Exploiting the SErvice Engineering Methodology to re-engineer Bergamo's bike sharing Product Service System

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Abstract: Many cities worldwide are struggling to reduce pollution and to maintain an effective and agile transportation system. Among the many available policies and green solutions, bike sharing programs are emerging as a cost effective and sustainable way to expand the portfolio of transit options, promoting the use of alternative transportation among citizens. However, it is still not clear how to design and consequently improve such a complex system. In this paper, the authors analyze the bike sharing system as a Product Service System (PSS) and explore the applicability of the Service Engineering Methodology (SEEM) to re-engineer and improve the Bergamo bike sharing system (BiGi). First, the paper presents an analysis of the current BiGi system offer; then, possible improvements and solutions are identified through the adoption of the Service Requirement Tree method. Finally, the improvements are proposed and discussed.

Keywords: Product Service System, bike sharing, process improvement, PSS re-engineering

1. Introduction

The field of transport in Europe is responsible for 24% of pollution emissions (CO2 and greenhouse gases), mainly due to urban road transport (72%) (European Union, 2012). Accordingly, many cities are struggling to reduce pollution and to maintain an effective and agile transportation system. Among the many available policy and green solutions, bike sharing programs are emerging as a cost-effective and sustainable way to expand the portfolio of transit options (Kisner, 2011).

The idea behind the bike sharing system is quite simple: citizens are offered the possibility to rent a bike in a bicycle parking station, use it for the time they need, and return it to any other parking station around the city. From the citizens' point of view, this implies high flexibility, lower risks (e.g. bike stealing) and a possible way to move and to keep fit. From the municipality perspective, it implies higher connectivity, lower traffic congestion and less polluting emissions. Therefore, it is not surprising that bike sharing systems have become an increasingly popular and powerful complement to public transit in cities around the world (Li et al., 2016). The bike sharing projects have begun to spread from 1960's (DeMaio, 2009) and the ease of use of the system, coupled with the growing awareness of green transportation boast the adoption of such system. Currently, there are more than 500 programmes in 49 countries (Larsen, 2013).

The bike sharing characteristics and the environmental gain related to the system make it a perfect example of a Product Service System (PSS). PSS indeed is "a system of products, services, supporting networks, and infrastructure that is designed to be competitive, satisfy customers' needs, and have a lower environmental impact than traditional business models" (Mont, 2002).

The city of Bergamo has a bike sharing system – referred to as BiGi - since 2009. In the BiGi system there are 22 stations for bicycle parking, for a total of 286 bicycle stalls. According to local statistics, the number of users is steadily growing: from 1614 users in 2009 to 4385 at the end of 2015. This is also due to the recent technological improvement of the system (i.e., new stalls that allow for a more rapid and secure bicycle parking, identification system for each bicycle, real time monitoring applications to avoid empty or full stalls, new management platform and real-time control for the timely rebalance of the system). Currently, ATB (Azienda Trasporti Bergamo), the local public transport provider is managing the BiGi PSS. Despite the BiGi system is working quite well, the ATB management, comparing Bergamo data with other cities, identified possible improvements, especially in relation to tourists who are increasing in the city of Bergamo (2,060,564 tourists/year according to the Tourism Observatory of the Province of Bergamo, 2015). The municipality of Bergamo would like to improve the offer to the tourists in order to make the figures comparable to those from another middle-sized European town.

However, although the quite relevant success of the phenomenon, the scientific literature about this topic is quite limited and it is hard to find guidelines or methods to specifically design or improve bike sharing PSS. Hence, the goal of this paper is to holistically focus on bike sharing and to adopt the SErvice Engineering Methodology (SEEM) (Pezzotta et al., 2016) to re-engineer the bike sharing system in Bergamo with the aim at improving its efficiency and its popularity (thus the profit and the environmental gain for the city).

After the introduction of bike sharing trends and the BiGi specific system in section 1, in section 2 the existing literature in the field, and in PSS area are presented. In section 3 the application of the SEEM approach to

improve the Bergamo bike sharing system is discussed. Finally, conclusions and further developments are illustrated.

2. Existing work in the area of bike sharing and PSS

In the last few years, some articles have focused on different aspects of bike sharing. Most of the articles published so far are related to the repositioning and rebalancing of the system (Ho and Szeto, 2016), to the reservation systems of the stalls (Kaspi et al., 2014) and to the demand forecast for the bike sharing (El-Assi et al., 2015; Liu et al., 2014). None of them deals with the bike sharing as a whole, therefore lacking a holistic perspective.

