Paper ticketing vs. Electronic Ticketing based on off-line system 'Tapango'

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***Abstract*—An electronic voucher system, which intended to replace paper vouchers by an electronic wristlet was developed by the e-lab, Artesis' research lab. This project has lead to the development of the Tapango system. The NFC technology has been used to create one, universal "wallet" for different events, the system is an attempt to replace paper ticketing services used nowadays. In this paper we provide a valid comparison between electronic and paper ticketing system by means of user feedback, benchmarking and real-life test cases.**

***Keywords*-Electronic ticketing; Paper ticketing; NFC; Mifare; Tapango; Electronic wallet;**

I. Introduction and Goal

Recently an electronic voucher system has been developed by the Artesis University College of Antwerp, to replace different paper tickets and vouchers by one electronic wristlet[1]. Since it was a proof-of-concept, there were still some concerns about performance, privacy, usability and security. Their work was adapted and continued by researchers from the e-lab research group at the Artesis University College in cooperation with 1OK Solutions to create a system that would meet the specifications and would be commercially available during the summer of 2009.

A few advantages that an electronic ticketing and voucher system have compared to the paper system are: people are able to buy their entrance ticket, drink vouchers and food vouchers in advance, all downloaded on one card. People can use their mobile phone to order tickets "over the air", instead of waiting in line at the cash registers for paper vouchers. Event organizers will have detailed logs about the consumption of different vouchers and tickets which is helpfull in planning resources in future events.

But is an electronic ticketing system really that much faster than a paper system? Will customers agree with the vision that one, compact card is easier than normal tickets? Will event organizers be convinced by a system that provides protection against reselling vouchers, but does not provide a physical proof of vouchers exchanging hands? These are some of the questions we aim to answer in this paper.

Using a new technology like NFC sounds promising, but doesn't it lack the speed or user-friendliness to compete with a traditional system? In this paper we discuss the pros and cons of the Tapango system, based on user feedback and timing benchmarks.

Two kinds of feedback were accumulated at several test cases: technical feedback and user feedback. Because all electronic payment systems are different we describe in the next section how the Tapango system works, including a brief overview of the NFC technology. Because it's an semi-offline system different steps influence the outcome of the benchmarks. Next, we will explain what methods we used to gather comparison data. Later on we discuss the results and conclude in the last section.

II. Tapango, it's easy

Depending on the event organizer, certain functionalities may or may not be enabled for a certain event. The main structure of the system and the way of working remains the same for every event. In this section we step through the system from the day posted on the website until the day of the event itself. We start with a brief overview of the technologies used and give a system architecture sketch.

A. NFC

NFC or Near Field Communication is a technology for wireless communication based on the ISO 14443 RFID [2] standard for contactless smartcards. Whereas RFID technology is mostly used in a wider communication area over larger distances, NFC, as its name states, focuses on the communication between two devices who are in very short range(approximately 10 cm theoretically)[3][4]. It operates at 13.56 MHz and transfers data at a rate of up to 424 kbits/s. Within the Tapango system different NFC devices are used:

- Active devices: an NFC enabled cell phone, an ACR88 terminal and ACR 122 card reader
- Passive device: in this case a Mifare Classic 1k card or another NFC cell phone operating in card emulation mode.

B. Mifare

Mifare is a trademark of NXP semiconductors and is a contactless smartcard working based on the ISO 14443 type A 13.56 MHz standard [2]. Because more secure cards are pricier and Mifare Plus was unavailable at the start of development, Tapango uses the Mifare Classic 1k . Which lends itself easily to this kind of distribution due to its low cost and portability to Mifare Plus. Each card is equipped with a unique ID, referred to as the Mifare-ID. Basically the card functions as a storage device for the electronic vouchers and can be used in various applications.[5] A drawback to the Mifare Classic 1k is that it has been cracked multiple times by researchers at the Radbaud University College.[6]

