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CO-CREATION OF E-SERVICES ENABLED BY THE DIGITALIZATION OF PHYSICAL PRODUCTS

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ABSTRACT

With the advent of digitalization, e-services are now enabled by embedded digital technologies in physical products such as vehicles, elevators, construction equipment. In spite of numerous instances of e-services enabled by the digitalization of physical products, little research has been carried out to investigate the characteristics of co-creation of such e-services. This paper attempts to fill the gap by reporting from a three-year long research project with a vehicle manufacturing company. Using the translation phases from the Actor-Network theory (ANT) as a theoretical lens, this paper presents three propositions that characterize the co-creation of e-services enabled by the digitalization of physical products. The propositions highlight the role of physical products, establishment of trust and setting priorities about digitalization.

Keywords: e-services, co-creation, digitalization, physical products, ANT.

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1. INTRODUCTION

Different platforms for e-services are continuously being developed in this digital era. Researchers in the field of information systems have focused on mobile platforms, such as Android and iPhone platforms (Ghazawneh & Henfridsson, 2013; Tilson, Sörensen & Lyytinen, 2012) and platforms resulting from the digitalization of physical products such as vehicles, elevators, and construction equipment (Jonsson, Westergren, & Holmström, 2008; Yoo 2010). These digital platforms are opening up opportunities for platform owners for co-creating e-services together with the customers. We have observed from the case of Apple's iPhone that their customers have the opportunity to make or include their favorite apps to their iPhones to serve their purposes (Zwass, 2010). This endeavor by Apple can be referred to as co-creation of e-services with their consumers. "Co-creation refers to allowing the customer to co-construct the service experience to suit his/her context" (Prahalad & Ramaswamy, 2004, p. 8). Although co-creation has been studied in the context of new service or product development (see e.g., Alam, 2002; Prahalad & Ramaswamy, 2004; Karhu, Botero, Vihavainen, Tang, & Hämäläinen, 2011), very few studies have been done on the co-creation of e-services that are enabled by the digitalization of physical products. Due to the growing instances of e-services enabled by the digitalization of physical products, gaining a better understanding of co-creation of such services is important for designing innovative e-services in this digital age.

User or customer involvement has been discussed in case of software and organizational information systems development (see e.g., Hirschheim & Klein 1994; Keil & Carmel 1995; Kujala 2003). E-services that are enabled by the digitalization of physical products are not the same as conventional organizational IT systems because the e-services are pervasive in nature due to their entanglement with non-digital physical products (e.g., navigation services in a vehicle). On the other hand, organizational software is part of the digital infrastructure of an organization and generally used within the organization. E-services enabled by the digitalization of physical products are not similar to e-commerce services either. An e-commerce service can be accessed from a desktop, laptop, smartphone, tablet computer connected to the Internet. E-services enabled by the digitalization of physical products are tightly coupled to physical products, i.e., the services are dependent on the data generated during the usage of the products. For example, Nike+ shoe users can know about how many calories are burnt or how much distance they cover while jogging (Blohm & Leimeister 2013). The e-services are highly dependable on the data generation through the usage of the shoes with embedded sensors. In this paper, we argue that as the e-services are enabled by embedded technologies in physical products and data generated from the usage of the products, the co-creation of the e-services have specific characteristics. Therefore, we seek answer to the following research question: *what are the specific characteristics of co-creation of e-services that are enabled by the digitalization of physical products?*

To seek answer to the question, this research presents findings from a three-year long research project concerning co-creation of e-services associated with digitalized vehicles. The project was carried out in collaboration with a vehicle manufacturing company. The company focused on the co-creation of e-services in relation to digitalized vehicles and digital innovation of vehicle maintenance services. Instead of using the regular manual maintenance services which are time consuming and less effective, the technology developers of the vehicle manufacturing company came up with the idea of remote monitoring and diagnostics of vehicles with the help of embedded digital technology in the vehicles. Introduction of this technology opened the door for creating e-services related to better vehicle maintenance. The technology developers of the vehicle manufacturing company decided to involve potential customers of the e-services to understand their needs and facilitate the co-creation. These e-services will be associated with the vehicles and have B2B setting. Looking at the involvement of different stakeholders and lack of understanding of co-creation of these special kinds of e-services in the literature, we have decided to investigate into the co-creation of such e-services. We have used the concept of 'Translation' from 'Actor Network Theory (ANT)' (Callon, 1986) as our theoretical lens. The concept will be helpful to understand how different stakeholders (actors) form alignment and co-creation activities are carried out and what are the influences of the actors during co-creation.