Even though bike sharing perfectly fits PSS definitions, there are very few articles treating it as a PSS. The bike sharing system is used to test different PSS design approaches (Hirth et al., 2015; Nikitas et al., 2013), to assess its environmental impacts (Bechmmann-Dobrev et al., 2015; Andriankja et al., 2015) and to analyse its potentials (Zhang et al., 2015). Currently, there is not any specific work dealing with bike sharing design and improvement from a holistic perspective; therefore, there is still a gap in the design, development and improvement of bike sharing system. In the PSS literature, several methodologies with practical mechanisms allowing an effective design and development have been proposed (i.e. Qu et al., 2016; Boehm and Thomas, 2013). Nevertheless, the majority of them are focused on customer satisfaction neglecting the provider perspective. Moreover, no one has been designed specifically for bike sharing neither applied in such context. In order to support ATB in improving the local bike sharing system, the analysis of the BiGi PSS through the SErvice Engineering Methodology (SEEM) (Pezzotta et al., 2016) has been carried out. The SEEM (Figure 1) has been selected because, differently from the other approaches, it also focuses its attention on the provider profitability that is the core interest of ATB. The reader might refer to Pezzotta et al. (2016) for further details on the SEEM. In this study we discuss the first three steps of the SEEM. The process validation phase will be part of a future and more detailed analysis.

3. Application of the SEEM to Bergamo BiGi

3.1. Offering identification and analysis

As a first step to improve the offer for Bergamo tourists, the current BiGi offer has been analyzed. Analysis have been carried out by a group of researchers from the University of Bergamo that collected all the information from the ATB consortium during the "Bergamo 2.035" project.

Three out of four main components of the BiGi PSS (Mont, 2002) have been analyzed in detail as summarized in the following paragraphs.

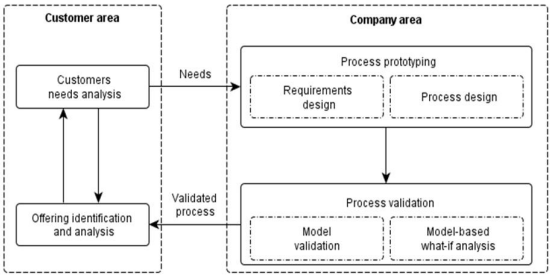

Figure 1 SEEM (Pezzotta et al., 2016)

- *The Product: The bike*

The product is a traditional city bike. It is accessorized with gears and a rear rack. All the bikes are of the same model, red with the BiGi brand on the bicycle frame, and equipped with a basket.

- *The Service process: Ticket purchase and bike usage*

Currently, three possible service subscriptions are available:

- *Annual subscription*
  It requires to reach the ATB physical customer point or to connect to the ATB website. It can be obtained after registration, signing the regulations for use and filling out the application form.
- *Occasional subscription*
  Online rechargeable card that could be bought at the ATB customer point or on the ATB website.
- *Occasional purchase* through APP
  Rates valid within 24 hours from activation. It can be bought through an app – currently only in Italian, available for free download for iOS and Android devices - by accepting the terms of use and entering the credit card details.

The BiGi ticket is personal, exclusive and cannot be used on other local public transport. Once the ticket is bought, the customer can reach the preferred parking station, take the bike and ride it. Then, at the end of the trip, the customer can park the bike in any station of the BiGi network. The process has been represented using blueprinting map (Bitner et al., 2008) (Figure 2). In the figure, the non-value added activities (registration and purchase) have been highlighted in red, whereas the added value activities (bike taking, usage and parking) are highlighted in blue. The most relevant activity that is the bike riding is in light blue.

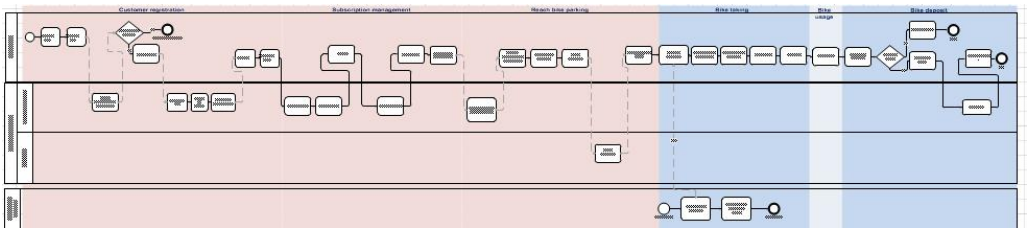

Figure 2 Blueprinting map of the BiGi process

From the initial analysis of the process, it emerged that the value added activity (the use of the bike) represents a limited part of the process with respect to registration and purchase activities. This emerges also from Figure 2.
This can be one reason at the root of the poor success of the BiGi system for tourist. It can be easily understood that they do not want to spend too much time in non-value added activities since they are going to use the service for a limited amount of time. E.g. if they have to spend time to find the selling point, purchase, register and then use the bike for 2 days maximum it does not make sense to select this kind of transport.

