Developing and Optimizing Mobile Games for a Public Transportation Context

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ABSTRACT
As gaming on touchscreen mobile devices becomes more widespread there is a growing demand for a development process that incorporates usability guidelines and evaluation techniques that are specifically designed for mobile games. Additional requirements arise if one wants to specifically design games for a public transportation context. In such a context the surroundings can be noisy, shaky, and crowded with people. In this paper we share guidelines and experiences we learnt from the development of Naval Combat for the iOS platform. Naval Combat is a single and multiplayer mobile casual game based on the paper and pencil guessing game "Battleship". From day one, the game was optimized for the special requirements that arise from being on a train or bus. We further discuss and evaluate the different evaluation techniques that have been used to integrate users and what implications can be made for the development process as a whole.

Author Keywords
Usability Engineering, Public Transportation Context, Apple iOS, Game Design, Mobile Gaming, Multiplayer Gaming, Multi-Device Gaming

ACM Classification Keywords
H.5.2 Information Interfaces and Presentation: Miscellaneous

INTRODUCTION
Touchscreen mobile devices capable of running games become more widespread and developers are offered new technological possibilities in creating attractive mobile games. Multitouch user interfaces allow for new gestures to be used for interaction and high resolution displays let graphical content look crisp. However complexities arise by the fact that games are played in diverse situations such as on a ride on the public transportation system. In such a context the surroundings can be noisy, shaky, and crowded with people. Under these circumstances, one can find it difficult to concentrate and interact with a mobile device.

In 2009, a report on mobile usability by the Nielsen Norman Group has shown that users find mobile devices harder to use than desktop computers. The average success rate, a simple usability metric, was 59% in their mobile studies compared to 80% when testing on a regular PC [7]. One should consider that the study was not specifically conducted in a public transportation context. We believe that this would have had a further negative impact on the average success rate.

Casual Games
One way to overcome difficulties related to a public transportation context is to develop less complex applications. Casual games often feature a simple set of rules and gameplay is less prone to suffer from the player being distracted by his surroundings. Popular examples include classic board games or puzzles ported for digital devices. According to a current survey conducted in 2011, 88% of all gamers or 141 million people in the United States play this kind of games including an estimated 76 million people playing on mobile systems such as a smart phone or an Apple iOS device [11].

Related Work
Even though the complexitiy of pure game logic of a casual game is to be considered lower than for a blockbuster video game, ongoing research shows that development effort is merely postponed to different aspects. Casual games require new design approaches as the game itself becomes a secondary activity and players can be distracted by parallel activities or his surroundings [5]. Kultima proposes a framework for casual game design values that takes the different affordances and user thresholds and the significance of the context into account.

When casual games are played in a public area such as in a public transportation context, further complexities arise as not only general usability but also social acceptability needs to be considered. For example, there is a need to thoroughly evaluate gestures in terms of acceptability for public use [9]. Uncommon movement or gestures that are considered weird or attention seeking can make the user feel uncomfortable and as such make a mobile game unusable when on the go. A public transportation context where the user is surrounded by people he may not know further amplifies the need for a deep evaluation of gestures.

Research on playability heuristics [4] has shown that the small screen size, insufficient audio capabilities, or limited

processing power of a mobile device itself create additional requirements when designing mobile applications. In their paper, Korhonen et al. therefore introduce playability heuristics that specifically take mobile aspects such as the mobile device, user distraction, and higher priorities of other mobile applications into account.

As shown by Hoggan et al. [3], a change in context also requires a change in feedback modality. User decisions in a game largely depend on feedback modality. As such this aspect has to be considered when designing a mobile casual game for a public transportation context. Not only must one consider multiple types of feedback but also evaluate these options in the context of the game and the surroundings it is played in.

