Movement Patterns in Location-based Multiplayer Games

Master's Thesis at the
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Aachen, AUGUST 2014
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Contents

List of Figures

List of Tables

Abstract

Mobile devices have been woven into the fabric of our lives, people carry it where ever they go. This brings up quite an interesting question as to what fun activities can be done taking into consideration all this movement and the answer is quite simple - location-based games. In many games the location-based information is used as content or input and the focus is on social or group interaction activities.

The foundation was laid out by Carl Huch [2013] Diploma Thesis. They successfully converted three quest concepts into a software prototype called "mLog". It consisted of two different location-based quests. They implemented a text messaging system to enable players to do long range communications between each other. From the evaluation of the user study which was conducted in the city centre, one can learn that the players' movement patterns are correlated to the quest types. There are lots of interesting findings about the aspects of group dynamics and a novel way to represent movement data which can be found in their work. This is an interesting area to investigate into, as one could mathematically formulate these group activities. With this aim in mind and inspired by work done already accomplished in this field, this Master thesis aims to build upon those works.

We intend to define a procedure to distinguish quest-wise movement data and find correlation between game elements and strategies involved in completing the quest. We will be adding a new type of location-based quest which involves covering a region in addition to the existing location-based quests. The existing quests are redesigned to use Bluetooth technology called iBeacon™ as against former one which was GPS-based. We will be including few of the features suggested by users like voice messaging and certain changes to user interfaces. All these make up the new software prototype called "mLog2". In the evaluation phase we were able to successfully distinguish mathematically the movement patterns between the three quests. The proximity plots shed some light on how the group members panned out in the different quests. Furthermore the questionnaire gave important feedback on the game, strategies involved and aesthetics of the game.

Überblick

Mobile Geräte haben in den Stoff unseres Lebens verwoben, die Menschen tragen sie, wo immer sie gehen. Dies bringt eine sehr interessante Frage, was Spaß Aktivitäten können unter Berücksichtigung aller dieser Bewegung durchgeführt werden, und die Antworten, ist ganz einfach - standortbasierte Spiele. In vielen Spielen der Standort-basierte Informationen werden als die Inhalte oder die Eingabe und der Fokus auf der sozialen Interaktion in der Gruppe oder Aktivitäten.

Die Stiftung wurde von Carl Huch [2013] Diplomarbeit gelegt. Sie konvertierten erfolgreich drei Quest-Konzepte in einem Software-Prototyp namens "mLog". Es bestand aus zwei verschiedenen standortbasierten Aufgaben. Sie realisiert einen Text-Messaging-System, um Spieler zu ermöglichen, Langstrecken-Kommunikation zwischen miteinander zu tun. Von der Auswertung der Benutzerstudie, die in der Innenstadt durchgeführt wurde, kann man lernen, dass der Spieler Bewegungsmuster, um die Quest-Typen korreliert. Es gibt viele interessante Erkenntnisse über die Aspekte der Gruppendynamik und einem neuen Weg, um Bewegungsdaten, die in ihren Werken zu finden sind vertreten. Dies ist ein interessantes Gebiet, um in zu untersuchen, wie man mathematisch diese Gruppenaktivitäten zu formulieren konnte. Mit diesem Ziel vor Augen und inspiriert von der Arbeit in diesem Bereich bereits erreicht getan, zielt diese Masterarbeit, auf solche Werke zu bauen.

Wir Absicht, ein Verfahren zur Suche weise Bewegungsdaten zu unterscheiden und finden Zusammenhang zwischen Spiel-Elemente und Strategien in der Abschluss der Quest beteiligt definieren. Wir fügen eine neue Art von Location-based Quest, die für eine Region, in Ergänzung zu den bestehenden Standort-basierte Quests beinhaltet. Die bestehenden Aufträge werden neu gestaltet, um die Bluetooth-Technologie genannt iBeacon™ gegen eine, die formal auf GPS-Basis war zu verwenden. Wir werden auch einige der Features, die von Benutzern wie Voice-Messaging und bestimmte Änderungen an Benutzerschnittstellen vorgeschlagen. Alle diese macht die neue Software-Prototyp namens "mLog2". In der Evaluierungsphase konnten wir erfolgreich mathematisch zeichnen die Bewe-

gungsmuster zwischen den drei Aufgaben. Die Näherungsstücke, etwas Licht auf, wie die Mitglieder der Gruppe verrissen in den verschiedenen Aufgaben. Außerdem der Fragebogen gaben wichtige Rückmeldungen zu dem Spiel, Strategien einbezogen und Ästhetik des Spiels.

Acknowledgements

Conventions

Throughout this thesis we use the following conventions.

