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Strategies and Movement Patterns for City-Wide Location-Based Games

Diploma Thesis at the
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I hereby declare that I have created this work completely on my own and used no other sources or tools than the ones listed, and that I have marked any citations accordingly.

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Aachen, June 2013
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Abstract

Nowadays, mobile devices with increased power and a broadening range of features such as built-in GPS receivers, are a ubiquitous part of many peoples' daily lives. This enables many different location-based services in domains like tourism, navigation, or gaming. In those, a particular focus is often laid on the location information as content or input, rather then emphasizing the groups' internal interactions. This is an important issue, because many of these systems are used simultaneously by multiple people in groups. In this diploma thesis we describe our research on group dynamics in location-based games for city-wide areas. Inspired by previous initiatives by our research group, we designed a quest-driven multiplayer game in order to collect as much applicable data on the movement and behavior of the players as possible.

We organized a Design Studio with the goal of generating new quest types and scenarios for location-based games. The resulting ideas were refined into four preliminary quests embedded in a connecting storyline. An analysis of these concepts using a low-fidelity board game prototype proved them to be appropriate for an interactive and collaborative game design.

Thus, we converted the three most successful quest concepts into a software prototype called "MLOG". Consisting of two different location-based and one other quest type, mLog supplies numerous opportunities for social interaction and collaboration. Moreover, we implemented a chat function to enable long range communication between group members.

From the evaluation of our user study we learned that the players' movement patterns correlate with the quest type. During the first quest that took place in an open accessible space players were found to move individually. In contrast, players split up into smaller subgroups during the second quest that extendrd over the market place and a winding street. Furthermore, we found evidence for an upper limit on how far individual users tend to separate themselves from their teammates. The analysis of the communication data showed that the chat function was useful, but still did not entirely fit the users' needs. We made several more discoveries on aspects of covered distances, duration of the game, group dynamics and the success of individual quest designs.

Überblick

Wir leben in einer Welt, in der mobile Geräte mit immer mehr Möglichkeiten und eingebauten Funktionen, wie zum Beispiel einem GPS Empfänger, allgegenwärtiger Bestandteil des Alltags sind. Dies ermöglicht ortsbasierte Funktionen in vielen verschiedenen Anwendungsgebieten wie Tourismus, Navigation oder in Spielen. Dabei wird häufig nur der Ort als eine Eingabe oder Spielinhalt gesehen, ohne dabei auch die Implikationen für die Gruppen-Dynamik zu betrachten. Das erscheint wichtig, da viele dieser Spiele in Gruppen von mehreren Personen gleichzeitig genutzt werden.

In dieser Diplomarbeit beschreiben wir unsere Forschung über Gruppen-Dynamik in ortsbasierten, stadtweiten Spielen. Inspiriert durch vorherige Forschungen in dieser Richtung durch unseren Lehrstuhl, entwarfen wir ein quest-basiertes Spiel für mehrere Spieler, um möglichst viele Daten über das Bewegungsverhalten der Nutzer zu erhalten.

Die mit Hilfe eines Design Studios entwickelten Ideen wurden in vier vorläufigen Quest-Entwürfen präzisiert und durch eine Handlung verknüpft. Eine Benutzerstudie anhand eines Bettspiel-Papier-Prototypen ergab, dass die vorgeschlagenen Ideen einem interaktiven und gemeinschaftlich spielbaren Design genügen.

Daher übertrugen wir die drei erfolgreichsten Konzepte in eine Software Version des Prototypen, der "MLOG" genannt wurde. Bestehend aus 2 ortsbasierten Quests und einem weiteren Quest, bietet er zahlreiche Möglichkeiten für soziale Interaktionen und Kollaborationen. Darüber hinaus erweiterten wir die Software um eine Chat-Funktion, um den Spielern die Möglichkeit der Kommunikation über weite Strecken zu ermöglichen.

Aus der Evaluation der zweiten Benutzerstudie konnten wir zwei Typen von Bewegungsmustern ableiten. Während des ersten Quests, der auf einem offenen Platz statt fand, bewegten die Spieler sich individuell unabhängig von einander. Beim zweiten Quest, der in einem verwinkelten und unübersichtlichen Gebiet gespielt wurde, teilten sich die Spieler in kleine Gruppen auf. Des weiteren fanden wir Hinweise für eine obere Schranke der Distanz, bis zu der sich Spieler von ihrer Gruppe entfernen. Die Analyse der Kommunikation zeigte, dass die Chat-Funktion eine nützliche, aber keinesfalls zufriedenstellende Lösung war. Es wurden darüber hinaus weitere Erkenntnisse über die Gruppendynamik, die zurückgelegten Entfernungen, die Dauer des Spieles, sowie den Erfolg der einzelnen Quest gewonnen.

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Thank you!

Conventions

Throughout this thesis we use the following conventions.

Text conventions

Definitions of technical terms or short excursus are set off in colored boxes.

EXCURSUS:
Excursus are detailed discussions of a particular point in a book, usually in an appendix, or digressions in a written text.

Definition:
Excursus

Source code and implementation symbols are written in typewriter-style text.

`CDBLocation`

All names of presented games are written in small capitals.

GEOCACHING

The whole thesis is written in American English.

Download links are set off in colored boxes. For the case the online resources are not accessible, a CD ROM provided with the print version of this thesis contains the linked files as well.

File: mLog Source Code Archive[a]

[a] http://hci.rwth-aachen.de/~huch/thesis/downloads/mLogSource.zip

Chapter 1

Introduction

In recent years, mobile devices have become a more central part of our life. Improvements in battery and processor design allowed for a much more economical and feature rich device conception. Human-Computer Interaction (HCI) Research in this area addresses many different location-based services in domains like tourism, navigation or gaming. Thereby, a particular focus is often laid on the location information. Several projects investigated how locations can be included as content or what kind of new interfaces became feasible by using position data as input. However, most approaches do not emphasize the group internal interactions. This is an important issue, because many of these games are used simultaneously by multiple players in groups. The game design often tend to isolate users from each other by splitting them into sub-groups without appropriate built-in communication support. This limited inter-group communication makes it hard to interact within the group. Consequently, the experience tends to be rather individual.

AIXplorer and GROUPAIXPLORER

In 2009, the Media Computing Group of the RWTH Aachen university developed the AIXplorer, a mobile audio and multimedia tour guide for the city of Aachen. In its current version, it serves as a multimedia guide for the town hall and its vicinity. It is planned to extend the system over the next years in order to help tourists explore the city and its rich cultural and historical heritage while offering loca-

tion aware information. The guide features automatic room detection through wifi tracking combined with a very intuitive interface and is thus easy to use.

Nevertheless, the original system lacks features for small groups, resulting in individual usage with low communication and interaction among group members. Wermers [2010] tackled this problem with the GROUPAIXPLORER game. Users had to solve tasks called *quests* about content in the city hall and discuss their experience with each other. But this enabled and encouraged communication and lead to a measurable increase of interaction between users in a small group. The proposed system was limited to the ground floor of the city hall, which is a rather small area.

To bring the concept of a quest-driven game to the next level, a larger area, which the group should explore freely, is necessary. Also new quest types need to be developed, which could cope with new game environments. The goal of this diploma thesis is to address these challenges by introducing a quest-driven location-based game for city-wide areas. To make the terminology clear, we defined for the course of this thesis a quest as follows:

Definition: *Quest*

QUEST:
A quest means "the hunt for a specific outcome, rather than just winning the game" (cf. Aarseth [2004]). Usually quests have a well-defined beginning and end, where the goal is to master a series of challenges.

Research questions

With this game we wanted to identify and analyze movement patterns of the players during different game situations. We were also interested in how the players reacted to tasks that led to a splitting of the group. Furthermore, we investigated if and how far were players willing to move away from the group. Providing and analyzing different communication channels was another objective we wanted to achieve, especially in the case of players separated from the group.

Since the game is set up in a public space, we wanted to investigate if this conflicts with players' comfort. To achieve these goals we planned a location-based game with a set

of three to four quests. The quests should not be independently, but rather embedded within a larger story and continuous theme.

Iterative game design

The design of the game evolved during two iteration cycles consisting of a paper prototype for proving our design decisions and a software prototype to evaluate the concepts and for gathering data for later analysis. The latter prototype we named "mLog" for its purpose to log movement related data. In the following, this term will refer to the implementation of the second design iteration.

1.1 Structural Outline of the Thesis

This thesis is structured as follows:

Chapter 2—"Related Work" presents other research on location-based games. We describe game concepts that were used in those projects. Many of these concepts inspired us and influenced the design of our own system. We explain why certain ideas were adopted and what we learned from the studies.

Chapter 3—"Design Goals" describes the approach that helped us to generate more ideas for quest and game scenarios. The ideas emerging from this Design Studio were then refined into four different quest types and a connecting storyline we presented in the second part of this chapter.

Chapter 4—"Towards a Working Game" gives a description of the paper prototype board game we created. This prototype was made in order to evaluate our previous design decisions. Based on the findings we selected the three most successful quest designs and modified them to be suitable for an interactive software prototype called MLOG.

Chapter 5—"Final Implementation" describes the development of the software quest game. The first sections explain the used hardware and introduces CouchDB as our database solution on the server side. The design process of

the graphical user interface as well as an overview on the underlying software architecture is documented in the later sections.

Chapter 6—"Evaluation" describes the evaluation of MLOG tested by six groups of players. Observations from the users and results from the questionnaires are presented and interpreted. We also developed a way to visualize the collected position data in a meaningful way.

Chapter 7—"Summary and Future Work" concludes this thesis and sums up the most significant results. The chapter finishes with a list of remaining design problems and further research ideas which should be addressed in the future.

Chapter 2

Related Work

Before going into detail about related research, located in the same field as this thesis, we will define the terms *location-aware*, *location-based* and *position-based* games as a convention for this thesis. (cf. Will [2013]POSITION VS. LOCATION)
A *location-based* game uses information in the real world as content for the game. A example of a location-based game is PAPER CHASE[1]. The goal of the game is to find a hidden treasure with the help of small hints, which were placed by one of the players. PAPER CHASE can be played in different places and the respective environment is a crucial factor, because it will change the game experience. *Location-awareness* describes a capability of the device on which the game is played. Nowadays most smartphones provide a build-in GPS-receiver and therefore are location-aware. The location-aware game in our example may not only use the street grid of a city, but can also tell where the players currently are.
A third class of games are *position-based* games. These are games that could be played anywhere with sufficient space, because only the player's position relative to the playground matters. The classic game [2] can be seen as position-based, since it can be played anywhere with enough open space. Specific real world features usually do not play a role for the game. In a variation of the game the player needs to

[1]http://en.wikipedia.org/wiki/paper chase
[2]http://en.wikipedia.org/wiki/Tag (game)

run into the safe-zone for them not to be tagged. This save-zone is a predetermined area, but has no further distinctive features.

In this chapter we will analyze projects from all three categories which had major influence on our work.
Beforehand we will take a look on publications that compare multiple location-based games for getting an insight into the fundamentals of location-based game design.
We will then discuss location-based and position-based games that feature some kind of team-based collaborative aspects. Moreover, we will consider studies focusing on communication and group dynamics. Both of these aspects are essential factors that have to be taken into account when conducting our own research. Therefore we will compare these studies in their respective main features to our own ideas and discuss the particular advantages and disadvantages of the presented systems.
Afterwards we consider commercially successful location-based games with a worldwide fan base. Finally, a summary of our findings and an overview on the adapted ideas will be given.

2.1 Theoretical Background

In this section we will discuss publications in which the authors compare several papers from the field of location-based games.

Montola et al. [2009] collected in their book different kinds of pervasive games and analyzed them from multiple point of views. They investigated what makes these games compelling and what concepts should be observed by game designers. Game researchers can use it as a source of a solid theoretical background of the genre. We took several examples from this book, like SONG OF THE NORTH or REXPLORER, into account. Those will be discussed in this chapter.

The dissertation written by Suomela [2006] gave us some guidelines on how to prototype and build location-based

games. Although the author examined location-based applications in general, she touched the gaming genre and gave some worthwhile insights. The distinction between location-awareness and context-awareness introduced by the author was very revealing and influenced our own classification as it was described above. Moreover they described how to combine real and virtual worlds and illustrated what effects could be.

At the same time as our own work was carried out, another diploma thesis was written by Will [2013] in the same field. The author focused on a pattern language for location-based games and shaped our viewpoint in how to design such a game. We kept this patterns in mind during our design phase, but most of them were still in process at this time.

2.1.1 The Role of Location

Reid [2008] concentrates on "the relevance of place" , therefore they compare several location-based games. In the definition of Harrison and Dourish [1996] *space* is only a geometrical arrangement, while *place* has more features, like its social meaning or cultural heritage as it is perceived by the player. This distinction is similar to our attempt to distinguish between position-based and location-based games. The former refers to spaces, while the latter is based on places.
The authors classify a number of location-based games along this dimension as shown in Figure 2.1. Some of the relevant ones will be described in more detail in the following sections.

Most of the games presented by the authors were designed using the mediascapes frameworkdevelopment by Hewlett Packard. We find especially the singleplayer game DOUBLOONS noteworthy, since it is a good example for a position-based game that has been designed with the help of this framework. Players in this game need a mediascapes-compatible device like a PDA and an open space. The Player first places five islands by walking

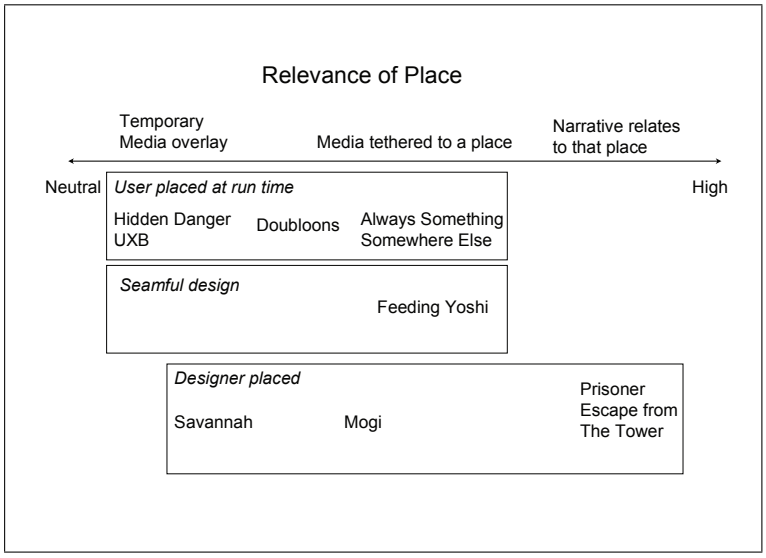

Figure 2.1: Figure 1 from "Design for Coincidence" by Reid [2008]

around and choosing a position for them. Once the islands are placed, the game starts. The goal is to trade goods between the islands and to avoid being robbed by pirates at the same time. The duration of the game is approximately 15 minutes.

A main finding was that when the user placed objects as part of the game, it became playable anywhere in the world, but still could be connected to a place. It also personalized the game experience, since the player specify how the virtual game world is integrated in their environment by tethering virtual objects to elements in their own location. In this way, the concept combines location-based gaming with position-based gaming. This and other insights about the distinction between place and space were of high value for our work. In addition, the discussed publications were a good start for our search for literature.

2.2 Games Based on Locations

2.2.1 Direct Predecessors

This section refers to two tourist guide systems developed by the Media Computing Group, which can be seen as predecessors of our own work. Consequently their design decisions and findings have much impact on our endeavors in this field.

REXplorer

A explorative study using the game REXPLORER was introduced by Ballagas et al. [2007]. The game is a pervasive tourist guide that is supposed to help tourists explore the historical city of Regensburg, Germany. The authors use a storytelling, quest-based approach to guide the tourists from one point of interest to another.

Each group of players gets a special *paranormal activity detector* build from a mobile phone and a GPS receiver that they can use to detect *spirits*. All spirits are based on mythological or historical persons telling a cliffhanger story. Each of them asks the players to fulfill a quest that leads them to a different point of interest in the city. The device is capable of speaking directly to the players, making itself a character too. It reacts to a great number of situations that might come up during the game. For example, if the player enters a so called *hotzone* around a point of interest, the device gives feedback via an audio signal and vibrations.
To activate or solve quests the device can be used as a magic wand by drawing one of four gestures in the air. The players' progress is tracked by a personalized *geo-weblog* that contains the players route, a list of all sites and characters they met and pictures and videos that they might have taken.

We were especially interested in the user-centered iterative-design techniques the authors used to develop this game,

since traditional desktop iterative-design techniques, such as paper prototyping, are of limited use for location-based games (compare Ballagas and Walz [2007]). After generating a number of game ideas they built a physical prototype in form of a board game. They also suggested to use dices and cards to trigger certain events and give a more realistic simulation of the actual game. Moreover the authors emphasized the importance of high quality narrative and graphical art in their final product. We created our first prototype with their recommendations in mind, but since we want to focus on how groups move and communicate, their design concept of a table board game was not suitable for us.

GroupAIXplorer

Wermers [2010] designed a collaborative quest game called GROUPAIXPLORER to overcome the limitation of traditional audio guides. Such guide systems are a popular way to transfer information about visited sites, but tend to isolate groups of users due to the use of headphones, which disrupts interaction and communication between group members.

The goal of the group consisting of up to five people is to find specific exhibits in a museum and solve related quests. Two types of quests are provided in the game. The *discussion quest type* presents an interesting fact or anecdote to the players and encourages them to discuss it freely. When they feel that they have discussed the topic enough, they can hear a short explanation from the device. The *interactive quest type* is a kind of riddle that the users have to solve. Each member of the group is assigned to a separate part of the riddle, they have to answer by themselves. In this game a distinction is made between the leader and the other team members. The leader is elected at the beginning of the game and only they can activate a quest or submit the solution.

As their game device they extended the already existing museum's guide AIXPLORER with a redesigned software. To avoid the above mentioned isolation problem, they used

monaural headphones and synchronized audio playback, which allowed the players to talk to each other while playing. Another notable design decision was the implementation of a message system that allowed a single player to send his group fellows a predefined text message, telling them to come over to his location or, on the contrary, informing them about their coming. This feature was particularly useful for call over the leader. There was also other, mostly quest-related, notifications broadcasted this way.

A part of the impact of the collaborative game design on the perceived degree of entertainment was, the design of the quest types was of particular interest. The discussion quest was proved to work, which implied that such quests do not have to be automatically verified. In this way it enables games to touch even complex topics without losing appeal.

The result from of user study showed that the leader concept was not ideal. Many users were bothered that the system only allowed the leader to make decisions. Another problem was the unreliability of the network infrastructure that the study used. In our design process, we tried to consider both problems.

2.2.2 Feeding Yoshi

Bell et al. [2006] investigated the question how people combine their everyday life with a game that runs all day long. They developed a long-run multiplayer game called FEEDING YOSHI for PDA and tested it on four teams of four participants in three UK cities of different sizes.

The game's concept is to find Yoshis and feed them with fruits picked from plantations. Every Yoshi likes five out of seven fruits and carries seeds for his favorite fruit, which the players can sow at plantations. For the Yoshis' locations secured WiFi spots are used, where as the plantations are positioned at unsecured WiFi spots. These WiFi spots are not placed or selected by an administrator like in MOGI (compare Section 2.4.1). The game device rather use the existing networks in each area.

This concept is called *seamful design* and means that the infrastructure itself becomes a feature of the game. As the presence of WiFi networks varies over a city, players need to explore their city in a new way. If the device reaches an area with new WiFi connections, the PDA gives acoustic and visual feedback. Nearby teammates are detected, giving the players an opportunity to trade fruits and seeds. The goal for the teams is to gain points by feeding a Yoshi with its desired fruits. Giving him all five favorite fruits gains the most points, while feeding him with unwanted fruits results in a loss of points. In the end the result is displayed in a highscore list.

The authors noted three important key issues the players experienced during the user studies:

- Fitting the game into everyday life
- Impact of friendship and collaborations
- Implications of the location used as playground

The players dealt with the first issue in two fundamentally different ways. Either they changed their everyday schedule to spare some time for the game and played it continuously for some hours or they interweaved the game with their normal activities and played a larger number of shorter turns. The second item referred to the relationship to other players and non-players. The authors found that the more time team members spent together, the higher their score got, because excitement came also from talking and being with teammates. Then again, non-player relation could suffer from spending too much time on the game. The implications of the location resulted from the distribution of WiFi spots. Firstly players in cities with a smaller density of access points have to cover greater distances to achieve the same points as players in cities with larger densities of access points. Secondly some areas like industrial and business districts gave negative feelings to the player, because they feared to be mugged. Other places were completely avoided because of the local camera surveillance.

Our work was influenced by the general idea of explorative game design and the quest concept of transferring virtual

items from one place to another in our game.
We also found the idea of using WiFi spots to be a creative way to generate a random setup. We did not use it, because we aimed for a stronger connection between virtual objects and the physical world.
In addition, we chose a playground in a more populated public area, but tried to avoid security cameras, because of the reported issues.

2.2.3 The Songs of North

The pervasive game THE SONGS OF NORTH is content of a case study by Lankoski et al. [2004] on possible technical and game design solutions for pervasive games. The goal of the study was to prototype a multiplayer game for mobile devices that takes advantage of all the device's capabilities. The authors particularly focused on communication aspects and location-awareness.

The storyline mixes the present time reality with a semi-fantastic reality. The player, in the role of a shaman is contacted by the elder gods of the north. The main interface is a shaman drum that is simulated by the game device. With this drum, it is possible to contact the forgotten spirit world. To interact with the spirits, the player can drum by selecting predefined button combinations on the device. Feedback is provided in the form of sounds from the invisible spirits and visual patterns of bones on the drum.
The game world is provided by a permanently reachable game server that maintains the game mechanics and rules. Spirit world and physical world are linked together. A player, as long as they are logged into the game and moves in the physical world, is also moving in the spirit world. When the client device is turned off, the player avatar disappears. That gives players the opportunity to reveal their identity to other players in the physical world, but it is not necessary to play the game. On can interact with other players or objects in the game via spells or chants.

To provide an ongoing motivation there are quests, partly cooperative, partly solvable by single players. However, most of the quests are solvable with multiple players in a more efficient or faster way. To motivate players' movement in the physical world, the spell in-game costs correspond to the distance of the target object. So the user could choose between investing physical energy by moving or spiritual energy within the game. However, moving had the benefit of seeing the teammates and discussing their progress. Communication as a major aspect of the design, is also supported by different roles and skill requirements. The game supports this by providing a simple text messaging service, but also fosters speaking face-to-face.

The concept of using the movement of players as a key game element was reported to have also disadvantages. Players need to spent time and effort to cover the distances between in-game elements. To overcome this drawback, the authors suggested to support team play and communication. For example it was found that a player in the lead was often seen as a common enemy, which encouraged the other players to ally and led to more communication. Also, trading in general was observed as a communication increasing factor.

We found the concept of distance as a measure of in-game costs promising. Also the authors thoughts about communication and the idea of a simple text messaging service seemed adaptable.

2.2.4 Conspiracy For Good

CONSPIRACY FOR GOOD (CFG) by Stenros et al. [2011] is an alternate reality game designed to examine how players' activities and a fixed storyline work together. The play profits from both content located in the real world and online, which the players need to explore and assemble. The design offers direct participation in a well-designed storyline in a combination of strong narratives with pervasive street play.

The online part of the game took four months, culminating in four live events in summer 2010 which were placed in the streets of London. It started with a viral teaser campaign, leading to the website where classic puzzle solving and distributed narrative were used to introduce the players to the characters and the storyline. At the same time, three free puzzle games, that served as another entry route to the game via Nokia phones, were issued.

The live events lasted six hours and had 80-120 participants each. Every live player group was equipped with a Nokia smartphone that was capable of Point & Find technology. By pointing the phone towards an object, the players retrieved related information. This enabled a game part similar to treasure hunt, which the authors called *environmental storytelling*. The players needed to uncover clues and other plot material by exploring real world places.

The authors mentioned a number of important issues that led to a partial or even a complete breakdown of the immersion. One of these problems was that their audience were split into online players and street players. While the online part could be played anywhere on the world, the live act needed physical presence in London on a certain day. Players that attended the latter often saw the game more as an ad-hoc-event that required very little preparation. In contrast to this, online players were better prepared for the live events. So several of the interviewed live participants showed unanticipatedly low involvement in the background story. This, in turn, led to significant drawbacks.
Other problems, the authors mentioned, were caused by design decisions. To keep the illusion of alternate reality, it was attempted to instruct the players about rules and background story from within the game. This turned out to be a inefficient way and could even lead to the players not understanding the goals of the game. The authors suggested to explain the goals and settings outside the fiction.
A second problem was that players missed a clear sense of achievement or failure and therefore it seems to them that their actions had no impact on the game. It was suggested to make possible winning and losing conditions more explicit, as they are an important motivational factor.

CONSPIRACY FOR GOOD influenced our work by showing that team play is highly appreciated by the participants. A team allows the players to compare their knowledge about the game with each other. This makes it easier for inexperienced players to get into the game. We also learned from their study that teams can pool skills and divide labor, for example not all team members need to carry out "awkward" social tasks (talking to bystanders, role-playing).

2.3 Games Based on Position Information

2.3.1 Savannah

Benford et al. [2005] present in their study a position-based educational game called SAVANNAH. The authors investigated how the dynamic group behavior and the used technology interacted with each other by combining video and voice recordings of the playing participants and logged data from their devices.

In the game groups of children pretend to be lions hunting together on a virtual savanna which is laid over an open playing field. Like real lions, they have to collaborate in sharing information or acting collectively, for example to successfully hunt a bigger prey. To do so they have to be together in one spatial area and need to coordinate their attacks against the prey. If a pride of lions is too small to lead a successful attack on e.g. a mature buffalo, all the players lose health points. Therefore careful decisions are required for weighing up between cost and benefits.
The maintaining for these rules, the layout of the map with different zones, and the current game state are stored on a server. Every player gets a PDA with WiFi and GPS capabilities. These clients continuously send location updates and notifications about interaction with UI elements to the server. The server responds by triggering the UI and sending notifications about the outcome of the user's actions.

The study focused on group dynamics and collaborative experience, where several co-located participants had to

coordinate their movements. Savannah was tested by groups of up to six school children aged between nine to twelve. One play consisted of three levels, each lasting approximately eight minutes. For analysis the authors used a combined interface that shows the players' locations and current UIs alongside video capture and voice recordings.

Although the game is engaging, the authors observed some coordination difficulties. Firstly, the participants had problems with GPS jitter, which led to "jumps" in and out of zones. Secondly, the first player in a group that found a target often did not walk further immediately after the UI signaled that they had crossed the invisible border. This led to a split in the team, leaving some players outside and some inside the zone. Each part of the team then saw a different state on the device. To address this boundary effect the authors suggested to either use two levels of boundaries with an inner trigger zone and an outer capture zone for the other players to join, or to introduce a personal *aura*, which extends the current zone by a given radius around the triggering person.

This paper drew our attention to the problem of boundary effects, which we will discuss in Section 4.2.1. We also liked the idea of video taping the participants while playing the game, because it provided a deeper insight into the group dynamics. But since we wanted the game to take place in a public location, video recordings might have resulted in privacy issues.

2.4 Commercial Games

In this section we will discuss four commercially successful location-based games. Even though they are free to play, we will regard them as commercial products, because of the nature of their distribution.

2.4.1 Mogi and BotFighters

Two of the oldest of location-based games are BOTFIGHTERS and MOGI, which was only popular in Japan. BOTFIGHTERS is a multiplayer game played on a mobile phone and has the goal of locating and destroying other robots. The player gains credits for destroying targets and thereby advances on the high score list. Credits can be used for new weapons or other upgrades for ones own robot. BotFighters is arguably one of the first commercial location-based games. It was produced by *It's Alive!* and was first launched in Sweden in 2001.
In MOGI players explore the real world collecting virtual items and trading them with other players. Since the items have to be placed beforehand by an administrator, it can not be played out-of-the-box.

Both games are mentioned in several publications including Montola et al. [2009] and Suomela [2006] and have only historical relevance for our work.

2.4.2 Geocaching

GEOCACHING is a treasure hunting game, in which the players use a GPS receiver to hide or seek containers called *geochaches* all over the world.

The game can be seen as a successor of the older LETTERBOXING hobby, in which players search for containers with only a map and a compass and some distributed clues. The origin of letterboxing can be traced back to the middle of the 19th century.
In May 2000 the US Army removed the Selective Availability, an artificial error on GPS position data. Dave Ulmer celebrated this event by hiding a box, filled with some "odds and ends" and a logbook. Afterwards he published its geocoordinates in a web forum for other people to find. This can be seen as the first geocache. Today there are more than 2 million[3] active caches of different sizes and shapes

[3] active caches according to: http://www.geocaching.com

in the world. Since most mobile phones are equipped with a built-in GPS antenna, the popularity increased dramatically.

The core concept of all GEOCACHING activities is to find a cache by information that was released on websites like the one run by Groundspeak. Most of those websites provide information about size and difficulty to find the cache. Beside the traditional caches, there are so called *mystery caches*, which require the player to discover information or solve a puzzle to find it. Another kind of cache called *multi-cache* consists of multiple discoveries, each one containing information about the next step.

GEOCACHING is one of the longest-running location-based games played by millions of gamers worldwide. Therefore, it offers some precious insights on what is fun in such a game and clearly shaped our own game design.

2.4.3 Ingress

INGRESS is an augmented reality massively multiplayer game created by Niantic Labs at Google that mixes geocaching with simple RPG elements.

The background story is about two factions, the "Enlightened" and the "Resistance", who argue about portals that are placed scattered all over the world and try to win them themselves. Players, who have the necessary keys, can link multiple portals together and thereby enclose a region. The resident individuals in this area are then credited as "Mind Unit" in a global statistic for the own side till the other faction fights back. Each portal corresponds to a landmark or site in the real world.
In the beginning each player selects, after a brief tutorial mission, one of the two factions. Afterwards the player can collect items by hacking portals and making action points (APs) in order to achieve higher levels. The most important items are "resonators", which are needed to claim a portal, and "xmps" as weapons to take over portals from the enemy.

The game is currently in a closed beta phase and only playable on Android smartphones. As Google constructed the game as an experiment on augmented reality gaming that runs at least 18 months, its continuance is uncertain. It only provides rudimentary interaction for defending portals and has, apart from the tutorial, no missions. Also the density of portals varies between urban and rural regions. Still, the game community is very active and elucidated the social component of the game. For example to build up a portal on higher levels a cooperative proceeding is necessary. Testers reported that even in distant countries INGRESS helps to quickly get to know other people.

