The impact of IoT Technologies on product-oriented PSS

The "Home Delivery" service case

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***Abstract*—The contribution aims to evaluate the impact that IoT technologies can have on PSS and services. Particularly, the analysis considers two dimensions: the typology of services enabled by the IoT, and the PSS lifecycle phases of the home delivery. By means of multiple use cases, authors found out that IoT technologies have huge impacts both on order placement and delivery phases. Particularly, they have a two-fold advantage for the main stakeholders involved: on one side they speed up operations and on the other they reduce the number of activities for completing the overall home delivery process.**

Keywords*— *IoT; PSS; Services; Home Delivery; PSS Lifecycle

I. Introduction

Nowadays, manufacturers are becoming more and more Product Service System (PSS) providers for surviving the increased global competition. 20% of the enterprises have already integrated some services [1]. Meanwhile, Internet of Things (IoT) is expected to dramatically grow 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 [2]. From an economic point of view, instead, it has been estimated that IoT impact is in a range of \$2.7 to \$6.2 trillion by 2025 [3]. IoT is surely an enabler of PSSs, allowing the collection and sharing of tons of information about products and Product Service Systems [4].

The purpose of this paper is to provide a first study for understanding and evaluating how IoT technologies can affect on services and Product Service Systems. In detail, the focus of this paper is limited to one of the categories of PSS provided by [5], the home delivery service. The aim is to study different use cases, in order to identify how IoT technologies can be applied within this type of PSSs, making services more efficient and/or effective.

The paper is organized in the following way: section 2 introduces the concept of PSS, while section 3 introduces the IoT concept. Section 4 describes the use cases analyzed, while Section 5 compares them, in order to identify findings. Finally, section 6 concludes the paper.

II. PSS

Several classifications are proposed in the literature ([6] [7] [8] [9] [10] [11] [12]) It seems that Tukker's one [11] is the widespread and large accepted among all the PSS classifications [13], which identifies three main categories, articulated in eight archetypal models of PSS.

In the *Product-Oriented Services,* some services are added to the physical product sales, which remains the core of the business model of the company [13]. This PSS type can be divided into two main categories: **Product-related service,** and **Advice and consultancy.**

In *Use-Oriented Services,* physical product exists and is extremely important in this kind of PSS. However, the ownership remains to the provider, which just makes it available for the user [13]. This PSS type includes **Product lease, Product renting or sharing, and Product pooling**.

In *Result-Oriented Services* companies offer a personalized mix of services while maintaining ownership of the product. In this case, the customer pays only for the provision of agreed results [13]. This PSS type includes three sub-categories: **Activity management/outsourcing, Pay per service unit, and Functional result.**

Starting from this classification, [5] provides several types of services included in the diverse typologies of PSS.

Another important aspect for PSS is its lifecycle phases (Fig.1), from its ideation to its decommission.

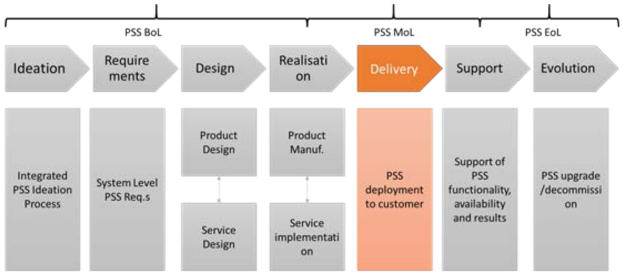

Figure 1 PSS Lifecyle phases (adapted by [14])

Within PSS lifecycle Product and Service lifecycles have to be integrated and made interoperable, thus resulting in a unique straightforward process. PSS lifecycle encompasses seven several phases from the ideation to the delivery, while ending with its decommission [14].

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III. IoT

Smart, connected products are composed of three core elements [15]: physical components, "smart" components, and connectivity components.

Physical components comprise the product's mechanical and electrical parts.

Smart components increase the capabilities and value of the physical components, impelling in many cases designers either to replace hardware components with software parts or to enable physical products to perform at a variety of levels. Smart components comprise sensors, microprocessors, data storage, controls, software, or an embedded operating system and enhanced user interface.

Connectivity components amplify the capabilities and value of the smart components, which can also become sometime a separate external part of the physical product itself. They comprise the ports, antennae and protocols enabling wired or wireless connections with the product.