- *The infrastructure: The parking station for bikes*

The network is developed in a radial belt that includes all the lower town where residential and commercial areas are located; the entire network remains within the municipal boundaries. Currently, the network is designed to encourage residents to use bicycles for short trips; particular attention is given to the links between highly populated suburban area and main working and commercial attractors in the city centre. At this point of the analysis, it was observed that bicycle parking stations were not present in tourist areas (i.e. museums, stadium, funicular to Upper Town). Even if there are bicycle parking stations nearby these sites, they are difficult to find for a tourist since they are not indicated in the bike sharing map.
The last component of a PSS according to Mont (2002) is the *Network*. It has not been analysed in this study since there is currently no specific network for the system. How to develop and organize a network could be part of a parallel analyses and in-depth studies.

3.2. Customer's needs analysis

Given the strong commitment of the municipality in reaching tourists, the customer needs analysis has been carried out focusing only on tourists/ foreign people. Their needs and preferences have been analysed through the adoption of persona model (Pirola et al., 2014).

During the analysis carried out through the project "Bergamo 2.035" (http://www.bergamo2035.it), three different personas were identified and described. They refer to three different categories: i) young tourists, ii) families, iii) elderly tourists. Figure 3 reports the persona model for the "young tourists" category.

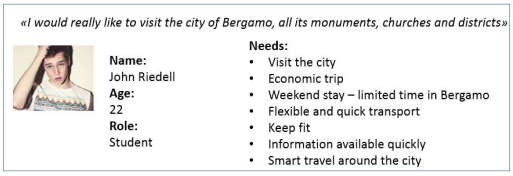

Figure 3 Persona model summary for young tourists

3.3 Requirement design

After the identification of the main customers' needs, the requirements design analysis of the SEEM has been carried out. This phase foresees the adoption of a method called Service Requirement Tree (SRT) (Rondini et al., 2016) to identify possible PSS solutions to satisfy customers' needs. In this case, since the PSS was already defined (the bike sharing in Bergamo), the SRT has been developed with a lower level of detail and has been used to identify bike sharing features and requirements that could possibly satisfy the needs of the identified customers. Figure 4 reports an excerpt of the SRT developed for the customer segment "tourist" considering all the three personas.

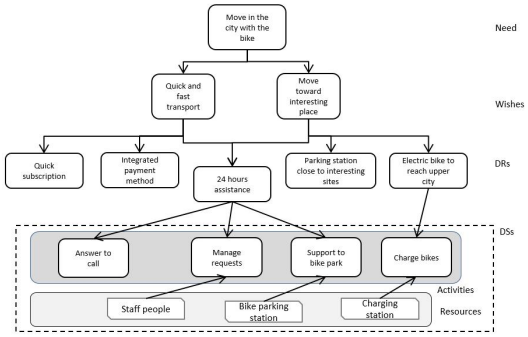

Figure 4 Extract of the SRT for tourist customers

The list of the main BiGi bike sharing features identified through SRT and currently not included in the BiGi system includes:

1. Electric bikes to reach the upper town;
2. Availability of different type of bikes (fat bike, Bmx, mountain bike);
3. Availability of baby seat to apply on bicycle in case of a family trip;
4. Availability of deposit to park strollers during the city sightseeing;
5. Availability of bike helmets at bike parking stations;
6. 24h assistance service;
7. Quick and costless subscription;
8. Payment method integrate with other public transports (special tourists' travel cards);
9. Web app to guide the customer that rent the bike through the interesting sites in Bergamo;
10. Bike parking stations close to all interesting sites in Bergamo (Uppertown included);
11. Bike parking stations close to the main infrastructural nodes (i.e. railway station, main bus stops, Uppertown funicular) to create an intermodal network;
12. Clear signage of bikes parking stations.

The identified improvements can be classified into the four main PSS components. Solutions from 1 to 5 refer to the product; from 6 to 9 refer to the service process to provide the BiGi system and from 10 to 12 refer to the BiGi infrastructure. No one refers to the network since in this stage it has not been considered. In the following section, the possible improvements are described in detail and designed. Particular focus will be devoted to the service process design that is the most critical part and that is also the focus of the SEEM. The product design phase will not be described in detail since it does not require technical improvements or complex product design features but just the adoption of bikes with different design and features. Regarding infrastructure design, some insights will be also provided. At this point, one gap of the SEEM emerged: it suggests methods only for the service delivery process

design, partially considering the network. The product and the infrastructure components are not considered. In the following part of this study, a possible re-engineering of the infrastructure is proposed, but, given the SEEM gap, no structured methods have been adopted..