Contributions
In this paper we propose guidelines and share experiences we learnt from the development of Naval Combat for the iOS platform. Naval Combat is a singleplayer and multiplayer mobile casual game based on the classic paper and pencil guessing game also known as "Broadsides, the Game of Naval Strategy". From day one, we specifically focussed on creating a game that is optimized to be used in a public transportation context. Still little is known how to integrate both, the gamer and his surroundings in the development process. We give a detailed description of the development lifecycle and the usability engineering process and show how the user and the public transportation context have been integrated in the different stages of development. Subsequently we review the evaluation techniques and guidelines we have used and describe what implications we draw for the development process as a whole.

NAVAL COMBAT DEVELOPMENT
Naval Combat has been developed using the Scrum methodology [10], an evolutionary and agile development process. The development team consisted of three members and it took approximately 900 person hours over a five month timeframe to finish the project. In the following we describe the iterations during the development process from Requirements Analysis to the final stages of the project. From a Usability Engineering perspective we focus on what techniques have been used to establish high usability and specifically how the user has been involved to validate our quality goals.

Requirements Analysis (Focus Group Study)
As the development team, in a first step we defined a narrow set of functional requirements:

- Realization of a mobile game according to the rules of the paper and pencil game Battleships

- Support for Bluetooth and WiFi multiplayer games

- Support for singleplayer games

In addition to our functional requirements, we also defined a set of high-level non-functional requirements to constrain the design and set ourselves a quality goal:

- The game must be playable in a public transportation context (noisy, shaky, crowded with people)

- It must be possible to start a game nearly instantaneously

- Fault tolerance for multiplayer games must be provided

- The game must be optimized to deal with user distraction

User Story
We created a user story that provides not only a high level description of how Naval Combat is meant to be played and who our intended target audience is, but also highlights the complexities that are introduced by a public transportation context. In the following, Sally, Jessica, and John are three daily commuters who are using the subway network in their home city to get around. Jessica and John both know each other and often meet each other in a subway train.

On a Monday morning John enters the subway train at the station that is close to his appartment. He finds a seat and starts playing Naval Combat on his mobile phone. John is tired and doesn't feel like challenging another player and starts a game against the computer. A few stations later Jessica surprisingly enters the train. John stops his game and talks to Jessica. After a while, they decide to play a multiplayer game over Bluetooth. When the inspector checks their tickets, they both pause the game. John sees an old man using crutches and offers him a seat. John is now standing in the train but continues to play Naval Combat with Jessica. John leaves the train at the main station. Jessica, who has to go a few stations further, wants to play on and looks for other players on the internet where she finds Sally. Both start playing a multiplayer game. In the evening when John goes back home he remembers that he did not finish his game against the computer in the morning. He resumes the match and finishes it on his way home.

Focus Group Study
In order to validate and extend our requirements we conducted a focus group study. To provide an incentive we offered each participant an iTunes coupon for Naval Combat which they received when the game was released in the App Store. Six participants aged 12 (1 female), 22 (1 female), and 24 (4 male) took part in the study. None of them were involved in the development process and they had no prior knowledge about the game. After a short introduction of the concept of Naval Combat and our quality goals we asked the participants specific questions about the gaming environment, the gaming experience, and social aspects of mobile casual games (see figure 1). Following the questionaire, we asked the participants to draw a quick sketch of how they imagine the game to look like. In the end, we discussed the results and presented the sketches. The study took approximately one hour.

To summarize the results of the study, the questionaire revealed that the participants are members of our intended target audience. All of them are regularly using the public transportation system even though only half of the respondents played mobile games in that context. The results also

Gaming Environment	
Identifier	**Question**
GENQ1	When and why do you use the public transportation system?
GENQ2	Do you play games on a mobile device while using the public transportation system?
GENQ3	Do you play games on a mobile devices elsewhere?
GENQ4	Would you feel embarrassed if you were playing games on a mobile device in a crowded subway train?