For our work, the variety and extent of the mentioned successful games in terms of dissemination, proves that location-based gaming became a more and more important field in game design over the last decade. The availability of GPS and other tracking technology and the enhanced distribution of smartphones with increasing computation power even enables further growth in this sector.

2.5 Influences on this Work

We already mentioned how some of these systems took influence on our work. The following Table 2.1 provides an overview of the described systems.

	Game Type	Design Goals	Key Features	Target Audience & Group Size	Duration	Influence on Our Work
REX-plorer	pervasive tourist game	storytelling, quest-based approach of a tourists guide	cliffhanger stories; gesture recognition; hotzones	city tourist in small groups	not specified	low-fidelity prototyping techniques; hotzones
Group-AIX-plorer	museum game	quest-based; opportunity for communication; individual freedom of movement	interactive quests; synchronized audio	small groups of young adults; 2-5 players	50-70 minutes	quest-based approach; importance of communication
Feeding Yoshi	long-run location-based multiplayer game	*seamful design*; how to interweave game-play and everyday life	using existing secured & unsecured WiFi as design objects;	city tourist in small groups	group of four young adults	explorative game design; transferring virtual items; public area as playground
The Song of North	case study of a pervasive game	location-aware multiplayer game for mobile phones; focus on communication aspects	device acts as magic drum; distinction between logged in & logged out players	not specified	not specified	moved distance as a measure of in-game costs; simple text messaging
Con-spiracy For Good	alternate reality game	combination of online gaming and pervasive street play	large-scale user study; strong narratives and a detailed storyline	not specified (online); 80-120 (live event)	not specified (online); six hours (live event)	team-play as motivational factor
Savan-nah	position-based learning game	educating children about natural life in a savanna; study on group dynamics	encourage collaboration by game design; playable on any open space like schoolyards	school children aged up to six years	not specified	awareness of zones; potential of splitting teams up

Table 2.1: Projects Comparison Table

Chapter 3

Design Goals

In this chapter we will describe how we created a game concept out of the ideas of the Design Studio that we held for this purpose. At first, we will define the target audience in Section 3.1. Subsequently in Section 3.2 the Design Studio methodology will be explained and the results of it will be summarized. At the end of the chapter in Section 3.3 we will drafted a preliminary game design.

3.1 Target Users and Research Goals

3.1.1 Research Questions

There are many questions of interest in the research area of location-based games. Some of them were discussed in Chapter 2. Other questions arose in the discussions during this thesis. In the following list we summarize and categorize them:

- **Movement**: Are there different movement patterns observable in the context of location-based games?
- **Quest types**: Can we identify different kinds of quests by comparing their movement patterns?

- **Communication**: What "bandwidth" of communication is necessary? Should the system provide predefined messages or should the players be free in their mode of expression?
- **Prototyping**: How can location-based games be prototyped in a cost-efficient manner?
- **Social Aspects**: Do we need to allocate certain roles, e.g. leadership of the group, by design or will they develop on their own due to group dynamics? What are actions that can lead to social awkwardness in public spaces?
- **Distance**: What is the largest distance, that players are willing to move away from each other.

Moreover, some further questions come up by combining the above categories. For example: Does the need of communication between the players change when they cannot see each other anymore.

3.1.2 User Profile

An iterative user-centered design process usually implies that one has to think early about who the potential users are and what they might expect of the game. In the following we will summarize some key values about our user group.

Users need to be flexible in timing

Our target audience consists of small groups of students and young adults. They should already have a basic understanding of touch interfaces and know how to use smartphones. The opportunity to play a game over longer periods is as important as the will to visit a predetermined location. However, we planned the minimum time for one game session to be less than an hour. This should make the game more spontaneously playable. The planned category of the game is somewhere between serious games and casual games. On the one hand, it should transfer some knowledge about medieval Aachen, on the other hand players should not feel like they are in a history lesson.

3.2 Design Studio

With all these concepts and questions in mind, we decided to hold a Design Studio to generate more ideas for quests and possible scenarios for our location-based game.

3.2.1 Methodology

The Design Studio Methodology

Originally the concept of Design Studio comes from the fields of architecture and industrial design. The way we will use it was introduced by Warfel [2009]. Basically, it is a concrete form of a classical brainstorming session with three components called *create*, *pitch* and *critique*. The participants of the Design Studio are grouped into three to four groups of about five members each.

Three phases of each iteration

A Design Studio starts with the create phase. Each team contains members of various professions and focuses on a design challenge for one or more scenarios. They often get Personas, short descriptions of the potential user, and empty storyboard templates. Their goal is to come up with as many ideas as possible. Ideally every idea is illustrated in a rough sketch. All this should take place in five minutes. After this mass brainstorming, in the pitch phase everybody gets three minutes to pitch their best idea. Each team, represented by a speaker, should mention what persona and problem they took, what they suggested for the design and how this accomplishes the goal. Nobody is allowed to interrupt or ask questions during this presentation. The final phase is critique. The other teams have two minutes to review the design of the presenting team, but should not give feedback by saying what they like or dislike. Instead they should focus on how good the concept is in achieving the goal. Regardless of the quality of the design, some positive and negative aspects should be mentioned.
After the completion of the first cycle, the teams again iterate their most promising ideas through the phases. Taking over good ideas from other teams is highly appreciated, because all teams are working towards the same goal.

Figure 3.1: This photo was taken during a different Design Studio session. It shows a gerneral view of the the room.

For us the greatest benefit was the opportunity to generate a lot of ideas in a very short time frame, without wasting to much effort on detail questions as it often happens on standard brainstorming sessions.

3.2.2 Course of Our Design Studio

Our guidelines for the brainstorming

We started our Design Studio session by introducing the concept of location-based games and presenting possible directions of our study to the eight participants who were invited. The participants were briefed to focus on collaborative game designs with a high degree of immersion, involvement of the physical world surrounding the player and the fact that enjoyment of the game should not come just from interacting with the smartphone itself. Aside from this introduction we did not interfere the brainstorming process of the participants with our own thoughts and ideas, to avoid influencing the outcome or shifting the focus of the discussion in any way.

Design Studio proceedings

Then the groups began a 15 minute mass brainstorming session on concrete quest design and overall theme and storyline of the game. The goal here was to write down or sketch as many ideas as possible on sticky notes (c.f. Figure 3.2) These should be seen as raw material to work on later and should therefore not be elaborated in great detail. In this phase criticism should not be expressed on any proposal. The mass brainstorming was followed by a short break combined with an idea shopping session, meaning that participants wander around and find out about the suggestions of others. They could rate them by putting small colored dots to those sticky notes they preferred the most. Afterwards the participants formed groups of four to recombine solitary ideas and give them a spacial layout on a cardboard. The groups then presented their findings to each other and gave short critique.

Raw materials from the mass brainstorming

All teams in our Design Studio chose a medieval background theme, although this was not predetermined in any form from our side. While one group focused on a potential location in the inner city of Aachen that could be used for quests, the other group was concerned with possible interactions that could be used for such a game.

In the next iteration of the Design Studio each team selected one of the previously generated quest ideas they thought worthy of exploring and worked out more detail. They presented their results to the whole group. This was followed by a discussion session and finally all members voted for the three best designs.

3.2.3 Proposed Ideas

In the following we want to list some of the good ideas that came up in the Design Studio. Even though not all of them made it through the refining process, they shaped the overall design of our game.

- **A coded message:** A knocking signal on the city gate that users have to enter by tapping on the device in a certain pattern. Alternatively a cipher-text sent by a

Figure 3.2: Presented ideas during the Design Studio

(virtual) carrier pigeon that the users had to send off by a swing gesture.

- **Archaeological windows:** Uncovering a hidden artifact by gently swiping over the display, whereby too much swiping can destroy the artifact.

- **Aachen creeks:** Setting a small (virtual) boat in the creek and tracking down where it is driven.

- **Market place:** A trading game, where the players try to get prescribed goods in a given time limit. It was also suggested that the trader could be distracted by some players, so that another player could get a chance to steal some of the goods.

- **The jail "Grashaus"**[1]: The general concept is releasing a "good guy" from prison while under the watch of an evil warden. This could either be done by cam-

[1]The "Grashaus" is an actual building in Aachen. Originally built as a town hall, it was used as a prison during 14^{th} - 19^{th} Century.

ouflaging the players (e.g. steal guard uniforms from a clothesline) or by stunning or distracting the guards.

- **Aachen's fountains:** Inspired by the above jail-break idea, this could put the guard to sleep and thereby help the "good guy" to escape. Mixing an alchemical potion and "poisoning" the well of the guardhouse with it.
- **Historical monuments:** Measuring the height or length of monuments by using GPS or video capturing techniques. Alternatively pictures of the same building can simultaneously be taken from different angles, or the players can try to find the position from which a given picture was taken.

Two ideas worked out in detail

Our Design Studio led to the proposal of the following two detailed quest ideas. The idea of an alchemical experiment was chosen by two groups:

- **An alchemical experiment or mixing game**: The players' goal in this quest is to brew a potion. There are several interactions that need to be done simultaneously in the right manner. Firstly, the correct amount of every ingredient must be added to a cauldron. Secondly, one player should be responsible for maintaining the fire by adding wood and keeping an eye on the heat level. Another player should act as a mixer by stirring the potion, if necessary. Too much stirring could cool off the potion. There is only one correct ratio among these three interactions, which is unknown to the players and depends on the used ingredients. The players get feedback via a status bar representing the current overall quality of the potion. Also, there are some visual hints if something goes wrong (e.g. the potion turns dark if it gets too hot). All these interactions should be implemented by gestures, like a rotation gesture for stirring the potion.
- **"Egg-And-Spoon Race" game**: The players get a virtual pot with an acidic or poisonous mixture. The goal is to get this pot along a certain distance in a certain time. The in-story explanation for this could

be either that the pot becomes hot over time or that the mixture loses its effect. This breakdown could be shown visually (e.g. by a crack in the pot) or tactilely by a vibration of the device. As an alternative the player gets more points or other benefits for being faster. If this quest is combined with the mixing quest, the mixing quality of the potion could be an upper limit for the time the users have to fulfill this quest. To avoid losing the potion by a breakdown of the pot, the players could hand the potion to another player with a special gesture of the device. This could lead to a stronger cooperative game similar to a relay race.

Why we only chose some of the ideas

Aside from these two ideas, only a few of the others that came up in the Design Studio, were taken into account for the game. The reason for this was mostly that we cannot possibly implement more than a handful of the suggested ideas in one prototype. In addition to this it turned out that some of them did not fit to the intention of a collaborative game design. We stayed with quest types in which players benefit from splitting up their group, but are not obliged to do so. Other ideas like the virtual boat looked promising, but we wanted to avoid augmented reality implementations. They usually have high implementation costs and a tendency to suffer from tracking errors, which will break the illusion for the user and therefore could destroy the immersion we wanted to achieve.

The chosen four quests

We decided to have four quests and chose the two concepts of the mixing game and and the Egg-And-Spoon Race. Additionally we made use of the trading and the archaeological concept. The former comes with a non- linear solution path, because players can interact with the traders in any order. Also Lankoski et al. [2004] reported trading as an communication-triggering concept. The latter combined with an treasure hunt gains an explorative character as in GEOCACHING or FEEDING YOSHI by Bell et al. [2006], which might further encourage the players to split up their group (cf. Will [2013]EXPLORATION).

3.3 Preliminary Game Design

To link the four chosen quest ideas in a meaningful way we came up with a small story. From Stenros et al. [2011] and Ballagas et al. [2007] we knew how important a strong narrative is to enhance the immersion
(cf. Will [2013] IMMERSION).

3.3.1 The Storyline of the Game

Our story begins when the players arrive on the market place in front of the fountain with Charlemagne's statue on top. The king addresses them directly asking for their help in a matter of great importance. To show their loyalty they are supposed search for the remains of an ancient document, which was torn to pieces and scattered over the city. It is the players' task to find and retrieve all of the pieces.

When the players bring the reassembled scroll to the king, he unveils that the scroll stores the secret formula to a highly explosive powder. A good friend of the king is (unjustified) in jail and needs their help to escape. The king requests the players to provide him with the needed ingredients. The players can retrieve these items by trading with the local merchants. The wanted ingredients are sulfur, charcoal and saltpeter. The regent supplies the group with some fishes and coats that can be used for exchange.

In the third part of the adventure the players have obtained the requested ingredient and brought them to the king. He congratulates the group and asks them to produce some of the powder by mixing all ingredients together. Unfortunately the formula is a little unspecific about the needed quantities of each ingredients, so the players have to find the correct ratio by means of trial and error.

The final challenge is to bring a powder-filled pot to the wall of the jail, to break into the "Grashaus". This is quite tricky because the mixture is extremely shock-sensitive. When the team succeeds, the wall breaks and the king's friend is free. The king is very thankful and declares all team members to heroes of the realm.

3.3.2 Four Different Quest Types

The Archeology Quest

Archeology treasure concept

As a game concept, a treasure hunt was chosen for this quest, inspired by the prominent basic concept of GEOCACHING. The quest consists of two parts. In the first part the players explore a bounded area for pieces of a document. If they find a suspicious looking place, they can excavate it and may find a part of the document, if no other player has found it before. Players need to remove layers of dirt carefully, just as archeologists do, in order not do destroy the document. In the second part the players assemble the pieces of the document and give the complete document back to the king.

Freedom of movement

It was intended that the group itself decides how to achieve this goal. For example even though it might be helpful to split up to cover a greater area in the same amount of time, this is not predetermined in any way by the game design. Also the users are encouraged to use the provided communication channels. For example, if someone finds a piece of the document they can inform the other group members about it or even call them over to their position to discuss further steps.

Player-to-player trading

The players can also transfer the found parts of the ancient document between each other. This becomes existential for the last part, where one player has to have all the pieces to assemble them and hand them to the king. Aside from this all players are equal in power and possibilities with regards to the game mechanics. Even this last task can be done by any group member. There is no leader concept as it existed in the GROUPAIXPLORER by Wermers [2010].

The Trading Quest

The game concept behind this quest is inspired by the FEEDING YOSHI game of Bell et al. [2006]. Other influences

were board games like THE SETTLERS OF CATAN[2] The overall theme came from our Design Studio.

In the beginning, the players get some resources supplied by the king. They are distributed among all players to avoid an unintentional favoring of any player that would put them in a leading position over the others.

Trading needs intermediate steps

As in the first quest, the players know that they have to explore a specific area in which the traders are located. They also know that not all traders take all goods in exchange for their goods and therefore can not hope to exchange their initial resources directly to the target products, they need in order to win. The fact that at least one intermediate good is needed remains hidden to them.

Prices are stable, but depend on traveled distance

In contrast to classic trading simulations we kept the underlaying economy model simple. On the one hand the prices of any good are stable and do not change as they would by market demand or pricing pressure. On the other hand we took into account which geographical distance the player has to overcome to get a certain trading good for exchange. If they need to reach the remotest corner of the game area for a specific item, it is very valuable for all other traders. This limitations are not mentioned to the players.

Trader may modify their offers

If a trader is detected by a player, he introduces himself, offers what he has in stock and says what he excepts in exchange. The players may now trade with him or leave. If they come back later the exchange rate may have changed.

Player-to-player trading

Again it is possible and wise to exchange goods between group members and inform other players about found traders and their offers via the provided chat. Nevertheless, it is open to the team how they manage to succeed. The quest ends if one player has all requested items in his inventory and hands them to the king.

The Mixing Quest

Change of concept

This quest is directly based on the idea of an alchemical experiment or mixing game from the Design Studio described

[2] THE SETTLERS OF CATAN designed by Klaus Teuber. http://www.catan.com

in Section 3.2.3. However the complexity of implementing and testing it in the proposed way would exceed the scope of our work. Thus we came up with the idea of a quest that can be won by solving a puzzle similar to the *interactive quest* type introduced by Wermers [2010]. Consequently, we designed a simpler variant of the classic board game MASTERMIND [3].

Rules of the original board game

In the original version one player becomes the *codemaker*, the other the *codebreaker*. While the former choses a pattern of colored pins, the latter tries to break the code by guessing the pattern. Once the codebreaker has selected a pattern, the codemaker provides feedback on the number of pins of the correct color and correct position. Since duplicates are allowed and color and order crucial, the number of possibilities with four slots and six colors are $6^4 = 1296$. Knuth [1976] demonstrated that the codebreaker can solve the pattern in five moves or fewer, using an algorithm with a minimax strategy.

Our simplified concept

However, we reduced the possibilities by not allowing duplicates and disregarding the order. We took five elements from a stack. Whereby the elements of the stack can have one of three different shapes and one of four different colors. Thus, the number of possibilities is $\binom{12}{5} = 792$.
In our quest each player gets one color or one shape depending on the number of players. The group acts together as codebreaker against the system and is supposed to solve the problem together. The system provides feedback when ever they submit a pattern. In contrast to the original game, we did not limit the number of attempts.

The Egg-And-Spoon Race

Keep the concept of a game of skill

Our quest concept that stems directly from the Design Studio session is the Egg-And-Spoon Race. We have decided to make no changes and to leave this idea in its original version. The vision behind this quest was to have something that can be solved by manual dexterity rather than strategic thinking.

[3] http://en.wikipedia.org/wiki/Mastermind (board game)

Chapter 4

Towards a Working Game

This chapter deals with design iterations before the final implementation of *mLog*. We will open the chapter with a description of the process of crafting and testing a low fidelity prototype. Afterwards we will discuss improvements on the quest design, based on the evaluation of this first prototype.

4.1 Low Fidelity Prototype

4.1.1 Paper Prototype Techniques

We used a player-centered iterative design throughout the design process, since the fields of HCI and Game Design have long recognized that user interfaces should be designed iteratively (compare Nielsen [1993a]). Not all requirements and potential error sources for an interactive system can be anticipated at the beginning of a project. Therefore, the design should be prototyped and tested with real users to reveal any false assumptions or unforeseen issues with the existing design. In the next iteration of the prototype these problems can then be corrected.

General benefits of using iterative design techniques

A quick and cheap way to evaluate first interface designs is to create a paper prototype. It consists of rough, hand-drawn pen and paper sketches. Most often each interface screen is drawn in its own sketch.

Flip-book style prototype

In corresponding literature various sorts of paper prototypes are described. In a flip-book style prototype each interface snapshot has its own page. If the user selects a specific UI (user interface) element, the instructor browses to the corresponding page that shows the changes in the interface. It is left open to the test user which actions are possible and what are the reactions of the interface.

Storyboard style prototype

By contrast, in a storyboard-like prototype several UI screen sketches are laid out on one page. Actions and their effects on the UI are visualized by labels and arrows. Often only one interaction scenario is shown at a time to explain how to accomplish a specific task.

Sticky note style prototype

Another variant of paper prototype use sticky notes. The instructor uses them for windows, dialogs and menus that can easily be rearranged if the UI changes. It is even possible to draw new UI elements on demand.
For more information on standard Paper Prototyping methodologies are explained in Snyder [2003].

Lack prototyping techniques for pervasive games

Currently we still lack the conceptual frameworks and tools for such prototyping in the domain of pervasive games, because existing techniques like the above discussed paper prototypes do not scale well for ubiquitous computing applications. (see Ballagas and Walz [2007] and Liu and Khooshabeh [2003]) A desktop environment typically consist of a single user with only one set of hardware and a single point of focus. In contrast a pervasive game is more complex, since there are multiple players with varieties of backgrounds, dynamic contexts and diverse spatial qualities.

One of the few attempts to show how to apply an iterative player-centered design process to pervasive game design was made by the authors of Ballagas et al. [2007]. They suggest to use storyboards and scenario outlines for the core mechanics of the game.

Boardgame style prototype

For a first physical prototype they used the form of a board game. This form of prototype was seen as very useful for early stage content testing by reading the content aloud as the players progress through the game. It helped to get a feeling for travel times, oversee geographical proximities and also ensured that the game is fun to play. Another suggestion by authors was to use dice and event cards to simulate the way people move through a city more realistically and thereby regulate the progress of the game.

We used these recommendations for our first prototype alongside a flip-book prototype and several scratches.

4.1.2 Creation of a Paper Prototype

To evaluate whether applying this game concepts encourages groups to split up but still feel as one group, a first board game prototype was created for three players.

What we want to verify

With this prototype we waned to verify that the general game concept is fun to play and the quest designs described in Section 3.3 are appropriate. Next to the design we were also interested in how players cope with the lack of a defined leadership and the possible impact on fairness and social treatment this has in the group.

Crafting the prototype

Since we could not mimic the explorative part of the Archeology Quest in a meaningful low-fidelity way, we only tested the uncovering and assembling of the pieces. For this we used an DIN A5 cardboard and wax crayons. A message was written on the cardboard with green wax and then covered by a layer of black wax. Afterwards the cardboard was cut in three segments. When the users scratch off the black wax gently with a hard object, like a coin, the black wax layer can be mostly removed and reveals the underlying green message text.

For the Trading Quest eight different trading goods icon were hand-drawn and copied. Each trader was simulated by a stack of record cards with three trading offers on the top site. An offer showed which good the trader would

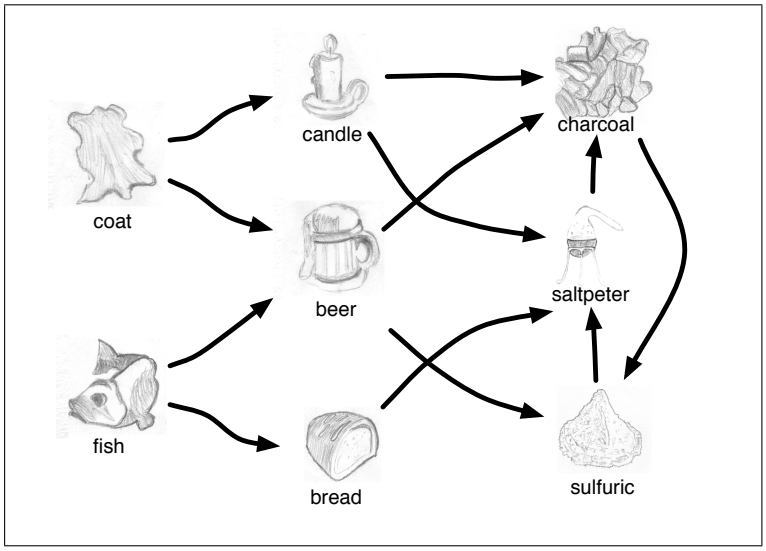

Figure 4.1: Sketch of the economy system for the paper prototype

accept for his product and how many of them he demanded in exchange. Figure 4.1 shows the cycle of goods in our basic economy system. In addition several little coin sized item cards were cut out to represent goods in the inventory of the player or the traders stock.

A flip-book was used in the mixing game to give the players feedback on how many correct elements were chosen in their submitted pattern. Also three representations of the quests main screen were created. They had a caldron in the middle and beneath buttons with the ingredients on them. Also cards with the three ingredients in four different colors were crafted to allow players to display their choice.

For the Egg-And-Spoon Race we kept the rules and interactions of the original child game. We used two wooden spoons with a rather flat shallow bowl and a light table tennis ball to make it more challenging for the players.

4.1.3 Evaluation of the Paper Prototype

Test user profile

We evaluated the prototype in four user-test-sessions at the Media Computing Group. The two female and the ten male candidates were aged 19-32 and all of them had a computer science background. Ten of them stated that they own a smart phone or tablet with a touchscreen. Most of these owners assess their capability on such devices as "good". This corresponded to a 1.7 average on a 5 point Likert scale (1.07 STD), where 1 is "very good" and 5 stated for "not at all". Although the first prototype required no such knowledge, this was an important result for the subsequent estimates of the UI to be assessed properly. In addition, seven of the respondents indicated that they have played a location based game before.

Preparation of the study

The archeology and the mixing quest took place in the same room. The test users were seated around a table and played them like a board game. For the Trading Quest, tables have been prepared in two adjacent rooms. On each of the tables a stack with exchange cards was placed with the top card faced up. Next to them a stack of item cards was added acting as stock the of the trader.

Course of action

A test session started with the filling out of the self assignments followed by a short introduction to the game and the user study itself. The users were told the first part of the background story and given the black-waxed-cardboard pieces with the hidden message mentioned in Section 4.1.2. The test candidates were asked to scratch them and reassemble the message.
Afterwards they were told the second part of the story. They got a couple of fish and coat items, and the information where they could find the traders. When they visited a trader in his room, they could trade with him at the exchange rates indicated on the top card. After the transaction, the top card was discarded and the next card from the deck was drawn. This was done to simulate a seemingly variable market.
When the players returned with the necessary ingredients, they were told the third part of the story. Again they were seated around a table and each player received a sketch showing the interface of the mixing game. They also got

four ingredients cards each of the same type in all four colors. After the rules were explained to the test users, they started by choosing five cards in total and placing them in the middle of the table. When this was done, the group received feedback about the chosen pattern from the instructor. To do so he turned to the corresponding page in the flip-book, showed the result as a series of images emulating an animation. In this way the group was informed about the amount of correct placements. The players continued by elimination of combinations by logical conclusions or via a try and error strategy.
The last quest was the Egg-And-Spoon Race which was introduced with the final part oft the background story. The test users had to run successively a course with the table tennis ball on the wooden spoon in a self-chosen order. The first player had to bring the ball from the current room to one of the rooms previously used in the trader game. There, the ball had to be carefully transferred to a teammate, who subsequently had to carry the ball to a third room. After the ball was passed again to the third player, they had to bring it back into the first room. All this had to be done in a given time limit. The instructor used a stop watch and informed the players on a regular basis about the remaining time. If someone lost the ball while running, they had to start again from the last room.

The whole game session including the story-telling and the explanation of the rules lasted about 30-45 min. All test users were asked afterwards to fill out a questionnaire which took about 5-10 minutes. The study ended with a debriefing, which is an informal discussion about the game and insightful feedback took place. This lasted about 10-20 minutes.

4.1.4 Results

The results from our first user tests looked quite promising. In the debriefing discussions several test users said it was fun to play and expressed interest in the successor prototype. Nevertheless, there was also numerous multifaceted criticism.

Questionnaires

Analysis of the questionnaires revealed a rather optimistic view of our previous efforts. The overall quest game was rated 2.17 on average on a 5 point Likert scale (0.34 STD), where 1 is "very good" and 5 signifies for "do not like it at all". The best rating was given to the mixing game with an average rate of 1.42 (0.67 STD), followed by the trading game and the Egg-And-Spoon Race. The last position in this ranking was taken by the archeology game with 3.0 (0.953). It must be remembered that in the version tested the players could only scatch the cardboard and do a simple puzzle. The exploratory character of the planed quest did not take effect here. In addition, some of the users said during the discussion that they would have rated the game higher if it would have been more challenging. The duration of the quest and the whole game was equally answered as being fine.

On the question of whether there should be more communication all participates answered positively. When asked which way of communication they would prefer, a voice service was rated highest with 1.92 on average (0.67 STD). Text messaging with or without predefined messages was rated nearly equal with 2.36 on average (1.20 STD) and a video chat was rated worst with 3.58 on average (1.38 STD). The player's wish for communication support by the device had been expected by us. In the interviews after the test many users said they were in the situation that they had found a trader for certain goods and want to inform the group without leaving the room.

The players were also asked whether they felt restricted in their freedom of movement by the quests, which on average was not the case. The question of whether players should take the same function in the game or not was answered neutrally.

Feedback on the Archeology Quest

The participants provided many interesting ideas for the game and feedback on how the game could be improved. The Archeology Quest was seen very controversially. Some of the participates did not like it at all, but most of them proposed to strengthen the explorative character of the game or to make the puzzle more challenging. One player suggested that the formula should be written in a secret

language, which the players had to decode in a series of smaller quests.

Feedback on the Trading Quest

The trader quest was discussed at great length. During the tests, we noticed that some players thought the price system to be more complexer than it was. Some hesitated to give away certain trading goods, because they thought it might be too worthy or they believed the prices would change over time. On the one hand, we expected this behavior, since our system was supposed to look like a realistic simulation for the player, without the effort of greater technical complexity. On the other hand the flow of the game stalled, because players could not see the outcome of their actions. The test users asked for a clear feedback on how the market will respond on certain actions, but we wanted to retain an element of uncertainty and therefore did not give this explanation in later versions of the game. Another suggestion was to link the position of a trader with actual local stores. For example an in-game trader of bread should be positioned in close proximity to a real-world bakery. This was something we had planed already, so we were confirmed by this statement. A synchronized inventory that shows all goods the team has got so far, was asked for, too. We did not provide it, because we believed that it would constrain the team play and the chat function could be used to transfer such information. Some players wanted more diverse interactions. For instance one should be able to threaten the trader in order to get a better price. Even it was noteworthy idea, we decided not to pursue it in this prototype and instead concentrated on the main features.

Feedback on the Mixing Quest

The mixing game has been little commented on. A few test users thought it might be to hard to solve for some people and it should provide a "give me a tip" function. We liked the idea to have more than one difficulty level in a game, but decided again to implement this only in a later prototype.

Feedback on the Egg-And-Spoon Race

Asked about the Egg-And-Spoon Race, the test user said it was quite funny, but they didn't believe it would be enjoyable on a touch device. Some of them suggested a special gesture for the transfer of the pot or letting all team members start at the same time to increase the competi-

tive aspect. We discarded this recommendation, because we wanted our game to be collaborative only.

General observations

In general we observed that the players did not split up most of the time in the trading game. The reason for this was, among other things, the lack of communication. When a player wanted to ask his teammates about their opinion on a presented offer, he had to leave the trader and see them in person. In fact, we noticed that players were reluctant to decide on their own about affairs that concerned the whole group. We observed several players, who found a matching trader for their goods, but did not trade with him. Instead they went back to their teammates and told them about the offer and asked how they thought about it.

Importance of the storyline

The storyline of the game was seen as another imported aspect of the game by the users. All users said they liked the idea of a story giving background to the game. One of the test users suggested to add a more satisfactory ending to the narration. For example a credit screen that shows a hole in the wall and the escaped guy or a rescue certificate for the players.

We can conclude that the first user-study confirmed us in our choices regarding the general design of the game. Although we got many suggestions on how to create and design a more detailed prototype, only minor changes to the existing one seamed essential.

4.2 Improved Quest Design

Since our proposed quest game was widely accepted by the users, we did not change much of the game general design. Instead we focused on how to model the prototypical board game in an interactive mobile game.

Redesigning quests types for use software

The next stage of the prototype required a series of careful and well substantiated design decisions regarding details in the quest, which will be described in this section. We tried to bring in the feedback and comments that came up in the first user study. The actual implementation of this design will be discussed in Chapter 5.

