Dynamic NFC-Displays as a Prototyping Platform for Direct Mobile Interactions with Public Displays

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ABSTRACT
Mobile interaction with public displays is usually indirect and depends on the limited input features of mobile devices. Dynamic NFC-displays combine the simplicity and directness of mobile interaction with NFC-tagged, physical objects and the visual output capabilities of public displays. In this paper, we explore this technology as a prototyping platform for the development of more direct and personal mobile interactions with public displays for Ubiquitous and Urban Computing. We present use case scenarios, discuss the basic technology and report our experiences with two applications for information exchange and gaming.

Author Keywords Dynamic NFC-displays, Near Field Communication, physical user interfaces, prototyping

ACM Classification Keywords H.5.2 [Information Interfaces and Presentation]: User Interfaces – input devices and strategies, interaction styles

General Terms Design, Human Factors

INTRODUCTION

The last years saw an increasing spread of technologies for Ubiquitous Computing like wireless networks, mobile devices or smart objects in our everyday environment, providing new ways to access and use digital information and services. This development is explored by Urban Computing, which focuses on interactions with ubiquitous, digital technologies in urban environments. Another technology for Ubiquitous and Urban Computing are large displays that provide information or entertainment in public places like stations, shopping malls, pubs or airports. In most cases, users can only passively consume the contents of these public displays but cannot actively interact with them. To improve the interaction with such displays, many approaches take advantage of mobile devices and their different input options, including keypads, joysticks, touch-screens, cameras or accelerometers, e.g. [1, 2].

Another approach to mobile interaction with public displays are dynamic NFC-displays [9, 4] that combine the physical interaction with NFC-tagged objects and the visual output capabilities of public displays (Figure 1). Dynamic NFC-displays comprise a server that manages the logic of an application and projects its graphical user interface (UI) onto a grid of NFC-tags that serves as a physical UI. Users can manipulate the projected application UI by touching the tags of the physical UI with an NFC-enabled mobile device. A mobile client returns the position of the tag in the grid to the application server which updates the projected application UI according to the interaction.

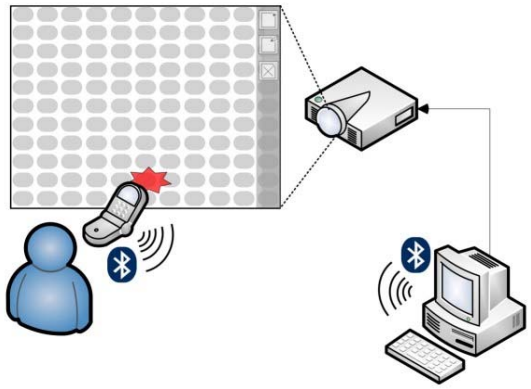

Figure 1. Basic setup of a dynamic NFC-display

This paper explores dynamic NFC-displays as a prototyping platform for direct mobile interactions with public displays for Ubiquitous and Urban Computing. The next section gives a short overview of related work. Section 3 presents different use case scenarios for dynamic NFC-displays in Urban Computing. In sections 4 and 5, we report our experiences with two prototypes that use dynamic NFC-displays for exchanging information and playing games. Section 6 concludes the paper.

RELATED WORK

Near Field Communication (NFC) is a radio-based technology for short-range data exchange between reading devices, e.g. mobile phones, and passive wireless tags [10]. Many applications take advantage of the simple, touch-like interaction between them to facilitate ticketing, payment or information retrieval. Other applications map features and options to multiple NFC-tags on everyday objects, turning them into physical UIs that complement mobile UIs. Examples are posters for mobile ticketing [3], control panels [7] for multi-media players or tagged maps [6].

In the next step, physical UIs are covered with a grid of NFC-tags to provide a completely interactive surface that can be combined with different display technologies. In a first approach to dynamic NFC-displays, Vetter et al. [9] used a grid of NFC-tags as a physical UI to manipulate a

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projected application UI. This technology was later refined by Hardy et al. [4] who developed new interaction techniques on top of improved hardware. Similarly, Ramírez-González et al. [5] combined an NFC-panel with a projected application UI. Seewoonauth et al. [8] used a grid of tags on the back of a laptop display to enable direct, touch-based interactions with applications.

USE CASE SCENARIOS FOR URBAN COMPUTING

Examples for dynamic NFC-displays in urban scenarios are applications for information retrieval or advertising in public places like pedestrian areas, shopping malls or airports (Figure 2). NFC-enabled mobile phones can be used as pointing devices to select information items or adverts, to download them, to open links or to switch between screens with different categories of items. The big display can give an overview of information items while the smaller displays of mobile devices can show further details.