Text conventions

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

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SavePeasantViewController
```

All names of presented games are written in small capitals

INGRESS

The whole thesis is written in British English.

Download links are set off in coloured boxes.

> File: myFile[a]
> _____
> [a]http://hci.rwth-aachen.de/~simha/thesis/file_name.zip

Chapter 1

Introduction

The increasing use of mobiles in everyday life has made it a necessity to build the mobile devices through an exact structured science. The hardware has got smaller, more powerful in terms of the computing power and lighter over the years. Similarly on the software front there has been amazing advancements like faster operating systems, user-friendly interfaces, etc. Human-Computer Interaction (HCI) is the topmost abstraction between the operating system and user. This abstraction needs to be designed carefully to make the users feel at ease when using the device. There is a great focus on navigation, gaming and touring aspects in the HCI research and in all of the above the location-based information is of at-most importance. Many projects are designed around the concept of location as content or are based on position data as input. Only a select few transforms all these possible usages into a game. These games even if they are designed for multi-players, they generally cause less group interactions and they constrain the players to form sub-groups with or without possible means of in-game communication. Consequently, this ends up being an individual experience rather than a group interaction.

Making of location-based games

The foundation of group interaction games were laid out by the game AIXplorer created at the Media Computing Group, RWTH Aachen University in 2009. It was originally designed as a position based guide for the city hall

AIXplorer

giving different content for each room in the hall at Aachen city centre. The newer version of this multimedia guide is aiming to connect different stations of the Route Charlemagne[1] informing about the heritage and culture of the city of Aachen. Despite the advancements, the system resulted in an individual usage with low communication and group interaction.

GroupAIXplorer

With the introduction of a quest-driven approach in 2010 by Wermers et al. [2011] these issues were overcome by the creation of GroupAIXplorer. It is a tour which is played by a small group of up to five participants. The game consisted of quests and each quest requires them to find specific exhibits in the museum and solve relevant questions. This game was very successful as there was increased group interaction and encouraged communication. But the system was limited only to the ground floor of the town hall, which is a relatively small area.

Design and finding
based on mLog
prototype

Improving upon this established quest-driven approach, the game called "mLog" was designed by Huch [2013] for a larger area in which the groups could freely explore. The aim was to identify, analyse movement patterns and understand how players reacted to tasks and how far were the players willing to move away from the group. The authors also developed a text messaging system to allow interactions when participants were moving separately in the city centre. These quests were embedded into a bigger storyline thus giving an impression of something larger at stake. The game was a success, leading to lot of group interaction and movement data, those were plotted using geo-sociograms which involves plotting relative distances between pairs of participants for a particular quest. The two location-based quests were played on areas of different sizes, so their movements patterns could not be correlated.

The aim of this Master's thesis is to demonstrate a game designed to be played in a large open field or park. We would also want to find correlations between the movement patterns in all the quests. There will be a new location-based quest added, which requires the players to covers a certain region on the playing field and based on that certain

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[1]http://www.route-charlemagne.eu/Startseite/index.html

events are triggered in the game. The existing location-based quests in "mLog" will be incorporated into the new game called "mLog2". These existing quests will be modified to Bluetooth technology called iBeacon™ as against the earlier GPS-based one. We will make use of proximity-based plots as they give contextual picture of how different players movements in all the quests with respect to the different points of interest in those quests.

What makes up
mLog2 prototype

The game design can be broken down into paper prototypes, software testing and evaluation of the software prototype for data analysis. The name "mLog2" was chosen to indicate that it is a newer version of the original logging prototype "mLog".

1.1 Structure of Thesis

The structures of the thesis is as follows:

Chapter 2 - "Related Work" gives an overview current state of research in location-based games. The different ways in which the game concepts and game design were influenced is described here. We will also mention the lessons learnt and explain why some of the ideas were adopted.

Chapter 3 - "Game Design" describes the aim of this research and the game concepts of the existing quest and of the new quest-based game. We will also be going into details about the storyline adopted for the new prototype.

Chapter 4 - "Completion of the Game" explains about the stages of prototype development, the new features which are introduced and design changes to the existing game. We will mention how some of the suggestions given by users in "mLog" were adopted as part of the new game. We will be also mentioning about how the new location to host the game was chosen.

Chapter 5 - "Final Implementation" emphasizes on the finalised user interfaces for all quests and features of proto-

type. This chapter goes into details of the software archi-
tecture and the findings from the pilot user studies.

Chapter 6 - "Evaluation and Data Analysis" describes the
software testing and evaluation. The interpretation of the
observations, users' feedback for questionnaire and mean-
ingful visualization of all data is given here as part of data
analysis.

Chapter 7 - "Recommendations for User Studies" describes
our contribution to the good practices and guidelines in or-
der to design and execute user studies better. Here we de-
scribed different aspects of user studies that one must take
into consideration.

Chapter 8 - "Summary and Future work" concludes this
thesis and sums up the important results. It also informs
about certain ideas which can be implemented in the fu-
ture.

Chapter 2

Related work

To begin with, there are certain terms that need to be defined before deep diving into related research. The terms *quest-driven*, *location-aware*, *location-based*, *position-based* games and *movement patterns* are used quite often in this thesis.

Firstly, one must understand that *position-based* games are those that could be played in any sufficiently open space but only the players' position relative to the playground matters. The players' positions in the classic game of Football[1] holds significant importance. In the game the roles of relative positions on the playing field are different like attacker or goalie and also being on different positions on the field itself defines if one is directly involved in the game or not. The work of [Will, 2013, p. 70] explains in great detail about the pattern *position vs. location*.

Players' position relative to playing field

A *location-based* game includes the real world surrounding information and that is used as content in the game. The popular reality television game show The Amazing Race[2] is based on different challenges which one must master at different locations in the real world in order to finish and win a price.

Location-based game explained

The *location-aware* game is based on the functionality avail-

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[1]http://en.wikipedia.org/wiki/Football
[2]http://en.wikipedia.org/wiki/The_Amazing _Race

<div style="margin-left:auto; text-align:right">
Understanding
location-aware
games
</div>

able in the devices, for example as most smart phones to-
day have a GPS-receiver, they are *location-aware*. The AIX-
plorer[3]is using interior GPS as this game is indoor based
and is thus able to pin point where exactly a player is within
the confines of the building.

<div style="text-align:right">
Our usage of
movement patterns
</div>

When we are referring to *movement patterns*, then we are
emphasizing on the way in which the players move around
the playing field. Changes in *movement patterns* directly af-
fect the movement data which is collected. We are not look-
ing into finding or deducing patterns from the movement
data for example convergence type of movement data.

<div style="text-align:right">
Quest-driven games
</div>

Finally *quest-driven* means to look for a certain outcome,
which generally involves making use of certain specific
skills to finish challenges and these quests have a well-
defined start and end. The old popular television game
show called The Crystal Maze[4] involved medieval, indus-
trial, futuristic and oceanic type quests. Each of them re-
quired a specific set of skills to be mastered in a stipulated
time to achieve a certain goal.

2.1   Literature Review

In the following sections we will discuss the publications
and thesis works in which the authors have contributed to
the field of location-based games. We will also discuss the
work of Huch [2013] and how his work is carried forward
in the current work. The diploma thesis written by Will
[2013], emphasize on pattern language for location-based
games have also shaped the way we design the game go-
ing forward. We shall also be deep diving into the area
of proxemics which will give a better understanding of the
different social interactions.

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[3]http://www.aixplorer.de/
[4]http://en.wikipedia.org/wiki/The_Crystal_Maze

2.1.1   Games based on Locations

The work of Huch [2013] was influential in determining
and understanding movement patterns. Thus, it formed
the built the foundation for the current work as movement
patterns were not extensively studied in this way before.
This also gave us an insight into the social aspects of group-
ing behaviour while the game is being played. The excel-
lent approach to visually represent data in the form of geo-
sociograms gave a whole new meaning as to how move-
ment data could be interpreted. This method of visualiza-
tion seems to be a derivative from Crnovrsanin et al. [2009]
work. We would be using this extensively in the analysis of
the movement data.

*Geo-sociogram data
visualization*
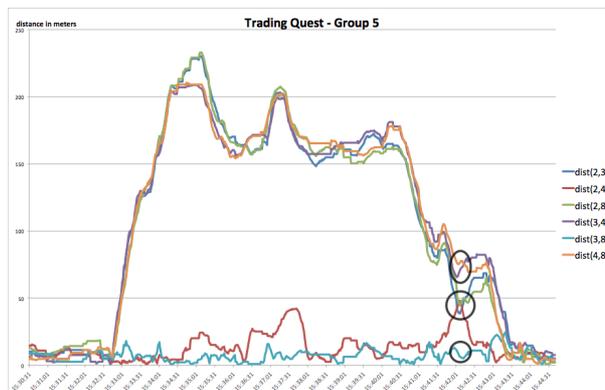
Figure 2.1: Geo-Sociogram for Trading Quest: Presented in
the work of Huch [2013]

In this thesis, we are working to build atop the research
done by Huch [2013]. Therefore we will be using the code
bases, adapting the best practices from the user studies and
data analysis from his work. We will work towards incor-
porating the suggestions and comments from users to make
an improved and robust prototype. We will in the follow-
ing chapters explain the details of the game design and the
various features which are implemented in the new proto-
type.

*Work atop existing
game*

The following paper gave us an overview of the various
games and technologies used in making certain games
come to life. The work of Lehmann [2012] describes the

different game patterns and new types of games possible in location-based games. It also closely examines the techniques to determine the geo-location of players and then does a comparison of the location-based games with the traditional video game experience. The description of the game patterns gave us ideas of the new possibilities in game concept, what changes could be brought in or how can the existing ones be changed.
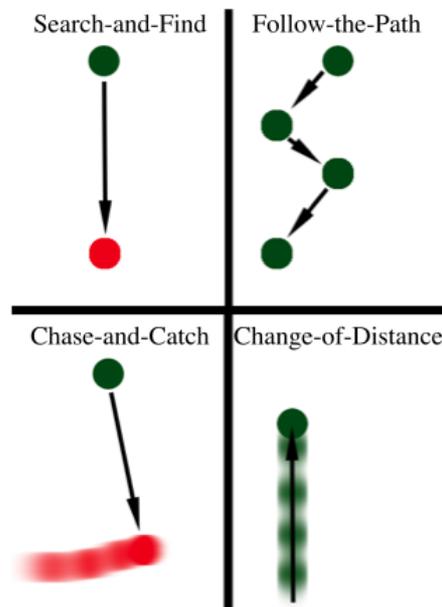
Figure 2.2: Game Patterns: Presented in the work of Lehmann [2012]

The author explains the technologies which are adapted in these location-based games in great detail and also presents the limitations, advantages and certain good practices associated with their usage.

To better understand the nuances of iterative approaches to design, testing and redesign we looked to the work of Reid et al. [2008]. The authors presented a game called PRIS-ONER ESCAPE FROM THE TOWER which uses GPS, active RF transmitters and receivers etc. to trigger certain events. The interactions happened in a particular location such as a tower and also involved certain actors playing the role of the guards in that tower called Beefeaters. Their work

made us realise how testing on-site gives a better under-
standing of the inter-working of GPS and audio feedback.
We realised that it is important to have certain key points
of interest such as locations in the game design itself, so
as to make the game more appealing and interesting to the
users. It was equally important to give different roles to
these points of interest.

From the work of Reid [2008] we realised the importance of
how to design for coincidence, how to incorporate certain
artefacts like props on the field to make game captivating
for the players. We learnt that one must observe certain
natural phenomenon and people around involved in it and
design the game to coincide the real world event with cer-
tain in-game actions. This would give the location a whole
new meaning. We understood that choosing a location for
the game based on size, duration of the game and infras-
tructure available for the game location is extremely critical
in associating the events in real world to the game. We got
the idea of designing the storyline from this work.

Importance of
choosing a location

The location-based software platform presented by Reid
et al. [2006] gives us the insight that rapidly iterating
through several design choices could make the game more
fun despite the erratic behaviour of the GPS. Their work
implied that the participants get divided into two groups -
those that wish to have more control in the game and those
that wish to just enjoy the game. The pause and resume
interaction of play so that GPS accurately records position
made us more aware of the nuances of how to work around
the issues with GPS. Their work emphasized on repeatable
story based content which we have incorporated in our sto-
ryline of the game.

Existing games with
GPS

The triggering of the idea of shifting the location of the
game was provided through the work of Benford et al.
[2005]. The game called LIFE ON THE EDGE which they de-
signed involved a virtual encounter between the animals
on the Savannah which was played in an open field by
group of children. There were certain location-based trig-
gers in the game, so that a player being in the same spa-
tial location could share information and act together. This
gave us the idea of designing the game in an open field,

Idea for an open field
location

to test and understand the movement patterns there. The sharing of information on a common platform which was designed in their game gave us the idea to build different new forms of communication between the players. The players in the game possessed roles based on the area of influence and those roles were triggered when the player was within a certain bounded location and hence leading to a particular type of group interaction. This had an influence on our work, on how we wanted to design a quest with a player who could posses such a particular role within a region of influence to control the course of the quest.

Idea for region of influence role for player

The work of Reid et al. [2005] goes which into detail on immersion of players based on quantitative and qualitative feedback can thus be useful in understanding how much better an overall gaming experience can be made. They presented how the different stages of immersion identified in video gaming experiences could be applied to location-based gaming experiences. They emphasized the importance of getting player more involved. The authors pointed out that players' immersion in the game will only be for a short while, with their attention switching between being predominantly in the real world to the digital world they are playing the game in. This has an impact on the safety aspect of the game with respect to the environment it is designed for.

Immersion of player in game

2.1.2   Role Play Games

The work of Björk [2008] explains that when researchers build a system they focus on the artefacts that encode rules and procedure, then the people who uses the artefacts and then on the interactions or the activities that the people engage in while using game artefacts. All the above translates to the game concepts like games, gamers, and gaming respectively. From this paper we understood how to properly distinguish these aspects of game development.

Game development aspects

The pervasive role-play game relates to playing a game in an environment, having tangible, unaltered experience of being part of complete and physical world of fiction. The

work by Montola [2007] goes into great lengths about pervasive role-play games. Pervasive games combine many of the features of the previous game styles with itself. And the fact is pervasive games has an essence of realism built into it. From this we could relate to the work of Reid [2008] to realise the importance of storyline and having appealing aesthetics.

Pervasive role-play games

Development of ubiquitous games will result in high level of sociability, usability, aesthetics and ease of use of the game design and this would benefit ubiquitous computing. A new type of game design where players' physical and social context influences the game play to create new style of computer entertainment. These are some of things that Björk et al. [2002] work emphasized on. They also discussed about existing computer game under the genre of networked gaming, mobile gaming and location-based gaming. This gave us a better understanding of how location-based games are having an impact on ubiquitous computing.

Location-based games influence ubiquitous computing

2.1.3   Game Design and Mechanics

The work of Reid et al. [2004] explained the design implication for spontaneous, network, sound-based game called FANCY A SCHMINK. They explained about designing an exciting game in a public space. Owing to the fact that our game would also be made in a public space this paper made us dig deeper into how the game concept and mechanics must be altered. The value of audio feedback which was emphasized in this paper made us introspect on our game design aspect.

Designing games for public spaces

From the work of Lundgren and Bjork [2003] we better understood the categorisation of location-based games. The game mechanics that could be involved like superimposed game world, allowed us to identify, design and analyse the design space of games which make use of sensors, novel output devices and other non PC computer technologies. The paper explains about the new types of games which are created using embedded computing, sensors, output de-

Game Mechanics clarified

vices, ad-hoc wireless networks and all the while maintaining the characteristic of the traditional non-computerized games.

2.1.4 Understanding Proxemics

Understanding
Proxemics theory

Proxemics interactions foresee interactive computer systems and it incorporates peoples' and devices' spatial relations to give a more natural interaction with ubiquitous technology. The paper by Marquardt and Greenberg [2012] identifies the different aspect of Proxemics theory like distance, movement, identity, location and orientation and throws light on the relevance of personal space for ubiquitous computer design.
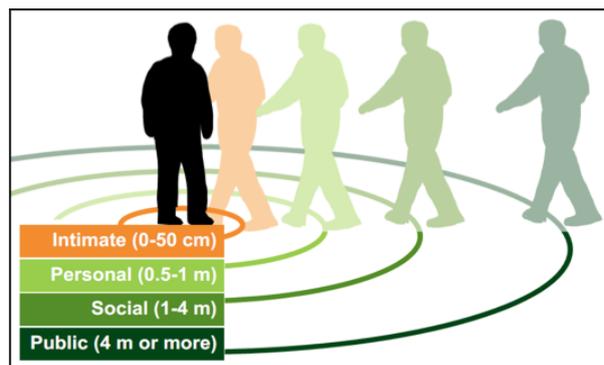
Figure 2.3: Hall's Proxemics Zones: Presented in the work of Marquardt and Greenberg [2012]

In above paper the explanation about the Hall's proxemics zones[5] gave us a better understanding of how grouping could occur during a game session and what kind of observations can be noted from this sort of behaviour. The proxemics zone made us aware of what kind of communication could happen and how that could be better captured in the devices.

There was an experiment conducted by Llobera et al. [2010] to better understand Proxemics theory. Here virtual characters representing people in a virtual world approached

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[5]http://en.wikipedia.org/wiki/Proxemics

the testers and the physiological arousal of the testers were noted in the experiment. The experiment was done based on multiple visits of those characters, the distance of their approach, type of characters, number of characters and the check of validity of those types of characters visited. This give us an insight into carefully planning the user studies. It also made us more prepared on the possible behaviour the participants might exhibit in a social interactions scenario and thus prepared us on how to go about with analysis of such data.

How social-interactions happen in a game

To come up with an unique way to visualize movement data is quite challenging. Most visualizations are usually very cluttered and confusing. The authors Crnovrsanin et al. [2009] present an excellent approach of proximity-based visualization of movement data. Here the distance is computed between an object in motion and a certain stationary point of interest and plotted against time. It is possible to combine several plots together and give them context based on what event is occurring. One could interpret movement patterns and common trends in movements in a group from these plots.

Proximity-based data visualization
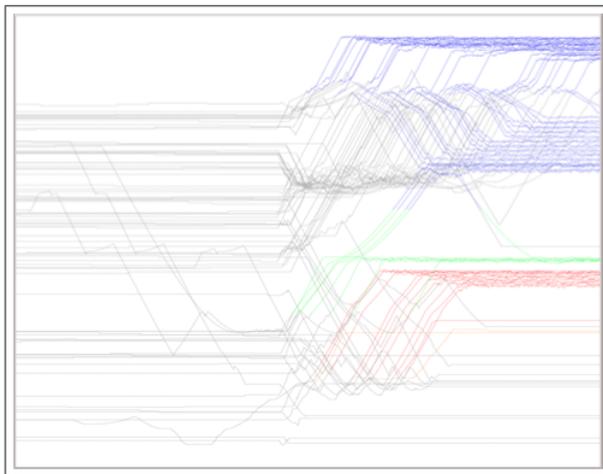
Figure 2.4: Proximity-based Plot: Presented in the work of Crnovrsanin et al. [2009]

We will be using this type of visualization to present the movement data for each of the quests. The points of interests against which the movement data is measured would

be specific to the quest. Therefore we will be able to draw contextual meaning from them.

2.2   Influences on Current Work

Summarising the impact on our work

We have mentioned how the various papers and articles that had an impact in shaping our work. The following ideas like changing the location of the game, game set up in an open field, having role based characters, having special points of interest, the importance of storyline to grasp players' attention, the importance of on-site testing, how to visualize movement data, how to understand various game patterns and social behaviour to design the game, etc. influenced our work.

Patterns in location-based games

The work by Will [2013] had a profound impact on the approach we took to create the new quest and design alteration in the existing game. The author has put together the common patterns in designing of a location-based game, thus helping designer and programmers alike in deploying these patterns while developing a game therefore avoiding unnecessary reinventing of the wheel. The patterns *Design for Coincidence*, *Co-located players*, *Location Granularity*, *Reachable Location*, *Exploration central to Game*, *Minimize Social Awkwardness*, *Communications Channels*, *Ephemeral Magic Circle* and *Network Infrastructure* influenced us in perceiving how a game could be better designed and thus improving the overall experience of the game.

Chapter 3

Game Design

We will first identify the audience for whom the prototype is made and emphasize on the goals of this research. Then we will describe the game concept for the existing quests and also explain the new game concept that will make up the new quest which will be added in the prototype. We will also be describing how we arrived at the storyline and what the storyline itself is.

3.1 Target Users

Similar to the works of [Huch, 2013, p. 24], the users which were targeted for the iterative user-centred design process were those who have basic understanding of touch interfaces, who are flexible with their timings when it comes to participating in the studies, who are willing to coordinate in small groups of four and know how to use smart phones. The users might be required to go a predetermined location in the game a number of times. The game session could last around one hour and these quests must be engaging, stimulating, should encourage social interaction and all in all it must be fun. In addition, owing to the game being played in an open field or park the participants must be ready for reschedule in case of weather related issues.

Knowing the
participants

3.2   Aim of this Research

In Huch [2013] they were able to address certain key questions like how to determine movement patterns in a location-based game, what forms of communication amongst the players is necessary, how can a cost-efficient prototype be developed, how far are players willing to move away from each other during a quest, how can movement data be better visualized and are there any actions which could lead to social awkwardness.

In this research, we plan to find answers to all of the following additional possibilities:

Distinguish quest-wise movement patterns
> Could it be possible to distinguish movement patterns between two different kinds of quest? Could we come up with a mathematical procedure or set of transformations to be able to classify the data sets separately?

Reduce confounding variables
> Could it be possible to reduce or eliminate the confounding variable like the narrowness of the streets in city centre, obstruction in the streets, etc. all of which are restricting or constricting the movement patterns?

Game played in open field

Goals of this research

> Design the game for open field or park and the change the technology used for the points of interest to improve the game play. This will allow us to correlate all the quests as they are played under similar circumstances.

New type of location-based game
> Could a new type location-based game be designed to add to the existing quests?

Freedom of transfer
> Allowing the players to transfer game elements between each other at any point of time rather than requiring them to gather together. This will allow unconstrained movement patterns.

Correlation between strategies and game elements
Could there be any correlation between different strategies that different groups adopt for any given quest to any of the game elements like number of transfer of scrolls between players? Could there be a correlation or causal relation between the total distance travelled by all the members and the time taken to complete the quests?

Freedom in communication
Is it possible to create communication systems or provide devices which will enable the participants more unrestricted movements. Could there be improvement in form of communication to make the game more free flowing.

3.3 Addition in Game Concept

Among the existing location-based quests in Huch [2013], the *Archeological Quest* requires the players to make abstract or random movements on the playing field and look for a certain object of interest as they're not easily visible. In this quest the players need to scan the playing field randomly thus in the process reaching these archaeological sites which is of great importance from the perspective of the storyline. While on the other hand the game concept for the *Trading Quest* is that there are a said number of points of interest which are directly visible and approachable on the playing field. The players are supposed to go to these points of interest and perform certain set of actions on their devices. On having successfully completed those actions they are required to abstractly move about to next possible point of interest in order to proceed towards completion of the quest.

Game concept of existing quests in the prototype

Now introducing new type location-based quest, in which the players have a possible range or region of influence within which they can protect a certain number of points of interest. The range of influence is something which the players can use only when they are in the vicinity of several of these points of interest simultaneously. This does

Idea behind the new quest

not change in size or strength during the quest. They need to use this range of influence wisely in order to maximize the number of the points of interest which they could protect. Hence the new quest involves player moving about in specific ways to cover a certain region around themselves.

Preventing possible
learning effect