Gaming Experience	
Identifier	**Question**
GEXQ1	Do you prefer playing against computer opponents or human opponents?
GEXQ2	Do you prefer playing against unknown opponents or people you already know?
GEXQ3	Do you prefer playing cooperatively or against each other?
GEXQ4	Do you prefer playing on the Internet or face to face?

Social Aspects	
Identifier	**Question**
SAQ1	How often do you use social networks?
SAQ2	Do you play games integrated in social networks?
SAQ3	Do you like the idea of your friends being informed when you win or loose a game?
SAQ4	Do you like to collect trophies?
SAQ5	Do you like to play with contacts from a social network?
SAQ6	Do you like to play against multiple opponents simultaneously?

Figure 1. Questions of the focus group study

Gaming Environment	
Identifier	**Answer (#Participants)**
GENQ1	Daily (4), Weekly (2)
GENQ2	Often (4), Never (2)
GENQ3	Yes (1), No (5)
GENQ4	Never (1), Only if my phone creates noise issues (4), Always (1)

Gaming Experience	
Identifier	**Answer (#Participants)**
GEXQ1	Computer (1), Human (5)
GEXQ2	Known (6)
GEXQ3	Cooperation (4), Competition (2)
GEXQ4	Face to face (6)

Social Aspects	
Identifier	**Answer (#Participants)**
SAQ1	Daily (5), Never (1)
SAQ2	Yes (2), No (4)
SAQ3	Very important (1), Less important (2), Not important (3)
SAQ4	Yes (4), No (2)
SAQ5	Yes (1), Only with friends (5)
SAQ6	Very important (1), Less important (5)

Figure 2. Results of the focus group study

show that human and especially known opponents are favored. All participants further agreed that playing from face to face is more appealing than playing over the internet. Regarding social networks, related feature proposals have been rated as being less important. All answers from the questionaire are depicted in figure 2.

The paper prototypes that have been sketched by the participants gave clues about where users expect buttons and what additional features they expect. One interesting finding was that all participants have knowingly drawn an unlabeled game board. During the discussion they agreed that even though it was present on the paper and pencil variant of Battleships it is unnecessary for Naval Combat. Other suggestions included a tabbed view for multiple simultaneous games, a zoomable game board, and extensions of the games' rules to include a story mode.

In summary the study has shown that our intital requirements were a good starting point. However all participants agreed that the most important non-functional requirement for a game was missing – an appealing visual design. Without the input we gained from the study we would not have known what the users' expectations look like.

Definition of Rules
During the focus group study, even though not asked for explicitly, discussions with potential users of the target audience have shown that many variants of Naval Combat with slightly different sets of rules exist [2]. What most of them have in common is that two players compete against each other and try to sink all enemy ships before their own ships are destroyed. It turned out to be important to agree on a set of well-defined rules. The importance is reflected by the fact that the rules are an essential element of the functional requirements for Naval Combat. For the development of casual games we specifically recommend to put effort into the definition of rules during requirements analysis as variations can have an influence on the actual design of the game.