C. Architecture

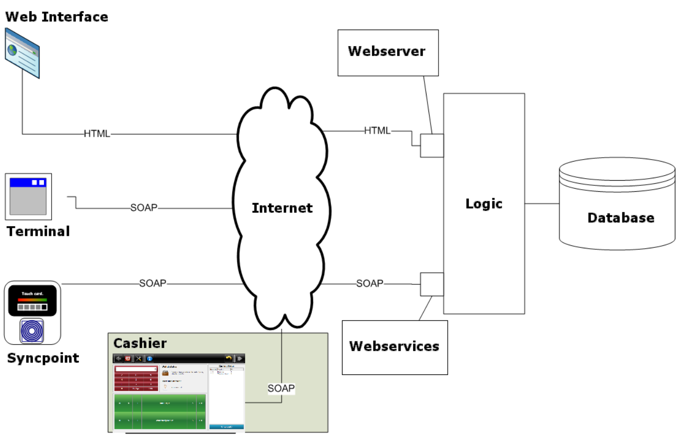

Figure 1. System Architecture

- Cashier: *vouchers are sold to the user and instantaneously downloaded to the e-Wallet*
- Webinterface: *users can pre-order tickets and vouchers on the event's website*
- Terminal: *vouchers are deducted from the e-Wallet, stored locally on the mobile terminal and via the terminal application uploaded back to the server*
- Syncpoint: *the pre-ordered vouchers are downloaded to the e-Wallet, it also serves as a place where users can consult their credit*
- Server: *all pre-ordered vouchers are stored untill they are downloaded on the e-Wallet and it contains multiple discount solutions. The vouchers are stored in the user's vault*

D. Tapango

All transactions within the Tapango system can be split into two groups. First everything until the day of the event, secondly everything that happens at the event itself. Other features and options are available for users and for event organizers, but they are not relevant in our comparison between the two systems. We decided only to take the voucher transactions into account because pre-event actions are less time critical.

1) Pre-event actions: An end-user can register on the webinterface, his account will be linked to his personal wallet upon receipt. As soon as pre-sale starts for a desired event the user can order tickets and vouchers on the same webinterface. Then he can, select his payment method and confirm his order.
If a user owns an NFC card reader he is able to synchronize his e-Wallet before he attends the event. Currently few users own such a reader, so they have to synchronize their e-Wallet at the event, as described in the next section.

2) At the event: When the user arrives at the event there are several different scenarios, depending on the fact whether the user already owns an e-Wallet. In order not to skip any steps we will describe it as if it were his first time.
The first thing the user does is pick up his e-Wallet and link it to his identity, this is done by an employee at the event. The user then heads over to one of the "SYNC points" spread across the event and touches it with his e-Wallet. The e-Wallet's unique ID is read, sent to the server to see if there are any vouchers in the user's "vault". The SYNC point moves these to the e-Wallet. Then the SYNC point displays the vouchers present on the user's e-Wallet in a summary so the user can consult his credit. This process is known as synchronizing or syncing the e-Wallet and it happens, on average, in only a two seconds.
With all vouchers present on his e-Wallet the user can enter the event. If the correct entrance voucher is present on the e-Wallet, the entrance terminal displays a notification, granting the user access to the event.
At the food and drink stands the user places his order after which a staff member asks the user to touch his e-Wallet against a mobile terminal. The terminal then deducts the vouchers as selected by the staff member from the e-Wallet and stores them in its memory. To minimize users finding themselves with a shortage of vouchers to pay for their order, SYNC points are placed near the stands so he can consult his credit before ordering. If the user runs out of vouchers, he can buy new ones at a cashier. At the cashier the unique ID is read and the user specifies the amount of vouchers he would like to receive. The order is sent to his vault and is synchronized on the e-Wallet again as described before.

E. Connectivity

During the whole round trip numerous network processes are used. In the test cases everything until the event is done over the Internet as described in section II-D1
When the pre-sale period ends, a local server containing the data of the event is set up at the event itself. The cash registers and SYNC points are connected to the server, they have to be online for logging and security purposes. The ideal image for the future is that everything is connected to the Internet and you can order your vouchers directly to your cell phone at the event, without even having to go to a cash register. This only works if you have an NFC enabled

cell phone.

III. User Feedback

To properly evaluate the system we retrieved data in two manners: the userfeedback is explained further on in this section, for the benchmark results see section V.

