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A proposal for a public transport ticketing solution based on customers' mobile devices

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Abstract

The worldwide economic and financial crisis is triggering a number of difficulties to several sectors, including public transport industry. Public Transport Operators (PTOs) have fewer resources to invest, nevertheless they need to achieve good results and improve their service offerings. Therefore, this paper aims to present an innovative ticketing solution based on customers' mobile devices, which intends to minimize the investment cost from the PTOs and customers' perspective, maximizing consumer's acceptance. The proposed solution doesn't require any interaction with PTOs infrastructures to purchase or validate a ticket, being solely based on customers' mobile devices with an internet connection. The approach presented in this paper is the result of a project involving the major PTO in Porto city and customers who contributed to the design, requirements elicitation and evaluation of the system. A prototype of the system has already been tested by a group of potential users.

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Keywords: Service encounters; self-service technologies; mobile payments; public transport; mobile ticketing.

1. Introduction

The explosion of new technologies is revolutionizing the public transport sector, allowing Public Transport Operators to broaden their service offerings by introducing new service interfaces and channels in their service delivery. Hence, a growing number of customers interact with technology to create service outcomes instead of interacting with companies employees. Due to increasing financial constraints it is important for companies to be

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aware of these new channels that are less costly and allow reaching a large number of customers at the same time. This paper aims to present a ticketing solution based on customers' mobile devices, which intends to minimize the investment cost from PTOs and customers perspective, and maximize the consumer acceptance.

The proposed solution is based on costumers' mobile devices that only need to have internet connection. Therefore the purchase and validation of tickets is made over-the-air (OTA), and location providers are used to locate the traveller and reduce the number of options when it comes to validate a ticket, making the system easier to use. The definition of the proposed mobile payment system is supported by a literature review on Human Computer Interaction, multi-interface service environments, mobile payment adoption theories and available technologies. This research was followed by several meetings with PTOs, public transport software companies and customers, allowing the development of a prototype, which was tested and validated by a group of users.

Since the system is totally based on customers' mobile devices, PTOs don't need to adapt or buy new infrastructures, like gates, ticket vending machines or ticket readers. Based on this system users will benefit from remote and ubiquitous access to payments, queue avoidance and lack of need to carry cash around. Additionally, other mobile phone features allows offering more services to passengers, such as instantly check ticket balance, access to real-time traffic information and timetables and view an interactive trip planner. Therefore, this closer interaction with customers will allow PTOs to know their customers' travel behaviour, and manage a vast and important database. These patterns and preferences expressed by customers can later be used, for instance, to advise customers of fares that suits better their travel profile or to create personalised journey plans.

The outline of the current paper is as follows: the next section describes and analyses the concept of service encounters, which motivated our approach. It also analyses the relation between multi-channel services and investment costs. In Section 3 the mobile payment system and traditional ticketing systems in public transport sector are characterized. Section 4 presents the research approach and the proposed system is described in Section 5. Finally, the conclusions and future research are presented in Section 6.

2. Service encounters: from interpersonal to technology based

The term "service encounter" was primarily used to describe all service encounters that take place when both an employee and a customer are present. However, Shostack (1985) proposes a broader definition of service encounter: "a period of time during which a consumer directly interacts with a service". This definition encompasses all aspects of the service provider with which the consumer may interact and suggests that service encounters can occur without any human interaction element.

In the literature related to the interpersonal based encounters, some researchers focused on the interactions between customers and firm employees (Bitner, Booms, & Tetreault, 1990). Others have explored customer-customer interactions in service settings, by identifying customers' actions that have a positive effect on other customers experience (Harris, Davies, & Baron, 1997) and actions that may cause dissatisfaction (Grove & Fisk, 1997; Huang, 2008). Some examples of dysfunctional customer behavior would be customers that smoke in the non-smoking area of a restaurant, travelers that disturb others by talking in overly loud voices inside a train and customers that cut into the check-out line when people are waiting to pay the bill. This negative behavior of other-customers diminish customer satisfaction with the firm, because they tend to blame the firm rather than the specific misbehaving individuals (Huang, 2008). Moreover, ineffective or unsuccessful service encounters can result in significant costs to the firm such as performing the service again, compensating customers for poor performance, lost customers, and negative word of mouth (Bitner, Booms, & Mohr, 1994; Tax, Colgate, & Bowen, 2006).