The following section of the paper presents a review of literature on co-creation of services and products. Later, the theoretical lens for this research which is the translation processes of Actor-Network Theory (ANT) is described. Later, the methodology will be followed by the empirical findings on co-creation of e-services. The paper concludes with a discussion of findings that include propositions on the characteristics of e-service co-creation.

2. RELATED LITERATURE

2.1 Co-creation during new service and product development

Co-creation is referred to as the collaborative processes with customers for innovation and value creation. Co-creation is one of the foundational premises of the service-dominant logic (Lusch, Vargo, & O'Brien, 2007). Co-creation is not the same as the notion of customization (Prahalad & Ramaswamy, 2004). There is a difference in the degree of customer involvement when "co-creation" and "customization" are discussed. Generally, customers play less active roles in customization than in co-creation (Kristensson, Matthing, & Johansson, 2008). When we refer to customization, customers often get involved at the final phase of innovation processes and suggest incremental changes to a nearly complete product or service. Customers usually play reactive role of responding to questions being posed by the manufacturer. On the other hand, customers actively collaborate from the start of an innovation process and the collaboration may go on during the product or service lifecycle.

von Hippel (1986) describes 'lead users' concept to develop novel products. Lead users are users whose present needs will become general in market place in the future and who often attempt to fill the need they experience. Therefore, while identifying the lead users, one has to find out those users who actively innovate to solve their existing problems. 'Lead users' concept discusses about an expert group of customers who can innovate products. It does not include those customers who are not experts on a particular aspect but still can provide useful insights on the same aspect that will be helpful for co-creating innovative products or services.

In the B2C (Business to Consumer) context, consumer co-creation is vital in new product development (Adams-Bigelow 2004; Hoyer, Chandy, Dorotic, Krafft, & Singh, 2010; Stevens & Burley 2003). A conceptual framework is presented by Hoyer et al. (2010) for consumer co-creation that presents the degree of co-creation which includes both the scope and intensity of co-creation. In their study the degree of co-creation is highlighted using three types of antecedents: consumer-level motivators, company-level impediments, and company level stimulators. The framework has limitations as it mainly focuses on co-creating consumer products in business-to-consumer (B2C) context. The e-services enabled by digitalization of physical products cannot be considered only as consumer goods as there is high probability of business-to-business (B2B) transactions.

There are several reasons for involving users in service development in B2B context: a) developing differentiated and superior services, b) reducing cycle time, c) training the users, d) rapidly diffusing innovation, e) improving public relations, and f) setting long-term relationships (Alam 2002). These purposes or objectives of user involvement are discussed with respect to conventional services, with paying little attention towards e-services enabled from digitalized products. In case of e-services enabled from a digitalized physical product, for example, a vehicle, the objectives of user involvement or co-creation with the customers might be different.

Co-creation with customers is also investigated for mobile phone services where seven key strategies are presented (Kristensson et al., 2008). The strategies are: a) generating knowledge from user situation, b) deriving knowledge from various user roles, c) providing analytical tools to users before involving them in co-creation, d) motivating users by explaining a clear personal benefit, and e) not isolating users from the their everyday contexts while involving them in brainstorming exercises.

The previous studies presented co-creation basically from three perspectives: manufactured goods, conventional services, and or consumer digital product (mobile phone). This paper focuses on e-services enabled from product-service combination with digital technology embedded in physical products. Although businesses are transforming due to this class of services, there is a dearth of knowledge regarding them.

3. DIGITAL INNOVATION

Digital innovation refers to the new combinations of digital and physical components to produce novel offerings (Yoo, Henfridsson, & Lyytinen, 2010a). If digital technology is embedded with physical infrastructure such as rail systems, vehicles, roads, bridges and buildings, the relationship among individuals with others and the surrounding environment will be changed (McCullough 2004; Mitchell 2003; Yoo 2010). Such digital innovation brings three characteristics: re-programmability, homogenization of data and self-referential nature of digital technology (Yoo et al. 2010a; Yoo 2012).

The first characteristic of digital innovation is re-programmability. Based on the von Neumann Architecture, the digital technologies can be flexibly reprogrammable (Eaton, Elaluf-Calderwood, Sorensen, & Yoo 2015). A specific hardware can be used for multiple purposes such as, phone, internet browsing, gaming and thus providing the users freedom of choosing and adding their favorite services (Eaton et al. 2015; Yoo et al. 2010a). The re-programmability characteristic allows a digital device to perform a wide array of functions, e.g., calculating distances, word processing, video editing, and web browsing (Yoo et al. 2010a; Yoo 2012).