According to [15], intelligence and connectivity enable an entirely new set of product functions and capabilities, which can be summarized into four areas: monitoring, control, optimization, and autonomy.

A smart, connected product can potentially incorporate all of them: it depends on the company decision about its competitive positioning and the customer value to be delivered. Each capability can bring value to the solution either if considered on its own or also being a foundation that could impel, enable and activate the others. Smart, connected products require a "technology stack", a new technology infrastructure tailored for the company, consisting of a series of layers. This technology enables the company to better develop and manufacture its solution that is hence able to support connectivity and collaboration along the whole value chain: the collection, analysis, and sharing of data generates value from providers to customers, inside (tangible part) and outside (intangible part) to the product.

In literature this kind of technology basis is commonly called Internet of Things (IoT). The RFID group [16] defines the Internet of Things as the worldwide network of interconnected objects uniquely addressable based on standard communication protocols.

The Cluster of European research projects on the Internet of Things [17] gives a proper definition of 'things'. 'Things' are active participants in business, information and social processes where they are enabled to interact and communicate among themselves and with the environment by exchanging data and information sensed about the environment, while reacting autonomously to the real/physical world events and influencing it by running processes that trigger actions and create services with or without direct human intervention.

According to [18], a smart environment uses information and communications technologies to make the critical infrastructure components and services of a city's administration, education, healthcare, public safety, real estate, transportation and utilities more aware, interactive and efficient.

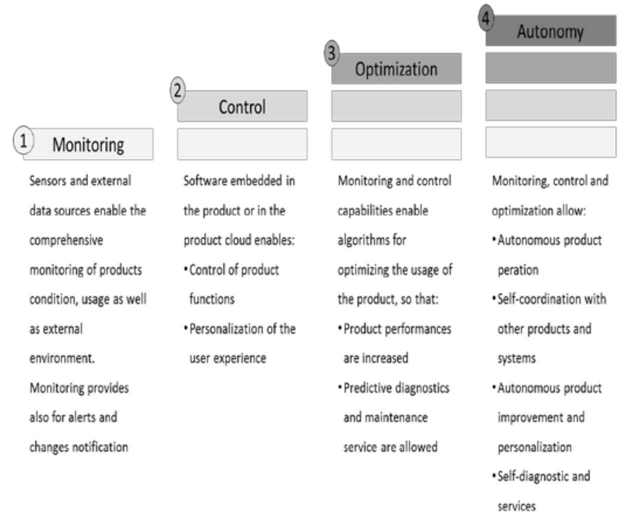

Figure 2. Capabilities of Smart, Connected Products. Adapted from [15]

The definition given by [19] is more user centric and not restricted to any standard communication protocol. [19] defines the Internet of Things for smart environments as: "Interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless ubiquitous sensing, data analytics and information representation with Cloud computing as the unifying framework".

Nowadays the number of applications enabled by the use of IoT is huge and is supposed to grow further in the next years. Every application can be linked to a particular IoT service and can be grouped in four main types [20]:

1. Identity-related services, which consist in two major components (the things, an identification detector, and the read device, which read the thing identity through its label). They can be either active (broadcasting information and usually associated with having constant power or at least under battery power) or passive (having no power source and requiring some external device or mechanism in order to pass on its identity).
2. Information Aggregation services refer to the process of acquiring data from various sensors, processing the data, and transmitting and reporting that data via IoT to the application. These types of services can be thought as one way: information is collected and sent via the network to the application for processing.
3. Collaborative-Aware services, which use aggregated data to make decisions, and based on those decisions perform an action. IoT should bring to the development of complicated services that make use of all of the data that can be retrieved from the extensive network of sensors and call for responses to the collected information to perform actions.
4. Ubiquitous services, they are the ultimate goal of the Internet of Things. A ubiquitous service would not only be a collaborative aware service, but it would be a collaborative aware service for everyone, everything, at all times, overcoming the barrier of protocol distinctions amongst technologies and unifying every aspect of the network.

In order to implement those services and fully realize the vision of the IoT, [3] detected the main challenges that need to be addressed by the service/solution providers and application programmers:

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availability, reliability, mobility, performance, scalability, interoperability, security, management and trust.

