

# IOT SUPPORTING SERVICITIZATION BY TRANSFORMING DATA INTO INFORMATION AND KNOWLEDGE

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## ABSTRACT

Digitalization is producing masses of data, which creates a challenging data overload for managers and engineers. There is also a gap between digital technologies and their influence on collaboration and co-delivery. The digitalisation offers solutions to handle data, but there is a lack of methods to transform it into usable information. The focus is prevalent with the technology, and this leads to difficulties in creating value from the data as the necessary action is unclear. There are three aspects to consider with innovation: new technology, a user, and a market. Technology by itself will not work when there is no user context. In an advanced services context, users are working with particular information. It requires a translation of the data into information leading to knowledge generated by a user experience, and there is much more on co-development. There are data analysts but no data knowledge managers or solution scientists. The aim is to develop a reference model to enable people turning data into usable information and create value in an industrial Product-Service System (PSS). It needs an understanding of perceptions that are hard to quantify, yet these intangibles most often lead to value creation. Methods from Service Design, which derive from social science can provide us with knowledge about the intangibles of perception. The industrial outcome is to develop a framework to turn data into usable information: – for the right person – at the right time – in the right form – to take the right action!

**Purpose:** The purpose of this research paper is to identify the early stage problems that exist when considering the design of complex industrial Product-Service Systems by manufacturing firms in the I4.0/IoT enabled world.

**Design/Methodology/Approach:** The combination of industrial Product Service Systems (PSS) with Data-Information-Knowledge-Wisdom (DIKW) hierarchy building with product avatars and persona avatars (individual and collective) as well as with the unified service theory (UST) might create another approach towards value detection, creation, and marketing plus build a new methodology by itself. To integrate these methods, we have reviewed the literature on PSS as well as on personas models applications to product-service systems design. We have discussed in small and large groups, with scholars, students, and managers, about the potential values from these research.

**Findings:** We suggest to develop computer-aided environments that, using product and personas avatars, can help to find and create value in industrial PSS building. We firmly believe that cognitive computing technologies, virtual reality and AI will also help the designers in the evaluations of relevant non-monetary value dimensions.

**Originality/Value:** The research aims at exploring the new world of I4.0/IoT. Together with the focus on human-centred aspects and information hierarchy building, the framework becomes highly original. We also suggest as our original contributions, that the integration of persona models (or persona avatar) in the virtual representation of the industrial PSS will create potential for further research.

**KEYWORDS:** IoT, Avatars, Industrial Product Service Systems, Data-to-Knowledge

## 1. INTRODUCTION

Today, manufacturing firms that produce industrial goods and deliver lifelong support services in the form of industrial Product Service Systems (PSS) can leverage cloud platforms, data connectivity, sensing technologies and cognitive computing to improve operational efficiencies as well as to increase the

value delivered to their customers. The rivalry around the provision of advanced (i.e. technology-enabled) services (Baines et al. 2011) is affecting manifold industries (Porter & Heppelmann 2014), and this capability in a manufacturing firm is probably the most visible outcome of a deliberated servitization strategy (Allmendinger & Lombreglia 2005, Ulaga & Reinartz 2011,). Remote monitoring systems installed on the customer base offer the possibility of collecting huge amount of data that bring great value to the manufacturer activities, logistic and customer support (Auramo & Ala-Risku 2005). To deliver advanced services a firm can either develop its own technology – example is Canon Ink, whose proprietary platform eMaintenance® is used by worldwide subsidiaries and dealers to connect large fleets of printers – or use some commercially available platforms. These latter are provided by software vendors and by other manufacturers, such as Bluemix by IBM, Hana by SAP, OSisoft, and Predix by GE.

The product-service offering that manufacturers put in place with the mentioned technologies is largely refined and can include, for instance, health management and lifelong support services, remote control, help desk and technical assistance, predictive maintenance based on diagnostic and prognostic models, reliability assessment, reporting about consumptions and usage conditions, spare parts and consumable management, fix & repair interventions, updates, upgrades, and End of Life (EoL) services.

Collecting product- and customer-related data, such as faults, anomalies, operating conditions, users' behaviours, product/process performance, can also be crucial in product design. In fact, data-driven design decisions are hardly biased by subjective assumptions and personal preferences.

