RFID TECHNOLOGY: FOSTERING HUMAN INTERACTIONS

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ABSTRACT

This paper presents a specific application of the RFID technology: the game "Plug – Secrets of the Museum" (PSM). It takes place in the museum of Arts and Crafts in Paris. The goal of PSM is to explore and demonstrate the potentials of the RFID in term of services and to explore the new type of interactions that it enables. In this paper, we first describe the design of PSM and its technical implementation. Then we describe how we tested the technology. We then present the results from the testers' feedback and from our observations of the game. We will see that NFC reader phones change the way museum visitors read, understand and interpret the artifacts by giving them an active role in the search for information while giving them the possibility to write and reorganize virtual museum contents. In this game, information becomes a valuable item to be negotiated with others in face to face interactions that are prepared by the virtual quest. Based on Goffman study of interactions, we analyze here how the technology is not only context aware but create new forms of communication based on mobility, proximity, shared activity, and physical contact that can eventually lead to new rules of civility.

KEYWORDS

RFID, Game Design, Interaction, Museum, Mobile Phones, Assessment.

1. INTRODUCTION

Pervasive technologies based on short range radio waves are technologically and economically more mature. A growing number of mobile phones equipped with RFID (Radio Frequency Identification) readers are available since the NFC norm (Near Field Communication) was developed in 2004 by Philips, Sony and Nokia. IDATE (French consultancy) estimates that by 2012, 14% of mobile phones sold in the US and Europe will be equipped with NFC chips. Moreover, people are increasingly familiar with contactless payment and circulation pass based on RFID chips (Pass Navigo, in France).

The question now is to develop new applications that explore the rationale of this technology. The research project "Plug"[1] explores some of the possibilities offered by RFID through a game: "Plug - Secrets of the Museum" (PSM)[2]. PSM was tested in November 2008 in the Museum of Arts and Crafts in Paris, and gave the opportunity to investigate the way a RFID-based system transforms the user's relation to her environment through the technology. Our main find was that pervasive technologies can lead from a virtual quest to actual face to face relationships between users, thus promote co presence. Though the phone is basically for distant exchanges, the game and its technical system triggered face to face interactions as Goffman defines them: "Interaction may be roughly defined as the reciprocal influence of individuals upon one another's actions when in one another's immediate physical presence." (Goffman, 1959) While Goffman

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[1] http://cedric.cnam.fr/PLUG/
[2] Plug - Secrets of the Museum, is part of an ongoing research program ANR-RIAM (2008-2009) that involves academic and industrial partners: the French Museum of Arts and Crafts in Paris (Musée des Arts et Métiers), the game design company Tetraedge, the mobile operator Orange, the Conservatoire National des Arts et Métiers and Telecom Institut.

concentrates on the influence of context and institution on interactions (Goffman, 1974), we also wanted to understand how a pervasive system based on RFID shapes the players' actions and gestures and how these actions and gestures shape the relation to others.

In this paper, we first describe the design of PSM, its technical architecture, and then we analyze how RFID devices can empower the users and change the interaction. We propose a first typology of actions: transmission, negotiation and seduction. This typology based on our testers' feedback and observations shows the close connection between the workings of the device and the type of civility developed by players.

2. DESIGN OF THE GAME

Few games have been developed in the context of a museum (Borriez F. et al, 2007). *Cicero* is a PDA-based framework designed to host interactive and cooperative educational games, tested in the Marble museum of Carrara (Laurillau, Y. and Paterno, F., 2004). *Via Mineralia* is another example. It is a PDA-based treasure hunt that takes place in the Terra Mineralia museum of Freiberg (Heumer et al., 2007). Both games rely on the availability of a global network. The *Musée des Arts et Métìers* (Museum of Arts and Crafts) was not willing to deploy such an infrastructure. The Museum, that has repeatedly tested new forms of visit (junior visits like "*Coffres à jeux*", thematic visits or pluri-disciplinary visits as in "*Voyages aux Coeur des techniques*") wanted to experiment with a new way of accessing the collection that would give the visitor an overall view of the History of technical inventions while entertaining the visitor, creating a special bond with the Museum, and contributing to a better understanding of the artifacts.

