equipment and been closely integrated to the development of intelligent equipment, and most of them continuously work closely with the customers, which provided a broad perspective towards the field of intelligent equipment. The aim was not to contrast the participants based on their work experience in years as the participants represented different operating areas and the development of intelligent equipment was still at relatively early phase. However, by using the snowballing technique the experts in this field could be found. Therefore the job title or position was considered to be adequately defining characteristics to understand the participant's perspective to the value co-creation in the context of intelligent equipment. The profile of the participants can be found in table 3. As can be seen from table 3, the participants provided a broad perspective on the subject, as there exists the bottom-up and the top-down perspectives. The participants were mainly men, as there were 19 males and only 1 female participant. 18 of the participants were from the case company and two represented the customer's perspective.

TABLE 3 Profile of participants

ID	Position	Organization	Sex
1	Product Specialist	Case Company	Male
2	Domestic Aftersales	Case Company	Male
3	Product Specialist	Case Company	Male
4	Domestic Service Manager	Case Company	Male
5	Service Offering Development Manager	Case Company	Female
6	Product Specialist	Case Company	Male
7	Territory Manager	Case Company	Male
8	Documentation Engineer	Case Company	Male
9	Technical Customer Service Support Manager	Case Company	Male
10	Product Manager	Case Company	Male
11	Product Specialist	Case Company	Male
12	Product Specialist	Case Company	Male
13	Product Specialist	Case Company	Male
14	Head of Construction	Mining contractor	Male
15	Team Leader / Chief Design Engineer, System Engineering	Case Company	Male
16	Product Line Manager	Case Company	Male
17	Head of Mining	Mining operator	Male
18	Technical Training Development Manger	Case Company	Male
19	Site Manager	Case Company	Male
20	Technical and Field Support Manager	Case Company	Male

4.3 Data collection

In this research the chosen qualitative technique for data collection was interviews. The data collection is influenced by the choice of research method and it can be done using one or more techniques. The qualitative techniques include interviews, observation of participants or fieldwork and written material, and in case study the data collection and analyse can combine both the qualitative and quantitative methods. In qualitative research distinction between the data collection and the data analysis is not clear. The researcher's presuppositions can affect the data gathering as the questions largely determine what the findings can be. The data affects the analysis and the analysis affects the data in significant ways. (Myers, 1997.)

The interviews were done using the laddering technique of Reynolds and Gutman (1988) that was originally used in marketing research. It is based on Gutman's (1982) Means-End Theory in a parallel with Rosenberg's (1956) Expectancy-Value Theory. The technique develops understanding about the consumers personal values related to product preferences through the linkages between the attributes of the product (means), the consequences of those attributes and the value that the consequences reinforce (ends). The linkages form association networks, or ladders, which represent how the product related preferences are processed and reveal the underlying personal motivations or reasons why an attribute or a consequence is important. The context of consumer behaviour provides a meaningful context for preceding the laddering interview, as the products are not used or consumed in general, it happens in a particular context. (Reynolds & Gutman, 1988.) The laddering technique supports the object of this research to understand how value is co-created in the context of CPSs in a networked business environment

In organizations the traditional top-down planning and development model can lead to the situation where it is assumed that all that can be valuable or that the organization needs are already known. The knowledge scattered around the organization is ignored, leaving the potentially valuable ideas disadvantaged. Peffers et al. (2003) outline the laddering technique more specifically from the perspective of IS research for understanding the reasoning why people prefer certain IS features. They also prefer the Personal Construct Theory (PCT) that shares with the laddering technique the view of value structures related to a certain product and its features. The PCT based data gathering methods seeks to understand people's knowledge and value structures by observing how they differentiate among stimuli providing valuable insights for designing features with potentially high customer value. (Peffers et al., 2003.)

For identifying and evaluating the reasons why people prefer certain IS features, Peffers et al. (2003) introduce the framework called the Critical Success Chain (CSC). It allows modelling the reasons why certain features of IS are preferred by limiting the attributes to a certain organizational context, the consequences of the implementation of these attributes and the values either or from the individual or organizational perspective. (Peffers et al., 2003.) As a part of this study the CSC was used to develop graphic maps as a result of the laddering interviews for illustrating the reasoning behind certain attributes that emerged in this context, the consequences as an outcome of the attributes and the values from either an individual or organizational perspective. The CIS model based laddering technique and the CSC enable to explore how value is co-created and what are the value propositions and value drivers in this context, which enable to answer to the sub question and support the answering of the main research question of this thesis.

The laddering technique involves a tailored semi-structured interviewing format. The technique seeks to elicit distinctions among stimuli, which are used as a meaningful basis for the respondent to start considering differences between them. The researcher can select which are the distinctions that are to be used, being based on prior knowledge or on a specific research issue. (Reynolds & Gutman, 1988.) Jüttner et al. (2013) consider that the personal values influence whether the stimuli receive responses on the interviewee's side, as there exists a causal link between the stimuli and personal values (Jüttner et al., 2013). Peffers et al. (2003) used a list of stimuli that was developed during the prestudy phase. In this research the list of stimuli was created based on the CIS framework that includes the elements of the value co-creation. The CIS framework was used as lenses to the literature review and formed the themes for the stimuli list based on the factors that emerged in the frames of the CIS. Before the fieldwork the case company's representatives approved the stimuli list.

In this thesis the list of stimuli was formed into six areas following the idea of the elements in CIS, which are listed in table 4. The complete stimuli list can be found in appendix 1.

TABLE 4 Elements and stimuli themes of the CIS framework

ID	CIS elements	Stimuli themes
1	Construction of identitites	Own role and intelligent equipment
2	Social nature of use	Sharing and receiving information related to intelligent equipment
3	Context of use	Use and operating environment of intelligent equipment
4	Service process experience	Use and service experience related to intelligent equipment
5	Participation in service production	Able to influence the functioning of the intelligent equipment or participate in service creation
6	Customer goals and outcome	Goals and objectives enabled by intelligent equipment
7	Additional theme	Interview's own choice

Following the objective of this research, the themes of the stimuli list seek to consider the context where the participants of the interview are accustomed to operation of the intelligent equipment and, from the perspective of CPSs, outline the possible opportunities that might emerge in that context according to the literature preview. In this research the term intelligent equipment was used in interviews for referring to the CPSs, because it was more familiar as a term to the participants.

4.3.1 Data gathering

In total 20 participants were interviewed individually, via phone. The participants were informed that the collected data will be anonymised and handled confidentially, mentioning also that the data analysis and the findings would be handled within the limits of Non-Disclosure Agreement. Through informed consent, the aim was to create a neutral environment for the interview, because it was not possible to meet interviewees face-to-face due to long-distance, and to ensure that the interviewees would be willing to speak freely. The participants were informed that the calls were recorded in order to support the interpretations and the data collection and would not be given to other parties or used for other purposes. The interviews were done in Finnish and afterwards during the analysis, translated into English.

At the beginning of each interview, the participants were informed briefly of the object of the research in general and requested to consider the intelligent equipment and the services related to them from the perspective of what elements would be important or relevant for them, not what would be technologically possible. The list of stimuli worked as the starting point for the interview as the themes were explained with the potential elements or operations that would be enabled by the intelligent equipment. Then the participants were asked to choose two themes that they considered to be the most important or interesting to them. The popularity of the themes can be seen from table 5.

TABLE 5 Popularity of the themes

ID	CIS elements	Frequency
1	Construction of identitites	2
2	Social nature of use	12
3	Context of use	6
4	Service process experience	18
5	Participation in service production	
6	Customer goals and outcome	2
7	An additional theme	

As all the participants selected two themes that they considered the most important their selections formed clear differentiation among the themes. The themes that the participants were interested most frequently were the fourth theme called the service process experience and the second theme called the social nature of use. As can be clearly seen, the fifth stimulus did not seem important or relevant from the participants' perspective. Neither did any participants suggest their own additional theme. Table 6 displays more specifically the relation between the participant's title and the chosen themes. As can be seen from the table, the most common combination was the themes two and four.

TABLE 6 Themes selected by the participants

ID	Position	Organization	Sex	Theme
1	Product Specialist	Case Company	Male	2, 4
2	Domestic Aftersales	Case Company	Male	3, 4
3	Product Specialist	Case Company	Male	2, 4
4	Domestic Service Manager	Case Company	Male	3, 4
5	Service Offering Development Manager	Case Company	Female	4, 6
6	Product Specialist	Case Company	Male	2, 3
7	Territory Manager	Case Company	Male	2, 4
8	Documentation Engineer	Case Company	Male	2, 4
9	Technical Customer Service Support Manager	Case Company	Male	4, 6
10	Product Manager	Case Company	Male	2, 4
11	Product Specialist	Case Company	Male	2, 4
12	Product Specialist	Case Company	Male	1, 4
13	Product Specialist	Case Company	Male	1, 2
14	Head of Construction	Mining contractor	Male	2, 4
15	Team Leader / Chief Design Engineer, System Engineering	Case Company	Male	2, 4
16	Product Line Manager	Case Company	Male	3, 4
17	Head of Mining	Mining operator	Male	2, 4
18	Technical Training Development Manger	Case Company	Male	3, 4
19	Site Manager	Case Company	Male	3, 4
20	Technical and Field Support Manager	Case Company	Male	2, 4

Tuunanen et al. (2011) advise to lead the laddering interview using a series of questions such as "Why would that be important to you? " as the way to elicit the consequences that are revealed through the participant's association networks. (Tuunanen et al, 2011). Reynolds and Gutman (1988) stated that the questioning generally requires the response of the participant that enables the interviewer to react to the response and repeating the same words that the participants has used when describing opinions (Reynolds and Gutman (1988).

In this research the interview started with the two themes that were selected and the participants were asked to choose which one would be the one to start. The actual laddering interview started with the questions targeted to the chosen theme by asking, "How would this work from your perspective?" or "What is essential in this theme from your perspective or from the perspective of intelligent equipment". This way the participants shared their first opinions about the theme and elicited the features that were important to them. The interview proceeded then by going through each of the features to elicit consequences by targeting the series of "Why would this be important to you" questions to all of them separately. The process continued and leaded to the eliciting of the values in the same way. The same was done to the other theme that the participant had selected.

The object of the interviewer for each of the ladders was to go through the chain from attributes to consequences to values. However the participants were not always able to explain more than a few consequences and could not name a specific value or the attribute did not invoke awoke any consequences easily. The interviewer then changed the format of the question or moved on to the next feature, returning later and to try again. In general the interview's proceeded easily, ranging from 20 to 60 minutes, the average lasted approximately 30 minutes.