This calls for research that aims at exploring this new world. Scholars from marketing, industrial design, operations and service management should investigate these topics to propose new methods for participatory design that address how data-driven decisions should be taken to improve IPSS. To this concern, we preliminary identify the following questions that can guide research in this field: a) how can data collected from installed base generate valuable knowledge for the design process? b) how can design teams that cooperate in the design of products, of basic and of advanced services, collaborate and share information, deliver insights, identify and understand their interdependencies and how their design decisions can affect the (subsequent) value creation process? c) how should data and information coming from specific product instances be accessed and visualised by designers?

In this paper, we preliminary discuss some ideas and suggest some theories – among the manifold ones – on which preliminary research around this field should be grounded.

## **2. OUR APPROACH TO THE PROBLEM**

### **2.1 FROM DATA TO KNOWLEDGE GENERATION FOR TAKING THE RIGHT ACTIONS**

To define how field data can be transformed into knowledge that is valuable for decision-making, we propose to use the Data-Information-Knowledge-Wisdom (DIKW) hierarchy (Rowley 2007). DIKW is a well-known model that describes how data are subsequently shaped into – respectively – information, knowledge and wisdom through a layered/hierarchical process. This model has been largely used in information systems research to discriminate the features offered by enterprise information systems, which provide a large set of functionalities, ranging from basic data management (e.g. tracing sales transactions), information reporting (e.g. measuring how the task has been executed) to more sophisticated functions, such as simulation, what-if analysis and decision support systems to be used for planning and control tasks. We summarise the discourse around the manifold issue that could be investigated in the following form. Manufacturing firms could leverage industrial internet platforms to deliver advanced services.

To this aim, they should: 1) handle the right data; 2) elaborate and integrate these data to create information; 3) deliver the right information to the right person/team at the right time and in the right form – considering accessibility, usability and quality of the information contents; 4) each person/team should be adequately skilled/equipped to produce from the accessible information new insights (i.e. knowledge); finally, 5) each person/team should be adequately skilled/equipped to evaluate how the

actions that – in the course of their responsibility – they could undertake and/or are requested will affect the value potentials in the ecosystem (i.e. the PSS they contribute to deliver). According to this line of reasoning, people achieve a higher wisdom as far as they get aware of how much their actions influence “the world”. Getting aware of this relevance is of paramount importance, as the “right” actions preserve the Pareto optimal condition for each stakeholders involved in the value ecosystem. In other term, actions are – to any given extent – right if they do fulfil the stakeholders’ value expectations at their best levels.

## **2.2 VALUE CREATION AND STAKEHOLDERS’ EXPECTATIONS**

To discuss the dynamics of value creation, we suggest to adopt theoretical models that focus on services and “value in use”, rather than on physical products. We consequently ground our research in the paradigms and constructs of service science (Maglio & Spohrer 2008) and of service dominant logic (Vargo & Lusch 2004, 2008). We firmly believe the mentioned theoretical frameworks are the most adequate to obtain the needed ecosystem perspective of value creation (or co-creation). As said, this brings more focus on services as interactive – value creating processes, rather than on products sales, ownerships or availability. Therefore, to visualize the value created, we employ methods that are typical of service design and engineering, such as service blueprints, customer journey maps, and empathy maps. An initial screening activity is necessary to: 1) identify and put in a stakeholders map all actors (i.e. individuals, teams, whole organisations) that participate to the value ecosystem; 2) analyse, understand and describe clearly what they do (i.e. what is the job to be done) and what they expect from their engagement to the PSS (i.e. what outcomes are important to them).

According to the premises of the service science, the service system map must include tangible and intangible resources such as products, spare parts, consumables, tools, facilities, data/information, skills, explicit and implicit knowledge to be shared, monetary flows. Then, we carry out an analysis of context-specific situations in which value is created. In the authors’ experience, situational analysis is often overlooked in the design of industrial PSS. Most OEMs consider the equipment first, whereas users and their situations (i.e. the context and circumstances in which they are asked/they want to create value) are rather neglected for design decisions. Conversely, we believe that designers should have the possibility of considering what is valuable by each key actor, and how each actor engages in value creating interaction inside the service system (i.e. the PSS), to access to the counterpart’s resources and to integrate these resources with the one that s/he already owns.

Following the line of reasoning, we consider value creation (co-creation) as a resource-integrating process. Therefore, designers must represent the combination of tangible and intangible resources that are provided by each entity participating to (mutual) value creation. Each entity owns some idiosyncratic resources. If the entity engages to the value creation process, it share/give access to the owned resources, thus sustaining the related costs (i.e. monetary payments, consumptions, time, efforts, inconveniences, disturbances, etc.), in order to achieve the expected benefits (i.e. the promised value realisation). As far as benefits overbalance costs, positive value is realised and the user is satisfied if this value is in line with her/his expectation. Again, designers should have a precise view on how two or more entities share and integrate their resources in order to create mutual value, in direct or technology-mediated interactions, that happen synchronously or asynchronously. We propose to use customer journey maps to deal with the understanding of these interactions and to visualize value creation opportunities.