IV. USE CASES

The work adopts a multiple use cases approach to understand the impact of IoT in the home delivery. Particularly, three use cases have been studied on the basis of public available data, i.e. data obtained from web search: Amazon, Food delivery and Intelligent Vendor. It is worthwhile highlighting that Amazon represents a multiple use cases itself, due to the several application of IoT technologies. More in detail, first use cases analysis has identified IoT applications and understood which type of services they provide. Then, use cases have been further explored to understand IoT on PSS phases in terms of two dimensions:

- *number of activities* for completing a PSS phase;
- *lead time to complete the activity*

A. Case 1: Amazon

Amazon[1] represents a meaningful use case for IoT application in a B2C retailing and delivery world. Indeed, Amazon competitive strategy heavily relies on continuous improvement in technologies for speeding and facilitating product delivery. Particularly, "Amazon PrimeNow", represents a high-speed delivery service (within the same day) enabled by recent technologies. The basic concept of this high-speed delivery is to limit it to a smaller spectrum (compared with the overall offer of Amazon) of products.

IoT technologies has a twofold goal for Amazon:

- to ensure quickness in the logistic phase, by reducing the lead time from the reception of the material to the shipment to the customers;
- to enhance process control thanks to real time information. For instance, here Amazon has the possibility to hide some products as well as limiting time windows temporary unavailable for high-speed delivery due to traffic problems.

Therefore, in this case IoT technologies provide an Information aggregation service.

From the customer's perspective, Amazon PrimeNow offers also a real-time tracking of his/her own order, thus reducing the activities he/she has to do for receiving it. Indeed, he/she can know with a higher confidence the time of the consignment, thus limiting his/her monitoring effort.

"Amazon prime Air" represents a further of this concept, with the usage of a drone to consign within 30 mins in a local area. From a technological point of view, the drone is a small self-driving robotic delivery vehicle equipped with a sensor suite (e.g. cameras, GPS, IMU, etc.) and microphones and speakers for communicating with humans.

In this case, IoT technologies aims at overcoming problem and uncertainties of transportation on road, while keeping the promised delivery time more reliable.

From the customer side, this service aims at improving the delivery phase by enhancing performances in terms of delivery time and reliability.

Finally, another service offered by Amazon, "Amazon Dash Button", aims at simplifying the order placement rather than the delivery phase. Thanks to a particular product, namely "Dash Button", a customers can re-order a single unit of a specific product with just one click. In this way, the overall order placement process consists just in one click. To standardize this process, indeed, the dash button is associated with just one product. Therefore, this service reduces the number of activities a customer has to do for ordering by automatizing completely the order placement phase.

[1] http://www.amazon.com/p/feature/zh395rdnqt6b8ea

For Amazon, the standardisation of the order placements works for a reduction of the uncertainty of the demand, thus resulting in a reduction of the complexity in the overall process.

B. Case 2: Food Delivery

Concerning food delivery, tons of example exist. Websites such as Just Eat[2], Foodora[3] and MyFood[4] provide the service to deliver at home a wide choice of meals and beverages, from pizza, kebab and sushi to gourmet dishes. The service is simple: you have to fill on website your address, in order to define which restaurants can deliver food at your home. Then, you can decide the restaurant and the list of meals you want to order. Some websites, furthermore, enable to decide if you want to pay by credit card or by cash. Finally, you have to decide when you want to receive order, keeping in mind at least a time to prepare the meals you chose. In these cases IoT technologies are not used.

Furthermore, it is possible to use IoT technologies, in order to make efficient and effective order and delivery phases. Indeed, an IoT solution similar to "Amazon Dash Button", "Click'n'Pizza"[5], enables the reduction of the number of activities needed to complete the order, since it is necessary just to push a button for ordering a pizza. In this case IoT allows to reduce the number of activities to make an order, reducing the lead-time necessary to complete the order itself, from both the customer and the provider side.

However, it is possible to use IoT technologies for monitoring and tracking the order, in order to keep under control where the order is. This IoT application doesn't reduce the number of activities or the lead time of the delivery phase, however it could be appreciated by customer.

C. Case 3: Intelligent Vending

Intelligent Vending represents an IoT application for the home delivery B2B market, giving as a result automatic distribution machines. Such machines, sprawled in the territory, would require, without an IoT technology, a constant management effort, due to the continuous need of supply them of the missing items they distribute.

With the introduction of IoT, the solution provider has thus the chance of:

- automatize the phase of order creation, monitoring in real time the stock actually in the machine,
- enable a preventive maintenance on the machine, constantly controlling the machine function parameters.

