Design and Evaluation of a Mobile Payment System for Public Transport: the MobiPag STCP Prototype

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***Abstract*— The general adoption of mobile devices and their increasing functionality allow their use to make payments. This wide-spreading reality is being applied to several sectors, including public transport. In fact, there are several advantages of mobile payment and ticketing over traditional systems, such as queue avoidance, ubiquitous and remote access to payment, and the lack of need to carry physical money. This paper presents a prototype of a mobile payment system for public transport using customers' smartphones with Internet connection. 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 purchasing or validating a ticket. This system was tested in the city of Porto, by real travellers of Sociedade de Transportes Colectivos do Porto (STCP), the main bus transport company, during their normal use of public transport services. The users considered the system extremely useful, since it is more convenient than traditional systems, improving the travelling process and experience. They also felt secure to pay with their mobile phones, and valued the fact they could access information about their journeys, tickets, and account. The ticket validation process revealed to be one of the main challenges that any payment system for public transport should address, as compared to the simplicity of traditional systems.**

Keywords–mobile payments; public transport; mobile ticketing; user experience; field trial.

I. INTRODUCTION

Mobile payment can be defined as the use of a mobile device (mobile phone, Personal Digital Assistant (PDA), wireless tablet) "to initiate, authorize and confirm an exchange of financial value in return for goods and services." [1]. For more than a decade now, several attempts have been done to use mobile phones for payment transactions. In fact, there are several advantages of mobile payments over traditional systems, such as queue avoidance, ubiquitous and remote access to payment, and lack of need to carry coins and cash [2]. For instance, the users can pay for transport tickets without the need to visit an Automated Teller Machine (ATM) or a ticketing machine [3].

In this paper, we present a mobile payment system for public transport based on customers' mobile devices that only need to have Internet connection. The purchase and validation of tickets is made OTA, and location providers are used to locate the traveller and reduce the number of options when it comes to purchasing or validating a ticket, making the system easier to use. Since the system is totally based on customers' mobile devices, Public Transport Operators (PTOs) do not need to adapt or buy new infrastructures, such as gates, ticket vending machines or ticket readers.

The system was tested in real environment in the city of Porto, by real travellers, during their normal use of public transport services. Twenty-six users tested the system during 2 weeks and were accompanied by a Facebook group created for this purpose. This evaluation method was a success, since it allowed users to report in real time their difficulties, opinions and improvement suggestions. After the experiments, individual interviews were carried out, being useful to explore additional questions related with travelling habits, security perception and mobile payment business models.

The outline of the current paper is as follows: the next section characterizes mobile payment systems and traditional ticketing systems in public transport sector. Section 3 describes the proposed mobile payment system and Section 4 details the evaluation procedure and the main results. Finally, Section 5 presents the conclusions and future research

II. RELATED WORK

PTOs already used basic mobile phone features, like making phone calls and sending text messages, to allow travel tickets purchase. For instance, Paybox in Austria allows the Austrian railway OBB customers to purchase travel tickets via Short Message Service (SMS) or through the Vodafone live! Portal [4], and enable the customers to pay through their monthly phone bills. Proximus SMS-Pay in Belgium, Mobipay in Spain and AvantixMetro in UK are other 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 [5]. 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. This problem is particularly pertinent when small payments are at stake.

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The evolution of mobile phones to smartphones has broadened the range of payment possibilities [6]. Also, when contactless technologies like Near Field Communication (NFC) were added to smart phones, more functionality became possible. 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 [7]. Several pilots of NFC-enabled phones have been launched in the public transport area. For instance, the Touch&Travel service in Germany allows passengers to make payments with their mobile phones. Travellers have to tap their NFC-enabled mobile phone to the Touchpoint device at the departing station and at the destination. The length of the journey and the ticket price are calculated at the end of the journey, and the customer receives, each month, a statement with all travel data and an attached invoice [8].

A NFC pilot was also launched in London [7], where 500 customers were given Nokia handsets with Oyster functionality. Passengers could top up their Oyster by touching their handset on Oyster ticket machines in tube stations or at Oyster tickets shops. Key findings of the research were that customers maintained high levels of interest and satisfaction throughout the trial and that the main customer benefits were convenience, ease of use, and status.