The growth and proliferation of new technologies and their infusion in services contributed to the extension of the service encounter concept to technological generated service encounters, without human intervention from the service provider (Bitner, Brown, & Meuter, 2000). Self-service technologies (SSTs) have increasingly changed the way customers interact with companies to create service outcomes. These technological interfaces enable customers to produce a service independent of direct employee involvement (Meuter, Ostrom, Roundtree, & Bitner, 2000). Examples of SSTs include vending machines, automated teller machines (ATMs) and services made available via Internet and mobile phones.

Companies have introduced self-service technologies to increase productivity and efficiency (Walker, Craig-Lees, Hecker, & Francis, 2002), to lower or avoid high labor costs (Dabholkar, 1996), and/or to offer customers access to services via new and convenient channels (Meuter, Ostrom, Bitner, & Roundtree, 2003). Technology based services have the potential to benefit customers and service providers. Customers can be offered additional or extended services, greater convenience and control, and access to data and support that may not have otherwise been available (Walker et al., 2002). Similarly, technology can be used by SP to improve operations, increase efficiencies, to reduce labor costs, and to acquire distinctive competitive advantages.

Areas of SSTs research include the elaboration of profiles for the distinct SST users based on demographic characteristics (Greco & Fields, 1991), evaluations of SST service quality (Dabholkar, 1996), and factors influencing customers evaluation and usage of SSTs (Lin & Hsieh, 2007; Wittmer, 2011). It is also important to refer Meuter et al. (2000) survey about the range of SSTs available to consumers. They identified four types of technology interfaces: 1) telephone-based technologies and various interactive voice response systems; 2) direct online connections and Internet-based interfaces; 3) interactive free-standing kiosks; and 4) video or compact disc (CD) technologies. Nowadays there are further technological interfaces that could be added to this model such as mobile phones, tablets, USB pens, cloud services and contactless technologies.

The introduction of SSTs in the service industry does not mean that other channels will disappear; it rather means that the number of interface service systems through which companies manage relationships with their customers will increase. These multi-channel services bring other important challenges to companies, like defining the mix of service offerings and interfaces, the tangible evidence, the service processes, and people's role in the processes (Patricio, Fisk, Falcao e Cunha, & Constantine, 2011). Many companies tend to ignore the importance of having an overall view of the firm's multi-interface offering, which frequently result in an incoherent service fragments that fail to provide satisfying service experiences to customers (Patricio, Fisk, & Falcao e Cunha, 2008). It is also important for companies to have awareness of the cost associated with the provision of a new channel to customers. None of the research attempts to examine the investment cost required per interface type. Thus, in the current study we propose a conceptualization of the existing interfaces available and the type of investment cost required from the company. This conceptualization is represented in Table 1. In Fig. 1 we compare each of the interfaces type identified in Table 1 in terms of the investment borne by service providers and the amount of infrastructures needed.

According to Table 1, the service encounter was divided in two types: interpersonal based and SSTs based. Interpersonal based are labor intensive and usually require a physical location where the transaction takes place. Offering services through this channel means a steady investment with employees (e.g. recruitment, training, wages) and with the physical location (e.g. rent, water, electricity). This means a higher cost per customer served when comparing with technology based services, which is represented in Fig. 1 by point A.

On the other hand SSTs based service encounters can be split into two types depending on the type of interfaces they are based. SSTs service encounters can use service provider' infrastructures (point B in Table 1 and in Fig. 1) requiring a huge initial investment on machines and infrastructures and a steady expenditure with maintenance, operational and logistic activities. For example, public transport service providers need to invest on ticket machines, gates, tickets readers and then they need to purchase, storage and distribute the tickets by the machines, collect and handle money. Technology generated service encounters can also be based on customers' devices. For instance, a customer can buy a concert ticket using his PC or his mobile. In this case, in order to assess the investment effort required from service provider it is important to distinguish two different scenarios. One is when to complete a transaction the customer' mobile device is not enough and the infrastructures of the service provider are needed. For instance, customers can buy travel tickets with their mobile phones by accessing the PTOs' application, but then they need to touch a Radio Frequency Identification (RFID) or a Near Field

Communication (NFC) reader to redeem the ticket. In this case, SP can save money, because the investment cost in infrastructures decreases, but they still have to invest, for example, in ticket readers and maintenance (point C in Table 1 and in Fig. 1).

The other scenario is when the service offering relies totally on customers' mobile devices, which may represent the most profitable solution for service providers. For example, a solution where the customer purchases and validates the ticket using his personal device, without requiring interaction with the service provider infrastructure, it would be the best solution in terms of investment cost required (point D in Table 1 and in Fig. 1). In this case, service providers would only have to invest in software acquisition and maintenance (e.g. mobile application) and database management. This type of investments also exists in the other types of service delivery interfaces, for instance, employees need a system to interact with and services made available through the internet need a website and database management.