4.3.2 Data modelling

To follow the interviewees' flow of thoughts, the interviewer made field notes on a spreadsheet by using Microsoft Excel. One spreadsheet included chains originating from one theme or stimuli, which the interviewee had chosen. Each chain was captured in an individual column to represent the thinking of the interviewee and started with the attribute or feature (A), continuing with various consequences (C) and leading to certain value (V), the letters preceding each statement in the spreadsheet. Darke et al. (1998) argue that a well-organized and categorised set of case data will facilitate the analysing phase and, referring to Yin (1994), suggest that the data collection should be well planned before and maintained throughout the process as it can, in principle, be reviewed by other researchers, increasing the reliability. (Darke et al., 1998.) In this research the structured format of recording the data eased the later data analysis phase and made it easier for the researcher to capture beginnings of new chains and for not to dismiss interviewees' thoughts, as there usually emerged various ideas inside one theme as the interview proceeded. Example of the field notes can be seen in table 7, where the attributes, consequences and values are separated in their own columns as they will be modelled in the later phase of analyse. During the interview the chains were coded in one column.

TABLE 7 Example of the field notes and data collection

Interview: 18 Stimuli number & name: 4 Use and service experience related to intelligent equipment Chain number: 5		
Attribute	**Consequences**	**Values**
A Equipment continuously interprets it's own performance	C Real-time information about the equipment's health and operations	V Proactive customer relationship
	C Wirelessly and autonomically transfers the information to manufacturer and customer	V Integration to customers process
	C Potential problems can be discovered in advance	V Predict needs and avoid unnecessary down-time
	C Can prevent the maintenance need	
	C Can notice if the equipment does not operate well with the current settings	
	C Can notice components wear in advance	
	C Maintenance service could proactively contact the customer	
	C Could interpret the situation and inform the effects to the customer's process	
	C Could interpret the situation and inform the effects to the customer's process	

Afterwards the researcher asked the interviewee to confirm that the researcher has made correct interpretations by briefly summarizing the chains. With the recorded interviews the researcher was able to supplement the interpretations and chains afterwards in order to maintain the idea that the interviewee had presented. The interviews resulted in 201 individual chains from 20 interviews. Each participant provided approximately 10 chains within the two themes that they had selected and almost 1420 individual statements.

4.4 Data analysis

In interpretive research the goal of analysis is to produce an understanding and provide an explanation of the phenomena that was studied. Walsham (1995) emphasizes the researcher's role in the analysis phase as the interpreter of other people's interpretations (Walsham, 1995). Darke et al. (1998), referring to Miles and Huberman (1984), describe the data analysis consisting of three concurrent activities. Data reduction is the first action that is based on selecting, simplifying and transforming the raw case data. That is followed by data display aiming to result as an organized assembly of information for enabling the drawing of conclusions. The data display includes narratives, graphs and tables. The last action refers to the building of a logical chain of evidence for drawing the conclusion or verification. This can be done by using clustering diagrams or causal networks including the coding of data segments into categories that are identified from a study's initial conceptual framework. (Darke et al., 1998.)

In this research for the analysis a two-step thematic approach was adopted to cluster the chains and to turn the data into meaningful graphic presentations. The analysis followed similar studies (Tuunanen & Govindji, 2011, Tuunanen et al, 2006) and offered an appropriate model for answering research question in this thesis. As a part of the analysis the idea of the CSC model was used for visualizing the chains of attributes or features, consequences and values and for creating meaningful network maps for every theme that was used as stimuli.

During the interviews the data was recorded using the participants own expressions. For ensuring the correct interpretations the recorded interviews were heard twice to fill the data set and the statements were simplified for shortening the expressions. All the chains from the separate spreadsheets were copied and inserted into one single spreadsheet to ease the handling of the 201 individual chains. After this, the next step was interpretive clustering analysis for developing consistent constructs from the unique statements that the participants had used when expressing their ideas. The aim of the interpretive clustering process was to find similar expressions and to create clusters including similar concepts, without losing too much information. In order to maintain the information referring to the origin of the chains each chain was numbered consecutively and marked with the theme number during which they had emerged.

The clustering analysis started by going through the attributes for clustering them. To achieve this all chains and attributes were interpreted and statements with similar meanings were searched for creating attribute codes that would describe the similar attributes. A new column for the attribute code was added and each chain was given the describing attribute code. If the chains could have been coded with more than one attribute code the whole chain was copied and coded separately with different attribute codes increasing the number of chains. When all of the chains had been interpreted and given an attribute code, the chains were sorted using the attribute code. After this the same process was followed for consequences and values. The coding of consequences and values was easier as the chains with similar attribute codes usually had similar consequences and values. In some cases the participant's expression did not include a clear attribute, consequence or value and these were coded as N/A, meaning not available. As a result and after copying the chains that needed to be coded separately with a different attribute, consequence or value codes, the number of chains increased from 201 into 265. The individual sorting of chains increased the reliability and the interpretations that emerged.

After sorting the chains according to the developed codes, the final phase was to create individual graphic representations of each theme by arranging the clustered codes into network maps. Microsoft PowerPoint was used as a drawing tool to create the network maps. The idea of the CSC model was used to visualize the associations between attributes, consequences and values, which are displayed as colour coded boxes for providing a clear graphic representation. Each of the network maps referring to the different themes had attributes placed on the left, consequences in the middle and values on the right. For creating clear graphic representations arrowed lines was used to display the associations between attributes, consequences and values. The boxes of attributes, consequences and values were re-arranged various times to avoid the crossing of arrowed lines and achieve as clear a graphic representation as possible. Also a number reflecting the amount of participants that had mentioned the specific attribute, consequence or value was inserted for internally evaluating the main factors of each theme. As a result of analysis, five theme maps are representing the associations of participants as networks of attributes, consequences and values of different themes.

5 Findings

This chapter presents the findings of the data analysis. First the distribution of values per CIS model's themes is presented. Then the theme maps that were developed as a result of the data analysis to illustrate the chains of attributes, consequences and values within each theme will be presented.

5.1 Value distribution at theme level

In this research the CIS model was used as a framework for value co-creation to investigate how value is co-created in the context of intelligent equipment, which are examples of CPSs. Intelligent equipment are the result of technological development in many areas, which has allowed new capabilities for traditional equipment and increased their intelligence. They are integrating the cyber world and the physical world and are able to facilitate continuous interactions between these worlds in multiple levels in the networked environment, where various actors are operating.

The stimuli list that was used in the laddering interview included six themes representing the six elements of the CIS model from the perspective of intelligent equipment. During the interviews the participants emphasized some themes more often than others as can be seen from table 8. In the context of intelligent equipment in the mining and construction industry the use and service experience related to intelligent equipment (ID 4, n= 122) was clearly the most significant theme for the participants, whereas the theme regarding being able to influence the functioning of the intelligent equipment or participate in the service creation (ID 5, n=0) was not chosen by any participants. After the most often chosen theme there was a clear gap before the second and third most emphasized themes, which were the sharing and receiving information related to intelligent equipment (ID 2, n= 63) and the use and operation environment of the intelligent equipment (ID 3, n=47). The two last were emphasized similarly.

When observing more specifically the distribution of values they seem to be divided into broad top-level values, more specifically emphasized and linked values and values that have broader implication than the number indicates. Efficiency (n=20), reliability (n= 22) and support customer's process (n=28) seems to be clear broader top-level values. Also the accuracy (n=6), safety (n=8) and cost-effectiveness (n=2) are top-level general values. Some values seem to be linked to others, like the support geological interpretations (n= 4) and integration into customer's process (n=4) seems to be linked to the support customer's process. Simple to use (n=16) and easier to adopt (n=13) seem to be also linked to each other. Furthermore, the values related to real-time information formed a clear group, including real-time awareness (n=17) and as a result of that the continuous follow up (n=13). These two values can be creator of systematic process (n=15), where the timely maintenance (n=16) reduces down time (n=16) and increases useful life (n= 5) and utilization rate (n=6). Some values seems to have broader implication than their numbers indicate as the prevent problems (n=13), easily interpretable information (n=4) and targeted training (n= 5) support and enable other values to emerge. As an outcome the justify benefit (n=6) seems to be a broad overall objective for revealing the benefit that can be achieve with intelligent equipment when compared to traditional equipment.

TABLE 8 Distribution of value per theme

Value / Theme ID	1	2	3	4	5	6	Σ
Accuracy	1	1		4			6
Continuous follow-up		5	5	1		2	13
Cost-effectiveness			1	1			2
Easier to adopt		2		11			13
Easily interpretable information		3		1			4
Efficiency	1	3	3	12		1	20
Faster problem solving	1	5	3	3			12
Increase useful life			2	3			5
Increse utilization rate		1	1	4			6
Integrate into customer's process				4			4
Justify benefit		2		3		1	6
Prevent problems (Failure, oblivion or environmental)		4	2	7			13
Real-time awareness	3	6	3	5			17
Reduse downtime		4	3	8		1	16
Reliability		12	5	5			22
Safety			5	3			8
Simple to use	3		1	12			16
Support customer's process	1	6	1	18		2	28
Support geological interpretations		2	1	1			4
Systematic process	1	4	4	6			15
Targeted training		1	2	2			5
Timely maintenance		2	5	8		1	16
Total number	11	63	47	122	0	8	251

5.2 Theme maps

The analysis of the data resulted in five theme maps of the six themes, excluding theme five that was not selected by any of the participants. The maps present the network of attributes, consequences and values based on the associations that the participants expressed. The theme maps presents the elements of the CIS framework, which was used as research lenses. The maps illustrate how the value can be co-created in the mining and construction industry in the context of intelligent equipment, presenting the attributes or features related to intelligent equipment on the left, the outcomes or consequences in the middle and the emerging values on the right. Tuunanen et al., (2006) underscores that when reading the maps, it should be noted that the links in the maps reflect the associations of the participants, rather than analysts' rationale. Therefore it is suggested to be cautious not to seek causality or particular logic from the linkages. (Tuunanen et al., 2006.)

It is also important to notice that when reading the theme maps the participants have emphasized the requirement of real-time in various occasions. However, the participants also emphasized that, as the mine is a challenging environment and the covering of network is inadequate in many locations, the requirement of real-time that could be expected is approximately two hours.

5.2.1 Own role and intelligent equipment

The first interview theme focused on the participant's role as a part of the organization or as a part of processes in site environment. This could be defined as how the intelligent equipment and services related to them are considered from the perspective of different roles and how they could enable the different roles to perform better. This could mean for example the information related to the intelligent equipment that the different roles require or are interested for being able to perform their tasks.

