Touch to Play - Mobile Gaming with Dynamic, NFC-based Physical User Interfaces

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ABSTRACT
Mobile devices can take advantage of physical interaction with their environment and its objects to compensate their constrained input and output capabilities. For that purpose, dynamic NFC-displays combine the physical interaction with NFC-tagged user interfaces and the output capabilities of public displays. We have adopted this technology for the Whack-a-Mole game to show how it can improve the accessibility and usability of mobile games. This paper describes the design of the game and explores how physical interaction with dynamic NFC-displays can compensate the constraints of mobile games and enrich their gameplay.

Categories and Subject Descriptors
H.5.2 [**Information Interfaces and Presentation**]: User Interfaces –input devices and strategies, interaction styles

General Terms
Design, Human Factors

Keywords
Mobile gaming, Near Field Communication (NFC), physical user interfaces, dynamic NFC-displays

1. INTRODUCTION
As much as mobile devices allow us to use applications and services ubiquitously, they also restrict their usage due to constrained input and output capabilities. Small screens, narrow keyboards, imprecise controllers or nested user interfaces affect the accessibility and usability of mobile applications and discourage their usage. One approach to compensate these constraints of mobile devices is the interaction with everyday objects. Examples are public displays that provide better output capabilities or physical objects that are tagged with visual markers or NFC-tags [2]. Users can physically interact with these objects by taking pictures of markers or by touching tags with their mobile devices, using the retrieved information as input for applications or services.

Small displays and clumsy controls also affect the user experience of gaming *on* mobile devices. Gaming *with* mobile devices on the other hand is a popular means for the playful exploration of mobile technologies, e.g. location-based interaction [3]. These games do not rely on the built-in controls of mobile devices, but take advantage of sensors like accelerometers, cameras or GPS to interact with the environment and its objects. Mobile games can take advantage of this physical interaction to compensate the constraints of mobile devices and to enrich their gameplay.

In this paper, we build upon the technology of dynamic NFC-displays [4] to explore how mobile interaction with tagged, physical objects can leverage mobile gaming. Dynamic NFC-displays combine the physical interaction with tagged objects and the output capabilities of public displays (Figure 1). They 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. In order to manipulate the projected application UI, users touch the tags of the physical UI with their NFC-enabled mobile devices. In order to show how physical interaction with dynamic NFC-display can improve the accessibility, usability and gameplay of mobile games, we have adopted this technology for the popular Whack-a-Mole game.

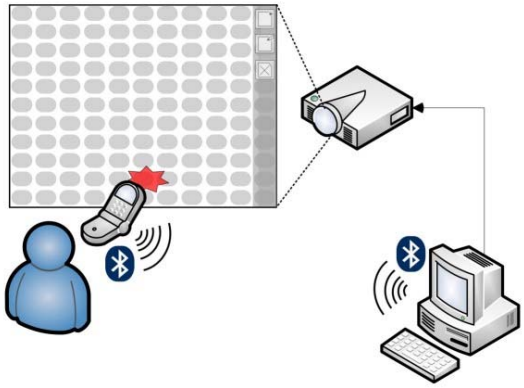

Figure 1. Basic setup of a dynamic NFC-display

2. THE WHACK-A-MOLE PROTOTYPE
The goal of the original Whack-a-Mole game is to hit as many moles as possible with a toy mallet while they pop up from holes in a cabinet. We have adopted this game because of its simple gameplay that is driven by physical interaction.

2.1 Hardware Setup and Implementation
Dynamic NFC-displays are a low-cost, experimental technology that emulates high-definition displays with integrated NFC for direct, touch-based interaction with mobile devices. The Whack-a-Mole prototype implements the original hardware setup of dynamic NFC-displays (Figure 1) with a grid of NFC-tags that is big enough to let two users interact with it at the same time

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(Figure 2). It is composed of reconfigurable tiles that have the size of a DIN A4 sheet and contain 5 by 8 Mifare NFC-tags each. The 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. The tags on the tiles and the assembled tiles overlap to form a completely interactive surface without gaps between tiles or tags. That way, users can touch the physical UI with NFC-enabled mobile devices in any place and hit an NFC-tag in most cases. A ceiling-mounted ultra-short focus low throw projector is used to project application UIs onto the physical UI from above users, producing less shadow that may handicap the interaction. 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.