Requirements were that: 1) the game should be both educational and entertaining, 2) it should use a limited infrastructure – in other words no Wi-Fi network, and depend on limited operating costs - no UMTS/HSDPA network to transmit data, 3) it could be played by anyone, whatever age or social category, and preferably by a family, 4) it could be played several times by the same player. The design of PSM tried to address all these requirements. Inspired by the classical Happy Families card game (*jeu des Sept Familles*), it is based on the use of RFID tags and mobile phones. The game was conceived with a seamful design (Chalmers & Galani, 2004) so as to enhance the pervasive, tagging and reading, and NFC-enabled dimensions of the system.

In the following part, the first subsection details PSM game design. The second subsection presents the technical infrastructure.

2.1 PSM Game Design: a Taste for Science

In addition to questioning players on the Museum artifacts, we decided on designing an experience that would give them a taste of science, that would reassure them and show them that everybody could be concerned. The rules therefore put a special emphasis on "scientific qualities".

To gain points, players must prove: their collector's ability, by gathering on their handset four cards of the same family (through a sequence of exchanges "card stored in their handset ↔ card stored in a RFID display" or "card stored in their handset ↔ card stored in another player's handset"; their **public-spiritedness**, by storing a card to its reference RFID display (thanks to an exchange "card stored in their handset ↔ card stored in a RFID display"); their **generosity**, by exchanging one of their cards with another player; their **curiosity**, by answering quiz related to the objects of the museum.

Eight players (individuals or teams of two) are involved in the game. Each team or player is equipped with a handset able to read/write RFID tags (in our project: Nokia 6131 NFC mobile phone) and with a map of the museum (so that players can locate themselves easily). During the game, thanks to the handset, players handle virtual cards holding two pieces of information: 1) the picture of a specific object of the museum, and 2) its family (for instance, *Ghost busters* family puts together famous scientists of the museum). Moreover 16 passive RFID tags are spread throughout the museum. Each tag is located on a display beside one of the real objects represented by a virtual card. Each tag contains 1 virtual card.

Once the game is set up, each player discovers the virtual cards hold by her handset. She can "zoom" to get detailed information on the object. Then she walks throughout the museum in order to interact with the tags on displays. To do so, the players put the phone on top of an RFID tag. The handset displays the virtual card stored in the tag, a *Clue* menu and possibly a *Quiz* menu.

The player can take this virtual card on the display and exchange with one of her cards of her handset. If the card which is transferred (written) on the display corresponds to the real object nearby, the player gains points for her **public-spiritedness** because she places "things" in the right place instead of planting her cards everywhere.

If the player selects the *Clue* menu, the handset displays the location of the virtual object that the player is looking for, as well as the "time code" for this information (when it was deposited there by someone). The player can estimate whether or not there is a chance that it might still be there.

When the player selects the *Quiz* menu, the handset displays a question (randomly selected among a set of questions) dealing with the object and gives choice between three possible answers: if the player chooses the correct answer, she gains points for her **curiosity**. To be able to answer correctly to the question, the player can read museum's information.

A player can also swap cards with another player by touching the other's handsets. The exchange takes place in peer-to-peer NFC mode and each player receives points for her **generosity**. To prevent two players from winning PSM just by exchanging cards without moving, a player can exchange no more than two cards with another one in a sliding window of ten minutes. During the tests made in November 2008, we had the opportunity to add operational SIM cards inside each mobile phone. Although this increases the operating costs of the industrial version of PSM, it adds an interesting feature: a player can call another to make an appointment to swap cards somewhere in the museum.

The game session ends after an hour. Each handset records all the points gained through collecting families plus the points earned for public-spiritedness, curiosity and generosity. Then it displays the final score to the player, before inviting her to go back to the starting point in the museum. There, the winner is determined.

