The role of Internet of Things (IoT) technologies for individualisation and service quality of a PSS

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Abstract: Nowadays, product manufacturers are compelled to increasingly becoming Product Service System (PSS) providers for surviving and managing the increased global competition. 20% of the enterprises have already integrated services in their product offerings. Meanwhile, the Internet of Things (IoT) is expected to grow significantly in the next years. Smart products are growing fast and are expected to reach 212 billion entities at the end of 2020. From an economic point of view, it is estimated that the impact of IoT is in a range of \$2.7 to \$6.2 trillion by 2025. IoT is surely an enabler of PSSs, allowing the collection and sharing of vast quantities of information along the whole solution life. This article aims to evaluate the impact that IoT technologies can have on the PSS provision when aiming at the satisfaction of highly diverting customer needs. Particularly, the analysis considers three dimensions: the typology of services enabled, the customization approach enabled, and the service quality gaps disclosed by IoT. By means of multiple use cases, the authors found out that IoT technologies have a huge impact on the different phases of the whole PSS lifecycle. Several advantages were detected for the different stakeholders involved in terms of both service efficiency and effectiveness. Based on these results, the strategic contact points to cope with possible trade-offs between the PSS individualization approach and its service quality are proposed.

Keywords: Product Service System (PSS), Internet of Things (IoT), Smart Connected Product, Mass Customization, Individualised Services, Service Quality

1. Introduction

Nowadays, manufacturers are increasingly becoming Product Service System (PSS) providers for surviving despite the increased global competition. 20% of the enterprises have already integrated some services (Santamarìa et al., 2012). Meanwhile, Internet of Things (IoT) is expected to grow dramatically in the next years, related to industries and services. Smart products are growing fast and are expected to reach 212 billion entities at the end of 2020 (Manyika et al., 2013). From an economic point of view, it is estimated that IoT impact is in a range of \$2.7 to \$6.2 trillion by 2025 (Al-Fuqaha et al., 2015). IoT is surely an enabler of PSSs, allowing the collection and sharing of vast quantities of information about products and PSS (Gantz & Reinsel, 2012).
The purpose of this paper is to provide a first study for understanding and evaluating how IoT technologies can affect services implementation in a PSS. In detail, the focus of this paper is limited to one of the categories of PSS provided by (Gaiardelli et al., 2014), the home delivery service. The assessment is conducted studying different use cases, in order to investigate how IoT technologies can be applied within the delivery service related to a PSS, making it more efficient and/or effective and personalised.
The paper is organized in the following way: the first four sections introduce the context and the theoretical pillars of the research, i.e. PSS, Mass Customization and IoT. Section 5 describes the use cases analysed, while Section 6 compares the use cases with one another through the framework proposed. Finally, sections 7 and 8 conclude the paper.

2. Product Service System

Academics proposed a number of definitions in the literature, each focused on a specific aspect of PSS (e.g. Roy, 2000; Tukker, 2004; Thoben et al., 2009; Meier et al., 2011). Among all these classifications, authors will rely on Tukker's one, as wide acceptance and simplicity (Baines et al., 2007). According with it, three main categories of PSS are identified (Product-Oriented, Use-Oriented and Result-Oriented) and declined in a total of 8 archetypal models (Tukker, 2004). Gaiardelli et al. (2014) declined all the different service types that could be related to each of the three PSS typologies, also supporting his analysis with practical examples.
A second important aspect for PSS is its lifecycle phases (Fig.1), from its ideation to its decommission.

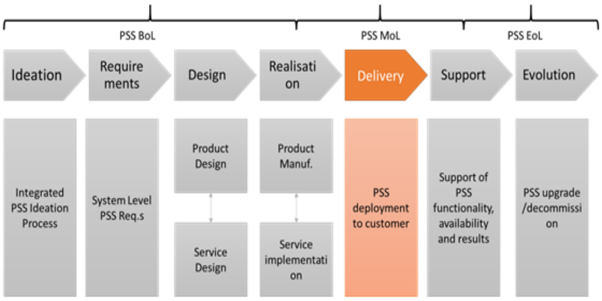


Figure 1 PSS Lifecyle phases (adapted by Wiesner et al., 2014)

PSS lifecycle comprises seven several phases from the ideation to the delivery, while ending with its decommission (Wiesner et al., 2014).
Particularly important is the deep synchronisation and interoperability of the design and realisation phase. Indeed, these two phases widely impact on PSS final performances during the delivery phase. A product design not taking into consideration services to be provided, may lead to a good with inconsistencies hindering the effectiveness and the efficiency of the overall system.