In our version of Naval Combat the following rules apply: Each player secretly places an aircraft carrier of length 5, a battleship of length 4, a destroyer and a submarine both of length 3, and a patrol boat of length 2 on a grid of size 10 by 10. Ships can be placed horizontally or vertically, however they are not allowed to overlap and must not be placed next to each other. After ships have been positioned, the two players alternately fire a shot on the enemy's grid. Whenever a player hits a ship he can immediately fire another shot, otherwise the other player continues. The game finishes when the winning player sank all enemy ships.
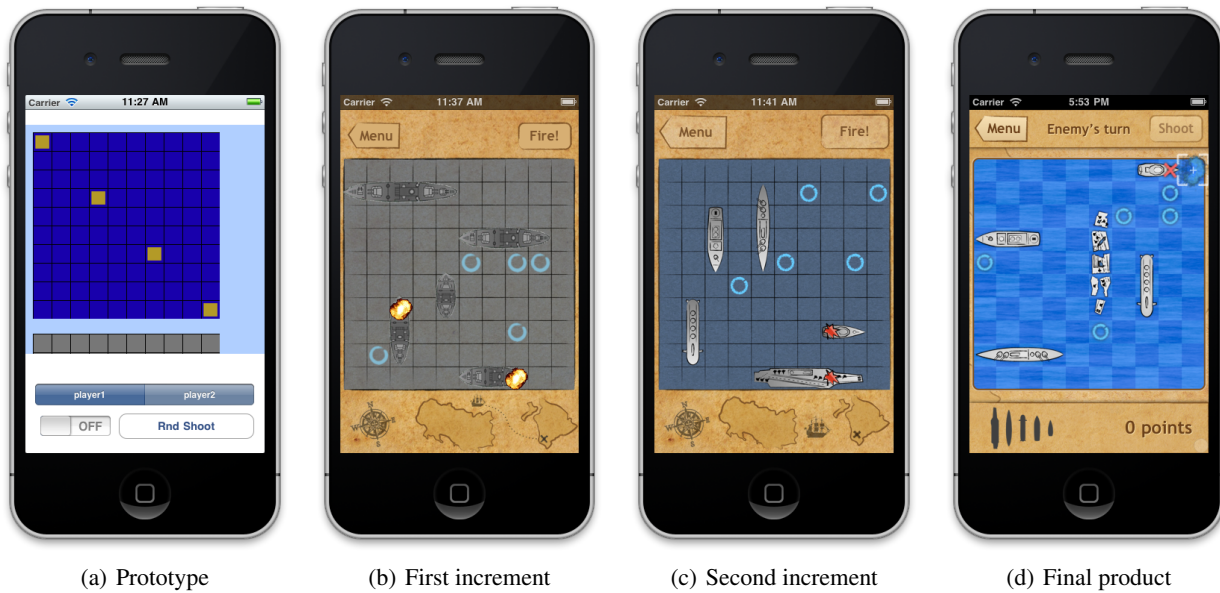
| (a) Prototype | (b) First increment | (c) Second increment | (d) Final product |

Figure 3. Screenshots of the different stages of development

Platform
From a technical point of view we decided to develop for the Apple iOS platform. The iOS platform and the mobile devices based on it offer an extensive set of development tools, up to date mulitouch interfaces, Bluetooth and WiFi copabilities, and high resolution displays. Our decision for this platform was further influenced by the release of Game Center [1], a social gaming network that handles multiplayer game matchmaking and allowed us to create achievements and online leaderboards. iOS includes Game Center since version 4 and offers an API that allows developers to integrate these functionalities in their games.

Throwaway Prototype
With the choice for the iOS platform being made and the requirements being verified we created an inital throwaway prototype.

In the horizontal dimension of the prototype we developed a user interface that implemented aspects of our own vision and ideas gained from the focus group study. A screenshot is given in figure 3(a). The prototype was demonstrated to and being tested by several students. The findings indicated that the size of the buttons is a crucial point for usability and that it is difficult to fit a 10x10 grid on the iPhone screen so that each cell is selectable with a fingertip. Modifications to the prototype had shown that it was no problem to scale buttons to a convenient size. However it had not been possible to achieve a similar effect for the grid because of the physically limited screen size. To deal with this problem we created a conzept for crosshairs that allowed for a greater click area without an increased size of the game board.

In the vertical dimension of the prototype we focussed on the connectivity between two devices. The protoypical implementation using the iOS APIs showed that it is possible to connect two devices either directly via Bluetooth or WiFi and over the Internet using WiFi or cellular data. For Internet connections the Game Center API was used to initialize and handle connections. Direct (or local) connections can also be created without the Game Center API. At this point we decided that for backwards compatability we also support older iOS devices that do not offer Game Center functionalities. Even though Internet games are not be supported on these devices, local connection can always be established.