4.2.1 Location-based Explorative Quests

First of all we concentrated on quests that have a strong location-based character as our overriding goal was to build such a game. Our proposed *Trading Quest* and *Archeology Quest* concepts felt in this category. In both of them the player has to search in a predefined area for a certain place with the help of the device. In the archeology game we called this place *excavation site* or shorted *site*. In the trading game this role is filled out by the trader market-stall. In both cases the player is informed when they come into a certain range of such a place.

Using zone concept for locations

We adopted the idea of concentric overlapping zones from Benford et al. [2005] for our game. However we expected the problem of GPS jitter not to affect the user experience to such an extent, because once the user reached a zone and interacted with the virtual objects there, GPS updates are no longer delegated to the client's UI. Furthermore, making the interaction-zones too large can have the disadvantage of inhibiting spacial memory, because the same virtual object is connected to a large area and thus different real places.

The Archeology Quest

Tutorial aspect

In a way the Archeology Quest should act as a tutorial for our game concept. Because the task is relatively easy, the users can try out how the game mechanics work while already playing the game. This applies especially to the chat function, the concept of an inventory and the general search-and-find pattern. See Chapter 4.2.3 for more detailed description of these features.

We opted to use the Katschhof between the city hall and the Aachen Cathedral as the play-field for this quest. It has the benefit being a rather small, open area bounded by the surrounding buildings and unpopulated most time of the year. Also the players could keep an eye on each other and call for help directly if something goes wrong (cf. Will [2013] REACHABLE LOCATIONS).

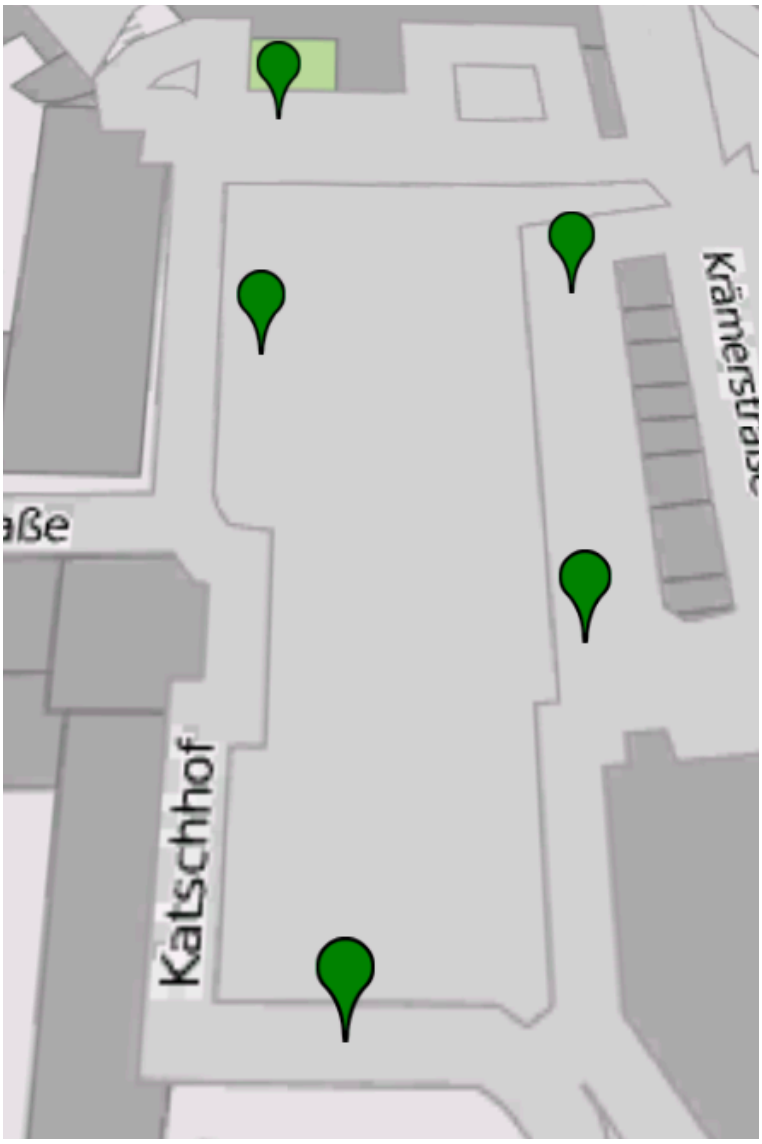

Figure 4.2: Map showing all virtual excavation sites (Courtesy of OpenStreetMap)

The basic functionalities were taken unaltered from the first prototype. The only extension was the concept of an excavation site as the searched place. To win this game one player needs to possess all parts of the scroll. The placement of the five excavation sites are shown in Figure 4.2.

The Trading Quest

Extended economy system

When the players have learned how the handling of the game works, they are confronted with the more difficult task of the trader quest. To make this quest more exciting, the trading system was set up to be much more complex than that of the first prototype. The number of different products had been increased from eight to 21.

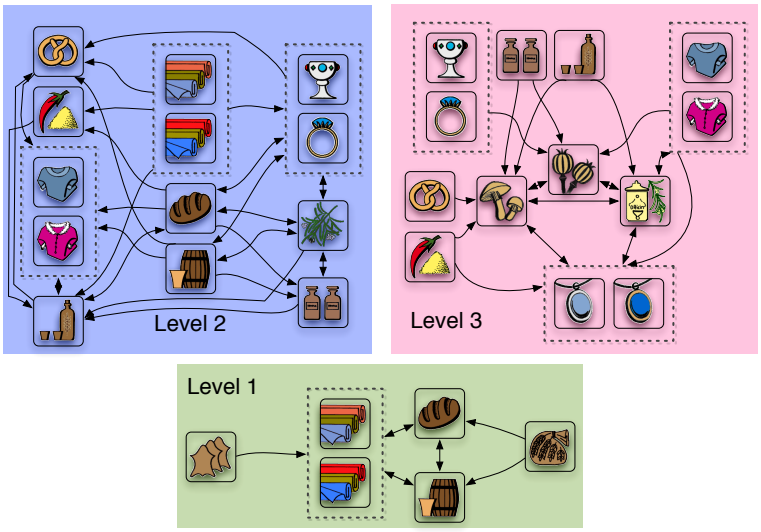

Figure 4.3: Sketch of the enhanced economy system for software prototype

More traders in with various professions

During the first prototype only three generic traders were present, we now provided seven different professionals with different offer-groups. Two of the professions could even be found in two different incarnations. Each trader in this version had two offers in his stock. One of them cheap and the other one extravagant. The players were supposed to buy the former in an early stage of the quest, so they could later on exchange those goods for the more expensive offer of an other trader. Figure 4.3 shows the increased cycle of goods.

The traders stalls were placed around the market place in front of the city hall and along the Krämerstraße. We carefully matched the profession of the virtual trader to that of the nearest local store as was pointed out in Section 4.1.4.

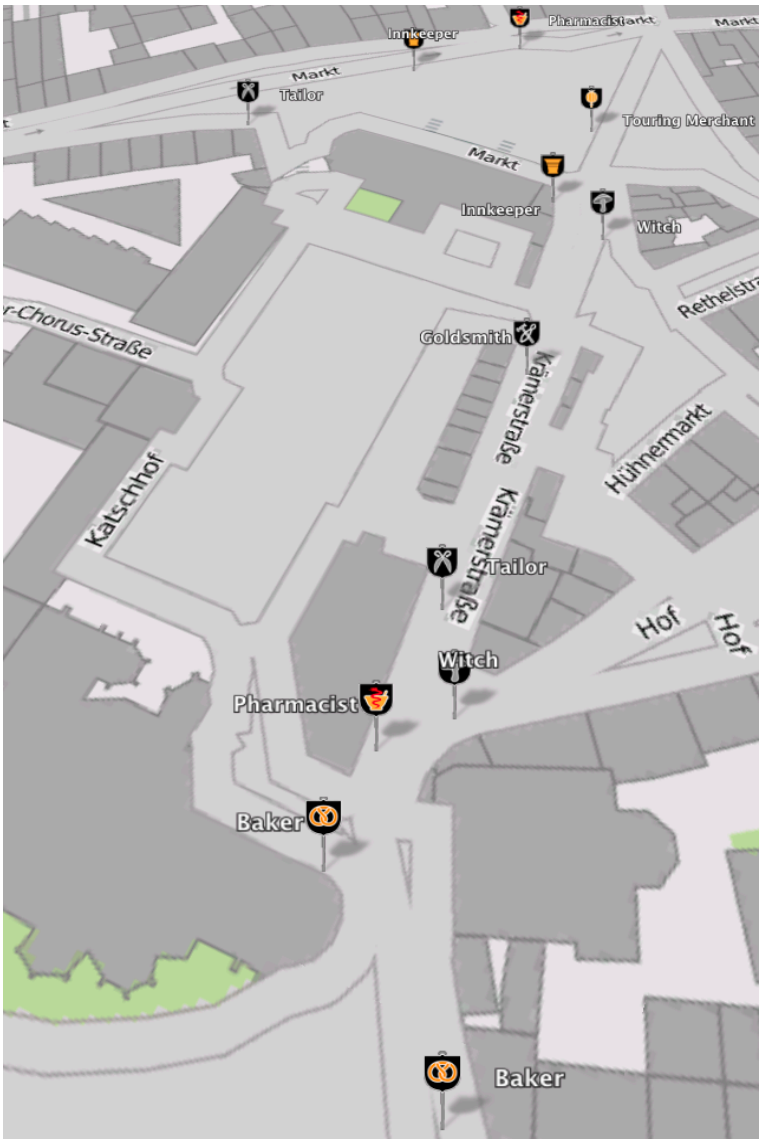

Figure 4.4: Map showing all virtual traders placements (Courtesy of OpenStreetMap)

This way, we wanted to further emphasize the location-based nature of the game. Players who recognized the connection gained an advantage. Table 4.1 gives an overview of all traders and their products. Figure 4.4 shows their placement on a map.

Icon	Profession	Offers	
	Pharmacist	tincture	herbs
	Baker	bread	pretzel
	Touring Merchant	spices	opium poppy
	Witch	flowers	mushroom
	Goldsmith	silver ring	amulet
	Tailor	fabric	garment
	Innkeeper	beer	spirits

Table 4.1: Trader professions in mLog

The goal in this game is to bring the king one unit of three different ingredients. Since we changed the background story a bit for the mixing game (see Section 3.3.2), they now need to find opium, herbs and mushrooms for the sleep potion brewed in the following Mixing Quest.

4.2.2 Other Quest Types

The Mixing Quest

Since the mixing quest was the one rated best in the user study, we decided to keep it in the software prototype. Some small changes were made in the theme of the background story. Instead of mixing an explosive powder to break the wall of the jail house, in this iteration of prototype the players brow a sleep potion to knock out the watch on duty. The game mechanics stayed the same as in the previous iteration. The players could now test the submitted ingredient-set on the dog of the warden. They got feedback on how long the dog slept which signified the correct parts they chose.

Change number of players

We also made a small change to the number of players. We planned the software prototype for four participants per

game, instead of three. We saw in the related work that this is a good number for collaborative games in general (cf. Will [2013] CO-LOCATED MULTIPLAYER).

Rejecting the quest

Although the Egg-And-Spoon Race was not particularly badly rated in the user study, it did not quite fit into the overall concept of our game. The focus was now more on the trader quest as the core of the game, which also took also the most effort in the implementation-part of the project. We therefore decided, to leave this quest open for a further prototype and concentrated on the other three quest types.

4.2.3 Additional Game Concepts

With the implementation of the software prototype some new game concepts became necessary. These are described in the following section.

Inventory

Enabling trade between players

For both, the archeology and the trader quest, the players needed a place to store the items they found or traded. We wanted to implement this, so that the result would be easily accessible. We supported two different kinds of inventory screens. One to get an overview of all items that had be found or traded so far. The other one was only visible while the player interacted with the trader. To provide more space for the trading itself, but also to keep the focus, the inventory was smaller.

Chat Function

The possibility for players to split up, was one of the main goals of our project. We meant to preserve the freedom of movement for individual players on the one hand. On the

other hand the group as a whole should not feel railroaded [1] by the quest itself.

Establishing long-range communication

Therefore, our system should support divided teams to still feel as one group. and foster Communication among them should be supported, as it is important to prevent members losing contact to their teammates. Furthermore, the participants of our first user study demanded more communication functionalities.

We planned to implement a voice service, but it turned out to be quite unreliable when it comes to mobile web connections. We also wanted to save the conversations by the users for later analysis. So we came up with a simple chat function, comparable to the messaging functionality practically every smartphone provides. Players were be able to send messages to a board that all teammates could see. Notification about incoming messages was given to all players immediately. Such a chat function was also used in games like INGRESS and THE SONGS OF NORTH with success (cf. Section 2.4.3 and Section 2.2.3)

Player to Player Trading

The ability to trade one's goods comes with an inventory. To provide this functionality the device should detect if players are close together, before it allows them to share their items. Moreover, players should get feedback, which of the teammate is near and available to trade with.

[1] "To railroad" means "to convict with undue haste and by means of false charges or insufficient evidence" form Merriam-Webster.com, Retrieved June 2013

Chapter 5

Final Implementation

In this chapter we will present how the design we defined in the last chapter is implemented. We start with the UI design, and then address the software architecture and the server model.

5.1 Applied Hardware

While our predecessor model, the GroupAIXplorer, was build upon the AIXplorer tour guide, we decided to build our own system. The reason for this was primarily the outdated hardware and software of the currently used devices. A new generation of the AIXplorer is planned, but has not be completed until now.

Hardware details

For our system we used four jailbroken Apple iPhones 4S[1] running iOS 5.1[2]. Even though the source code did not need any jailbreak feature, is simplified the downloading of the log files following the user study. We did not use any casing or other means of hiding the home button from the user and the device was clearly identifiable as an iPhone. We employed the location-awareness capabilities of the iPhone, which are realized by a framework called

Location-awareness

[1] http://en.wikipedia.org/wiki/iPhones 4S
[2] At the time of writing, the latest iOS version is 6.1.3.

CoreLocation. It uses information obtained from the built-in cellular networks, WiFi, and GPS hardware to triangulate the device's current location.

We decided to forgo audio playback in our prototype because of the associated disadvantages of headphones for social interaction within the group and the considerable additional implementation work load.

5.2 Graphical User Interface

Since the implementation made further design decisions necessary and we could not build upon an existing system with a well established graphical user interface (GUI), a new user interface had to be created to fit our requirements described in Chapter 4. This section explains the design decisions.

UI language

We created all content and GUI elements in German language. This was deemed appropriate, because German was presumably the native language of all participants and we wanted to achieve a high rate of intelligibility with our system. However, we translated some of the interface screens to include them in this thesis.

5.2.1 Artwork

We wanted to support the game experience by inducing a certain level of immersion. This was achieved by using a high quality artwork. Even though our prototype should not appear as a market-ready product, we used graphics made by Sigrid Riese[3], a professional artist as it was suggested by Ballagas and Walz [2007]. The graphics for all icons and item symbols were created according to our specifications, but the artist had room for artistic freedom. The purpose is to support the medieval character of our game so that it fits to the historical buildings surrounding the Aachen market place.

Cooperation with a professional artist

[3] Homepage: http://www.sigrid-riese.de

Hence, the artist drew the portraits of the traders in a medieval style similar to the illustrations used in the Codex Manesse [4]. This codex is a middle high German Minnesang poetry famous for its miniatures that was written at the beginning of the 14th century.

The traders portraits and goods icons can be found in Appendix B.

5.2.2 The King's Screen

When the game starts for the first time, an introductory screen is displayed by the device (cf. Figure 5.1-a). The text field below the portrait of the king presents the first part of the story, which instructs the player about the king's request.

(a) **(b)**

Figure 5.1: Introductory Screen: (a) First time appearance presenting the narrative (b) Short summary of the current task

If the player has finished reading, they can touch the button in the upper left corner to start the first quest. If the

[4] http://digi.ub.uni-heidelberg.de/diglit/cpg848

group succeeds in a quest the screen appears again, giving visual feedback on the progress in the storyline and the objectives of the next quest. If the game is continued after being paused, the introductory screen appears first, showing the current game state. From any quest view, it is possible to go back to the introductory screen by clicking on the "quest log" button presented on the right side of the top bar on any quest screen. While doing this, the test is shortened to display the current quest description only (cf. Figure 5.1-b). This might be necessary when a player wants to refresh their memory about the objectives of the current quest.

Quest log

After finishing all quests, the same screen appears again. The king gives thanks to the players for helping him and declares them to heroes of the realm.

5.2.3 Chat Screen

The chat screen (Figure 5.2-a) looks similar to the standard interface of the messaging app provided by iOS. The table in the upper part lists all messages received so far, sorted in increasing order of their arrival date. Each message contains the time when it was send and the sender's name written under the actual message text. The player can scroll up and down to see all messages.

Beneath the list is a text field and a send button. If player touches the text field, the keyboard appears (cf. Figure 5.2-b) and the player can start writing a message. The text field resizes itself according to the text length.

Server-based chat messaging

If the player presses the send button, the list is updated and the message is sent to the server. The server then distributes the message to the other players who will be informed about an incoming message by a banner on top of any screen currently shown. The banner disappears after three seconds and does not steal the focus of the player.

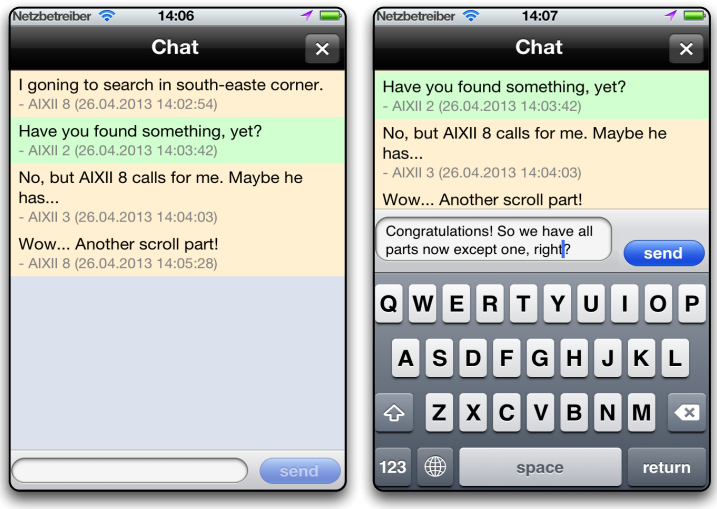

Figure 5.2: Chat Screen: (a) Chat with hidden keyboard (b) Chat with keyboard displayed

5.2.4 Archeology Quest GUI

Main Archeology Quest Screen

The main Archeology Quest screen is dominated by a map surrounded by a top and a bottom bar. The map shows the market place and the current position of the player (cf. Figure 5.3-a). The player can scroll and zoom freely on this map, but is bounded to the inner city of Aachen. If the player tries to scroll further afar, the map would be reset to the previous area. In this way, the player is encouraged to stay in the vicinity and does not get lost trying to find the playground again. On the other hand, we did not want to patronize the player by strictly specifying the part of the map shown to them.

If the player selects either the inventory button in the bottom bar or the chat button in the upper right corner, the corresponding screen appears.

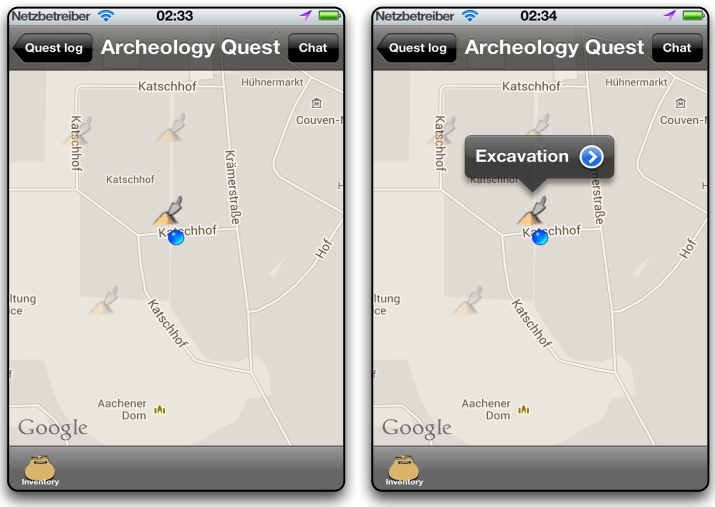

Figure 5.3: Main Archeology Quest Screen: (a) An excavation site near the player is highlighted. (b) A pop-up with the description over the excavation site

Reveal hidden excavations

At the start of the game, the map is empty. If an excavation site comes into range, the player is informed by a notification and a visual representation appears on the equivalent position on the map. On top of the icon a pop-up (cf. Figure 5.3-b) with the name of the site is shown. If the player leaves the area of the excavation site, the icon on the map is grayed out and the player can not interact with it anymore. In this way, the player receives feedback which site has been found and can only interact with it when they get close enough.

If the player touches the pop-up on the blue arrow button on the right side, the excavation screen is loaded. Otherwise, the pop-up disappears.

Excavation Site Screen

We designed a rather straightforward task in order to support the tutorial character we mentioned in the description of the Archeology Quest (cf. Section 4.2.1).

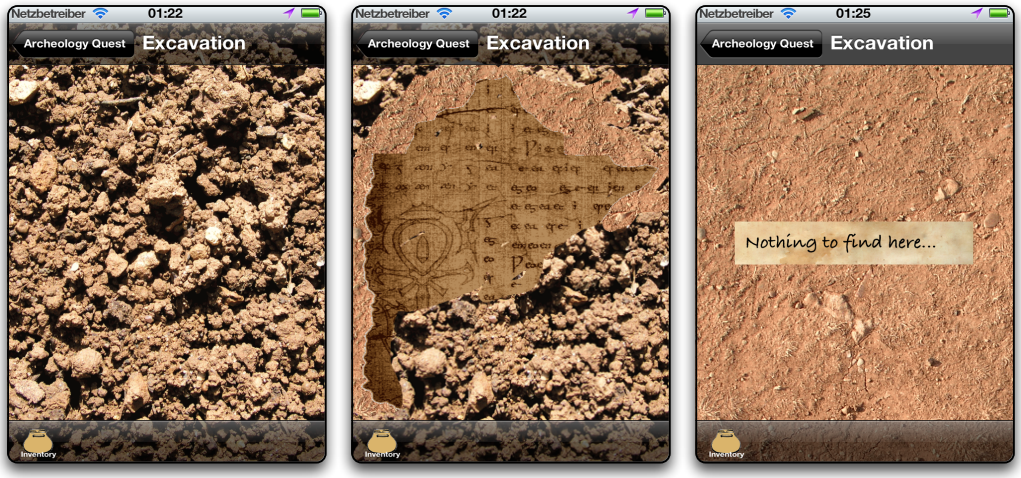

Figure 5.4: Excavation Site Screen: (a) Untouched soil when the screen appears (b) Partly uncovered document part (c) Empty excavation site

If the player touches the icon of a site on the map, the corresponding screen is loaded. Then a screen-sized picture of soil is shown overlaid by the top and bottom bars (cf. Figure 5.4-a). The button in the upper right corner directs the player back to the main screen again. If the scroll has been found by a teammate, the player sees an empty screen with a note (cf. Figure 5.4-c).

Uncovering technique with alpha blending

In order to uncover the missing scroll part below the soil, the player has to gently swipe over the display (cf. Figure 5.4-b). The scroll is pictured on a second image which is positioned under the image of the soil. The upper image will become transparent as the player swipes over it. To simulate the cautiousness of a real archaeologist, a too heavy swiping of the same area destroys the hidden scroll and the player has to start over.

If enough soil is removed, the player receives a notification about the discovered part of the scroll. This is followed by an animation showing how the scroll is transferred to the inventory, which is also a means of instructing the players on where they can inspect the find. Additionally, the scroll can be exchanged with other players or submitted to the king.

Inventory in the Archeology Quest

The inventory screen has two functionalities. First, it allows players to see which scroll parts they currently possess (cf. Figure 5.5-a). The items are shown in the lower part of the screen. If another player sends their scroll part to the player, this screen gets updated immediately. In the upper part of the screen, all teammates currently close to the player are listed.

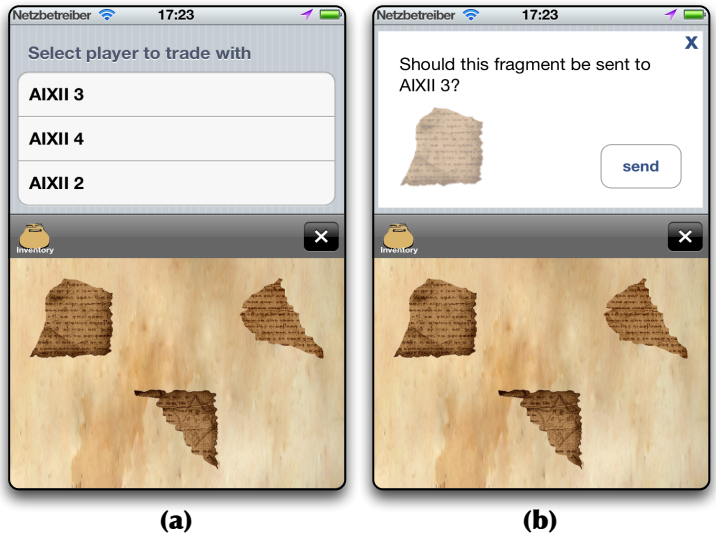

Figure 5.5: Inventory Screen in the Archeology Quest:
(a) Overview of nearby players and gathered scroll parts
(b) Same screen with trading overlay

Second, the screen is used for trading items with other players. The user selects one of the players and one scroll part from the grid below. An overlay appears (cf. Figure 5.5-b) to ask for confirmation of the trade. After pressing "OK", the selected scroll part is sent to the chosen player.

The screen can be left by touching the "×" button on the right side or by touching the inventory button again.

5.2.5 Trading Quest GUI

The graphical user interface of this quest looks similar to the main Archeology Quest screen. This allows the players to familiarize themselves with the interface easily and be able to start the new task directly.

Main Trading Quest Screen

The trading screen contains, similarly to the archeology screen, a map of Aachen and a top and bottom bar with almost the same functionality as described before (cf. Figure 5.6-a).

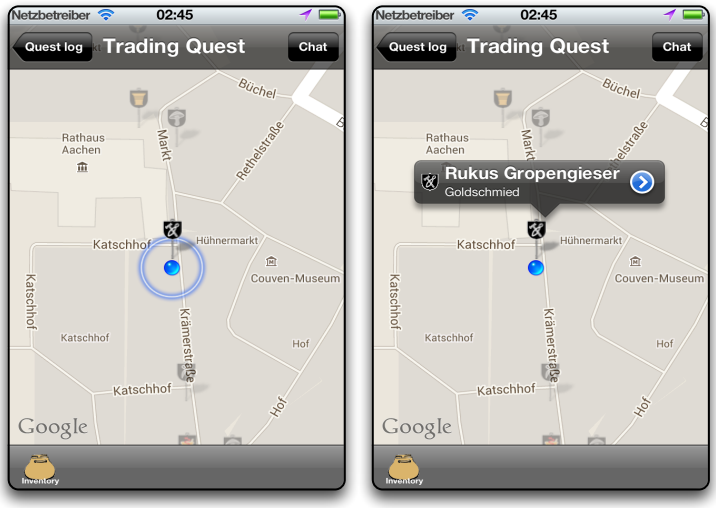

Figure 5.6: Main Trading Quest Screen: (a) A trader near the player is highlighted (b) A pop-up with the description over the trader appears

Reveal hidden trader

The map is initially empty. If the player approaches the position of a yet unknown trader, they will be notified by a message. A banner appears on the map (cf. Figure 5.6-b) with the merchant's guild icon corresponding to the trader on it. If pressed, the trader's stall screen is shown. If the

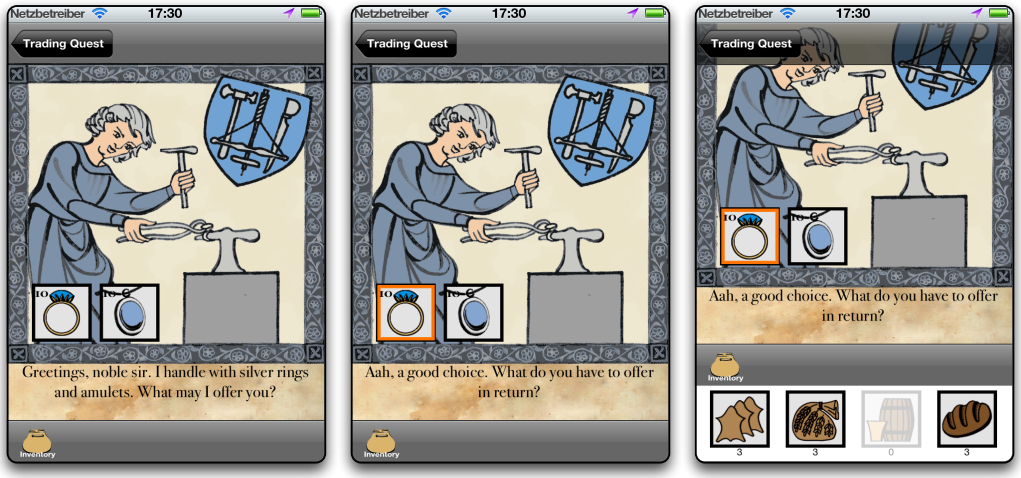

Figure 5.7: Trader's Stall Screen: (a) The trader greets player after the screen appears (b) The player chooses offer from stock (c) The player searches the inventory

player moves too far away, the banner becomes grayed out and cannot be touched anymore.

Trader's Stall Screen

The screen is dominated by a portrait of the trader in the upper part of the screen. In the lower left corner two buttons show the goods that the trader offers. A small number in the corner of this button indicates how many of the corresponding goods are in the trader's stock. In the text field below the image, the trader responds to the player's interaction. The top bar shows the "Trading Quest" and the "Chat" button, while the bottom bar contains the inventory button.

Possible game states

During the first interaction the trader greets the player (cf. Figure 5.7-a) and offers the two goods that are in stock. The player can now select one of the offers (cf. Figure 5.7-b) or first take a look in his inventory by pressing the corresponding button. If the inventory button is touched, the portrait and the text field move up and a miniature version of the inventory is shown on the bottom of the screen (cf. 5.7-c).

(a) **(b)** **(c)**

Figure 5.8: Trader's Stall Screen: (a) The player selects exchange good from the inventory (b) The trader reacts on the player's selected quantity (c) Screen after the trade

The miniature version shows only four goods simultaneously. With a swiping gesture the player can scroll through the entire inventory and select what to offer to the trader.