The second characteristic of digital innovation is homogenization of data. In case of analog technology, there is tight coupling between specific information types and the associated transmission technologies, storage formats and processing technologies (Tilson, Lyytinen, & Sörensen, 2010). That means a specific device is required for a specific kind of data processing. This will potentially be removed through the technical process of digitizing. A digital representation maps any analog signal into a set of binary numbers (Yoo et al. 2010a). This results in a homogenization of all data accessible by digital devices. All kinds of digital content such as, music, video can be stored, transmitted, processed, and displayed using the same digital devices and networks. Moreover, digital data from heterogeneous sources can easily be combined with other digital data to deliver diverse e-services, diffusing product and industry boundaries. In this way, the homogenization of data and the emergence of new media separate the content from the medium (Yoo et al. 2010a, Yoo, Lyytinen, Thummadi, & Weiss 2010b).

The third and final characteristic self-referential nature of digital technology means that digital innovation requires the use of digital technology (Eaton et al. 2015; Yoo et al. 2010a). This self-reflexive nature of digital innovation means that ubiquitous access to digital tools, such as inexpensive PC as a design platform and the internet as a distribution network, radically lowered the entry barrier for small companys and independent entrepreneurs to enter into the competition. Many other physical resources require extensive capital to acquire, but with the help of digital technology users could more readily participate in innovation activities. The radical reduction of price, improvement in the performance of computers and the emergence of the Internet have made the digital tools affordable to a broad spectrum of previously excluded economic and innovative activity. Therefore, digital technology has democratized innovation and almost anyone can now participate (Yoo et al. 2010b).

The discussion on digital innovation helps us to understand the uniqueness of digitally innovative e-services. Based on the discussion on re-programmability, we can say that there is always possibility for the users to create e-services according to their own needs. It can be expected that the co-creation activities during digital innovation will delineate some challenges and opportunities which will help us to develop new knowledge regarding digital innovation.

4. THEORETICAL LENS

The ‘Translation’ concept from the ‘Actor Network theory (ANT)’ (Callon 1986) is chosen as the theoretical lens for this research. The reasons behind choosing a concept from ANT are the following. ANT describes how actors: a) form alliances, b) involve different other actors and use non-human actors (artifacts) to strengthen such alliances and to secure their interests. ANT can be useful to overcome the poor understanding of IT artifacts (Hanseth, Aanestad, & Berg 2004). ANT is relevant for studying innovation and it is relevant to study the emergence and use of information and communication technology. We argue that there is a lack of understanding about e-services enabled by the digitalization of physical products. From this point of view, applying the translation concept from ANT seems very logical.

The process of translation in ANT is defined as the method by which a main actor enrolls other actors to form an actor-network (Lee & Oh 2006). Translation consists of phases such as problematization, interessement, enrolment, and mobilization. In the beginning of a problematization phase, a problem or an opportunity is presented by the main actor. Other actors in the actor-network are persuaded by the main actor to find solutions to the presented problem or opportunity and dedicate resources for the purpose. Although different actors may have different interests, it is important to find out a solution that can match common interest for all actors. At the end of the problematization phase, the obligatory passage point (OPP) is defined. An OPP can be an information system that every actor within the network has to pass through the situation to accomplish its objectives (Rodon et al., 2008).

Interessement is the phase when other actors get interested in the solution proposed by the main actor and start changing their affiliations to form a group in favor of the main actor (Rodon et al. 2008). Interessement phase aims at interrupting all potential competing associations and to construct a system of alliances (Mähring, Holmström, Keil, & Montealegre, 2004; Rodon et al. 2008; Callon, 1986). A successful interessement phase affirms the grounds of problematization (Rodon et al. 2008).

Enrolment phase includes multilateral negotiations, where actors try the strengths from the interessement phase to enable them achieving success (Rodon et al, 2008; Callon, 1986). This phase does neither imply nor eliminate pre-established roles (Callon 1986). The five strategies for the main actor at this phase are: (a) to maintain others' interests; (b) persuade others that their usual ways are discontinued; (c) to entice them through a detour; (d) to rearrange targets and interests (modifying targets and designing new targets; and (e) to become absolutely essential to other actors (Latour 1987; Rodon et al. 2008).

Mobilization phase deals with finding the proper representatives as the spokespersons for the whole actor-network (Callon, 1986). During this phase the actor-network is stabilized as the network becomes a single actor with irreversible and durable relationships (Callon 1986; Latour 1987; Rodon et al. 2008).