Attributes: In this theme the collaboration and communication are mentioned including a distinct feature set describing a message wall that would be equipment specific. The message wall would enable the sharing of pictures, videos, voice records, notes, notifications and visualize a track of events and it would be the first view that the user sees after logging in and starts to use the intelligent equipment. The participants described that this could enable the user's with user profiles to save and share their own achievements and share them to others. This could for example enable the sharing of knowledge during the changing of shifts. User profile, user interface and simple troubleshooting are also mentioned in this theme related to the usage of the intelligent equipment. Data collection has a clear relation to the collaboration and communication and it also enables the integrated operation planning in general and during the single process. The user profile based data collection is also mentioned in this theme.

Consequences: The clear consequence for data collection and integrated operation planning is that it enables following the process in real-time and, with the integrated operation planning people in different roles, designing the next operations in advance as they have the latest information concerning the progress and recent actions in the operating environment. The data collection also enables the equipment specific database, which was emphasized by the participants as an important tool to for situational awareness of the equipment, and could assist in the ordering of correct spare parts. Furthermore, the distinct feature set related to the collaboration and communication not only increase the information in the equipment related database, but also improves faster troubleshooting as the users in different roles can share their knowledge to the benefit of others, and the complexity of intelligent equipment could be easier to handle. The outcome of having an equipment specific database makes information available to everyone, which also improves the ability to design next operations in advance. The participants often mentioned the right level of intelligence as the link between the competence requirements and the intelligent functions, which are not yet in line. The user profile based data collection and using the data for modifying the training are considered a solution for supporting the acceptance and adopting of intelligent equipment.

Values: As the process and operations become more transparent and they can be followed in real-time, the accuracy and efficiency will increase and the process in general becomes more systematic. Faster problem solving and simple to use demonstrate the core values that are important to tackle the complexity of intelligent equipment. Supporting customer's process seems to be one of the main values to pursue. The figure 3 illustrates the theme map for the theme 1 below.

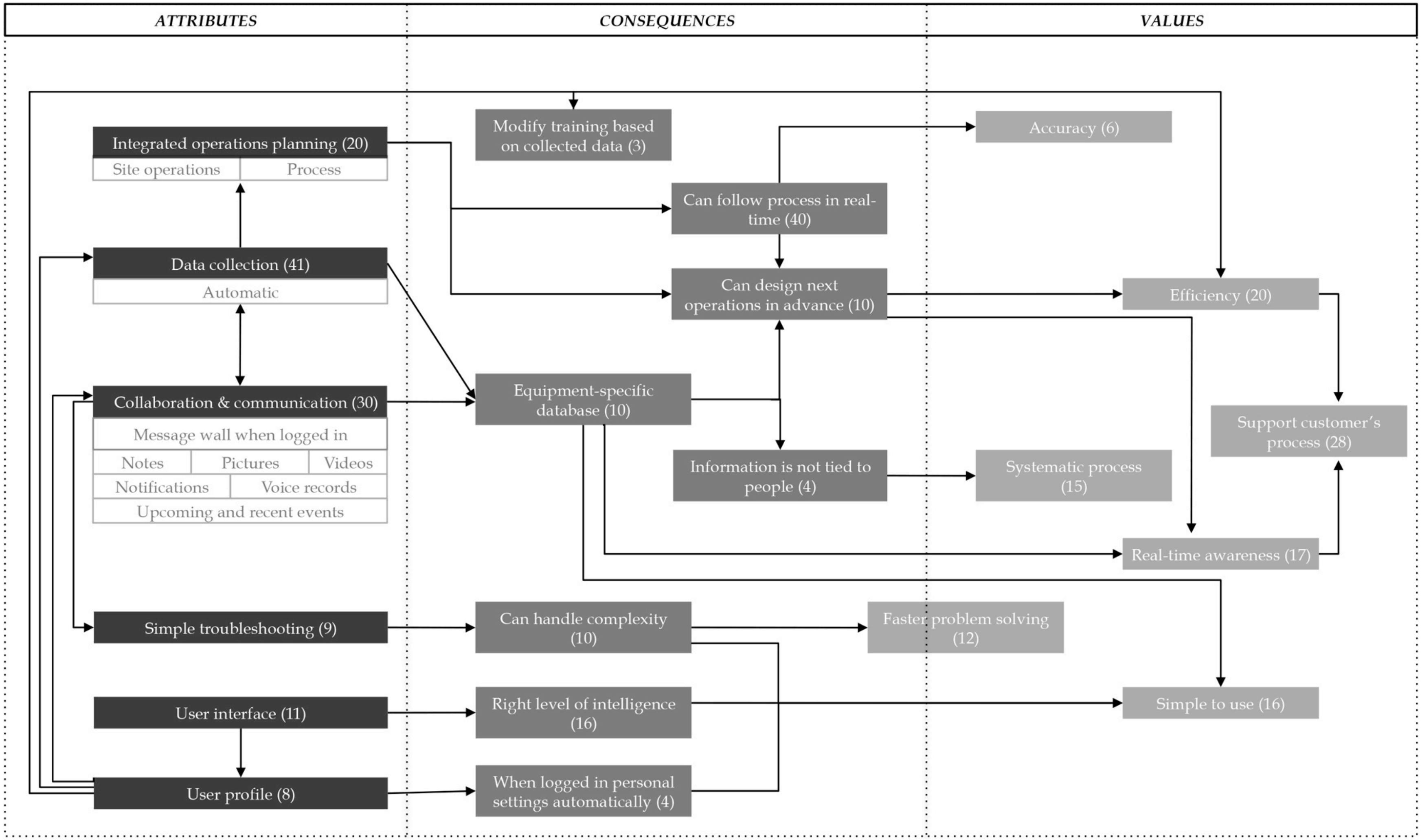

FIGURE 3 Theme 1: Own role and intelligent equipment

5.2.2 Sharing and receiving information related to intelligent equipment

The second theme focused on to the collection of data. For example, this means what kind of data the participants would be interested about, who would have the access to the data or how the data should be interpreted. This could also mean what data, in what format should be delivered and how the participants would want to receive and control it in order to share it in the network surrounding the intelligent equipment. This theme also denotes all kinds of expectations that are directed to the data and what kind of information would be relevant for the participants.

Attributes: This theme includes attributes that are related to data collection and the obtaining of information related to intelligent equipment. The basic issue in this theme is that data collection is expected to take on bigger role in the future when compared to the current situation, but while the equipment is able to collect data there should be clear objectives about what to collect and why. The participants expressed that the data related to equipment performance, users, process and the environment would be important and should be measured with multiple variables. The participants, for example, required a camera system that, together with the remote monitoring, would improve the quality of the interpretations of current situations and processes. The remote access and self-awareness are also considered meaningful attributes for obtaining the information of current actions. According to the participants automatic wireless data transfer should be a standard feature in all of intelligent equipment to provide the unchangeable data and, for example, ensure that the manufacturer could, via remote access, see the current settings during an error. It is also considered to be the prerequisite for integrated operation planning in order to deliver the updated plan directly to the equipment when planning the operations in general and single processes in real-time. In this theme tracking was also mentioned and described as a web mapping application, that would show in real-time the intelligent equipment and their locations with colour coded icons to show the status of the equipment, for example, in use, awaiting maintenance, etc. Collaboration and communication are mentioned also in this theme and training is emphasizes as the way to support the learning and sharing of knowledge with others as new features and processes arise due to the increasing intelligence. Furthermore the participants mentioned troubleshooting to be a complex process with intelligent equipment and expected that it should be implemented in other ways such as clearer error messages. The participants also expected that they could use their own devices for having access to the information related to intelligent equipment or the process and easily read notifications in different locations.

Consequences: The outcomes of integrated operations planning, real-time data and tracking reveal the expectations that the participants have for intelligent equipment. The participants expect to be able to follow the process in real-time and, if needed, to advise in real-time. The need for preventing maintenance delays and the ability to order spare parts automatically by the user or the equipment, itself, are also described as outcomes in this theme. Even as data collection was heavily emphasized and the participants required more measurements, the participants also expected the data to be provided in a meaningful format in order to make decisions based on that data. The outcome improved data collection enables continuous interpretation of conditions and formation of the equipment specific database. The consequence can monitor all equipment is closely related to the synchronization of operations, which also is related to the information that is not tied to people. The clear error messages and the ability to help via remote access are also related to each other. The usability related to the responsive design would enable access to the information with users own devices. The deeper understanding of customer's process is a heavily emphasized outcome, as it should be guiding the development of the functions and operations that the intelligent equipment enables.

Values: The main value emerging from this theme is the support customer's process that is driven by various other values. The preventing of problems, such as failure, oblivion, breakdown and environmental issues, is expected to be an important issue for being able to perform timely maintenance and increasing the utilization rate of the equipment as the downtime can be reduced with planning and accuracy. The continuous follow-up also drives the increased utilization rate. The value justify benefit is driven by the consequence can make decisions based on data and leads to the ability to demonstrate one of the benefits that the customer can receive with intelligent equipment as they provide more specific measurements. An interesting value is the supporting geological interpretations as the participants emphasized its ability to drive the general support of customer's processes. Especially the real-time awareness and systematic process seems to be important values to achieve reliability. The synchronization of operations drives cost-effectiveness, which surprisingly is not a very heavily emphasized value. Efficiency also seemed important in this theme, being driven by faster problem solving, targeted training and easier to adopt. The figure 4 illustrates the above relationships for theme two below.