3. Mass Customization

Today, a growing number of customers request individual products tailored to their specific needs (Piller & Kumar, 2006). Companies increasingly acknowledge the great heterogeneity of customer demands and try to turn them into a business opportunity (Salvador et al., 2009). However, providing the customer with a product tailored to their individual needs and producing at low manufacturing costs are usually considered to be two incompatible strategies. The concept that links the low costs of mass production with the flexibility of individual customization is called mass customisation (Pine, 1993). The term is defined by Joseph Pine as "developing, producing, marketing and delivering affordable goods and services with enough variety and customization that nearly everyone finds exactly what they want." (Pine, 1993, p.48). A company willing to offer individualized goods according to the concept of mass customisation, needs to reflect upon several questions of how to make mass customisation work. Salvador et al. (2009) propose a set of three capabilities that are required to be a successful mass customiser. First, companies have to identify the needs of their potential customers, find out where needs diverge most and develop a customisable product offering. This task is termed solution space development (Salvador et al., 2009). Second, a robust and flexible process design has to guarantee that the product or service can be produced at reasonable costs. The process must be flexible enough to produce customised goods with low effort and inventory while aiming to realise economies of scale (Feitzinger & Lee, 1997, Duray et al., 2000; Salvador et al., 2009). Third, the offer has to be communicated to potential customers. Customers need to be aided to fulfil their co-creation task specifying their needs and by choosing between different options according to their specific requirements respectively. This task is termed customer choice navigation (Salvador et al., 2009).

Gilmore and Pine (1997) proposed a scheme of four different types that may be used to distinguish between different mass customisation approaches. These four approaches are: (1) "Collaborative Customisation" (Designers dialogue with customers on product and packaging), (2) "Adaptive Customisation" (A standard product can be altered to individual needs by the customer), (3) "Cosmetic Customisation" (Standard products are presented specifically to each customer), (4) "Transparent Customisation" (Customers can alter standard products during use).

4. Internet of Things

Nowadays, manufacturers need to move towards services in order to secure growth and remain competitive (Jacob & Ulaga, 2008). The provision of additional services related to an integrated product-service offering is often enabled by the adoption of digital technologies (Porter & Heppelmann, 2014). For example Ponsignon et al. (2015) highlight the importance of installed bases, as already done by Oliva & Kallenberg (2003), as the most valuable asset for manufacturers through which leverage ICTs to collect, analyse and interpret field data: in this way, better PSS can be obtained using the feedback loop from the side of both customers and providers. Smart, connected products are the result of the servitization phenomenon supported by the third revolution era of ICT technologies (Porter & Heppelmann, 2014): physical components are thus empowered with smart parts, also through a software integration, with the final aim of increasing their capabilities and value. However, smart parts (as sensors, microprocessors, data storage, controls, etc.) are still not enough. Intelligent systems are matched and linked to the rest of the world through connectivity components amplifying their capabilities and value. Ports, antennae and protocols enable product connections with the physical web (composed by web technologies plus IoT) (Want, Schilit, & Jenson, 2015): devices equipped with IoT are directly accessed, monitored, or controlled by web technologies. As a result, people, places, and things have webpages to provide information and mechanisms for user interaction (Want et al., 2015). This requires a "technology stack", a new technology infrastructure tailored for the company, consisting of a series of layers. As a result, four new sets of product functions and capabilities are enabled: monitoring, control, optimization, and autonomy. Each capability can activate the following one and thus gradually drive the surge of IoT adoption in manufacturing companies. In literature this kind of technology has been explored to a certain degree. A proper definition of IoT is given by (Gubbi, Buyya, Marusic, & Palaniswami, 2013) who focused on its ubiquitous aspect. Also concepts like 'things' (Vermesan et al., 2009) and 'smart environment' (Bélissent, 2010) have been detected as strategic for this kind of context. Moreover, (Al-Fuqaha, Guizani, Mohammadi, Aledhari, & Ayyash, 2015; Gigli, 2011; Gubbi et al., 2013) assessed the main properties and detected the open issues to be solved for its adoption (availability, reliability, mobility, performance, scalability, interoperability, security, management and trust (Al-Fuqaha et al., 2015)).

Nowadays, the number of applications enabled by the use of IoT is huge and a surge in its adoption is forecasted in the next years, with the final aim of achieving its full potential, i.e. ubiquitous services. Indeed, every application can be linked to a particular IoT service and can be grouped in four main types (Gigli, 2011): “Identity-related services”, “Information Aggregation services”, “Collaborative-Aware services” and “Ubiquitous services”.

Finally, since consumer choice has increased steadily during the last decades (Piller & Kumar, 2006), it is useful to evaluate the IoT impact on PSS provision for the satisfaction of highly diverting customer needs. Profitable mass customisation of products and services requires success in two broad areas (Gandhi, Magar, & Roberts, 2014): identifying opportunities for customisation that create value for the customer (supported by smooth, swift, and inexpensive transactions for both consumers and producers) and achieving a manageable cost structure and cost level for the producer even as manufacturing complexity increases.