A strong in-game narration will ensure the players are engaged and more connected to the game. This is one of the key things game designers include in their games and this was quite rightly pointed out as a pattern in the work [Will, 2013, p. 103]. The storyline which must be embedded as part of the game will be presented in the following section. Also the storyline is designed keeping in mind the experimental design of between-groups and to prevent possible learning effects during the course of game session. *Learning effect* could happen if the *Archeological Quest* is made to be played after the new quest, this is because the various points of interest like sites in the *Archeological Quest* even though they are not directly visible but in the course of playing the new quest will become aware of their positions. Hence this situation would tamper the results of the experiment. Therefore the *Archeological Quest* is placed before the new quest and followed by *Trading Quest*.

3.3.1   Storyline for the Game

Story behind *Lost
Recipe* quest

The story begins in a park a little outside of Aachen centre and the king *Charlemagne* himself addresses the gathering of four brave warriors. The king requests the warriors to help him as it is of the at-most importance that the Archduke be saved. It is unfortunate that an Archduke is seriously injured in battle and to help him quickly recover there is a need for certain special commodities from the East. But the scroll that has the recipe to mix these commodities to make the medicine has gone missing. The king's spies have found out that some outlaws have stolen this recipe and torn it into ten pieces and hidden away in different locations all around the park. The aim of the warriors is to find these ten scroll pieces and they must be very careful while digging as the scroll piece could get damaged. During their quest the warriors must hand in all the scrolls to either one

of them and they will keep these scrolls in a safe inventory. The warriors can only see these sites which they have discovered but once they do reach a site which is already discovered they might see it empty if that site is already dug or if its not dug yet they can still dig it.

On having completed this quest the warriors are required to return back to the king, where they will be appreciated for their efforts. The king asks the warriors for their help in the next task, which involves saving as many peasants as possible. The peasants are the working class of the society and they help build and improve the well being of others in the kingdom. The least the king could do for them is to secure their families and homes. The king establishes this by sending along his best guards along with the warriors who will serve and protect these peasants from dangers like kidnapping, murder, etc. The guards are only capable of safe guarding the peasants and their families who are under the guards' direct influence that is they are in the sight of vision of the guards. Thus to make sure maximum number of the peasants are saved the warriors' duty is to place the guard at the perfect location in the park. The warriors would not be able to see where their compatriots have placed the guards, but certainly can ask the peasants if they feel safe or not.

Build up to the *Save Peasants* quest

Meanwhile the king has asked an assistant to put the pieces of the scrolls together to decipher the recipe for the making the medicine which can heal the Archduke. The warriors on having accomplished their task return back to the king in expectation of a big price and they are greeted with high accolades but the big price has to wait as they are sent on their final quest. The assistant having deciphered the scrolls informs the king that to make the medicine there are three key ingredients which are required namely herb, mushroom and opium. The king advises the warriors to go the local market which is on the park and they are given a sack of skins and wheat to begin their trading. The warriors are required to trade multiple times with multiple shop owners as per the medieval barter rules in order to obtain the above mentioned goods. The warriors are allowed to trade between each other directly with the goods in their inventories. To finish their quest all the above mentioned

The importance of *Trade and Commerce* quest

goods must be with one warrior in their inventory. Thus on having traded and found those precious goods the warrior should return to the king where they have a heroic welcome and given a hefty price for their efforts. Then with the goods the medicine is made and thus the Archduke is saved.

Chapter 4

Completion of the Game

In this chapter we will be dealing with design iteration for the new quest that is added and the additional features which will be incorporated into the software prototype. We shall also be discussing about how the location of the user study was finally chosen.

4.1 Low Fidelity Prototype

In the new prototype "mLog2" the *Archeological Quest* and *Trading Quest* are retained and renamed as *Lost Recipe* and *Trade and Commerce* respectively. As the rework is only on the technology side of these quests, there is no need to iterate through the user-centred design as there are not any significant changes in graphical user interface (GUI). Here we are only designing paper prototypes for the new quest and then based on user input, changes are made in the paper prototypes and correspondingly the new GUIs are implemented.

Renaming exiting quests

4.1.1 Paper Prototype for New Quest

We have decided to call the new location-based quest *Save Peasants* and this requires the players to cover a certain re-

gion around themselves. We are following the user-centred iterative design and have made the low fidelity paper prototypes. The paper prototypes were prepared with the image editor tools like pixlr[1]. The images used or combined in the paper prototypes are all obtained via an internet search on Creative Commons. On testing the paper prototypes with users there were certain suggestions made. Here we are only summarising the changes that will be made.

Making of the low-fidelity prototype
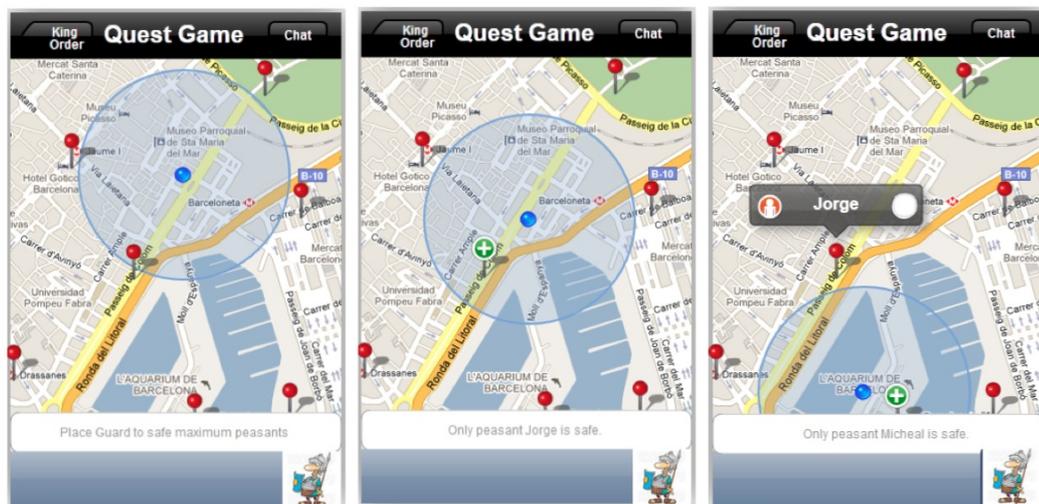
Figure 4.1: (a) Quest begins, no Peasants are safe (b) Player within a Peasant's safe zone (c) Status of a Peasant outside safe zone checked

UI consistency

There must be a text hint to indicating completion of players' quest in the figure 4.3(b). In all images there must be a consistency in the labelling of all the buttons.

Peasant status

User-centred design

On seeing the figure 4.1(c), it was pointed out to add information if a peasant is secure or not in the annotation and to change the colour of the peasant image according to the proximity of player to the peasant.

Default GPS behaviour

The blue region around the player which is representing the area of influence of the player could be mis-

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[1]http://pixlr.com/editor/

Figure 4.2: (a) About to place the Guard (b) Player can still reposition Guard (c) Two Peasants are in safe zone

leading with the default setting of GPS-tracker on the iPhone hence a decision was taken to drop the indication of region of influence around the player.
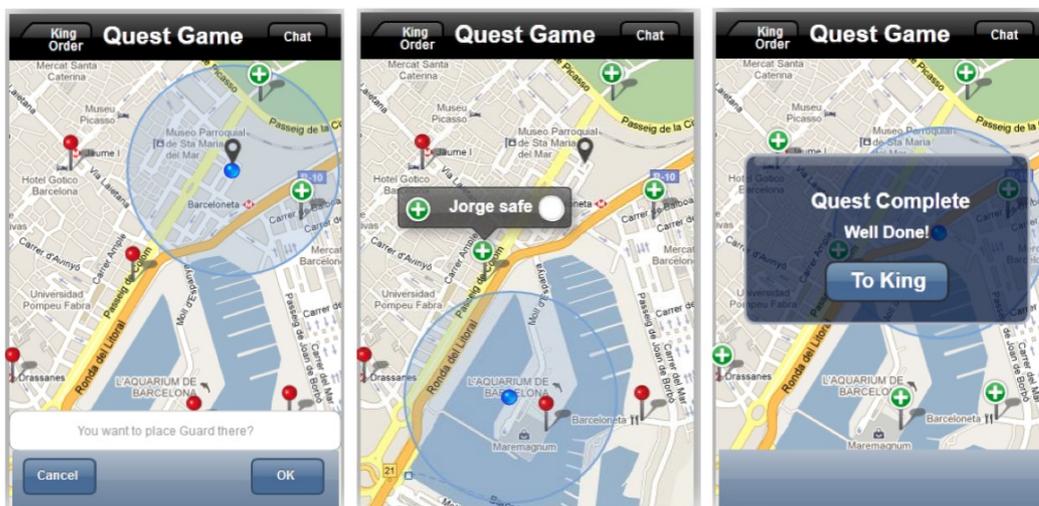
Figure 4.3: (a) Repositioning Guard (b) Status of a Peasant saved by other player checked (c) All Peasants safe

Several peasant regions

It was suggested to have lots of regions or groups of

peasants in the game just to ensure that game can be finished. In the case when some of the players decide to save peasants among two separate regions together, in the case when certain regions are so designed that the peasants aren't near enough to be saved simultaneously while in other regions they are closer together and thus the player needs to find such a *sweet spot* themselves to save these peasants simultaneously.

4.2   New Features for the Game

Following subsections will discuss about the new features and design changes which were needed for the existing game that will make up the new prototype.

4.2.1   Usage of iBeacons

Initial intended usage
of iBeacons

The iBeacon™ was designed by Apple Inc. and is intended to be used for indoor proximity tracking. In our work the beacons were originally intended to play role of the fixed positions of the peasants in the *Save Peasants* quest, in other words the beacons represent the peasants on the playing field and iPhone on approaching these points of interest will receive push notification depending on the proximity of the iPhone from them. This would mean that a player who is at similar proximities from more than one peasant can then safe guard them using the placing guard functionality. We started to introspect if the players' mental model of the quest, would match the expectations that we have set out as the game concept for this quest. We figured as players have to encompass these multiple points of interests simultaneously, the players will miss this game concept as they can see many of these points of interests physically on the field but in the game they have the power to save only a few. And the inaccuracy in GPS might position them incorrectly on the field thus confusing themselves with what they see on the field to what they see in the game. Hence we

decided not to use the beacons to represent the stationary points of interests in the new quest.

While on the other hand the beacons will be used to represents the fixed points in the other two existing quests. The fixed points of interests being *sites* and *shops* corresponding to the *Lost Recipe* and *Trade and Commerce* quests respectively. Here the mental model of the players would rightly perceive the game as these positions are independent of each other and do have any binding relation between each other as compared what would have been the case in *Save Peasants* quest. Therefore the technology end of the *Lost Recipe* and *Trade and Commerce* quests will be changed from GPS-based to Bluetooth-based. Using this technology the distance can be ranged into four distinct categories[2] they are *Immediate*, *Near*, *Far* and *Indefinite*. For both the quests the ranges *Immediate* and *Near* must indicate that the participants are closest to those points of interest and therefore corresponding actions like enabling or opening of the *sites* and *shops* can take place. The ranges *Far* and *Indefinite* would mean they are further away from those points of interest thus disabling or closing of the same should take place. Owing to the huge size of the field or park as compared to the points of interest which one has to find in the *Lost Recipe* quest we decided to add a sound feedback in the form of a beeping sound when the players are within the *far* range of the beacons for the *Lost Recipe* quest alone while in the *Trade and Commerce* quest the players can see those points of interest clearly.

Defining the proximity ranges for the quests

4.2.2   Voice based Communication

The users in the feedback form provided by [Huch, 2013, p. 106] suggested to make a seemingly easy communication channel like a walkie-talkie system or a voice messaging system. To design the iPhone to have the capabilities of a walkie-talkie we first looked into the already established audio chat system libraries. And here were a few options

Audio Chat Systems

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[2]http://en.wikipedia.org/wiki/IBeacon#Ranging

which were explored like OpenTok[3], Twilio[4], CeedVocal[5], TeamSpeak[6] and Bluetooth Audio chat. These audio chat systems can be used over WiFi or internet and these systems provided APIs which can be used to build their own audio chat messaging system. With each of these audio chat systems we worked towards executing their samples, using their public APIs to add the audio chat functionality to our code base and testing them thoroughly. The following are our findings for each of these systems which we explored.

OpenTok consumes high bandwidth

The OpenTok system v2.1 is what we tried to integrate with our prototype. The samples themselves are very well documented, easy to explore and understand. The prototype was relatively slow, not echo free and consumed a lot of bandwidth. There were also certain defects like video stream must be used even when we only required audio. Due to all these reasons we had to move on to another type of audio chat system.

Twilio is an expensive solution

Twilio system allows making of phone calls between the connections which the mobile is set up with in their cloud base. To do so this would require one to call a particular number via their APIs which isn't toll free. And this was turning out to be a very expensive solution to our voice based communication system, as during the testing and game sessions we would end up doing a huge number of calls. On testing the samples, we found out that the voice messaging did not take up that much of the bandwidth but the integration of code with our prototype was not easy due to API issues and version compatibility issues. Thus we had to abandon this option and move on.

Testing CeedVocal

We tried to test the CeedVocal system as it gives the option of speech recognition and speech to text conversion. Then on migrating to the newer version of iOS we were able to use the features of Siri, as it is capable of doing speech to text conversions for a given text field. So we decided to stop exploring CeedVocal.

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[3]http://tokbox.com/opentok/
[4]https://www.twilio.com/voice/api
[5]http://www.creaceed.com/ceedvocal
[6]http://www.teamspeak.com/

TeamSpeak software is a very established system for audio chat system and the SDK is freely available. The set up required a separate server base to which all the clients need to integrate but this could not be directly integrated with our prototype and had to developed separately. But this was not an easy system to create within the stipulated time as it seemed like creating the audio chat system from scratch. Therefore we decided not to go with this system.

Development with TeamSpeak SDK

The Bluetooth Audio Chat system was a free app. This was a good option owing to good performance, one could get into an on-line groups and start the audio chatting. But while playing the game one would have to switch between this app and our prototype to be able to select the group and player with whom one wants to chat. The Bluetooth range being very short it was not playable on a big park or field. Similarly chat systems using internet were also experimented but again the problem with switching between the apps in order to communicate was not suitable.

Testing with Audio Chat Apps

Having decided that none are appropriate to go ahead as our audio chat system, we decided to build our own audio chat system. This was done by recording the voice for a certain given period of time and then uploading it using the existing APIs provided by CouchDB. When the server updates then it is broadcast the newly uploaded voice recording to all the clients. On the clients the voice recording are played immediately. These voice messages can be replayed by click on each individual voice message and they will be displayed along with the text messaging under the Chat functionality. In the iOS 7.x onwards all text fields are capable of using *Siri* for speech to text conversion and we have enabled this functionality.

New voice messaging system using CouchDB

4.2.3   Design Alteration for Existing Game

Cognitive Walk-through based changes

We decided to do the cognitive walk-through[7] of the prototype "mLog", then some of following changes were needed

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[7]http://en.wikipedia.org/wiki/Cognitive_walkthrough

Cognitive
walk-through based
changes

in the design of the prototype. We needed to change the type of the Google maps so as to give the players a sense of context with respect to their surrounding. We were required to provide the game in both English and German. The other quests *Puzzle Solver* and *Mixing* had to be removed from the code base as the new prototype was purely location-based quests only.

Order of quests and
UI Consistency

Fixing the order of the quests which would be loaded as the game began and progress was important issue to be addressed. The players should not be allowed to select any quest to begin with as the storyline and the quest being played must be cohesive just giving a sense of connection for the player with game. All the screens in the game were set to be shown in full screen mode. It was necessary to mark clear exit points in all the screens and thus bring a sense of consistency in the UI and functionality for all the screens. There were changes in code necessary to ensure that the *Chat* link is consistently accessible from all the screens.

CouchDB related
issues and
functionality fixes

And also the player instances were getting added multiple times in the CouchDB on restarting the game. There were changes introduced in the code to avoid this scenario. In the *Archeological Quest* if a player wants to send a fragment or scroll piece to another player, the player to whom the scroll needs to be sent does not appear on the screen. This issue needed to be addressed with high priority. Also it was necessary to prevent sending of these scroll pieces back to oneself. There were changes made to the UI strings as they were causing CouchDB related errors.

Suggestions from User Feedback

Feedback on
discovery of sites
and shops

Under the user comments section [Huch, 2013, p. 105], a suggestion was made to alert the discovery of a *site* or *shop* through a phone vibrate as many a times the player said they missed the spot where the *sites* or *shops* were, thus informing players of such a discovery even when they are walking around. The positioning of the contents of *Inventory* in the *Trading Quest* must begin from left-most position therefore giving an impression that there are more items or goods to scroll through in the inventory.

It was pointed out that players might not be aware of what each of the icons in the *Trading Quest* mean. Thus in the new *Trade and Commerce* quest on clicking on the goods icons either in their inventory or in the shop owners' inventory the players are informed about which goods have been selected through the contents in the text area. For the *Lost Recipe* quest we decided to add five more scroll pieces to the existing five scroll pieces to make the quest more involving and exciting. This was also one of the suggestions by the users. An user suggested to add another location-based task which is more on the lines of a strategic game. And on very similar lines the new quest *Save Peasants* was added.

Identifying game elements and new strategy quest

Migration of iOS on the iPhone

Migration related changes had to be taken into consideration as the iOS version on iPhone was changed from 6.1 to 7.0 and then to iOS 7.1.1. The annotations representing all the fixed points of interest in *Lost Recipe* quest did not appear on loading the game, so that had to be addressed. The alignment of certain UI components were altered and this had to be addressed. The fonts used to represent all written text had to be changed, thus the font style had to be explicitly written wherever there were written text being used. The *disabled* type button is used on the inventory screens to present game elements are transferred to other player like the *scroll pieces* and *goods* in the *Lost Recipe* and *Trade and Commerce* quests correspondingly and this had to be fixed. It was important to note that "Legal" link at the bottom-left corner of the map must be retained and based on that UI changes were made.

Map annotation changes and font-style related issues

4.3   Location of the Game

As one of the aims of this research is to design the game for a location like an open field or park, we needed to first find such a location. We went scouting to examine all the possible parks and open fields which we had discovered by searching on the internet of the areas in the vicinity of the Aachen city. We fixed these criteria to choose a location:

Searching for an open field

1. Size of the area where the game will be held

2. Check how is the terrain: flat, hilly or has slopes

Criteria to select
location

3. What kind of surface will the participants walk on and will it be an issue in bad weather days

4. How accessible is that location

5. Is that location available to use or one must take special permission

Park selected

Based on these criteria the fields which were accessible, met most of the criteria but we were not able to contact the owner to get permission to use those fields, so this forced us to leave out those options. There were couple of locations which were wide and flat enough but they were not available in the period when we were playing to have the studies. Finally we narrowed down to these parks *Kennedy Park* and the park between Kirchratherstrasse and Pariserring in Aachen given by these coordinates (50.774061, 6.051898). Given the fact that the *Kennedy Park* is much wider we initially chose this location to host the game.

Chapter 5

Final Implementation

Here we will be presenting how the game design comes to life. This chapter would be covering the final form of the GUIs, the software architecture and changes to the server model.

5.1 Hardware Used

In our system we have used four Apple iPhone 4S running on iOS 7.1.1. The home button was not prevented or hidden despite the charger casing which we used during the user testing. The devices were identifiable as an original iPhone. We are making use of the good features that were implemented in Huch [2013] work, like the use of location-awareness capabilities of the device obtained through *CoreLocation*. We planned to introduce another form of communication along with voice and text based systems by providing the participants with walkie-talkies.

Devices and hardware used

5.2 Graphical User Interface

The design changes that were required for the existing prototype have been mentioned under the section 4.2.3 and

these changes have been incorporated in the implementation phase. In the following sections we will be describing about the final form of the graphical user interface (GUI). At this point one must note that the artworks used to increase the level of immersion and have a better overall gaming experience were already created for "mLog". The high quality artwork was made by a professional graphics artist Sigrid Riese[1]. The graphics for all icons, symbols, portraits of the shop owners in the game were made by the artist. These artworks were retained in the making of the new prototype. We will be changing the location of the study and this has been explained in section 4.3. The positions of *sites* and *shops* are altered according to these images shown in the figure A.2. From the work of Huch [2013] we are retaining the code bases which will be explained in this section 5.3. We would be retaining the packages pertaining to *abstract UI*, *UI Elements*, *Chat function*, *Back end*, *General Function*, *Archeology Game* and *Trading Game* classes. We have mentioned in the section 4.2.3 that the UI strings have been translated into both English and German.

New prototype built upon existing work

5.2.1   The 'King Orders' Screen

The *King Orders* is the introductory screen of the game. The text area below the image narrates the story. The storyline is a direct request from the king to the participants in the game. Once the players have read the story they can press the *Done* button at the bottom of the image seen in the figure 5.1(a). This introductory screen updates based on the progress the group makes in the game together, in other words if a quest is completed then on all the devices this introductory screen informs about the completion of that quest and continue with storyline as mentioned in section 3.3.1. If a participant decided to go back to the king while playing a given quest, then the text area reads a shorter version of the king's request.

Storyline screen

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[1]Homepage: http://www.sigrid-riese.de
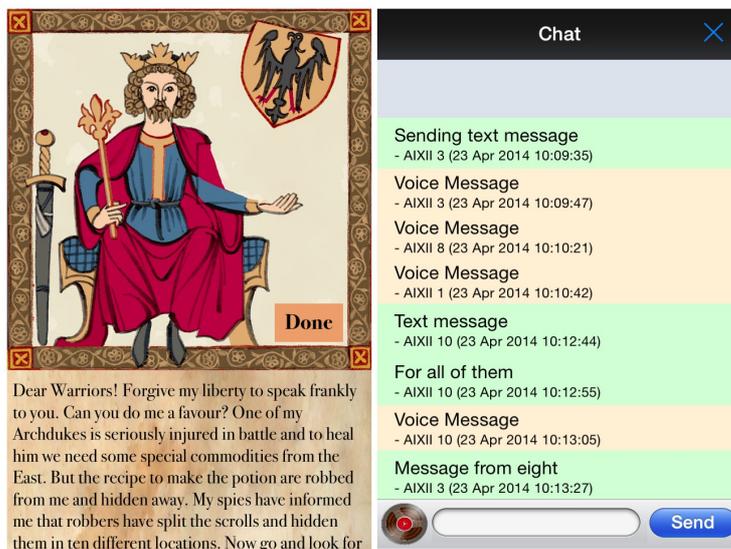
Figure 5.1: (a) Storyline Screen at beginning of game (b) Chat Screen

5.2.2   The Chat Screens

The chat screen maintains the similar interface from the work of [Huch, 2013, p. 54]. This is designed to be a standard interface for a messaging app provided on iOS. The upper portion contains the list of messages which have been received till now and they are sorted in chronological order that is the top most message is the oldest. Now with the addition of voice messages the messages are colour coded. Text messages have a pale green colour as background while pale orange is the colour code for the voice messages seen in the figure 5.1(b).

Centre of all in-game communication

At the bottom of the screen there are three UI elements namely an image which looks like a recording spool, text field and a button labelled *Send*. On selecting the text field with touch gesture, a keyboard to type the text pops up from the bottom of the screen as shown in 5.2(a). Once the player types a message and presses the *Send* button then the list above is updated and this message is sent to the server. All the other clients pick up this message from server and a notification is displayed to alert participants of a new incoming message which is seen as a banner on the top of

Text based messaging with and without Siri
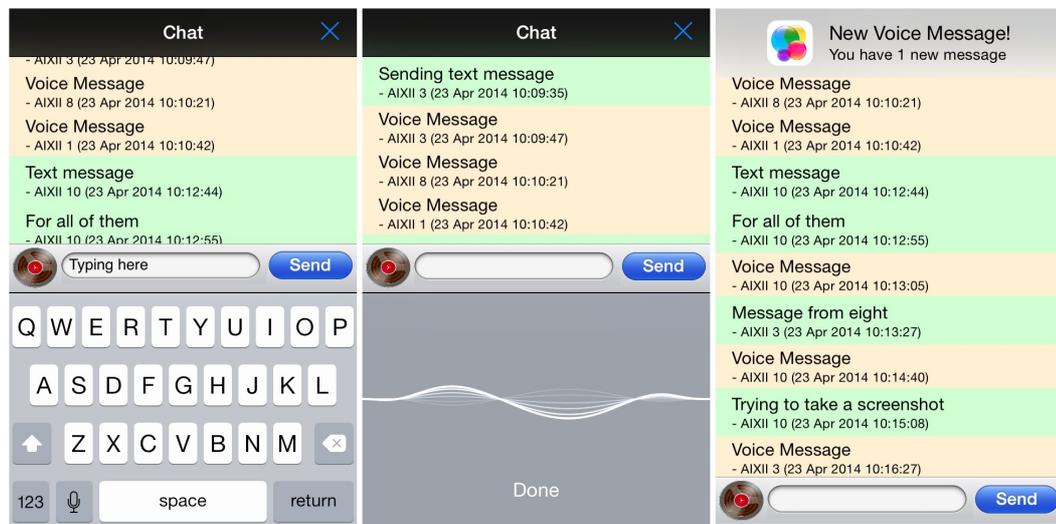
Figure 5.2: (a) Text Messaging (b) Text Messaging with Siri (c) Voice message being received

any screen. The banner disappears after a time out of three seconds. Touching on the text field if the player chooses to press the microphone image which is on the left side of the space bar then a screen seen in the figure 5.2(b) will appear. Here one must speak and on pressing the *Done* link at the bottom of the screen, *Siri* will do a conversion of speech to text. This will appear in the text field which the player can choose to send.

Voice Messaging

Voice recording and messaging

The voice based messaging has been implemented based on the framework the text messaging was designed. This was intended so as to not change the mental model of the players when they choose to switch between the two functionalities. At the bottom of the screen 5.2(c) on the left side next to the text field is an image of a recording spool. The players are required to press this to begin the period of recording. Once they have recorded what they wanted to say, then the player is required to press the *Send* button. This is updated in the chat list with a voice message and once the audio has been uploaded onto the server, it will be updated to all the clients simultaneously and once the audio has been downloaded on the clients it will automati-

cally play. There is a visual clue informing the players that there a new incoming voice message in the form of a banner notification. The players can also go back to the chat screen and press any voice message that they want replay. It is recommended that the players record about ten seconds long audio messages for best performance given that the network connectivity being used on the device is 3G. This feature mimics the functionality of a walkie-talkie.
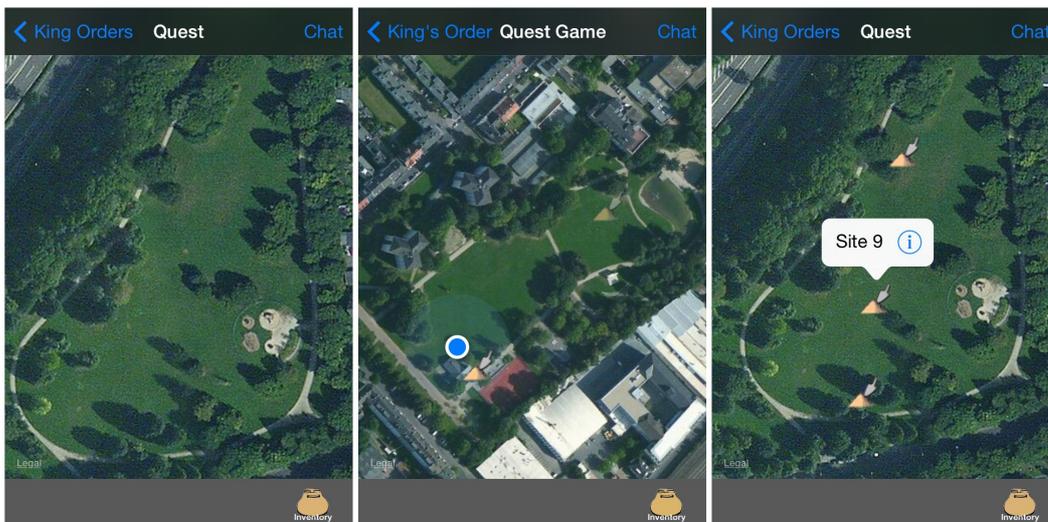
Figure 5.3: (a) Home screen visible at beginning of quest (b) When a site is discovered (c) Pop-up on pressing on a site

5.2.3   Lost Recipe Quest

Home Screen of Quest

The *Lost Recipe* quest begins with the screen seen in the figure 5.3(a). The top navigation has links to go back to the *King Orders* on the left side and *Chat* screen on the right side. On pressing the *King Orders* the player goes to the following screen in the figure 5.1(a) and on pressing the *Chat* link the player goes to screen in the figure 5.1(b). The position of the link to the inventory screen had to moved to the bottom-right corner on the bottom navigation bar and the reason has been explained in the section 4.2.3. The centre portion of the screen shows the satellite type Google

Screen showing all the sites in form of annotations

map which players can freely navigate and zoom in and out using touch gestures. When this quest begins the map is empty without any annotations. Once a player has discovered a site then that will appear in form an annotation indicated by an image of a *shovel* as shown in 5.3(b) at the location where the site was found. On selecting that annotation an icon pops up seen in the figure 5.3(c). Then on pressing the twistie image the following screen opens up seen in the figure 5.4(a). If the player is beyond the vicinity of the site in the actual location then this annotation of the shovel is partly visible or transparent.
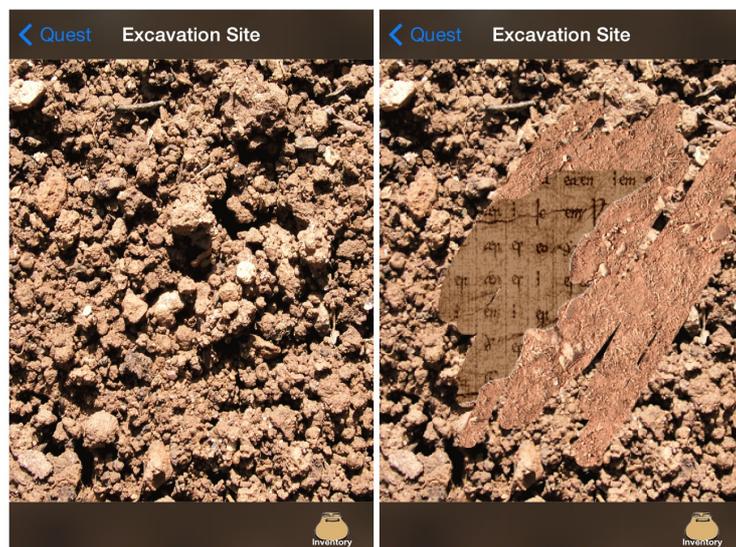
Figure 5.4: (a) One enters site (b) When a part of scroll is visible

Archaeological Site Screen

The design of the archaeological site screen has not changed from the work of [Huch, 2013, p. 55]. The player may go back to the home screen of the quest by pressing on the top left link on the top navigation bar or to to the *Inventory* by pressing the image at the bottom left. The soil or mud image represents the portion of the screen untouched or not dug.