5. RESEARCH METHODOLOGY

We have followed case study methodology for this research. Case studies can be exploratory, descriptive or explanatory (Yin 2003). As this research aims to explore co-creation of e-services that are enabled by the digitalization of physical products, we have found that exploratory case study is suitable for our purpose.

5.1 Research context and case description

This paper presents findings from a research project called "RDS (Remote Diagnostics System)". The project was initiated by a global vehicle manufacturing company IntelligentBus (a pseudonym). During the project the company was focusing on the digitalization of vehicles and creating e-services for better vehicle maintenance. IntelligentBus sells vehicles (buses) to variety of customers all around the globe including public transport operators. The company also provides maintenance services to the vehicles once they are sold. Prior to the initiation of the RDS project, maintenance services for the vehicles of IntelligentBus were mostly done manually by following a preventive way of maintenance. In this particular way of maintenance, a customer used to sign a service contract with the company and the vehicles were brought to the maintenance facilities on a scheduled basis, for example, once in every three months. This implies that the customers were required to bring the vehicles for maintenance even if there is nothing wrong with the vehicles. This often resulted in additional labor cost, unnecessary replacement of parts and redundant maintenance activities that added to overall cost. In spite of the routine maintenance, the unexpected breakdowns could not be reduced significantly. To solve the problem, the technology development department of IntelligentBus decided to initiate the RDS project for developing e-services enabled by the 'Remote Monitoring and Diagnostics Technology'. The aim of the technology was to remotely monitor the vehicles to facilitate diagnosing and predicting faults in advance before any breakdown occurs. This would allow the customers not to bring the vehicles for maintenance service on a scheduled basis, rather bring the vehicles when maintenance is required. The technology aimed at significantly reducing the possibility of sudden breakdown of a vehicle while on the road. This could be done as the anomalies were predicted in advance using remote monitoring and diagnosis. This technology enabled service such as diagnosing faults in engines, as well as it facilitated the design of numerous e-services associated with vehicle maintenance. The company decided to involve customers to co-create e-services to solve customers' needs with the technology. Therefore, the company decided to carry out the project in two parts: technology development part and service development part. The technology and possibilities to create e-services pave the way to build intelligent vehicles.

The author of this paper was fully involved in the service development part of the RDS project for three years. The RDS case is suitable for this research because it has created the opportunity for exploring co-creation of e-services and digital innovation. For successful co-creation, in-depth knowledge was required about the current problems in vehicle operations and maintenance. The technology developers of IntelligentBus did not have thorough understanding about customers' experience with their vehicles. The developers did not have enough idea about the operations of the customers and how the vehicles were maintained. The exploration with customers also created opportunity to know about the customers' views about the 'Remote Monitoring and Diagnostics Technology' and their expectations from the technology.

5.2 Data Collection

Several activities have been performed to collect data while involving different stakeholders. The data collection activities included service design meetings, monthly project meetings, interviews, service design workshops, e-mail correspondences. Following sub-sections describe the activities.

The first step of this exploratory study was service design meetings that initially aimed at planning, finding, and creating a project aim. Later, the service design meetings aimed at designing services, preparing for meetings and interviews, analyzing interviews, and developing business models. Twenty six service design meetings were held. Each of the meetings lasted between 1-2 hours. Meeting notes and summary documents provided the participants' expectations.

Semi-structured interviews were conducted with the purpose to get rich information. The interviews were framed following the guidance of Myers and Newman (2007) and Schultze and Avital (2011). Nine Interviews were carried out with different stakeholders. The interviews were digitally recorded and later transcribed. We have also supplemented the interviews with number of activities listed below.

Besides service design meetings and interviews, monthly project meetings (every meeting was 3-hour long) were also arranged. In the monthly meetings, the project members discussed various issues in the project related to the technology development part and the service design part. Inter-disciplinary inputs about technological and business opportunities and challenges were gathered using notes and meeting minutes.

Four service design workshops have been conducted as half-day activities. The workshops consist of discussions and scenario buildings with the representatives from IntelliegentBus and public transport operating companies. The aim of the scenario building activity was to provide the participants an opportunity to express their expectations regarding e-services and co-create the e-services. During the discussions with the business area representatives of IntelligenetBus, they drew the business networks of the company to find out current status and potential business opportunities of remote diagnostics systems. Previous service design meetings, monthly meetings and available project documents formed the basis of the workshops. The project documents include meeting notes, internal company documents, and weekly project reports prepared by the project manager, meeting notes, and company documents. The multiple sources of data were useful for data validation (Yin, 2003). The data collection activities are shown in Table 1.