Actually, these tools are rather easy and facilitate also the identification of new entities that can act as partners of the ecosystem (i.e. in the PSS provision), which could be outside of the original system configuration but have joined to it further.

### **3. DIGITAL VISUALIZATION OF PSS-ENABLED VALUE CREATION PROCESS**

#### **3.1 PRODUCT AVATAR**

To visualize how entities interact, access and share the product-related resources we also suggest to introduce the concept of product avatars and of personas models. In particular, we suggest that at least each tangible and intangible resources that the manufacturer provides as a constituent of the PSS, should have a digital representation, i.e. an “avatar”, to which the design effort must be directed. In analogy to the human ones, the concept of product avatars is becoming established in industrial engineering research, as a possible way to handle and visualise information about product status and attributes (e.g. performances, location, operating conditions, etc.) (Wuest et al. 2015). To this concern, the product avatar is primarily viewed as an advanced extension of PDM/PLM paradigms (Cassina et al. 2009). Elaborating this concept, we propose that as far as the PSS is designed in a collaborative form, a virtual environment should be created in which – as said – each tangible and intangible resource that has a specific role in value creation, should be modelled with a unique identity, that clearly indicates which ways the resource will be accessed to, shared with, used for, combined and thus transformed into new – more elaborated – resources.

Personas then support the problem definition of each actor by helping to clarify their pains and gains, this combined with the job-to-be-done provides a detailed understanding of their problems. From the problem definition different solutions and be created and the ‘best’ then turned into customer value propositions that can be then tested with the customer.

We suggest also – as our original contributions – to integrate personas models (or personas avatar) in the virtual representation of the PSS to which the product avatars concepts apply. This concept is further developed in the next subsection.

#### **3.2 PERSONA MODELS**

Previous research agree on the benefits that persona-based models (hereafter, persona models or simply personas) can bring to the design process (Miaskiewicz & Kozar, 2011). Although the risk of incurring in stereotypes is unneglectable (Turner and Turner 2011), there is consensus of the fact that, if correctly used, Personas facilitate needs-finding (Pruitt & Adlin 2006) It is also said that using Personas the designer can avoid self-centeredness (Cooper et al. 2014), embrace social and political implications of her/his decisions, improve product usability (Long 2009). Last, in design team the use of Personas sets the basis for collaboration and participatory design (Grudin and Pruitt 2002). Originally applied to information systems design (Grudin & Pruitt 2002, Ma & LeRouge 2007), personas has been used in a variety of fields such as marketing (Teixeira et al. 2012), new product development (Pruitt & Adlin 2010), service innovation (Hara et al. 2009), PSS (Pirola et al. 2014). Floyd et al. (2008) suggest that each persona model differ to a certain extent as its constituents vary. For instance, information sources and collection methods, the quantity of details provided, the purposes for which the model was constructed can differ. In some cases, there is the need of guiding and informing design decisions so to consider any available field data. Interviews and observations allow to obtain intuitive understanding of target customers/users characteristics. Usually, these traits are condensed to produce a model for each kind of customer/user. Although grounded on real empirical data, the resulting models unfrequently correspond to real people.

Personas can be proficiently applied in contexts well beyond product design (Grudin & Pruitt, 2002). For instance, adding information such as the size of the population that each character may represent and the attitudes towards digital media, personas can support marketing decisions (Pruitt & Adlin, 2010). Nielsen and Madsen (2006) applied persona models to projects focused on introducing information systems in large organisations. They demonstrate that empowering persona models with personal information (e.g. psychological traits, social background, emotions) that are then disclosed through storytelling, the engagement of the design team raises. In this sense, personas should not be

simply viewed as the summative description of the characteristics of a fictional user. Indeed, they can evoke empathy and raise a defense against detached reasoning.

As far as collaborative tools and knowledge management systems have become the backbone of innovation in the modern product design landscapes, there is the need of considering collective behaviours and team dynamics. Therefore, some research (Matthews et al. 2011) in technology design explore the possibility of using persona models that rather than individuals, focus on groups (i.e. collaboration personas). In these studies, personas are viewed as “empirically derived descriptions of hypothetical groups, including details that inform the design of collaboration tools.” (pp.). Collaboration personas distinguish from traditional personas as they:

- (a) have multiple interconnected roles, each one played by some individual;
- (b) focus on the team goal, but at the same time consider the influence of individual goals;
- (c) characterize the dynamics of collaboration inside and outside the team. This latter aspect refers to the fact a complex project team can change frequently during the project lifecycle.