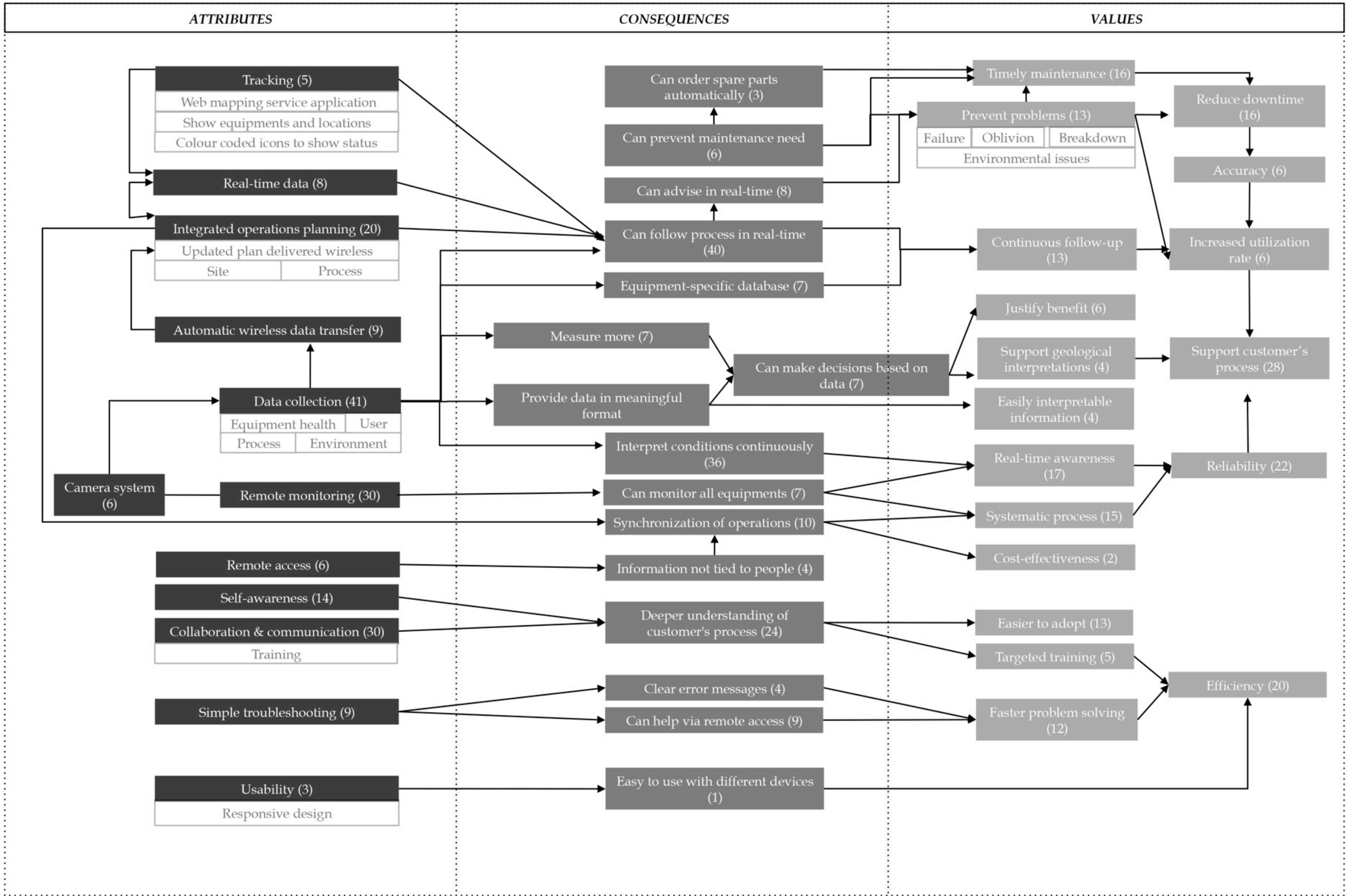

FIGURE 4 Theme 2: Sharing and receiving information related to intelligent equipment

5.2.3 Use and operating environment of intelligent equipment

The third theme concentrated to the operating environment, where intelligent equipment is used and where the service opportunities occur. This could mean for example how the changes in the operating environment affect to the use of intelligent equipment, how these changes should be noticed when designing the services or how the equipment should react to the changes.

Attributes: Data collection is also mentioned in this theme and described with the need for real-time data. Automatic wireless data transfer and automated fault reports are related to data collection, as is the analyzing of data in real-time, which together enable integrated operation planning. As a part of integrated operations planning, the participants mentioned the need for software for process planning, which would be used by both the manufacturer and the customer, enabling better integration. Remote monitoring, environmental monitoring and continuous process analysis are mentioned in this theme, indicating the need to increase the ability of be aware of actions whereas camera systems and self-awareness would increase the awareness of the current situation. User profile is mentioned as one source of data collection. The user profile also includes the ability to turn on and off the intelligence and training, referring to the need to recognize the different competency levels of users and for finding the right relation between the competence that is required and the intelligence that is offered. Collaboration and communication also seems to be an important attribute in this theme as is simple troubleshooting. In this theme the attribute suitability for site conditions, referring to the quality of the components, seems also to be a valid attribute. The maintenance including the record of completed actions is also mentioned in this theme.

Consequences: The outcomes can prevent maintenance need and interpret conditions continuously enabling the synchronization of site operations. A future vision of one operator operating multiple pieces of equipment is also mentioned. The participants also emphasized the ability to interpret conditions continuously since, in the mine environment, the ability to prevent environmental problems is a key issues. For example it was suggested that with an advanced camera system, such as the infrared camera, and by adding dyes to oil, the camera system could enable the detection of oil spills before the environmental damage occurs. The participants also suggested that intelligent equipment could scan the operating environment continuously while operating and update the site profile, which then could be observed when planning the next process phases. Moreover, the operator could receive different process model options, from which the operator could choose the best one when starting the next phase. The equipment could also form a summary concerning the chosen stock for the process and the predicted or estimated information about the process, including the average time, fuel consumption, etc., based on the history or user profile. In this theme, the compare performance to history, can follow process in real-time, measure more, can make decisions based on data and provide data in meaningful format are all outcomes that allow better controllability in an otherwise challenging operation environment. In this theme with the ability to modify the training based on collected data enables the organization of mine-specific training, if some special competence requirements become apparent. Can design next operations in advance is the outcome of collaboration and communication indicating that in a challenging environment, effective communication is required. The suitability for operating environment is a motivator for testing the equipment in real conditions. Moreover in this theme the equipment specific database is important and is related to a deeper understanding of the customer's process as it includes a tracking of events and reduces the risk that, for example, some updates are not installed. Ability to advise in real-time and help via remote access are also important in the challenging operating environment. A deeper understanding of customer's process is a central consequence in this theme.

Values: In this theme the values emphasize the possibility of improving the continuity of the processes by predicting potential obstacles. The main values in this theme are reliability, efficiency, safety and support customer's process. Timely maintenance drives the increase of utilization rate, which are similar values with reducing downtime and increasing useful life. They all refer to the ability to improve equipment endurance in a challenging environment and support the continuity of the process. Furthermore targeted training also supports the customer's process by improving the level of knowledge and the ability to better exploit the intelligent equipment. Prevention of problems and faster problem solving seem to be important values for the continuity of the process and for the customer's process in general. The figure 5 illustrates the above relationships for the theme three.

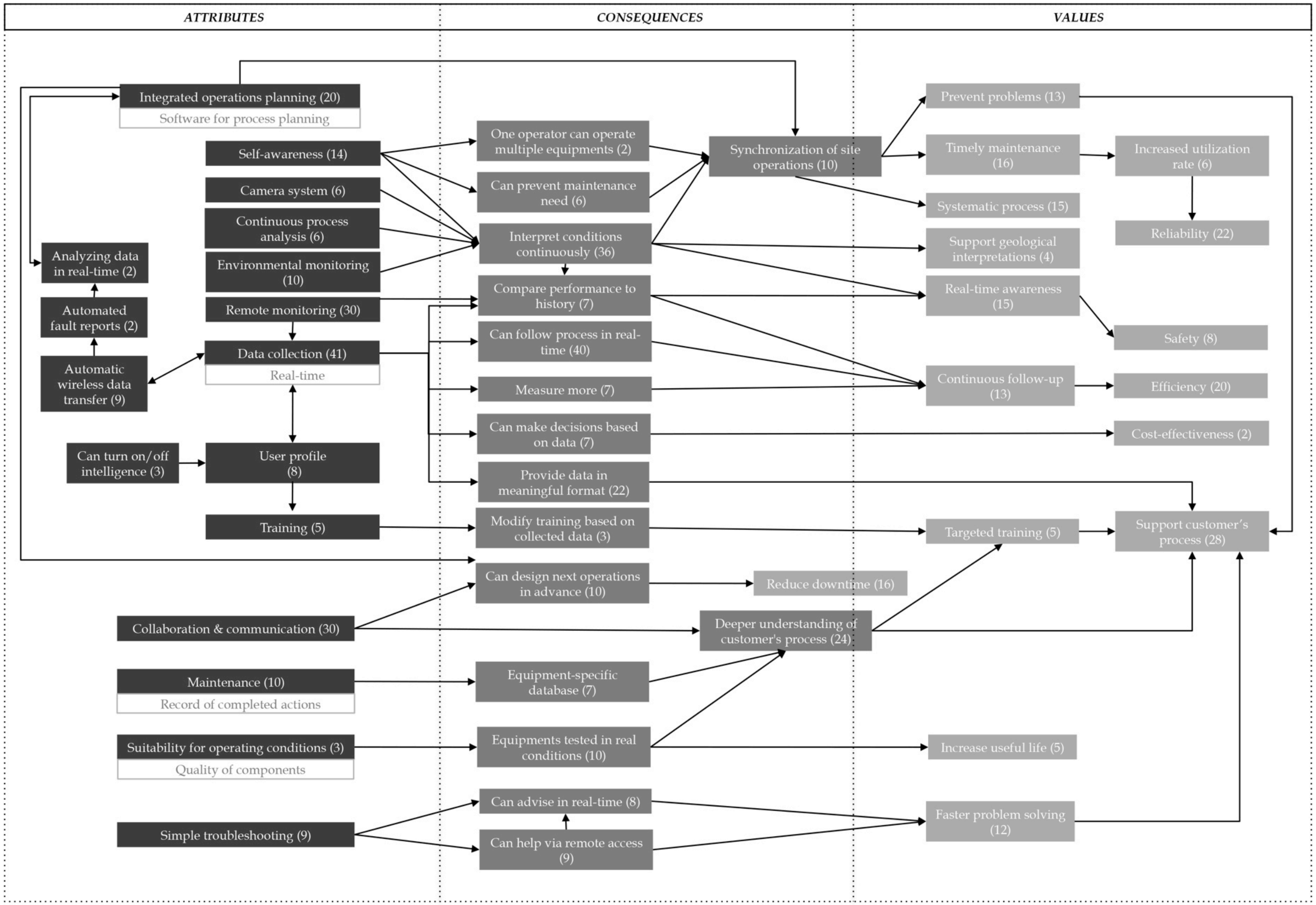

FIGURE 5 Theme 3: Use and operating environment of intelligent equipment

5.2.4 Use and service experience related to intelligent equipment

The fourth theme focuses on the use and service experiences that intelligent equipment enables. This refers to how intelligent equipment is expected to operate, how the maintenance should be designed or how the manufacturer could better recognize different needs or requirements of different customers or users in order to perform better with intelligent equipment.

Attributes: This theme is described with various attributes. Data collection, automatic wireless data transfer, data analysis in real-time and camera system are central items in this theme as well. The integrated operation planning is considered in this theme to be based on a special planning program offered by the manufacturer and also to support multitasking as next operations can be designed on the basis of the on-going process and the data that they produce. Furthermore a related attribute to this is continuous process analysis that could enable the analysis of rock types, users and equipment performance. Self-awareness is also mentioned in this theme referring to the equipment's ability to see, feel, hear and sense like a human. Participants emphasized environmental monitoring, remote monitoring and tracking in this theme and also the better planning of maintenance. Collaboration and communication internally and with the customers is a attribute similar to suitability for the site conditions as these both refer to the need for better understanding of authentic environments in order to obtaining realistic views of the challenges that intelligent equipment confront. Changing competence requirements and new terminology are mentioned in this theme in relation to training. Simple troubleshooting is described with automatic fault reports. The ability to turn the intelligence on or off is related to user-specific settings in general. The user-specific setting includes features such as screen colours and contrast, volume, movement speed and ergonomic adjustments, which are related to user profiles. Also from the perspective of usability the ability to learn and remember seems to be important. User interface is also related to the usability with features such as having all intelligent equipment with the same user interface, manuals would be embedded, pop-up info windows to support the user and a simple search option would be included.