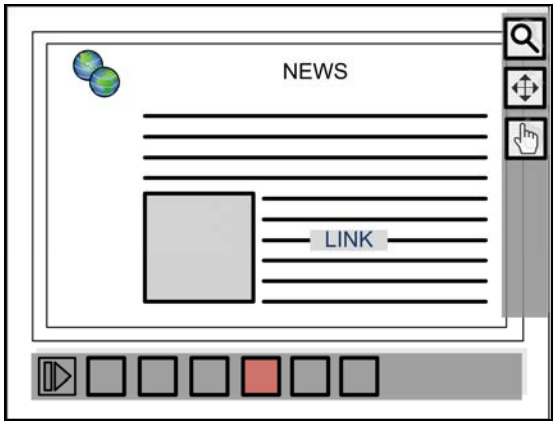

Figure 2. Information retrieval on a dynamic NFC-display

More elaborate use cases are applications in malls or stations that sell digital content like tickets, music or videos that can be stored and used on mobile devices. Customers can interact with the application UI on the large NFC-display to get an overview of all available items, browse product categories, see product details or add products to the virtual shopping cart. The more private screens of mobile devices can display sensitive data like payment information or the contents of the shopping cart.

The big screens of dynamic NFC-displays also qualify for map-based applications (e.g. [4]) at sights or tourist information centers. Typical interactions with maps include zooming, panning, showing details of points-of interest or defining routes between them. Games can take advantage of the physical interaction with dynamic NFC-displays to compensate the clumsy controls of mobile devices. Games like Battleships can be set up at public locations like stations, arcades or pubs where they serve as social hubs and encourage spontaneous interactions between people. Players can carry out secret actions, e.g. placing their own ships, on the mobile device and interact with the public NFC-display, e.g. to hit the ships of their opponents.

SHARING INFORMATION WITH AN NFC-PINBOARD

To show how dynamic NFC-displays can be deployed in everyday environments, we used this technology to implement an NFC-pinboard. It emulates the features of a regular pinboard and can serve as an information hub at private (e.g. family homes), semi-public (e.g. companies) or public places (e.g. shopping malls) that allows users to post, view and share digital content from their mobile devices.

Application Design

The graphical UI of the NFC-pinboard contains different items like messages or pictures that can be manipulated by touching the subjacent tags of the physical UI with an NFC-enabled mobile device (Figure 3). The content of items can be shown on the public NFC-display or on the private screens of mobile devices. Users can touch the NFC-pinboard with their NFC-enabled mobile devices to upload and download items, to select items or to move them with drag&drop. A toolbar contains different features, e.g. to filter the items on the display. The prototype also supports different patterns of touching tags, e.g. from the left side of the display to the right side, to facilitate certain interactions, e.g. switching between different views.

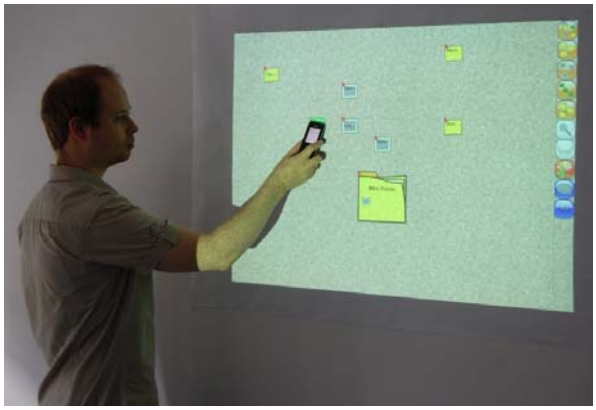

Figure 3. Interacting with the NFC-pinboard

Technical Setup

The NFC-pinboard implements the basic hardware-setup of dynamic NFC-displays (see Figure 1) in the most straightforward way (Figure 4): The physical UI of the prototype is a sheet of paper (90 by 67.5 cm) with a grid of 20 by 15 Mifare NFC-tags on its back (Figure 5). The server application for the NFC-pinboard has been implemented with Java SE and runs on a laptop. A regular LCD projector is used to project the graphical UI of the NFC-pinboard onto the physical UI. The prototype is completed by a Java ME application that runs on NFC-enabled mobile phones, e.g. the Nokia 6212. The phone serves as a smart pointing device to manipulate the projected application UI, to read the tags of the physical UI, to communicate with the application server via Bluetooth and to provide feedback during the interaction with the tags.

