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Implementation Model for Near Field Communication in Croatian Ferry Ticketing System

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Abstract

Paper introduces framework for development of Near Field Communication based ferry ticketing system in Croatia. Four topics are discussed addressing facts and specifics of Croatian ferry lines and reasons for implementation of such solution, general Near Field Communication specifications, Near Field Communication ferry ticketing framework logic, Near Field Communication security concerns and discussion about possible advantages caused by framework implementation.

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Keywords: ferry; ticketing; near; field; communication

1. Introduction

Main objective of this article is to present possibilities of implementing Near Field Communication (NFC) technology for use in ferry ticketing system framework with respect to Croatian ferry lines specifics. Although ticketing systems based on NFC technology are being widely accepted their implementation is primary focused on mass public transportation (PT) systems like trams, railways, subways and/or busses [1,2]. The main characteristic of such PT ticketing systems is their single user or entity orientation providing end-users with possibility to electronically manage their tickets and void unnecessary time losses found in classical over-the-counter ticketing systems. While PT NFC ticketing systems are designed to process single transaction implying single entity, NFC based ferry ticketing system (NFTS) has a different challenge – it should be designed to process single transaction

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implying multiple entities. More specifically it should be able to process single transaction consisting of different tariffs for vehicles and persons. This prerequisite represents a major challenge for successful implementation of NFTS.

Current Croatian ferry operators' ticketing system represents classical over-the-counter ferry ticket system (OTCFTS) at ferry ports and characterized by almost absolute absence of any electronic payment options. Such system setup is offering very limited set of options for end-users to decide when and where to purchase their ferry tickets. Additionally based upon previous empirical experience it is also one of the reasons resulting in generation of waiting queues in Croatian ferry ports [3]. Negative characteristics of OTCFTS are especially emphasized in summer period when Croatian ferry operators are challenged to meet high ferry transportation demand with very little possibilities to influence on transportation offer side of the curve. Due to very high divergence in seasonal and non-seasonal ferry transportation demand in Croatia number of ferries is kept within optimal range meaning there is a very small variance in number of operational ferries during the whole year. The only factor left for operators to influence on is increasing a ferry line frequency which is in most cases inadequate measure to compensate for low time management quality provided by classical over-the-counter ticketing system. High ferry transportation demand in peak periods in combination with OTCFTS often results in occurrence of situation where end-users arrive to ferry ports more than several hours before they actually can start ferry boarding. Such early arrivals consequently lead to creating vehicle queues stretching out of ferry port areas and extend to connecting urban street network causing additional traffic congestions. More ironically sometimes even such early arrivals do not provide guarantee of immediate ferry boarding for end-users and result in additional waiting time needed to be spent in ferry ports until next cycle of ferry boarding can begin. The final result of such highly non-optimized process is leading to unavoidable time loss. Along with inflexible time management present in OTCFTS additional aggravating element in ferry boarding process causing additional delays represents manual ticket authentication prior to ferry boarding usually performed by ferry crew. Both mentioned facts can be clearly identified as the main obstacles for Croatian ferry ticketing system optimization. Tenable solution which would allow system optimization is implementation of electronic based ferry ticketing system.

PT NFC ticketing systems have already been proven and widely accepted as management optimization instrumentality and since their basic function is identical in PT and ferry transportation, logical assumption would be to propose NFC implementation as basis for defining a revised Croatian ferry ticketing system. Drawbacks found in current OTCFTS are not only related to end-users. They are also reflected on operators' side in form of absolute lack of timely information about level of demand to be expected in high ferry transportation peak periods. Availability of (real-time) system load information would provide quality basis for Croatian ferry operators to optimize ferry line schedule even with unchanged number of ferries in service [3].

Accordingly the main aim of this paper is to present framework for development of NFTS which would allow end-users to avoid geographical and time constraints present is current OTCFTS. Optimized ticketing system could provide additional features and possibilities for end-users like online ferry ticket purchase from their homes or any Internet enabled place or real-time information deliver about any possible delays in the system. Such information would provide end-users with more control over their time of arrival at ferry ports as well as speed up ferry boarding. At the same time implementation of NTFS would provide various advantages to ferry line operators' allowing them to acquire necessary information needed for optimization of their business process.