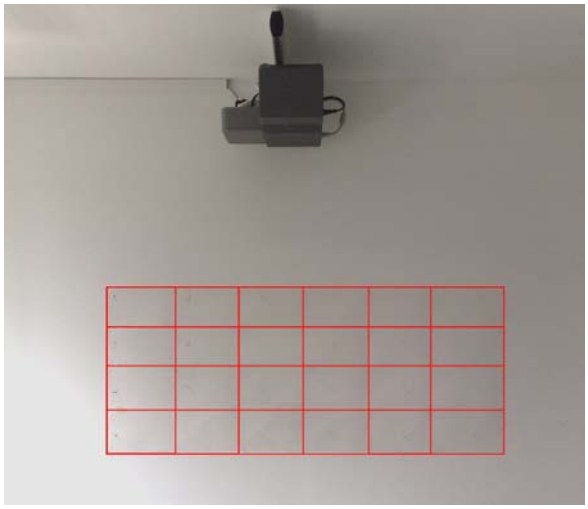


Figure 2. Hardware setup with an ultra-short focus projector and a grid of 24 tiles with 960 NFC-tags

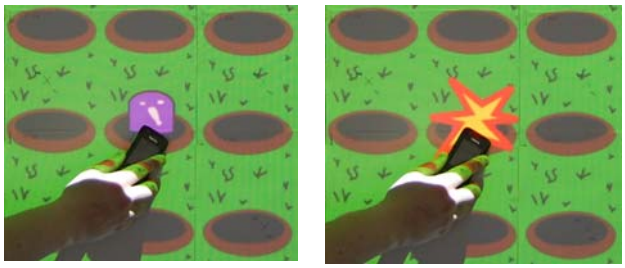
2.2 Game Design

The design and the gameplay of the Whack-a-mole prototype follow the design of the original game. In order to play the game, users need an NFC-enabled mobile device and the mobile client that reads NFC-tags, communicates with the game server, displays status updates and comprises the controls to start new games and to suspend or quit running ones. These controls are on the mobile device in order not to waste space on the actual game UI. After a player has started a new game from his mobile client, he and other players can join it by touching the dynamic NFC-display in any place. Upon joining a game, each player is assigned a specific color which is indicated in his status bar on the projected game UI and on his mobile device. Up to 4 players can play a game and compete against each other at the same time.

The graphical UI of the game (Figure 3) contains 4 status bars at its top for up to 4 players, a countdown for the remaining playing time and the gaming area which is filled with holes from where the moles pop up during the game. While the complete gaming area is projected onto the grid of NFC-tags, the status bars are projected above it and are not interactive.

Figure 3. The graphical UI of the Whack-a-Mole game with status bars for the players, a countdown and the gaming area

During the game, moles rise and recede from their holes. Players can hit them by touching the NFC-tags beneath them with their mobile phones (Figure 4a). A successful hit is indicated by visual feedback on the projected game UI (Figure 4b) as well as by vibration on the mobile device. In order to win the game, the players have to hit as many moles as possible until the countdown runs out after 100 seconds. 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, players not only have to whack moles of other players, but also have to guard their own moles against them.



a) **b)**

Figure 4. Moles pop up from their virtual holes (a) and can be hit with NFC-enabled mobile devices (b) to earn credits

2.3 Designing for Accessibility and Usability

The fixed installation of physical UIs and projectors do not exactly predestine dynamic NFC-displays for gaming on the go. Nevertheless, the Whack-a-Mole prototype shows how this technology can leverage physical interaction with mobile devices to compensate their limited input and output capabilities and enrich the gameplay, usability and accessibility of mobile games.