NFC was considered a good choice for mobile payments in terms of speed, security and usability when compared with traditional mobile payment service concepts, such as Interactive Voice Response, SMS, Wireless Application Protocol and One Time Password Generator [9][10]. In fact, NFC allows two-way contactless communication, offers faster connection between devices, less chance of interference, and has a shorter range, making it more secure for use in crowded places. However, NFC is failing in get critical mass, since it requires service providers to invest in new POS and NFC-reading systems and enough number of customers with NFC-enabled phones and wanting to use them to use them for payment purposes.

Bohm et al. [11] and Ferreira et al. [12] propose further mobile ticketing models for public transport based on Global Positioning System (GPS). According to these models, apart from having a smartphone with Wi-Fi and GPS technologies, the user only needs to check-in when starting a trip and check-out at the end. The customer is also located by the service provider during his trip at defined intervals. At the end of the journey, the system determines the route within the public transport network and calculates the price, which is then debited from the customers' account. This kind of system is really convenient and easy to use for customers, as they are not required to have any particular knowledge about tariffs or ticketing machines [12].

Mobile phones' features make them unique and suitable to be used to make payments and to offer additional services. Mobile phones are network-connected, have easy-to-use sound and text interfaces and provide anytime-anywhere access to information. When applied to the public transport sector, mobile ticketing systems allow PTOs to reduce operational and maintenance costs, acquire better knowledge about customers' travel behaviour, and shorten the interaction with the customers.

III. Proposed Mobile Payment System

The proposed mobile payment system is the result of a project involving the main bus transport company in Porto – STCP – and potential customers. The mobile payment system was designed taking into consideration this specific service provider and its characteristics. Nevertheless, the concept and design of the system are scalable and adaptable to other realities. In the next subsection we describe the background and the challenges beyond this development. In Subsection B, we present the architecture of the system and finally, in Subsection C, we present the system itself.

A. Background and challenges

The Metropolitan Area of Porto (AMP) is served by an extensive public transport network which includes buses (from 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 is 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 traveller must validate the ticket again. The price of the tickets also depends on the characteristics of the passenger (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 [13]. Travellers can buy the contactless cards or recharge them at ticket vending machines, Service Provider Stores and spots, 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 travellers must validate the travel card every time they change vehicle.

One of the main challenges of this work was to propose a ticketing solution for public transport services requiring the minimum investment cost from PTOs point-of-view, achieving at the same time the maximum consumer acceptance. The proposed system is based on customers' mobile devices, which are widely available and offer numerous functionalities, and is based on wireless communication technologies (3G and/or Wi-Fi) and on location providers, such as GPS and network triangulation.

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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. 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 is 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 Subsection C. 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 do not lose this precious information, rather we enhance it. PTOs have access to individual customers' travel behaviour and preferences. This may represent a shift in public transport service delivery, since SP may direct recommendations, services and institutional and operational information particularly suited to a specific customer. We move from mass communication to one-to-one communication.

B. System Architecture

The system architecture comprises three main components: server, client and conductor (see Fig. 1). The client component allows customers to interact directly with the services. This interaction is achieved through the use of a mobile phone, tablet, or any other mobile device running the Android operating system. This component allows buying, store and validating travel tickets, as well as checking tickets balance, account movements, validation history, check prices and maps, and find near stations.

The conductor component allows conductors to verify if a traveller has a valid ticket for the journey or not. The client and conductor components are integrated in the same application, in the customers' mobile phone, which removes the need of an additional device to be carried by the conductors.

The server may be considered the heart of the system, since it provides the services to the other components of the architecture. It comprises three subcomponents:

a) Database: all information is stored in a database, only accessible by server-side business logic.

b) Webpage: acts as a control panel through which the platform manager can manage all aspects of the system and access to the customers' travelling information.

c) Web service: most of the logic of the system will be processed by this component, which function as an intermediary between the customer/conductor component and the central database.