If a good from the trader's stock and a good from the inventory are selected (indicated by an orange frame around the icon), the trader will decide whether the deal can be accepted and informs the player. If the offer is unacceptable, the trader will explain why the exchange was rejected (cf. Figure 5.8-a). The player can then pick another good from their inventory or choose another good from the stock.

If an agreement is reached, the player is asked about the quantity they want to trade. They can choose the number of goods they are willing to offer via a stepper in the center of the screen. The trader responses with the number of goods offered in exchange (cf. Figure 5.8-b). If the deal suits the player, they can accept it by touching the "OK" button next to the stepper. After accepting a deal the player can either start a new trade or leave the trader by touching the "Trading Quest" button (cf. Figure 5.8-c).

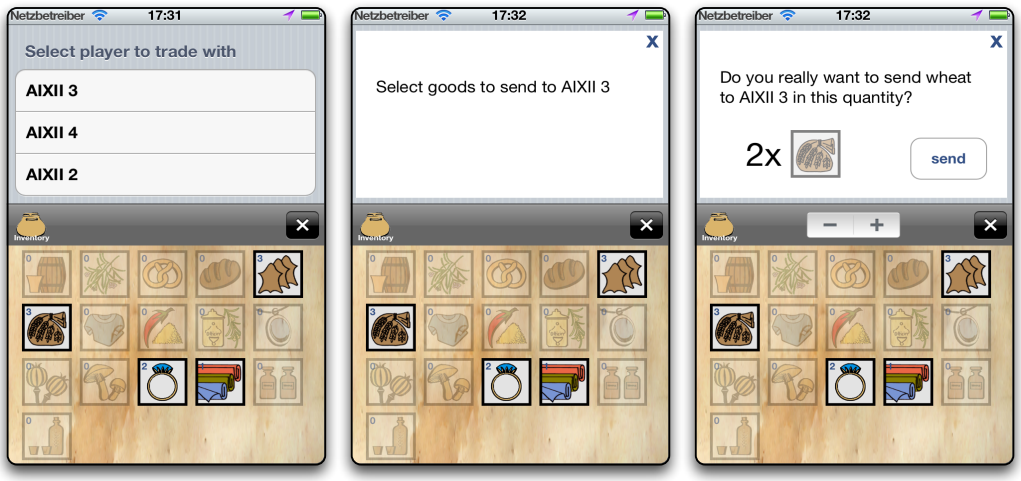

Figure 5.9: Inventory Screen in the Trading Quest: (a) Overview of nearby players and gathered goods (b) Inventory with trading overlay (c) Inventory with trading overlay and selected quantity

Inventory in the Trading Quest

The inventory screen also resembles the one in the Archeology Quest. Moreover, the lower part shows an overview of all trading goods in the game. Goods the player does not own are grayed out (cf. Figure 5.9-a).

In order to trade with another player, the respective teammate is chosen from the list and the trading good is selected from the lower part of the screen. A confirmation appears that covers the upper section of the screen (cf. Figure 5.9-b). The player can specify the quantity they would like to send (cf. Figure 5.9-c). After doing so and confirming the selection by pressing the "OK" button, the goods are sent to the chosen teammate.

5.2.6 Mixing Quest GUI

The screen of the final quest is divided into two parts. Below the top bar, a table area is displayed that lists the previously committed submissions. The lower part shows

Figure 5.10: Cauldron Screen: (a) First appearance of the screen (b) Screen after two players made their choice (c) Screen after a submission

a cauldron resting on a fire place. It is surrounded by four groups of three icons each, showing the three ingredients in four different colors. The icons on the bottom are slightly larger to indicate that those ingredients belong to the player. In the beginning, all other icons are grayed out and the table area is empty (cf. Figure 5.10-a).

Each player is allocated a set of colored ingredients that they can put in the potion. Touching a button on the lower side of the screen marks the icon as selected by framing it in orange color. When the player finished the selection, they confirm the choice by pressing the "Done" button. The title of the button switches to "Undo" and the selection becomes fixed. If a player wishes to change their selection, they can click on the "Undo" button and reset their submis

If a teammate confirmed his selection, the corresponding icons around the cauldron become active and display the selection (cf. Figure 5.10-b).

After all players confirmed their selection, the device tests the chosen pattern and gives feedback in the table area. If the number of chosen ingredients is too high or too low, a warning appears. Otherwise, a new row shows the se-

lected icons and a picture of a sleeping dog with the number of correct items in the selection (cf. Figure 5.10-c). If the players did not guess right, they can change their selection again.

5.3 Software Architecture

We want to give a brief overview of the software implementation. Only the most important classes and their usage will be explained in detail. A step-by-step guide on how to install the game on an iPhone and how to set up the server is provided in Appendix A. The client software was developed by using Xcode 4.6.2[5] as the integrated development environment (IDE) and the iOS 6.1 SDK. The development target was iOS 5.1, which was also the installed OS on the devices.
We assume that the reader of the following section is familiar with the programming language Objective-C and the essentials of Apple's Foundation Framework.

As a server-side database service we used Apache CouchDB 1.2.1 that provides an easy to use database concept, which will be discussed in the following section. The source code for the MLOG prototype software is available at this URL:

File: MLOG Source Code Archive[a]

[a] http://hci.rwth-aachen.de/~huch/folder/file_TODO.file

5.3.1 CouchDB

Basic Properties

CouchDB is an open source database that utilizes JavaScript Object Notation (JSON) to store data. JavaScript is used as

[5] https://developer.apple.com/xcode/

the query language instead of SQL. In contrast to conventional relational database management systems (RDBMS), CouchDB is document-oriented. Moreover, it also differs from other document-oriented database like Lotus Notes in some ways. The fundamental distinction between a RDBMS and CouchDB is that the latter does not stores the data in tables, rows and columns, but manages them in documents that consist of JSON objects. This is useful in several ways. Firstly, it allows us to model data *after the fact*. This means that a relational database requires to know the schema of your data beforehand, whereas each document in CouchDB can be enhanced separately when new information has to be added.

Document-oriented databases

An example for a data model provided in Anderson et al. [2010] is a stack of business cards. While most of the cards contain the same information like name, address or phone number, the visual appearance of the card can vary. Some cards might contain a fax number, others an email address. Although the *semantics* are very similar, the *syntax* is not. CouchDB tries to emulate this real-world documents.

Business cards example

To avoid read-write blockades, CouchDB uses a multi-version concurrency control (MCC) instead of locking. Instead of overwriting old data, CouchDB always adds a completely new version of the document. This is of particular interest, because it offers us a chance to track intermediate steps of a dataset later on.

Multi-version concurrency control

CouchDB stores data structured as *views*. A view is constructed by a JavaScript function called *mapReduce*. The map part of the function takes a document as a parameter and transforms it into a single return value. The reduced part is optional for computing a value over multiple documents.

Furthermore, CouchDB was developed with the problem of latency in mind. One of the major difficulties identified in prior studies was the unreliability of the connection. Even in a WiFi network, a conection failure while roaming can occur. Moreover, whenever players wait for an application to respond on a web service, the human time limit of one second as defined byMiller [1968] and used by Nielsen

Latency

[1993b] is often exceeded.

Human deadlines

If the system reacts faster than a second, the user will feel that they are freely navigating the game without waiting for the device. A delay of 0.2-1.0 ore more seconds does mean that users notice the delay and thus feel the device is "working" on something.

To overcome this problem CouchDB prioritizes the three aspects of *consistency*, *availability* and *partition tolerance* in another way than a traditional RDBMS does. In the context of distributed systems, consistency means that all nodes see the same data at the same time. A guarantee that every client request is answered is called availability. When the system splits over multiple servers, partition tolerance means it still works if messages get lost or parts of the systems fail.

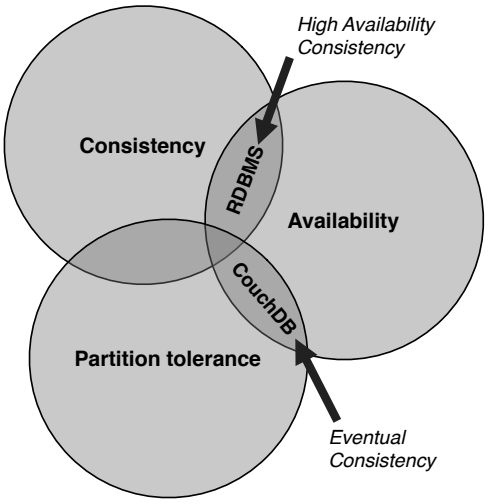

Figure 5.11: The three distinct concerns of the CAP theorem

The CAP theorem says that it is impossible to guarantee these properties simultaneously for more than two of them. Figure 5.11 shows the placement of CouchDB in relation to other database systems. As seen in the figure, CouchDB

Eventual consistency

implements the concept of *eventual consistency*. This means it lets clients write data to a node in a distributed network, without waiting for other nodes to agree. This behavior is contrary to traditional relational databases, where each performed write action leads to an expensive, database-

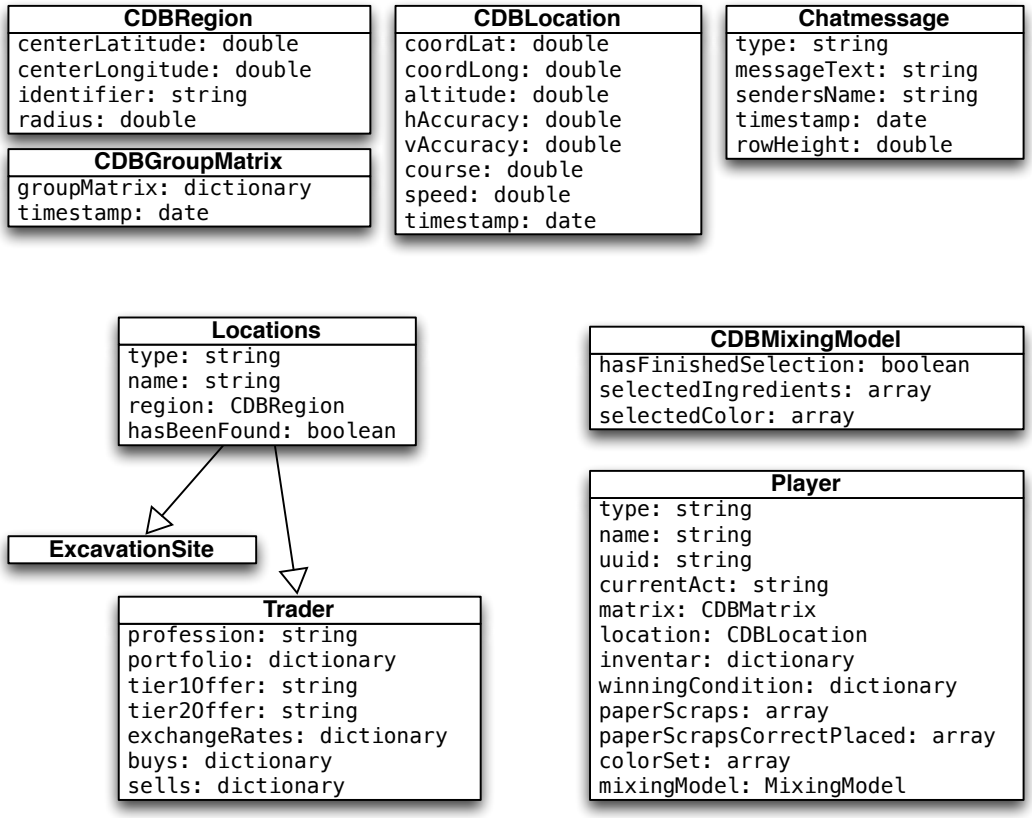

Figure 5.12: A diagram showing all types of CouchDB documents

wide consistency check. To achieve consistency in a local context, CouchDB uses MCC. For distributed consistency it uses *replication*. This means it periodically exchanges copies of all documents between all servers. In case a document changes in two different databases, CouchDB use an automatic conflict detection and resolution system. Moreover, CouchDB saves not only the winning version, but also the losing version in a conflict as a previous version in the document history.

Server Implementation

We chose CouchDB for its awareness of latency issues and the opportunity to to change the database scheme later in the design process in an easy manner. In our prototype, one

database stores all data related to the game state. For the chat function a separate, independent database was used. We used views to retrieve only the data we were currently interested in. For example the view "`allPlayers`" maps all player models to a result dictionary and sent it to the client. The views were implemented as small JavaScript functions.

5.3.2 Client Source Code

Used Frameworks and Adopted Classes

CouchCocoa framework

On the client side we used a framework named *CouchCocoa*[6] that acts as a medium-level API for iOS. While it implements all the low level HTTP and API calls, it still works with CouchDB-style documents and queries. It has the advantage of a dynamic class called `CouchModel` that exposes document properties as Objective-C object properties, making them directly accessible. For sending changes to the server, an asynchronous save function is used. If such a save request is performed while another save request is in progress on the same couch document, a conflict arises. To avoid this situation, we encapsulates properties that often change in separate couch documents. This is the case for `CDBLocation` and `CDBGroupMatrix`. Furthermore, `CouchModel` objects are Key-Value-Observing[7] compatibly. Thus, we can easily update the GUI by tracking changes on the server. We used this feature heavily in all parts of the software.
Figure 5.12 gives an overview on our data model. The propose of the different model classes is discussed in following section.

pLists for initialization

The initial game state is created from a resource file in property list format (pList format). Apple defines it as a public document type in an "Extensible Markup Language" (XML) format for storing serialized objects. No separate singleton class is used to read in the pList. Instead, the

[6] https://github.com/couchbaselabs/CouchCocoa
[7] http://developer.apple.com/library/ios/#documentation/Cocoa/Conceptual/KeyValueObserving/KeyValueObserving.html

`dictionaryWithContentsOfFile` method was used to generate multiple instances of `NSDictionary`. This is done, because in our prototype software only JSON-compatible types are serialized, such as arrays, dictionaries, strings, numbers or boolean, which are also supported by the pList format. Each dictionary references object instances from either “Excavations.plist” or “Traders.plist”.

We added the prefix CDB to all CouchDB related self-written model classes to distinguish them from classes related to MLOG itself.

Model Classes

AppDelegate

The runtime starting point regarding code execution for the application is the `AppDelegate` class. This class sets up the `GPSLocationTracker` and adds a shared instance of the `SystemLogger` to itself. When the app is in the foreground, the tracking of the device and the logging is started. Otherwise this functionality it pause to save battery power. Finally, it creates an instance of `MenuViewController` and pushes it on a standard iOS `UINavigationController`, which is the root view controller for this navigation stack.

Movement tracking

The centerpiece of the tracking functionality is the `GPSLocationTracker` class. It can be considered as a kind of wrapper class for extending the Core-Location Framework. It sets up an instance of the `CLLocationManager` and registers itself as a delegate. Other classes can register `CLRegions` in its monitoring list. When the location is updated, it filters the result and informs the `SystemLogger`. Furthermore, it performs a hit test on all registered regions. To counter the GPS jitter we distinguish between an inner and an outer range. The inner zone needs to be hit for an entering event. The hit test on the outer zone must fail for leaving event. The corresponding instance gets a notification in both cases.

Logging events

One goal is to log player positions and activities for later analysis. For this purpose the `SystemLogger` was designed.
The singleton instance is informed about interesting events directly as they occur. A definition of interesting events are described in Section 6.1.2. The `SystemLogger` implements the corresponding notification handlers and adds a row to a SQLlite database managed by itself.

Main menu

The `MenuViewController` acts as the king's screen described in Section 5.2.2 by using the `currentAct` property of the `Player` object. It also works together with the `SetupViewController` as an administrator view for debugging proposes. When it gets instantiated, a singleton instance of `PlayerList` is created and filled with data from the server.

PlayerList

The `PlayerList` encapsulates the complete server communication in terms of the players game state. It manages queries to the database and serves as a kind of associative array that stores and maintains `Player` objects. Each player is modeled by a such object. The list has a property `ourself` that refers to the player model corresponding to the device and dictionary with all players sorted by the Universally Unique Identifier (UUID) of their device. A helper class called `DeviceHelper` provides us with all information related to the device.
A second important task of the `PlayerList` is to determine the grouping of players. For this purpose, it keeps a matrix comprising the distances of all players to each other. Change in a player's position updates the corresponding entries. To check which other players stay close to its own position, the entries can be tested against an upper limit. All `Player` objects that pass the text successful are committed to the view as a set.

For the quest we distinguished between the location-based Archeology Quest and Trading Quest on the one hand, and the Mixing Quest on the other hand. The `MainQuestViewController` is the parent class of all location-based quests and is subclassed by `ArcheologyQuestViewController` and `TraderQuestViewController`. The primary function is to provide a map view and to react if a player enters or leaves a zone around a specified quest location.

Quest's locations model

The quest's locations are modeled by `LocationBasedQuestModel`. The quest related subclasses are the `ExcavationSite` class and `Trader` class. Both refer to a subclass of `CDBModelList` named `ExcavationList` and `TraderList` that acts mainly like the `PlayerList` described above. The

`LocationBasedQuestModel` has two main tasks. On one hand it manages `CLRegion` objects as defined by Apples CoreLocation Framework and transforms them to `CDBRegion` objects that we defined to save its information in a CouchDB document. On the other hand it implements the `MKAnnotationProtocol` defined by Apples MapKit. We use it to display the traders' banners on the map and the excavation sites' icon respectively.

If such an icon or banner is clicked, the corresponding `DetailQuestViewController` is loaded. The subclass in the Archeology Quest is named `ArcheologyDetailQuestViewController` and provides a `CanvasView` on top of two other image layers. The canvas displays an image of dirt. The player can draw with a transparency brush on canvas to uncover the underlying image of the scroll part. As a winning condition the view controller estimates the amount of transparent pixel and fires an event if a certain ratio is reached.

Trading functionality

The Trading Quest subclass is the `TraderDetailViewController`. This class is probably the most complex one, as it implements a state machine that models the possible reactions of the trader during the trading with the player. To show a smaller variant of the inventory we used a `FHHorizontalPickerView`[8]. It basically provides an array of buttons that can be scrolled horizontally with a scroll gesture.

Every quest view provides a button to the inventory and the chat function. The former is implemented by the `InventoryViewController` and subclassed by `ArcheologyInventoryViewController` and `TradingInventoryViewController`. It uses the groupMatrix property of the `Player`'s objects to derive nearby players that will be listed in a table view in the upper part. The table gets updated when changes in the matrix are notified via Key-Value-Observing. The same applies in a similar way to the inventory in the lower part of the screen.

Chat

The chat function is implemented by the `ChatViewController`. The message model class is

[8] https://github.com/florianheller/FHHorizontalPicker

named `ChatMessages`.

The `CaldronViewController` implements the mixing game explained in Section 5.2.6. Its model is implemented by `CDBMixingModel`. Since it is not a location-based quest there is no need for a main view controller or an inventory. Moreover, the chat function is unavailable in this game, because the players should stay together and communicate directly, which provides a richer communication channel. Therefore, it should be favored in this situation.

An overview of all the software architecture is provided in Figure 5.13

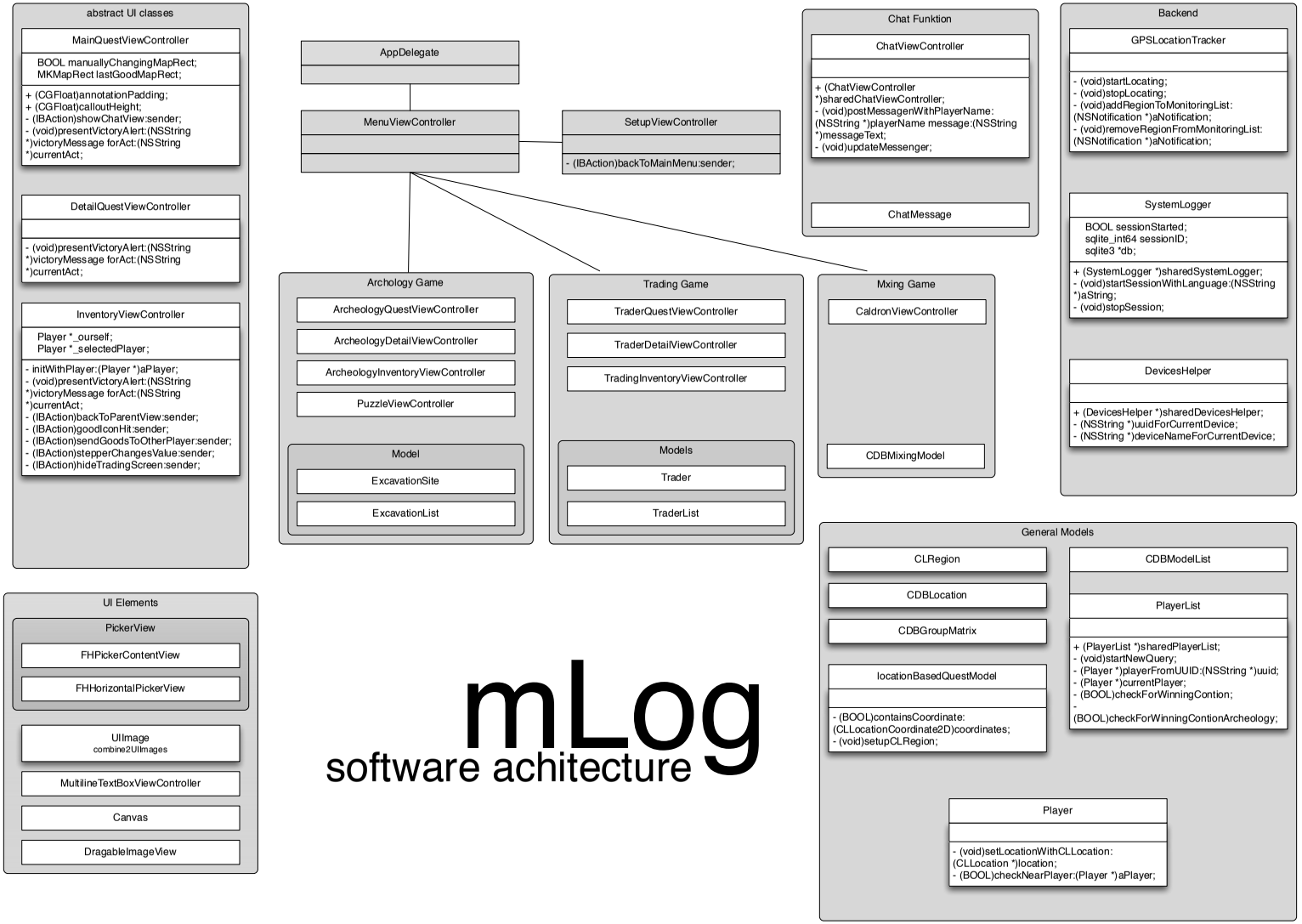

Figure 5.13: Overview of all classes used in MLOG

5.4 Pilot User Study

After completing the first version of MLOG, we tested it under real world conditions with four players.

Network issues

Due to unexpected network problems combined with a failure in our database implementation this first group could not play the game in the intended way. Particularly the Archeology Quest was affected and remained a little unstable. Sometimes players could not interacted with the founded excavation sites and recover the document parts. This had to be fixed in some cases by a restart of the device and the reset of the game state on the server.

Multiple server requests

Another problem was that in the first implementation all interactions like adding or withdrawing ingredients on a device were sent to the database and reproduced on all other devices. This worked quite well in the preliminary tests, but resulted in a bottleneck in the pilot study. Because of the limited bandwidth the time between an interaction and the reaction on the other device grew over the human deadline of 10 seconds and could even led to unresolvable states that broke the game.

Although it was possible for group 1 to play all quest, several interruptions clearly affected the flow of play. Still we treated them like all the other user groups during the user test and asked to fill out a self-assessment and a questionnaire, but did not use their results. Moreover, Likert scale ratings and log files of this pilot user study was omitted from later analysis.

We used the feedback to improve our prototype. The issues with the Archeology Quest were partly solved by increasing the tracking zones around the excavation sites. For the Mixing Quest we decided to only send the information about selected ingredients when the player pressed the "Done" button to reduce the server communication.

Chapter 6

Evaluation

After the description of process from the initial design to the implementation of MLOG the next section concentrates on the structure and execution of the user study.

First we will discuss the setup and the background of the participants of our user study in Section 6.1, then we will describe in detail our observations in Section 6.2. Afterwards we will analyze our findings and try to interpreted the outcome in Section 6.4.

In this chapter we will use the following notation:

PLAYER NAMES:
The players are named in the following according to their device and group number. This means, for example, player 6.2 references the player from group six holding the device with the number two in hand.

Definition:
Player names

6.1 Setup

6.1.1 Task and Procedure

For the study of the second prototype we had 24 participants, which we divided into six groups. Before starting

each testing session with a short introduction, all participants were asked to fill out a consent form and a self assessment for statistical purposes. In the introduction, the goal of the game and a short demonstration of the interface was given. Additionally the chat function was explained. The group was told that it might come to GPS errors, induced by buildings.

In this case the player position on the map would differ from the actual position. The users were requested to move a little further or wait for compensation, if this occurred. Furthermore, they were asked to stand together if they want to exchange goods or parts of the document.

Afterwards the device were given to the players. The app was already started and showed the first screen, where the king explains the Archeology Quest. After all players read the introduction, the instructor affirmed that the challenge of the first quest was understood by the players.
From now on, the instructor did not interfere with them, but observed the group from a distance and only helped users in case of technical problems. After each quest, the group met again and the instructor confirmed that the following quest was clear. After solving all quests, the participants were requested to fill out a questionnaire. The overall duration of the study never lasted longer than 90 minutes.

6.1.2 Intention and Data Sources

As mentioned earlier, we will not postulate any hypotheses, to be verified by the user study. The reason for this is that movement patterns for large-scale location-based games have not been studied before in this manner. Thus, we did not know which factors would influence the outcome and which of those should be seen as potential confounding variables. In fact, the development of such hypotheses, to be confirmed in later works, was one of the aims of this study. To establish a ground truth (in the statistical sense) we tried to gather as much objective data as possible.

rowid	time	sessionID	type	action
2845	2013-04-29	1	kPlayerChangedLocation	AIXII 8<+50.77648320,+6.08383116> +/- 5.00m (speed 0.23 mps / course 15.82) @
2846	2013-04-29	1	kPlayerChangedLocation	AIXII 8<+50.77648391,+6.08383418> +/- 5.00m (speed 0.20 mps / course 15.82) @
7	2013-04-29	1	kQuestActiveNotification	Das verschwundene Rezept
8	2013-04-29	1	kPlayerChangedCurrentAct	AIXII 2ArchologyInProcess
893	2013-04-29	1	kPlayerChangedLocation	AIXII 3<+50.77658047,+6.08381675> +/- 5.00m (speed 0.00 mps / course 189.49)
1943	2013-04-29	1	kQuestActiveNotification	Das verschwundene Rezept
1944	2013-04-29	1	kPlayerChangedCurrentAct	AIXII 4ArchologyInProcess
2847	2013-04-29	1	kPlayerChangedLocation	AIXII 8<+50.77650286,+6.08383276> +/- 5.00m (speed 0.20 mps / course 15.82) @
2848	2013-04-29	1	kPlayerChangedLocation	AIXII 8<+50.77650164,+6.08383510> +/- 10.00m (speed 0.21 mps / course 15.82)
9	2013-04-29	1	kPlayerChangedLocation	AIXII 2<+50.77660336,+6.08394172> +/- 5.00m (speed 0.15 mps / course 189.14)

Figure 6.1: Example from the log of group 5

We deployed three means to acquire this data. Firstly, the instructor took notes during the observation of the groups. Naturally, not all participants could be observed by one person, especially when they split up. But we found some interesting insights on the usage of the game and the communication behavior.

The questionnaire (see Appendix C) handed out after the users completed the game was another source for data. It consisted of 15 statements on different aspects of the game. The users were requested to rate this statements on a five point Likert scale.

The most important source for data was a log file on each device and the MCC on the server-side database. The following listing shows the different kinds of logged events:

- Position of the device, normally one update per second.
- Game state, referencing the current act in the story and progress in the quest.
- Interaction with the user interfaces, e.g. current selected trade goods and selected ingredients in the Mixing Quest.
- Inventory state in Archeology and Trading Quest.
- Trading between players in these quests.
- Usage of the chat function.

6.1.3 Participants

Our game was tested by six groups of four people aged between 21 and 30. Seven of them were female and the other 17 male. When asked for their profession, seven were employees and 21 students, while some selected multiple professions.

Most of the participants have a degree in a physical or technical subject, but only eight were affiliated with the Media Computing Group. The arrangement of the groups were determined according to the schedules of the individual users. Thus, in most case they did not know their team mates in advance, but most of them knew at least one other team member.

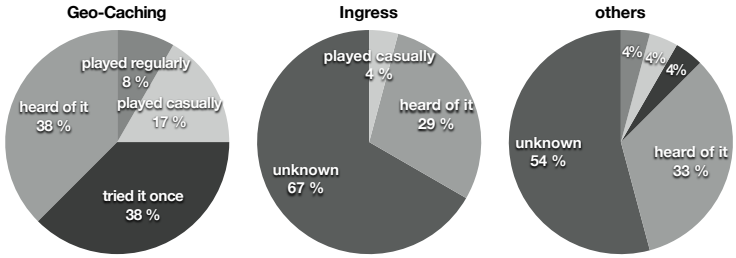

Figure 6.2: Level of awareness for two popular location-based games of the participants

In the self assessment form that can be found in the Appendix C, 61% of the participants stated they use a smartphone or tablet pc with a touchscreen interface in their every day life. In average they consider their knowledge about using a smartphone to be *good* (2.1 on the Likert with 1,18 STD).

We asked about two commonly known location-based games: GEOCACHING and INGRESS on the five point Likert scale. Options to select from were *played regularly*, *played casually*, *tried it once*, *heard of it* and *unknown*. The detailed results can be seen in Figure 6.2. All participants stated that they knew about GEOCACHING and most of them even played it at least once. Unexpectedly, INGRESS was unknown to nearly two-thirds of the participants, also this is partly explainable by the closed beta status. Only

four could name another location-based game. Three mentioned *Mister X* as an example, which is an adaptation of a famous board game, where a group of players chase a single player known as Mister X on the streets of London.

6.2 Results

All groups finished the game. In two cases a quest was finished, but one device missed the corresponding server notification and the player could not catch up to the others without a reset of the game.

6.2.1 Developing a Meaningful Graphical Representation

Initial data preparation

Our primary goal in this study was to identify and describe characteristic movement patterns for location-based games. To achieve this goal, we designed the Archeology Quest and the Trading Quest and generated copious log files in form of SQLite databases on each device. After performing the study, these databases were copied from the devices and merged together. For this and most of the following data mining tasks, we used small Python [1] scripts.