In respect to its defined aim this paper is structurally divided as follows. Second head describes basic concept of NFC technology with quick overview of its acceptance by end-users. Third head describes proposed framework for NFTS structure from both general point of view and at compositional level. Fourth head describes possible security concerns regarding NFC technology and its possible implications to NFTS integrity and stability. Finally fifth head concludes facts from previous heads and provides final remarks and plans for future research on discussed topic.

2. Near Field Communication technical specifications and end-user acceptance

Development of NFC standard began in 2004 when Nokia, Sony and Philips coupled together to define a standard for near field communication technology [4,5]. From technical point of view NFC is based on principles and relationship between magnetism and electricity known as inductive coupling. Accordingly NFC is sharing the same working principles as other similar wireless technologies like Bluetooth, Wi-Fi, ZigBee, Radio Frequency

Identification (RFID) and various contactless smart cards [6]. First NFC enabled mobile phone was introduced by Nokia in 2006 [4] but commercial interest in NFC enabled smartphones became popular and gained strong market acceptance in 2010 after Samsung introduced Nexus S smartphone [11]. By general classification NFC is defined as short range wireless technology requiring a distance between two devices of 10 centimetres or less (usually 4 centimetres) [6]. Its operating frequency is 13.56 MHz and is able to support data transfers of 106, 212 or 424 Kbit/s. Additionally NFC powered devices can simultaneously support one of the following three main modes of operation – reader/writer mode, Peer-2-Peer (P2P) mode and card emulation mode [7] as shown on Fig.1.

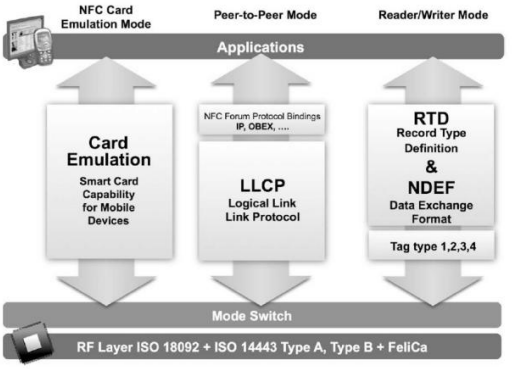

Fig.1. NFC operating modes [17].

Establishing a NFC communication requires two NFC enabled devices - initiator or active device and target or passive device. Active device is usually referred to as powered one - usually battery powered when being referred to in terms of smartphone usage but it can also be referred as the one currently transmitting data towards the other NFC enabled device which is then regardless of its power capabilities referred to as passive device. Therefore if NFC device is powered it can be both active and passive device whilst non powered devices are referred as passive devices only. NFC's attribute of simplification of first time connection and short range data transfer make it particularly suited for access control systems because it provides a strong assurance of user's current location [12].

From the scope of this paper first prerequisite for implementation of any NFC based system represents availability of NFC enabled devices which can be considered to be met as active NFC chips are being present in large number of various manufacturers' smartphones with further tendency to increase their presence by market leader brands [14]. NFC technology increased its popularity with influential technology oriented companies like Google and various financial institutions (i.e. Visa) introduced and actively promoting various NFC based services like Google Wallet [8] and various mobile payment systems (i.e. payWave). Mobile payment is considered by many experts as one of the applications with the greatest potential in this sector, as the future "star" or "killer" application in mobile communications. In such context NFTS could be defined as any kind of individual or business activity involving an electronic device with connection to a network enabling the successful completion of an economic transaction. It therefore mainly consists of completion of payments and transactions between two parties in a fast, convenient, safe, and simple way using a mobile device. Significant advantages for companies include (among others) increased versatility considering the large number of existing mobile phones, faster transactions, greater convenience, time-saving and lower costs, etc. On the other hand users experience safer interactions for economic transactions thanks to wireless technologies which permit better encryption of transaction data thus improving reliability and reducing wait times and errors among others [16].