2.2 PSM Technical Design: a Fully Mobile and Distributed Architecture

To implement PSM game design, we had to take into account two major requirements. We had to use the RFID technology (and mobile phone to read/write these tags) without relying on any global network (Wi-Fi, UMTS, HSDPA…). Thus the architectures used in classical RFID applications could not be reused for PSM. We had to design an original architecture that took advantage of the players' movements to compensate for the lack of global network.

Indeed, in the context of GS1 EPCglobal, Armenio et al. describe a standard centralized architecture: each product is equipped with an RFID tag. The RFID reader reads the RFID identifier stored on the tag and gives this information to a dedicated application (Armenio F. et al, 2007). Thanks to this identifier, by accessing a central database, the application is able to identify this product and the procedure to handle it. It is important to notice that to make this architecture operational, a global network is required all the time in order to link the RFID reader and the central database.

On the other hand, some RFID applications rely on a fully distributed architecture. A writable RFID tag is associated to each of the product that needs to be monitored. Each time there is an event on that product (for instance, it is put in the hands of a new carrier), this event is stored inside the tag. Thus, at any time, the history of the product can be read on the tag. PSM technical design is inspired by this fully distributed architecture.

In our project, we used passive writable RFID tags, more precisely NFC tags (ISO 14443, Mifare-NFC), in order to be able to use standard mobile phones equipped with NFC readers. To represent the virtual cards defined by the game design, we used a byte value per card. Before the very first session, on each player's mobile, we initialized a local database which associates to each of the possible byte values (that is to all of the museum's objects concerned by the game), the name of the associated object, its picture, its detailed information, its quiz and its sounds files (corresponding to what a virtual card says when it goes to or comes from a tag).

When setting up a game session, a dedicated mobile phone is used to compute the initial distribution of the 48 virtual cards mentioned by the game design. To do so, this dedicated mobile shuffles a byte array of 48 elements. Then, thanks to Contactless Communication API (JSR-257) and NFC peer-to-peer protocol, this mobile gives to each player's mobile phone its initial distribution of 4 cards. Moreover this mobile is used to initialize, on each tag, the byte corresponding to the virtual card it initially holds. Notice here an interesting difference with the standard fully distributed architecture where tags hold events related to the product they

are associated to. With PSM technical design, the RFID tag extends the object it is linked to: it adds a virtual card, thus a new contents, to this object. And this new content evolves during time, thanks to teams who carry virtual cards in their mobile phones from one RFID tag to another one. Somehow players form a "human network" which carries information between all of the RFID tags that are connected to this "network".

To make this content evolution possible, a jar application is permanently run on each player's mobile during game time. It displays the game interface. Moreover, when a mobile is put near a tag, a read operation is triggered inside this jar application: The byte value (thus the virtual card) hold by the tag is read. Thanks to this value and the mobile local database, the name of the object associated to the virtual card and its picture are displayed on the mobile. If a player exchanges one of its virtual cards against the one currently stored in the tag, the jar application just writes the byte value of the virtual card on the tag.

3. EVALUATION OF THE GAME AND RESULTS

To assess the technology and its gaming potential, we included the question of evaluation early on in the project, so that we had time to define protocols of investigation and develop specific tools to collect data. We organized three different tests: we retrieved and analyzed the generated log files from the terminals (statistics on game sessions), and conducted in depth qualitative interviews. Eventually, we distributed questionnaires to understand the players relationship to the game, the technology and to other players in the museum. These tests were conducted during two days (22 and 23 November 2008). Twelve game sessions were held, with a total of 96 teams and 150 players. In this first subsection we describe the tests.

3.1 Statistics on Game Sessions and Creative Assessment

In order to be able to observe the players' behavior, the jar application logs events in a dedicated file of the mobile file system. Once all of the game sessions are over, all of the log files are analyzed to compute statistics on the sessions. After the last November 2008 game session, all of the generated log files have been transferred via Bluetooth® on a computer in order to be analyzed.