Because this study is a comparison between two systems, where one has the intention to replace the other, we figured that user acceptance is a key factor to success. Taking the resources, opportunities and the possible response rate into account we decided that the best way to collect user feedback was a closed-question questionnaire, with additional open interviews [7].

A. Technology Acceptance Model

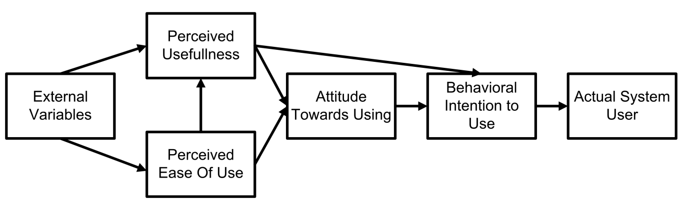

Figure 2. Technology Acceptance Model

The Technology Acceptance Model, as seen in fig 2, is a proven instrument in anticipating user behavior, which states that there are two main determinants influencing the intention of a user accepting and using a certain system[8] [9]. The first one being perceived usefulness, which can be defined as the extent to which the user believes that the proposed system will improve his performance. This is also influenced by the second determinant: perceived ease of use, which can be defined as the degree to which the user believes that using the system will be free of effort. This relation is very important, because a user can agree that a system is useful but at the same time believe that it is too complex to use.

Together with undetermined external variables these factors result in an attitude the user has towards the system. That attitude combined again with the perceived usefulness forms the intention to use the system, which results in the user (not) using the proposed system. TAM has been revised extensively over the years resulting in multiple extended, improved and adapted versions of the model. Several accepted revisions take factors such as job experience, gender, job relevance and voluntariness into account.[10] We decided that these factors could be slightly relevant in explaining the questionnaire results, so a couple of them were taken into account in creating the questionnaire for the final test case. They are discussed in section III-D

B. Hypotheses

Taking the Technology Acceptance Model and the aims of Tapango into account, we created multiple hypotheses to be evaluated. Compactness, speed and cross-event usability are three main goals included in the Tapango system, so user acceptance will be high. This leads to the following hypotheses:

- Hypothesis 1: *compact e-Wallet design will have a positive influence on perceived usefulness.*
- Hypothesis 2: *a reasonable speed of transactions will have a positive influence on perceived usefulness.*
- Hypothesis 3: *potential universal use at multiple events will have a positive influence on perceived usefulness.*
- Hypothesis 4: *a self-explanatory and attractive interface or flow will have a beneficial effect on perceived ease of use.*
- Hypothesis 5: *a high sense of security and reliability will have a positive effect on perceived usefulness.*
- Hypothesis 6: *the implementation of the system at events of a well known organizer will have a positive effect on behavioral intent.*
- Hypothesis 7: *adding an extra incentive to using the system will have a positive effect on acceptance.*
- Hypothesis 8: *users will prefer an electronic ticketing system.*
- Hypothesis 9: *behavioral intent is influenced by perceived ease of use and perceived usefulness.*

Keeping these hypotheses in mind, a questionnaire was created which asked people about their opinion and vision concerning the Tapango system. With the answers it would be possible to reject or validate to the hypotheses.[11]

C. Statistics

In order to eliminate false results, every questionnaire was designed with positive and negative statements and a control question. If doubt remained after a full review, the questionnaire was considered to be an outlier and was not taken into account. The valid results were then used to perform one-proportion z-test on the hypotheses and to create confidence intervals.