Consequences: The ability to design next operations in advance, interpret conditions continuously, follow processes in real-time, help via remote-access, monitor all equipment and synchronization of site operations enable more proactive process planning in general. Remote monitoring enables better visibility, as the information is not tied to people and subjective opinions. The outcome of providing data in a meaningful format will make the information more relevant for the receiver. The motivator for multidiscipline knowledge sharing is that it could provide broader understanding of the possibilities that the intelligence provides. For example the mining industry could benefit from benchmarking other industries that have successfully adopted intelligent systems, such as the aircraft industry. In this theme participants consider a deeper understanding of the customer's process and testing equipment in real conditions essential. This is also related to the ability to offer the right solutions for the customer. Measuring more and comparing the equipment's performance are leading to the ability of preventing the maintenance need, which could be supported by the ability to automatically order spare parts or even change some spare parts automatically. In this theme the ability to handle the complexity and the ability to advise in real-time are outcomes of usability and user interface, which can also enable the users to change from one piece of intelligent equipment to another. The right level of intelligence and the personal setting when logged in are mentioned in this theme as outcomes that support the user in general. Another important outcome that the participants emphasized is the ability to modify training and support the development. Clear error messages indicate that the amount of messages should be reduced and the message should be more specific not only code.

Values: This theme resulted as highest amount of values. Supporting customer's process seems to be one of the most essential values in this theme. Increased utilization rate, justify benefit, systematic process, efficiency and increased useful life reflect the need for an increase in monitoring and real-time data. Real-time awareness drives continuous follow-up where as timely maintenance and safety drive reliability. Accuracy and reduce downtime can be achieved with preventive maintenance. The value easier to adopt also seems to be an important value in this theme. Faster problem solving is also mentioned in this theme as a result of the ability to advise in real-time. Furthermore simple to use is one of the key values in this theme that can, with targeted training, tackle the perceived complexity and improve the ability to get the maximum benefit from the intelligence. Support geological interpretations and easily interpretable information also are mentioned in this theme. The interpretation of information related to the customer's process with the outcome deeper understanding of customer's process could provide new opportunities for the manufacturer to become integrated with the customer's processes. In this theme cost-effectiveness is an interesting value as it is the result of the outcome referring to the testing of equipment in real conditions. The figure 6 illustrates the above relationships for theme four.

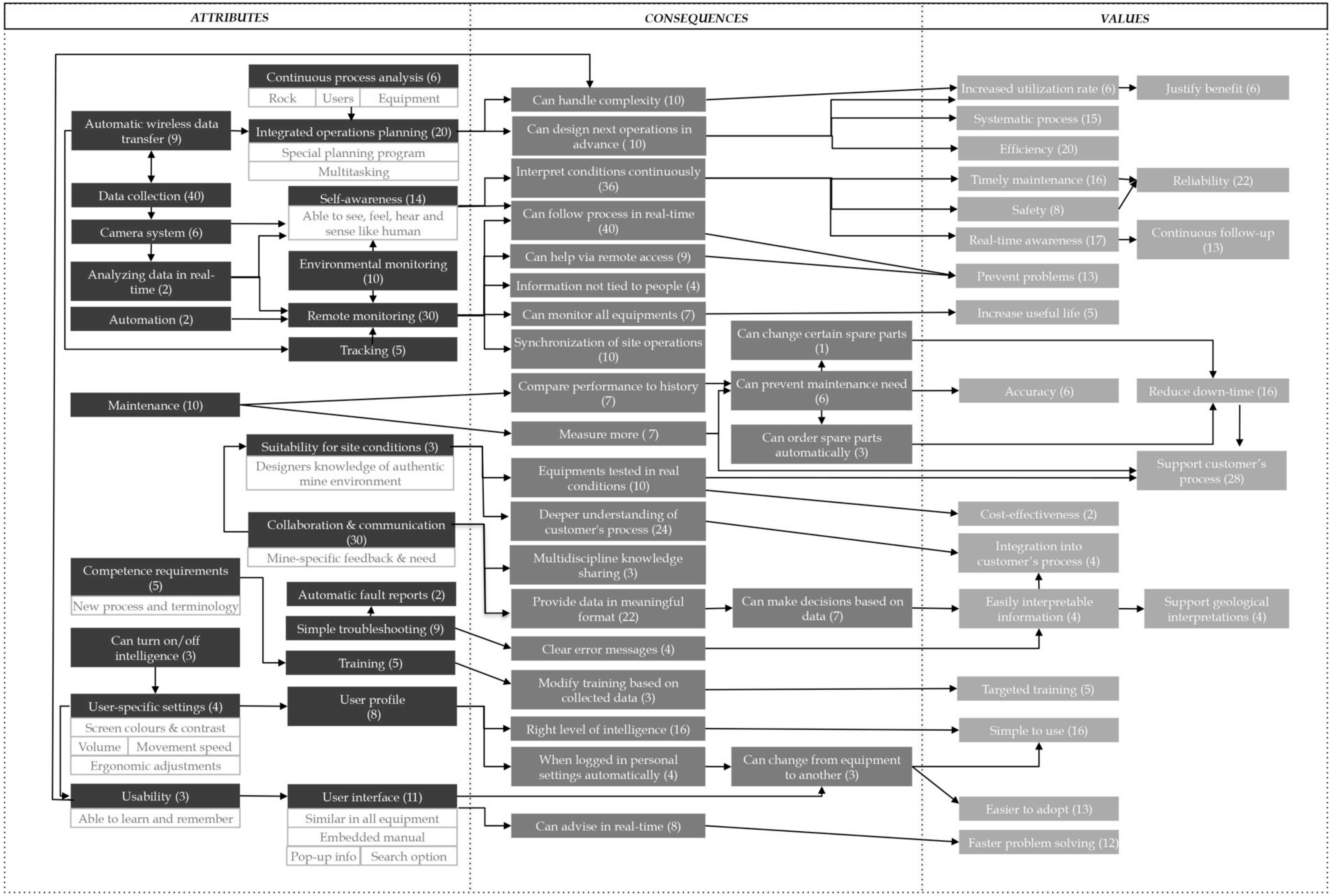

FIGURE 6 Theme 4: Use and service experience related to intelligent equipment

5.2.5 Goals and objectives enabled by intelligent equipment

The sixth theme concentrated to all the goals and objectives that could be enabled by intelligent equipment either from the perspective of single users' or employees, the customers or the organization.

Attributes: In this theme remote monitoring is an important feature as the participants emphasized that a basic level of monitoring or tracking capability should be a standard feature in all intelligent equipment. It allows together with the real-time data collection the gathering of information concerning the operating conditions and the customer's use of equipment, which can be different than what the manufacturer has intended. This enables improved knowledge and suitable preparation of the equipment for site conditions. Analyzing data in real-time a has got strong relation to collaboration and communication enabling the manufacturer to proactively consult or inform the customer based on data.

Consequences: The outcome remote monitoring allows more specifical measurement of factors related to equipment performance and operational factors. Providing data in meaningful format is also an important outcome in this theme. The outcome of analyzing data in real-time and improving collaboration and communication with customers enables a deeper understanding of the customer's process. Furthermore the outcome of improving the equipment's suitability for site conditions can improve processes in general.

Values: The values emerging in this theme are related to supporting of customer's process. Continuous follow-up and timely maintenance reduce downtime, which in turn improve cost effectiveness. Also efficiency emerges in this theme as a result of improving processes. Figure 7 illustrates the above relationships for theme six.

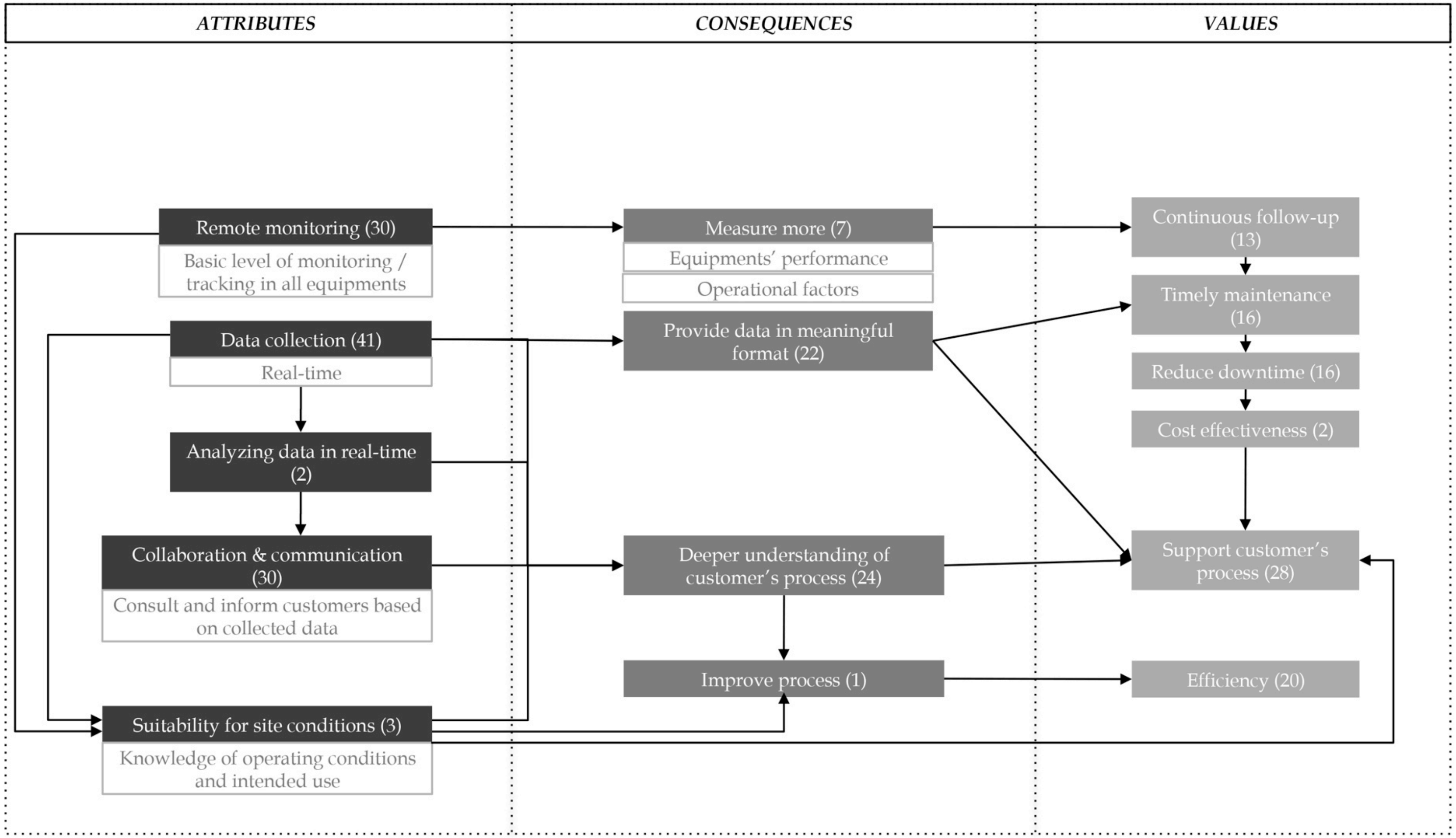

FIGURE 7 Theme 6: Goals and objectives enabled by intelligent equipment

6 Discussion

The purpose of this study was to understand how value is co-created in the context of CPSs in a networked environment. The focus was on intelligent equipment in the mining and construction industry, which are an example of CPSs. In this chapter the case study findings will be discussed and evaluated and implications for research and practice will be given.