To investigate the movement patterns we developed two different representations to analyze the data. In the first representation we only considered the distances between the players. As this did not provide satisfying results in all cases, we also made use of a direct illustration of the coordinates and timestamps using Google Earth[2].

[1] http://www.python.org
[2] http://earth.google.com

Distance Graphs

Treating missing values

In order to develop a representation of the first kind, we considered the distance between the players at any given point in time. To do such an analysis, we needed to synchronize the events of all four devices. Unfortunately certain events like location updates happen at random intervals. Treating missing values is a separate research area in the field of data mining. The most popular way to solve it on time sequences, like our data, is to use interpolation techniques as Zhang et al. [2012] summarized. Instead of doing this, we kept the respective last position value, because we can reasonably assume that players stop walking from time to time to check the screen. In fact the instructor observed them doing so.

The *CoreLocation* framework from the Apple SDK is designed to only deliver updates when the position of the device changes. Therefore, receiving such updates while the player stands still is not possible. We transformed the received data in time sequences with an interval length of one second and derived the six possible distances between the respective players. We used the logged start and stop timestamps for the quests, to divide the time sequence according to the played quest.

Coping with measurement uncertainties

Since the measurements of the positions have uncertainties due to measurement limitations, we had to consider the error propagation in the calculation of the distance. For a function with independent parameters, this works in the following way: Given a function $f(x_1, x_2, \dots)$ with a number of independent input variables $x_1, x_2, \dots$ and their corresponding standard deviation $u_1, u_2, \dots$, then its uncertainty u_f can be derived from the Gaussian Formula:

$$u_f = \sqrt{\left(\frac{\partial f}{\partial x_1} \cdot u_1\right)^2 + \left(\frac{\partial f}{\partial x_2} \cdot u_2\right)^2 + \dots} \qquad (6.1)$$

In our case, the Equation 6.1 simplifies to a simple addition:

$$f(x_1, x_2) = x_1 + x_2 \tag{6.2}$$

$${u_f}^2 = {u_1}^2 + {u_1}^2 \tag{6.3}$$

Because the SDK provided us only with an uncertainty on the map projection measured in meters, we could not use this formula directly. Instead, we used the sum of the errors, as it is an upper boundary for the error on the distance. We logged the GPS uncertainty with its corresponding position and determined its error propagation. Table 6.1 shows the distribution of errors into two error classes. On average, in 84% of all cases it was 5 meters or less, which is near the optimal value for basic civil GPS measurements. In the remaining cases, the position values had an error of 10 meters, which in the worst case means an uncertainty of 20 meters on the distance measurement. In the following we will exclude the errors from the graphs for ease of legibility.

	total number of measurements			**ratio**	
	sum	**± 5m**	**± 10m**	**± 5m**	**± 10m**
Group 1	12294	10141	2153	82 %	18 %
Group 2	9826	8722	1104	89 %	11 %
Group 3	4376	3638	738	83 %	17 %
Group 4	5361	4515	846	84 %	16 %
Group 5	3477	3125	352	90 %	10 %
Group 6	5785	4424	1361	76 %	24 %
Average	6853	5761	1092	84 %	16 %

Table 6.1: Distribution of measurements by error class

First results

After we generated the time sequences in the above described way, we displayed all six distances in one graph. For example Figure 6.3 shows the result for group 5 during the Trading Quest. This group was chosen, because by means of their values the evaluation strategy can best be explained.

This simple graph already shows some interesting characteristics. While in the beginning and the end of the quest

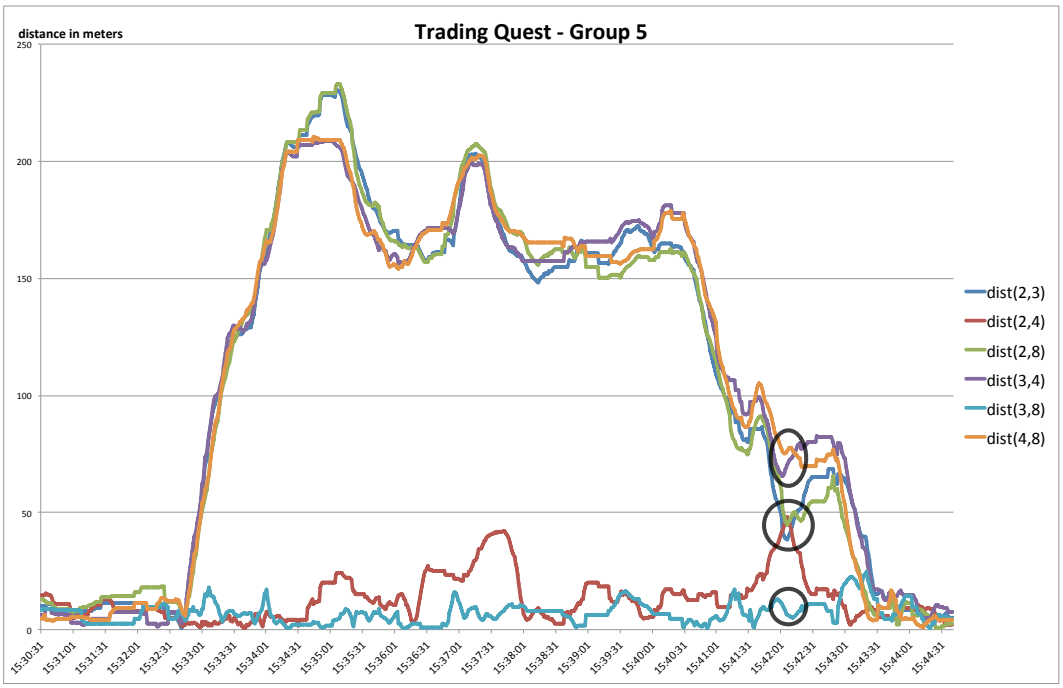

Figure 6.3: Distances between the players during the Trading Quest of group 5

all distances are nearly equal and very low, in the middle of the game four distances had high values, while the other two remained below 25 meters most of the time. The lower ones are between player 5.2 and player 5.4 and between player 5.3 and player 5.8. This indicates that for most of the time the participants were split up into two subgroups of two players each.

An even closer look on the end section (see mark in Figure 6.3) reveals that player 5.2 has equal distance to all other devices, while 5.3 and 5.8 stand together and player 5.4 stands further apart. It can be deduced that player 5.3 and 5.8 formed a group, while player 5.2 and 5.4 played rather individually at this time.

Grid graph

Still this graph is too cluttered to see all aspects of the group dynamics. To understand this effect better, we developed another format of display. Instead of drawing all distances in one graph, we created a separate graphical representation for each distance. These images were arranged to-

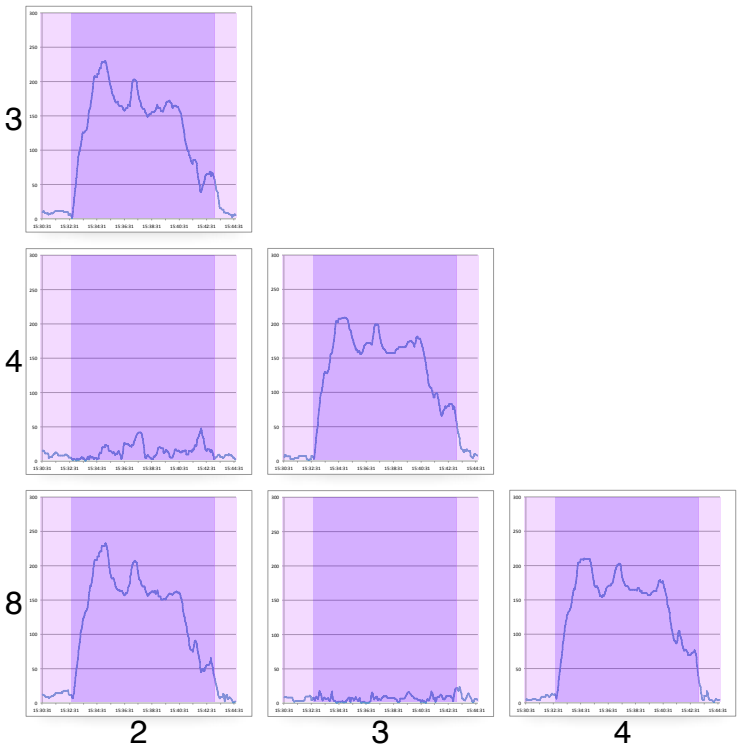

Figure 6.4: All distances of group 5 in form of a matrix

gether in a grid so that each column and each row correspond to a particular grouping of devices. The result is displayed in Figure 6.4 and looks similar to a lower triangular matrix. To determine the distance between a particular player and a certain teammate now only the graphs of the corresponding row or column have to be compared.

Towards an abbreviated notation

Since this representation still is relatively large, we replaced it with a shorthand matrix notation. This will be explained in more detail with Figure 6.4 as an example. As discussed above, the division into high and low curves symbolizes a strong separation of the group. It can also be seen in the graph that this splitting into groups is not permanent, but only takes place in certain phases. We have marked such phases in the diagrams with different background colors.

$$\begin{array}{c} \\ 2 \\ 3 \\ 4 \\ 8 \end{array}\begin{array}{c} \begin{array}{cccc} 2 & 3 & 4 & 8 \end{array} \\ \begin{pmatrix} 111 & 101 & 111 & 101 \\ 101 & 111 & 101 & 111 \\ 111 & 101 & 111 & 101 \\ 101 & 111 & 101 & 111 \end{pmatrix} \end{array} \Rightarrow \begin{array}{c} \\ 3 \\ 4 \\ 8 \end{array}\begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 101 & & \\ 111 & 101 & \\ 101 & 111 & 101 \end{pmatrix} \end{array} \tag{6.4}$$

In our abbreviated notation we replaced a high curve by a zero, which indicates that there is no grouping between these players. In the opposite case, we wrote a one to represent a low distance, indicating to players being next to each other. Each entry of the matrices contains a series of digits, where each digit represents one phase. The resulting matrices are shown in Equation 6.4. Since it is a symmetric matrix the description can be further shortened as is shown in the right side of the equation.

Matrix notation

From these matrices it is easy to understand that the players divided into two subgroups, as we have determined laboriously from the Graph 6.4 above. This simplification came with a loss of detail information as for example the changes of direction. But since we were interested in general movement patterns this is an acceptable price. It should be noted that the lengths of the phases do not have to be equal. A phase begins and ends when there is a significant change in the distances, so that a new grouping is created. Hereafter we will only use this matrix notation. The detailed graphs can be found in the Appendix D.

Direct Representation Using Google Earth

Unfortunately our distance matrix notation did not work well for movement patterns with smaller distances. For example, the Archeology Quest is limited to the Katschhof which measures approximately 40 x 90 meters. In this area the players can barely walk more than 100 meters apart. Therefore, a division into groups by distance is very inaccurate as Figure 6.5 shows.

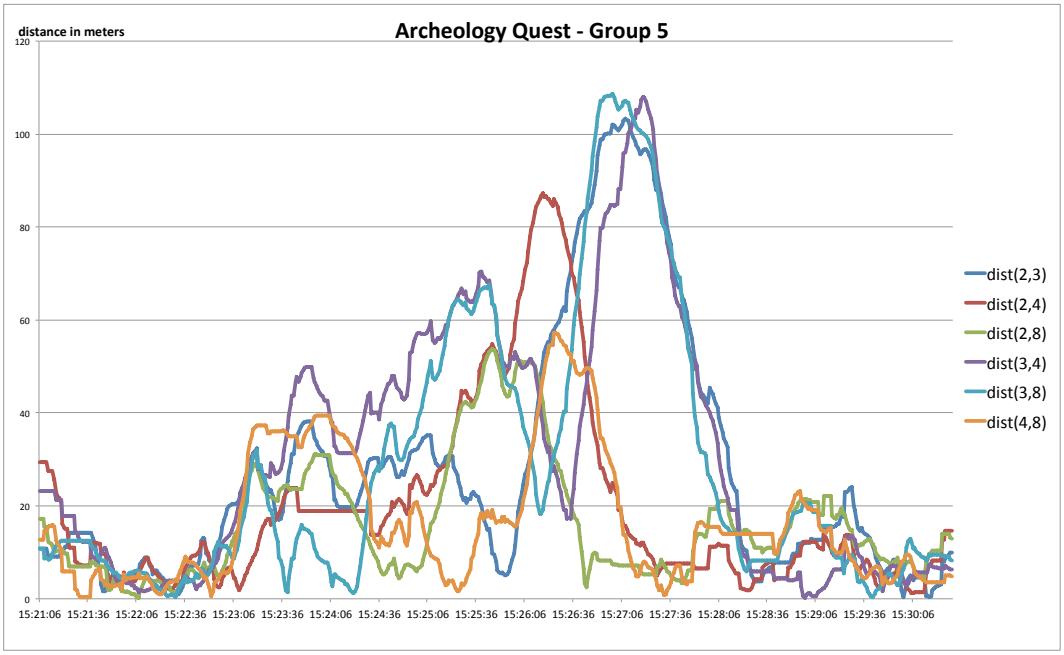

Figure 6.5: Distances between the players during the Archeology Quest of group 5

Using KML for track description

Looking for a better way to illustrate the movement pattern of this quest, we came up with the idea of displaying them as paths on a map. Therefore, we generated a path file in KML data format from the logged coordinates and timestamps. KML stands for Keyhole Markup Language and is a Google developed notation used in combination with Google Earth to describe spatial data in XML syntax.

Google Earth offers the possibility to make time-stamped records that can be displayed as an animation. This makes it possible to consider not only a static path, but also information such as dynamic changes in direction and periods of rest. We used OpenStreetMap map material instead of Google Earth satellite images to improve readability and to avoid copyright infringements.

6.2.2 Group Dynamics and Movement Patterns

Trading Quest Patterns

The appliance of the previously established representation to the data of the Trading Quest, led to the following matrices:

$$Group_1 = \begin{array}{c} \\ 3 \\ 4 \\ 8 \end{array} \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 101 & & \\ 101 & 111 & \\ 111 & 101 & 101 \end{pmatrix} \end{array} \tag{6.5}$$

$$Group_2 = \begin{array}{c} \\ 3 \\ 4 \\ 8 \end{array} \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 101 & & \\ 111 & 101 & \\ 101 & 111 & 101 \end{pmatrix} \end{array} \tag{6.6}$$

$$Group_3 = \begin{array}{c} \\ 3 \\ 4 \\ 8 \end{array} \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 101011 & & \\ 111001 & 101001 & \\ 111001 & 101001 & 111111 \end{pmatrix} \end{array} \tag{6.7}$$

$$Group_4 = \begin{array}{c} \\ 3 \\ 4 \\ 8 \end{array} \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 111111 & & \\ 110001 & 110001 & \\ 100011 & 100011 & 101001 \end{pmatrix} \end{array} \tag{6.8}$$

$$Group_5 = \begin{array}{c} \\ 3 \\ 4 \\ 8 \end{array} \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 101 & & \\ 111 & 101 & \\ 101 & 111 & 101 \end{pmatrix} \end{array} \tag{6.9}$$

$$Group_6 = \begin{array}{c} \\ 3 \\ 4 \\ 8 \end{array} \begin{array}{c} \begin{array}{ccc} 2 & 3 & 4 \end{array} \\ \begin{pmatrix} 100001 & & \\ 111011 & 100001 & \\ 100001 & 110111 & 100001 \end{pmatrix} \end{array} \tag{6.10}$$

Splitting in subgroups is a typical movement pattern

It is immediately apparent that the groups 1, 2 and 5 have very similar movement patterns. In fact their matrices are equivalent except for permutation of the device names and therefore appear to be very typical for this quest. Players started together and then split up into teams of two. Later, they came back together and remained like this until the end of the quest. Something comparable happened

in group 7. Again, the players divided into teams of two. However, the members of one team remained close together while the members of the other team temporarily moved so far apart from each other that we could no longer speak of a group.

The interpretation of the other matrices is more difficult. Matrix 4 shows that in the beginning the players stayed together for a moment before player 4.8 separated from the rest of the group. Later player 4.4 also separated from his team and met player 4.8. This typical constellation persisted for a while before player 4.8 left his partner alone and joined players 4.2 and 4.3. At the end all players got back together.
A similar picture emerges from the consideration of matrix 3. Here the players 3.2, 3.4 and 3.8 formed a subgroup, but player 3.3 took off on their own. After a while all players met again, but after a brief discussion they split up again. This time players 3.3, 3.4 and 3.8 stayed together and player 3.2 went their own way, before all players came together in the end.

Players prefer to be in pairs

In all cases no player was alone during the entire quest. Even if a player was walking alone for some time, a little later a teammate accompanied them. In most cases, more or less stable groups of two players were established.

We also applied the direct visualization analysis by using Google Earth on the Trading Quest, but came to no important new findings regarding the movement patterns. Although some insights about the dynamic behavior of the group, such as short-term separations of the subgroups, were revealed. But extensive changes were not detected and therefore we approved the distance measurement method as a valuable tool.

Archeology Quest Patterns

As we mentioned in Section 6.2.1 the distance measurement method was not suitable for short range quests. But it emerged from the observations of the instructor that the

players have moved freely and independently. Although it has been observed that players sometimes met to discuss the progress or to show their findings, there were no sustained identifiable groups formed.

We examined the data from the Archeology Quest using the KML path with Google Earth (cf. Section 6.2.1). Figure 6.6 shows 16 screenshots of the Archeology Quest of study 6. Each of the pictures shows the player's positions during a 30 seconds timespan. The timestamp below each picture displays the starting time in minutes and seconds. A missing marker indicates that the corresponding player did not move during the timespan. For the placement of the excavation sites see Figure 4.2.

It is important to note that some players appear to be in houses. This is due to inaccurate position data, but is not an obstacle for our statements as was shown by our considerations for error estimation in Section 6.2.1. We found that the course of the movement pattern is very similar for all groups. Therefore we will explain it by going through the logs of Group 5 as an example. For the data of the other groups, see the Appendix D.

Analysis of a typical course of events on the basis of group 5

The first Image 6.6-a of the series shows how the players have entered the Katschhof from the right side as a group. While player 5.3 (orange) and player 5.8 (green) discovered the excavations at the so called herb garden in the northwestern corner and player 5.2 (blue) found the excavation in the west, player 5.4 (red) found the excavation on the eastern side, as can be seen in Figures 6.6-b to 6.6-e.

A short time later player 5.4 (red) and 5.8 (green) were examining the southern section together, while player 5.3 (orange) joined player 5.2 (blue) in the eastern part before he went further to the South and leaved the square behind. Meanwhile player 5.2 (blue) had discovered the empty excavation on the eastern side (cf. Figures 6.6-f to 6.6-h).

In the next section player 5.8 (green) tried to recover the document at the old tree and was joined by player 5.2 (blue), while the other players searched for more archaeological sites all over the eastern part of the Katschhof.

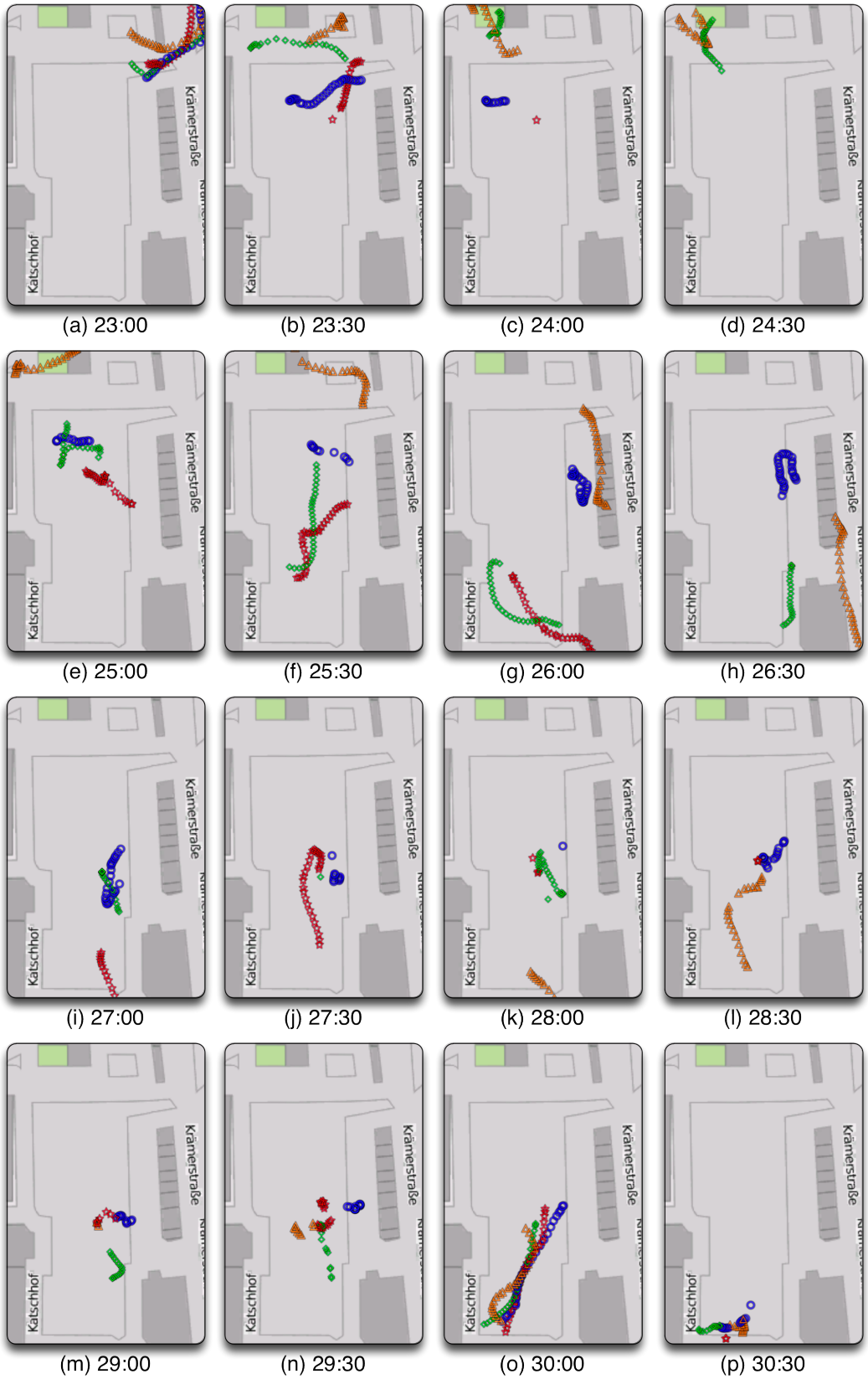

Figure 6.6: Sceenshots showing Group 5 playing the Archeology Quest.
blue: player 5.2, orange: player 5.3, red: player 5.4, green: player 5.8

Player 5.3 (orange) entered the square from the south and joined the others. This is shown in Figures 6.6-i to 6.6-k. After a while, the group lacked only one part of the document, but no one was able to find it. Therefore, the players came together and discussed the problem as a group. (cf. Figures 6.6-l to 6.6-n).

As a result, they found that no one had examined the southwestern corner of the square and went together to do so. Finally, the last part of the document was found at the cathedral (cf. Figures 6.6-o & 6.6-p).

Analysis

We have observed that during the Archeology Quest the players stood alone most of the time, while they operated in groups in the Trading Quest. There are several possible reasons for this.

Importance of seeing other players

Firstly, the Archeology Quest was intended as a tutorial quest as we mentioned in Section 4.2.1. For example did the opportunity to see all teammates while playing make it easy to call someone over, if this was necessary. In contrast to this the Trading Quest the players spread over a larger area, which contained the narrow medieval street of shopkeepers and the market square outside the town hall. This made it difficult to keep track of the other teammates. As we saw in the related work, team play and direct interaction with the teammates was an important fun factor. This could also explain the frequent meetings that we observed during the Archeology Quest.

Simplicity of the task

Secondly, the task in this quest is quite easy. The decision to excavate a found document has no far-reaching consequences for the team. In contrast to the Trading Quest, where the selling of a resource directly influences the course of the game. We assume that players were afraid to make such decisions alone and therefore gladly stayed together.
The observations of the instructor support this assumption.

Below is a brief excerpt from a conversation overheard between two players.

PLAYER A: [*points on a good on its device.*] Should I try this? How many should I give away?
PLAYER B: Don't know. Not everything...
PLAYER A: [*tries to trade a good, but the trader rejects the offer*]
PLAYER B: Who knows, maybe another trader will take it.
PLAYER A: [*tries flowers as exchange good*] Aha..
PLAYER A: [*the trader asks for more flowers*] I need flowers. Which trader has them?
PLAYER B: The witch, I think.
PLAYER A: OK. Can you please send me your bread?
PLAYER B: Sure. [*selects and send it*] I sent it.
PLAYER A: Ok, where exactly is she?
PLAYER B: At the upper end of the street. [*points in the direction*]
PLAYER A: Ok. [*walks off*]
PLAYER B: I will try my luck with the pharmacist. [*concentrates on the map*]

In addition to the collaborative aspect, the conversation shows that before the purchase decision was made feedback was asked for by a teammate.

6.2.3 Grouping in General

Observations

Finding an upper limit for the distance defining a group

One of the goals we wanted to achieve with this study was to find an upper distance boundary for grouping. Where not only the distance, but also the amount of time spent in the respective distances is taken into consideration.This was important for some game mechanics like the player-to-player trading, but also is a question of scientific importance. To show the amount of time that players in subgroups spent in a certain distance to each other, we plotted

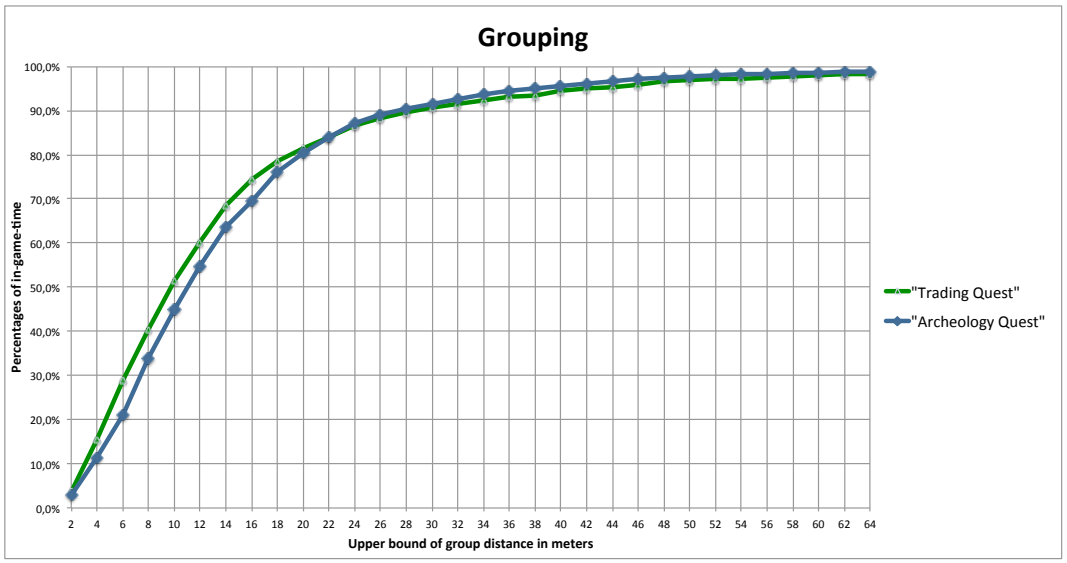

Figure 6.7: Percentages of in-game-time in which the distances of members of selected subgroups do not exceed an upper boundary

graphs like Figure 6.7. On the x-axis the pairwise distance within subgroups is given, while the y- axis shows the percentage of in-game time that the subgroups spent in the respective distance. It shows that 80% of the time the distance between members of the pre-selected subgroubs were less than 20 meters in both location-based quests.

Analysis

The upper boundary of 20 meters presented above is to be treated with caution for two reasons. Firstly, our data set was generated with only two quests that were tested in limited extent. To make a more general statement about this question, the experiment must be repeated in different environments with more participants. Secondly, the selection of the sub-groups was made according to the interpretation of distance graphs and may not have been completely objective. Furthermore, it must be considered that the mentioned measurement uncertainty affected the result.

Nevertheless, with 20 ± 10 meters we found a reasonable value that can serve as an assessment guideline for this purpose.

6.2.4 Mixing Game

Observations

While the first two designs were location-based, the Mixing Quest is a classic puzzle game. During the user study we logged how many attempts were needed to crack the code. The result is displayed in Table 6.2

Group number	**1**	**2**	**3**	**4**	**5**	**6**
Number of attempts	11	18	6	6	8	4

Table 6.2: Number of attempts to crack the code

Behavior during the Mixing Quest

The instructor reported that all groups sat down for this quest. Some formed a circle, others sat together on a park bench. Group 1 and 2 even went to a coffeehouse, after they asked the instructor if that was allowed. Some of the participants said that a brainteaser like this was a welcome change from the motion-heavy quests before. A deeper insight into the analysis of the questionnaires and the comments is located in Section 6.3.

During this quest rich communication was observed. The players talked about what in their opinion was the logical conclusion from the results of the last trial and which combination they had to try next. In addition, players explained the game's concept to each other.

Analysis

The game was very differently perceived by the participants. Particularly members of groups 1 and 2 had a hard time with the game. In retrospect it turned out that they had not understood that there was a difference between shapes and colors in the game concept, although this was explicitly stated by the instructor. In studies of the subsequent groups, this fact was therefore particularly emphasized.

The observed number of discussions demonstrated that the quest design seems to be well suited to enhance the direct communication within a group.

6.2.5 Duration & Walked Distances

Observations

	Distance covered by Device No. (in meters)				
	2	**3**	**4**	**8**	**Average**
Group 1	2190	2687	2865	1975	2429
Group 2	1386	1579	1727	1621	1578
Group 3	1511	1891	1185	993	1395
Group 4	1750	1705	2114	1602	1793
Group 5	996	1354	1137	1269	1189
Group 6	1577	2543	2160	1578	1965

Table 6.3: Covered distances in meters while playing the game

Table 6.3 lists the distances the individual players walked during the game play and Table 6.4 lists the durations of the game and the individual quests for each group. In both of the tables the values are varying greatly.

The largest distance was laid back by members of group 1 with an average of almost 2.5 km. But to go through the entire game required the group members at least 80 minutes. In contrast, the shortest game lasted only half an hour and was played by group 5. They also walked little more than one kilometer.