Therefore, this is a Collaborative-Aware Service enabled by IoT that has also been carried on through a collaboration between Intel and SAP[6]. Through the adoption of the IoT technology, the order phase complexity, for both the provider and the customer, is reduced or almost null, in terms of activities needed for the order creation. Furthermore, during the delivery phase of the service, complexity doesn't change: customers have anyway the need to monitor the order delivery status.

V. CASE STUDY COMPARISON

Use cases described in the previous section present different IoT technologies and different pervasion of their usage in the home delivery service. To structure this analysis a two-step comparison is presented here.

[2] https://www.justeat.it/
[3] https://www.foodora.it/
[4] http://www.myfood.it/
[5] http://www.clicknpizza.com/
[6] http://download.intel.com/newsroom/kits/iot/pdfs/Intelligent_Vending_factsheet.pdf

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First, the three use cases presents different services offered by IoT technologies. Amazon Prime Now and Amazon Dash are examples of the basilar service, provided by IoT i.e. "Identity Related" (Tab.1). In both cases, IoT technologies help in collecting information while keeping the customer order tracked. In Amazon prime this is obtained trough a real-time monitoring of the courier position accessible to the customer via app. On the contrary, Amazon Dash Button helps in tracking the specific item to which is associated.

Use cases	IoT service Type			
	Identity-related	Information Aggregation	Collaborative-Aware	Ubiquitous
Amazon Prime Air			x	
Amazon Prime Now	x			
Amazon Dash	x			
Food			x	
Intelligent vending			x	

Table 1 Services provided by IoT in use cases

In "food delivery", "Amazon Drone" and "Intelligent vending", IoT provides a "collaborative-aware" service, thus enabling stakeholders involved in the home delivery, i.e. just provider and customer, to take decision based on info collected. Particularly, the intelligent vending enables the provider to optimize daily replenishment orders.

The second step of the use cases analysis focuses on the impacts of IoT technologies on the Order Placement phase ("Order") and Delivery phase. Particularly, the study comprises two performances both for the customer and for the provider: number of activities and lead time.

From the customer's perspective, it can be observed that only in the intelligent vending IoT impacts on both the phases. Indeed it strongly simplifies and speeds up the "Order" phase for the two actors. At the same it works for reducing the number of activities in the delivery phase for the customer, who has not involved at all in the delivery.

In all the Amazon use cases we see that both customer and provider have benefits by the application of the IoT technologies in the PSS provision. Particularly, in "Amazon Prime Air" and "Amazon Prime Now" IoT reduces the lead time in the delivery phase, by speeding up the process without eliminating some activities. On the contrary, in the third Amazon use case, the IoT technologies arise "Order" lead time and complexity performances.

Finally, IoT application positively impacts in the order phase by the customer viewpoint in the food delivery use case. Moreover, improvements in terms of less number of activities are observed for the provider in "Order" phase.

Use cases	Lifecycle Phase							
	Order				Delivery			
	Provider		Customer		Provider		Customer	
	# activities	Lead time	# activities	Lead time	# activities	Lead time	# activities	Lead time
Amazon Prime Air						x		x
Amazon Prime Now						x		x
Amazon Dash	x		x	x				
Food			x	x				
Intelligent vending	x	x	x	x			x	

Table 2 IoT impact on performances in the use cases

VI. Conclusion and Further Discussions

This paper aims to evaluate the impact of IoT technologies on services. Particularly, this work starts a first analysis on a specific service category, the home delivery, within a PSS bundle. The goal of this analysis is to understand which type of services IoT technologies can provide in home delivery, while evaluating their impact on PSS performance. The research is just started, thus it is limited by the number of use cases and by the analysis of the use cases themselves. However, this research is promising, helping to define which of four types of service IoT is able to provide, within the specific case of home delivery service, besides to identify the lifecycle phases where IoT impacts. Further step is to extend this analysis to all PSS and services, particularly on those services that can be affected by IoT technologies. Furthermore, the analysis has to deep how the service quality and the perceived quality by customers can change [21], bringing competitive benefits to the companies.

VII. Acknowledgement

This work was partly funded by the European Commission through Manutelligence (GA_636951), Diversity (GA_636692) and Psymbiosys (GA_636804) Projects. The authors wish to acknowledge their gratitude to all the partners for their contributions during the development of concepts presented in this paper.

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