5. Use Cases

The work applies multiple use cases approach to define the impact of IoT in home delivery service customisation. Particularly, three use cases have been studied on the basis of publicly available data, i.e. data obtained from web search: Click’n’Pizza, DPD Panel Navigator and ParcelHome Packbox. First, it has been explored which kind of services IoT provides in each use case (Gigli, 2011). Then, each use case has been mapped in a bi-dimensional framework. The first axis represents the Mass Customisation, i.e. the Mass Customisation approach presented in section 3 (Gilmore and Pine, 1997). The second axis stands for the Service Quality, which is represented here by the four Service Gaps (Bitner et al., 2010). Particularly, for each use case, gap(s) partially or totally fulfilled by the IoT technologies, have been identified. These gaps can be of 4 types and are aimed to reduce the difference from the customer side between the expected and perceived service, acting on the company point of view. Gap 1, the Listening Gap, is the difference between customer expectations of service and company understanding of those expectations. Gap 2, the Design and Standard Gaps, focuses on converting expectations into actual service designs and creating standards to measure service operations against customer expectations. Gap 3, the Service Performance Gap, is the divergence between customer-driven service design and standards and the service actually delivered: this happens when the provider is unable to deliver the service in the way it was previously designed. Gap 4, the Communication Gap, focuses on the divergence between service delivery and what is communicated externally to customers through tangible communications (e.g. advertising, pricing).

5.1 Click’n’Pizza

Click’n’Pizza is a device provided by Lacomanda.it. The concept is, as reported by the website, “Creating great value by closing small gaps!”. The idea was to develop a device, with the philosophy to “Put a tool in your customers' hands, and you'll always have the opportunity to build a daily, ongoing relationship with them." Click’n’Pizza is a food home delivery device, which offers an easy and fast ordering experience and creates a unique channel to communicate directly between providers and customers. This device offers three different features. The first one is the “One Click”, where one needs to keep the device button pressed for five seconds to order the desired meal, food, beverage, or shopping list. The second feature is the “Turn’n’Click”, where one has to turn and click for customising the order. Finally, the last feature is the “Promo’n’Click”, where one receives special offers and promos directly on the display’s device. Furthermore, Click’n’Pizza enables to track the status of the order. The device is equipped with a full featured Wi-Fi module, and it can be connected directly to the home hotspots.

5.2 Parcel Home Delivery

Several IoT technologies have been widely applied in the parcel home delivery for improving the efficiency as well as the customisation of the home delivery. In the majority of cases, smart technologies enable the tracking of customer orders (e.g. Amazon Prime, Just Eat, Foodora,etc.). In this study, two use cases, where IoT supports several functionalities, have been selected: DPD Parcel Navigator and ParcelHome Packbox.

In DPD Parcel Navigator, through the usage of an app, a customer can obtain highly personalised delivery modalities in different ways:

- by setting and eventually changing the date and the hour for the delivery.
- by selecting where exactly the parcel is left by the courier, e.g. garage or garden shed.
- by choosing the exact delivery address, e.g. friends or office. A customer can name a person to whom the parcel is delivered upon presentation of ID.
- by indicating a neighbour to whom the parcel can be delivered, if the customer is not there the parcel will be delivered to a different neighbour.
- by selecting a pickup parcel shop, where the parcel is stored for seven days. After this deadline, it is sent back to the shipper.

The second use case, ParcelHome Packbox, is a “smart box” that can be rented for a monthly fee. The carrier stores the parcel by means of an access code, Bluetooth or NFC. The customer receives an alert in an app on his smartphone and can open the box with this app. The box can also provide a detailed history of customer deliveries by means of its integrated weighing sensors. Finally, it can be used also for returning the parcel to a carrier.

6. Use Case Comparison

First, the three use cases present the same type of service offered by IoT technologies. They all refer to the more basilar one, the “Identity Related” (Tab.1). Indeed, in all of them IoT technologies help in collecting information while keeping the customer order tracked. Click’n’Pizza enables the customer, through the device use, to create his order, get the same another time in a very simple way and reduced time or also to receive promos by the vendor. Thanks to this last functionality (Promo’n’click) the device can also provide Information aggregation IoT services. In DPD Parcel Navigator Delivery a real-time monitoring of the courier, via app, verifies when the specific customer requests for the delivery are satisfied. Instead, ParcelHome PackBox uses an app to identify the status of the delivery and the device as physical interface for the deposit of the package by the courier and for the pick up by the customer.