6.1 Research questions

The object of this study was to investigate how the value is co-created in the context of CPSs in the networked business environments, including different actors and the embedded environment. The main research question was:

1. *How is the value co-created in the context of CPSs in networked business environments?*

To provide an answer to this question, a case study was carried out on CPSs in the mining and construction industry and the focus was on intelligent equipment, which are examples of CPSs as they integrate the computational processes that interact with the physical elements. From the service-centered perspective the value co-creation in the context of CPSs in a networked business environment in mining and construction industry includes a variety of different actors and components, all of which contribute to value co-creation based on their own competence. The value creation network clearly challenges the traditional view of the value chain, as the value creation process is an evolving process in network, not a pre-designed continuum. As Vargo et al. (2010b) argue, the value creation in networked environment requires adaptability and learning capability from the organization for being able to serve the value network and integrate needed resources. In the industrial context the core issue is the basic problem addressed by Grönroos and Helle (2010), who argue that the business logic of product manufacturers is traditionally product-oriented. Adopting the service-centered perspective to value creation requires that the manufacturer's activities and processes and the customer's corresponding activities and processes form a stream of actions (Grönroos & Helle, 2010). As the different actors create the network horizontally and vertically, from the manufacturer's sphere and from the customer's sphere the CPSs needs to be able to coordinate the co-operation and interactions, and still enable the autonomy of individual actors.

In order to answer the main research question in the context of intelligent equipment, a sub question was included:

> *1a. What are the value propositions and the value drivers in the context of intelligent equipment?*

The CIS framework was adopted to explore the value co-creation in the context of intelligent equipment in the mining and construction industry. While the CIS framework by Tuunanen et al. (2010) focuses on consumer IS, the findings indicate that it also can be adapted to study IS in organizational contexts in networked business environments. From the perspective of research and theoretical understanding the CIS framework enables understanding of value co-creation in the context of CPSs, by integrating the cyber and physical world, which the previous research has often separated due to the lack of models and frameworks (Baheti & Gill, 2011). The main findings are summarized in table 9.

TABLE 9 Main findings

ID	CIS elements	Main findings
1	Construction of identitites	Data collection from the perspective of different actors in manufacturer's / customer's organization, user profile based data collection (share own knowledge, learn from others)
2	Social nature of use	Richer, planned & more accurate data collection, sharing of data in right format for different target groups, real-time requirement & wireless data transfer, integrated operations (remote access, monitoring, tracking), multidiscipline communication capability over functional areas
3	Context of use	Continuous monitoring of user, process, equipment's performance & environment, integrated & updated process planning in real-time, real-time awareness, suitability for challenging operating conditions, user/customer specific & targeted training
4	Service process experience	Balance between user's competence & equipment's intelligence, adaptability to different needs, high degree of automation, predicting/ learning capability, usability <> adopting, communication in network, user- & customer-specific monitoring, simple troubleshooting, remote help
5	Participation in service production	-
6	Customer goals and outcome	Proactive customer relationship (consulting process & device choices), reduce downtime & increase utilization

The CIS framework includes six elements, which are divided into system value propositions and customer value drivers. The system value propositions include the construction of identities, the social nature of use and the context of use. The value drivers include the service process experience, participation in service production and customer goals and outcomes associated with system use. In the CIS framework the value proposals indicate features enabling value co-creation and the value drivers indicate the reasoning driving the customer or user to co-create value. The findings indicate that in the context of intelligent equipment in the mining and construction industry these two sides are weighted differently. The CIS element participation in service production did not seem to be relevant in this context, as any participant did not select it. The service process experience was clearly the most important CIS element and also the most important value driver as the use and service experience related to intelligent equipment was the most weighted theme. This emphasizes the need to find the balance between the human strengths and weaknesses and the equipment's corresponding strengths and weaknesses. This also indicates that CPSs are more of a socio-technical system than a system or piece of equipment performing certain operations, as the human is the core of the system. This also indicates that intelligent equipment should be seen as a platform for service with a close link to people, and not just a technical system or product performing certain operations.

The social nature of use is also relevant in this context as the sharing and receiving of information related to intelligent equipment was often selected theme. This emphasizes the ability to manage the increasing amount of data, as intelligent equipment are able to measure of variety of variables. The context of use seems to be also a significant system value proposal in this context, as the use and operating environment of intelligent equipment is underlined in the mining and construction industry, where the operating environment is closely linked to security and increased need of reliability. Unlike Tuunanen et al. (2010) argued the context of use seems to have significant role in organizational settings in the context of CPSs, where the environment is embedded to the value co-creation process. Even though the construction of identities was not the most important theme in this context, the ideas that emerged in that theme indicated that user profiles could be used as a away to collect user based data and modify training or for supporting communication with other actors. Also the customer goals and outcome was a less weighted CIS element in this context, but the capability of the intelligent equipment to enable new goals and objectives was recognized.

The CIS framework's fifth theme didn't seem important in the context of CPSs. Rather the systems ability to learn and predict based on history seemed more important and the participants considered that the less the user or other actors needed to change settings or, for example, manually order spare parts, the better. It also increases the requirements for automation. However, based on the findings the CIS framework seems an appropriate model for exploring the value co-creation in the context of CPSs. It also is a model that integrates the cyber and the physical worlds, which the previous research has often studied separately due to the lack of multidisciplinary models (Baheti & Gill 2011).

Tuunanen et al. (2010) argue that the balance between hedonic and utilitarian use of the system may differ between consumer and organizational users (Tuunanen et al., 2010). The study by Vartiainen and Tuunanen (2013) investigated the value co-creation in the context of geocaching with the CIS framework and the findings indicated that the values from the participants were more hedonic than utilitarian. On the contrary, in the study of Tuunanen et al. (2006) the outcome indicated that in the mobile finance service field the values from the participants were more utilitarian. Additionally, Tuunanen and Govindji (2011) focused on interactive television services and the development of an online IPTV learning system for university students. The values from the participants in that context were goal-oriented and more utilitarian than hedonic indicating that the participating university students wanted the system to support their learning activities.

The findings of this study indicate that the utilitarian value and goal-oriented perspective towards values are more relevant than the hedonic values in the context of CPSs in the mining and construction industry. The support customer's process, efficiency and reliability were clearly the top values. Integrate into the customer's process is a value that indicates that a better understanding of the customer's process could enable richer interactions between the manufacturer and the customer, and the value support geological interpretation is an example of this. The values called continuous follow-up, real-time awareness, reduce downtime and timely maintenance are closely related to the value systematic approach. Also accuracy, increase useful life and increase utilization rate are values that indicate that the better planning capability in the challenging environment including various different actors could improve the efficiency in general. Easier to adopt, faster problem solving and simple to use indicate that the transition from the traditional equipment into intelligent equipment requires special attention for being able to support the users, which is also emphasized by the value targeted training. As the competence levels among users the readiness to adopt new equipment, new processes and new theory might vary. Safety in the challenging environment is a self-evident value, but the value prevent problems is an interesting perspective as it can prevent the decrease of utilization rate but also prevent human errors.

The justify value is an interesting value, as the findings indicate that for example the targeted training based on data collection could reduce downtime and prevent problems, which for the customers could justify the benefits of intelligent equipment compared to traditional equipment. Surprisingly, the cost-effectiveness is less emphasized, which indicates that the service-centered perspective and the ability to see beyond the value-in-exchange are emerging. However, the findings revealed also some hedonic aspects as the participants described the required attributes for usability and user interface from the perspective of hedonic value. They also described some applications that they are used to using in personal life that have better usability than the ones that they use at work.

Based on the findings there emerged multiple issues to discuss from both theoretical and practical perspectives. Next the implications on research and practice will be discussed.

6.2 Implications on research and practice

This study shows that the S-D logic, supplemented with the Service logic, offers a comprehensive mindset to understand service and value co-creation from the service-centered perspective in the manufacturing industry. For understanding the value co-creation in the context of CPSs the CIS framework is an appropriate approach by integrating the cyber and physical world. The laddering interview enabled to understand value co-creation from the perspective of the actors in the network surrounding the CPSs, and with the CSC approach, to understand the associated chains leading to certain values. The combination of these methods enables an understanding of the environment of value co-creation and helps the discovery of the underlying opportunities that exists in the context of CPSs. It also paves the way towards understanding the networked value co-creation process, indicating that the linear value chain is not capable of defining the networked environment and the different actors contributing to the value co-creation. CPSs are capable of facilitating the networked value co-creation process with the capability of adapting to changing requirement. Moreover they also represent a combination that is more of socio-technical systems than technical systems, indicating that CPSs enable almost limitless service opportunities, if they are viewed as a platform for service, not the latest phase of incremental development. However the question still exists as to how to design CPSs as socio-technical systems being capable of recognizing the different needs of different actors in the network to facilitate the value co-creation? Also it remains unclear how CPSs affect their environments, the behaviour of the actors, and to the value co-creation process.

6.2.1 Implication 1: The CPS should be viewed as a socio-technical system for understanding the value co-creation in networked business environment

The research field of CPSs is still in its infancy. The findings of this study also indicate that the intelligent equipment of mining and construction industry are still strongly evolving, and some of the ideas and concepts that emerged are still at idea level even the needed technology is there. The previous research in the field of CPSs is directly focused on the technical opportunities and the special features and functions that CPSs enable. From the perspective of what is technologically possible the needed technological architecture and the components are already there. The ability to connect these to the needs of the physical world and practice remains unclear.