Second prerequisite for implementation of NFTS relies on end-users willingness to accept and use NFC technology. Regarding current ratio of acceptance for different variations of mobile payment and PT ticketing systems as well as conducted empirical tests [3,15,16] this prerequisite can also be considered to be fulfilled. Having both prerequisites fulfilled next head describes Framework for development of NFTS in Croatia.

3. Framework for NFC application in Croatian ferry ticketing system

Since NFTS is implying bidirectional NFC device communication P2P NFC mode has been chosen for communication between end-users and NFC port infrastructure (NFCPI) of NFTS because it does not require any additional NFC enabled hardware like NFC tags on the end-user side. Imposing any further hardware requirements towards end-users could also increase NFTS operational costs but more importantly it could decrease model acceptance on end-user side [16] therefore it is strongly recommended to be avoided if possible.

With large number of NFC enabled smartphones already owned by end-users it is possible to establish a fully operable NFTS which could in most part completely replace existing OTCFTS allowing each end-user to make a secure on-line transaction and store all NFTS transactional data locally on their smartphone from any Internet enabled location. End-users would be given an option to initiate and make purchases days, weeks or even months prior to their actual arrival in ferry port. Such system would also be capable of providing end-users with complete set of information about ferry operator's service including information about exact time when their ferry boarding will begin. In case of any unpredicted delays in ferry operator's service end-users could also promptly be notified of any unpredictable delays and situations that might occur. As it can be seen the whole process is based on allowing users to take over their time management and providing them with information helping them to optimize their time schedule. If end-users would be presented with accurate information about their ferry boarding schedule they could decide not to arrive at the ferry port too early. This would start a chain reaction and result in positive effect on reducing vehicle queues in ferry. At the time of purchase users could also have the possibility to define their date and desired time of return allowing operators to possibly offer certain discounts for ferry service like it is a common practice in aviation [3].

On the operators' side of the framework such approach would enable ferry operators to optimize their business concept at the strategic level starting with optimization of ferry lines timetable during both high and low ferry transportation demand periods. Once again as a result of such optimization a positive chain reaction would be started allowing ferry operators to reduce their operating costs and improve overall efficiency by reallocating ferries on lines where they are most productive.

From the technical point of view there are three main elements required to setup NFTS in Croatia – server, ferry port on-site (FPOS) NFC infrastructure and end-user smartphone with appropriate client application installed. In such framework structure server is dedicated to keeping database, processing payments, issuing and keeping adequate security certificates and issuing on-line tickets. FPOS NFC infrastructure would be dedicated to fulfilling authentication process of purchased digital ferry tickets (DFT) stored on end-users smartphones against ones stored on server once authentication process has been initiated by end-user. Last element implies end-user smartphone with NFC enabled application serving as interface for system interaction with end-user as well as to (securely) keep purchased DFT data. As mentioned before end-user smartphone would also be used as initiator element once end-users reach ferry port and wish to start boarding process.

During first time usage of NFTS end-user would need to install dedicated application on its smartphone as main interface with the NFTS. Main purpose of such application would be to enable user to preview complete Croatian ferry infrastructure information – ferry ports, timetables and prices. End-user would have the option to choose certain term and make a reservation or final ticket purchase. Once initialized, end-user application should provide classic secure client-server connection to ferry ticketing server for further processing. Methods and possibilities of establishing secure connection in this particular application are based on Public Key Infrastructure (PKI) principle [15] and based on widely accepted Internet secure transfer protocols. Some other NFC related security approaches including symmetric encryption [18] or encrypted stenography graphical password scheme [12] could be applied in order to increase NFTS security.