The statistical results of the logs were confronted to the testers' feedback through the interviews and questionnaires. For the qualitative interviews, we recruited 17 testers over the two days. Each one was directly concerned by the themes of the project (game design, museology, ambient intelligence, etc.). These "qualified" testers were explained the technical functions and rules of the game, then they tested the device to get used to it, and finally they played. We followed the testers during the whole session, noting their reactions and comments on the run. We then conducted open qualitative interviews about the experiment proper but also to explore any kind of analogies, comparisons, recollections that the experience triggered. The interviews addressed different questions on game practice, mobility practice and social and cultural expectations in terms of services. We were interested in practical details as well as in larger imaginary views. We did not limit ourselves to game design but encouraged any kind of suggestions concerning the situation. This type of creative assessment based on people's experience produces a clear analysis of how people feel about their mobility, their relation to the museums and what they expect from a technically mediated relation. These interviews also show how people confronted with the technology and its services can integrate them in their own experience and build up a new meaning that is a hybrid between different experiences. A written questionnaire conducted with all the other players completed the survey.

The results presented below are the result of these tests and their analysis.

3.2 A Typology of Actions

In this subsection, we focus on the interactions between players, museum and technologies. We will describe a typology of actions engaged by the application. These actions worked as regulators of interactions between players within this particular context.

The design of the game faced a double challenge. The first one is to teach History of sciences to visitors. Audio guides do that very well but they follow a top-down model of communication that the Museum wanted to complete with a more active search of information on the part of the visitor. On the other hand, playing

means winning and losing. While in a traditional quiz that one can play repeatedly losing is not a problem, for a visitor who might not come back, this can be a major issue as there would be no second chance. What's more, the Museum is not in a position to assess visitors' culture but to encourage it. The game had to rely on rules that valorize the players. Asking too easy questions made no sense whereas encouraging and rewarding "scientific qualities" might. The RFID technology helped us design a game that would lead the players to actively seek the information and play on civic qualities based on the exchange of cards. In fact three new practices appeared. Though the testers were not convinced that they had learnt much with our game, they enthusiastically acknowledged that the game had given them the desire to come back to learn more. This pleasure of the game that translated into the pleasure of the Museum was based according to testers and from our observations, on three atypical activities within the Museum that turned the acquisition of knowledge into a fully social and sociable practice: first, players became purveyors of contents; second, information had to be negotiated; third, exchanging information became the basis for new forms of sociability within the Museum (see Figure 1).

Figure 1. Interactions with a Tag (Picture on the Left) and between Players (Picture on the Right)

3.2.1 Transmission of Contents and Common Interest

As we have seen, in PSM, the phone is able to *read* the information found on the RFID tag and on the phones of other players. It is also able to *write* information on the tags regardless of their location.

The device is therefore considered as a channel of transmission through which one can update contents. The device is not considered as a "terminal" but as a communicating object (Gentes, 2008). It empowers the player because it gives her the ability to remove the virtual cards and deposit them in other station. Thus, the player writes information where she wants. Any player can get close to a RFID display and then transmit data. The transmission of content by the players is embodied by this gesture of contact between displays and mobile phones. The player reaches out her arm and "drags" the information from her phone to the terminal. Some players have described the phone as a magic wand. "While there it's me, I can give something at any place of the path. That's unique."

This gesture allows them to act on the gaming system, configuring and reconfiguring the space of the game, and to manipulate the conditions of movements and meetings. Each deposit of information changes the visible content of the station. The players are always facing contents that have been transformed by others before. From this point of view, the other players always retrieve the data another player has set down. Games statistics show that 1884 cards were swapped this way.