In addition, professionals participate to more projects and teams simultaneously. Overburdened workers can hardly retain motivation, raise engagement and create a positive attitude toward collaboration in each team (Matthews et al. 2012). Further study shows that using collaboration personas the discourse on the project goals is more complete (Judge 2012). The positive effects of these models on collective creativity is confirmed by Bornet and Brangier (2015) and Liao et al. (2011). These authors demonstrate that personas help in discriminating cultural profiles of social collaboration in business contexts. Buisine et al. (2016) find similar results, and show that personas support appropriately user-centered innovation strategies. These authors go a step further and develop dynamic personas in the form of “avatars”, that can thus interact in real time with the designers. This opens room for the real embodiment of the fictional user characters, the so-called Proteous effect. Following this line of research, Cajander et al. (2015) propose a modified version of personas, namely contextual personas, that address people needs and their interactions with digital technologies in modern working environments. In sum, Persona-based models can improve our ability to form an exhaustive vision of people and needs surrounding us, irrespective we can only deal with fragmented data and partial knowledge. This can lead to a greater sense of involvement and a better understanding of reality.

#### **4. VALUE CREATION AS RESOURCE-INTEGRATING (SERVICE) PROCESS, ENABLED BY THE PSS RESOURCES**

In this section we summarize how the mentioned models should be applied to help the design of IPSS. The theoretical frameworks that we integrate provide a way for representing, in a virtual environment, some selected instances – that may be relevant for showing relevant data and information, that can be made available from the mentioned industrial internet cloud platforms. These data can be related either to the product (e.g. status, performance, conditions, use modes, etc.) and to the (basic or advanced) services that – through the product itself – have been provided to the actors of the service system. These latter can be modelled as individual and collective personas, their characteristics and willingness coming from continuously updated stakeholders’ and empathy maps. In addition, this virtual environment allows designers to create new product avatars, to represent products that do not exist yet, as they are under development. This helps designers to view how each released product feature contribute to a new level of value potentials that is brought to the ecosystem. In this process, designers from different departments (i.e. engineering, marketing, sales, product support, etc.) can create new personas models, or use the existing ones, to understand value creation mechanisms. As said, value creation is viewed as a resource integrating process. In line with the service dominant logic, we thus postulate that value can be created only as value in use, and that physical products/goods are only mechanisms that convey the resources needed to the value creation process. In other terms, value is created through “service processes” (namely, through services). As a result, we suggest that avatars

should be employed to create a digital representation of input and output resources to and from the service processes, and that services should be viewed more as interactions / interactive processes, among product avatars (as well as avatars of other resources) and personas avatars (individual and collective), rather than outcomes. Value originates as the outcomes that these interactions may produce, and the designers can appreciate the value creation in term of modifications to the avatars' states. Viewing services as value creation processes is also in line with the premises of the unified service theory (UST) by Sampson (Sampson & Froehle 2006). In this case, the service provider transforms the inputs received from its customers into outputs for which the customers themselves show a higher willingness to pay for. Being compliant with the UST opens room for introducing in the proposed model interesting conjectures about operations management of the PSS. These conjectures can be very useful to the designer of the PSS, in order to understand the implications of diverse service options (e.g. self- and super-services).

## 5. CONCLUDING REMARKS

This research argues with a method to help the collaborative design of integrated product-service systems (PSSs) by manufacturing companies, in the age of industrial internet platforms and smart connected products. We suggest to develop computer-aided environments that, using product avatars, individual and collective personas, can help designers to figure out the contexts and situations in which the products will be used, and in which the product users will create (or co-create) value by means of interactive processes. Interactions are the way people use to communicate their willingness to access and share resources. As far as cognitive computing technologies, virtual reality and AI become more and more sophisticated, we firmly believe that these tools will also help the designers in the evaluations of relevant non-monetary value dimensions. Finally, a contribution to this avenue could come from the growing body of research dealing with empathic avatars in computer-based simulation environments, and from more effective implementation of human traits in software agents and chatbots. The impact of academic research and especially action research will support industry with selective problems at the moment. Moreover it will create a wide space to be explored in cooperative projects between academia and industry for the future.

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