In our opinion the overhead introduced by the prototype was justified as it yielded valuable results that could have led to difficulties during the implementation of Naval Combat. Two major advantages of the early prototype were:
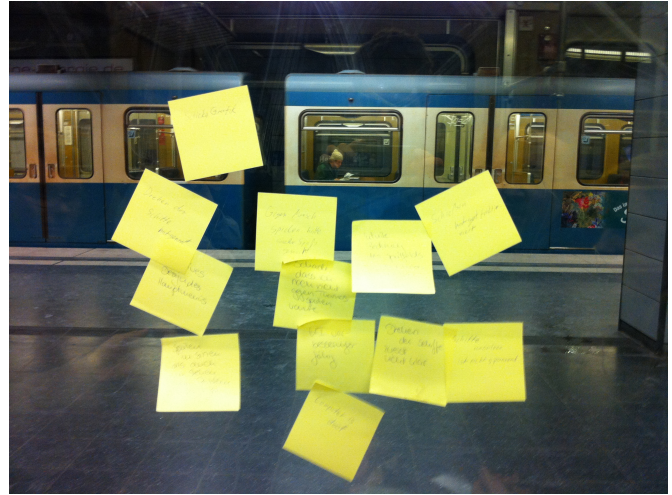
1. An abstract version of the user interface was tested and usability constraints were introduced by the vertical prototype.

2. The horizontal prototype has shown that it is feasible to realize the requirement that two devices can be connected.

First Increment (Field Test)
Right after the development of the prototype and with the new insights gained, we started to built the first increment of Naval Combat. In a month, we tried to implement as many items on the backlog as possible. Our goal was to have a runnable version for the singleplayer mode and the ability to start a multiplayer game using Bluetooth. Game Center functionality was not integrated in this increment. Regarding usability, the focus lay on the development of crosshairs to select specific fields on a game board and the creation of gestures that let users rotate and place ships on the game board. We also followed the suggestion to concentrate on the visual design of the game. Figure 3(b) shows a screenshot of the first increment.

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<table>
(a) Participants during the field test | (b) Participants clustering impressions and suggestions on a subway train window using sticky notes
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Figure 4. Field test conducted on a subway train

Field Test

Using our first prototype we conducted a field test in the actual setting of a public transportation system. We have chosen to use a subway train for the field test because it was easier to install cameras in this environment compared to busses. Furthermore, the study has been conducted at night-time in order to avoid inference with commuters. Two university students, one female (age 23) and one male (age 24), were participating in the test. Both are commuters and use the local public transportation system on a daily basis. To better observe what reactions both participants show and how they use the game we installed four cameras that simultaneously recorded the field test. Two cameras were adjusted to record both iPhone screens and another two cameras filmed the students head-on. Additionally a microphone was used to record the participants' conversations and acoustic reactions. Figure 4(a) depicts the setting of the study.

For the test, both students were given an iPhone with an installation of the first increment of Naval Combat. The participants were asked to perform the following tasks:

- Get familiar with the game and try to start a game.

- Start a singeplayer game and try to place ships randomly, then start the game and play it for a few rounds.

- Start a multiplayer game between the two devices and play it for a few rounds.

During these tasks we randomly asked the participants to pause the game for a simulated ticket check. We also requested one student to stand up and continue to play the game while standing in the subway train. To better test the accuracy of the click areas for the buttons and fields of the game board we asked both participants to press specific buttons, place ships on specific positions, or shoot at a specific field. The study took about 45 minutes.

After playing the game the participants wrote impressions and suggestions on sticky notes and clustered them on a subway train window (see figure 4(b)). The findings suggested that the gestures for ship rotation and ship placement were difficult to get right and that it sometimes was difficult to hit a specific ship. The impressions also stated that animations felt sluggish and that the computer was shooting to fast when playing in singleplayer mode. Feature requests included an introduction for the gestures that can be used, an indicator that shows how may enemy ships are left, and a randomize button to place ships randomly on the game board.