Figure 4. Hardware-setup of the NFC-pinboard

The NFC-pinboard is a first step towards more elaborate hardware-setups for dynamic NFC-displays and still suffers from some technical handicaps: Although the setup of the prototype is rather easy, the position of the projector has to be re-aligned with the tag-grid every time it is moved. In order to interact with the application, users inevitably have to step between the projector and the physical UIs, creating shadows that affect the whole interaction (see Figure 3). The accuracy of the interaction with the NFC-tags is affected by the composition of the tag-grid on the back of the poster. Its tags have a round shape and are placed next to each other, creating blind spots in the middle of four adjacent tags. Rectangular or overlapping tags could increase the accuracy of the interaction.

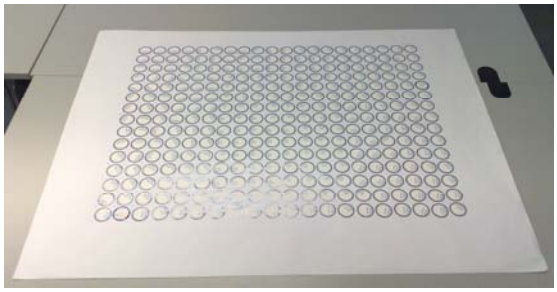

Figure 5. The physical UI of the NFC-pinboard with a grid of 20 by 15 adjacent NFC-tags

WHACKING MOLES WITH FRIENDS AND STRANGERS

The second application for dynamic NFC-displays takes advantage of the physical interaction with them to implement the Whack-a-Mole game. This and other games on dynamic NFC-displays can be set up at public locations like underground stations, arcades, shopping malls or pubs, where they enable spontaneous interactions between people, e.g. playing a game while waiting for the train.

Application Design

The design of the Whack-a-mole prototype follows the design of the original game. The graphical UI contains 4 status bars for up to 4 players, a countdown and the gaming area which is filled with holes from where the moles pop up during the game. Players can hit moles by touching the NFC-tags beneath them with their mobile phones (Figure 6). In order to win the game, players have to hit as many moles as possible until the countdown runs down. The moles are colored and players earn one credit for hitting a mole. To make the game more challenging, a player loses a credit if anybody hits a mole of his color. That way, the gameplay leverages the competition between multiple players, who have to hit moles of other players while guarding their own moles against them.

Figure 6. Playing Whack-a-Mole on a dynamic NFC-display

The game benefits from the physical interaction with NFC-tags which improves its accessibility, provides easy controls and complies with its gameplay. Users do not have to struggle with login procedures and do not need much experience with physical interaction. Instead, they can quickly set up, join and play a game by touching the physical UI, which accommodates their limited time.

Technical Setup

The Whack-a-Mole game upgrades the original hardware-setup of dynamic NFC-displays (see Figure 1) in several ways: The prototype comprises a larger grid of NFC-tags that is composed of reconfigurable tiles that have the size of a DIN A4 sheet and contain 5 by 8 Mifare NFC-tags each (Figure 7). The complete physical UI of the prototype consists of 4 by 6 tiles, resulting in a total size of 164 cm by 69.5 cm and a total of 960 NFC-tags (Figure 8). The tags on the tiles and the assembled tiles overlap to form a completely interactive surface without gaps between them. Compared to the NFC-pinboard, users can touch the physical UI in any place and hit an NFC-tag in most cases.

A ceiling-mounted short throw projector is used to project application UIs onto the physical UI from above users, producing less shadows that handicap the interaction (Figure 8). The hardware-setup is completed by a laptop that runs the Java SE game server and several NFC-enabled Nokia 6212 mobile phones for the interaction with the physical UI and the manipulation of the projected game UI. Each phone runs a mobile Java ME client in order to recognize the tags on the physical UI and to communicate with the game server via Bluetooth.