D. Results

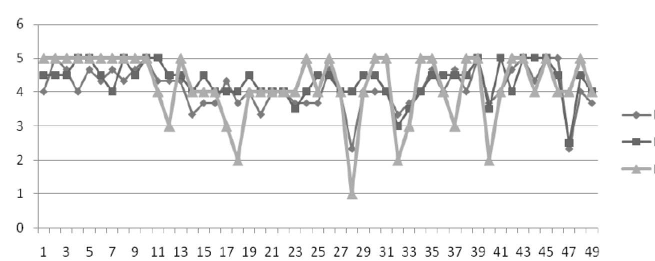

Figure 3. Perceived Usefulness(PU), Perceived Ease of Use(EOU) and Behavioral Intent(BI)

Figure 3 shows that when the average perceived ease of use is strongly lower than the average perceived usefulness, the behavioral intention is low as well. These are cases in which a person might find the system useful, but does not want to put in the extra effort to work with it. If we evaluate this graph, we can state that only 8.16% of the visitors would prefer a paper ticketing system over the Tapango system, another 8.16% is indecisive about using one over the other and 83.67% is nearly or fully convinced about using the Tapango system. We keep in mind, however, that most of the visitors were electronicly educated people who probably are excited about new technologies and are more willing to use similar systems than the average user in the target audience.

IV. Test cases

The second important factor is the time each system (Tapango and traditional) takes to complete a same amount of orders, this is the only property both systems have that can be measured in absolute values. This was done by a benchmark in specific test scenarios with specific users as is explained in the next section. In order to improve the system it had to be tested extensively and since the target audience are people from every age group with variable computer skills, this could not just be done internally in our research institute. Therefore, we did different test cases throughout the development of the system, each of them growing in size as the development progressed. In order for the system to be competitive, it needed to have an equivalent for every aspect used during the normal way of procedure for every event.

V. Benchmark

In section IIIall results were mainly formed by the opinion of visitors or staff members by means of a questionnaire and interviews. These results, though useful, could possibly be biased by random events or preferences of the questioned person at that time. The best way to fully answer our research question was to make a comparing study between the electronic Tapango system and a paper voucher system.

A. Setup

In order to create an environment with equal parameters for both systems, some variables from the normal round trip those independent of the system not influencing its performance were removed.[12] Keeping this in mind the following actions needed to be eliminated from the round trip:

- Cash payment for vouchers at the cash register: this action is identical in both systems, but is not influenced by any part of the systems.
- Bartender making orders: the same can be said for this action. Since the time it takes for every order to be made is different depending on the bartender and the order itself, this action can be eliminated.

These eliminations results in the following round-trip:

- The user hands over his e-Wallet at the cash register and orders vouchers / User orders paper vouchers
- The cashier enters and confirms order, synchronizes the e-Wallet and returns it to the user / Cashier counts and hands over the correct paper vouchers
- The user places an order with a bartender, who deducts the corresponding vouchers from the user's e-Wallet / receives the corresponding paper vouchers from the user

This procedure provides an early indication that more actions are required with the Tapango system. To retrieve enough data several trials were set up with a group of users performing both round trips. First, a benchmark was held with five end users, a cashier and bartender, containing five sessions for every system. A session consisted of users repeating the round trip until fifty predefined orders were made. The orders were randomly distributed over the session, but were identical for every session in order to create an identical environment.

In total two hundred fifty orders were made in every system for a total of five hundred orders. The cashier and bartender's functions were performed three times by people who had no previous experience with the system. The two other sessions contained an experienced cashier and bartender. It was an important parameter to evaluate if an experienced user would have a beneficial effect on the systems' performance time. A minimum of four participants was required for the benchmark to exclude the external parameter of time intervals between orders. Every order was placed right after an other one was finished, simulating rush hour at the food- or drinks stands

In another benchmark both an experienced and an unexperienced user were asked to complete a hundred round trips on the Tapango system. They performed eighty round trips with paper vouchers. Finally, an experienced user performed another hundred round trips on the Tapango system, fifty with the cash register web application and fifty with a touchscreen and embedded SYNC point. All sessions were timed individually for further evaluation.

B. Results

1) Benchmark: Taking the average of five sessions, the Tapango system scored an average of thirteen minutes, fifty-one seconds and seven hundreds (13'51,07") or an average of 16,62 seconds per transaction. The paper ticketing system scored an average of ten minutes, five seconds and ninety-four hundreds (10'05,94") or an average of 12,12 seconds per transaction. Fig. 4 shows the individual timing for every session, as well as the average, in seconds. In this figure you notice the experience difference between the Tapango sessions. The first two sessions used a person already familiar with the system, which created a time difference of about sixty seconds or 1,2 seconds per transaction.