The video and audio recordings had proven to be helpful for an in-depth analysis of the study. To develop better gestures and resolve bugs, the video material gave an insight what users might expect from specific actions.

Second Increment (Heuristic Evaluation)

For the second increment we mainly focussed on the integration of Game Center for Internet multiplayer games, achievements, and leaderboards. It was a major goal to have processed all functional requirements that we had defined at the beginning of the project by the end of this iteration. Besides adding these features, the findings of the field test were used to improve the existing game and fix bugs. A screenshot of the second increment is shown in figure 3(c).

Heuristic Evaluation

To receive further user feedback we conducted a heuristic evaluation as proposed by Nielson and Molich [8]. Six evaluators were given an iPhone with the second increment of Naval Combat installed on the device. During the evaluation they first inspected the interface alone. After that the evaluators communicated and aggregated their findings. The evaluation took about one hour of time. The aggregated set of findings were sent to the evaluators. In the email, we asked them to prioritize each finding on a scale of 1 (low prior-

#	Finding	Average
1	Saving and resuming a game is not possible (for singleplayer games)	5.6
2	Interactive help, tutorial, or explanation of rules is missing	5.0
3	Consistency of the look and feel of in-game buttons is violated	4.6
4	Some gestures are unknown	4.4
5	Back button on the difficulty settings screen is missing	4.0
6	Indicator for destroyed and remaining ships is missing	4.0
7	Animations do not feel smooth enough	4.0
8	Selecting a ship by tapping it feels sluggish	4.0
9	Dragging the crosshair is not possible	3.4
10	Button to randomize initial placement of ships is missing	3.2
11	Acoustic feedback is missing	3.0
12	Crosses on a ship should be hidden when it is completely destroyed	2.4
13	The click area of buttons needs to be larger	2.4

Figure 5. Results of the heuristic evaluation (lowest priority (1) – highest priority (7))

ity) to 7 (high priority) and send the ratings back to us. The results of the heuristic evaluation are depicted in figure 5.

Having had a list of prioritized findings for the second increment we knew what users are concerned about. The list further helped us to plan what bugs needed to be fixed in the final version of the game. As the development team, we investigated each list item and discussed and estimated the amount of work to process the finding. Taking the estimation into account, we agreed to fix every aspect related to existing features such as the animations not feeling smooth enough and to implement all feature requests besides finding #1. Even though the lack to persist a singleplayer game was rated highest among the evaluators, we estimated a huge workload to implement this feature. Our design did not take this into account and major internal changes would have been needed to include this feature. We therefore decided to postpone singplayer game saving to later increment of the game and instead process all other findings for the first release version of Naval Combat.

Final Product (User Evaluation)

For the final product, i.e. the version of Naval Combat that had been submitted to the App Store, we implemented the feature requests we received during the heuristic evaluation and focussed on general stability. As shown in figure 3(d), the graphical user interface was given a more vivid look and feel. Furthermore, the source code of the game was intensively refactored in this iteration and prepared to be reused for updates and new games based on Naval Combat's foundation.

User Evaluation

One month prior to the submission to the App Store, a last user evaluation was conducted with four participants (one female (age 22), three male (age 24–25)). The study was conducted in a crowded environment with four iPhones and participants were asked to play Naval Combat without any further instructions. It was specifically important to us that the study was not conducted inside a laboratory but in a surrounding were it is intended to be played. Later, the participants evaluated the game according to the playability heuristics introduced in [4].

The results showed that Naval Combat does barely violate any of the mobility and game usability heuristics. However, participants wished for more possibilities to express themselves during gameplay. This feedback gave a hint on what future updates to the game should contain: different playing styles, different graphics for ships, and more customization for users in the multiplayer environment.

IMPLICATIONS FOR THE DEVELOPMENT PROCESS
[[TODO]]

CONCLUSION

[[TODO]] In April 2011, Naval Combat has been released on the App Store [6].

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