Table 1. Interface types and investment cost required from service providers

Service Encounter	Interface Types	Interface Examples	Types of investment costs supported by the company
(A) Interpersonal Based	Labor Intensive	Employees	Recruitment, selection, training, wages, workplace.
(B) SSTs based	Service Provider' Infrastructure	ATM, Vending Machines, Kiosks	Machines, maintenance, operational, logistics.
SSTs based	Customer' Device	Mobile Phone, Tablet, Computer, USB PEN, TV	(C) Require Service Providers' interfaces (e.g. gates, readers). Costs: Machines, Maintenance, operational, logistics.
			(D) Do not require Service Providers' interfaces. Costs: Software development and updating. Database Management.

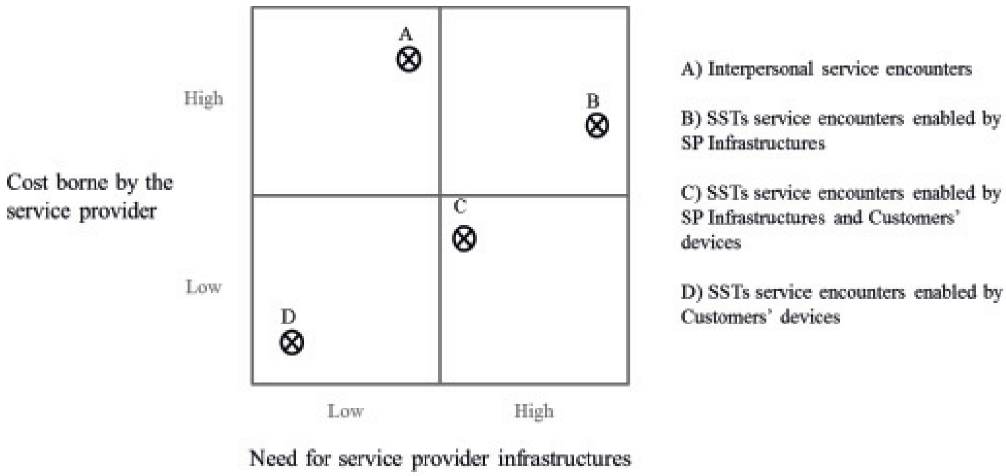

Fig. 1. Relation between cost borne by service providers and service providers' infrastructure per interface type

3. Payment and validation services in public transport sector

Service encounters are critical moments of truth in which customers often develop indelible impressions of a firm (Bitner et al., 2000). Each encounter is an opportunity for a firm to sell itself and to satisfy the customer, but also an opportunity to disappoint. Several studies have been conducted in order to explore customer satisfaction with public transport services. Researchers studied the impact of frequency of negative critical incidents on overall satisfaction (Friman & Gärling, 1999), the reasons behind poor experiences in public transport services (Hutchinson, 2011) and the customer travel experience from a holistic point-of-view (Carreira, Patrício, Natal Jorge, Magee, & Van Eikema Hommes, 2013). However, the focus of this study is in the payment and validation services concerning public transport sector. In this sector, the infusion of technology also revolutionized the overall service offerings. Formerly, the tickets were sold in physical stores, and they had to be delivered to the bus driver. More recently, ticket vending and reader machines appeared, improving efficiency and productivity.

Meanwhile, the ticketing systems also evolved. Paper tickets were the first to appear and are still widely used worldwide. Despite of being less expensive and easy to combine with other payment technologies, they are susceptible to fraud and have limited data collection capabilities. Magnetic stripe cards are also a ticketing media and although they support a high number of uses, they are susceptible to accident erasure and have a large variance in reliability. The emergence of new communication technologies like RFID or NFC enabled the development of contactless cards, which are rapidly replacing the two other types. They offer advantages when comparing with traditional payment methods such as secure data transfer, large memory capacity, high reliability and resistance to fraud. The ticketing systems mentioned so far, totally rely on service providers' infrastructure, which, according to Table 1, require large investments in acquisition of ticket vending machines, ticket readers, tickets production, storage and distribution, and maintenance costs.