First, players perfectly realize that these new devices contribute to modify their status in the museum. These devices can switch from receiving a simple top-down communication to other situations of communication: bottom-up when the communication goes from the user to the museum; or horizontal when the communication is between users directly or through the museum. They become actors in the Museum

narrative. This re- organization and re-writing of contents also impact the players' strategies because to put the card on the corresponding display gives you points of "public-spiritedness". Players calculate that if the others try to win points this way, then a majority of cards will easily be localized. Because the game and the technology give players a new responsibility in structuring the information, the latter consider whether or not they are going to contribute to the common interest. In PSM, the player's own good relies on others' willingness to play fair. This common interest through possible collaborative writing is the first stratum of a sociability based on pervasive re-positionable information. If we go back to Goffman, we understand that the technical architecture and the game organize ways to acknowledge not only each other's presence but also each other's dependency that is the basis for any kind of community.

3.2.2 Negotiation and Collaboration

Unlike the traditional technical-mediated interactions, where people communicate remotely, PSM gathers the players in situations of co-presence. The cards have been scattered in RFID stations but also in the mobile phones of the players. Thereby, players are not only willing to explore the content of the RFID stations but also the ones on mobile phones used during the game.

Looking for other players and their cards is not easy for three reasons. Firstly, because players are mobile; secondly, because it implies that people agree to share (information) about the set of cards they have; and thirdly, because to be realized, the exchange has to be interesting for the two players, and they need to negotiate and eventually to collaborate. The player doesn't just have, like for an exchange with a RFID display, to find the RFID "station", to read its content and if he wants it, to choose a card from his set for the exchange and activate the process. As a matter of fact, exchanging cards with other players, collaborating and/or negotiating is rewarded whereas the basic exchange of cards with RFID displays is not.

The game banks on the fluidity of the system enabled by the RFID "touch" technology to encourage this specific kind of interaction. The players do not have to stop their flow. They answer the other players for their set when they meet ("Do you have a green family card ?"), and just touch their mobile phone to make the exchange. This was the most widespread scenario during the test. Statistics show that 286 exchanges between players took place which shows that the reserve proper to this kind of establishment can be overruled by the use of the device and the game. The action was not anticipated, the players exchanged "on the move", on a spontaneous mode. They were just scanning the museum and exchanging with others players when they had the opportunity. To give meant that they were waiting for something in return and the relation is based on this principle, this exchange. "He (another player) owes me something", told one of the testers of PSM.

Other strategies were observed during the test. Some players organized the way they exchanged points and locations. They called each other by phone to check what cards were available and to meet somewhere to proceed to an exchange. This is an interesting trait of pervasive applications as a virtual quest for information turns into a distant call that negotiates the exchange, that leads to an actual meeting. A gradual approach is organized, relying on the technical device. Players therefore invented new rituals of interaction (Goffman, 1967), benefiting from the technology and adjusting the different functions of the device to organize their sociability.

The way people played and exchanged cards depended also on the players and on their relationships before gaming. A lot of testers did not come alone but with members of their family or with friends. A feeling of complicity existed for these players as soon as the game began that was not obvious for the other ones. It does not mean that there was no competition between these players, but they organized their strategies in order to help the others: *"we exchange with people we know to help them"*. These players communicated a lot, each time they met or by phone, in order to adapt their strategies to that of their "partners": *"I have got a support in the museum, each time I met him, we didn't miss, we helped each other… so, you choose your options according to the handset of your ally"*. The device both in its phone and RFID capacity, reinforces bonds. But exchanges also took place between perfect strangers. The use of the device becomes a way to qualify each other. These exchanges were not only about cards. They were also about information on the contents of the different RFID stations or of the other players' handset they consulted.

3.2.3 Conviviality and Seduction

In PSM, the phone is used to exchange information by just "touching" other mobile devices. This interaction becomes the heart, the center of a relation not only between players and their environment but also between players themselves through actual contact. As noted by Goffman, the interactions are predefined by their environment. The Museum offers a context which defines people as culture oriented, safe, and properly behaving. Being in a museum makes this close physical relationship non threatening even though it is still felt as transgressive. The players had the feeling of having broken the traditional practices of visit but they also felt entitled to this new relationship to the Museum and its wake of consequent original interactions. In PSM, communities of players appear, gathered by the use of a specific terminal/device and by the unusual mobility that the game initiates (going to one RFID display to exchange a card, seeking for the other players etc.). Because of this shared situation, players agree to communicate with players they don't know in a place where it's usually forbidden to talk. They recognize other players with the same mobile phone and especially through the gestures linked to the game and that signal a "shared categorical identity": they are part the game.