To support purchasing functionality server would need to provide appropriate secure payment link to on-line payment processor (gateway). Upon received payment approval server should create a record of executed payment transaction in ferry ticketing database as well as store all relevant information related to payment – end-user selected ferry port, date and time of boarding, vehicle registration number, type and number of persons entitled to ferry boarding. Server should also support purchasing person only ferry tickets in which case procedure would be the same except no vehicle related data would be required and stored into ferry ticketing database. Upon successful receipt from payment gateway NFTS server would generate end-user specific data – unique DFT. Process of DFT

generation should be primary based on maintaining security level high while taking into account generation of just one file (smallest possible in size) to keep future end-user, FPOS and NFTS infrastructure communication transfer rates as high as possible. This request originates from NFC technical specifications and defined transfer speeds where even at lowest supported speed of 106 Kbit/s (13.25 Kbyte/s) NFTS should provide support for fastest possible ferry boarding authentication and avoid creating any kind of delays. More detailed NFTS end-user to server communication logic is presented on Fig 2.

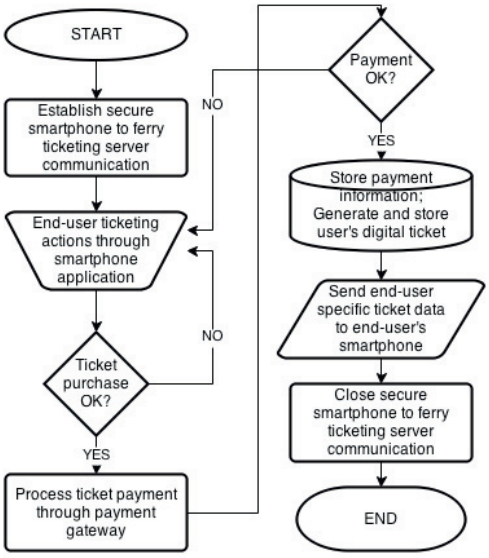

Fig.2. NFC ferry ticketing system end-user to server communication logic.

NFTS framework could be based on simpler communication logic requiring smaller amounts of data to be exchanged between end-user and NFTS server where end-user application would only be in charge of establishing a secure connection, fetching, displaying and generating unique user identification (UID). No other NFTS data would be stored on end-user side except the UID whilst all other data would be kept on server side of NFTS. Even simpler this approach could have a serious deficiency in state of any system unavailability (although not very probable) when end-user would have absolutely no proof of ticket purchase, leading to authentication denial therefore it will not be discussed.

Initiating end-user boarding process in ferry port would only require single end-user action – launching NFTS application installed on smartphone and bring smartphone closer to FPOS NFC infrastructure and begin DTF authentication. Once initiated such transaction should not last longer than several seconds. For better understanding of the process NFTSC FPOS authentication logic is presented on Fig.3.

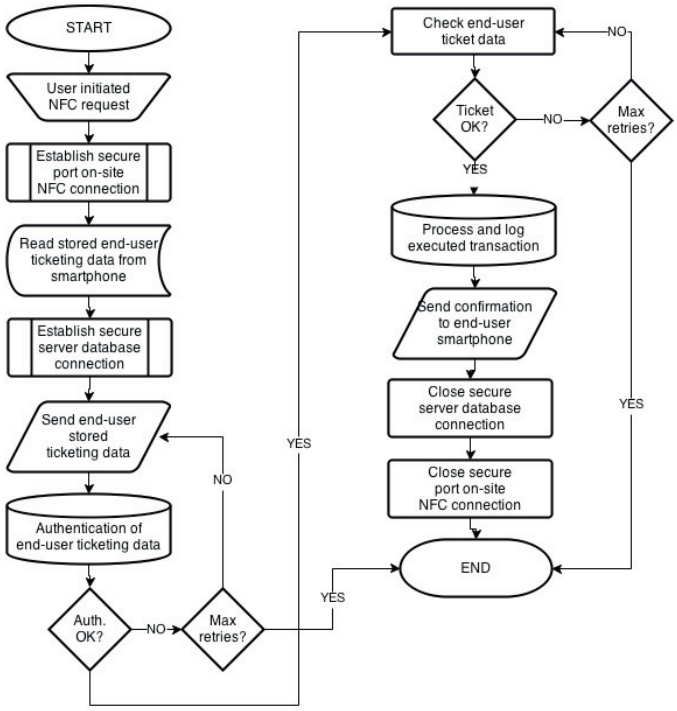

Fig.3. NFC ferry ticketing system port on-site authentication logic.