Table 1. Data collection activities

Data Source		**Description**
Project meetings	Service design meetings	26 meetings. A meeting normally had a duration of 2-3 hours
	Monthly meetings	8 meetings. A meeting normally had a duration of 2-3 hours
Interviews	9 interviews. Interviewees include business area representatives of IntelligentBus, representatives of a public transport operating company (PTOC), computer science researchers and engineers, and service developers of IntelligentBus	
Workshops	4 workshops with the representatives from the vehicle industry	
Documents	Project proposal	A project proposal written by a group of employees of IntelligentBus
	Technical reports	6 reports regarding the projects written by the engineers and computer science researchers of the project
	Short reports on project updates	53 reports sent by the project manager regarding the updates on the project.
	Final project report	A report written by all project members
	Market analysis report	A report prepared by service developers to compare existing vehicular diagnostics technologies
	Emails	113 -mail correspondences between project members

5.2 Data Analysis Process

The interviews and conversation during the workshops were transcribed. Meeting notes were taken during the monthly and service development meetings. To analyze the data we have followed qualitative content analysis approach (Elo & Kyngäs 2007; Hsieh & Shannon 2005). Following Elo and Kyngäs (2007), the process of conducting data analysis was: selecting the unit of analysis, making sense of the data and whole, developing Analysis Matrix, data gathering by content, grouping, categorization, abstraction and Model, conceptual system, conceptual map or categories.

To give an illustration of how the process will be used, we would like to describe the data analysis process. As described earlier, the concept 'translation' from "Actor Network Theory" has been applied as theoretical lens. Translation has four phases: problematization, interessement, enrolment and mobilization. The transcribed material was read carefully, highlighting all texts that appeared to describe above mentioned four translation phases. All highlighted texts were grouped and coded for each of the predetermined categories (problematization, interessement, enrolment and mobilization).

6. FINDINGS

Our empirical findings from the data analysis show four phases of translation. The following description from the RDS project of IntelligentBus will delineate how translation phases help us to understand the activities carried out by different actors in the vehicle industry while co-creating e- services enabled by the digitalization of vehicles.

6.1 Problematization

The problematization phase of translation process constitutes the identification of problems, solutions and key roles (Callon, 1986). IntelligentBus's technology developers realized that the preventive maintenance of the vehicle that was done on a scheduled basis often led to unnecessary changes of vehicle parts and engine oil. In spite of the changes, the maintenance does not bring significant reductions in the sudden breakdowns of the vehicles. As a technology developer stated:

Scheduled maintenance at present is the central activity of current preventive maintenance service. Every three months customers send us the vehicles that are covered by service contracts and our personnel check the vehicles, change parts and engine oil even if that are not required. Still unexpected breakdowns frequently occur as it is difficult for the maintenance staff to check everything manually in a vehicle within a short time.

Therefore, the technology development department of IntelligentBus started looking for solutions to the problem. They came up with the idea of remote monitoring and diagnostics technology and services for vehicles. For the sharing of technical knowledge and the implementation of remote monitoring and diagnostics technology, the technology development department first invited technical researchers (computer scientists) from the academia. The researchers started working directly in the technology development part of the RDS project. Later, two employees of IntelligentBus started working as service developers in the service design part of the project. They worked on customer requirement analysis, market research, business modeling, etc. Service developers invited informatics researchers (the author was one of them) to collaborate in the service design part. In this way, the service development group was formed and the people working in the group was called the service developers. The aim of this collaboration was to co-create e-services and share experience and knowledge on digital innovation. Different business area representatives were contacted by service developers to know more about existing customers and maintenance services of vehicles. Public transport authorities of neighboring cities were also contacted and they agreed to cooperate in the project. One particular public transport operating company allowed using their buses as prototypes for the project. They acted as the target customer for the e-services enabled by the remote monitoring and diagnostics technology. The service developers also interviewed maintenance service technicians, traffic managers, and drivers from the public transport operating company who agreed about sudden breakdowns. A traffic manager confirmed this by stating:

Sudden breakdown occurs during our operation. The worst thing is that there are not many spare buses we have right now. So any transport operating company would like to avoid breakdowns.