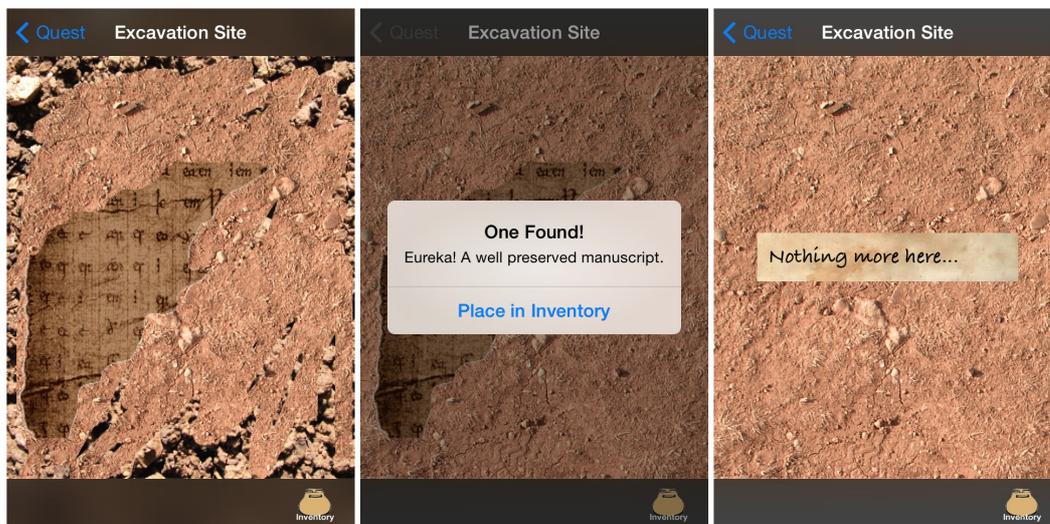
Figure 5.5: (a) The site already dug (b) Found scroll to be placed in *Inventory* (c) Revisiting an already dug site

Thus to excavate the site the player must gently swipe across the screen till about 80% of the area around the scroll is visible. If the swiping is done with lot of force that could damage the screen and also cause the screen to go back to the home screen of the quest. This particular behaviour of swiping could not be prevented as this is the default behaviour of hard swipe to allow return to previous screen in iOS 7.x onwards. On having swiped enough of the soil or mud out to reveal the scroll 5.5(a) then a pop up will appear seen in the figure 5.5(b) informing one about a successful find and prompts one to place the found scroll piece in the *Inventory*. If the player chooses to dig an already completely dug out site then the player sees the following screen seen in the figure 5.5(c).

Digging an archaeological site

Inventory Screen

The design of the archaeological site screen has not changed from the work of [Huch, 2013, p. 56]. There were minor change which have been mentioned in the section 4.2.3. The inventory screen seen in the figure 5.6(a) allows players to see which scrolls they have discovered or they have received from other players and allows them to send these scroll pieces to other players. The upper half of the in-

Transfer of scrolls via inventory

ventory screen gives selectable choices of iPhone names and the bottom half shows a canvas of found scroll pieces. On selecting the player to whom they wish to transfer the scroll, then one must select the scroll at the bottom of the screen. The player must press the *Send* button to transfer that scroll to the player of choice seen in the figure 5.6(b). To exit or cancel the transfer a player may press 'x' button on the left part of bottom navigation bar or the *Inventory* image itself.
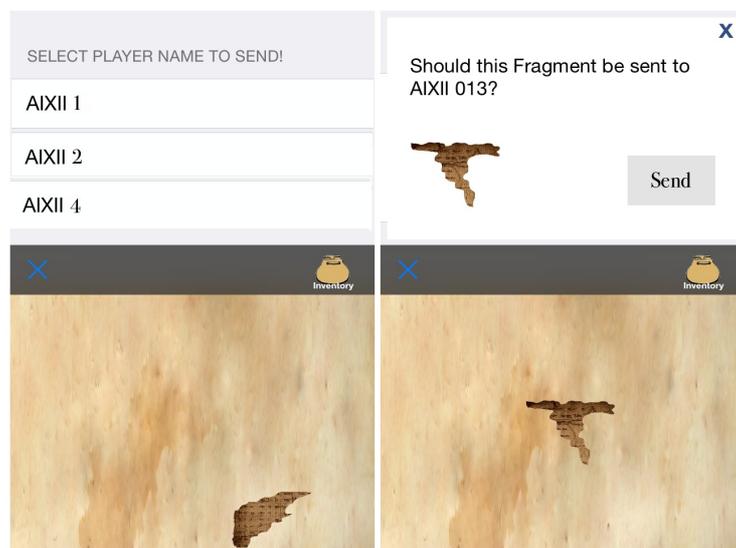
Figure 5.6: (a) Information about players and scrolls found (b) Transferring a scroll to another player

5.2.4   Save Peasants Quest

The quest begins by showing all the peasants and are by default coloured red to indicate they not safe seen in the figure 5.7(a). The centre portion of the screen shows the satellite type Google map which players can freely navigate and zoom in and out using touch gestures. The top navigation has link to go back to the *King Orders* on the left side and *Chat* screen on the right side. On pressing the *King Orders* the player goes to the following screen seen in
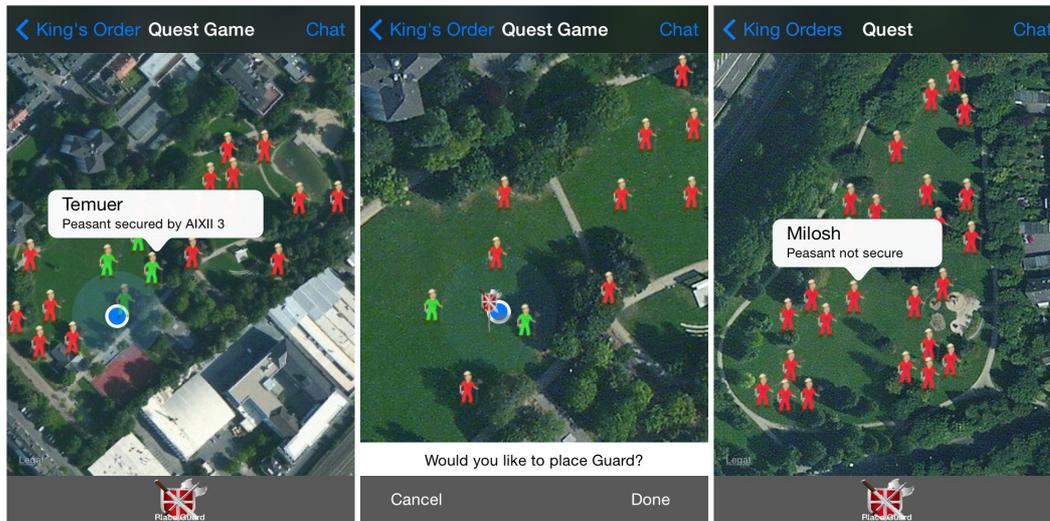
Figure 5.7: (a) Pressing on Peasant for status (b) On placing the guard (c) Having placed a guard

the figure 5.1(a) and on pressing the *Chat* the player goes to screen seen in the figure 5.1(b). One can check the status of the peasants by selecting the peasant as shown in 5.7(a). At the bottom navigation there is a button in the middle called *Place Guard*.

As the aim of this quest is to maximise the number of peasants that can be saved at once, the *Place Guard* button allows them to place the guard to save those peasants. The peasants can be saved only if the player is within the vicinity of a peasant and the peasant changes from default red to green colour seen here 5.7(b). Once one or more peasants has changed to green colour then a player can press *Place Guard* button seen in the figure 5.7(b) and then press *Done* to place the guard at the current position. One can also choose to press *Cancel* button to cancel placing of the guard at that position. The player after having placed a guard can always reposition so as to save more peasants and in order to do so they will have follow the above mentioned procedure again. The player is only given one guard but may reposition it as many times as they want until the maximum number of peasants a guard can be save is met.

How to save peasants

5.2.5   Trade and Commerce Quest
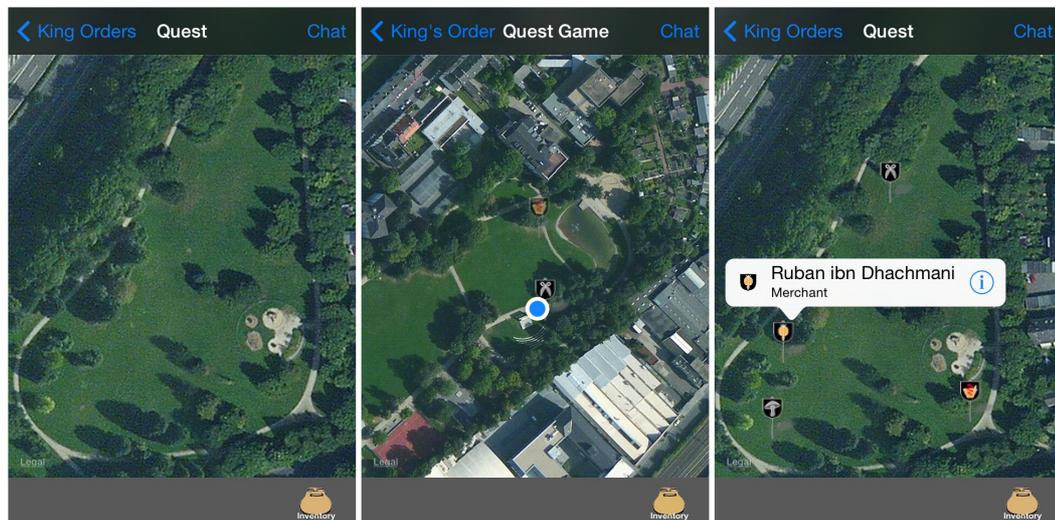
Figure 5.8: (a) Quest is loaded (b) Shop is discovered (c) Pop-up on pressing on a shop

Home Screen of Quest

Screen showing all the shops in form of annotations

The home screen of the *Trade and Commerce* quest is similar to the *Lost Recipe* quest and these were designed with an intent to keep a similar mental model for the users. There are no changes in the design for this screen as compared to work of [Huch, 2013, p. 59]. The top navigation has link to go back to the *King Orders* on the left side and *Chat* screen on the right side. On pressing the *King Orders* the player goes to the following screen seen in the figure 5.1(a) and pressing the *Chat* the player goes to this screen seen in the figure 5.1(b). The position of the link to the inventory screen had to be moved to the bottom-right corner on the bottom navigation bar and the reason has been explained in this section 4.2.3. The centre portion of the screen shows the satellite type Google map which players can freely navigate and zoom in and out using touch gestures. When this quest begins the map is empty without any annotations. Once the player has discovered a shop then corresponding shop annotation with image of that type of shop is displayed as shown in the figure 5.8(b). To enter the shop for trading one must press the annotation and then the pop up appears as shown in the figure 5.8(c) and then one must press the

twistie to enter the shop shown in the figure 5.9(a). If the
player is beyond the vicinity of the shop in the actual loca-
tion, then this icon of the shop is partly visible or transpar-
ent.

Trader's Shop Screen

The screen with top navigation bar allows players to nav-
igate back to the home screen of the quest or go to *Chat*
screen. We intended to put the *Chat* link here as players
would need to find out what goods to trade from each
other. The top portion of the screen shows the portrait of
the trader and also has two selectable buttons representing
the goods the trader has to offer and the number at the top
left corner of those button inform how many of those goods
are still available. The mid section containing the text is
where the player is informed of what the shop owner is
telling. The shop owner greets like seen in this screen in
the figure 5.9(a), or on selecting the trader goods the shop
owner informs about which goods were selected seen in
the figure 5.9(b) and all this information is displayed in the
middle text area. The player may also press the *Inventory*
button at the bottom right, then the inventory with all the
goods the player possess slides up, seen in the figure 5.9(a).

Shop owners screen
to work trade deals
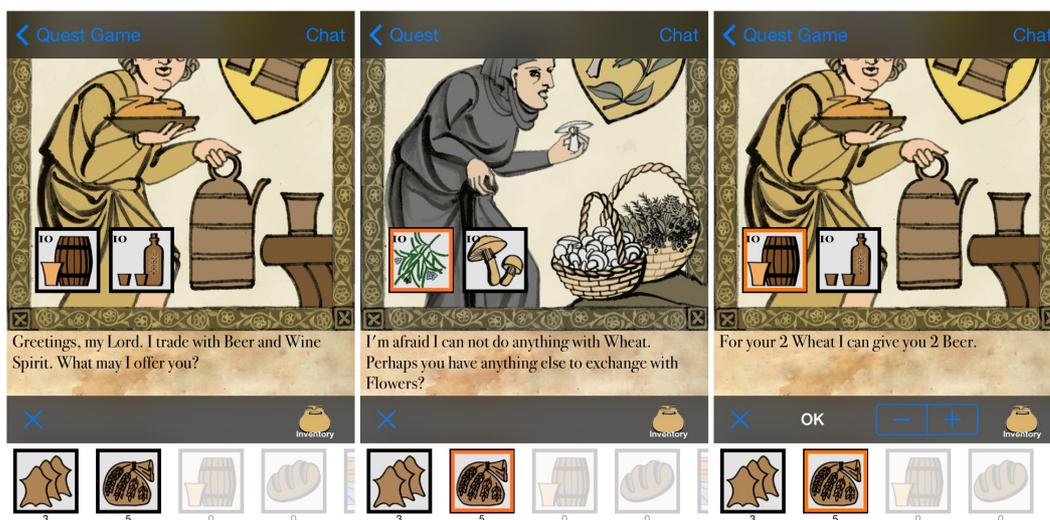
Figure 5.9: (a) Trader Greets (b) Inventory and trader goods selected (c) A deal
works

In the text area one can read what the shop owner informs when the player selects goods the inventory and when the player presses the goods in the shop, as shown in the figure 5.9(b). If the player has selected goods from their inventory and the goods the trader offers then the traders informs if such a deal would work. The game was designed in tone with medieval times Barter[2] system of exchange of goods.

Barter system based trading If the traders agrees to a particular trade that is the deal works as shown in the figure 5.9(c) then the player must choose the quantity of goods to exchange. This can be dealt with by using the '+' and '-' which appear above the inventory. The player can find out the quantity of each of the goods they possess by checking the number under each of the goods in their inventory. On having decided how many goods to exchange then player must press the *OK* button which appears above the inventory. She may decide to cancel the deal and this is possible by pressing 'x' button on the left part of the bottom navigation or the inventory button.

Inventory Screen

The design of the shop screen has not changed from the work of [Huch, 2013, p. 62]. There were minor change which have been mentioned in the section 4.2.3. The inventory screen mainly 5.10(a) allows players to see which goods they have or they have received from other players and enables them to send these goods to other players. The upper half of the inventory screen gives selectable choices of iPhone names of other devices and the bottom half shows a canvas of all the goods that they posses with corresponding quantities in their inventory. The player is

Transferring goods amongst each other required to select the player to whom one wishes to transfer the goods and then must select the goods seen in this bottom of the screen in the figure 5.10(b) in order to transfer the goods. The player can select the quantity of goods using '+' or '-' button in the middle of bottom navigation bar. Then the player must press the *Send* button to transfer those goods to the player of choice. To exit or cancel the transfer, the player may press 'x' button on the left part of bottom navigation bar or the *Inventory* button itself. On completing any quest a victory screen is shown, this screen 5.10(c) is seen on completing the *Save Peasants* quest.

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[2]http://en.wikipedia.org/wiki/Barter
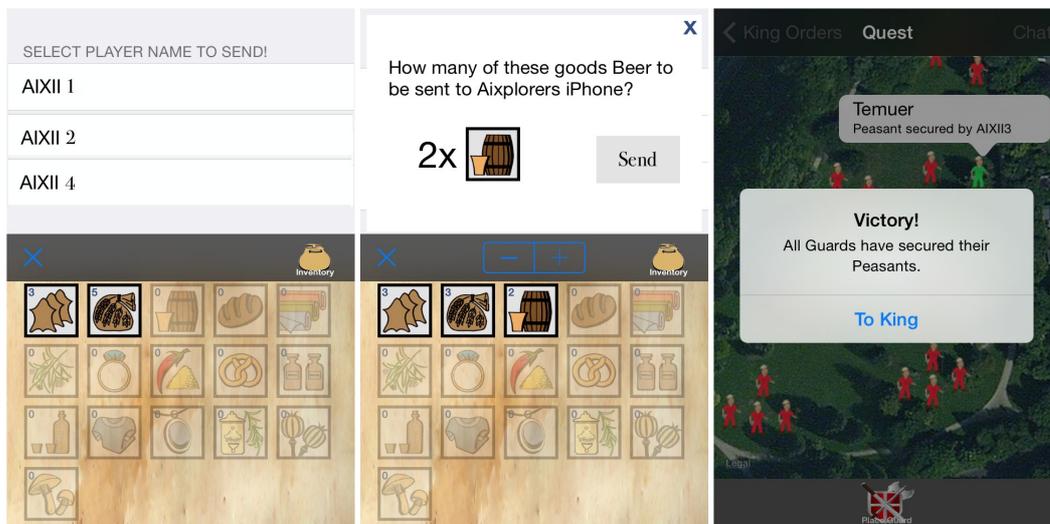
Figure 5.10: (a) Information about players and goods they have (b) Transferring goods to a player (c) Victory Screen on completing *Save Peasant* quest

5.3 Software Architecture of Prototype

Here we will be giving an overview of the existing software implementation and the changes that were made atop it. Some of the classes which are vital to understanding the crux of the software implementation are explained in detail below. The reader must be familiar with Objective-C and basics of the Apple's Foundation Framework. The source code, steps to install the prototype and procedure to set up the game session can be found in Appendix A. The client-side software was developed using Xcode v5.1 as the integrated development environment(IDE), with iOS SDK 7.1 and the deployment target as iOS v5.1.

5.3.1 Server-side Implementation

CouchDB is an open source database which uses JavaScript Object Notation(JSON) to store data. The JSON data can be accessed easily with JavaScript queries. The Apache CouchDB 1.5 was used for all the server-side implementation. The CouchDB is *document-oriented database* that consists of JSON objects. This allows the data to be mod-

CouchDB features

elled and enhanced separately when new information is required. The CouchDB uses a *multi-version concurrency control* (MCC) instead of a locking of the documents. This enables completely new version of the document to be added. The data on CouchDB is stored in form of *views*. A JavaScript function constructs a view called *mapReduce*. The documents are parametrised in a *map* function and returned as a single value. The *reducing* of multiple documents is an optional function.

CAP Theorem and CouchDB implementation

The CouchDB was developed to reduce the latency, which is top priority issue when dealing with unreliable connections. From CAP Theorem[3] it is known that it is not possible for a distributed computer system to guarantee the following properties *consistency*, *availability* and *partition tolerance* at the same time. CouchDB implements the concept of eventual consistency which is that the clients write data to a node in the network without waiting for others to agree. And for distributed consistency the CouchDB uses replication, while in a local scenario it uses MCC. Thus periodically exchanging all documents between all servers. So if a document changes at multiple locations then CouchDB detects the conflict and resolves them. It was an excellent choice of a database made by [Huch, 2013, p. 64] and we are retaining it in this current work.

Views in CouchDB

The CouchDB database namely `game_test` was used to store all the game state, game elements like *players*, *groupmatrix*, *locations* of *sites*, *peasants*, *guards* and *shops*. As we mentioned *views* are used by CouchDB, like "allPlayers", "allExcavations", "allPeasants", "allGuards" and "allTraders" retrieve the data from the server. They were received as a dictionary on the client. For the chat functionalities like text-based messaging and voice-based messaging we used the database namely `chat_test`. Here all the data from the view "allChatMessages" is retrieved from the server. These views can be seen in this image A.1.

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[3]http://en.wikipedia.org/wiki/CAP_theorem

5.3.2 Client-side Implementation

We used the *Couch-Cocoa*[4] framework which is a medium-level API for iOS routines. This framework implements all low-level HTTP and API calls which works with CouchDB type documents and queries. These features are used in implementing the `CouchModel` which are directly accessible and provides document properties as Objective-C objects. The `CouchModel` has objects which are key-value pairs. Hence these can be easily accessed through an URL to the GUI. The image as seen in 5.11, shows an overview of the data model present in the form of different Couchdb documents. An asynchronous save function uploads the changes to the server. To prevent simultaneous saves Huch [2013] had implemented properties that often change in separate couch documents. This was in the case of `CDBLocation` and `CDBGroupMatrix`. The class diagrams are drawn using this website[5].

Framework used and CouchDB documents
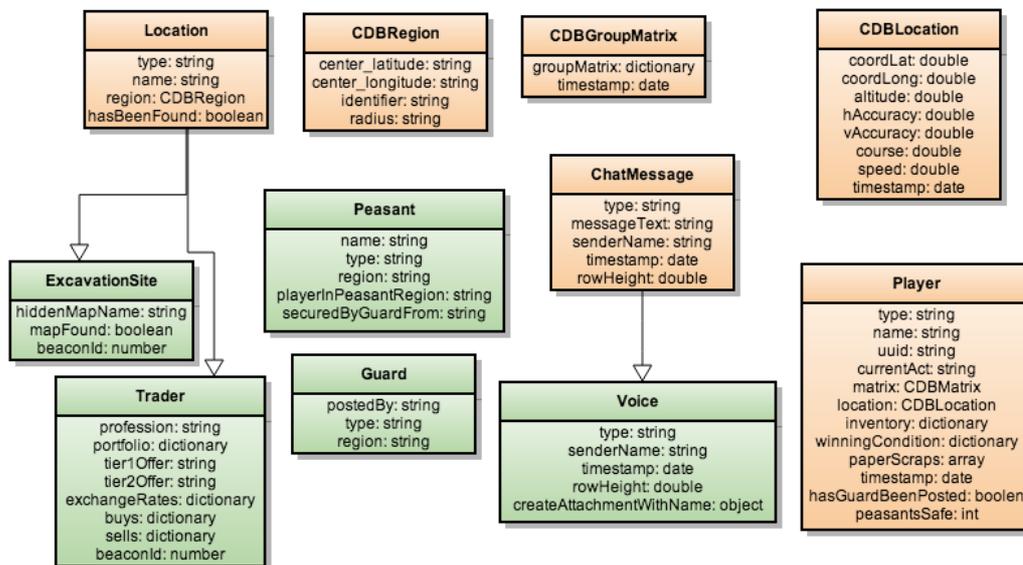
Figure 5.11: All the different CouchDB documents

To store the game state we used the resource files in property list format (pList). The JSON compatible type

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[4]https://github.com/couchbaselabs/CouchCocoa
[5]https://www.gliffy.com/

Storing game state in pList files

data were easily serialized in the form of arrays, dictionaries, strings, numbers, boolean, etc. and all of them are supported in pList files. This is defined as a public document type in Extensible Markup Language(XML) format for storing serialized objects. The method `dictionaryWithContentsOfFile` was used to generate instances of `NSDictionary` for the pList files "Excavations", "Peasants", "Guards" and "Traders". We have retained the prefix convention of CDB to all the CouchDB related model classes.

Existing Model classes

The following are the model classes which were made during [Huch, 2013, p. 70] work. The `AppDelegate` class is where the code execution begins at runtime. The set up for `GPSLocationTracker` is added as a shared instance of `SystemLogger` to itself. The logging and tracking of the device coordinates happens only when the app is in foreground. Then the `MenuViewController` is instantiated and sets standard iOS `UINavigationController` as the root view controller. The tracking functionality is done in the `GPSLocationTracker` class. It extends the functionality of the Core-Location framework. Its instance of `CLLocationManager` registers delegate to itself. To be in the monitoring list the classes have to register with `CLRegions`. In the `SystemLogger` originally only logging of player positions and activities was done and now different game elements, game state are also tracked. This section 6.2.1 gives details of all the events and activities which are tracked. This class implements the notification handler of each class and adds a new row element in the SQLite[6] database. We have mentioned the possible design changes in this section 4.2.3 and they are implemented in these classes.

Existing Singleton instance

The `MenuViewController` was designed to act as the screen for the *King Orders* which is described in this section 5.2.1. The `currentAct` acts as property of `Player` object informing of the game state and thus correspondingly loading the screens for each quest. On instantiating this, a singleton instance of `PlayerList` is created and filled with the "allPlayers" view from the server. Each player has a corresponding `Player` object which is managed via

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[6]http://www.sqlite.org/

the changes in the databases. The property `ourself` corresponds to a player model which has all the devices and dictionary with sorted Universal Unique Identifier (UUID) for each of the devices. The `PlayerList` also determines the grouping of the players and this is done by a matrix, which has the distances of players to each other. There were certain new properties which were added to the `PlayerList` and `Player` objects which were required as part of the new quest or changes to the existing game.

For all the quests `MainQuestViewController` is the parent class, thus sub-classed by `ArcheologyQuestViewController`, `SavePeasantViewController` and `TraderQuestViewController`. They all implement `MKAnnotationProtocol`. This functionality is used to display the *shovel* image seen in the figure 5.3(b) in *Lost Recipe* quest, *peasants* seen in the figure 5.7(a) and on placing a *guard* seen in the figure 5.7(b) in the *Save Peasant* quest and displaying the icons of the shops seen in the figure 5.8(b) in the *Trade and Commerce* quest. The quest related sub-classes are `ExcavationList`, `PeasantList`, `GuardList` and `TraderList` that are modelled similarly to the `PlayerList`. We have mentioned the possible design changes in this section 4.2.3 and they are implemented in these classes.

For the iBeacon™ related quests *Lost Recipe* and *Trade and Commerce* an instance of `CLLocationManager` is registered to itself and `CLBeaconRegion` is instantiated with Beacon UUID and Beacon string identifier. The `CLLocationManager` starts ranging the beacons which are in region. On having filtered the beacons based on their *rssi* values (Received Signal Strength Indication) and ranging is done according to the details in this section 4.2.1 by the functions `beyondBeaconRange` and `withinBeaconRange`. These functions disables or enables the icons allowing them to be pressed if enabled depending on the proximity of the players and the beacons in the quest.

On pressing the icons their corresponding `DetailQuestViewController` are loaded.

How were the quests implemented

iBeacon implementation for the quests

This is sub-classed in the *Lost Recipe* quest as `ArcheologyDetailQuestViewController` and provides a `CanvasView` atop couple of image layers. The top of the canvas displays an image showing dirt or mud. The player draws with a transparency brush on the canvas to uncover the scroll which is behind it. Once a certain portion of pixels are transparent then an event is fired indicating the scroll is found. Similarly in the *Trade and Commerce* quest it is sub-classed as `TradeDetailViewController`. [Huch, 2013, p. 72] have implemented a state machine that models the reactions of shop owners during trading with a player. We have mentioned the possible design changes in the section 4.2.3 and they are implemented in these classes.

The modified `FHHorizontalPickerView`[7] provides the functionality of the *inventory*. The *inventory* is implemented by the `InventoryViewController` class which are sub-classed by `ArcheologyInventoryViewController` and `TradingInventoryViewController`. These make use of the *groupMatrix* property of the `Player` object to determine the list of players in form of a table which can be seen in the upper half of the screen seen in the figures 5.6(a) and 5.10(a). These entire screens update when there are changes notified from the key-value pairs. The chat functionality is implemented by the `ChatViewController`. The model class for text messages is `ChatMessage`. We needed to include *AVFoundation*[8] and *AudioToolbox* frameworks for the voice-based messaging feature. The voice messaging is established by first recording and are designed to immediately play back on the other clients once the server updates. A player can choose to replay any particular voice message as explained in this section 5.2.2.

The `SavePeasantViewController` implements the game logic for the *Save Peasant* quest. The *peasant* locations are modelled by `LocationBasedQuestModel`. It manages `CLRegion` objects and these are saved on the CouchDB document. Once a player is in this inner zone, a region *hit* notification is sent. And when multiple of such notification come together then player is able to place their

Screens opened on pressing icons (margin note)

Inventory functionality and chat features (margin note)

Save Peasants quest game logic (margin note)

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[7]https://github.com/florianheller/FHHorizontalPicker
[8]https://developer.apple.com/av-foundation/

guard as seen in the figure 5.7(b) depending on state of the
`Player` object. Once the player is in the outer zone, a re-
gion *gone* notification is sent. The *peasants'* state is updated
periodically so that players know the *peasants'* status.
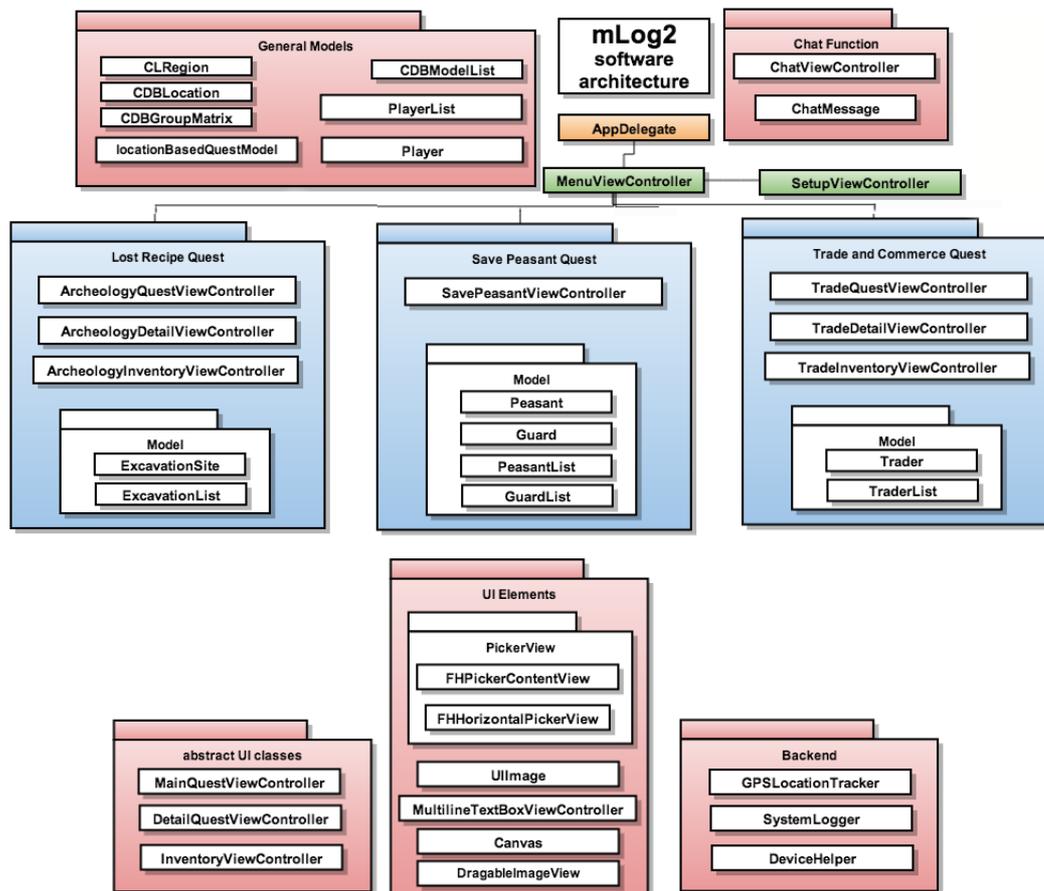
Figure 5.12: Overview of the Software Architecture

5.4   Pilot User Study

Once we had created a testable version of "mLog2", we
conducted a pilot user study at the *Kennedy Park*. Hav-
ing made all the set up in advance with an assistant and
on having completed the explanation of the all the quests
the participants started the game. While the participants
were playing the game, on the far end of the park cer-

tain teenagers were vandalising and tampering the props which contained the beacons. This had gone unnoticed as the park is quite wide and some parts are not directly visible. Having suffered loss of three damaged beacons we had to decide to rerun the pilot user study. We decided to change the playing field to the park in between Kirchratherstrasse and Pariserring in Aachen given by these coordinates (50.774061, 6.051898) as this area seemed more safe.

Now with the change of location we were ready to do our Pilot User Study. Considering the feedback from the users in the primary pilot test, now we had a more established clearer instruction set, questionnaire and an efficient way to set up the field. The participants started the game after understanding the rules and features available in the game. Just before the end of the last quest a couple of the devices ran out of batteries, so the group was very close to completing the game. The reason for such high usage of battery could be due to screen being on all the time and the GPS consuming a lot of the power. The battery in one of the beacon was not working as expected thus that beacon was not detectable and also one of the site was visible at the beginning of the *Lost Recipe* quest and these situations must be avoided.

The participants complained in these pilot user studies that when they come close to the beacon the *sites* or *shops*, they did not show right away and they need to wait for a while. And once these points of interest do show up on the screen they become disabled as participants stand up. This had been happening as the beacons that were provided had certain issues with how the batteries slots were soldered, thus some of the beacons used to show up clearly while other beacons used to falsely range despite the player being very near the beacons. This required a design change to improve the prototype which meant not to disable the points of interest once the beacon has been ranged as *far*. This change was incorporated into the prototype and the latest code base was used for all the following user studies.

Chapter 6

Evaluation And Data Analysis

On completion of the implementation and the pilot user study, we will now discuss how the user study was structured and how we proceeded to completing these studies. We will be going into details about the evaluation phase and analysis of the data obtained.

In this chapter we will be using the following convention:

> **PLAYER NAMES:**
> The players are named using this notation X.Y where X represents the group number and Y represents the device number. For example 4.3 implies a player from group 4 with the device number 3 in hand.

Definition:
Player Names

6.1   User Study Setup

The prototype "mLog2" was changed based on the user inputs from the pilot user study the details are explained in the section 5.4. The new prototype was tested with 28 participants which made up 7 user groups. The game sessions were started with a short introduction of *Solomon Agreement* and then participants filled it, seen in the figure B.9.   Then

Figure 6.1: (a) Participant next to the site beacon which is on the ground (b) Participants grouping to finish the *Trade and Commerce* quest

Figure 6.2: Participants next to the shop beacons

Procedure for the
game sessions

they were briefed about the features in the prototype and certain recommendations for all the quests seen in the figures B.3 and B.4. Then rules of the first quest were clarified. After the participants had completed the first quest, they were requested to get back to the start point and then briefed about the next quest and so on. The start point for all the game sessions remained the same. On having completed the game the participants were asked to fill in the questionnaire seen in the figures B.7 and B.8. And on hav-

ing completed that the group members were given as compensation, goodies and souvenirs worth 26 Euro. The details of the exact procedure conducted for the game session are explained in Appendix A.

The prototype is not designed to synchronize the beginning of the game session, so we had to request the participants to start the game together almost at the same time. This would mean that in the initial part of the recorded logs there are certain differences in the beginning of the game. It did happen that some of the more curious participants did start the game much earlier than other members in the group did. To solve all these time synchronization issues we decided to start the clock for counting and tracking movement from the point when the last player starts the game to the finish of the game. Thus we would be discarding certain initial movements on the logs for some of the devices in all the groups.

Time synchronization for start of game session

The movement data tracked by the devices is based on the combination of the Global Position System(GPS) and the use 3G internet to give a more accurate positioning. We had asked the participants during the game sessions to walk slowly so that the GPS reports their location accurately. As the game sessions were designed to be played in an open park therefore there were no impending building or slopes to really cause the GPS values to jump drastically. And even the game elements like the points of interest were positioned away from the trees and also the participants were not asked to go near the area with large trees as there was nothing in that region. This gave the participants a more accurate feel of where they are with respect to the surroundings when they look at the maps on their devices. While setting up the field we used GPS tracking to position the beacon props in their correct locations. On having done the set up of field several times the beacons props were shifted due to the GPS error between 2 to 4 metre over the entire course of all the game sessions. During the game sessions there are certain jumps that have occurred between 5 to 10 metre and this could be seen in geo-sociogram and proximity plots where the slope of the curve becomes very steep. But these are outliers and do not occur that often thus affecting about 5% of the all the measurements.

GPS-based errors and positioning error of props during set up

6.2   Results

Six group data used
for analysis

The user study as mentioned earlier was conducted with 28 participants in 7 user groups. Only for one of the participant, 5.3, the complete device logs were not present. That device has logs for the first two quests while in the third and final quest the logs were not completely present. Such an issue did not occur for any other group and we were unable to find the root cause of this issue despite looking through the possible device crash logs. This meant the movement data for group 5 was not complete. Thus for the purpose of evaluation of the results we have used only *6 groups* out of the 7, but we have maintained the original numbering of the groups. However, for the sections under questionnaire 6.4 and the quest related data section 6.2.3 we have used the data from all the groups.

6.2.1   Data Collection

In this thesis we are trying to test the hypothesis that given a set of movement data, which are from different quests, they be mathematically distinguished from each other. In other words, it is possible to segregate movement data obtained from a quest-driven game into different classes of data sets. The setting up of the study in an open park has eliminated these confounding variables such as the narrow streets of the city centre, size of the playing field, impediments like vehicle, people, activities on the streets, etc.