End-user ferry boarding process would start at the time end-user brings closer NFC enabled smartphone and active NFTS application to FPOS infrastructure. Next step implies establishing secure connections between end-user and FPOS infrastructure and FPOS infrastructure and NFTS server. Once secure connection is established NFTS DFT data would be securely transmitted to NFTS server via FPOS infrastructure. Upon successful receipt by NFTS server would first run authentication of received DFT and if successful proceed to checking DFT data. As a measure for reducing technical errors if any of latter steps would fail system could be setup to retry executing it certain number of times. If end-user DFT was successfully authenticated and validated transaction data would be logged on NFTS server and DFT would be marked as used and confirmation would be sent to end-user application. Finally NFTS server to end-user communication channel via FPOS infrastructure would be closed. In a final step FPOS infrastructure would be instructed to allow ferry boarding (in form of removing some sort of physical barrier). Once the whole process is finished FPOS would be ready to repeat the whole procedure when next end-user in queue approaches and initiates authentication process again.

Security concerns as well as security measures to prevent them between NFTS and FPOS and NFTS and end-user communication have already been addressed but due to the nature of NFC technology it is still possible for certain security issues to occur. Therefore next head will provide brief overview of such possible NFTS and FPOS security issues and propose solutions to eliminate them.

4. NFC ferry port ticketing system security concerns

NFC classification as short range wireless technology defines it as most appropriate technology for use in ferry ticketing system. It represents widespread technology present in large number of smartphones which makes it widely applicable and its short range of operation makes it highly preferable option from security point of view. Although theoretically is possible to intercept even such short distance wireless communication, the fact only one device can be transmitting data at the same time during (serial) communication and fact maximum of two devices

can communicate with each other at the same time makes it the hardest one to compromise in terms of wireless communication security [9]. To assure complete protection of NFC communication once end-user reaches desired ferry port and initiates DFT authentication between NFC enabled smartphone and FPOS infrastructure, certain level of security measures must be implemented within communication logic between end-user and FPOS NFC infrastructure. This step is primary related to assuring additional security layer for NFC regarding its classification as wireless based technology which could not be immune to commonly known wireless attacks [9]. Certain alternative security solutions which could be used have also been mentioned this process but since there is no evidence of their thorough security validation and verification, as a starting point only existing and proven principle of asymmetric keys encryption based on PKI used in everyday Internet client-server communication [10] as shown on Fig.4 should be used.

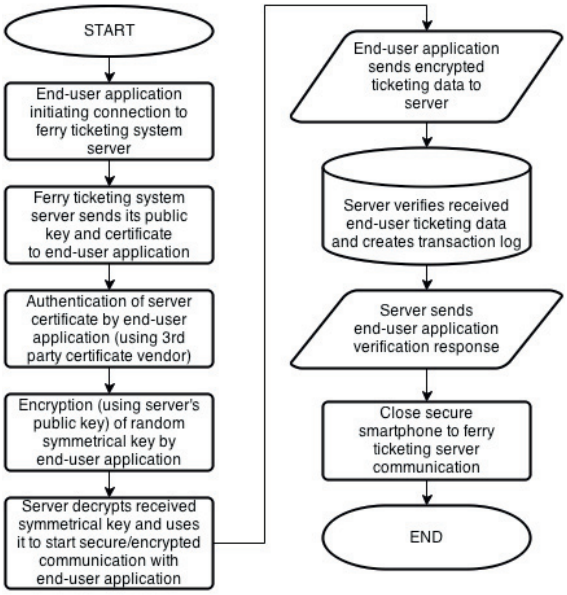

Fig.4. NFC ferry ticketing system end-user to port on-site enhanced security logic.