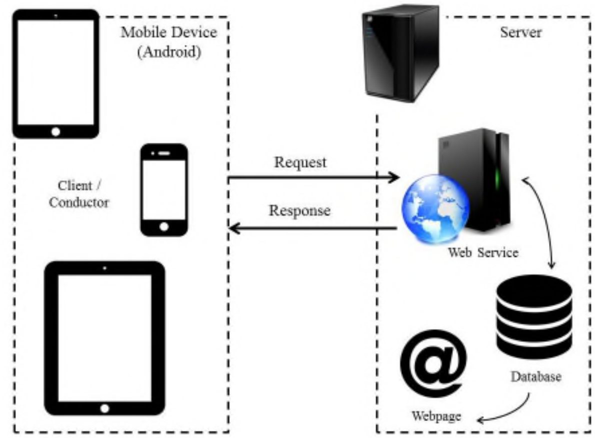

Figure 1. MobiPag STCP architecture.

C. MobiPag STCP Application

According to the proposed mobile payment system, the purchase and validation of tickets is made OTA and location providers are used to locate the traveller and reduce the number of options when it comes to purchase or validate a ticket, making the system easier to use. Before choosing which ticket the user wants to buy, a list with the tickets already stored in his wallet is presented to him, 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 (see Fig. 2 (a)), or alternatively, he chooses the departure and the arrival station and the system automatically converts this information into zones.

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 valuable information, users must also select the bus line they are entering (see Fig. 2 (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

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

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passenger can travel in the zone he chose for a certain time, and check the remaining time on the display. The user is also warned when the journey time expires.

If a conductor wants to verify if a traveller as a valid ticket for that journey, the user only needs to show the active ticket screen on his mobile phone (see Fig. 2 (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 to see if the title is valid. In Fig. 2 (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. For instance, the user can check tickets balance, account movements, validation history, check prices and maps, and find near stations.

IV. EVALUATION

In this section, we explain how we evaluated the MobiPag STCP system. Our goals were to understand users' perception about the concept of buying and validating travel tickets with the mobile phone, and to analyse the usability of the application, identify major problems and potential improvements. The next subsection explains the evaluation procedure that was used. Subsection B details the sample characteristics. The test phase is described in Subsection C, and finally, Subsection D presents the major results.

A. *Procedure*

The experiments were conducted in real environment, by real travellers, during their normal use of public transport services in the city of Porto. The recruitment and selection of the participants was carried out by STCP, who solicited participation through their website and information inside the buses. In order to get as much heterogeneity in terms of various demographic factors (gender, age, occupation), 37 travellers were selected, from which 26 participated in the tests. The users tested the application for two weeks.

There were some prerequisites that the participants had to meet in order to participate: owning a mobile phone with Android operating system, being a frequent user of public transport (at least 5 validations per week), and have Internet connection via mobile phone.

The experiments were divided in three phases:

1) *Pre-test phase:* Explanation of the evaluation process (by email and in person) and administration of a questionnaire to characterize the sample.

2) *Test phase:* The users tested the application in real environment and in the context of use of public transport services. During this phase users were accompanied by a Facebook group created for this purpose and by email, which allowed for a very detailed review in real time.

3) *Post-test phase:* In depth interviews in order to gather additional information about the experiments.

B. *Sample Characterization*

Before starting the experiments, the participants had to fill in a questionnaire that was applied online using the google drive platform. The main objective was to characterize the sample in terms of socio-demographic characteristics, and smartphone and public transport usage. Participants had also to rate, according to five-point Likert scale [14] ranging from strongly disagree to strongly agree, several statements related with the purchase and validation of tickets through traditional methods and through mobile devices.

From the total of 26 participants, 16 are male and 10 female, aged between 21 and 68 years and average age of around 34 years (see Table I). Most users (23) have a smartphone for 6 months or more, which indicates some familiarity with the use of smartphones, making it easier to adapt to the application. They are all frequent users of public transport services and about half of the users perform intermodal transhipment (bus-subway; bus-train; etc.).

Most users buy their tickets at vending machines (18) or through third party agents (11) and ATM network (9) and use both debit card (15) and money (11) to make payment. The most used additional services are checking timetables (25) and transport network maps (11), being the access to this information mostly done via the website of the operators (23) but also in stops and stations (18).