Recently another ticketing system has emerged, known as mobile ticketing. This system is based on the use of travelers' mobile phone to pay for a trip. PTOs started to use the most basic mobile phone features, like making phone calls and sending text messages, to make travel tickets purchase. Paybox in Austria, Proximus SMS-Pay in Belgium and Mobipay in Spain are examples of implemented mobile ticketing systems based on SMS. While SMS can be considered a simple and easy to use technology, it has limitations when used to make payments. SMS uses store and forward technology, does not use any encryption method and there is no proof of delivery within the SMS protocol (Boer & Boer, 2009). Most SMS-based mobile payment models do provide a proof of delivery, requiring a second separate message to be sent, which increases the costs of a transaction.

The evolution of mobile phones to smart phones has broadened the range of payment possibilities, especially when technologies like NFC are added to mobile phones. Tickets can be purchased, downloaded, and accessed on the phone, and when in contact with NFC-enabled readers, the tickets are redeemed and a receipt is sent (NFC Forum, 2011). Several pilots of NFC-enabled phones have been launched in the public transport area, for instance, Touch&Travel in Germany, Czech Telefonica O2 in Czech Republic and Citi NFC trial Bangalore in India and m-Ticketing Transportation Kaohsiung in Malasia. Although NFC based ticketing systems use customers' mobile phones to purchase the ticket, they need service providers' infrastructures (e.g. NFC readers) to validate it. According to Table 1 service providers need to invest in ticket readers, maintenance and operational activities to offer this additional channel to customers. Only the SMS based ticketing systems, presented above, don't need interaction with PTOs' infrastructure, but they have the disadvantages already mentioned.

When comparing mobile ticketing with traditional ticketing systems several advantages can be outlined such as remote and ubiquitous access to payments, queue avoidance and lack of need to carry cash around. It also reduces operational and maintenance costs, as it will decrease the need of tickets production, storage and distribution, ticket sellers and collectors and cash handling. Operational and productivity gains may also be achieved, by increased throughput in closed gate systems and improved bus boarding times.

Additionally, other mobile phone features like the screen, web browser, camera and sound allow PTOs to offer more services to passengers, enhancing the customers' travel experience. Travelers can, for example, check ticket balance, access real-time traffic information and timetables and view an interactive trip planner. Therefore, this closer interaction with customers will allow PTOs to know their customers' travel behaviour, and manage a vast and important database. These patterns and preferences expressed by customers can later be used, for instance, to advise customers of fares that suits better their travel profile or to create personalised journey plans.

A new mobile ticketing solution totally independent from PTOs' infrastructure will be presented in this paper. Next, the research methodology will be explained, followed by a description of the mobile payment system.

4. Research approach

The definition of the mobile payment system was based on user-centered design process that follows the international standard 9241 (ISO 9241-210, 2010). According to this approach the design addresses the whole user experience and is based upon an explicit understanding of users, tasks and environments. This methodology was combined with Boehm, Kwan, & Madachy (1998) WinWin spiral model which suggests as iterative framework that allows ideas and progress to be repeatedly checked and evaluated. Comparing to the former spiral model (B. . Boehm, 1988), this WinWin spiral model has the advantage of involving key stakeholders throughout design and development phases in order to achieve a satisfactory outcome for each stakeholder group.

Along this line, before and during the design of the proposed system several interviews and meetings with public transport service providers, third-party agents, and technology and software companies were conducted. These allowed understanding the public transport environment and identifying service providers' needs. Also interviews with users were carried out in order to assess their needs. After this research, the needs were identified, the use cases defined and the requirements elicited. This process resulted on a web prototype of the mobile payment application, developed with Proto.io tool.

After the definition of the mobile payment system, it has been necessary to validate the concept and to evaluate the proposed prototype. Evaluation represents a very important step in product/service design, since it provides users and experts' feedback about the system (Sharp, Rogers, & Preece, 2007), and allows the identification of usability issues in the prototype before presenting it to end-users. In this case, the evaluation of the system comprised two different and complementary procedures. The first procedure was based on Heuristic Evaluation. This technique developed by Nielsen & Mohlich (1990) consists on the evaluation of an interface design by experts. Evaluators are guided by a set of usability principles (heuristics) and evaluate whether user-interface elements are conform to those principles. This evaluation was done by three experts (Nielsen (1992) recommends between three and five experts) and allowed to identify some usability problems, such as lack of feedback and undo buttons in some screens, words inconsistency and complex information presented to the users. The problems identified by the experts were solved, allowing the preparation of the next evaluation phase.