Table 1 Services provided by IoT in use cases

Use cases	IoT service Type			
	Identity-related	Information Aggregation	Collaborative-Aware	Ubiquitous
Click'n'Pizza	X	X		
DPD Parcel Navigator Delivery	X			
ParcelHome PackBox	X			

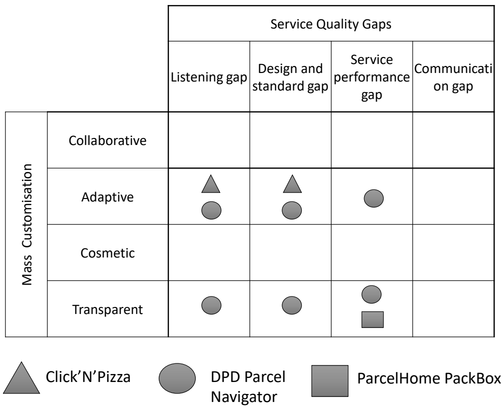
The Click'n'Pizza device offers the opportunity to choose between a standard order (based on the last purchase), a new customisable order or an order based on a recently received promotion. The process of customising the pizza according to individual customer desires is standardized by the system navigation of the IoT device enabling a structured and easy way of customisation. This standardization, however, implies a limited scope of customisability (e.g. the quantity of an ingredient). According to the mass customisation framework, Click'n'Pizza is a typical example for adaptive customisation: the pizza as a standard product can be modified by the customer in the purchase process. Regarding the service quality of the PSS, the IoT device can help to close the listening gap as it guarantees the receiving of customer input (pizza ordering) in a standardised way. Moreover, Click'n'Pizza can provide information about the status of the order through the device and thereby manage customer expectations accordingly.

DPD Parcel Navigator can be seen as both adaptive or transparent according to the usage of the customer. If the customer decides on a regular basis how to receive the parcel it is adaptive customisation (the service is customised to the specific requirements of the customer). Otherwise if the customer just communicates his preferences once, the DPD Parcel Navigator service can be considered as a transparent customisation (the customer does not perceive the product as customised). Regarding service quality, IoT helps to reduce the probability of non-delivery, since customers can select multiple solutions for the delivery (neighbour, hour, etc.). In this way, DPD Parcel Navigator ensures that the delivery is completed at the first time, without further appointments for completing the delivery.

Parcelhome Packbox aims at coping with the individual needs of the customer while offering a standardised (one for all the courier) "interface" for the home delivery. It can be considered as a transparent customisation because the customer does not perceive the service provided through the Packbox as customised. Nonetheless, in the wider sense it indeed provides a service tailored to individual needs: if the sensors of the Packbox detect an item it informs the customer (or in case of return shipment the shipping company). In this case, the Packbox helps in reducing the probability of non-delivery (Service performance Gap), as in DPD Parcel Navigator. Indeed, delivery success does not depend on customer presence, since the courier can store the package in the box in case the customers is not at home.

Table 2 Use Cases Mapping Framework

7. Results



Wrapping up the results from this limited use cases assessment, home delivery services provided by IoT are mainly identity-related. Only the Click'n'Pizza device can also provide an information aggregation service thanks to one of its particular functionalities. Moreover, the study identifies a link of these kinds of services with adaptive and transparent mass customisation approaches. From a service quality point of view, IoT improves the PSS provided to the customer in three ways: through a better codification of the real customer expectations, an enhancement of the solution design and finally through the efficacy in actually providing the market what has been previously designed.

In the cases analysed, some fields are still empty. IoT is a promising technological application but still at an early stage of adoption. Furthermore, collaborative and cosmetic individualisation approaches are not involved in the provision of the presented solutions. However, this does not mean that PSS cannot be customised in these ways: IoT technologies could also foster both the collaborative and the cosmetic personalisation. New solutions will be likely available in the future also in the home delivery market.

8. Conclusions and Further Discussions

This paper proposed a research framework to evaluate which kinds of services IoT technologies can foster for the provision of PSS. The study applied this framework to a set of use cases dealing with home delivery solutions. In detail, this study assessed two important dimensions: the customisability of the PSS and the service quality gap IoT

is able to disclose. The study revealed several connections between the different concepts. IoT easily enables identity related services, fosters adaptive and transparent customization and is able to support the disclosure of the listening gap, the design and standard gap as well as the service performance gap.
Future research should aim to extend the application of the framework to all the types of services that could be added to PSSs. In this way, future research can help to lead companies to adopt IoT technologies in the servitization process, enabling them to satisfy the diverse needs of their customers in an efficient (service quality) and effective (personification approach) way.
Finally, the research is at an early stage and is, thus, limited by the number of use cases. Furthermore, the use cases do not cover all aspects considered in the framework. Further explorations in both the academic and market contexts can improve the assessment framework while introducing a quali-quantitative approach aimed at effectively exploring the impact of IoT technology on PSS.

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