In some situations, users do not know what kind of ticket to buy to perform a certain trip. Despite considering easy to buy tickets in vending machines, it is frequent not to have change to make the purchase. The need to go to a physical store to purchase the monthly pass is considered inconvenient, especially at the end or beginning of each month because of the long queues. Users also stated that it is rather more likely to leave the Andante card at home than the mobile phone.

Regarding the purchase and validation of tickets with the mobile phones, users revealed very receptive to it, considering this payment method useful and secure, and compatible with their lifestyle and normal use of the phone. However they showed some concern about connectivity problems and short battery life that may jeopardize the completion of the payment operations.

TABLE I - SAMPLE CHARACTERIZATION

Characteristics	Number of Participants
Sample number (n)	26
Age	20-29y (11), 30-39y (8), 40-49y (4), 50-59y (3)
Gender	Male (16), Female (10)
Smartphone Ownership	More than six months (23), less than six months (3)

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C. *Test Phase*

The Mobipag STCP application was made available via Google Play two days before the beginning of the experiments, and only the authorized participants could download it. This allowed users to get familiar with the application and clarify doubts.

During this test phase, the users had to buy and validate travel tickets through the mobile application during their normal use of public transport. Since the mobile tickets had no legal value, users had also to buy and validate physical tickets at the same time.

In two weeks, the users made 723 validations with their mobile phone, in 234 different stops and 111 different routes and 36 transhipments. Analyses of Fig. 3 indicate a sharp decline of validations during the weekends and an average of 50 validations per day during the week. The users bought 24 monthly passes and made 63 purchases of single tickets.

To promote the communication among participants, it was created a group on the social network Facebook, where users were encouraged to share their experience, doubts and questions. This method was a success, since it allowed users to report in real time their difficulties, opinions and improvement suggestions. They interacted with each other by sharing their experiences and trying to solve common problems. It also allowed us to correct, in real time, any bug they reported and to gather a lot of information regarding the experience.

Every comment on the Facebook group was analysed and coded. These codes were then aggregated into categories, according to the relationships between them. After the testing phase, the participants were interviewed individually. Each interview was recorded and lasted about 50 minutes. The interviews were useful to explore additional questions related with travelling habits, security perception and mobile payment business model. The interviews content was then analysed and coded. Some codes were related to the ones founded in the Facebook content analysis, while others have led to the emergence of new categories. Regarding the problems of the application and improvement suggestions, the Facebook group comments revealed to be much richer, since they were reported in real time. The main conclusions regarding the analysis of the Facebook comments and interviews are presented in the next subsection.

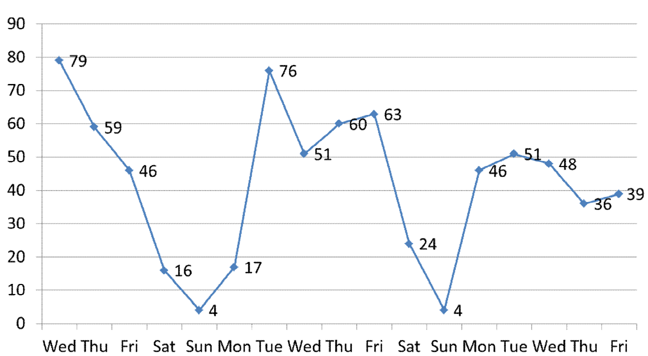

Figure 3. Number of validations per day.

D. *Discussion*

The comments on Facebook group and the individual interviews were analysed, coded and grouped in five main categories: perceived value, suggestions, concerns and issues, security and fraud, and business model. These categories were summarized in Table II and are detailed below.

1) *Perceived value*

The users liked the concept of buying and validating tickets with the mobile phone and considered the application very intuitive and easy to use. The possibility of buying tickets everywhere and anytime was greatly valued. They also found very useful the additional information about the journeys and users' account provided by the application. Such customized information, like tickets balance, remaining time of the journey, and journey details, is not possible to provide through a contactless card with no screen.