Analysis

Walking Speed

To examine the relationship between duration and length of the path, we calculated from the medium walked distances and durations an average speed for the groups. It lays approximately between $24m/min$ (group 2) and $37m/min$ (group 3). This corresponds approximately to

	Archeology Quest	Trading Quest	Mixing Quest	All Quests	Total Game
Group 1	18:44	34:56	05:05	58:45	82:42
Group 2	15:37	20:36	22:26	58:39	64:03
Group 3	09:27	20:35	04:47	34:49	37:01
Group 4	19:50	22:55	07:15	50:00	55:23
Group 5	09:25	13:12	05:28	28:05	32:29
Group 6	12:21	38:48	03:59	55:08	58:56
Average	14:29	25:23	09:22	49:14	56:02

Table 6.4: Duration of the individual quests for each group

$1.44-2.22km/h$, which is near the empirical value of pedestrian speed, when resting times are taken into consideration.

The differences in walking speed corresponds to the amount of communication that took place beforehand, in which the players agreed on a common strategy for the given task. The skill level on location-based games, also had an influence on the groups walking speed.

Impact of training

For example, Group 5 was composed of players, who, except for one player, had extended experience with location-based games. The instructor noted that two experienced players suggested to split up into teams of two at the beginning of the Trading Quest. They also determined the product the subgroups should aim for. This strategy appeared to be successful, as this group finished the quest in about 13 minutes and was substantially faster than every other group.

6.2.6 Communication

In this section, we will analyze the communication between players via the chat function and face-to-face. Before we discuss the chat function in detail, we will define what a game-related message is in the context of this thesis.

Definition: *Game-related messages*

GAME-RELATED MESSAGES:
By game-related message we mean that the content of the message advances the game or serves to spread information on the game state. Messages that are written just for fun, are considered non-relevant.

Observations

Table 6.5 is a summary of the chat log files that can be found in the Appendix D. It showed, that all groups wrote messages during both the Archeology Quest and the Trading Quest. Even though the usage of the chat function varied greatly between the groups. While group 6, for example, used the chat extensively in all quests and sent over 50 game-related messages, group 5 sent only nine messages with valuable content. On average 22 game-related messages were sent during each game session.

	Number of messages	Game-related messages
Group 1	34	22
Group 2	21	17
Group 3	19	15
Group 4	22	14
Group 5	9	9
Group 6	55	52
Average	27	22

Table 6.5: Number of chat messages sent during the whole game

Content of the messages

Also the content and purpose of the messages differed. Some wrote only two-word-messages like “get something”, while others, especially members of group 6, wrote whole sentences. During the Archeology Quest messages were mainly about the location of excavation sides and the number of items in the inventory. The traders’ offers and the current resources of the teammates were the subject of messages during the Trading Quest. Also, the chat function was used in both cases to report the current position and to arrange meetings of the whole group. Sometimes the chat function was used to initiate a trade between players.

The instructor noticed that all groups preferred direct communication. It was observed that more players visited a nearby teammate or called out to them than post a message. This also happened partly when the players were out of earshot.

Analysis

In the questionnaire, which we will discuss in detail in Section 6.3, participants were asked to estimate how often they had used the chat function. We compared this data with the actual number of sent messages. It was found that in most cases the self-assessment was consistent with the recorded chats, but participants tended to estimate a slightly lower number. However, as the questionnaire only asked about the general use of the chat function, which may include sending several messages or reading only, and not for the pure number of sent messages, the comparison is only partially meaningful.

Visual versus textual discretion

A possible reason for the behavior noted by the instructor could be that it is much easier to show an interface, for example the inventory, instead of describing it with words. It is particularly noteworthy that players often helped each other when they had problems with the operation of the game. Only for grave technical errors, the instructor was called.

Since we have made no voice recordings during the execution of the study, we could say little about the direct communication. However, the observations of the instructor and the participants' comments indicated that there was much active collaboration and social interaction. We concluded that the aspect of team play has been well implemented by the proposed design.

6.2.7 Trading Between Players

Observations

The log files also proved to be an interesting source of information in regard to trade between players. All groups used the trading functionality. This was expected, since the quest design only allowed one player to transfer the document parts or the goods to the king.

Group number	**1**	**2**	**3**	**4**	**5**	**6**
Number of trades	16	11	7	20	2	20

Table 6.6: Trades between players in the game

It was observed that players partly used the unresponsiveness of the position tracking and the range of our grouping algorithm to transfer items over long ranges, which was not intended by us. In fact, the instructor had asked the players to stand closely together for trading.

Analysis

While some groups limited their trading to the occasions at the end of each quest, where the game design forced them to do so, other groups used this function very extensively, in particular groups 1, 3 and 6. Having a look at Table 6.4 revealed that those groups were also especially fast. Overall, the concept of trading seems to have been well received by the participants of the study.

6.2.8 Problems

In addition to the findings described, the user study revealed some issues in the design of the quests and the GUI.

During the Trading Quest some participants struggled with the usage of the small inventory that we used for the trader.

They did not realize the scroll functionality, which could be used by swiping left or right. We must admit that in our design there was no visual hint to do so. A simple solution would have been to place animated arrows at the edge of the inventory to illustrate the usage. Another visual problem arose with the icons in the inventory. The traders would ask for a certain good in exchange for their product, but some of the goods were unknown to the players and therefore the graphical representations were not recognized. For example, a few players never saw poppy plants before and therefore did not recognize the symbol we used to represent them in the game. Some participants suggested in the comments of the questionnaires that name labels could increase the comprehensibility of the goods.

Additionally, there also were problems with the game concept in the Mixing Quest, as discussed in Section 6.2.4.

All this demonstrates the importance of a careful design. It also shows that the approach of an iterative design process eliminates such mistakes in an early stage, before the a game reaches the market.

6.3 The Questionnaires

6.3.1 Likert scale ratings

The intention of the first part of statements in the questionnaire was to receive ratings on a Likert scale about communication aspects and the chat function we implemented.

Figure 6.8 illustrates the results. The corresponding data for the Likert scale ratings can be found in the Appendix C. The rating of statement Q.1 has little significance, but as we already discussed in Section 6.2.6, the chat function was widely used during the game. Another explanation for this rating could be, that players tend to split tasks in their team. One participant interacted with the quest screen, while the other held the chat screen open to communicate with the other teammates.

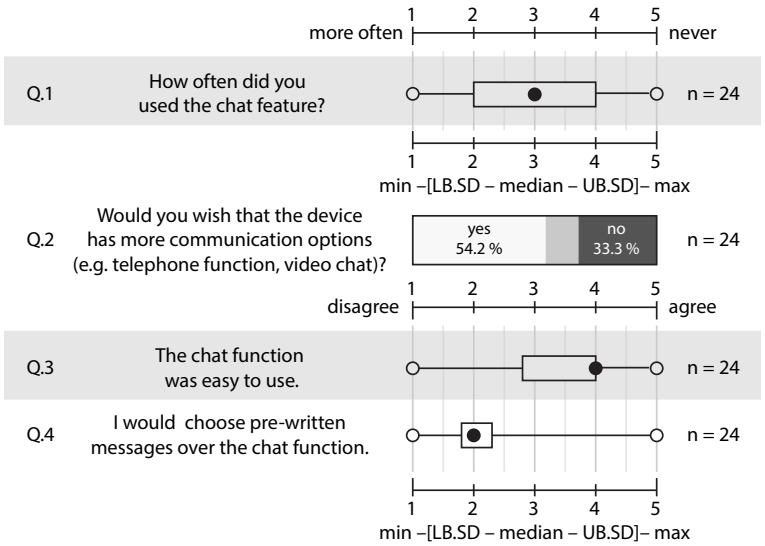

Figure 6.8: Questionnaire results about the chat function, measured on a five-point Likert scale.

We also asked, whether the device should support other forms of communication like a speech service or a video chat function (Q.2). This was assessed positively by the participants. More details about the desired kind of communication came from the comment section. On this point their wishes resembled the ones professional players prefer: A direct speech connection as for example services like TeamSpeak provide, would be highly appreciated.

The usability of the chat feature is being received unexpectedly positive, as statement Q.3 shows. This was particularly surprising, because players complained to the instructor about the poor usability of the chat function often. On the one hand, they had problems with the auto-correction feature Apple provides, on the other hand, many preferred the swipe keyboard they knew from android phones.
Furthermore, the idea of using predefined messages instead of free text chat was rated very low (Q.4) in context of the results of Q.2 and Q.3. Also the analysis of the chat log showed the diversity of the content of the messages. It would have been difficult to cover the diversity of the messages with predefined messages.

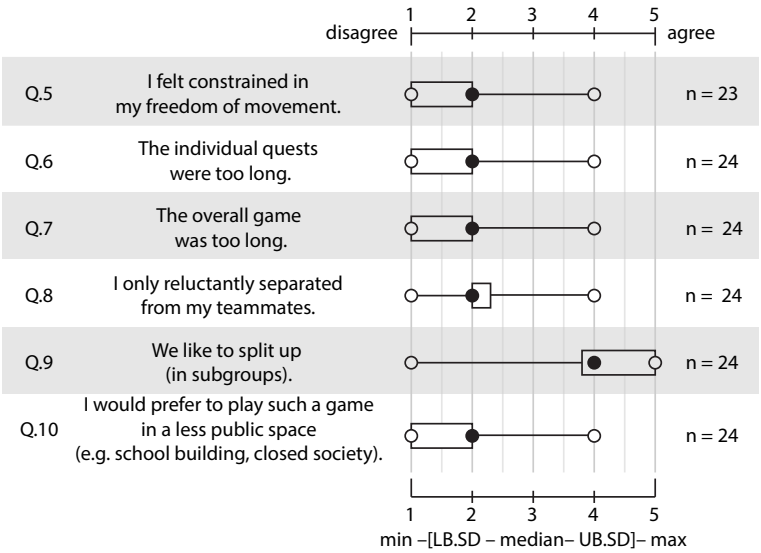

Figure 6.9: Part one of questionnaire results about design decisions, measured on a five-point Likert scale.

The statements Q.5-Q.11 and Q.16, Q.17 deal with design decisions we made during the development (cf. Figure 6.9 and Figure 6.10). The users confirmed our observation, that they did not feel restrained in their movement (Q.5). This was not obvious because we made certain specifications where players had to go by the design of the quests. In statements Q.6 and Q.7 we asked whether individual quests or even the whole game lasted too long. The players negated this, but feedback from the comment section suggested that the Archeology Quest was in fact too short. However, as we determined in Section 6.2.5 one hour can be considered a good time frame for such a game.

We also found that the majority of participants had no problems with separating from there teammates (Q.8). The context of statement Q.9 and the comments at the end of the questionnaire indicated that the splitting into teams of two was a popular strategy. This is also consistent with the observations of the instructor. The level of social awkwardness was very low as the result from statement Q.10 indicated and supported our design decision to use a public

area for the game.

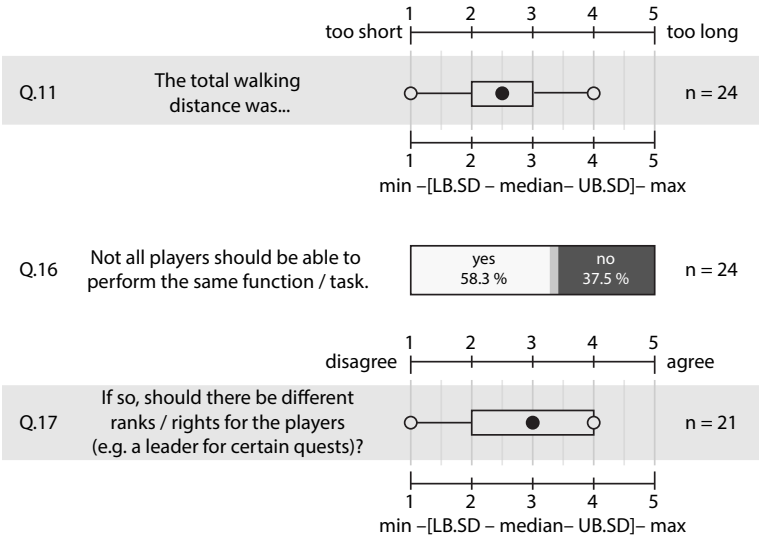

Figure 6.10: Part two of questionnaire results, measured on a five-point Likert scale.

The result of statement Q.11 clearly shows that the overall distance the players had to walk was not too long, but for most players even a little short. It has to be noted that according to the self-assessments there were some geocachers among the participants who were accustomed to long distance walks. With the Questions Q.16 and Q.17 we tried to find evidence for the need of a leader concept as it was established in the work of Wermers [2010].Even though, the participants liked the idea of different roles, the instructor noted that the participants imagined rather different classes like warrior or wizards, as usually exist in classic fantasy role-playing games. In some comments we found prove for this. We liked the idea of adding different roles in this sense, but keeping the shared responsibility.

The general impression of the instructor that groups liked the game concept and had an entertaining group experience was approved by the Likert scale ratings from the questionnaire as Figure 6.11 showed. Statement Q.12-Q.14 asked for the rating of the different kinds of quests. The location-based quests were both rated highly. However, the Mixing Quest was more polarizing (Q.14). Some partici-

pants wrote explicitly that they liked this quest very much, but in light of the problems outlined in Section 6.2.8, the divided reaction is not surprising. The rating of the overall game (Q.15) was very good. This indicated that the technical issues did not break the flow of the game and it was fun to play.

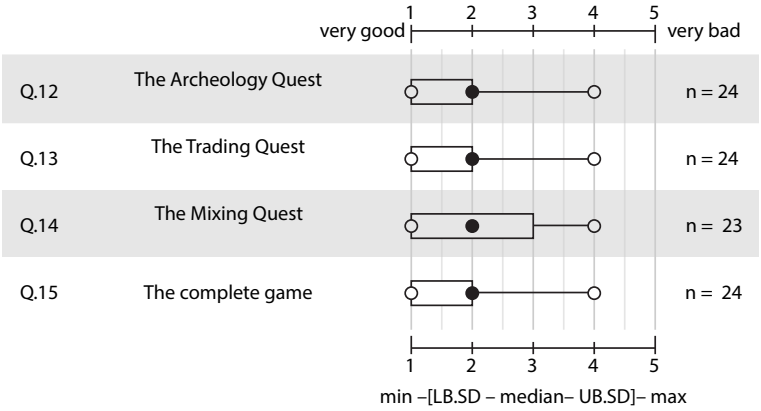

Figure 6.11: Questionnaire results on grading the quests, measured on a five-point Likert scale.

6.3.2 User Comments

In the following section, we want to present some of the numerous interesting comments made in free text form at the end of the questionnaire. All comments from the questionnaire can be found in the Appendix C

More Feedback for the users

Many of the participants asked for better feedback when reaching a zone that allows interaction or receiving messages. This could either be done by playing a short sound or a vibration of the device.

Critique on the level of complexity

Many comments criticized the quests in their current form. A player of the first group said that the Archeology Quest was too short and to simple to solve. They suggested to add more location-based tasks as for example counting windows on the surrounding buildings. Another player was inspired by the idea of different roles and wished that not

all players could uncover all document parts, since they had not found any.

The Trading Quest was a widely discussed topic. Another player from group 1 demanded that a product should become significantly more valuable when it has been carried over a great distance. Some players expressed the desire to get more hints on which goods a trader accepts or better information on what the other players have in their inventory. Even a shared inventory was suggested. It should be noted, that we designed the game without this feature by purpose to increase the need for communication. For the same reason the other players were not shown on the map, as called for by some participants. Another extension that has been proposed was to rotate the map according to the orientation of the viewer. We did not implement this, because the compass in the iPhone does not work reliably all the time.

Shared inventory

Improved Map

There was much praise for the Mixing Quest, although many users complained about the unspecific introduction as described in Section 6.2.8. One player mentioned that they liked to have a quest, where they had to use her brain instead of her legs. Such quests could be used in breaks, where everyone sits together and rests.

Because the GPS reception was often rather poor, the players suggested to cope with that by enlargement of the zones. We doubted that this would be a sufficient solution for reasons mentioned by Benford et al. [2005] we discussed in Section 2.3.1. The chat function was also often noted in the comments, mostly because of the poor performance discussed above. One player suggested to add a simple walkie-talkie function as a better concept. We planned to implement something like that, but feared the bandwidth requirements that such a voice service would have could lead to further problems.

Walkie-Talkie function

In general the feedback was mainly positive and overall very constructive. We noticed that some of the suggestions and critique was already mentioned after the user study of the first prototype. Most of the repetitions were related to deliberate design decisions from our side which pursued a

higher goal. For example we wanted to force users to talk about the content of their inventory rather than to show it directly.

High-quality artwork

Some players said that the high quality of the graphics made the game appear more valuable. Other participants mentioned, that the Trading Quest had such a high level of immersion, that they forgot about the people around them and almost collided with strangers.

Asked by the instructor after the study, the players said that they have sensed a connection between the virtual traders and the real world shops near to them. We were particularly pleased that a group was approached by a passerby during the game. He asked if he could play with them and where to download the game. Apparently, he had observed the group and saw that the game was fun.

6.4 Discussion

We have shown that the two quest types we developed induced completely different movement patterns. While during the Archeology Quest the players met and divided up arbitrarily, a clear preference for subgroups was observed during the Trading Quest. We saw possible reasons for this difference in the size and type of the playing field and in the nature of the assignment of the respective quests. Designers of future games should note that players may split into subgroups, if they cannot see their teammates directly and the task requires them to make decisions with implications for the whole group.

Through analysis of the recorded motion data, we tried to find a reasonable upper boundary for the definition of groups. We found, that in 80% of cases, group members did not move further apart from each other than 20 meters.

The game was suitable to support communication and team play, as was shown by the chat logs and notes of the instructor. Although it became clear that a simple chat function could not replace direct talks, it was deemed

necessary and appropriate to have such a communication channel for groups that have split up.

Another noteworthy finding was that players tend to rather walk over to a fellow player than to send them a message, even though this fellow player is out of reach. This could not only be explained by the incapability of the chat function, but rather by the benefits of direct communication over any other communication channel.

It was interesting to see that the participants understood the implementation as something more than a tool that helped them to play a game.Proposals as for example a common inventory for all players show that the participants are willing to blur the boundary between game world and physical world, because such a shared inventory is not possible in the real world.

Chapter 7

Summary and Future Work

This chapter provides an overview of the entire project. First, an outline on the progress is given, in which we recapitulate incorporated design decisions and implementation steps we made. Contributions to the field of location-based games are highlighted, as well as previously presented concepts that were proved unsuccessful.

In the end, further ideas that were not considered in this thesis are presented together with recommendations for future research in this field.

7.1 Summary and Contributions

The goal of this thesis was to investigate group dynamics and identify movement patterns for location-based games. To accomplish this goal, we designed and implemented MLOG, a quest-driven collaborative multiplayer game that takes place in the inner city of Aachen.

Chapter 2—"Related Work" presents how other work in this field has influenced our system. On the one hand we considered papers that examine aspects of the group dy-

namics in location-based games or dealt with other collaborative aspects. On the other hand, we gained a deeper insight into the matter in more theoretical works that compared several studies in this research area. We also examined commercially successful games and found out that concepts like team play and game designs like treasure hunt were widely used.

To gather more ideas for possible quests and scenarios for our game design we held a Design Studio that we described in Chapter 3—"Design Goals". Out of the variety of proposed ideas we refined four quest types. The first one lead to the Archeology Quest in which the players exploratively hunted for parts of a mystical document. The second concept was the basis upon which the Trading Quest was designed where players had to obtain certain goods by exchanging other valuables with virtual traders. The third quest handled the collaborative brewing of a potion inspired by the game MASTERMIND. The final fourth quest was an egg-and-spoon race with a high focus on the player's dexterity. We also present a short narrative that helps to connect the individual quests.

To test these quests in a user study we crafted a low-fidelity board game prototype as shown in Chapter 4—"Towards a Working Game". The evaluation showed that quest-style game design offered several possibilities for collaboration and encouraged social interactions. Therefore, we implemented the three most successful quests into the design in an interactive prototype called MLOG. We added other concepts like a chat function to communicate with teammates over longer distance and an inventory for visualizing the players' possessions and allowing them to trade with other players.

In the Chapter 5—"Final Implementation" we described how the quest game was realized in a software prototype. The design of the UI is explained as well as the design philosophies behind the client and the server.

In Chapter 6—"Evaluation" we presented the feedback we received from the final user study and discussed its results. The game fulfilled our expectations, since it was reported

to be fun to play. Our data analysis identified two different movement patterns and linked them to certain aspects of our design.

Furthermore, we found indications that there exists an upper limit of how far user groups tend to spread. The analysis of the communication data showed that the chat function we developed was useful, but still did not entirely fit the users' needs. Several more discoveries on aspects of walked covered, duration of the game, group dynamics and the success of individual quest designs were summarized in this Chapter.

7.2 Future work

We conducted our research with a relative small set of only six groups with four participants each on in game with three quests. For a deeper understanding of group dynamics, a larger study with possible more quests is necessary. Moreover, the study should be tested in other environments to prove the general validity of the statements we made.

We interpreted distances between players as time sequences. There are multiple methods and tools known from the field of data mining that are concerned with similarities between times series (cf. Faloutsos et al. [1994] and Ding et al. [2008]). These could be used to verify our findings or search for new correlations in the data. In a different approach Keogh et al. [2006] described how dissimilarities between time sequences can be found, which might be useful for recognition of uncommon movement patterns.

The feedback done by the user in the comments and interviews offered us ideas for possible design improvements. For instance the chat function was reported to be unhandy in many cases, especially when it comes to transfer visual appearance into textual descriptions. A simple extension could be created that uses the built-in camera and supports screenshots. In this way, players could send pictures of what they want to communicated. Another improvement

of the chat function would be to present the current position of the sender on a map. This would simplify finding other players.

Many participants asked for a walkie-talkie function like professional gamers use for team play. This would not only supply an additional communication channel for the player, but also allow communication during the game. We strongly supported this idea, but did not see a reasonable way to provide this feature based on a mobile connection. Therefore, it should be further investigated how such a service can be implemented in a reliable manner.

Appendix A

Installing the game on an iPhone

The source code of the MLOG software prototype is available at the following URL:

File: mLog Source Code Archive[a]

[a] http://hci.rwth-aachen.de/~huch/thesis/downloads/mLogSource.zip

We explain step-by-step how to install the software on a jailbroken iPhone on what follows:

1. Open the MLOG project with Apple Xcode
2. Change the SERVER_URL and SERVER_PORT preprocessor macros in the prefix file according to the used CouchDB Server.
3. Compile the software using the iOS 5 or iOS 6 SDK. Make sure that the target version is 5.1. Select the debug version if you wish to see all locations on the map during the game. For user tests always compile a release version.
4. Copy the app bundle to the device by connecting the iPhone to the computer and selecting it as target in Xcode. Click "Run" to install it on the device.

5. The MLOG program icon will then appear on the home screen.

Log files are stored in the folder “documents” in the app bundle as SQLite files. The only way to access these is via SSH.

Appendix B

Artwork

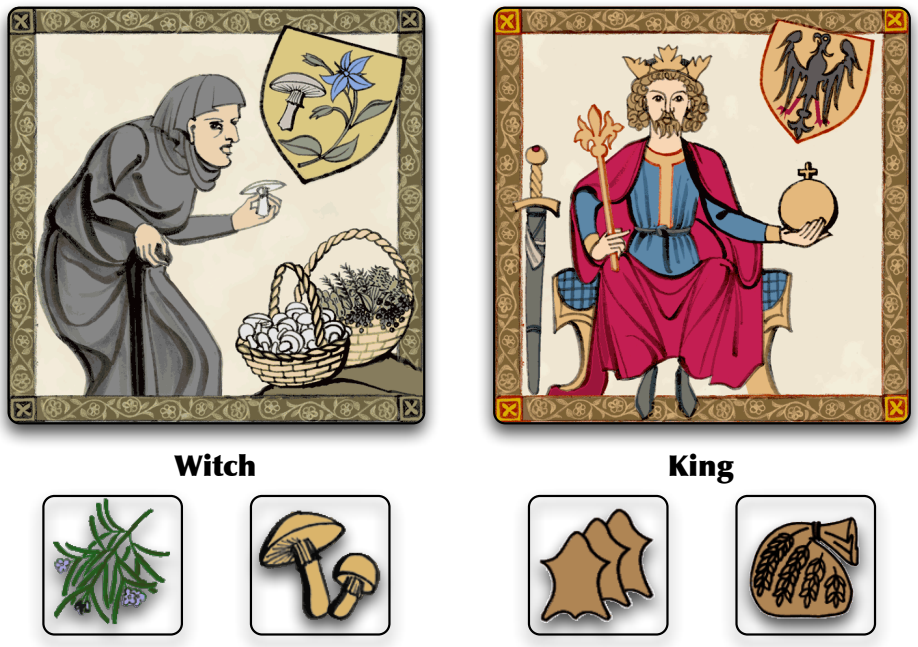

Figure B.1: Overview on the artwork of the Trading Quest, page 1

Figure B.2: Overview on the artwork of the Trading Quest, page 2

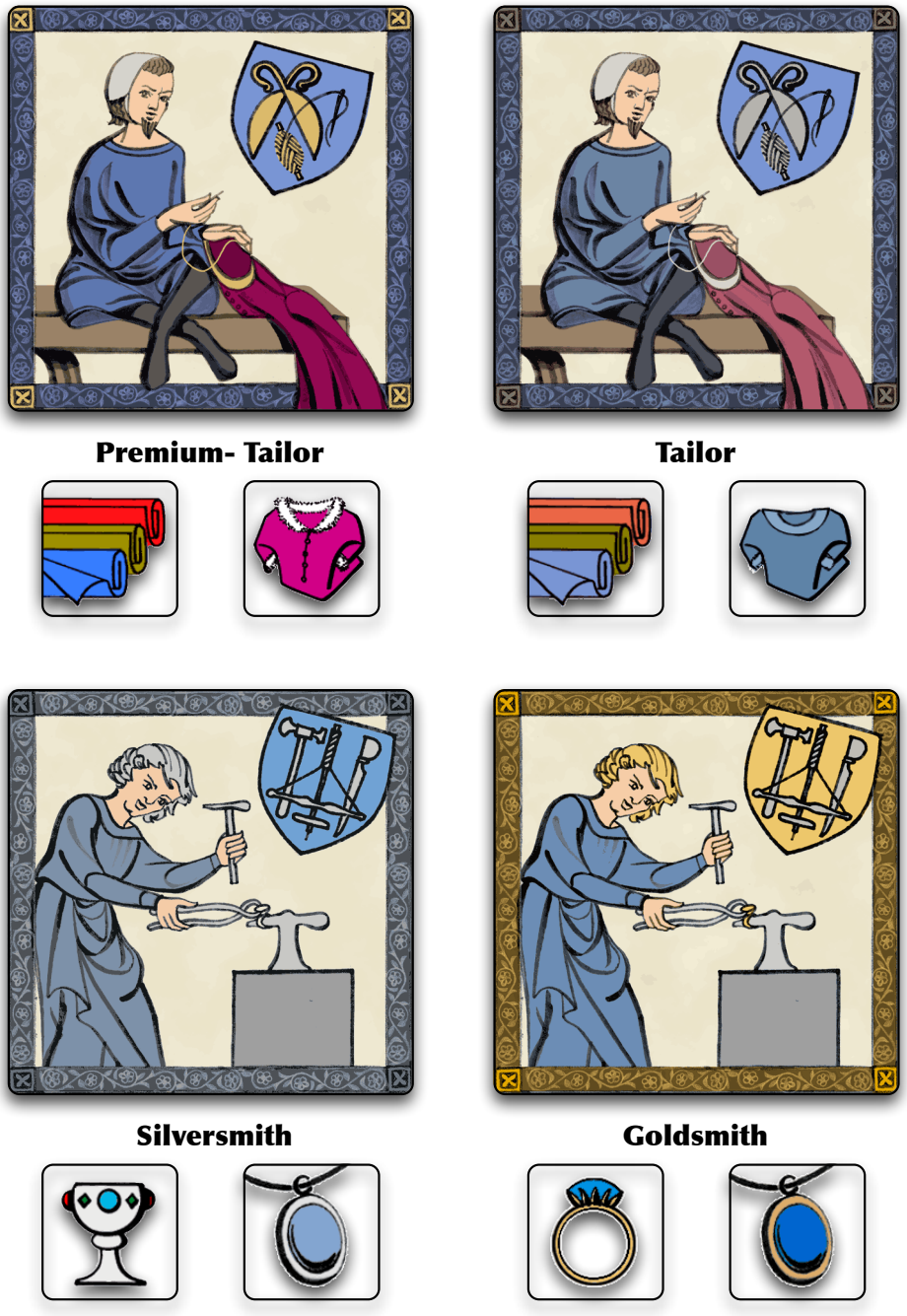

Figure B.3: Overview on the artwork of the Trading Quest, page 2

Appendix C

User Study

Figures C.1 - C.6 show the German questionnaire of both user studies handed out to the users. The Figures C.7 - C.9 present the questionnaire data, which were used in Chapter 6. Particularly, Figures 6.8, 6.9, 6.10, and 6.11 are based on this data.

These tables and the complete raw data from the questionnaires are also available for download:

File: All results from the questionnaires[a]

[a] http://hci.rwth-aachen.de/~huch/thesis/downloads/rawQuestionnaireData.zip

File: Likert scale results of the questionnaires[a]

[a] http://hci.rwth-aachen.de/~huch/thesis/downloads/likertScaleResults.zip

The Figures C.10 - C.12 present the comments from the questionnaires. Figure C.13 displays the chat logs of all groups.

The log files, derived distances and generated tracks (in kml format) can be found under the following URL:

File: All logged data[a]

[a] http://hci.rwth-aachen.de/~huch/thesis/downloads/allLogFileData.zip

User ID (Gruppe)

_____

Fragebogen

User Study für **MLoG**

Carl Friedrich Huch
Media Computing Group, RWTH Aachen University

Vor der Teilnahme an der Studie, möchten wir Sie um ein paar Angaben zu Ihrer Person bitten.
Diese Angaben helfen uns die Ergebnisse der Studie besser einzuordnen.