The second evaluation procedure was the usability testing. This can be seen as an irreplaceable usability practice, since it gives direct input on how real users use the system (Nielsen, 1992). This technique was combined with the administration of a questionnaire, which allowed gathering some qualitative data. The tests were conducted in a test environment, and users were randomly sampled in the campus of the University of Porto in both strata among 17-60-year-old citizens. This usability testing was divided in two phases, and each phase comprised 7 different participants (Dumas & Redish (1999) consider that 5-12 users is acceptable). The main goals of the usability testing evaluation were to check how users navigate around the application to perform a number of pre-specified tasks, and how the topics categorization was understood by the users. These tests and the questionnaires were also valuable to receive initial comments about the usefulness of such an application and the acceptance of the concept of paying with mobile phones. Further details about usability testing results can be reviewed in Ferreira, Nóvoa, & Galvão (2013). After the concept validation and prototype evaluation, an enhanced version of the mobile payments application was developed for Android devices and is being tested in real environment in collaboration with the major public transport operator from Porto city. The mobile payment system is presented in the next section.

5. Proposed mobile ticketing solution

5.1. Background

The approach presented in this paper is the result of a project involving the major PTO in Porto city and potential customers. The mobile payment system was designed taking into consideration this specific SP and its characteristics. Due to its high complexity we believe that the proposed system can be easily adapted to other realities and situations.

The Metropolitan Area of Porto (AMP) is served by an extensive public transport network which includes buses (STCP), light rail (Metro do Porto) and trains (CP – Portuguese railways). The electronic ticketing system in AMP is an open (ungated) system that required a significant technological investment, such as card readers along the platforms at each metro station and at each bus vehicle, and handheld devices for conductors.

The pricing policy implemented in the AMP is based on two types of price discrimination: journey-based and passenger-based price discrimination. The price for the journey-based perspective was settled based on a zone concept. The AMP network was divided into zones, with a flat rate within each zone, and the price is determined according to the number of zones crossed by the passenger. Once the ticket is validated, the passenger can travel, within a certain period of time, in the zone he chose. After that period of time, the traveler must validate the ticket again. The price of the tickets also depends on the characteristics of the passenger – passenger-based price discrimination. Thus, the price varies depending on whether the passenger is a child, student, senior or pensioner.

Tickets are available in several types: zonal single ticket, season ticket and multi-journey ticket. The ticketing system adopted in AMP is the contactless card – Andante – based on RFID technology. Travelers can buy the contactless cards or recharge them at ticket vending machines, SP Stores, Third Party Agents and inside the vehicle (bus). Each Andante card can only contain one type of ticket at the same time (e.g. it cannot have a Zone2 ticket and also a Zone3 ticket), but it can contain several tickets of the same type (for instance, 10 Zone2 tickets).

In order to travel along the AMP network, passengers must buy the Andante contactless card and charge it with zone tickets. Then, they must validate the travel card in the reader at the beginning of the journey, and the ticket is redeemed. There is no need to validate the Andante at the end of the journey, but travelers must validate the travel card every time they change vehicle.

5.2. Challenges

One of the main challenges of this work was to propose a ticketing solution for public transport services that requires the minimum investment cost from PTOs point-of-view, achieving at the same time the maximum consumer acceptance. The types of service delivery interfaces that require the minimum investment cost are those that totally rely on customers' devices, represented by point D in Fig. 1. The proposed system is based on customers' mobile devices, which are widely available and offers lot of functionality, and is based on wireless communication technologies (3G and/or Wi-Fi) and on location providers, such as Global Positioning System (GPS) and network triangulation. SMS and NFC technologies were not considered a viable option, due to different reasons. SMS has several limitations (already referred) and have a premium price associated. This premium price would increase PTOs costs if supported by them, or cause a low adoption of the system if supported by customers. NFC technology would require huge investments to convert existing infrastructures into NFC readers and would not represent a ubiquitous solution.

Another challenge we had to face was to guarantee the supervision of valid tickets by conductors. Since AMP is an ungated system, Porto PTO must have a way to confirm that a certain ticket still valid for a specific journey. This confirmation is visual and uses security symbols and sequence numbers. This process is described in detail in the next section. Such information can also be confirmed by assessing the backend system, in case of mobile phone's dead battery. Another concern has to do with customers' information and data gathering. It is true that PTOs have heavy infrastructures installed and incur in maintenance costs every month, but these infrastructures are powerful data collectors that helps PTOs to know customers' travel patterns and to adjust service offerings. With the proposed system we don't lose this precious information, rather we enhance it. PTOs have access to individual customers' travel behavior and preferences. This may represent a shift in public transport service delivery, since SP may direct recommendations, services and institutional and operational information and that suit a specific customer. We move from mass communication to one-to-one communication.