2) Individual Round Trips: Fig. 5 shows a comparison of the first hundred round trips performed on the Tapango

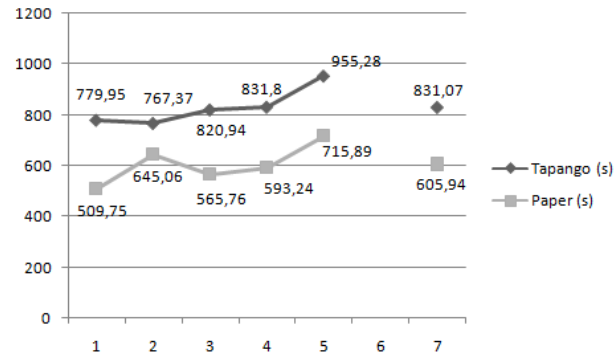

Figure 4. Timing for each session (in seconds) with the average on the right

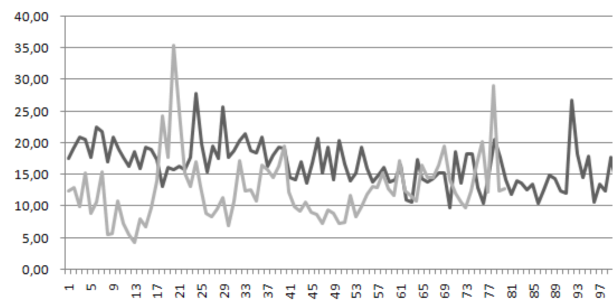

Figure 5. Comparison of individual round trips Tapango (dark) vs paper vouchers (light)

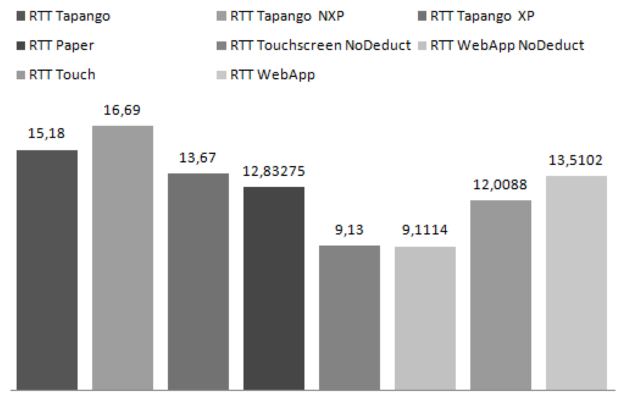

Figure 6. Average times of the different measured round trips

system and the eighty individual round trips with paper vouchers. Again it is noticeable that a system with paper vouchers is faster than the Tapango system. The average round-trip-time of the Tapango system was 15,18 seconds opposed to 12,83 seconds for paper vouchers. However, when examining the graph for the latter fifty round trips, it shows that both lines overlap. This can be explained by the average timing for the experienced user, which is 13,67 seconds per round trip and only 0,84 seconds slower than the average paper voucher round trip. The average round-trip-time for the unexperienced user scores higher at 16,69 seconds. A remarkable result in the individual timings showed that the RTT for Tapango practically remained constant, independent of the amount of ordered vouchers. Whereas the RTT for paper vouchers rose along with the amount of ordered vouchers. Logs from different events (conferences, parties and concerts) show that the average user on parties or festivals is more likely to exchange multiple vouchers at once. This speaks in the advantage of the electronic system.

As a final comparison we include the round trips measured with a cash register on a touchscreen as shown in fig. 6. The difference between the touchscreen and the web application is that the e-Wallet's Mifare-ID is automatically provided and the order is placed by touching the screen. This makes the input actions less complex. The implementation with the touchscreen includes an input for the cashier to confirm the payment. A further investigation makes it seem that both solutions provide the same round-trip-time. However, if we take the average time of confirming the payment into account (1,52 seconds) a slight difference is noticeable. The average time for the touchscreen is 12,01 seconds, which is 0,82 seconds faster than the average round-trip-time of the paper voucher system. This can prove to be very beneficial since it is a possibility that (part of the) cash registers at an event are automated with this implementation allowing the users to place their own orders.