Welches Geschlecht haben Sie?	männlich ☐	weiblich ☐	k.A. ☐		
Wie alt sind Sie?	_____				
Was machen Sie beruflich	Schüler/in ☐	Student/in ☐	in Ausbildung ☐	Angestellte/r ☐	
	Selbstständig ☐	Rentner/in ☐	Sonstiges ☐		
Haben Sie schon einmal einen Multimedia Guide in einem Museum benutzt?	ja ☐	nein ☐			
Haben Sie ein Smartphone oder Tablet mit Touchscreen?	ja ☐	nein ☐			
Haben Sie schon mal ein location-based game gespielt (z.B. Geocaching)?	ja ☐	nein ☐			

	1 sehr gut	**2 gut**	**3 mittelmäßig**	**4 schlecht**	**5 gar nicht**
Wenn ja, wie gut kennen Sie sich auf einer Skala von 1 - 5 mit dem Smartphone aus?	☐	☐	☐	☐	☐

Figure C.1: First user study questionnaire, page 1

	trifft gar nicht zu	**trifft eher nicht zu**	**weiß nicht**	**trifft eher zu**	**trifft voll zu**
Ich habe mich durch das Questspiel in meiner **Bewegungsfreiheit** eingeschränkt gefühlt.	☐	☐	☐	☐	☐
Nicht alle Spieler sollten die gleiche Funktion/Aufgabe übernehmen können.	☐	☐	☐	☐	☐

Fragen zur Kommunikation zwischen den Spielern:

Würden Sie sich wünschen, dass das Gerät Ihre Kommunikation unterstützt? ja ☐ nein ☐ k.A. ☐

Falls ja, würden Sie sich wünschen, dass ...

	trifft gar nicht zu	**trifft eher nicht zu**	**weiß nicht**	**trifft eher zu**	**trifft voll zu**
...es einen Button gibt, um jemanden zu sich zu rufen	☐	☐	☐	☐	☐
...es vorgefertigte Text-Nachrichten gibt (z.B. "Ich den Händer X gefunden. Er handelt mit Y").	☐	☐	☐	☐	☐
...es selbstdefinierte Text-Nachrichten gibt.	☐	☐	☐	☐	☐
...es eine Sprachverbindung gibt. (z.B. wie ein Telefon)	☐	☐	☐	☐	☐
...es Audio/Videoverbindung gibt.	☐	☐	☐	☐	☐

Ich wünsche mir eine andere Form der Kommunikation: _____

Fragen zu den Quests:
Bitte ordnen Sie die einzelnen Quest mit Schulnoten. Mehre Quests können die gleiche Note bekommen.

	1 sehr gut	**2 gut**	**3 mittelmäßig**	**4 schlecht**	**5 gar nicht**
Das **'Archäologiespiel'**	☐	☐	☐	☐	☐
Das **'Händlerspiel'**	☐	☐	☐	☐	☐
Das **'Mischspiel'**	☐	☐	☐	☐	☐
Das **'Eierlaufen'**	☐	☐	☐	☐	☐
Das gesamte **Questspiel**	☐	☐	☐	☐	☐

	trifft gar nicht zu	**trifft eher nicht zu**	**weiß nicht**	**trifft eher zu**	**trifft voll zu**
Die einzeln Quests waren zeitlich zu lang.	☐	☐	☐	☐	☐
Das Spiel war insgesamt zu lang.	☐	☐	☐	☐	☐
Ich kann mir vorstellen, ein solches Spiel auf dem Marktplatz zu spielen.	☐	☐	☐	☐	☐

Vielen Dank!

Figure C.2: First user study questionnaire, page 2

Einverständniserklärung

Evaluierung eines ortsbasierten Spieles

STUDIENLEITER Carl Friedrich Huch
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Ziel der Studie: Das Ziel der Studie ist es, zu verstehen, welchen Einfluss ortsbezogene Spielinhalte auf die Gruppendynamik und das Spielverhalten haben. Die Teilnehmer werden gebeten, ein prototypisches ortsbasiertes Spiel zu spielen. Interaktionen mit dem Gerät und Positionen der Spieler werden in der Analyse ausgewertet.

Ablauf: Die Spieler werden gebeten ein dreiteiliges Spiel zu spielen, während dessen sie sich im Bereich der Aachener Innenstadt zu Fuß bewegen müssen.

Nach der Studie werden wir Sie bitten, den Fragebogen über das getestete System auszufüllen. In diesem Fragebogen werden wir Ihnen einige allgemeine Fragen über Ihre Gewohnheiten, ihren Umgang mit Smartphones und das Spiel stellen.

Risiken/Beschwerden: Es könnte sein, dass Sie die Teilnahme an der Studie ermüdet. Sie werden mehrere Gelegenheiten haben, sich zu erholen; zusätzliche Pausen sind ebenfalls möglich. Es sind keine weiteren Risiken im Zusammenhang mit der Studie bekannt. Sollte die Aufgabe oder der Fragebogen zu anstrengend für Sie sein, die Bearbeitung sofort abbrechen.

Nutzen: Die Resultate der Studie werden im Rahmen einer Diplomarbeit über ortsbasierte Spiele generell ausgewertet.

Alternativen zur Teilnahme: Die Teilnahme an der Studie ist freiwillig. Es steht Ihnen frei, Ihre Teilnahme zurückzuziehen oder abzubrechen.

Kosten und Entschädigung: Die Teilnahme an der Studie wird Ihnen keinerlei Kosten verursachen. Unter allen Teilnehmern der Studie wird am Ende ein 25€ Amazon-Gutschein verlost.

Vertraulichkeit: Alle Informationen, die während der Studienphase gesammelt werden, werden streng vertraulich behandelt. Ihre Daten werden nur durch Identifikationsnummern identifiziert. Keine Publikationen oder Berichte aus diesem Projekt werden personenbezogene Informationen über die Teilnehmer beinhalten. Wenn Sie sich bereit erklären, an dieser Studie teilzunehmen, unterschreiben Sie bitte unten.

_____ Ich habe die Hinweise auf diesem Formular gelesen und verstanden.
_____ Man hat mir die Hinweise auf dem Formular erklärt.

Name des Teilnehmers	Unterschrift des Teilnehmers	Datum
	Studienleiter	Datum

Wenn Sie Fragen zu dieser Studie haben, wenden Sie sich bitte an den Studienleiter.

Figure C.3: First user study concent form

User ID (Gruppe) _____

Fragebogen

User Study für **MLoG**

Carl Friedrich Huch
Media Computing Group, RWTH Aachen University

Vor der Teilnahme an der Studie, möchten wir Sie um ein paar Angaben zu Ihrer Person bitten.
Diese Angaben helfen uns die Ergebnisse der Studie besser einzuordnen.

Welches Geschlecht haben Sie? männlich ☐ weiblich ☐ k.A. ☐

Wie alt sind Sie? _____

Was machen Sie beruflich Schüler/in ☐ Student/in ☐ in Ausbildung ☐ Angestellte/r ☐
Selbstständig ☐ Rentner/in ☐ Sonstiges ☐

Besitzen Sie ein Smartphone oder Tablet mit Touchscreen? ja ☐ nein ☐

	sehr gut	**gut**	**durch-schnittlich**	**schlecht**	**sehr schlecht**
Wenn ja, wie gut kennen Sie sich auf einer Skala von 1 - 5 mit dem Smartphone aus?	☐	☐	☐	☐	☐

Meine Erfahrung mit den folgenden location-based games

	spiele ich regelmäßig	**spiele ich gelegentlich**	**habe ich ausprobiert**	**habe ich von gehört**	**kenne ich gar nicht**
Geo-Caching	☐	☐	☐	☐	☐
Ingress (Google)	☐	☐	☐	☐	☐
andere Spiele	☐	☐	☐	☐	☐

Welche anderen location-based games kennen Sie? _____

Figure C.4: Second user study questionnaire, page 1

Fragen zur Chat-Funktion

	öfter	**6-10 mal im Spiel**	**3-6 mal im Spiel**	**1-2 mal im Spiel**	**gar nicht**
1. Wie oft haben sie die Chat-Funktion benutzt?	☐	☐	☐	☐	☐

2. Würden Sie sich wünschen, dass das Gerät mehr Kommunikationmöglichkeiten hat (z.B. Telefonfunktion, Videochat)?	ja ☐	nein ☐	k.A. ☐

	trifft gar nicht zu	**trifft eher nicht zu**	**weiß nicht**	**trifft eher zu**	**trifft voll zu**
3. Die Chat-Funktion war einfach zu bedienen.	☐	☐	☐	☐	☐
4. Ich würde vorgefertigte Text-Nachrichten dem Chat vorziehen.	☐	☐	☐	☐	☐
5. Ich habe mich durch das Spiel in meiner **Bewegungsfreiheit** eingeschränkt gefühlt.	☐	☐	☐	☐	☐
6. Die einzeln Quests waren zeitlich zu lang.	☐	☐	☐	☐	☐
7. Das Spiel war insgesamt zu lang.	☐	☐	☐	☐	☐
8. Ich habe mich nur ungern von meinen Mitspielern getrennt.	☐	☐	☐	☐	☐
9. Wir haben uns gerne (in Untergruppen) aufgeteilt.	☐	☐	☐	☐	☐
10. Ich würde ein solches Spiel lieber in einem weniger öffentlichen Rahmen spielen (z.B. Schulgebäude, geschlossene Gesellschaft).	☐	☐	☐	☐	☐

	viel zu kurz	**zu kurz**	**gerade richtig**	**zu lang**	**viel zu lang**
11. Die gelaufene Gesamtstrecke war:	☐	☐	☐	☐	☐

Fragen zu den Quests:
Bitte vergeben Sie für die einzelnen Quests Schulnoten. Mehre Quests können die gleiche Note bekommen.

	sehr gut	**gut**	**durch-schnittlich**	**schlecht**	**sehr schlecht**
12. Das **'Archäologiespiel'**	☐	☐	☐	☐	☐
13. Das **'Händlerspiel'**	☐	☐	☐	☐	☐
14. Das **'Mischspiel'**	☐	☐	☐	☐	☐
15. Das gesamte **Spiel**	☐	☐	☐	☐	☐

Figure C.5: Second user study questionnaire, page 2

16. Nicht alle Spieler sollten die gleiche Funktion/Aufgabe übernehmen können. ja ☐ nein ☐

	trifft gar nicht zu	**trifft eher nicht zu**	**weiß nicht**	**trifft eher zu**	**trifft voll zu**
17. Falls ja, sollte es verschiedene Ränge /Rechte für die Spieler geben (z.B. Anführer für bestimmte Quests)?	☐	☐	☐	☐	☐

18. Kommentare/Anmerkungen:

Vielen Dank!

Figure C.6: Second user study questionnaire, page 3

	A1	A2	A3	B4	B5	B6	C7	C8	C9	D10	D11	D12
Geschlecht	m	w	m	w	m	m	m	m	m	m	m	m
Alter	25	19	32	27	27	29	29	28	29	27	25	25
Beruf	Student	Auszubildende	sonstiges	Student	Student	Student	Student	Student	Angestellter	Student	Student	Student
Haben Sie schon einmal einen Multimedia Guide in einem Museum benutzt?	y	y	y	y	y	y	n	y	y	y	y	n
Haben Sie ein Smartphone oder Tablet mit Touchscreen?	y	y	y	n	y	n	y	y	y	y	y	y
Haben Sie schon mal ein location-based game gespielt? (z.B. Geocaching)	y	n	y	y	y	y	n	n	y	n	y	n
Wenn ja, wie gut kennen Sie sich auf einer Skala von 1 - 5 mit dem Smartphone aus?	1	1	1	3	4	3	1	1	1	2	1	1
Ich habe mich durch das Quest- spiel in meiner Bewegungsfreiheit eingeschränkt gefühlt.	5	5	3	4	4	5	4	2	4	5	4	4
Nicht alle Spieler sollten die gleiche Funk- tion/ Aufgabe übernehmen können.	5	1	4	2	2	4	3	2	4	5	3	2
Würden Sie sich wünschen, dass das Gerät Ihre Kommunikation unterstützt?	y	y	y	y	y	y	y	y	y	y	y	y
...es einen Button gibt, um jemanden zu sich zu rufen	1	1	3	4	1	3	5	2	2	2	2	2
...es vorgefertigte Text-Nachrichten gibt. (z.B. "Ich den Händer X gefunden. Er han- delt mit Y")	2	1	2	2	1	3	5	1	2	3	2	2
...es selbstdefinierte Text-Nachrichten gibt.	3	2	2	4	2	3	5	4	2	1	1	2
...es eine Sprachverbindung gibt. (z.B. wie ein Telefon)	2	1	2	2	3	2	1	3	2	1	2	2
...es Audio/Videoverbindung gibt.	4	1	3	5	5	5	4	2	2	5	3	4
Das 'Archäologiespiel'	4	2	3	3	4	2	5	3	2	3	2	3
Das 'Händlerspiel'	2	2	2	1	1	2	3	2	1	1	2	2
Das 'Mischspiel'	1	1	2	1	1	1	1	2	2	1	3	1
Das 'Eierlaufen'	1	1	2	2	3	2	2	3	3	2	3	2
Das gesamte Questspiel	2	2	2	2	2	2	3	3	2	2	2	2
Die einzeln Quests waren zeitlich zu lang.	5	5	3	5	5	4	2	4	4	5	4	4
Das Spiel war insgesamt zu lang.	5	5	4	5	5	4	4	4	4	5	4	4
Ich kann mir vorstellen, ein solches Spiel auf dem Marktplatz zu spielen.	4	1	3	5	1	3	2	2	2	1	2	4

Figure C.7: First user study result table 1

Gruppe	Gruppe 1				Gruppe 2				Gruppe 3			
Gerät	2	3	4	8	2	3	4	8	2	3	4	8
Geschlecht	w	m	m	w	w	w	m	m	m	m	m	m
Alter	25	30	25	27	25	24	23	28	28	28	27	25
Beruf	Student	Student	Student	Student	Student	Student	Student	Angestellter	Angestellter	Angestellter	Student	Student
Benutzen Sie ein Smartphone oder Tablet mit Touchscreen?	Nein	Ja	Ja	Nein	Ja	Ja	Ja	Ja	Ja	Ja	Ja	Ja
Wenn Ja, wie gut kennen Sie sich auf einer Skala von 1 - 5 mit dem Smartphone aus?		1	1	3	1	3	2	1	1	2	3	1
Geo-Caching	2	4	4	1	4	3	4	4	3	2	3	4
Ingress	5	5	4	5	5	4	5	2	5	5	4	5
andere Spiele	5	5	4	5	5	5	2	1	4	4	4	5
Welche anderen Spiele kennen Sie?									Mobile Scotland Yard			
Wie oft haben sie die Chat-Funktion benutzt	1	1	1	1	3	4	3	3	3	3	5	2
Würden Sie sich wünschen, dass das Gerät mehr Kommunikationmöglichkeiten hat? (z.B. Telefonfunktion, Videochat)	Nein	Ja	Ja	Nein	Nein	Ja	k.A.	k.A.	Ja	Nein	Ja	Ja
Die Chatfunktion war einfach zu bedienen	5	4	4	5	5	1	4	4	2	4	3	4
Ich würde vorgefertigte Text-Nachrichten vorziehen	1	2	2	2	2	2	3	2	3	2	1	2
Ich habe mich durch das Quest- spiel in meiner Bewegungsfreiheit eingeschränkt gefühlt.	1	1	2	2	3	1	1	4	2	2	3	3
Die einzelnen Quests waren zeitlich zu lang.	1	2	2	1	1	3	2	2	2	2	1	2
Das Spiel war insgesamt zu lang.	1	3	2	1	1	4	2	2	2	1	1	3
Ich habe mich nur ungern von meinen Mitspielern getrennt.	4	2	2	2	2	2	3	2	1	3	4	2
Wir haben uns gerne (in Untergruppen) aufgeteilt.	5	5	2	4	5	4	4	4	4	4	3	1
Ich würde ein solches Spiel lieber in einem weniger öffentlichen Rahmen speilen (z.B. Schulgebäude, geschlossene Gesellschaft)	1	1	2	1	2	2	2	4	2	2	1	2
Die gelaufene Gesamtstrecke war	2	3	3	2	1	2	3	4	3	2	2	2
Das 'Archäologiespiel'	4	2	2	2	1	2	2	2	2	4	3	2
Das 'Händlerspiel'	2	2	2	2	1	2	2	3	3	1	2	4
Das 'Mischspiel'	1	4	1	1	1	4	3	4	4	2	1	3
Das gesamte Questspiel	3	2	2	2	1	2	2	3	2	2	2	2
Nicht alle Spieler sollten die gleiche Funktion/ Aufgabe übernehmen können.	Ja	Nein	Nein	Nein	Ja	Nein	Ja	k.A.	Ja	Ja	Ja	Nein
Falls Ja, sollte es verschiedene Ränge/Rechte für die Spieler geben? (z.B. Anführer für bestimme Quests)	4	1			2		4	4	4	3	4	4

Figure C.8: Second user study result table 1

Gruppe	Gruppe4				Gruppe 5				Gruppe 6			
Gerät	2	3	4	8	2	3	4	8	2	3	4	8
Geschlecht	m	m	m	m	m	m	m	m	w	w	m	w
Alter	28	27	29	25	27	21	28	27	24	23	25	24
Beruf	Angestellter	Student, Angestellter	Student, Angestellter	Angestellter	Student	Student	Student	Student	Student	Student	Student	Student
Benutzen Sie ein Smartphone oder Tablet mit Touchscreen?	Nein	Ja	Ja	Ja	Nein	Ja	Nein	Ja	Ja	Ja	Nein	Nein
Wenn Ja, wie gut kennen Sie sich auf einer Skala von 1 - 5 mit dem Smartphone aus?	4	3	2	1		1	2	1	3	3	5	
Geo-Caching	2	2	1	3	3	3	3	4	4	3	3	4
Ingress	5	4	5	5	5	4	4	4	5	5	5	5
andere Spiele	4	4	5	5	5	4	3	5	4	5	5	5
Welche anderen Spiele kennen Sie?	Mister X	Mister X					Zombie Run					
Wie oft haben sie die Chat-Funktion benutzt	3	2	4	3	4	3	1	2	2	2	3	2
Würden Sie sich wünschen, dass das Gerät mehr Kommunikationmöglichkeiten hat? (z.B. Telefonfunktion, Videochat)	Nein	Ja	k.A.	Ja	Nein	Nein	Ja	Nein	Ja	Ja	Ja	Ja
Die Chatfunktion war einfach zu bedienen	4	2	3	4	4	4	2	4	4	2	2	4
Ich würde vorgefertigte Text-Nachrichten vorziehen	2	5	5	4	1	2	4	1	2	1	2	1
Ich habe mich durch das Quest- spiel in meiner Bewegungsfreiheit eingeschränkt gefühlt.	2	1	2	1	2	2	1	1	3	2		2
Die einzelnen Quests waren zeitlich zu lang.	2	2	2	1	2	2	1	3	4	1	1	1
Das Spiel war insgesamt zu lang.	2	1	2	1	2	2	1	2	4	1	2	1
Ich habe mich nur ungern von meinen Mitspielern getrennt.	2	2	3	2	2	3	2	2	2	1	1	1
Wir haben uns gerne (in Untergruppen) aufgeteilt.	3	3	4	4	3	4	4	5	4	5	5	5
Ich würde ein solches Spiel lieber in einem weniger öffentlichen Rahmen speilen (z.B. Schulgebäude, geschlossene Gesellschaft)	2	1	2	1	2	1	1	3	3	1	3	1
Die gelaufene Gesamtstrecke war	2	2	2	3	2	3	2	3	3	1	3	3
Das 'Archäologiespiel'	1	3	1	2	1	2	1	2	3	2	1	1
Das 'Händlerspiel'	2	2	3	1	1	2	1	1	2	1	3	2
Das 'Mischspiel'		2	3	3	1	3	1	1	2	2	2	2
Das gesamte Questspiel	4	2	3	1	1	2	1	1	2	1	2	1
Nicht alle Spieler sollten die gleiche Funktion/ Aufgabe übernehmen können.	Nein	Ja	Nein	Nein	Ja	Ja	Ja	Ja	Ja	Nein	Ja	Ja
Falls Ja, sollte es verschiedene Ränge/Rechte für die Spieler geben? (z.B. Anführer für bestimme Quests)	3	4	2	3	2	4	1	3	4	1	4	1

Figure C.9: Second user study result table 2

Gruppe 1

Spieler-Gerät 2
- Beim Archäologenspiel würde ich mir etwas anderes vorstellen, als nur hinzukommen und fertig. Man könnte eine Aufgabe machen (Fenster zählen oder so)
- Die „Einführungsbilder“ kleiner und mehr Platz für den Text, damit man nicht scrollen muss.
- Das letzte Spiel war gut! =)
- Das nötige Aus- und Anmachen, damit die Händler am Platz angezeigt werden.
- HUND!

Spieler-Gerät 3
- Sound wenn Händler entdeckt werden oder Chatnachrichten kommen
- Hints, was Händler brauchen könnten
- „Tauschen“ mit anderen eher lästig = ein gemeinsamer Pool, alle müssen zustimmen bevor getauscht wird? ; zu mindestens ein automatischer Überblick was Mitspieler haben
- Kein Anreiz weit entfernten Bäcker zu besuchen, selbst wenn der eine bessere Tauschkarte hatte, scheint das egal zu sein
- Andere Spieler auf Karte anzeigen
- Spielernamen wären gut
- Tauschen per Drag & Drop (s. Minecraft)

Spieler-Gerät 4
- „Spielbereich“ in Karte markieren!
- GPS-Region größer machen (besser kennen auch bei schlechten GPS)
- Peer-to-Peer beim letzten Spiel ;)

Spieler-Gerät 8
- 2-8: Bei der Kommunikation den Namen integrieren. Z.B. durch anfängliche Abfrage des Namens.
- Ich musste das Spiel leider zu oft neu starten.
- Es hat sich gut spielen lassen mit der 2*2 Aufteilung. Bei uns hat jeweils einer gehandelt und einer den Chat mit der 2. Untergruppe gemanaged. Schwierig hierbei ist, dass man leider absolut keinen Überblick hat was die 2. Untergruppe macht und Kommunikation über Chat war schwierig das herauszufinden… Plötzlich waren alle Zutaten da =) Sonst schon cooles Spiel!

Gruppe 2

Spieler-Gerät 2
- Es wäre schön gewesen, wenn es noch ein Ende der Geschichte ala „Ihr habt Roland befreit“ gegeben hätte =)
- Mir ging einzelne Episoden mit 4 Spielern zu schnell = Absprache schwierig, zu schnell getauscht
- Der Übergang zwischen den einzelnen Quest war zu schnell, ich hätte gern noch das komplette Rezept gesehen etc.
- Eine etwas genauere Anleitung zu Quest 3 wäre gut gewesen
- Info, dass 1.Spieler alle 3 Zutaten haben muss, um Quest 2 zu vollenden

Spieler-Gerät 3
- Chatfunktion sollte Swipe verwenden
- Karte sollte sich in Laufrichtung drehen
- Anleitungen sind zum Teil unklar z.B. Farben sind relevant beim Mischspiel, Inventar muss durch gescrollt werden beim Tauschen.
- Beim Archäologenspiel sollte es reichen den Gegenstand frei zu rubbeln
- Tauschspiel = 1 muss auch als richtig anerkannt werden
- Die Bildchen brauchen Namen Kräuter, Opium etc.

Spieler-Gerät 4
- Es wäre schön wenn man die Position der anderen Spieler sehen könnten
- Schöne Grafik =)
- Eine bisschen detailliertere Einleitung wäre schön, sodass man Aufgaben besser aufteilen kann. Bsp. Eine Kleingruppe soll Kräuter, die andere Gruppe Opium besorgen
- Bitte die Beschreibung für das Mischspiel etwas eindeutiger formulieren

Figure C.10: Second user study comments, page 1

Spieler-Gerät 8
- Karten sollten Position der Mitspieler anzeigen
- Info „Händler nimmt x um y zu verkaufen“ sollte angezeigt werden (ggf. noch discover durchprobieren); Händler: Inventar zeigt nur relevante Dinge an? (Feature Request)
- Erklärung Tauschspiel zu kurz (u. Rückgriff auf Kurzerklärung reicht nicht)
- Bugs beim Ausgrabespiel: nicht attraktive Stoffe
- Bugs beim Tauschspiel = 1 und nicht größer oder gleich 1
- Bug. Beim Trankspiel: einzelne Tränke fehlen
- Karte beim Händler spiel sollte Aktionsradius anzeigen
- Handel- Inventar am Anfang völlig unklar. Scrollen vom Inventar nicht erklärt.

Gruppe 3

Spieler-Gerät 2
- Das Spiel sollte mehr Kontrollfunktionen bieten, wie z.B. eine automatisches Inventarupdate zu den anderen Spielern, Anzeigen des Spielernames im Chat, Beschriftung der Inventargegenstände; Backlog der Tauschmöglichkeiten bei den Händlern, die man bereits besucht hat, usw.

Spieler-Gerät 3
- Archäologenspiel: nicht jeder sollte hier alles können, sonst werden alles Sachen weggeschnappt! (hier zählt mehr nur die Geschwindigkeit)
- Bei Händlerspiel ist das besser verteilt.
- Nettes Gesamtkonzept! =)

Spieler-Gerät 4
- Chat ersetzt nicht das persönliche Gespräch.
- Besser die Position der anderen auf der Karte darstellen.

Spieler-Gerät 8
- Auf der Karte Position der anderen angeben.

Gruppe 4

Spieler-Gerät 2
- Die Idee vom Mischspiel ist gut, nur macht es die langsame Serververbindung schwierig das Spiel zu spielen

Spieler-Gerät 3
- übersichtliche Karte; mittelalterlicher Stil, Randbegrenzung, aufgezeichnete Orte für Quest (e.g. Marktplatz) + Gebäude, Rotation in Blickrichtung
- Übersicht über Gesamtstatus der Aufgaben; es: n/m Items ausgegraben, alle Questitems (Handel-Spiel)
- Auszeichnung der Questitems (Roter Rahmen etc.)
- Position der Mitspieler auf der Karte
- „Ausgraben“ im Quest nicht gut erkennbar --> was muss man tun
- Handelsmöglichkeiten unübersichtlich
- Bedienung des Mischspieles unnatürlich (reinschieben, anstatt klicken)

Spieler-Gerät 4
- keine

Spieler-Gerät 8
- Bei Questeinführung und Handel ist das Bild viel größer als das Textfeld. Platz lässt sich dort besser aufteilen.

Figure C.11: Second user study comments, page 2

Gruppe 5

Spieler-Gerät 2
- War super toll =)
- Hatte wenig Erfahrung mit Smartphones, ging aber doch ganz gut.

Spieler-Gerät 3
- Kommentare sind schlecht erkennbar
- GPS ist unpräzise
- Netzwerksync könnte besser sei
- UI unresponsive
- Taktisches Feedback fehlt

Spieler-Gerät 4
- Chat muss neue Nachrichten besser anzeigen
- Scrollen des Inventars nicht er sichtbar
- Händler überlagern sich – manchmal Schwierigkeiten anzuklicken

Spieler-Gerät 8
- Vibration wenn neue Objekte gefunden werden, sonst glotzt man konstant aufs Handy
- Vibration wenn neue Chatnachricht erhalten
- Ausgrabespiel braucht Tiefe = frei rubbeln, vielleicht etwas weniger, aber ok; Puzzlespiel am Schluss?

Gruppe 6

Spieler-Gerät 2
- Kein Spiel für Kälte
- Gutes Spiel, leider wahrscheinlich nicht alttagstauglich, da immer andere Spieler notwendig sind und man sich an einen bestimmten Ort treffen muss
- Chat: Nachrichten der anderen Spieler müssten länger auf dem Display sichtbar sein und sich mit Signal ankündigen (Vibration, Ton)
- Mehr Audiofunktion (z.B. Marktschreier, Musik oder so über Ohrstöpsel)

Spieler-Gerät 3
- Chatfunktion: Autokorrektur war störend
- Ein Signalton oder Vibration beim Eingehen einer neuen Nachricht wäre hilfreich

Spieler-Gerät 4
- es war zu kalt für das Spiel
- Automatische Benachrichtigung, dass Mitspieler folgenden Handel vollzogen haben
- Vibrationsalarm für empfangene Nachricht

Spieler-Gerät 8
- zu 15 = bestimmte zusätzliche Fähigkeiten für einzelne wären spannend, aber Aufgaben für handeln etc. sollten alle können
- Es sollte deutlicher werden, dass man Nachrichten hat (vl. Audiofunktion)
- Man sollte auch als Frau angesprochen werden. =)

Figure C.12: Second user study comments, page 3

Gruppe 1

date	player	message
27.04.2013 14:35	AIXII 4	"Hi!"
27.04.2013 14:35	AIXII 3	"Hallo!!!"
27.04.2013 14:35	AIXII 2	"Hi?"
27.04.2013 14:35	AIXII 8	"Hallo"
27.04.2013 14:35	AIXII 4	"Super!"
27.04.2013 15:20	AIXII 8	"Nee Wat is Sat schön"
27.04.2013 15:23	AIXII 2	"Wir holen Bier"
27.04.2013 15:25	AIXII 8	"Wir können den Händler nicht mehr anklicken Marian"
27.04.2013 15:26	AIXII 4	"[Instructor] kommt sofort geflogen!!"
27.04.2013 15:26	AIXII 8	"Geht wieder"
27.04.2013 15:27	AIXII 3	"[Spielername]"
27.04.2013 15:30	AIXII 2	"Hab 2 Bier geholt"
27.04.2013 15:35	AIXII 8	"Jungs habt ihr schon was?"
27.04.2013 15:35	AIXII 4	"Brot! Und Brezeln"
27.04.2013 15:36	AIXII 4	"Gleich haben wir Pilze"
27.04.2013 15:36	AIXII 8	"2bier 8weizen 6stoffe"
27.04.2013 15:41	AIXII 8	"Apotheker hat Kräuter und Tinktur, "
27.04.2013 15:41	AIXII 8	"Stoffhändler Stoffe und Shirts"
27.04.2013 15:42	AIXII 8	"Biermannbier und Wein"
27.04.2013 15:42	AIXII 8	"Was braucht ihr?"
27.04.2013 15:43	AIXII 3	"Wissen wir nicht, schickt alles an4"
27.04.2013 15:43	AIXII 4	" Wir schicken euch mal alles was wir haben"
27.04.2013 15:44	AIXII 2	"Wir haben Kräuter"
27.04.2013 15:44	AIXII 8	"Gequert und Opiumhändler gefunden"
27.04.2013 15:44	AIXII 3	"Habt jetzt alles von uns"
27.04.2013 15:44	AIXII 8	"Alles bitte an 2 schicken"
27.04.2013 15:45	AIXII 3	"8 hat unseren Kram schon :)"
27.04.2013 15:45	AIXII 8	"Alles bekommen und an 2 weiter geleitet"
27.04.2013 15:45	AIXII 8	"Treffen am Brunnen?"
27.04.2013 15:45	AIXII 2	"8 wo bist du??:€"
27.04.2013 15:46	AIXII 2	":-)"
27.04.2013 15:47	AIXII 8	"Jungs kommt ihr auch? Teambesprechung"
27.04.2013 15:48	AIXII 4	"Sind unterwegs "
27.04.2013 15:49	AIXII 8	"Wir haben alles"

Gruppe 2

date	player	message
27.04.2013 16:43	AIXII 8	"Hallo"
27.04.2013 16:44	AIXII 2	"Huhu"
27.04.2013 16:44	AIXII 4	"Zach"
27.04.2013 16:44	AIXII 8	"Lach"
27.04.2013 16:48	AIXII 2	"Yannick, komm doch mal"
27.04.2013 16:48	AIXII 4	"Hier ist aber ne Ausgrabung"
27.04.2013 16:51	AIXII 2	"Wir sollen alle kommen :-)"
27.04.2013 16:54	AIXII 4	"Buäääh!!!"
27.04.2013 17:05	AIXII 2	"Habt ihr schon was erreicht?"
27.04.2013 17:06	AIXII 8	"Habt ihr schon was getauscht?"
27.04.2013 17:07	AIXII 2	"Wir haben Brot und Tuch"
27.04.2013 17:07	AIXII 2	"Und Brezel"
27.04.2013 17:07	AIXII 2	"Und ihr?"
27.04.2013 17:08	AIXII 4	"Habt ihr was?"
27.04.2013 17:08	AIXII 3	"Das geht ja garnicht"
27.04.2013 17:09	AIXII 4	"Wo seid ihr?"
27.04.2013 17:09	AIXII 3	"Kramerstraße"
27.04.2013 17:11	AIXII 2	"Wir haben gleich pilze"
27.04.2013 17:11	AIXII 4	"Wir haben grad welche"
27.04.2013 17:16	AIXII 8	"Ich hab drooogen"
27.04.2013 17:17	AIXII 4	"Haltet ihr euch wohl an die Regen!!"