TABLE II - PERCENTAGE OF PARTICIPANTS THAT MENTIONED EACH TOPIC RELATED TO THE MOBIPAG STCP APPLICATION

Categories	% of participants mentioning the argument (n=26)	Argument in favour or against the proposed system
Perceived Value		
- Satisfaction (e.g., easy-to-use; intuitive; great functionalities (historic, purchase, remaining time))	86%	+
Suggestions		
- Improvement suggestions (e.g., PIN and password; colours; method of selecting the stops; storage and upload of personal photo)	71%	+ -
- New functionalities (e.g., languages; maps; historic of most used stops; alerts)	57%	+ -
- Application Bugs (e.g., aplicattion crashes; unknown characters; wrong alert about ending station; wrong price)	67%	-
Concerns and Issues		
- Technology (e.g., GPS bad performance)	29%	-
- Insatisfaction (e.g., takes too long to complete the validation process)	33%	-
Security and Fraud		
- Security (e.g., security when paying with the mobile phone)	71%	+
- Fraud (e.g., people may not validate tickets; use of the same account in different mobile phones)	24%	-
Business Model		
- Payment method (e.g., pre-paid account for travelling purposes)	86%	+
- Pay for the mobile ticketing service (e.g., willing to pay a modest fee for the application)	76%	+

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2) Suggestions

The participants were very active in identifying problems and bugs related to the application. The use of the social network Facebook in the evaluation process was a major advantage, since users were able to communicate in real time the bugs they were finding, and the developing team was able to fix those errors immediately.

A lot of improvement suggestions were also identified by users, such as the design and colours of the application, PIN and password procedures, method of selecting the stop (by alphabetical order, by most used, etc.). New functionalities were also suggested, such as adding new languages to the application, historic of most used stops, alerts about the expiration of a monthly pass. In Table II the topics improvement suggestions and new functionalities have the "+" and "-" signs simultaneously. These topics are a negative argument against the application because those functionalities were not (well) covered by the application, but at the same time are in favour because some of those were implemented during the tests.

These inputs were fundamental to improve the application and to set new ideas for future versions of the system.

3) Concerns and issues

The validation process was considered more complex when compared with the traditional one. Users had to choose the stop, the route and the ticket before the validation. They proposed several ideas to simplify the process: provide the last used stops, create favourite stops, and use other technologies, such as NFC or QR codes. The validation process is a major challenge in the design of a ticketing solution.

In order to facilitate the validation process, the system locates the user through triangulation or GPS to indicate the departure stop where he is. However, GPS location takes some time to locate the user and the location through mobile networks proved in many cases to be inaccurate. This meant that in most cases it was necessary to resort to a manual selection of the stops (which was thought to be used only in special cases), requiring an extra step in the validation process.

4) Security and fraud

The users felt secure to pay with the mobile phones. They even compared this system with mobile banking systems. The participants that were already familiar with the use of mobile banking applications, they felt equally safe to purchase tickets with the phone.

From service providers' point-of-view some concerns regarding security and fraud may emerge due to the inspection process. The process for conductors to check the validity of a ticket is mainly visual, which may require adding further security to the process, such as providing reading devices to the conductors.

In addition to these, there will always be risks associated with the behaviour of the people itself, regardless of the ticketing system used. For instance, some participants raised some concerns about what prevented people from validate the ticket only when they saw the conductor approaching.

5) Business Model

Most of users stated they prefer to have a pre-paid account for travelling purposes instead of having the ticketing application linked with their bank account or mobile phone bill. This is important for PTOs, since it means that users are willing to pay before they travel. This lag between the payment for the service and its provision, functions as a way of funding for PTOs.

When questioned about how much they were willing to pay for the mobile ticketing service, most users stated that they were willing to pay a modest fee for the application, but not an additional amount per ticket purchased.

V. CONCLUSIONS AND FUTURE WORK

In this paper, we presented the design and evaluation of a prototype for a mobile payment system for public transport. This system is based on customers' mobile devices that only need to have Internet connection. The purchase and validation of tickets is made OTA, and location providers are used to locate the traveller and reduce the number of options when it comes to purchase or validate a ticket, making the system easier to use.