In this context, players who came alone had to find their place and the game created connections. The fact that people were playing the same game reinforced this link, this feeling of being part of the same event that set them apart from the rank and file of other museum goers. The game brought the players together first because it gave them an identity related not only to the museum but also to the game itself; they could identify each other, know that they had something in common. PMS created a community (the players) within a community (the other museum visitors) (Augé, 1992).

In the end, all players were developing the same kind of solidarity on purpose. Even if the action was always strategic, exchanging cards provoked, opened a form of conviviality in the game and in the museum. People met and talked through these exchanges of cards and depending on the frequency and the nature of their exchanges, they got "in touch" during the game.

This complicity and feeling of sharing was given a particular flavor because, not only did people talked to each other, they touched each other with their phones which is far more sensual and intimate than just talking to someone. The game allows physical contact with other players as well as with objects. As such, testers appreciated the fact that they were being encouraged through the technology and the device to touch the others. Many people explained that the phone is an intimate device, a part of oneself, in the game (it is the tool for connection) and outside the game (because it is an object used in daily practice). To touch the other's phone with one's own was considered as a physical contact.

They undertook this contact in order to earn points (exchange of cards), but this type of interaction often provoked reactions of fun and discussions. Indeed, when the exchange occurred, the phone began to vibrate. The lurch of the players revealed a surprise and was so much fun that people were suitably impressed. Several testers spoke of an *"erotic gesture"* to describe this exchange. *"What's so funny is that for once you have to touch the phones. This is completely disturbing, we are always on the phone with people you cannot see, pretty girls, there is necessarily some embarrassment."* In return, players realized the distances that usually kept them away from each others in the museums.

4. CONCLUSION: PERVASIVE THEREFORE SOCIABLE?

Though played on a mobile and using virtual information, the game gives the players an opportunity to present an expressive behavior to each other. First the Museum constitutes a specific background that gives a status to its visitors. Second, the game gives a set of rules that reinforces certain cultural values (like curiosity or the willingness to store and to file documents), but also promotes new forms of interactions like negotiating information with other museum visitors. Third, the technology encourages public sociability and users find ways to gradually organize meetings.

Thus, the game in the museum not only works as a mediation towards the museum and its artifacts but also towards other visitors, giving them a reason but also tools to interact with each others whereas the museum is most of the time a zone of reserved sociability, to say the least. This affects the way visitors interact with the museum as they are given the right to move around virtual objects. The Museum relinquishes some of its prerogatives to enhance the visitor's role and status. It also affects the way visitors consider each other and their relation to a collective writing of the Museum. Because it allows swapping cards between players, the game introduces a dimension of collaboration and negotiation around the museum

artifacts that become the subject not only of the visit but of the personal collection of the visitor/ player. Visitors become collectors that have to interact within this cultural public space. Eventually, the mobile phone becomes a tool that involves touch. Visitors gain a power of seduction that allows them to go beyond the functional exchange to build up a friendly or at least sociable relationship (One of the players did go away with a newly met other player). The role of the phone was already noticed by Goffman (1959) as emphasizing the popularity of its user. The more you got called the more popular you are. In our experiment, the device brings its own logic of use. People use the phone to call other players, not only to augment their score but to parade their communicating skills and easy social connection, and to actually augment it.

Contrary to most ideas received about RFID technologies, people not only gather, provide or transmit information, but also develop a full model of interaction both mediated and face to face that play on all the facets of sociability. In particular, the specific context of the Museum and our dedicated application fostered civic behavior on the basis of shared objects and activities, safe interactions and the pursuit of common interest. In this perspective, the design of pervasive applications should not only take into consideration a scenario of action in a context, but also scenarios of communication and sociability between users through their NFC enabled devices.

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