5.3. Prototype

According to the proposed mobile payment system the purchase and validation of tickets is made OTA and location providers are used to locate the traveler and reduce the number of options when it comes to validate a ticket, making the system easier to use. Before choosing which ticket the user wants to buy, a list with the tickets stored in his wallet is presented, preventing the user to buy tickets he already has. The user can buy the travel tickets in two ways: he chooses the zone ticket he wants to buy and selects the number of tickets for each zone (Fig. 2 – Part a), or he chooses the departure and the arrival station and the system automatically converts this information into zones. This option represents a major improvement in the actual solution implemented in Porto city, since it is very confusing for travelers to know what type of ticket they need to buy. There are about 800 routes where the outward and back corresponds to a different type of ticket. Another improvement has to do with the fact that the system can hold more than one type of ticket at the same time and several tickets of the same type. Currently, travelers must carry as many travel cards as different tickets they want to have.

To validate a ticket, location providers (GPS and network triangulation) are used to identify customers' location. From the given list of near stops the user chooses which stop he is going to enter and then he selects the ticket he wants to redeem from those stored in his virtual wallet. In order gather precious information, users must also select the bus line they are entering (Fig. 2 – Part b). This requirement allows the Porto PTO to know exactly which vehicle the user is entering, by crossing this information with time and vehicles on the road. Once the ticket is validated, the passenger can travel in the zone he chose for a certain time, and he can check the remaining time on the display. The user is also warned when the journey time expires.

Fig. 2. Mobile payment system screens: (a) buy ticket by choosing the type (zone); (b) validate ticket; (c) active ticket

If a conductor wants to verify if a traveler as a valid ticket for that journey, the user only need to show the active ticket screen on his mobile phone (Fig. 2 – Part c). This screen has information about the ticket (stop, date and type of ticket), a security symbol, and a sequence number. The security symbol, represented by the watermark image, will act as a secure element to prevent users from creating false tickets images. This symbol changes every day, and the conductor has access to it in order to know what he expects to see on customers' mobile devices. The sequence number acts also as a secure element. Each validation corresponds to a different sequence number, so the conductor will be able to verify a pattern (sequence numbers very close) inside a bus. If he identifies a sequence number very different from others, this acts as a warning sign for the conductor to check carefully the other information. In Fig. 2 – Part c this number is represented by the number 746321.

The proposed mobile payment system also comprises several additional services beyond payments in order to attract potential consumers. User can, for instance, check tickets balance, account movements, validation history, check prices and maps, and find near stations.

6. Conclusions and future research

Nowadays, companies interact with their customers through several channels, and the public transport sector is no exception. Nevertheless, each channel has different implications in terms of investment cost required from firms. A contribution of the current study is the conceptualization of the existing interfaces available and the type of investment cost they require from the company, as suggested in Table 1. Additionally a comparison between interfaces types in terms of investment cost and infrastructures needed is also provided. These representations may be useful for future research. For instance, are cheaper channels the ones that customers prefer? Is the cost per channel an important factor that influences the firms to include it in their service delivery? Whereas the proposed conceptualization was important to the current study, further research could be designed to explore these cost-company-customer relations.

Multi-interface services research and technology evolution were important drivers that allow proposing the innovative ticketing system presented in this paper. Thus, one of the main objectives was to propose a ticketing solution for public transport services that requires the minimum investment cost from PTOs point-of-view, achieving at the same time the maximum consumer acceptance. These constraints led to the decision of relying the total system in customers' mobile phones and on wireless communication technologies. Therefore, customers don't need to interact with PTOs infrastructures to purchase or validate tickets. These actions are performed OTA, and the location providers' technologies are used to locate the traveler, making the system easier to use. The user can also access to additional services that are currently scattered across different channels or even do not exist, such as access past traveling and real-time traffic information, check tickets balance, prices and maps,.

The design and development of the proposed system was based on service providers' requirements collection and on customers' needs. The concept and the system were already tested with users through a prototype. They considered the system easy-to-use, intuitive and functional. The usefulness of such a system was also consensual among participants and the major advantages reported by users were remote and ubiquitous access to payment, queue avoidance, and the possibility to have several types of tickets in the same device (Ferreira et al., 2013). The system is already developed for Android devices and will be tested soon in real environment in collaboration with the major public transport operator from Porto city. From a managerial perspective the proposed system represents a plausible solution for public transport operators that intend to broaden their service offerings, thus reaching more customers. It also represents an opportunity for service providers to reduce costs and to shorten their relationship with their customers.

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