The system was tested in real environment, by real travellers, during their normal use of public transport services in the city of Porto. The 26 users tested the system during 2 weeks and were accompanied through a Facebook group created for this purpose. After the experiments individual interviews were carried out, in order to explore additional information related with travelling habits, security perception and mobile payment business model.

The users liked the concept of buying and validating tickets with the mobile phone and considered the application very intuitive and easy to use. They also felt secure to pay with the mobile phone and valued the fact they could access to personal information about their journeys, tickets and account. They also stated they prefer to have a pre-paid account for travelling purposes instead of having the ticketing application linked with their bank account or mobile phone bill. The ticket validation process revealed to be one of the main challenges in the design of mobile ticketing systems, since the validation through traditional physical systems is very simple.

This field trial allowed corroborating the great potential that mobile ticketing systems have over traditional systems. They are more convenient (tickets can be purchased everywhere, anytime), users have access to more information about their journeys and PTOs can interact more closely with their customers, opening doors to a one-to-one communication. In order to maximize the potential of such solutions, the validation process should be as simple as possible and additional and complementary services should be integrated.

As future work, we want to improve this payment system and add additional and complementary services. It is our intention to involve further service providers beyond public transport operators, since the travellers' value constellation is composed by other players.

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REFERENCES

[1] Y. Au and R. Kauffman, "The economics of mobile payments: Understanding stakeholder issues for an emerging financial technology application," *Electron. Commer. Res. Appl.*, vol. 7, no. 2, pp. 141–164, 2008.

[2] N. Mallat, "Exploring consumer adoption of mobile payments – A qualitative study," *J. Strateg. Inf. Syst.*, vol. 16, no. 4, pp. 413–432, Nov. 2007.

[3] M. Mut-Puigserver, M. M. Payeras-Capellà, J.-L. Ferrer-Gomila, A. Vives-Guasch, and J. Castellà-Roca, "A survey of electronic ticketing applied to transport," *Comput. Secur.*, vol. 31, no. 8, pp. 925–939, Nov. 2012.

[4] "Paybox." [Online]. Available from: http://www.paybox.at/ 2014.05.22

[5] R. Boer and T. de Boer, "Mobile payments 2010: Market Analysis and Overview," Chiel Liezenber (Innopay) and Ed Achterberg (Telecompaper), 2009.

[6] A. Becker, A. Mladenow, N. Kryvinska, and C. Strauss, "Aggregated survey of sustainable business models for agile mobile service delivery platforms," *J. Serv. Sci. Res.*, vol. 4, no. 1, pp. 97–121, 2012.

[7] NFC Forum, "NFC in Public Transport," 2011.

[8] "Touch&Travel." [Online]. Available from: http://www.touchandtravel.de/ 2014.05.22

[9] M. Massoth and T. Bingel, "Performance of Different Mobile Payment Service Concepts Compared with a NFC-Based Solution," *ICIW 2009, The Fourth Int. Conf. Internet Web Appl. Serv.*, 2009, pp. 205–210.

[10] K.-Y. Chen and M.-L. Chang, "User acceptance of 'near field communication' mobile phone service: an investigation based on the 'unified theory of acceptance and use of technology' model," *Serv. Ind. J.*, vol. 33, no. 6, pp. 609–623, May 2013.

[11] A. Bohm, B. Murtz, C. Sommer, and M. Wermuth, "Location-based ticketing in public transport," in *Proceedings of the 8th International IEEE Conference on Intelligent Transportation Systems 2005.*, pp. 837–840.

[12] M. C. Ferreira, A. Cunha, J. F. e Cunha, H. Nóvoa, T. Galvão, and M. Moniz, "A survey of current trends in smartphone based payment and validation services for public transport users," in *The Art & Science of Service Conference, Maastricht*, 2012, pp. 1–28.

[13] "Andante." [Online]. Available from: http://www.linhandante.com/ 2014.05.22

[14] M. S. Matell and J. Jacoby, "Is There an Optimal Number of Alternative for Likert-Scale Items?," *J. Appl. Psychol.*, vol. 56, no. 6, pp. 506–509, 1972.