3.4 Product design

Regarding product design features, it is worth mentioning that the brainstorming allowed the identification of some additional elements that can be added or integrated in the bike. Such elements as the baby seat or the helmets could be designed so that they can be easily applied on the bike (the helmet could be attached to the bike when it is parked). Additional product improvements are related to the change of the bike design proposing different kinds of bike according to the customers' preferences. Since both areas of improvement do not represent complex design activities, they are not discussed in this work.

3.5 Process design

The most relevant part of the BiGi re-engineering is related to the process re-design of the service delivery process. As previously highlighted, this analysis refers to the service process to buy the tickets and to ride the bike. The new service has been improved considering the ideas generated in the SRT and has been represented in a blueprinting map as well as the old one (Figure 5). At a first glance, it is clear that the non-value added activities (shaded in red) have been significantly reduced making the entire process easier and quicker. The new process works as following: upon arrival in the city center, the customer can buy a tourist travel card with a fixed duration (i.e. 24h, 48h, 72h) which includes the use of the bus service, the bike sharing and the funicular to access the upper town. The purchase can be completed through the app (that should be available in foreign languages, or English at least) with a credit card or at a newsagent stand. Once at a bike sharing parking station, the customer can take a bike manually through the station, or by indicating the identification number of the bike station and the bicycle on the app. At this point, through the map available on the site and the mobile app, the client can identify which are the points of interest and see which bikes stations are closer. Once reached its destination, the customer can park the bike. If a malfunction occurs during the bike parking the customer can contact a 24-hour service that allows a manual deposit.Once visited the place of interest, the customer can choose, consulting the app, to reach the next destination again using the bike sharing service or, using the same ticket, via the bus service according to his own preference.

3.4 Infrastructure design

As previously discussed, the infrastructure is designed to promote the use of bicycles among residents and not for tourists; therefore, some modifications are required to adapt it to the new customers' necessity. One of the main changes is to place the bikes parking stations closer to major intermodal nodes (i.e., railroad station, main bus stops, funicular to the upper town) and touristic sites (i.e. churches, museums, historical center in the upper town, the hills and Astino monastery). To achieve these changes, it is possible to act on two levels: initially, the information network has to be enhanced, adding for each bikes parking station a panel on which the nearest points of interest and connections to other transport services are displayed. It would also be interesting to create a map on the app that allows having the same information for the entire bike parking stations. It would also help the activation of a 24 hours help desk service, potentially shared with other cities that use the same bike sharing system, in order to help customers in the event of malfunctions during the bike returning process. Then, it would be possible to expand the system by adding further parking stations in tourist areas. In particular, to reach the upper town and the hills, it would be interesting to take advantage of electrically assisted bicycles. Clearly, this solution would imply a substantial investment for the purchase of the bicycles and the installation of new parking stalls able to ensure electric bikes charging. For this reason, this enhancement of the system is not expected in the short term.

4 Conclusion and further developments

One of the next targets of Bergamo's public administration and the bike sharing managers is to make the system attractive for tourists, as well as for residents. To do so, an analysis on the Bergamo PSS bike sharing system has been carried out through the adoption of the SEEM. The analysis pointed out the main needs of the "tourist" customer of the BiGi system and guided the identification of possible product improvements, the service and the infrastructure of the system. Several advancements are necessary: some of them require a low level of modifications and investments (i.e. touristic informative panel, English version of the app with tourist city map, tourist integrated travel tickets) and have been already implemented, while others need deeper changes (i.e. adding electric bikes, new parking stations, different types of bikes). The last one are still under investigation.

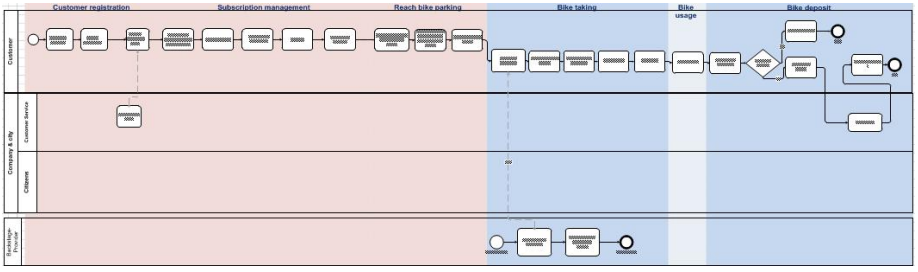

Figure 5 To- Be blueprinting map of the BiGi process

For the implementation of complex solutions, a detailed analysis would be necessary even for the service components relating to the network and to the product. For what concern the academic results, the SEEM has been demonstrated a good approach to identify and elicit bike sharing requirements and improvements (see section 3.3). However, some weaknesses regarding the infrastructure and product design emerged. The application to the BiGi case showed that in order to re-engineer a PSS in a holistic manner, all the component of the PSS have to be taken into account. Future improvements will be related to the enhancement of the SEEM.

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