Described security logic should provide adequate level of protection for communication between end-user and FPOS NFC infrastructure and make it immune to various wireless attacks more precisely to interception and manipulation of end-user DFT. Empirical NFC security tests concluded [9] only possible threat in NFTS application represents denial of service (DOS) kind of attack which if successful would cause overflow of data transmitted towards FPOS NFC infrastructure and therefore no communication would be possible with it. Even in case of such scenario, FPOS could easily stay fully operable with additional optical (bar-code) reader built in. If secure NFC communication could not be established between end-user NFC enabled smartphone and FPOS NFC infrastructure, end-user NFTS application could render and display adequate DFT UID in form of certain optical code (i.e. bar or QR code). Such solution would provide satisfactory level of FPOS operational redundancy by diverting communication between end-user and FPOS from wireless to optical. The whole process could be completely automated and would not require any additional end-user interaction with FPOS. Based on described security logic as well as NFC technical specifications it can be concluded how NFTS represents reliable solution from security point of view with smallest security risks regarding to other available wireless technologies.

5. Conclusion

NFTS framework presented in this paper represents one of many possibilities NFC technology can offer in order to achieve certain level of system automation and optimization. Technical specifications as well as widespread NFC hardware components in form of NFC enabled smartphones provide excellent platform for development and implementation of transportation ticketing system. Although such systems are nowadays widely present in urban mass PT systems their implementation in form of ferry ticketing system has not yet been recognized. One of reasons for lack of such implementation definitely could be somewhat different nature of ferry transportation system defined by several very different factors like demand level, number of ferries, ferries' navigating speed and destination distance and weather conditions. All of the mentioned factors can cause ferry transportation system to become irregular compared to other means of urban mass public transportation systems. On the other hand this very same irregularity provides a great platform for optimization of such system. Since all the needed software and hardware prerequisites for development of such system have been met in form of already widely used technologies like NFC, server-client communication, databases and secure connections from technical point of view this implementation of such system is completely feasible.

Except technical feasibility implementation of NFTS in Croatia would definitely bring various positive effects for both end-users and ferry line operators' respectively. Since highest demand for ferry transportation in Croatia is closely related to summer period and peak of touristic season providing end-users with possibility to plan and control their vacation would have positive effects on their overall perception of Croatia as well organized touristic destination. Implementation of NFC in ferry ticketing system should result in simplification of the whole ticketing retail process and providing more comfortable way of purchasing tickets on end-user side. End-users would have access to the real-time information about time of boarding including real-time (instant) distribution of any service related information like delays or special offers as well as distribution of any related tourist offers. For example if end-users arrive at ferry port too early they could be offered to visit certain landmark(s) at a discounted price.

Since no additional hardware requirements are set towards end-users in order to use NFTS it would definitely make it more popular and user-friendly as one of the main prerequisites any new system should meet. At the same time implementation of NFTS should also have positive effects on ferry operators' side in a manner of much better statistical control over real demand for ferry transportation on Croatian ferry lines. Such approach would definitely allow enhanced cost-benefit analysis and detailed planning of operational and capacity optimization of each ferry line served in Croatia. System allowing ferry line operator to know the exact number of users at any time would easily allow them to optimize their lines capacities in form of number of ferries and their capacities as well as their frequency also leading to optimizing generation of vehicle queues in ferry ports. Such statistical data would also provide basic information on future planning on operators' fleet [3].

Implementation of NFTS should also show benefits to the third parties such as government allowing better control over preference tickets issued to inhabitants of Croatian islands and also help reduce number of their misuses. Since Croatian island inhabitants enjoy subsidized privileged prices of ferry transportation certain statistical data indicates certain level of inconsistency especially in summer period. Finally implementation of NFTS would provide basis for defining and managing national traffic flow origin-destination (O-D) matrix [3].

Regarding discussed NFTS framework implementation it is of great importance to conduct further both scientific and empirical research. NFTS framework implies development of both software and hardware components, end-user smartphone application and NFTS database as well as hardware component in form of designing best suited FPOS NFTS infrastructure. Empirical test should be conducted to provide results for choosing optimal NFTS security protection model. Overall efficiency of NFTS greatly depends upon defining adequate solution in form of physical barrier in charge of ferry boarding. Most crucial part of NFTS would be to have denied boarding requests canalized away from ferry boarding area in shortest possible time. Therefore special attention must be given to development and empirical testing of FPOS infrastructure in order to retain system integrity in peak periods. After all elements have been individually proven final integration test must be conducted to assure full NFTS stability. Presented facts clearly indicate great possibility of implementation of NFTS system in Croatia.