The technology developers started developing a system that will remotely monitor the vehicles with the help of embedded devices. The use of the devices, wireless transmission and a sophisticated algorithm are used for diagnosing and predicting faults in advance. As one technology developer clarified during a meeting:

Our ongoing technological development will result in a different system from what IntelligentBus has now. The embedded devices in a vehicle will facilitate remote monitoring and collect information about all parts of the vehicle. The devices will then wirelessly transmit precise information to the back-office of IntelligentBus. An algorithm will be applied on the information to diagnose and predict vehicular faults if there is any. This means that diagnosis and prediction will be done in real-time, i.e., when the vehicles are in operation. So, the vehicles will be called for maintenance before any breakdown occurs.

Another technology developer said,

Gaining knowledge on different types of problems that occur in the buses is important to take initiative for solving the problems through remote diagnostics. The knowledge will create opportunities for developing different services based on remote diagnostics technology. So, talking to the people who deal with bus maintenance and operation is important.

The employees of the public transport operating company were positive about the remote diagnostics technology and services. As one of them stated:

Our job will be really easy if a system can really predict the faults before it takes place.

The table below presents the actors that formed the actor-network.

Table 2. Identified human and non-human actors and their interests

Actors	**Actors' Definition and Interest**
Technology developers	Main actor. This department consisted of basically two groups of people: technology developers and computer scientists from the academia. Their interest was to develop the remote diagnostics technology.
Maintenance Service providers	They worked with maintenance of the vehicles. The group consisted of maintenance managers and other service technicians. Their task was to provide information to main actor about the faults that take place in vehicles and maintenance activities. This information might be useful is solving the problems regarding vehicle maintenance.
Public transport operating company	The company operated buses in a city. The participating members were traffic managers, mechanics, and drivers. They provided information to main actor from daily experience on public bus operation and maintenance to assist the technology developers in developing maintenance services that could reduce breakdowns and maintenance cost
Service developers	This group consisted of employees from IntelligentBus and the informatics researchers from the academia. Their interest was in sharing and gaining knowledge on customer requirements, designing digital services and business models.
Local transport authority	They provided knowledge about transport operation in the region for better operation.
Remote diagnostics Technology	This non-human actor was the technology that enabled remote monitoring and diagnosing of problems in the buses so that breakdowns can be avoided.
Buses	These were another non-human actors that carried passengers and should be well-maintained so that minimum breakdowns took place.

With the definition of problems, potential solution and identification of other actors in the network, the technology development department set itself as the obligatory passage point.

6.2 Interessement

Interessement phase focuses to make other actors interested in the solution proposed by the main actor (Rodon et al., 2008). The phase consists of actions by which the main actor attempts to impose and stabilize the identity of the other actors (Callon, 1986). The other actors adjust to the proposed identity as well as to the actor-network's future. They also play the roles assigned to them in the network (Mähring et al., 2004). The technology developers of IntelligentBus described the potential benefits of remote diagnostics technology to the other actors during the project meetings, interviews and workshops. They described the features of remote diagnostics technology to the actors in the network and claimed that the technology would predict and diagnose problems involving engines, brakes, and many other vehicular parts which would result in the reduction of breakdowns. Later, the technology developers and the service developers inquired into other actors' interests and expectations from the remote diagnostics technology.

The other actors communicated their opinions about the remote diagnostics technology. For example, a participant stated about his expectations from remote diagnostics in a workshop:

… I have heard about sensors used for identifying faults. The extent to which you are claiming to use onboard information is new to me. Anyway, the information received from the remote diagnostic system should be accurate so that nobody can misinterpret it. The information should report us facts pointing at possible breakdown of a component. We are looking for clear information that are either black or white, not grey and confusing. ….and the information must also guide us with the next necessary steps.

A maintenance manager was a bit skeptical about the technology,

The current technology that we now have for measuring the tire pressure is not reliable. That is why the tire pressure is measured manually. So, an issue with remote diagnostics will be reliability and hence services enabled by remote diagnostics need to reliable and trustworthy.

A few other participants in the project activities expressed their opinions during the interviews, workshops and meetings. A business area representative of IntelligentBus had a suggestion for the initial phase of implementation of the technology:

In the beginning, the technology should be implemented in a smaller scale. The technology can be used for identifying some fatal errors and observing the results in rectifying the errors.

The reason for introducing remote diagnostics technology and the possible use of the information retrieved from the technology became clearer from the following statement of a business representative in a meeting:

We can use the technology to develop uptime services for the city buses and coaches, and create market offerings to the customers. The information retrieved from remote *diagnostics will be used by the customer service representatives as a notification for the next service.*

Saving time for maintenance is a strong point for the remote diagnostics of vehicles. A technology that can save some time in maintenance activities will be considered a big asset. Remote diagnostics provides a great opportunity for saving time. As one business area manager stated:

Vehicle maintenance and repair are two extremely time-consuming things. Some parts in an automobile can take a large amount of time to repair once they break. We can save time if a system predicts that a part is deviating from its normal feature and it should be changed.