The findings of this study are in line with the previous research (Ficher, 2012, Geisberger et al., 2011,) and indicate that the human-machine interaction needs to be further developed in the fields of reasoning behind adopting, training and practical implementation. The adoption of CPSs is the central issue as the previous experience of intelligent equipment and the existing competence level of users influence it. Horváth (2014) emphasized the importance of situational adequacy, usability of equipment and ergonomics issues, which are similar to the findings of this study. Horváth (2014) also emphasized the importance of further investigation into the possible impacts of CPSs on the environment, society and people and their relation to self-learning, self-adaptable and self-evolving CPSs, which are also considered important for understanding the socio-technical nature of CPSs. Additionally the computing for human experience (Sheth et al., 2013) and the hedonic attributes enhancing the ease of use of business users of IS products (Kakar, 2014) have been noticed previously and the findings of this study also emphasize these as central issues when considering the socio-technical nature instead of focusing on technical capabilities. While these findings also indicate that even in the mining and construction industry, where the balance between hedonic and utilitarian values was strongly weighted towards utilitarian values, the hedonic values are important based on the participant's statements, and they should be more studied within the field of intelligent equipment. Also an important usability issue related to intelligent equipment is the requirements for human-like sensing capability for supporting the experience and facilitating value co-creation.

The findings of this study also concur with Sztipanovits and Ying (2013) whose study recognized the issue of human-machine interactions (HMIs) and the requirements necessary to understand the link between human strengths and weaknesses with the corresponding strengths and weaknesses of the intelligent equipment (Sztipanovits & Ying, 2013). The balance between the human and the equipment is central issue for CPSs as a socio-technical system. The adaptive behaviour and self-optimization are also considered important capabilities of CPSs (Sanislav & Miclea, 2012) but a lack of models that enable the designing of such system that is able to correspond to various needs in different time scales and locations is still evident. Horváth (2014) argued that the ability to self-learning and self-adaption are recognized capabilities of CPSs but to apply them in the human domain lacks in knowledge. Horváth (2014) suggest profile-based learning as a way to turn the vision of CPSs towards the socio-technical system and the findings of this study also indicate that the user profile based data collection could be used to monitor users and use as a way to monitor training and support the adoption of intelligent equipment. The data collection in general is a well recognized issue (Fischer, 2012) but more research is needed to understand what the data collection in networked environment enables and how the CPSs influence the distribution and receiving of relevant information to different actors.

The findings of this research indicate that the CIS model is an appropriate framework to explore the value co-creation in the context of CPSs. However, the findings also support the observation of Grönroos (2010), who states that the fundamental concept of value co-creation and the role of interactions in S-D logic does not offer a clear definition for what is the focus of value co-creation, what actors are involved and when does value co-creation occur. Grönroos and Gummerrus (2014) also emphasize the role of interactions in value co-creation process and argue that only direct interactions, including two or more actors or intelligent non-human resource, enable co-creation between different actors as they are influencing each other's actions and emerging value-in-use. For understanding the value co-creation in the context of CPSs in networked business environment, it becomes necessary to create a more comprehensive concept for value co-creation. In the context of CPSs in networked environment the understanding of interactions between the cyber world and the physical world, and between the different actors and components in physical world are essential. It is also important to understand what actors or components are involved and what is the focus of value co-creation in networked environment.

The CIS framework could be supplemented to cover more comprehensively the socio-technical nature of CPSs. The CIS framework's theme five didn't seem important in the context of CPSs. The findings of this study indicate that the research of CPSs as socio-technical systems instead should focus on the equipment's ability to learn, predict and suggest options, which also are important in order to enable direct interactions and facilitate value co-creation. Concepts such as long-term learning, self-adaptation and self-evolving and approaches such as real-time systems (RTSs), distributed intelligence systems (DISs) and collaborative adaptive systems (CASs) (Horváth, 2014) and more comprehensive understanding of interactions between the cyber and physical world could provide valuable insights on how to supplement the CIS framework further in the context of CPSs.

6.2.2 Implication 2: Deploying the full potential of CPSs requires service-centered perspective on manufacturing industry

The manufacturing industry and the digitization of manufacturing are still heavily affected by the traditional G-D logic. An example of this is the suggestion of Brettel et al., (2014) that intelligent products should be seen as a platform for further service sales over time to achieve competitive advantage by providing value adding services, such as long term contracts for maintenance (Brettel et al., 2014).

The findings of this research indicate that the premises of S-D logic, supplemented with the Service logic, and contrasted with the G-D logic, provide a comprehensive model to understand service as a phenomena and value co-creation approach in the manufacturing industry. The CIS framework provides a simple way of understanding the value co-creation process in the complex networked world of CPSs by including the system value propositions that enable the value co-creation and the value drivers that are driving value co-creation. The theme maps provide a graphical presentation of association chains of participants including the attributes, consequences and values according to the CSC model (Peffers et al., 2003), which provides insights to the value co-creating opportunities in the networked environment of CPSs. Using these models broadens the perspective of the ability of CPSs to facilitate value co-creation and reveal the tacit needs and relationships.

The findings also indicate that there exist various new value co-creation and service innovation opportunities when viewing CPSs from the service-centered perspective. This requires that the whole business is viewed from the service-centered perspective, when the service is not a separate function or the services are limited by the equipment lifecycle. Based on the suggestions of Grönroos and Helle (2010), the service-centered perspective requires that all the activities and processes of the manufacturer that are relevant to its customer's business are coordinated with the customer's corresponding activities and processes to form a stream of actions. (Grönroos & Helle, 2010.) By understanding how CPSs can support that stream as a platform, there might emerge new value creation and service innovation opportunities.

The service-centered perspective does not reduce the meaning of product development or the traditional services, such as maintenance, spare parts or service contracts. Rather it means that product development is the enabler and the traditional services can be deepened and broadened with the organization wide service-perspective. For example instead of maintenance contracts and pre-scheduled and designed maintenance, the maintenance could be based on the intelligent equipment's self-awareness ability and to predicted need based on history, which would reduce the downtime as the equipment could communicated need before the breakage occurs or when the components are to be changed. This would require a new kind of process model and organizational structure from the manufacturer to enable the quick turnaround of maintenance and monitoring of customer- and equipment-specific spare part stocks.

Like Brettel et al., (2014) observed the labour work will change as the intelligence of equipment increases, but still remain irreplaceable since the roles of humans evolve towards coordinators and problem-solvers. From the service-centered perspective this opens new possibilities for the manufacturer to coordinate new processes and integrate to the customer's processes by offering the needed competence and knowledge to analyse and interpret the collected data. This also pushes the need of new business models, which enables the organization to support the value co-creation process. The approaches such as servitization and product-service systems and the product or lifecycle related services such as after sales services (Oliva & Kallenberg, 2003) are challenged by the findings of this study, that intelligent equipment are more of a distribution mechanism for service and a platform for value co-creation, than merely the latest phase of incremental product development.

In the mining and construction industry the lack of service-centered perspective is preventing the deploying of the full benefit of CPSs. As a traditional industry the challenge is the network of different actors with different motives and objectives. The manufacturer of intelligent equipment for the mining and construction industry has the role of the driver to turn the focus towards service. As the findings of this study indicate, CPSs enable the manufacturer to support the customer process with a better understanding of the customer's business and customer-specific needs. The manufacturer could transform from manufacturer towards customer consultant, for example, by organizing the needed capability to analyse the collected data, and from which the manufacturer could consult on the process model or the equipment choices. This requires that the manufacturers move closer to the customer's sphere. In the mining and construction industry these are strongly related to the different operating environments and the qualities of rock, as the participants emphasized that the manufacturer could support by increasing the measurements of geological variables. The manufacturer is also responsible for teaching the customers to understand the service that the intelligent equipment enable, which then enable the customer's to recognize the benefit. The challenges in the manufacturing industry are the R&D budgets, the technical silos and the disciplinary focus. More open and multidisciplinary approaches are required to deploy the full benefit of CPSs (Sztipanovits & Ying, 2013). For manufacturing organizations this requires a fundamental change in thinking. It also requires the willingness to shift the focus from its own process and production towards the customer's processes, and that link enables the value co-creation.

Even though the operating environment of intelligent equipment in the mining and construction industry is special and challenging, the approach including the CIS model, laddering interviews and the CSC approach enable an understanding of other value co-creation opportunities in the context of CPSs and enable a broad perspective to the requirements emerging not only at the top-level but organization wide. The theme maps in this research offer a broad perspective for the reasoning behind value co-creation. For example in the forest industry, the ability to interpret the environment and monitor equipment performance and collect data could reduce process steps and increase the efficiency, when the tree-related variables could be measured more accurately. Also in other industries where the environmental issues are central challenges, such as the marine industry, the value co-creating opportunities that the increased performance and environmental monitoring, self-awareness and data collection enable could be similar to the ones that emerged in this research.

7 Conclusions

This chapter presents the conclusions of this study. The research outcomes are summarised and linked to the research objectives and questions. This chapter also presents contributions for research and practice and the limitations of this study. Finally the suggestions for future research are presented.

7.1.1 Summary

Cyber-physical systems (CPSs) are socio-technical systems, which integrate the cyber world and the physical world. Based on data collection in the physical world, the cyber world is able to adapt its services to the changing situations in the networked physical world, including different actors and components. This capability enables CPSs to act as a platform for the value co-creation process, where different actors contribute to value co-creation based on their core competences. This perspective on value co-creation is based on a service-centered perspective on business, which challenges the traditional product-centered perspective and its value chain approach. By understanding the interactions between the cyber and physical world the CPSs can open various new service innovations and value co-creation opportunities.

To understand the value co-creation process in the context of CPSs in networked business environment a case study was conducted on the mining and construction industry, where intelligent equipment are examples of CPSs. To explore value co-creation, the CIS framework was adopted as the framework for value co-creation including the value proposals and the value drivers. Data collection was conducted via interviews using the laddering technique, which enabled to understand how the participants perceived the value co-creation. In total, 20 participants were interviewed, 18 from the case company and two from representatives of their customers. Based on the critical success chain (CSC) model five thematic maps were illustrated as a result of the data analysis, which present the association chains of the participants related to different CIS framework elements.

The findings of this study indicate that the value co-creation in the context of CPSs in a networked business environment includes a variety of different actors and components, which all contribute to value co-creation based on their own competence. In the context of CPSs the central challenge is the understanding of the interactions between the cyber world and the physical world, and between different actors and intelligent components in the physical world. This challenges traditional value chain thinking and requires adaptability and learning capability from the organization and from CPSs in order to serve the value co-creation network and integrate needed resources for value co-creation. Since CPSs are closely integrated with the human domain and the human is the core of CPSs, they should be seen more as socio-technical systems than technical systems. CPSs are required to be able to coordinate the co-operation of different actors horizontally and adapt its performance to the changing needs. Therefore it is a platform for service and an enabler, not the value itself.