Gruppe 3

date	player	message
28.04.2013 12:11	AIXII 8	"Heya"
28.04.2013 12:11	AIXII 2	"Hallo Leitz"
28.04.2013 12:11	AIXII 3	"Hallo"
28.04.2013 12:11	AIXII 3	"Geht"
28.04.2013 12:11	AIXII 8	"Nr 8 ist [Spielername]"
28.04.2013 12:12	AIXII 3	"3 Ungar"
28.04.2013 12:12	AIXII 2	"2 Chris"
28.04.2013 12:16	AIXII 8	"Also ich hab 2 bisher"
28.04.2013 12:16	AIXII 2	"Got One"
28.04.2013 12:16	AIXII 2	"Und noch ein"
28.04.2013 12:17	AIXII 2	"Und Nr 5"
28.04.2013 12:18	AIXII 8	"Dann müssen wir noch tauschen"
28.04.2013 12:30	AIXII 3	"Habe Brote und Stoffe"
28.04.2013 12:30	AIXII 2	"Habe 5 Bier"
28.04.2013 12:30	AIXII 8	"Habe nix. Suche Händler :)"
28.04.2013 12:32	AIXII 2	"Korrigiere: ich habe nix, Weizen weg, kein bier bekommen :-("
28.04.2013 12:35	AIXII 8	"Wir haben schon opium und Pilze. Brauchen noch Kräuter"
28.04.2013 12:36	AIXII 2	"Ok, Bier wiedergegeben :-)"
28.04.2013 12:40	AIXII 3	"Habe Kräuter"

Gruppe 4

date	player	message
29.04.2013 13:24	AIXII 8	"Ich hab was"
29.04.2013 13:24	AIXII 4	"Ich auch"
29.04.2013 13:25	AIXII 2	"Hab such eins"
29.04.2013 13:27	AIXII 4	"Sammeln Ain der Mitte"
29.04.2013 13:27	AIXII 8	"[Spielername] wo bist du"
29.04.2013 13:36	AIXII 4	"Hab 3 tuch"
29.04.2013 13:38	AIXII 8	"Hab 4 Pilze"
29.04.2013 13:42	AIXII 2	"Hab 2 kräuter"
29.04.2013 13:42	AIXII 4	"Fehlen noch opiums"

Gruppe 5

date	player	message
28.04.2013 15:13	AIXII 8	"Hallo"
28.04.2013 15:13	AIXII 4	"Recke [Spielername] bereit"
28.04.2013 15:13	AIXII 3	"Quäk"
28.04.2013 15:14	AIXII 2	"Hi"
28.04.2013 15:23	AIXII 3	"Sammeln"
28.04.2013 15:24	AIXII 2	"Ilos"
28.04.2013 15:24	AIXII 4	"Hab was"
28.04.2013 15:33	AIXII 4	"Wer hat was"
28.04.2013 15:38	AIXII 4	"Habe 3 Bier"
28.04.2013 15:42	AIXII 4	"Hat jemand was neues"
28.04.2013 15:43	AIXII 8	"Habe den Opiumhändler"
28.04.2013 15:47	AIXII 4	"2 Tinktur 3 blumen"
28.04.2013 15:48	AIXII 8	"2 ringe für 3 Bier"
28.04.2013 15:48	AIXII 4	"Weingeist"
28.04.2013 15:51	AIXII 4	"Habe Opium"
28.04.2013 15:51	AIXII 3	"Auf zumarkz"
28.04.2013 15:57	AIXII 2	"Hab kraeuter"
28.04.2013 16:08	AIXII 4	"Gewonn0n"
28.04.2013 16:08	AIXII 3	" RFC"
28.04.2013 16:09	AIXII 3	"RFC"
28.04.2013 16:09	AIXII 4	"Whoot"
28.04.2013 16:09	AIXII 3	"Tftc"

Gruppe 6

date	player	message
29.04.2013 17:20	AIXII 2	"Hallo\n"
29.04.2013 17:20	AIXII 3	"Hallo"
29.04.2013 17:20	AIXII 3	"Bin ich gelb\n"
29.04.2013 17:21	AIXII 2	"Ich habe zwei schätze gefunden. Ihr?"
29.04.2013 17:21	AIXII 3	"Ok"
29.04.2013 17:21	AIXII 3	"Einen "
29.04.2013 17:21	AIXII 2	"Das macht drei"
29.04.2013 17:22	AIXII 8	"Ich schicke an [Spielername]"
29.04.2013 17:22	AIXII 4	"Ich Au"
29.04.2013 17:23	AIXII 3	"Dann mache ich das auch\n"
29.04.2013 17:23	AIXII 4	"Ich habe auch ein"
29.04.2013 17:30	AIXII 8	"Haben die krauet gefunden können"
29.04.2013 17:31	AIXII 2	"Wir haben Stoff gekauft."
29.04.2013 17:33	AIXII 3	"Konnt ihr uns den Stoff schicken der Händler will etwas hochwertiges"
29.04.2013 17:34	AIXII 4	"Ich habe 2 bier erworben"
29.04.2013 17:36	AIXII 2	"Ich habe den Stoff gerade wieder verkauft. Gegen Weingeist. Wir kommen den Drogen näher. :-)"
29.04.2013 17:36	AIXII 2	"[Spielername] besorgt gerade neue Stoffe"
29.04.2013 17:36	AIXII 2	"Wie viele Stoffe braucht ihr denn?"
29.04.2013 17:38	AIXII 4	"Habe ein Stoff abzugeben :)"
29.04.2013 17:38	AIXII 3	"Ok"
29.04.2013 17:38	AIXII 8	"Wir tauschen Grade Tinktur gegen Blumen"
29.04.2013 17:43	AIXII 2	"Ok. Konnten wir was von den Blumen haben? Wir haben das Opium entdeckt, aber der Schnösel-Händler will weder Fell,noch Bier,noch Wein,noch Weizen!"
29.04.2013 17:43	AIXII 2	"Habt ihr sonst noch was? Tinktur könnte vielleicht auch klappen."
29.04.2013 17:45	AIXII 8	"Wir handeln fleissig"
29.04.2013 17:45	AIXII 4	"Habe trinktur und Kräuter entdeckt"
29.04.2013 17:45	AIXII 3	"Kann mir jemand Tinktur schicken\n"
29.04.2013 17:45	AIXII 2	"Ich hab Opium!"
29.04.2013 17:45	AIXII 3	"Bitte Zinn"
29.04.2013 17:46	AIXII 3	"Scheiß autokorrektur"
29.04.2013 17:47	AIXII 3	"8 oder 2 iCh Bitte tinktur zuruck \n"
29.04.2013 17:48	AIXII 8	"Hat noch jemand Stoff den er mir schicken kann?"
29.04.2013 17:48	AIXII 2	"Tinktur wurde gegen Opium gekauft."
29.04.2013 17:48	AIXII 2	"Kräuter hab ich auch. Hat jemand Pilze?"
29.04.2013 17:49	AIXII 8	"Habe keine Tinktur"
29.04.2013 17:49	AIXII 3	"ICh Steve bei dee hexe die hat pillar"
29.04.2013 17:49	AIXII 8	"Wer hat noch Stoff?"
29.04.2013 17:49	AIXII 3	"Pile"
29.04.2013 17:50	AIXII 2	"Pilze?"
29.04.2013 17:50	AIXII 3	"Jap"
29.04.2013 17:50	AIXII 8	"Lauft ja Super hier"
29.04.2013 17:50	AIXII 2	"Ich Schick dir mal, was ich habe"
29.04.2013 17:50	AIXII 3	"Die will meier ware niche"
29.04.2013 17:52	AIXII 2	"A3, du hast alles von mir. Inklusive Opium und Kräuter."
29.04.2013 17:53	AIXII 2	"A3, wo bist du? Virtuell hast du mit zu viele Rechtschreibfehler. Ich komm mal rum.."
29.04.2013 17:56	AIXII 2	"[Spielername] und ich sind bei derPilzefrau. Könnten wir noch was haben? Sind aktuell mittellos."
29.04.2013 17:56	AIXII 3	"Pile d"
29.04.2013 17:56	AIXII 4	"Mir ist kalt!"
29.04.2013 17:57	AIXII 3	"Wit haven pilsen"
29.04.2013 17:57	AIXII 2	"What?"
29.04.2013 17:57	AIXII 3	"Pilze"
29.04.2013 17:57	AIXII 2	"Habt ihr Pilze? "
29.04.2013 17:57	AIXII 2	"Dann habt ihr jetzt alles."
29.04.2013 17:57	AIXII 8	"Mir ist auch kalt"
29.04.2013 17:58	AIXII 8	"Nicht ganz [Spielername] hat Grade krauter gegen Pilze getauscht"
29.04.2013 18:00	AIXII 2	"[Spielername] hat jetzt alles!"

Figure C.13: Chat log, page 1

Appendix D

Data Analysis

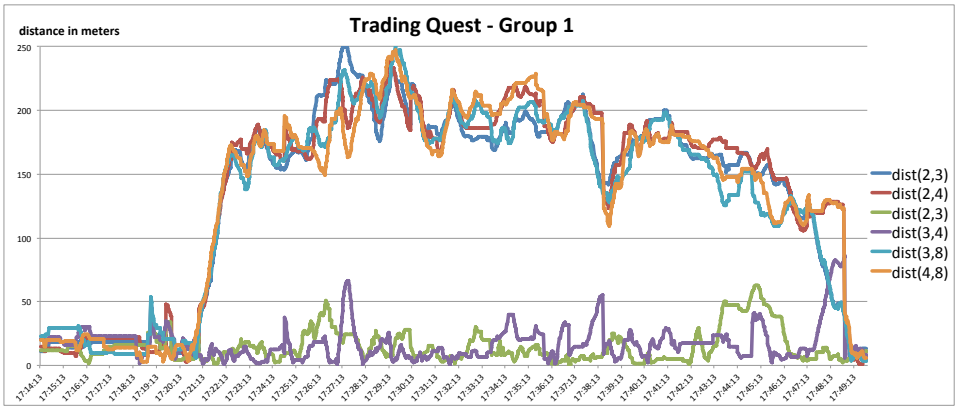

Figure D.1: Time sequence - Trading Quest (Group 1)

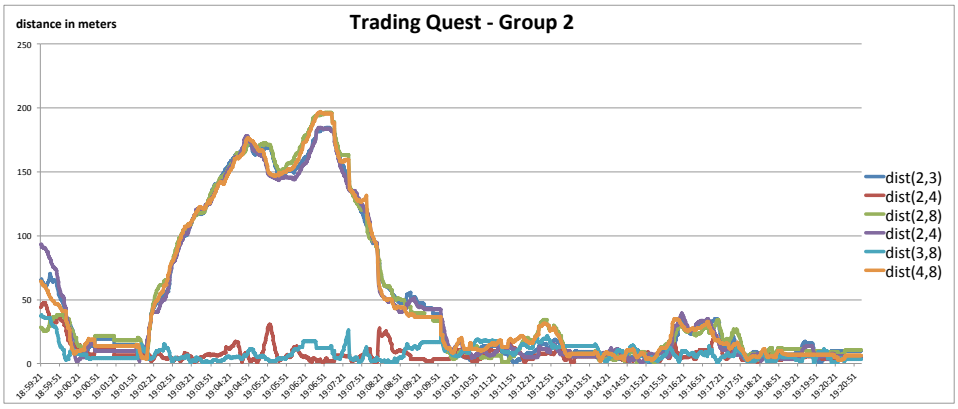

Figure D.2: Time sequence - Trading Quest (Group 2)

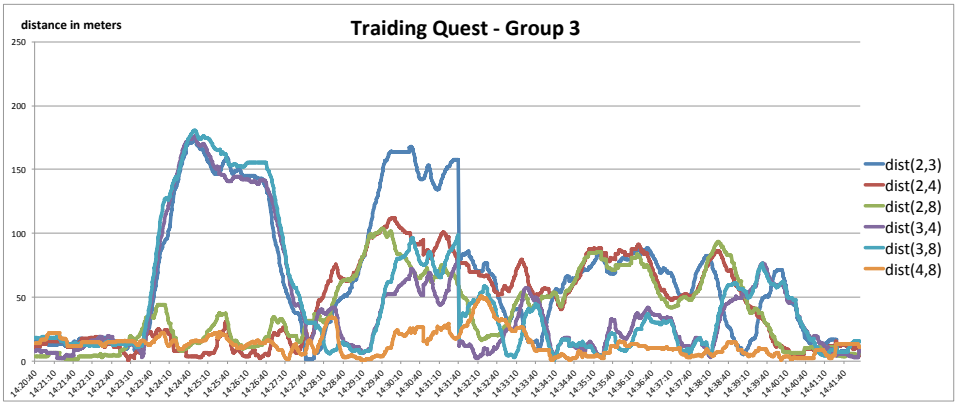

Figure D.3: Time sequence - Trading Quest (Group 3)

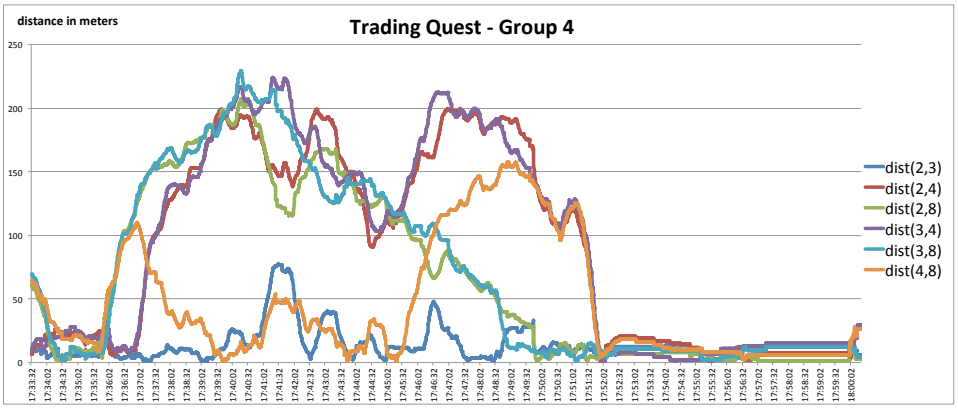

Figure D.4: Time sequence - Trading Quest (Group 4)

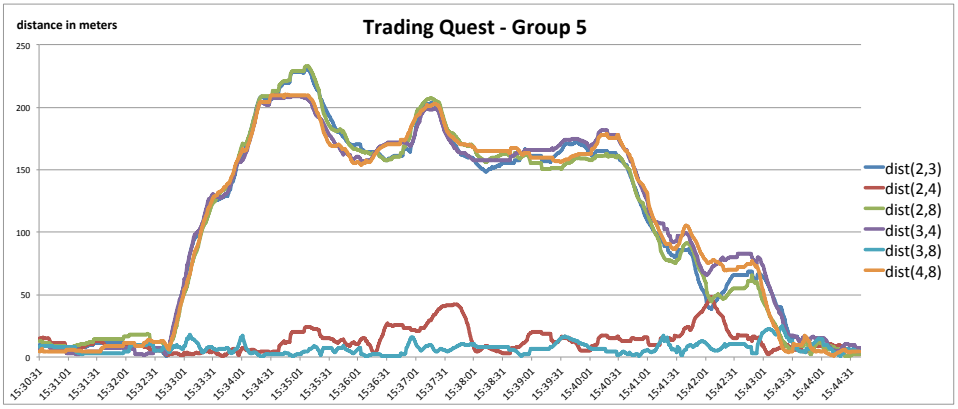

Figure D.5: Time sequence - Trading Quest (Group 5)

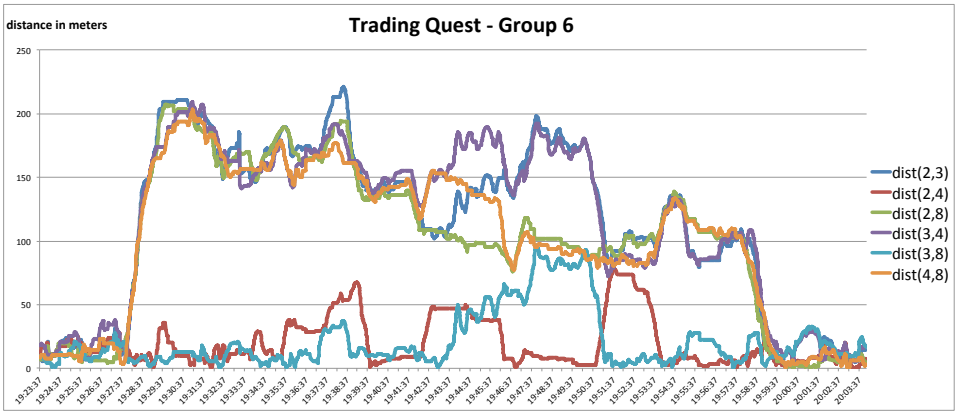

Figure D.6: Time sequence - Trading Quest (Group 6)

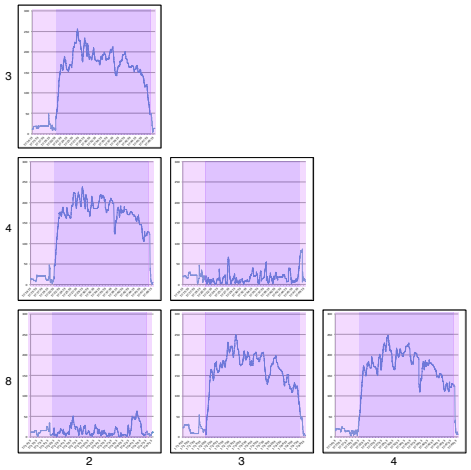

Figure D.7: Grid diagram (Group 1)

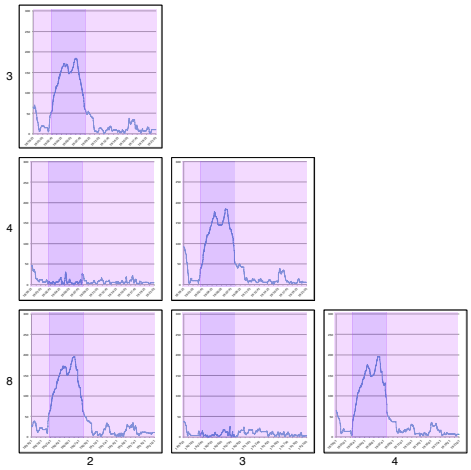

Figure D.8: Grid diagram (Group 2)

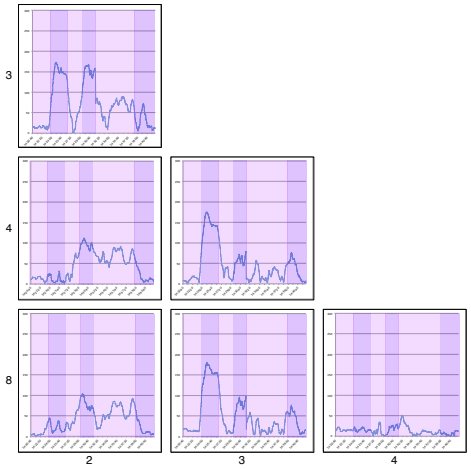

Figure D.9: Grid diagram (Group 3)

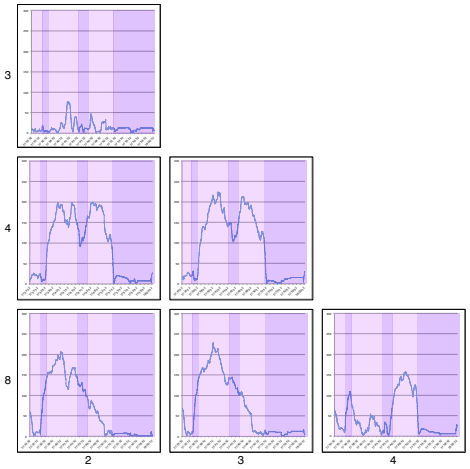

Figure D.10: Grid diagram (Group 4)

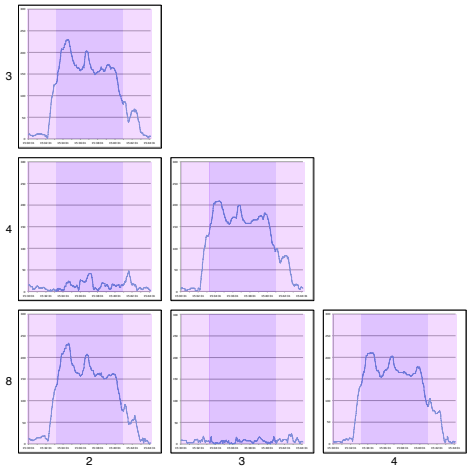

Figure D.11: Grid diagram (Group 5)

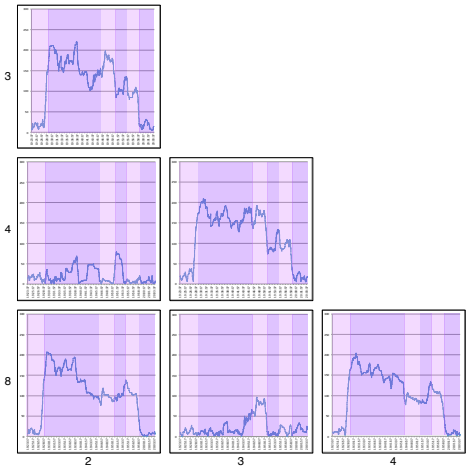

Figure D.12: Grid diagram (Group 6)

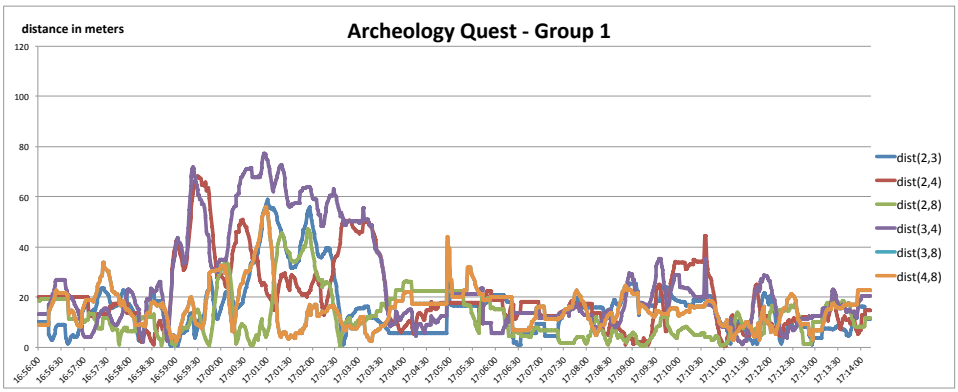

Figure D.13: Time sequence - Archeology Quest (Group 1)

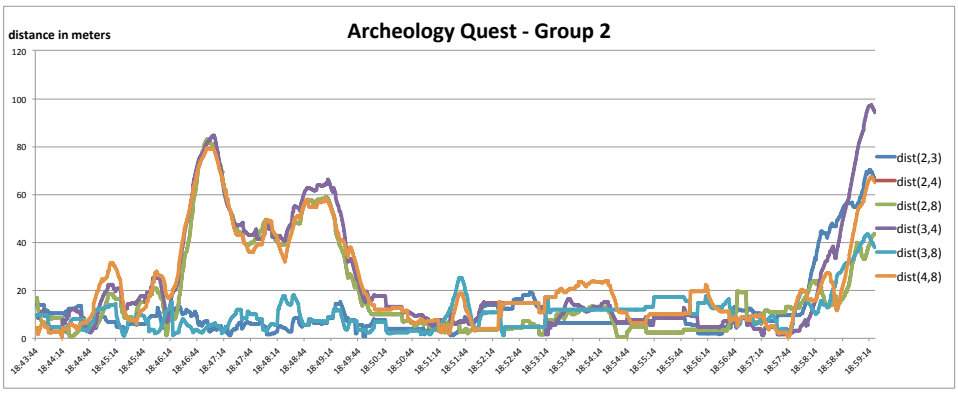

Figure D.14: Time sequence - Archeology Quest (Group 2)

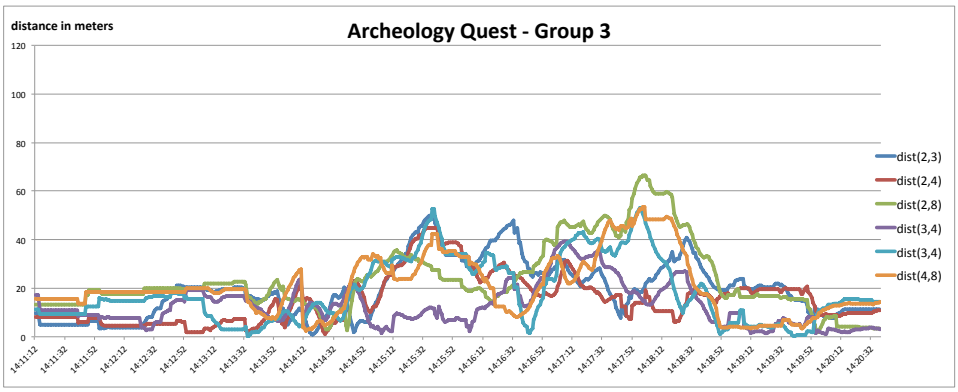

Figure D.15: Time sequence - Archeology Quest (Group 3)

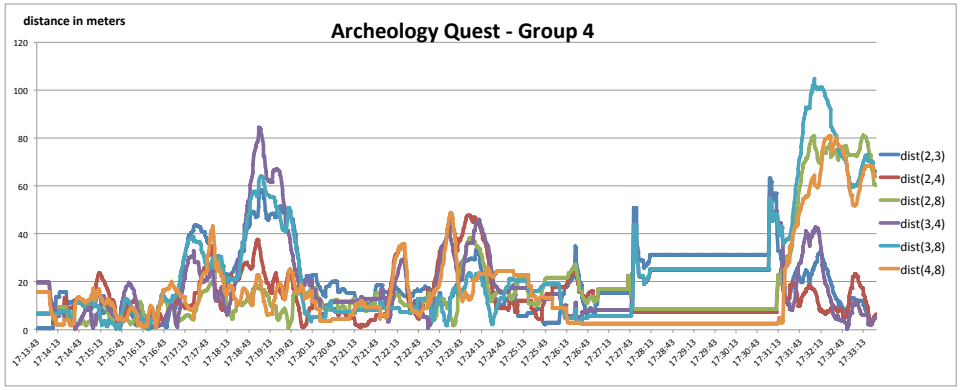

Figure D.16: Time sequence - Archeology Quest (Group 4)

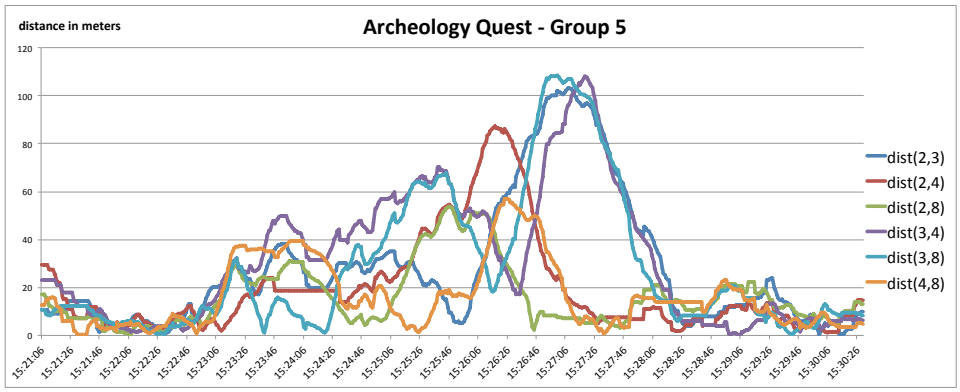

Figure D.17: Time sequence - Archeology Quest (Group 5)

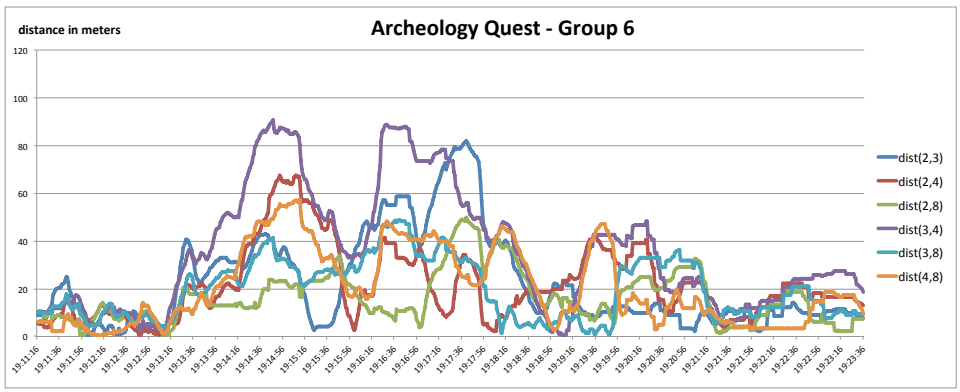

Figure D.18: Time sequence - Archeology Quest (Group 6)

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