In this way, different actors got interested in remote diagnostics technology and services and started collaborating in the RDS project. The technology developers paid special attention to the views of the actors who showed skepticism regarding the technology. They agreed to develop the technology in a way to minimize the possibility of existing problems with the current technological systems in the upcoming remote diagnostics technology. Because of the verbal agreement, the skeptical participants showed interests in collaborating in the actor-network.

6.3 Enrolment

Enrolment phase focuses on how different actors negotiate their roles in the actor-network during its formation (Callon, 1986). IntelligentBus made an agreement with a public transport operating company to install digital devices in the transport company's buses. The installment enabled the experiments regarding the remote diagnostics of different vehicular parts could be done. This experiment in turn could help the transport company for continuous monitoring and possible reduction of breakdowns of their buses. Thus the public transport operating company was enrolled in the RDS project.

At the same time, technology developers kept communicating with the traffic managers and drivers of the public transport operating company to know about their day-to-day experience regarding bus operation. The service developers had conversations with a maintenance manager and a traffic manager of the public transport operating company to explain the opportunities of remote diagnostics technology. As one service developer explained:

Remote diagnostics system (RDS) can be compared to electricity which was initially used only for lighting bulbs. If we look at what happened later we could see the development of numerous electricity-driven home appliances. Probably new types of electrical devices are being developed at this very moment. We also now have electric cars. Similarly, RDS is simply not about monitoring the engine of a vehicle; different other services can be designed based on the RDS. Several services can be included with the existing services. It is difficult right now to identify all possible services. For example, I can see driver behavior can also be monitored with this technology to check how much steadily or roughly a driver drives a bus.

The service developers invited the traffic manager in a service design workshop to co-operate in developing e-services that will be helpful for them in future. Together with a few drivers and service technicians, the traffic manager assisted in visualizing the future services that could be developed around remote diagnostics. The plan was to draw various futuristic e-services related to maintenance together with him, a few drivers and service technicians.

The technology developers were continuously negotiating with the public transport operating company to get more information about the company's day-to-day operation. The developers involved the drivers of the company in the discussion regarding the bus operation. The drivers pointed at a problem with the buses that the developers initially did not anticipate at all. A major concern for the bus drivers is the doors. As a driver said:

Doors are supposed to be closed when the connected button is pressed from the driver's panel. Sometimes doors simply do not get closed following the process and then it can be a headache. We are not allowed to drive the bus without closing the doors because it is not safe. Something needs to be done with this problem.

The technology developers initially did not focus on the doors. They first wanted to make sure that the remote diagnostics technology works perfectly for engine, brakes etc. However, according to the drivers the doors should be emphasized. Later, service developers started more discussion with the drivers and traffic managers and they also pointed to the problem with the doors. During a monthly project meeting the service developers summarized the findings from the discussion with the bus drivers and traffic managers. Then the technology developers finally realized that they should take the door issue seriously otherwise it would be problematic to involve the public transport operating company in further activities.

6.4 Mobilization

Mobilization is the phase when the actor-network becomes stabilized (Callon, 1986). The network between technology development department and the public transport operating company, maintenance service provider, academics kept acting according to the agreement. The service developers from the technology development company and the academics invited the traffic managers and drivers from the public transport operating company to visualize and build some scenarios regarding the maintenance of vehicles that can be obtained through remote diagnostics technology. The main purpose of this activity was to build e-services around the scenarios. They started discussing among themselves regarding existing problems with vehicles and vehicle maintenance and scenarios where the problems could be solved with the technology. They started thinking about eliminating some major problems in vehicle maintenance so that the whole bus operation could become smooth. They identified three big problems with bus maintenance and built scenarios that showed the solution to those problems. As one of them explained:

There are quite a few problems in the bus operation. I am just anticipating a technology that can solve those problems. If that happens, my job will be really easy.

The other participants were also emphasizing on the fact that they would like to have e-services that will release pressure from their professional lives that they now face when they deal with the non-digital products and service.

Taking the inputs from the actors regarding the expected services, the technology developers continued to implement the services. Thus all the phases of translation were completed.

7. DISCUSSION

This section discusses the findings regarding translation processes. Following translation processes (Callon 1986), this paper aims to identify the specific characteristics of co-creation of e-services that are enabled by the digitalization of physical products. The characteristics will be discussed in the following sections.