The CIS model is an appropriate framework to understand and explore value co-creation in the context of CPSs in a networked business environment, since it includes the system value proposals enabling the value co-creation and the value drivers driving actor to co-create value. CPSs include similarly two sides, the cyber and the physical world. The findings indicate that in the context of intelligent equipment in the mining and construction industry, these two sides are weighted differently, as the CIS element participation in service production did not seem to be relevant in this context. The service process experience was clearly the most important CIS element and also the most important value driver. The findings also indicate that the actors in the networked business environment in the mining and construction industry were more goal-oriented as the values that emerged in the context of CPSs were more utilitarian than hedonic. The most important values were support customer's process, efficiency and reliability. However some hedonic values emerged also, which need to be further studied in the context of adopting intelligent equipment.

Even though the mining and construction industry is a specific and challenging environment for intelligent equipment and challenged also the CPSs adapting capability, the thematic maps provide an overall view to the emerging value co-creation opportunities in the context of CPSs. However the findings indicate that more research is needed to understand the balance between the human strengths and weaknesses and the equipment's corresponding strengths and weaknesses, in order to achieve the required level of intelligence from the different actors perspective. The findings also indicate that more research is required in areas of human-machine interactions, to understand the factors affecting to the adoption of CPSs and the role of interactions in the value co-creation process. Furthermore, since the networked environment challenges the adapting and learning capabilities of CPSs, more research is needed to understand how the environment impacts on CPSs and how the CPSs impact to environment.

The technological capability of CPSs is already there. For the manufacturing companies the deployment of that from the service-centered perspective requires practical means to view the whole business from the service-centered perspective and models to perceive the networked value co-creation environment facilitated by CPSs.

7.1.2 Contributions to research and practice

This research has some contributions to both research and practice. This research aims to improve the understanding of CPSs from the service-centered perspective and improve the understanding of these systems as platforms for service and value co-creation. This research also supports the previous literature by stating that the S-D logic offers an appropriate mindset to understand the service and value from the service centered-perspective on manufacturing industry, but more research is needed to support the fundamental change of perspective and the organizational structure for enabling the true discovery of service-centered perspective on business. From the perspective of the mining and construction industry this study shows that even though it is a traditional and strongly product or process oriented industry, the service-centered perspective could enable new opportunities both for the equipment manufacturer and the customer by improving their processes and value co-creation capabilities. From the perspective of CPSs as research field, this research indicates that CPSs should be studied as socio-technical systems to understand, for example, the adopting of CPSs and the balance between the human and the equipment competences and required intelligence. Also the role of interactions in value co-creation process in the context of CPSs and the networked environment including different actors should be studied more. For research and theoretical understanding this study shows that the CIS model can be adapted to other domains than the consumer information systems and it is an appropriate model to explore the value co-creation in the context of CPSs. However, this research is scratching only the surface of CPSs, which are full of potential but still largely lacking of cohesion as a research field. More research is needed to explore the other possible system value proposals and value drivers in the context of CPSs.

From the practical perspective the theme maps enable the different actors of the network, such as equipment manufacturer, customer and user, to easily understand the value co-creation process from the service-centered perspective, instead of the traditional product and process-oriented perspective. The theme maps (figures 3-7) also provide a graphic representation of the value co-creation process that intelligent equipment could facilitate and how the overall operating environment could be improved to serve both the manufacturer and the customer. For different operational areas in the manufacturer's side, the theme maps provide an overall picture of the whole environment of intelligent equipment and the operational areas related to it. For equipment manufacturers this research demonstrated the need for adopting a service- and -customer-centered perspective on business, since the technological innovations can be diffused, but when the manufacturer is able to find new ways to integrate the customer's process, the competitive advantage is greater.

In the development of intelligent equipment, the manufacturers of intelligent equipment could benefit from a bottom-up perspective and organization wide knowledge sharing. Also, when adopting the customer- or user-centered perspective to the development, the level of intelligence is in balance with the human competence, and supports the adoption of the intelligent equipment, instead of being to complicated or difficult to use. The role of the intelligence is to enable actions that are beyond the human capability, not to make the user feel inadequate. The manufacturer should transform from stand-alone producer into a proactive customer consultant who can support the customer in the adoption of intelligent equipment and the new processes that they enable.

7.1.3 Limitations

This research has some limitations. First of all the used framework for value co-creation ignores the technical issues, such as the linkages to cloud computing and other enterprise systems, and it does not cover how the organizations should be managed from the service-centered perspective. The mining and construction industry is also a challenging environment for CPSs and therefore might emphasize some features or elements that are not as relevant in other domains of CPSs. Also, because the participants were usually from the manufacturer's side, the view of the equipment manufacturer is emphasized and therefore the perspective of the customer's side is relatively limited. Also some possible participants that would have had valuable knowledge might have missed or could not be reached. Although the case company acts globally, possible participants from abroad or from the other operationally important areas than Finland could not be contacted due to schedules, which might influence understanding. Despite this, it can still be assumed that the participants formed a comprehensive sample since the snowballing method was used to find the participants who were the experts or well aware of intelligent equipment.

Since this was the first study of value co-creation in the mining and construction industry from the service-centered perspective focusing on CPSs, as far as the researcher knows, and since the CPSs as a research field includes various subdisciplines, such as sensors, communication engineering, computer science, control theories and human-computer interaction, some theory that could have influenced the stimuli list might have been missed. As the stimuli theme number five was not selected by any participants this theme might still be relevant in the context of intelligent equipment, but the researcher was unable to describe it correctly in this context. Also the participants did not suggest other themes beside the six provided, which does not mean that the CIS framework included all the value proposals or drivers. Finally the stimuli list might have had other deficiencies and as this research used the stimuli themes for illustrating the theme these deficiencies might have affected to the theme maps also.

The researcher might have also interpreted the participants' associations or statements incorrectly or missed beginnings of association chains or consequences or values. The interviews were conducted in Finnish and translated into English during the analysis phase and the chosen words or terms might have altered the original meaning of the participant. All the interviews were conducted by phone, which may also have affected the participants' understanding of the purpose of the interview or the understanding of the stimuli. Also some of the participants were busy, which may have decreased their association chains. As well, the clustering of the chains might have missed some important items or flattened some features during the coding. The theme maps might have missed some links as they represent the associations of the participants. However the findings were in line with the previous research, which indicates that there are no major deficiencies.

7.1.4 Future research

Based on the limitations and findings of this research, more research is needed to further elaborate the value co-creation in the context of CPSs in a networked business environment. The research in the field of manufacturing should study more service as business logic, not as a separate function, for supporting the manufacturing companies to manage their entire business from the service-centered perspective. The value co-creation in the networked business environment is also another interesting area for future research.

The previous research of CPSs has emphasized the technical perspective and more research is required from the service-centered perspective. A unified terminology for CPSs and clear definition for the term would improve the understanding in general. The findings of this research indicate that more research is needed that views CPSs as socio-technical systems. Understanding the link between human strengths and weaknesses with the corresponding strengths and weaknesses of the intelligent equipment are central issues in order to understand the reasoning behind the adoption of intelligent equipment and to further study the areas such as changing competence requirements and training.

For obtaining better understanding and a broader perspective to the networked value co-creation in the context of CPSs, the subject should be studied with more participants and from the global perspective. The human-machine interactions (HMIs) are also a central issue when further investigating the interactions between the cyber and physical world and between the different actors and intelligent components in physical world. The direct interactions according to Grönroos (2010) enable the value co-creation, and in the context of CPSs, where there exist various actors and components influencing the value co-creation, the role of interactions in the networked value co-creation process should be studied more. The cyber world should be able to continuously monitor and perform intelligent actions by adapting the applications and services to the physical world's needs, which requires seamless interactions between the cyber and physical world. From the service-centered perspective all the activities and processes of the manufacturer that are relevant to its customer's business should be coordinated with the customer's corresponding activities and processes, since the stream of actions enables the value co-creation (Grönroos & Helle, 2010). The role of self-learning, self-adaptation, self-evolution and self-reproduction capabilities of CPSs could be interesting to explore further from this perspective.

The role of interactions in the CIS framework in the context of CPSs should be studied more to understand how the CPSs can support and enable the seamless interactions. In the mining and construction industry a follow-up study could include further elaboration of the themes of the CIS framework to further explore the broad value co-creation area.

This leads to the one central question of how to design CPSs as socio-technical systems being capable of recognizing the different needs of different actors in the network in order to facilitate value co-creation? Currently the technical capability of CPSs is there, but for example, without a clear objective on why to collect data, who analyses it, and who is interested about it, the results are relatively weak. Also the ability to monitor the performance, process, users and environment exists, but without the link to the practical implementation and capability of real-time process planning, the benefit is non-existent.

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APPENDIX 1 – STIMULI THEME LIST

1. **Own role and intelligent equipment:** This means actions and tasks, which are related to your own role. For example this could mean how you could disclose your own expertise or share your knowledge concerning the intelligent equipment or about the services related to them for example via user profiles
2. **Sharing and receiving information related to intelligent equipment:** This means how the data should be interpreted, shared, received and managed in the network surrounding the intelligent equipment. This could mean in what format the data should be and who should have access to the data, or how it could be more effectively used to support collaboration between manufacturer and customer and also internally.
3. **Use and service experience related to intelligent equipment:** This means the environment, where intelligent equipment are operating and where the services are created or implemented. For example, this could mean how the operating environment should be observed and how the changes are affecting the performance of the intelligent equipment or the creation of the services. This could also mean how intelligent equipment should communicate with other pieces of equipment or actors or how the changes should be informed in the network.
4. **Use and service experience related to intelligent equipment:** This means all the experiences that emerge when using intelligent equipment or the service experiences. For example this could mean the usability of the intelligent equipment or how the adopting of the intelligent equipment should be supported. This could also mean for example how the maintenance need should discovered and organized in order to integrate the manufacturer to the processes of the customer.
5. **Able to influence the functioning of the intelligent equipment or participate in service creation:** This means the opportunity to participate and affect the performance of the intelligent equipment or the creation of the services. This could mean for example how the users could participate to the requirement elicitation or be involved in the creation of the services.
6. **Goals and objectives enabled by intelligent equipment:** This means all the goals, objectives and values that intelligent equipment could enable. This could mean, for example, how the customer can pursue certain objectives with intelligent equipment.
7. **Additional theme: What else is essential in the context of intelligent equipment?**