VI. Conclusion

Taking all time comparisons into account we can conclude that the Tapango system is slightly slower than its paper counterpart. However, these time differences of less than a half second per round trip are hardly perceived by the end user and do not disturb the acceptance of this new electronic ticketing and voucher system. A remarkable result in the individual timings showed that the RTT for Tapango practically remained constant, independent of the amount of ordered vouchers. Whereas the RTT for paper vouchers rose along with the amount of ordered vouchers.

If we combine these results with the user feedback of both everyday users and reputable names in the NFC business (at the WIMA NFC Conference, WCTI Expo, etc.), it seems that a system like Tapango has the potential to replace the traditional system. Where paper ticketing systems have possibly ran out of creative advantages, a universal, electronic ticketing system is only just starting to show its possibilities (eg. the implementation of a touchscreen in an automated cash register for a quick self-service system, similar to the automated parking payment terminals). The rapid evolution of technologies nowadays can be an advantage for the breakthrough of electronic ticketing systems. Eventually the system will convince either the intended end-users or the event organizers of its convenience. It is likely that this can be done by expressing technological qualities such as compactness and trustworthiness, which are highly valued by end users as replacements, and maybe adding a little extra incentive to set off a first reaction. To conclude the comparison it is fair to state that paper ticketing systems are an established value at events and provide few effort in event logistics. Taken into account that the Tapango system is a semi-online system, we could conclude that a full online system would even take longer for a RTT. The advantage of these online systems lies in the “touch time”. While a semi-online system requires almost half a second of “touch time” the online system needs only about 100 miliseconds, which seems faster to the user. The semi-online and online ticketing and voucher systems each have their own advantages and disadvantages. However, the Tapango system can already be considered a decent electronic equivalent for a paper system and has the potential to exceed this convenience by matching the speed of transactions, its perceived usefulness and ease of use as seen by the end-user.

References

[1] K. Hellinx, T. V. Daele, I. Mees, and R. V. Mol, “The event manager, an nfc proof of concept,” Master’s thesis, University College of Antwerp Departement of industrial Sciences and Technology, 2008.

[2] ISO/IEC 14443, *Identification cards - Contactless integrated circuit cards - Proximity cards.* ISO, Geneva, Switzerland.

[3] S. Ortiz Jr, “Is near-field communication close to success?” *Computer*, vol. 39, no. 3, pp. 18–20, 2006.

[4] G. Madlmayr, J. Ecker, J. Langer, and J. Scharinger, “Near field communication: State of standardization,” *INTERNET OF THINGS*, p. 10.

[5] N. Semiconductors, “Mifare classic 1k,” http://mifare.net/products/smartcardics/mifare_standard1k.asp.

[6] G. de Koning Gans, J. Hoepman, and F. Garcia, “A practical attack on the mifare classic,” in *Proceedings of the 8th Smart Card Research and Advanced Application Workshop (CARDIS 2008). LNCS*, vol. 5189. Springer, pp. 267–282.

[7] M. Saunders, P. Lewis, and A. Thornhill, *Methoden en technieken van onderzoek (Research methods for business students) third edition*. Pearson Education (Benelux), 2004.

[8] A. Alrafi, “Technology acceptance model,” *Leeds Metropolitan University*, p. 12, 2005.

[9] N. Park, K. M. Lee, and P. H. Cheong, “An application of the technology acceptance model,” *Journal of Computer-Mediated Communication*, p. 13, 2007.

[10] Y. Lee, K. Kozar, and K. Larsen, “The technology acceptance model: past, present, future,” *Leeds School of Business - University of Colorado*, p. 30, 2003.

[11] R. De Veaux, P. Velleman, and D. Bock, *Stats: data and models*. Pearson/Addison Wesley, 2005.

[12] L. Lamel, S. Bennacef, J. Gauvain, H. Dartigues, and J. Temem, “User evaluation of the mask kiosk,” *Speech Communication*, vol. 38, no. 1-2, pp. 131–139, 2002.