7.1 Co-creation requires the enrolment of digitalized physical products in an actual use scenario

During the enrolment phase, the technology developers have persuaded the public transport operating company to utilize their buses to install the device so that they can check whether the technology works or not. In that way, the public transport operating company was successfully enrolled in the translation process. Callon (1986) states different ways of enrolling actors. Utilizing non-human actors as experimental objects adds to that discussion as it has proved to be an effective way of enrolling other human actor such as the public transport operating company because of the close inter-relationship between the human and non-human actors. The public transport operating company has always been interested for a technology that can solve the maintenance related problems that occur with their buses. They tried different things for smooth bus operation and were successful to some extent but there are still many problems. So, it was easy to create interest among them regarding the technological innovation. But the technology development department wants to make sure that the technology they are developing can be used in real-time scenario and they need to install the devices in some buses that are operated on the road on a regular basis. There is always a requirement to enroll public transport operating companies so that their buses can be utilized for the experimentation with the innovative technology.

Enrolment is an important phase as it enables the success of the interessement phase. Enrolling the non-human actors is always challenging as they cannot represent themselves (Callon, 1986). But the non-human actors are often important for the human actors for business purposes. In the case of digital innovation, enrolling human actors depends on enrolling the non-human actors that are currently being used by human actors in real-life. The human actors will not really disagree for this experimentation if the negotiation is done in a proper way and they can realize that it will be useful both for them and the non-human actors. If the products are not currently in use in real-life use scenario, i.e., co-creation of e-services in settings that are isolated (similar to a lab testing) will not give expected outcome. Thus we can present the following proposition:

Proposition 1: Successful co-creation of e-services enabled by the digitalization of physical products depends on enrolling the digitalized physical products in an actual use scenario.

7.2 Co-creation requires establishment of trust

Although the main actor was successful in creating interest among other actors regarding their proposed solution to the problem, there was doubt among other actors regarding the outcome of the technology. Callon (1986) states that interessement succeeds if problematization is valid, but in this case the problematization was valid but still there was a possibility of failure at the interessement phase because of lack of trust in technological outcome. During the interessement phase, we have found that actors can have skepticism and lack of trust on technology and technological innovation relating to physical products. The main actor (in the RDS case, the technology development department) has to make sure that the functionality of physical products (in the RDS case, vehicles) and the business related to them will be improved by digital innovation. Based on this observation, it can be argued that in the interessement phase the main actor should establish trust among other actors about the positive outcome of business through the digitalization of physical products. Therefore, we present the following specific proposition for the co-creation of e-services enabled by the digitalization of physical products:

Proposition 2: Successful co-creation of e-services enabled by the digitalization of physical products depends on establishing trust among the users regarding the improvement of the business through the digitalization of physical products.

7.3 Co-creation requires setting priorities about digitalization

From the findings we can see that during co-creation, a conflict arises regarding a particular issue at the interessement phase. The main actor has initially did not focus on a problem which was important for other actors. Later, when main actor realized that the problem is indeed needed to be prioritized due to emphasis from other actors, the main actor then put it in their priority list. Therefore, it can be argued that prioritization can be an issue in co-creation of e-services enabled by the digitalization of physical products. The main actor may have some pre-understanding about the problems and emphasized to solve those problems while digitalizing physical products. However, other actors show importance to other problems based on their operational experience involving physical products. The conflict of prioritization can be problematic in co-creation activities and digital innovation. Negligence by main actor regarding the views of other actors can result in the failure of the interessement phase. This leads us to the following proposition:

Proposition 3: Successful co-creation of e-services enabled by the digitalization of physical products depends on successful negotiation among actors on setting priorities about the digitalization of physical products.

8. CONCLUDING REMARKS

The research contributes to the existing knowledge on co-creation of e-services and digital innovation by using ANT's translation processes as analytical lens. Moreover, we showed in our discussion that if translation is applied in digital innovation context, at the interessement phase of translation, it is required to establish trust among actors regarding the outcome of digital innovation. It is also important to establish common priority among actors at the interessement phase in the case of digital innovation. The research contributes to the literature of digital innovation by delineating what are the influences of different actors when they come together to co-create the e-services that are results of digital innovation of existing non-digital product or service. Specifically, this research shows the importance of using non-human actors (physical products) as experimental objects to enroll human actors in the co-creation activities. The research makes practical contribution by showing how different stakeholders create a network for developing e-services enabled by the digitalization of physical products.

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