6. References

[1] Swedberg, C., ORCA Puts Ferries, Buses and Trains on One Ticket, retrieved 2014-10-01, from RFID Journal: http://www.rfidjournal.com/articles/view?5320/, 2009-10-22
[2] Sharma, T., RFID tags from UPM Raflatac streamline ferry traffic to Hailuoto., retrieved 2014-09-15, from "rfid ready": http://www.rfid-ready.com/200812126558/rfid-tags-from-upm-raflatac-streamline-ferry-traffic-to-hailuoto.html, 2008-12-12
[3] Zupanovic, D., Advanced ferry ports infrastructure capacities management system; Scientific master's thesis, Faculty of economics and business, Zagreb, October 2011.
[4] History of Near Field Communication, retrieved 2014-10-09, from NearFieldCommunication.org: http://www.nearfieldcommunication.org/history-nfc.html
[5] Vanderkay, J., Nokia, Philips And Sony Establish The Near Field Communication (NFC) Forum, retrieved 2014-09-20, from NFC Forum: http://nfc-forum.org/newsroom/nokia-philips-and-sony-establish-the-near-field-communication-nfc-forum/, 2004-03-18
[6] About the Technology - NFC and Contactless Technologies, retrieved 2014-10-01, from NFC Forum: http://nfc-forum.org/what-is-nfc/about-the-technology/
[7] NFC Forum Technical Specifications, retrieved 2014-10-01, from NFC Forum: http://members.nfc-forum.org/specs/spec_list/
[8] Google Wallet, retrieved 2014-09-10, from Google: https://www.google.com/wallet/
[9] Ernst, H., Breitfuss, K., Security in Near Field Communication (NFC),Philips semiconductors, Gratkorn, 2012
[10] Mozilla Developer Network contributors, Introduction to Public-Key Cryptography, retrieved 2014-10-10, from Mozilla Developer Network: https://developer.mozilla.org/en/docs/Introduction_to_Public-Key_Cryptography, 2012-10-26
[11] Want, R. , Near field communication, Pervasive Computing, IEEE, 10(3), 4–7, 2011.
[12] Cheong S.N., Ling H.C., Teh P.L., Secure Encrypted Steganography Graphical Password scheme for Near Field Communication smartphone access control system, Expert Systems with Applications , Elsevier, 41, 3561-3568, 2014
[13] Reina D.G, Toral S. L, Barrero F, Bessis N, and Asimakopoulou. E. The role of ad hoc networks in the internet of things. Internet of Things and Inter-cooperative Computational Technologies for Collective Intelligence, Springer Berlin Heidelberg, 2013, pp. 89-113
[14] NFC ICs and Devices, retrieved 2014-11-10, from ABIresearch, https://www.abiresearch.com/market-research/product/1008132-nfc-ics-and-devices/
[15] León-Coca J.M., Reina D.G., Toral S.L., Barrero F., Bessis N., Authentication Systems Using ID Cards over NFC Links - The Spanish Experience Using DNIe, Procedia Computer Science, 21, Elsevier, 2013, 91- 98
[16] Liébana-Cabanillas F., Sánchez-Fernández J., Muñoz-Leiva F., Antecedents of the adoption of the new mobile payment systems : The moderating effect of age, Computers in Human Behavior, 35, 464–478, Elsevier, 2014
[17] NFC Forum Specification Architecture, retrieved 2014-10-01, from NFC Forum: http://nfc-forum.org/our-work/specifications-and-application-documents/specifications/
[18] Su H., Wen X., Zou D., A secure credit recharge scheme for mobile payment system in public transport, IERI Procedia, 4, Elsavier, 2013, 303-308