Figure 7. Modular tile with 40 overlapping NFC-tags

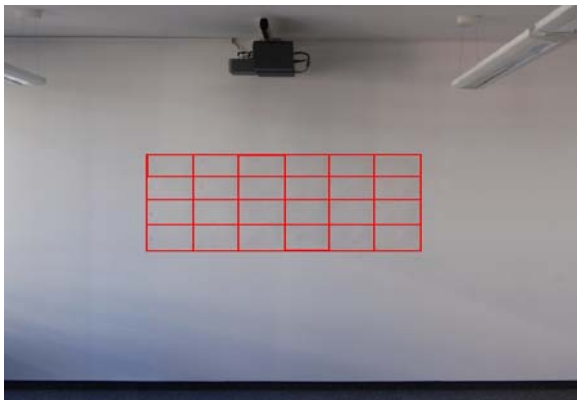

Figure 8. Hardware-setup of the Whack-a-Mole game

DISCUSSION AND OUTLOOK

This paper showed how dynamic NFC-displays can be used in everyday environments and presented two prototypes for sharing information and gaming that build upon this technology. These examples show the possibilities of dynamic NFC-displays for direct mobile interactions with public displays in Ubiquitous and Urban Computing.

Dynamic NFC-displays are not a commercial, but a prototyping technology that emulates direct, touch-based interaction between mobile devices and large displays. It combines properties of public displays, touch-screens and tagged physical UIs and omits some of their constraints: Dynamic NFC-displays have a more flexible GUI than static physical UIs like tagged posters [3] or maps [6] that have to rely on mobile devices for dynamic visual feedback. Opposite to other physical UIs and public displays, dynamic NFC-displays comprise a completely interactive physical UI, providing a higher degree of interactivity and a more direct interaction with mobile devices. Although touch screens provide an even more direct interaction with their contents, dynamic NFC-displays allow a more personal interaction between displays and mobile devices.

One focus of future work on dynamic NFC-displays concerns the technical advancement of their components. Smaller NFC-tags enable more precise interactions, new kinds of projectors could reduce shadows even further and mobile devices could read multiple tags at the same time and thus allow continuous interactions with NFC-displays.

Another important area of future work is the evaluation of dynamic NFC-displays in a real world context. So far, we have only used this technology in controlled indoor environments. Beyond that, it would be interesting to see how much the interaction with dynamic NFC-displays in (semi)public places is really accepted and appreciated by regular people. Such evaluations include the applicability of the basic technology, its comparison with related technologies like touch screens, the usability of applications or privacy concerns that result from the separation of application UIs between mobile and physical UIs.

REFERENCES

1. Ballagas, R., Borchers, J., Rohs, M., and Sheridan, J. G. 2006. The Smart Phone: A Ubiquitous Input Device. IEEE Pervasive Computing 5, 1 (Jan. 2006), 70.
2. Boring, S., Jurmu, M., and Butz, A. 2009. Scroll, tilt or move it: using mobile phones to continuously control pointers on large public displays. In Proc. of OZCHI '09, vol. 411. ACM, New York, NY, 161-168.
3. Broll, G., Rukzio, E., Paolucci, M., Wagner, M., Schmidt, A., and Hussmann, H. 2009. Perci: Pervasive Service Interaction with the Internet of Things. IEEE Internet Computing 13, 6 (Nov. 2009), 74-81.
4. Hardy, R. and Rukzio, E. 2008. Touch & interact: touch-based interaction of mobile phones with displays. In Proc. of MobileHCI '08. ACM, New York, NY, 245-254.
5. Ramírez-González, G., Muñoz-Organero, M., Kloos, C. D., and Astaiza, Á. C. 2008. Exploring NFC interactive panel. In Proc. of Mobiquitous 2008. Dublin, Ireland, July 21 - 25, 2008.
6. Reilly, D., Welsman-Dinelle, M., Bate, C., and Inkpen, K. 2005. Just point and click?: using handhelds to interact with paper maps. In Proc. of MobileHCI '05, vol. 111. ACM, 239-242.
7. Sánchez, I., Riekki, J., and Pyykknen, M. 2008. Touch & control: Interacting with services by touching RFID tags. In Proc. of IWRT 08, June 12-13 2008.
8. Seewoonauth, K., Rukzio, E., Hardy, R., and Holleis, P. 2009. Touch & connect and touch & select: interacting with a computer by touching it with a mobile phone. In Proc. of MobileHCI '09. ACM, New York, NY, 1-9.
9. Vetter, J., Hamard, J., Paolucci, M., Rukzio, E., and Schmidt, A. 2007. Physical Mobile Interaction with Dynamic Physical Objects. Demo at MobileHCI´07, Singapore, September 9, 2007.
10. Want, R. 2006. An Introduction to RFID Technology. IEEE Pervasive Computing 5, 1 (Jan. 2006), 25.