Dynamic NFC-displays can be set up at public locations like underground stations, arcades, shopping malls or pubs. There, they can serve as social hubs that advertise applications or games, draw the attention of passer-bys and encourage spontaneous interactions between people, e.g. playing a short game while

waiting for the train. People can quickly learn how to interact with the dynamic NFC-display and its applications by watching other users. The physical interaction with the NFC-display can also leverage the interaction between users. The gameplay of the Whack-a-Mole prototype benefits from the competition between multiple players, who have to engage physically with each other in order to hit moles of other players and to guard their own moles against them (Figure 5).

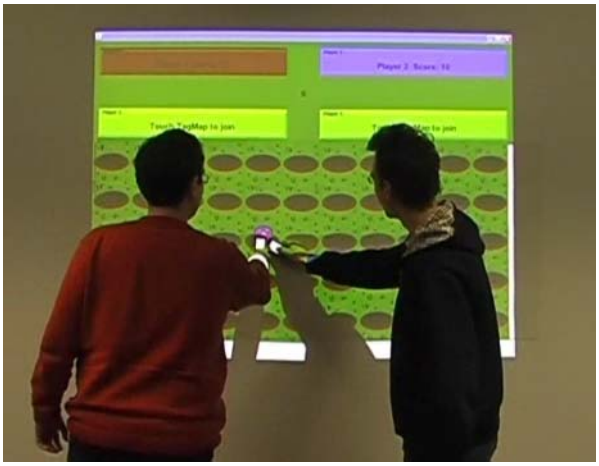


Figure 5. Increased competition between multiple players

Physical interactions like pointing, waving or touching are becoming increasingly popular for the interaction with computer systems and are adopted by commercial devices like the iPhone or the Wii. Instead of having to master complex controls on mobile devices, players can use the whole device to perform more natural or familiar physical interactions. Holleis et al. [5] pointed out that such interactions can be more interesting and engaging than regular phone interactions.

The Whack-a-Mole prototype benefits from the physical touching of NFC-tags which improves the accessibility of the game, complies with its gameplay and provides easy controls for playing it. 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 with their mobile devices, which accommodates the limited time and attention of mobile users. As users do not have to concentrate on the mobile device to play the game, they can pay more attention to the action on the projected game UI. As a result, the focus of interaction moves from the constrained mobile devices to the physical UI, reducing the number of attention shifts. Complementary, the prototype also benefits from the size of the dynamic NFC-display, providing more space for the game UI than the small screens of mobile devices.

The Whack-a-Mole prototype also highlights different advantages of dynamic NFC-displays compared to other technologies for physical interaction with objects in the real world:

- As their name suggests, dynamic NFC-displays possess a more dynamic and thus richer and more flexible GUI than static physical UIs like smart posters [2] or advertising columns, whose GUI does not change upon interaction.
- Opposite to other physical UIs and public displays (see [1]), dynamic NFC-displays comprise a completely interactive physical UI, resulting in a higher degree of interactivity and a more direct interaction with mobile devices.
- Touch screens provide an even more direct interaction with their contents, but users can often only manipulate them with their fingers, not their mobile devices. That way, the interaction cannot take advantage of the mobile device and is less personalized. Regarding the Whack-a-Mole prototype, users could not join and play a game by simply touching the physical UI, but would have to register to personalize their interaction with the application.

3. OUTLOOK

Using the Whack-a-Mole game as an example, we showed how mobile games can take advantage of the physical interaction with dynamic NFC-displays to leverage their own usability, accessibility and gameplay. In addition, this technology can leverage the physical and social interaction between users and thus improve the user experience of applications and games beyond the mere interaction with NFC-tags on a wall. This paper only highlighted some features of dynamic NFC-displays to support these aspects. Future applications can take greater advantage of mobile devices to show private information opposite to public information on the projected application UI. Other applications could use this technology to support cooperative interaction between players instead of competition.

4. REFERENCES

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