Sources of data
collection

During the studies we focused on gathering data in four different ways. First was that the instructor, who will observe the activities happening during the session and take notes in the format mentioned seen in the figure B.10. Secondly audio recording of the entire game session. Thirdly the device logs kept track of all the interactions with game elements and movement across the park. Finally at the end of the session the participants were handed out these B.7 and B.8 questionnaires.

The data logged on each of the devices, the data logged on

the CouchDB database through text messaging and voice messaging chat systems were the primary data sources. The different activities which were logged are:

- Position of the device containing the longitude, latitude, speed and course at a given point in time and this was updated ever second.

- Game state indicating the current act and tracking the progress of the quests.

- When and which player enters within the vicinity of any site or peasant or shop and when the player moves away.

- Interaction with the user interface like player enters a site or shop, player digs a particular scroll out, where and when the guard is placed, which and how many peasants were saved due to the placing of that guard, selection of trade goods, selection of goods from their inventory, also if the placing of the guard was cancelled and when and where was that, etc.

- State of the inventory in the *Lost Recipe* and *Trade and Commerce* quests.

- Transfer of scrolls and goods between players.

Logging activities on the devices

Owing to the fact that the game was hosted in an open park the observer could take notes and find out possible strategies used when the players grouped or separated at any point of time. It gave insightful details about different approaches to the quests.

6.2.2 Interpreting Geo-Sociograms

The method to represent movement data visually in [Huch, 2013, p. 82] work was Geo-Sociogram. We implemented this approach to do the analysis of the data. This involved computing relative distances between a pair of devices. The relative distances can be computed using Euclidean distance on a plane. If $\mathbf{p} = (p_1, p_2)$ and $\mathbf{q} = (q_1, q_2)$ where

p_1, q_1 represent latitude of a said location and p_2, q_2 represent longitude of a said location then the distance is given by:

$$d(\mathbf{p}, \mathbf{q}) = \sqrt{(p_1 - q_1)^2 + (p_2 - q_2)^2}$$

This above relative distance has been calculated using python script. The `geopy` package gives a coordinate having passed latitude and longitude values of a point and `distance` package implements the above Euclidean distance formula. The *sqlite* log files are converted to *csv* with each row corresponding to distance and time by the python scripts. The Matlab scripts generated the geo-sociogram data set from the *csv* files. This would give us a geo-sociogram for a particular pair of devices. The data set would not change despite changing the order of the pairs of devices. For all the data sets, the distance component represented along *y-axis* was normalized to the maximum relative distance between any two players for all geo-sociograms and time component is represented along *x-axis* and this was normalized to two states that is beginning of the quest and end of quest. The idea behind such normalization was to be able to compare all the geo-sociograms on a similar scale.

Normalising data and generating geo-sociograms

2	21		
3	31	32	
4	41	42	43
	1	2	3

Table 6.1: Geo-sociogram pairs between devices 1, 2, 3 & 4

One could compute the data set for all the pairs of devices and this would give us 6 unique pairs of devices, hence for a given quest and group there are 6 unique geo-sociogram plots. The table 6.1 shows how the six unique pairs were constructed. All geo-sociograms are in the Appendix C.

Lost Recipe Quest Geo-sociogram

In the geo-sociogram 6.3 one can observe that there are sev-

eral peaks and spikes in the all the graphs. From this one can infer that during the course of the quest the players met quite often or crossed over each others' paths often. This particular group spent some of their initial time discussing a strategy to find all the sites, while many of the groups after having listened to the instructions decided to start walking randomly. In this particular group after about two-thirds of the time one can see that all the four members of the group met together. This happened in scenarios either to transfer the scrolls which were found, or to check who has found which scroll or to find out if there were any more scrolls undiscovered.

Interpreting the geo-sociograms
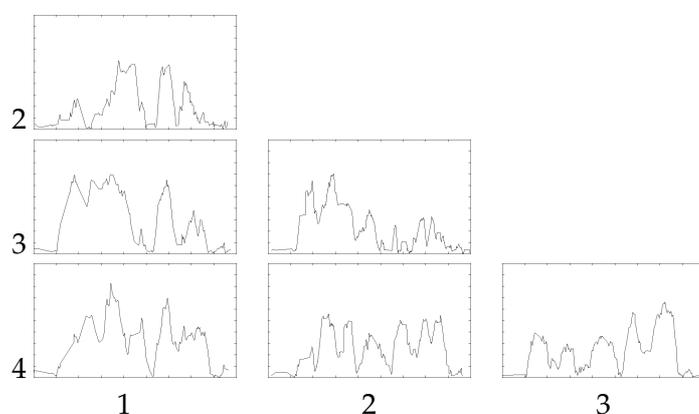
Figure 6.3: Grid based Geo-Sociogram Group 2 in Quest 1

Observations

In few of the groups the members had found 9 out of the 10 sites. But the last missing site took quite a while to find as they revisited the same site multiple times rather than communicating between each other to inform which site one should not visit. In couple of the groups the members had found all the sites, but one of the members had not dug out one of the ten sites. This also caused the players to revisit all the site on multiple occasions to decide which one is left to be dug. Here we could concur that not all the members in a group understood the game concept completely which led to extra movements. Despite having given the freedom to transfer the scrolls at any point of time, many of the groups decided to regroup before the end of quest transfer the scrolls to one person as the game required.

Why were the sites approached often

Save Peasant Quest Geo-sociogram
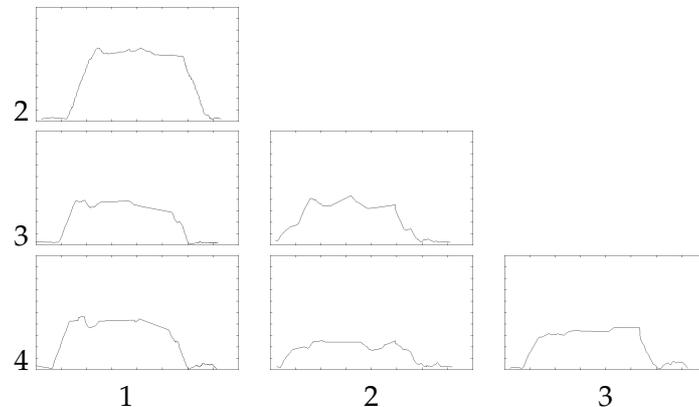
Figure 6.4: Grid based Geo-Sociogram Group 4 in Quest 2

In the geo-sociogram 6.4 one can observe that all of the curve are bell shaped. Thus indicating that all the members of the group were moving away from each other for most part of this quest. The *Save Peasants* quest game concept required players to play individually. In this geo-sociogram it looks likes the group decided to go in separate directions to safe guard the peasants in particular regions. This scenario occurred for most of the groups. In couple of the groups the members either unintentionally encroached the region of another member hence end up trying to save peasants of their group members'. Therefore those players had to go out of their way again to a separate region to save the peasants there.

How were the
peasants saved

Observations

In many of the groups the members found the *sweet spot* in between the peasant regions very quickly hence were able to save the maximum number of peasant at first go, while the few who were unable to find that *sweet spot* ended up trying multiple times in different peasant regions. This confirmed that the participants did understand the game concept clearly.

Trade and Commerce Quest Geo-sociogram

In the geo-sociogram 6.5 one can observe that some of the

curves either partly or fully have a bell shape and some of them do have spikes. This rather implies that the couple of the group members met in between the quest. In couple of the groups they made strategies at first to decide on how to tackle the quest while most of them started the quest by randomly walking to the nearest visible point of interest which were the *shops*.
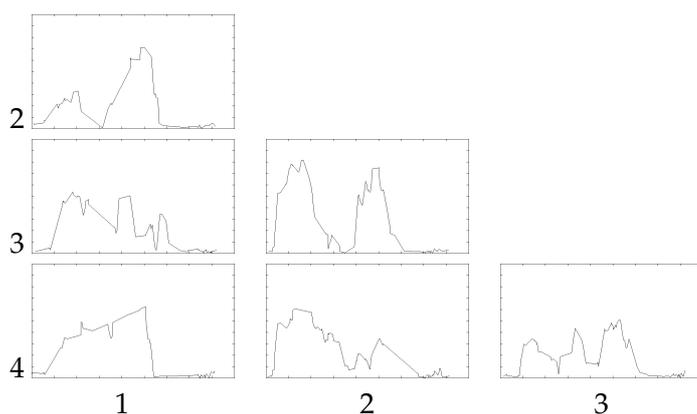
Figure 6.5: Grid based Geo-Sociogram Group 6 in Quest 3

Observations

A few of the groups strategically decided to meet after having bought some of the necessary goods and then either transferred between each other to finish the quest or exhaustively transferred all the necessary goods to one member so that that member can finish the quest. In couple of the groups, one of the members decided to go to all the points of the interest to trade with the shops, while most of the members in all the groups only went to a handful of shops. In a few of the groups all the members are playing this quest independently in different locations, though they might cross over each other or transfer goods between one another but the quest was finish by one member without others members realising that the quest is completed by that individual. All these different strategies adapted by different teams had a profound impact on the movement patterns. From this example one can see that all the participants understood the game concept and thus were able to come up with different ways to solve the quest.

Different approaches to complete this quest

6.2.3 Quest Related Data

We are now doing data analysis for the quest related data and we first start with the *Lost Recipe* quest. In this section we are trying to find correlation between game elements and strategies involved in the quest.

Sites Found and Entered: Collated Data

The archaeological sites are numbered from 1 to 10 and in the table 6.2 the column two *Sites Found* indicates all the sites which were initially found by the members but that does not mean the scroll was discovered right away on digging. Thus the sites where the scrolls were not dug out are indicated with red colour. The numbers in black indicates the sites which were found and the scroll was discovered. Thus among all the group members the total count of the sites in black colour in this column must sum up to 10.

Describing how to interpret the following table

The column three *Enter Found Site* shows the sites which were entered after having been found by another player. The player could have entered the discovered site multiple number of times but here we are only informing about the various sites which were entered and not the count of the number of visits. In some of the cases the found sites where the scroll were not initially dug out, they might entered by another player later in the quest and it could still remain not dug. These sites are indicated in this column with red colour. And then later during the quest the player who found the site went back to dig that particular site. One must note that against a member the sites in *Sites Found* are not listed again in the column *Enter Found Sites* as re-entering the found site on multiple occasions is not accounted for here.

Observation

From the table 6.2 one can observe that in all the groups at least one of the members who had found a site missed out on digging it right away and those sites were dug by the same member later in the quest or perhaps was dug by another member of the group. One would also notice

Members	Sites Found	Enter Found Sites
1.1	7, 8, 9, 10	1, 2, 3, 4, 5, 6
1.2	1, 3, 6	2, 4, 5, 7, 8, 9, 10
1.3	4, 8, 9	1, 2, 5, 6, 7, 10
1.4	2, 5	1, 3, 4, 6, 7, 8, 9, 10
2.1	2, 4, 5, 7, 9	1, 3, 6, 8, 10
2.2	1, 4, 7	3, 5, 6, 8, 9, 10
2.3	6	1, 2, 3, 4, 5, 7, 8, 9, 10
2.4	3, 8, 10	2, 3, 4, 5, 6, 7, 9
3.1	5, 6, 8, 9	1, 2, 3, 4, 7, 10
3.2	2, 4	1, 3, 5, 6, 7, 8, 9, 10
3.3	1, 3	2, 4, 5, 6, 7, 8, 9, 10
3.4	6, 7, 10	1, 2, 3, 4, 5, 8, 9
4.1	1, 3, 6	4, 5, 8, 9
4.2	2, 7	4, 5, 9, 10
4.3	5, 9, 10	1, 2, 3, 4, 7, 8
4.4	4, 8	2, 3, 5, 6, 7, 9, 10
5.1	4, 7, 8	1, 2, 3, 5, 6, 9
5.2	9	3, 4, 5, 6, 7
5.3	3, 6	2, 4, 5, 9
5.4	1, 2, 5, 10	3, 9
6.1	2, 9, 10	7, 8
6.2	7, 8	1, 2, 3, 4, 5, 6, 9, 10
6.3	5	1, 2, 3, 4, 6, 7, 8, 9, 10
6.4	1, 3, 4, 6	2, 5, 7, 8, 9, 10
7.1	3, 4	1, 2, 5, 6, 7, 8, 9, 10
7.2	7	2, 3, 5, 8, 9
7.3	6, 8	1, 2, 3, 5, 7, 10
7.4	1, 2, 5, 9, 10	3, 4, 6, 7, 8

Table 6.2: Sites Found and Entered

that some of the sites which were found but not dug out remained not dug despite of being scanned by other members of the group. This scenario repeated on multiple occasions for some of the groups. The missing out on digging a site right away or a site that has already been found has led to lot of movement and thus has been time consuming.

Finding a pattern in how sites were dug

One could conclude that for some of the members the game concept was not clear at first. And we can confirm based on the audio recordings that those members did understand

how to finish the quest with help from their group members. This can also be confirmed as no one member had finished the quest without having to discover a site and not having dug it. The multiple found sites which were entered indicates either the members went about arbitrarily to each site in order to find which site was yet to be dug or which one was the missing site that is to say not found. One could also concur that the members did not use the different forms of communication at their disposal to avoid multiple visits to the same sites.

Transfer of Scrolls between Players: **Collated Data**

Group	Number of Scrolls Exchanged
1	14
2	6
3	7
4	7
5	7
6	6
7	8

Table 6.3: Number of scrolls transferred between players

In the table 6.3 we are presenting all the groups against the total number of the exchanges of scrolls that happened amongst each other. The standard deviation of the above data set is 2.58, variance being 6.69 and the mean being 7.85.

Observation

In most of the groups at the beginning of the quest a scroll receiver was selected. Thus one could infer from this table 6.3 that, the scrolls the receiver was transferred were the remaining scrolls which that member had not dug out. Only in one of the groups there was distribution of the scrolls amongst the members on multiple occasions before the quest was completed. Now we will be analysing the data from the *Save Peasant* quest.

Placing of Guards: **Collated Data**

In the table 6.4 we are presenting all the groups against the

Group	Number of Guards Placed	Guards Cancelled
1	6	0
2	5	0
3	8	0
4	4	1
5	12	0
6	4	0
7	8	2

Table 6.4: Placing of Guards

total number of times all the members placed their guards and also giving details of corresponding total number of times all the members cancelled placing their guards. The standard deviation of the above data set under the column *Number of Guards Placed* is 2.65, variance being 7.06 and the mean being 6.71.

Observation

The best case scenario for achieving the maximum safe guarding of the peasants was by each member of the group placing their guard once that means four guards in all. From the above table 6.4 one will observe that this was achieved by two groups while other groups tried a few more times to finish the quest. Only one group found it quite hard complete the quest quickly thus taking more time to complete and covering more distance. It can be seen that the cancelling of placing a guard function was seldom used by the members. This could be because the players were able to reposition a guard in spite of a wrong placing, thus rendering the cancel placing guard feature useless.

It is about finding the *sweet spot*

Peasant Safe Guarded: **Collated Data**

In the table 6.5 we are presenting all the groups against the total number of times all the members entered into the safe zone of the peasants and also giving details of corresponding total number of peasants saved by all the members. The column *Count of Safe Zone Entries* takes into account the multiple times a member entered the safe zone of the same peasant. Also the column *Peasants Saved* considers all dis-

How to interpret this table

Group	Count of Safe Zone Entries	Peasants Saved
1	45	15
2	27	14
3	26	14
4	31	12
5	24	17
6	34	12
7	35	16

Table 6.5: Safe Guarding of Peasants

tinct peasants saved by a member, this could also mean that a given peasant could be saved by more than one member. The standard deviation of the above data set under column *Count of Safe Zone Entries* is 6.62, variance being 43.91 and the mean being 31.71. The standard deviation of the above data set under column *Peasants Saved* is 1.74, variance being 3.06 and the mean being 14.28.

Observation

The best case scenario for achieving the maximum safe guarding of the peasants was by each member of the group placing their guard once, that is four guards in all hence saving a maximum of 12 peasants. In the table 6.5 from the column *Peasants Saved* one would realise that this was achieved by only two groups. While the other groups ended up saving a few more peasants simultaneously before they achieved the aim of the quest together. Even though the best case scenario was achieved by two groups those groups attempted to enter more safe zones of the peasants before they decided to place the guard at the *sweet spot*. Now we will be analysing the data from the *Trade and Commerce* quest.

Contrast on how peasants were saved

Shops entered: **Collated Data**

In the table 6.6 we are presenting all the groups against the total number of times all the members entered all the shops. The above table also accounts for multiple entries into the same shop. This data does not distinguish between the different types of shops. It must also be noted that in all the

Group	Count of Shops entered
1	56
2	58
3	74
4	54
5	61
6	59
7	58

Table 6.6: Count of Shops Entered

groups all the 12 shops were visited by at least one member of that group. The standard deviation of the above data set is 6.07, variance being 36.85 and the mean being 60.

Observation

Owing to the trial and error natural of which trade deals work in this quest one can see in the table 6.6 that several attempts were made in the course of completion of the quest. From this table one can not perceive any form of strategy involved in the quest or infer if the quest was completed individually or by a group as a whole.

High average number of shops entered

Trades with shop owners: Collated Data

Group	Count of trades
1	19
2	24
3	26
4	18
5	20
6	18
7	27

Table 6.7: Count of trades of goods with shop owners

In the table 6.7 we are presenting all the groups against the total number of trades all the members did with the shop owners. The standard deviation of the above data set is 3.57, variance being 12.77 and the mean being 21.71.

Observation

The table 6.7 throws light on how many trades with the shop owners were required in total amongst all members to complete this quest. The trades segregated into different shops is not of great interest here as the deals which do work between two goods has been selected arbitrarily in the work of [Huch, 2013, p. 46], that is the total number of trades would be the same even if the deals between a pair of goods is altered.

Transfers of goods between players: **Collated Data**

Group	Count of transfers
1	17
2	5
3	4
4	15
5	3
6	15
7	3

Table 6.8: Count of transfers of goods between players

In the table 6.8 we are presenting all the groups against the total number of transfer of goods between each other. The standard deviation of the above data set is 5.96, variance being 35.55 and the mean being 8.85.

Observation

As we had mentioned earlier in the sub-section describing geo-sociogram for this quest, certain game sessions was completed by individual's effort rather than collaborating as a group. In other words some of the groups strategically transferred all the goods which each possessed to one member in the group and then that member completed the quest under the supervision of others while they were all grouped together physically. We will call this the *grouping strategy*. As all the members of the group are together, all of them were aware of the state of the quest and knew when the victory was achieved.

On the other hand there were groups in which this kind of strategy was not followed and an individual worked out a way to finish the quest after receiving some help from others by transfer of certain key goods. We will call this the *individual strategy*. It was observed during the game sessions, that a particular individual has finished the game while the others are not aware of this happening amidst them as all of them are in different locations and only the prompt *To King* made the other members realise that the game is complete.

Individual Strategy

There is a correlation between the strategy to the number of goods transferred between the players. The groups which have considerably more transfer of goods between each other adapted to the *grouping strategy*. The groups with fewer transfer of goods adapted the *individual strategy*. Thus the nature of the above correlation is causal between the strategy and count of transfer of goods between players.

Causal relation between strategy and number of transfers between players

Total and Quest-wise Time: **Collated Data**

Group	Quest1	Quest2	Quest3	Total
1	23:21	17:52	23:55	1:05:08
2	30:43	11:35	21:16	1:03:34
3	26:00	10:39	22:23	0:59:02
4	36:24	12:54	25:03	1:14:21
5	26:39	12:58	21:39	1:01:16
6	25:37	13:13	28:52	1:07:42
7	34:13	11:08	23:24	1:08:45

Table 6.9: Quest-wise and total time taken

In the table 6.9 we are presenting all the groups against the time taken to complete each of the three quests and total time for all the quests put together. All the times in the columns *Quest1*, *Quest2*, *Quest3* are in *mm:ss* format and in the column *Total* is in *h:mm:ss* format. The mean values for the data in column two is 29:00, in column three is 12:54, in column four is 23:47 and in column five is 1:05:41.

Observation

In the table 6.9 we can observe that the *Lost Recipe* quest was

the most time consuming and the *Save Peasant* quest was
the least time consuming. We have explained already the
possible reasons and situations why the *Lost Recipe* quest
was so long and why the *Save Peasant* quest was so short,
in the section 6.2.2 corresponding to each of the quests.

Total and Quest-wise Distances: Collated Data

Group	Quest1	Quest2	Quest3	Total
1	668.5	563	513.75	1745.25
2	1354.5	372.75	803.5	2530.75
3	1239	297.75	455.5	1992.25
4	1149.3	254.75	616.75	2020.75
5	867.75	326.5	948	2142.25
6	751.75	332.5	758.75	1843
7	1079.8	399.5	540	2019.25

Table 6.10: Quest-wise and total distances travelled

In the table 6.10 we are presenting all the groups against
the distance travelled to complete each of the three quests
and total distance for all the quests put together. All the
distances in all the columns are measured in metre(m). The
mean values for the data in column two is 1015.78, in col-
umn three is 363.82, in column four is 662.32 and in column
five is 2041.92.

Observation

In the table 6.10 we can observe in the *Lost Recipe* quest
participants travelled the longest to complete it and in the
Save Peasant quest travelled the least. We have explained
already the possible reasons and situations why the *Lost
Recipe* quest was so long and why the *Save Peasant* quest
was so short. There is a correlation between the data in the
above table 6.10 and the data in the 6.9. One can observe
that more time was taken to complete a quest as more dis-
tance was covered. There are some outliers to this, thus the
above correlation must not be concluded as causal.

6.2.4   Proximity Data Plots

In this section we will be describing how the proximity-based data plots can used be to visualize our data set and analyse the graphs that result from those plots. As we have mentioned earlier in the "Related Works" chapter 2.1.4 how the work of Crnovrsanin et al. [2009] has had an impact on our work. Now we will be giving a more visual meaning to that concept.

To be able to make the proximity plots we first needed to extract the movement data from *sqlite* log files from the devices and generate *csv* against all the different points of interests. This was done using the python scripts. We generated proximity-based data against all the 10 sites in the *Lost Recipe* quest, against all the peasants who were saved in the *Save Peasant* quest and against all the 12 shops in the *Trade and Commerce* quest and this was done for all the members in all the groups. The links to all the proximity-based graphs are available in the Appendix C and one can find them categorised against the above mentioned points of interest namely *sites*, *peasants* and *shops*. This generated a huge amount of data to be analysed. Here we will take an example from each of these categories. From the following graphs it not directly possible to deduce if players crossed over each others paths. Also it is only possible to detect grouping near the said point of interest at a given point of time. The strategies used by different groups in the different quests are not deducible from these plots.

Generating proximity-based plots

Proximity Plot for Lost Recipe Quest

In the figure 6.6 we have plotted the proximity data of group 2 against site 4 and the lines with colour red, green, blue and black represent movement data of 2.1, 2.2, 2.3 and 2.4 respectively. The point in time when the site was dug out is marked with the a yellow annotation giving details of the coordinate. As one can observe that this site was approached several times by other members but neither of them dug it. 2.1 was the one eventually to have dug out that site. On tracing back we found that 2.2 had discovered the site but had missed out on digging. Even though sev-

When did players not dig a site
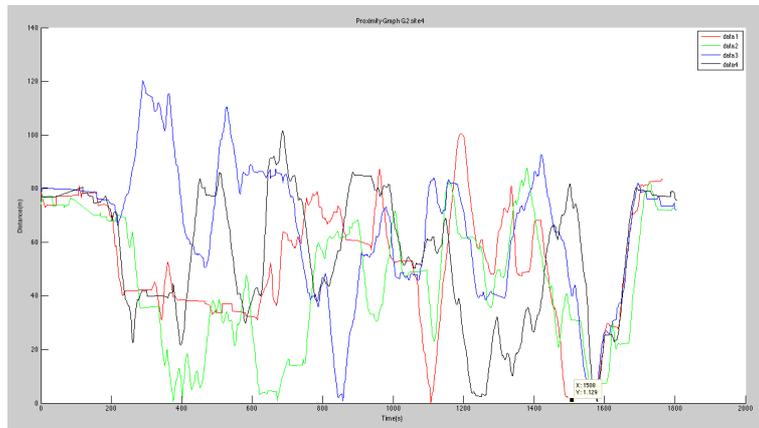
Figure 6.6: Proximity Plot Lost Recipe Quest

eral other times 2.1 and 2.3 got to that site but were under
the impression that site was completely dug out either by
miscommunication or the UI did not communicate this fact
directly when they saw that site was discovered. The UI
only informs a player if a site was dug only if they enter the
site. The proximity-based plots confirms the behaviour of
players and observations made from the table 6.2.

Save Peasant Quest
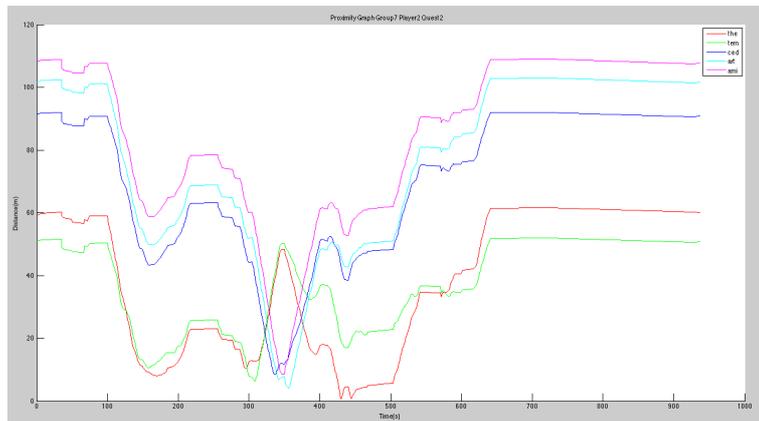
Figure 6.7: Proximity Plot for Save Peasant Quest

In the figure 6.7 we have plotted the proximity data of 7.2
against all the peasants saved by that member. And the
coloured lines represent the change in distances of that de-
vice against all those peasants. This is an interesting form

of visualization as one may notice that distances to peasants shown by red and green colours reduced to within the distance so that the player could simultaneously save those peasants. Then the player places the guard there but having not achieved the maximum, the player moved to a new location on the field to a region where more peasants could be saved. Once the peasants shown by the colours magenta, cyan and blue lines were within the distance so as to simultaneously save them then the player decided to repositioned the guard at that location. The proximity-based plots confirm the behaviour of players and observations made from the table 6.5.

How peasants were saved is inferred from the plot

Trade and Commerce Quest
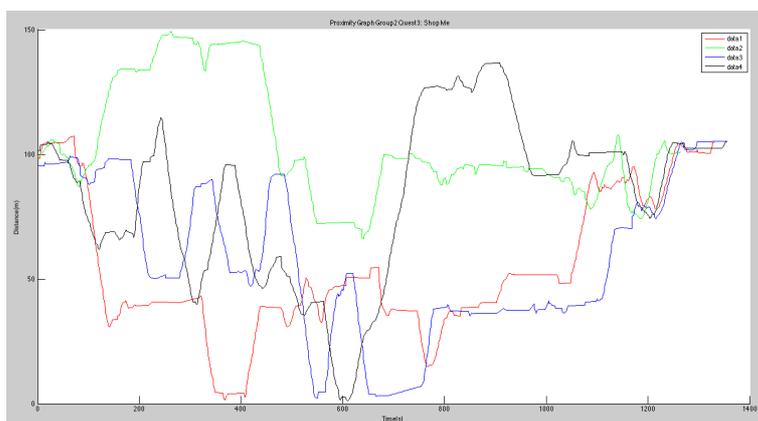
Figure 6.8: Proximity Plot for Trade and Commerce Quest

In the figure 6.8 we have plotted the proximity data of group 2 against shop of the *merchant* the lines with colour red, green, blue and black represent movement data of 2.1, 2.2, 2.3 and 2.4 respectively. One can observe that 2.1, 2.3 and 2.4 approached this shop at least once. Those members spent some time trying to negotiate a deal with the shop owner. It can be confirmed from audio recording that 2.3 approached the shop at first and having not been able to work a deal, then approaches the shop a second time after having obtained the necessary goods to trade with the goods the *merchant* provides. As one of the required goods requested by the king is provided by the *merchant*, thus revisiting the *merchant* often was a necessity in figuring out which goods the members posses could be traded. The

How often were the shops visited

proximity-based plots confirm the behaviour of players and observations made from the table 6.6.

6.2.5   Distinguish Movement Data

In this section we will look at the procedure we followed in order to distinguish quest-wise movement data, in other words to classify given set of movement pattern data into different categories based on which quest they belong to. The purpose behind distinguishing movement patterns is to help game designers and developers become aware of what kind of movement patterns could be associated with a given type of quest. The current work will assist them in predicting the movement pattern for a similar type of quest which they might create. Now that we have the data sets of each of the groups for each of the quests, we would need to do certain transformations on the data sets in order be able to classify them.

Simple Low Pass Filter

This technique is used because in many of the data sets there are several peaks and spikes. We would like to trim them or cut them thus result in smoother curve for all the data sets. The following represents the simplest low pass filter which can be run on the data set.

$$y(n) = x(n) + x(n-1), n = 1, 2, ..., N$$

The filter function implements the following iterations over all the elements in the input data set to implement any linear, finite-order, causal, time-based digital filter:

$$y(n) = \sum_{k=o}^{M_n} B(k+1)x(n-k) - \sum_{k=1}^{N_n} A(k+1)y(n-k)$$

$$n = 1, 2, ..., N_x$$

where $N_x\Delta = length(x), N_n\Delta = min\{N, n-1\}, M_n\Delta = min\{M, n-1\}, M+1$ is the length of b, $N+1$ is the length of a and a(1) is assumed to be 1. The Matlab equivalent in-built function which performs the above mathematical equation, the syntax is as follows:

```
y = filter(b,a,X)
```

where X is the input data in form of vector, y is the output data in form of vector, a is vector of filter *feedback coefficients* and b is a vector of filter *feed forward coefficients*. After a few trials in Matlab the most approximate values for the parameters a and b were chosen and we completed the initial data filtering.

Sub-Sampling

On having filtered, the data sets in all the quests and groups must be uniformly and randomly sampled with a fixed number of samples. The sampling is based on a probabilistic model of selecting a particular value. The Matlab equivalent code which perform the above mentioned mathematical operation is:

```
y = datasample(data, k)
```

where y is an output uniformly sampled vector, data is the input vector to be randomly sampled and k is the number of randomly distributed samples to be taken.

Area Under the Curve

The mathematical representation for finding the area under a curve is given by the following formula in integral Calculus:

$$z = \int_{a}^{b} f(x)\mathrm{d}x$$

This in Matlab is translated as the Trapezoidal Rule and here is the code equivalent for it:

```
Q = trapz(Y)
```

Computing area
under the curve

This above code implements the following equation on the
uniformly sampled data:

$$\int_a^b f(x)\mathrm{d}x \approx \frac{h}{2}\sum_{k=1}^{N}(f(x_(k+1)) + f(x_k))$$

Couple Pairing Algorithm to Sort

Now that we have a filtered, sub-sampled data sets for all
the quests in all the group and also we have been able to cal-
culate the area which each data sets subtends. We needed
to follow a certain algorithm to sort the 6 data sets in each
quest. For this we used the *Stable Marriage Problem* solving
technique.

Algorithm to sort
data sets

We started with a reference data set and that was ordered
data based on values of the area under the curve for those
data sets from smallest to largest. The following is the algo-
rithm which was followed to sort the remaining data sets
in each of the quests.

```
Input: Data set ordered by size for Group 1
Result: Sorted quest-wise data sets for a group
Function: StableMatching(Quest-wise Data sets)

While(Data Set exists)

  ForAll(Pairs of data sets against input
    ordered data set)

    Determine differential integrals between
      Ordered Set and new data sets

    If(Least differential integral pair found)
        b = Data set
        Sort the position of 'b' according to
        the Input
    endofIf

  endofForAll

endofWhile
```

Clustering Algorithm using Support Vector Machine

Having sorted the data set with a reference data set using the above mentioned algorithm, now we need to classify these data sets. We were able to achieve that using clustering algorithm and we used Support Vector Machine. Here one needs to provide set of training data set with a separate data set informing about the correct classification of the training data set. Then one must provide the test data of equal size to classify.

Binary classification using SVM

With a training data set D, a set of n points represented in this form:

$$D = \{(x_i, y_i) \mid x_i \in R^p, y_i \in \{-1, 1\}\} \ \forall \ i \in [1 \ n]$$

where y_i indicates the class to which the point x_i belongs. Here x_i is a p-dimensional vector. The aim is to find the maximum-margin hyperplane that divides the points having $y_i = 1$ from those having $y_i = -1$. This hyperplane can be represented by a vector plane:

$$w \cdot x - b = 0$$

If the training data are separable linearly by selecting two hyperplanes so as to separate the data with no points between them, thus trying to maximise the distance. These hyperplanes can be described by a singular equation:

$$y_i(w \cdot x_i - b) \ \geq \ 1, \forall \, 1 \ \leq i \leq \ n$$

As we are making use of non-linear classification thus making use of the homogeneous polynomial form of kernel:

$$k(x_i, x_j) = (x_i \cdot x_j)^d$$

This above mathematical formulae is implemented in Matlab using this code snippet for training a data set along with

Training data sets

a data set 'groups' which informs to which class each of the training data is categorised into:

```
SVMStruct = svmtrain(train_data,groups,
'kernel_function','polynomial')
```

The Matlab code snippet for predicting the test data is as follows:

```
class = svmclassify(SVMStruct,test_data)
```

We ran these data sets with the Matlab binary classification SVM. Here we did the training in a cyclic fashion that is by doing a binary classification between the first two quests data, then between the second and third quests and then finally between third and first quest data. Based on the *class performance* function available in Matlab the data sets `groups` and the `class` are gauged together to determine the prediction accuracy. The table 6.11 gives the complete training set and test set predictions for binary classification using Matlab. Here Q1, Q2 and Q3 correspond to *Lost Recipe*, *Save Peasants* and *Trade and Commerce* quest respectively. The columns three *Q1, Q2*, column four *Q2, Q3* and column five *Q3, Q1* gives the prediction values for how accurately the SVM was able to do the binary classification for the data sets under those corresponding quests. Here we were able to achieve on an average accuracies of predictions between 52%-70%. The possible short comings of such level of prediction are listed here 6.3.1.

Accuracy of prediction of test data set

Alternative multi-class SVM

We found another alternative LibSVM[1] gives support for multi-class SVM classification as we had to categorise our data sets for three quests into three classes. We had to convert our sorted data sets into the format for LibSVM and this was done using Matlab scripts. We generated the training data sets from each of the quests from three different groups and similarly the test data sets from the remaining groups. On running the test data sets for multi-class the accuracies of predictions came between 34%-47%. This implies that the training data is very similar hence LibSVM is finding it hard to distinguish between the data sets into three classes.

---

[1]http://www.csie.ntu.edu.tw/~cjlin/libsvm/

Training Set	Test Set	Q1, Q2	Q2, Q3	Q3, Q1
G1, G2, G3	G4, G6, G7	66.67	57.93	67.07
G1, G2, G4	G3, G6, G7	66.11	66.48	58.89
G1, G2, G6	G3, G4, G7	66.47	52.26	65.63
G1, G2, G7	G3, G4, G6	66.00	54.37	63.96
G1, G3, G4	G2, G6, G7	65.33	55.63	61.70
G1, G3, G6	G2, G4, G7	64.70	60.67	61.41
G1, G3, G7	G2, G4, G6	65.56	55.41	64.15
G1, G4, G6	G2, G3, G7	65.15	59.81	64.37
G1, G4, G7	G2, G3, G6	65.63	53.56	64.93
G1, G6, G7	G2, G3, G4	61.19	58.74	63.30
G2, G3, G4	G1, G6, G7	67.10	54.74	66.19
G2, G3, G6	G1, G4, G7	66.78	66.67	62.11
G2, G3, G7	G1, G4, G6	63.78	57.96	65.26
G2, G4, G6	G1, G3, G7	65.41	60.89	58.44
G2, G4, G7	G1, G3, G6	65.01	53.37	64.22
G2, G6, G7	G1, G3, G4	66.19	54.44	60.00
G3, G4, G6	G1, G2, G7	62.12	53.78	69.52
G3, G4, G7	G1, G2, G6	66.89	60.96	63.33
G3, G6, G7	G1, G2, G4	66.56	57.41	62.85
G4, G6, G7	G1, G2, G3	66.15	66.70	66.48

Table 6.11: Accuracy of Clustering Predictions using SVM

6.3   Implication of Results

The results which were obtained in the table 6.11 implies that, there are possible correlations between the movement data of the different quests. The accuracy of prediction of the movement data into distinct categories is not very accurate that is between 85%-90%.

Data Statistics	Q1,Q2	Q2,Q3	Q3,Q1
Mean	65.44	58.09	63.69
Standard Deviation	1.54	4.541	2.764
Range	5.91	14.44	11.08

Table 6.12: Statistics of the Accuracy of Binary classification

From the table 6.12 it can be inferred that the SVM is pre-

dicting the movement data in the quests Q1 and Q2 better than between the quests Q2 and Q3. This implies that the movement data are relatively similar in Q2 and Q3 hence the SVM is not able to distinguish them apart clearly. This can also be observed from the geo-sociograms which are explained in 6.2.2. The movement data have led to geo-sociograms with more bell shaped curves in quests Q2 and Q3. While in Q1 there are lots of spikes and peaks. Therefore the SVM could better categorise the pairs Q1, Q2 and Q3, Q1 as they are relatively more distinct. The above table also implies that it is mathematically possible to distinguish between the movement patterns in a quest-driven location-based game.

Similarity in movement data

We have designed our experiment to reduce several confounding variables like narrowness of streets, obstacles on the streets, etc. by relocating the game to an open park. The criteria for selection of the open area have been described here 4.3, thus eliminating certain confounding variables for the game session set up. This allowed more free movement between the various points of interests and players creatively adapted many different strategies to complete the different quests.

Effect of confounding variables

Also allowing freedom in transfer of goods or scrolls from any point on park at any point in time between the players also encouraged them to move about freely. This did not constrain them to get back together to complete the transfers but a few groups did intentionally adapt this strategy. The communication devices which were provided separately like the walkie-talkies give the participants more freedom to discuss or clarify quest related topics at will. The voice messaging and text messaging chat systems were capable of being used any where on the park even when the walkie-talkies are out of range. Thus a seamless means of communication connected all the participants at all times.

Transfer of game elements and seamless connection between players

We have already mentioned about the causal relationship between the different strategies adapted by participants in the *Trade and Commerce* quest and the total number of trade of goods between players. This was a significant result as it gave a numerical meaning to the particular strategies adapted in that quest. Also we could find that there is a

Causal relation and correlations

correlation between the total distance travelled by all the members of the group in a given quest to the time taken to complete that quest.

6.3.1   Cause of deviation from high accuracy predictions

The accuracy of prediction of classification using SVM is not quite high and following section briefs why this has not been achieved. In the quest *Lost Recipe* many of the groups ended up finding all but one site and therefore had to randomly search, revisit already visited sites, meet up on multiple occasions before they could find that site. A couple of the groups who thought that they found all the sites but had mistakenly not dug at least one of the sites which they had found. This caused a slightly different movement pattern from the groups which had only site left to be found. Thus the movement patterns are quite unique for many of the groups and so its hard to categorise them under one class of movement data.

What happened in the *Lost Recipe* quest

From the geo-sociograms for the quest *Save Peasant* one can observe that, in few of the groups after some of the members had completed their part of the quest then one of the members went around to help the others who had not completed the quest by physically moving to the others' location. In couple of the groups the members encroached into each others regions where one was trying to save the peasants, hence causing the encroaching members to move away to a different region in order to complete their part of the quest. As this scenario did not happen in all of the *Save Peasant* quests the movement patterns are not quite similar to be categorised under a single class of movement data.

Participants on completing *Save Peasants* quest

We have already mentioned there are different strategies which were adapted in completing the *Trade and Commerce* quest, even though there were two prominent strategies in this quest the *individual strategy* also had certain tactical difference between them. For example one of the members in the couple of the groups which adapted this *individual strategy* went about visiting all the points of interest that is the

Strategy oriented quest

shops while others just visited a handful. This caused quite unique movement patterns. While the movement patterns in the other strategy were completely different. Hence it was not easy to classify all of movement data under one class for this quest.

Some of the groups for a few of the quests initially discussed together on how to go about to finish the quest while many of the groups just started the quest right away after the instructions were orally presented. Lack of communication among the members caused some members to move lot more and this was observed in some of the groups. There were multiple visits to different points of interests. Thus causing more uniqueness in the movement data.

Here are ways to improve the accuracy of predictions:

Ways to improve accuracy of prediction

- Increase the number of data samples.

- Explain the game concept clearly with demonstrations so that grouping might not occur to clarify the game concept amongst members or help each other.

- Increase the number of complete groups which can be included in the data analysis.

- Depending on the strategy adapted by the groups classify those groups for that particular quest together.

6.3.2   Contrasting with previously obtained Results

In this section we will discuss about the key aspects which had a profound impact on the result obtained in this study as contrasted to the results obtained in the work by [Huch, 2013, p. 93]. In his work there were distinct subgroups formed during the *Trading Quest* while there was no distinct sub-grouping in the *Archeological Quest*. The distinct sub-grouping was due to the layout of the streets or due to game location. The ease of communication when in groups out weighs being separate, therefore players are able to help

Clear grouping phases observed

each other figure out the game concept better and finish the game more quickly.

In the current work there were no distinct times when there were grouping, though players did come together occasionally in some of the quests. This could be due to the openness of the park which allowed players to see or be in the line of sight of one another. The provision of walkie-talkie and other forms of in-game communication virtually connecting them as a group together hence they did not form subgroups during the quests. The confounding variables which we had considered while designing the new prototype have made the difference in the results which are obtained. This caused less distinct grouping phases in the quests and allowed more movement patterns.

No distinct grouping phase and cause behind it

6.4 Questionnaire

The Likert Scale is a very powerful tool which can be used for evaluation feedback. The 5 point Likert Scale is for values between 1 to 5 and the corresponding answers in the questionnaire would range from *Strongly Agreed*, *Agreed*, *No Idea* or *Neutral*, *Disagreed* and *Strongly Disagreed* respectively. In our user study we are following this convention:

Likert scale convention

1. Agreed

2. Rather applies

3. No Idea

4. Not really applies

5. Disagreed

The questionnaire can be accessed from these images B.7 and B.8. As explained earlier for the analysis of the feedback all seven groups are considered. The following Likert Scale images were created using this website[2].

---

[2]http://www.likertplot.com/

6.4.1   Demography Details

Who were the
participants

The prototype "mLog2" was tested by 28 participants in 7 user groups. The participants were between the age of 23 and 30 years, six of them female and the rest male. Amongst them only one was doing a job, one was on internship while the rest were students. And only six of them had played a location-based game before. Many of the participants were from computer science background. The sessions were scheduled based on when they were all free together and also based on when the weather was favourable. In many of the groups the team mates knew each other before hand and only for couple of the groups had this scenario with each team member knowing only one other member.

### 6.4.2   Investigating the Feedback
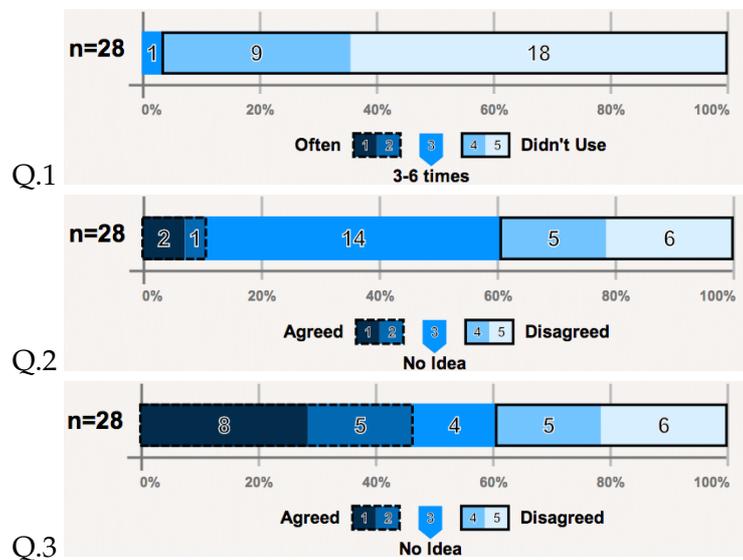
Figure 6.9: Take on Features

The first set of questions were dedicated to getting to know the users opinion on the various communication features in the prototype. The Q.1 was **How often did you use the Text Messaging with Siri**. The option for this question varied

between *Often, 3-6 times* to *Did not Use*. More than half answered that they did not use this feature and only a handful tried this feature during the quests. Q.2 till Q.11 was based on the Likert Scale which we had mentioned earlier 6.4. The Q.2 was **Text messaging is easier with Siri** and exactly half answered that they did not have the slightest clue, while others who had tested this feature answered saying it was not so easy to use though a few did find it easy to use. We speculate that as text messaging feature itself was not so extensively used they were not able to judge it very well, as previously in [Huch, 2013, p. 101] work the text messaging was found to be relatively easy to use and the participants had tried it extensively.
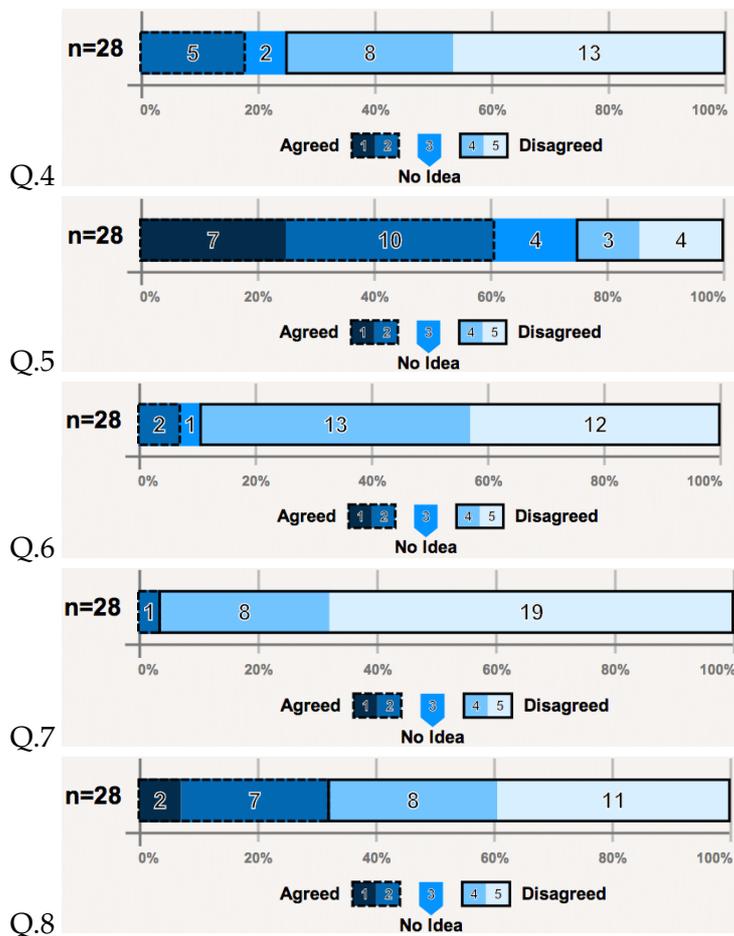

Figure 6.10: Game Aesthetics

From the Q.3 we needed the users poll on **I prefer the Voice Messaging (not walkie-talkie) over Text Messaging** and here opinions were very mixed. As voice messages are logged onto the server we can find out which groups had used it for communication purposes and only a couple of groups used this feature. So we could only speculate that some of the participants might have misunderstood the voice messaging feature for the walkie-talkie. One thing can be observed from all these is that owing to the ease of use and convenience of walkie-talkies, participants rarely used the other communication features in the prototype like voice messaging, text messaging either with or without Siri.

In the next part of the user feedback we wanted to understand what they felt about the game aesthetics. The Q.4 was **I felt the movement in the quests were limited or constrained** and for this nearly half of the user felt they were not constrained while a handful did feel they were nearly constrained. In the comments, suggestions section in the feedback only one user explained that their movement was probably constrained due to the presence of trees and bushes.

The Q.5 was **The Beacon props on the ground in the *Lost Recipe* quest acted better as a visual clue rather than the beep sound**. This question was posed to find out if the audio feedback that a player would have heard when the player enters within a certain vicinity of an archaeological site is useful and to understand if people saw the sites first and then they heard the sound. More than half felt that sound was not that useful as they saw some of the sites first. Only a few were inclined in saying that they heard the audio feedback and then followed it around to find the site itself. This can be noticed in the suggestions which were written in text form where a few of them said to hide or camouflage these archaeological site better as they saw it first. Though some did agree that the audio feedback was really useful.

The Q.6 was **Was the *Lost Recipe* quest too long** and nearly every one felt this quest was not very long though a handful of them did express that it was long. The Q.7 was **Was**

Users take on the features of the prototype

How were the game aesthetics

the *Save Peasant* **quest too long** and more than half found
it was not long at all. The Q.8 was **Was the *Trade and Com-
merce* quest too long** and nearly half thought that this quest
was too long and rest felt it was time consuming.
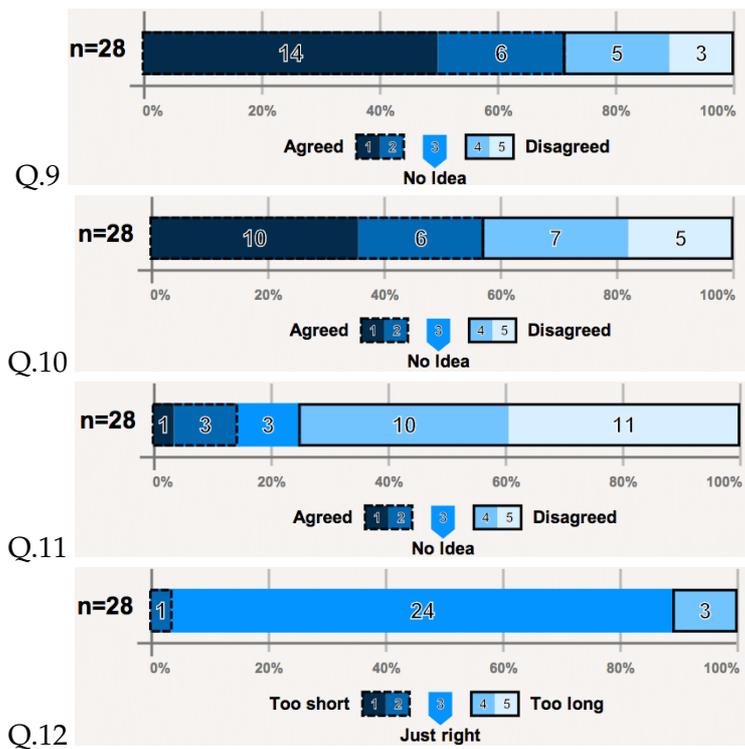
Figure 6.11: Strategy Involved in the quests

In the next section of questions we wanted to know what
sort of strategies the player adapted while playing the
quests. The Q.9 was **I intentionally separately from my
team mates** and well over half accepted that they inten-
tional split up from their team mates during the course of
the game. The opinion to this question has no bearing with
the finding of correlation between the different strategies
used and number of trade of goods between players.

The Q.10 was **We strategized to go together as subgroups**,
thus getting the players' perspective if they did move
around in subgroups at any point in time. And little over
half of them did concur to the above statement. This was
likely as many a time the player crossed over others' path

and on doing so discussed what were the next steps to be taken or find out the state of each others' game, thus giving the players an illusion they formed subgroups while in reality there were no clear elongated periods of subgroups which one can be notice from the geo-sociograms.

Strategy deployed in the quests

The next Q.11 was **I prefer the individual quest rather than the group strategizing** and this was to see if player feel opinionated to say that they want to play some of these quests as individuals. And only very few said they preferred a more individual type of quest. As from this data we can not pin point which members in the group preferred the individual type quest hence can not verify if they were the same individuals who adapted the *individual strategy* in the *Trade and Commerce* quest. The final question in this section was to find out Q.12 **Total walking was**. Here the options varied from *Too short*, *Just right* to *Too long*. And nearly every one felt that the total walking was just right. Perhaps this was because they had certain breaks in between the quests and had enough resting time when the next quest was being explained.

Rating of the quests and the game

In the final section we wanted the users to rate each of the quests and give their opinion about the entire game. Here the options varied from *Very good*, *Average* to *Very bad*. The Q.13 was on **Lost Recipe Quest** and here lot of them rated the quest quite high. This was despite the troubles the members of the group got into with not being able to find the last site or finding a site but not digging it. That was perhaps because this quest was designed to captivate and engross the players well. The Q.14 was on **Save Peasant Quest** and here lot of them rated the quest quite good. We speculate that the player did not take too much to finish this quest thus might were not mentally stimulated or most of the players understood the game concept so did not find it as challenging. The Q.15 was on **Trading Quest** and here well over half agreed and rated it quite high. And this was perhaps because this last quest was little more time consuming, complex and thus challenged the player more than the other two quests did. And finally the Q.16 was on **The Game** and nearly everyone rated the game either good or high.

Q.13

Q.14

Q.15

Q.16
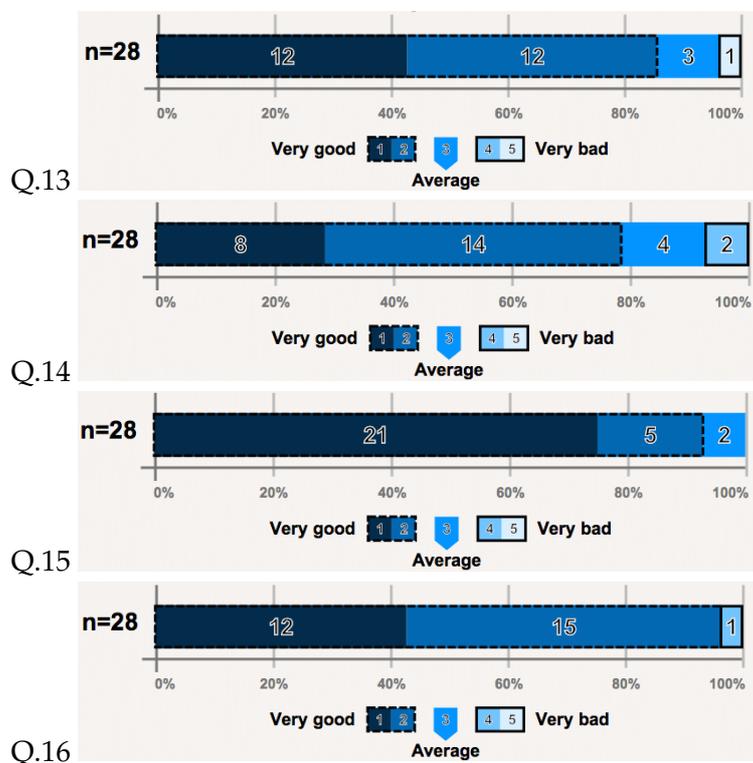
Figure 6.12: Rating each quest and the game

6.4.3 User Comments

Here in this section we will discuss certain interesting comments and suggestions that were written in text form at the end of the questionnaire. Also we will be mentioning certain comments which the bystanders said while watching the game or while setting up of the game. Only a few of the participants gave written feedback while all of them did mention their thoughts and their opinions vocally. All the written feedback can be accessed through Group Questionnaire in Appendix B.

A couple of the participants complained about not able to hear the audio beeping which assists the players in finding the sites in the *Lost Recipe* quest. This was due to low volume on that iPhone which might have got changed from the original settings of high volume as we later verified.

Audio related issues

Prop related change suggested

Some of them suggested to make the beacons on the ground less visible by putting a possible form of camouflage or to hide them in the bushes and trees therefore making the quest more interesting. They said that some times after the first two beacons they realized how the beacons looks like and thus saw the beacons first and then heard the beeping sound. And also one of them suggested there could be possible improvements to UI but did not go into any specifics.

Game changing idea

There was an interesting suggestion to split the entire group into two teams and pitch one another to make the game more interesting and fun as it brings in a feel of competition to it.

Demonstrate or Trial

Couple of them did suggested to have like a trial run for some of the parts of the game or give a test demonstration of how the device works in relation to the props so as to get a feel of the game. Also perhaps randomising the positions of the *sites* and *shops* was suggested.

User Critics

In the *Lost Recipe* quest couple of players did express that it was quite painstaking to swipe most of the screen to dig out a site. A few of them did find the jumping of GPS and having to wait for it to update in the *Save Peasant* quest a little annoying. And one did say that the bushes or tree did constrained their movements. Many of them did not like the beacons as they found that concept a little hard to grasp. This was due to the fact that the players were required to stay close to the beacons for a little while before they could proceed in the quest. One of them did criticize that the chat related feature were useless with the use of walkie-talkies and also felt that the quest idea was not very exciting to that participant. One of them did suggest to have the walkie-talkie built in completely as part of the prototype as that participant found it difficult to switch between the two devices. One participant also suggested to show direction of movement or to align the map in the direction of movement.

Users delighted with the Game

Most of them really enjoyed and liked the game, complimented positively on the wonderful game. All of them enjoyed the interactions in the game via the walkie-talkie. Some did mention that the complete game was time con-

suming, but most of them liked the final quest *Trade and Commerce* as compared to the other two. All of them found the *Save Peasant* quest was the easiest to play.

Lots of bystanders at the park were very curious about the game itself and asked all sorts of questions. A few of them took a keen interest in finding out if it was possible to download the game and if it was free. A few of the children wanted to see how the game is being played and were curious for a demonstration. A few of them were kind enough to help retrieve the beacons and props after the game was done in the hope of taking part in the game.

Bystanders' curiosity

Chapter 7

Recommendations for User Studies

While conducting the user study in an open field and having use special props to indicate the points of the interest in the game, there are several things one must keep in mind while designing and executing the study. So here are some of the lessons learnt which one should consider while designing an user study or game of this nature.

7.1 Equipment and props on field

In our user studies the *sites* for the *Lost Recipe* quest needed to be close to the ground hence the props were made from 10mm thick and 10cm long wood pieces with ends sharpened with a hand knife to be able to stick it into the ground. These flagpoles are intended to be partly hidden by being stuck to the ground. As these can attract the attention of the onlookers especially children and pets it is advised to stick these flagpoles deep into the ground so that any tampering of these props could be immediately spotted. Also one must put a sign seen in the figure B.11 on them. Similarly for the *shops* in the *Trade and Commerce* quest the props were 1m long and 10mm thick round wood pieces with ends sharpened by a hand knife. These flagpoles were also la-

Theft proof prop design

belled with a sign seen in the figure B.11. Thus any tampering or position alteration is easy visible. Here is an image of the props which we designed and used on the field:

Figure 7.1: Prop Design

The props should also be designed to withstand certain weather conditions like rain, wind and heat. So it is advised to use all weather proofing for the props. This will also gives more flexibility in terms of playing the game in non-idealistic conditions. The props must be clearly labelled to indicate that they should not be tampered with. In case of the children and pets who perhaps might not be able to grasp the crux of the on going situation, do convey the purpose of the study to the supervisors of the children or pets and requesting them to keep away.

Weather proofing equipment and making bystanders understand

7.2 Setting up the field

Efficient field set-up plan

Do ensure to keep a helper to assist in the setting up of the field for the study and to prevent the props from getting tampered or damaged. To optimize how quickly all the flagpoles can be placed, one can make use of certain reputed shortest distance edge tracking graph algorithms.

Improve accuracy of prop positioning

While setting up the field or park for a game session one would use GPS tracking to position the props in their correct locations. On doing so there is a good chance of erroneously positioning of the props and it could be off from its correct location by over 5 metres. To make a more reliable positioning of the props its recommended to keep certain physical marker for example the positioning of the prop is based against something relatively stationary on the field like a tree or a big rock or at a certain distance from a walk-

ing path etc. These will help improve the positioning better over all the game sessions and give a possible positioning error of 2 to 4 meters.

One could design the game to be set up in a much smaller size area, given that the technology used could clearly distinguish the positions in the smaller area. Then the data collected could be extrapolate via simulation for an equivalent larger size field or park. Therefore this would avoid the issues one could face while conducting an user study in an open field or park like weather related issues, interruptions by bystanders, etc.

Game designed for smaller location

7.3 Preparing participants for study

It is recommended not to give the participants any instruction manual as more often they will not listen to the instructions which is being said and nor will they have enough time to read the instructions. Hence the participants will have lot more questions while playing the game. It is best to present the instructions orally. It is advisable to have a demonstration session to train the participants on how to use the devices in relation to the props on the field, thus allowing participants to practice before hand.

Demonstrate game to train participants

When creating a group try to shuffle the participant together in such a way that, a participant knows at least one other participant in that group. Also plan the group in a such a way that the they have reasonable similar knowledge of that type game that is being tested like about the language of instructions and know-how of the technology being tested. This could be established by a survey prior to the user study to understand the demography better. It could be possible that participants do not turn up for the user study despite having agreed to come, so keep a person as back up just for such a scenario. It is quite possible that the props used are not suited for all weather conditions. Do make sure that the study is closely scheduled based on the availability of the participants, freeness of the park or field and appropriate weather condition. Hosting such an user study in a controlled indoor environment would be best.

Knowing your demography and weather related preparation

7.4   Device used in study

As our studies were taking about an hour, the batteries on the devices were heavily consumed due to GPS-tracking and the iPhone screens not locking at all. Thus it is advisable to use mobile-battery charger packs which fits direct on the phones. And if the user study involves logging of the data on the devices do make sure to immediately check if all the logs are present after the entire study is complete. Owing to the big size of the playing field it is advisable for the observer to have a walkie-talkie tuned to same channel and frequency as the players so as to assist them at any point without having to travel the distance to reach the players.

Figure 7.2: Battery pack for iPhone

After having set up the field and devices, do not shut down the devices to save battery power as this would possibly replicate number of instances of game elements on restart depending on how the game is designed. In game sessions it is necessary to have a common start and finish points in time, thus it is important to design the game or prototype keeping time synchronization as a high priority item. Relying on the participants to sync the beginning of the game session is not the most recommended plan.

Chapter 8

Summary and future work

Here is an overview of the entire project highlighting the design decisions and implementation. We will mention the contributions to the field of location-based games and idea which could be implemented as part of future work.

8.1   Summary and contributions

The aim of this thesis was to distinguish the movement data based on which quest it belongs to. To reach this goal we redesigned game concepts, designed a new location-based quest, reimplemented certain parts of the existing game and introduced new features to create the "mLog2" prototype. The quest-driven multi-player location-based game was redesigned to be played in an open park. Here is the summary of what were described in all the chapters.

Overview of the thesis

This Chapter 2 - "Related Work" gives details of how others work in the field has influenced our work. We did explore the field of proxemics, some good practices for design of location-based games and other types of game designs that moulded the field. These gave us invaluable insight, ideas and thus influenced our work.

The Chapter 3 - "Game Design" goes into details about game concept and how it has been changed for this thesis work. We described the goals of the thesis and how this thesis will answer those questions. We described the storyline or the plot which we have adopted for this prototype.

Here in the Chapter 4 - "Completion of the Game", we go into details about the process of making the new quest. We mentioned about the changes in design of existing game, the new features that are added and how the location of the game was chosen. We also deep dove into all the audio based chat systems which were explored.

In this Chapter 5 - "Final Implementation" we mentioned about the graphical user interface and what was its final form in the prototype for all the screens. We clarified about the hardware usage for the user study. The software architecture used in the prototype was also described in detailed. We emphasized about the pilot study and how the user feedback from those studies influenced our work.

The Chapter 6 - "Evaluation and Data Analysis" discusses in great details about the results of the experiment and its implications. Firstly we indicated how the data was collected, then the procedure we followed to arrive at the results from the available data and then how we inferred the obtained results. We also go into details about why the results were so and explained them. Here we contributed a procedure to follow to distinguish movement data for a location-based games played in a park. We also tried to find correlation in the quest related data and observed a causal relationship between the game elements and strategy used for a particular quest. We interpreted the contextual meaning for quests based on the proximity-based plots. Then we explained the feedback and comments by users.

Finally in the Chapter 7 - "Recommendations for User Studies", we described certain recommendations that one must consider for an user study. We examine the various aspects like preparing equipment, devices, participants, bystanders etc. which one must keep in mind while designing and executing an user study.

8.2 Future work

In the current work we had initially set the goals of the research in this section 3.2. We have designed and set up the game for an open park location hence reducing the confounding variables which were present in the earlier "mLog" game. We have allowed more freedom in movement by allowing the transferring of game elements at any point in time and at any location during the game session. Also introducing more forms of communications enabled the participants to move more freely during the game sessions. We have created a new type of location-based game and tested the prototype in an extensive user study. On analysing the logged data, we have been able to define a procedure to categorise the movement data into different data sets. We have found causal relationship between the strategies used in a particular quest to the game elements in that quest. We have also found correlations between the distance travelled during the game and the total time taken to complete it. The other contributions were the recommendations and good practices for an user study. Thus we have achieved the goals we had set in this current work.

Achieved the goals of current work

We have emphasized in the section 6.3.1 that a particular strategy has bearing on how the movement patterns turn up, we would like to explore categorising movement data based on strategies deployed for a quest and then classify them using the described procedure in this thesis. We would require to learn and observe the various strategies that are involved in the quests. We believe that this initial segregation will allow us to better categorise the data, thus giving higher accuracy of prediction on using the binary classifier. To prevent the issues with the accuracy of prediction by SVM due to numerical stability of the training data, it would be appropriate to randomise the start location of the game session and randomise the various points of interest like sites, peasants and shops for each of the game sessions. As part of future implementation we will work on improving this prototype by including the above mentioned changes and incorporating valuable user feedback. And will put to practice the recommendations for any user study that would follow.

Strategy based classification and robust prototype

Appendix A

Setting up of the game

The source code of the "mLog2" is available at the following URL:

> File: mLog2Source[a]
> _____
> [a]http://hci.rwth-aachen.de/~simha/thesis/mLog2Source.zip

The source code of the "BeaconStatusCheck" is available at the following URL:

> File: BeaconStatusCheck[a]
> _____
> [a]http://hci.rwth-aachen.de/~simha/thesis/BeaconStatusCheck.zip

Here are the steps to install the software on a jail-broken iPhone 4S with iOS 7.1.1 installed:

1. Open the "mLog2.xcodeproj" file with Apple XCode 5.1

2. Change the SERVER_IP and SERVER_PORT under preprocessor macros in the prefix file according to the used CouchDB Server.

3. Change the Beacon UUID and Beacon String Identifier under preprocessor macros in the prefix file according to the iBeacon™ used.

4. Compile the software using the iOS 7.1 SDK and with deployment target version set to 5.1 and select the "Debug" mode if you wish to setup the playing field or park, thus allowing you to see all the points of interest loaded, like sites and shops. To run an user test always compile in "Release" mode.

5. Connect the iPhone to computer and then click "Run" to install it on the device.

6. The game "mLog2" will appear on the home screen.

The corresponding log files are stored in the folder "Documents" in the app bundle as SQLite files. The only way to access these by opening the "Organizer" window in XCode and selecting the particular device and specific application and downloading the App Data file (extension .xcappdata).

Following are the steps to be followed to setup the field for the game with flagpoles and devices before beginning the user study:

1. Charge all four iPhones, iPhone battery chargers, walkie-talkies and Macbook Pro to full 100%.

2. Go to the park between Kirchratherstrasse and Pariserring in Aachen given by these coordinates (50.774061, 6.051898).

3. Make sure to have one iPhone with "mLog2" App installed in "Debug" mode and start placing flagpoles corresponding to locations of the shops in the *Trade and Commerce* quest. Open the "mLog2" App on the iPhone and after pressing "Done" enter into *Trade and Commerce* quest. Once the map is loaded, find the positions of the shops here A.2(a), then find the corresponding iBeacon Minor number and place the beacons at that location. There could be error due to GPS while placing so do wait till the GPS has stabilized.

4. Similarly reopen the "mLog2" App on the iPhone and after pressing "Done" enter into *Lost Recipe* quest. Once the map is loaded, find the position of the sites here A.2(b), then find the corresponding iBeacon Minor number and place at that location. There could be error due to GPS while placing so do wait till the GPS has stabilized.

5. While placing the beacon open the beacon container and place the battery in the beacon chip then close the container. With the "BeaconStatusCheck" App determine the battery status and replace battery accordingly if the status is estimated to be less than 20%.

6. After having placed all the beacons are in the right locations and secure, go to these following links where your CouchDB is installed:

   game_test `http://SERVER_IP:SERVER_PORT/_utils/database.html?game_test`

   chat_test `http://SERVER_IP:SERVER_PORT/_utils/database.html?chat_test`

and clear the contents of those two databases or delete them.

7. Set up the databases afresh with code here and save those databases:

```
game_test
{
  "_id": "_design/clientviews",
  "language": "javascript",
  "views": {
    "allExcavations": {
      "map": "function(doc) {\nif (doc.type == \"excavation\") {\n  emit(doc.name, doc);\n}\n}"
    },
    "allPlayers": {
      "map": "function(doc) {\nif (doc.type == \"player\") {\n  emit(doc.name, doc);\n}\n}"
    },
    "allTraders": {
      "map": "function(doc) {\nif (doc.type == \"trader\") {\n  emit(doc.name, doc);\n}\n}"
    },
    "allPeasants": {
      "map": "function(doc) {\nif (doc.type == \"peasant\") {\n  emit(doc.name, doc);\n}\n}"
    },
    "allGuards": {
      "map": "function(doc) {\nif (doc.type == \"guard\") {\n  emit(doc.name, doc);\n}\n}"
    }
  }
}

chat_test
{
  "_id": "_design/chat",
  "language": "javascript",
  "views": {
    "allChatMessages": {
      "map": "function(doc) {\n  emit(null, doc);\n}"
    }
  }
}
```

Figure A.1: JavaScript functions for CouchDB views

8. Install "mLog2" App in "Debug" mode to be able to pre-load all the *Peasants,Guards,Excavation Sites* and *Traders* in the CouchDB by going to each of the three quests separately. Once all of them are preloaded delete the instances of *players*, *locations* and *group matrix* in the database.

9. On all the iPhones kill the corresponding process for the "mLog2" App and remove "mLog2" App.

10. One at a time install "mLog2" App via XCode in "Release" mode and stop running the installation from XCode once the "King Orders" screen appears. Then kill the corresponding process for the App on that iPhone.

11. After each of the iPhones have been installed with the game then, in the same order of installation restart the game and lock the screen.

12. Once participants have arrived explain to them the "Solomon Agreement" document one can find it here B.9 and get their signatures.

13. Explain the features of the game and only one quest at a time until they complete a quest and return back to the starting point with the help of the "Instructions" document one can find it here B.3.

14. Start the "Voice Memo" on each of the iPhones and then hand them the iPhones which is placed in a battery pack and walkie-talkies.

15. Check and note if there are any technical or non-technical issues either informed by participants or observed and note them in "Notes for Observer" document one can find it here B.10.

16. Once all the quests are complete the participants are requested to hand back the iPhones and walkie-talkies. Then stop the and save the "Voice Memo" on each of the phones. Then the participants are handed over with the "Questionnaire" document one can find it here B.7 which they need to fill and then finally give away the goodies.

(a) **(b)**
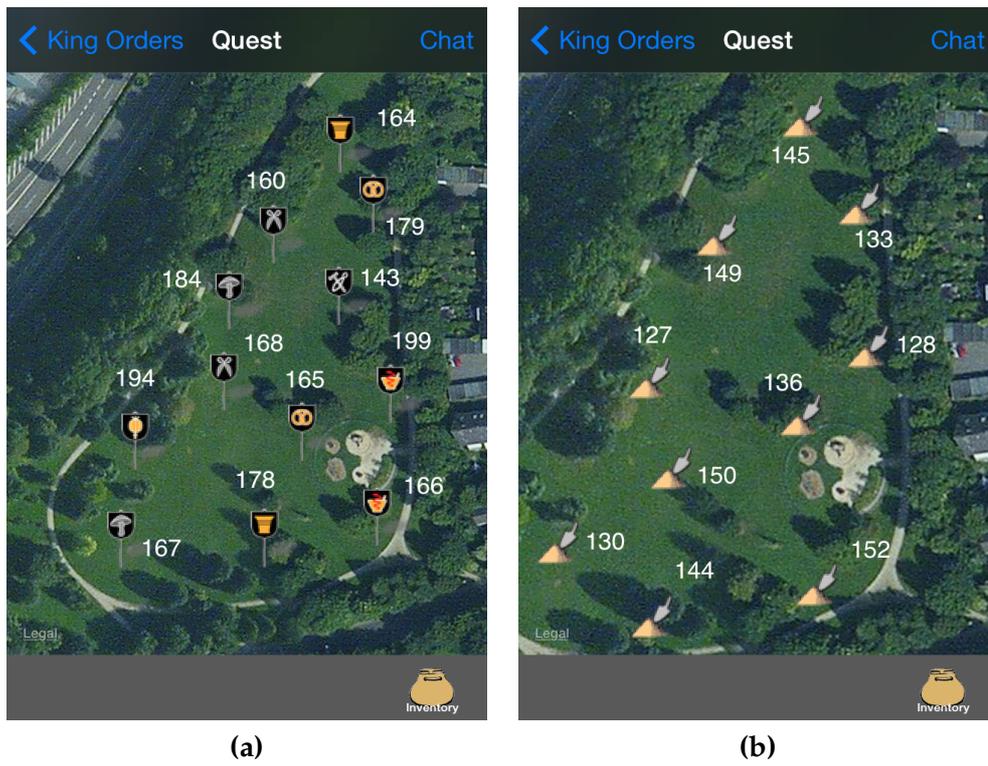
Figure A.2: (a) Shop Locations (b) Site Locations with corresponding iBeacon minor numbers

Appendix B

User Study

This section contains all the actions or activities which took place during the User Study. The URL to all the questionnaires by each of the participants :

> ### File: Group Questionnaire[a]
> ---
> [a]http://hci.rwth-aachen.de/~simha/thesis/Group_Questionnaire.zip

The URL to all logs collected from all device in all quests for all the study groups:

> ### File: Group Logs[a]
> ---
> [a]http://hci.rwth-aachen.de/~simha/thesis/Group_Logs.zip

Here is the URL to all the voice memos which are the entire game play recordings from each of the devices for all the study groups:

> ### File: Voice Memos[a]
> ---
> [a]http://hci.rwth-aachen.de/~simha/thesis/Voice_Memos.zip

Here is the URL to all notes made by observer during the User Studies :

> ### File: Observers Notes[a]
> ---
> [a]http://hci.rwth-aachen.de/~simha/thesis/Observers_Notes.zip

Here is the URL to all the voice messages which were broadcast between players:

> File: Voice Messages[a]
> ────────────────────────
> [a]http://hci.rwth-aachen.de/~simha/thesis/Voice_Messages.zip

Here is a table of all the text messages which were broadcast between players:

Time stamp	Sent by Player	Message
2014-05-18 12:45:06 0000	AIXII 1	Found one

Table B.1: Text Messages by Group 2

Time stamp	Sent by Player	Message
2014-05-19 16:16:18 0000	AIXII 2	Hi all
2014-05-19 16:28:48 0000	AIXII 3	Where is the last one?

Table B.2: Text Messages by Group 3

Time stamp	Sent by Player	Message
2014-05-21 18:41:43 0000	AIXII 1	What have u Guys Forums
2014-05-21 18:42:01	AIXII 2	Found*

Table B.3: Text Messages by Group 5

Time stamp	Sent by Player	Message
2014-05-18 16:45:06 0000	AIXII 1	Juju
2014-05-23 17:00:32 0000	AIXII 4	Who needs fabric?

Table B.4: Text Messages by Group 6

Time stamp	Sent by Player	Message
2014-05-24 10:35:10 0000	AIXII 1	Hola amigos
2014-05-24 10:43:49 0000	AIXII 1	Who is gathering the scrolls
2014-05-24 10:54:34 0000	AIXII 1	Number 3 what
2014-05-24 11:05:18 0000	AIXII 1	Nobody reads my messages

Table B.5: Text Messages by Group 7

Questions / Groups	G1.1	G1.2	G1.3	G1.4	G2.1	G2.2	G2.3	G2.4	G3.1	G3.2	G3.3	G3.4	G4.1	G4.2	G4.3	G4.4
Participant Background																
Age	27	25	24	26	26	24	25	29	25	29	29	30	25	25	24	27
Sex (F/M)	M	M	M	M	M	F	M	F	M	M	F	M	M	M	M	M
Occupation (Student/Job/Internship/Others)	Student	Student	Student	Student	Student	Student	Student	Student	Student	Student	Student	Student	Student	Student	Student	Student
Have you played a location-based game before (Yes/No)	0	1	0	0	0	0	0	0	0	1	1	0	0	1	0	0
Take on the features																
How often did you use the Text Messaging with Siri (Often/6-10 times/3-6 times/Barely used/Didn't use)	5	5	5	5	4	5	5	4	4	5	4	5	5	5	5	5
Text messaging is easier with Siri (Agreed/Rather applies/No idea/Not really applies/Disagreed)	3	3	2	5	4	4	3	1	4	3	3	3	5	3	4	3
I prefer the Voice Messaging (not walkietalkie) over Text Messaging (Agreed/Rather applies/No idea/Not really applies/Disagreed)	4	2	4	1	1	3	1	1	4	3	2	3	1	1	5	3
The Game Aesthetic																
I felt the movement in the quests were limited or constrained (Agreed/Rather applies/No idea/Not really applies/Disagreed)	5	5	4	4	5	5	5	4	2	5	5	5	4	5	5	2
The Beacons props on the ground in the Lost Recipe (first) quest acted better as a visual clue rather than the beep sound (Agreed/Rather applies/No idea/Not really applies/Disagreed)	3	1	4	2	5	1	1	5	2	2	2	3	2	5	2	3
Was the Lost Recipe quest too long (Agreed/Rather applies/No idea/Not really applies/Disagreed)	5	4	5	5	5	5	5	5	4	4	5	5	4	5	4	5
Was the Save Peasant quest too long (Agreed/Rather applies/No idea/Not really applies/Disagreed)	5	4	2	5	5	5	5	5	5	4	5	5	5	5	4	5
Was the Trade and Commerce quest too long (Agreed/Rather applies/No idea/Not really applies/Disagreed)	1	2	4	5	4	5	4	5	4	4	4	2	2	1	2	5
Strategy Involved in the quests																
I intentionally separated from my teammates (Agreed/Rather applies/No idea/Not really applies/Disagreed)	1	2	2	1	1	1	1	1	4	1	1	1	4	1	5	1
We strategized to go together as subgroups (Agreed/Rather applies/No idea/Not really applies/Disagreed)	1	2	2	5	5	5	5	4	1	4	4	5	1	4	1	4
I prefer the individual quest rather than the group strategizing (Agreed/Rather applies/No idea/Not really applies/Disagreed)	1	5	4	5	4	4	4	5	4	5	5	2	5	5	4	4
Total walking was (Too short/It was short/Just right/It was long/Too long)	3	3	3	3	4	3	3	3	2	3	3	3	3	3	3	3
Rating each quest and the complete game																
Lost Recipe Quest (Very good/Good/Average/Bad/Very bad)	1	3	1	2	2	2	2	2	2	2	2	1	3	1	1	3
Save Peasant Quest (Very good/Good/Average/Bad/Very bad)	2	2	2	1	2	2	2	2	1	4	1	2	3	2	1	2
Trading Quest (Very good/Good/Average/Bad/Very bad)	1	1	1	1	1	1	1	1	1	1	2	1	1	3	2	2
The Game (Very good/Good/Average/Bad/Very bad)	1	2	1	2	1	2	1	2	1	2	2	2	2	2	1	2
Suggestions/Comments									*	*				*	*	*

Figure B.1: Questionnaire Combined Data 1 of 2

Questions / Groups	G5.1	G5.2	G5.3	G5.4	G6.1	G6.2	G6.3	G6.4	G7.1	G7.2	G7.3	G7.4
Participant Background												
Age	27	26	23	27	24	26	24	25	29	25	24	24
Sex (F/M)	M	F	M	M	F	M	M	M	F	M	M	M
Occupation (Student/Job/Internship/Others)	Student	Student	Internship	Student	Student	Student	Student	Student	Student	Student	Student	Job
Have you played a location-based game before (Yes/No)	1	0	1	0	0	0	0	0	0	0	0	0
Take on the features												
How often did you use the Text Messaging with Siri (Often/6-10 times/3-6 times/Barely used/Didn't use)	4	4	4	5	4	5	5	5	5	4	5	3
Text messaging is easier with Siri (Agreed/Rather applies/No idea/Not really applies/Disagreed)	1	5	4	3	3	3	5	5	3	5	3	3
I prefer the Voice Messaging (not walkietalkie) over Text Messaging (Agreed/Rather applies/No idea/Not really applies/Disagreed)	4	1	5	2	5	5	5	2	1	4	3	2
The Game Aesthetic												
I felt the movement in the quests were limited or constrained (Agreed/Rather applies/No idea/Not really applies/Disagreed)	3	4	2	4	5	2	4	4	2	3	5	5
The Beacons props on the ground in the Lost Recipe (first) quest acted better as a visual clue rather than the beep sound (Agreed/Rather applies/No idea/Not really applies/Disagreed)	2	2	4	3	1	1	2	4	5	1	1	2
Was the Lost Recipe quest too long (Agreed/Rather applies/No idea/Not really applies/Disagreed)	4	4	4	4	5	3	4	4	2	2	4	4
Was the Save Peasant quest too long (Agreed/Rather applies/No idea/Not really applies/Disagreed)	4	5	4	4	5	5	5	4	5	4	5	5
Was the Trade and Commerce quest too long (Agreed/Rather applies/No idea/Not really applies/Disagreed)	2	4	5	4	5	2	5	2	4	5	5	5
Strategy Involved in the quests												
I intentionally separated from my teammates (Agreed/Rather applies/No idea/Not really applies/Disagreed)	5	5	2	1	1	4	2	4	2	2	1	4
We strategized to go together as subgroups (Agreed/Rather applies/No idea/Not really applies/Disagreed)	2	1	1	1	1	1	2	2	4	4	1	2
I prefer the individual quest rather than the group strategizing (Agreed/Rather applies/No idea/Not really applies/Disagreed)	4	4	5	2	4	5	3	2	5	3	5	3
Total walking was (Too short/It was short/Just right/It was long/Too long)	3	3	3	3	3	3	3	4	3	4	3	3
Rating each quest and the complete game												
Lost Recipe Quest (Very good/Good/Average/Bad/Very bad)	1	1	2	1	1	2	2	2	1	5	1	2
Save Peasant Quest (Very good/Good/Average/Bad/Very bad)	2	4	1	1	3	1	2	2	2	3	3	1
Trading Quest (Very good/Good/Average/Bad/Very bad)	2	1	1	1	1	1	1	2	1	3	1	1
The Game (Very good/Good/Average/Bad/Very bad)	1	2	1	1	1	2	2	2	1	4	2	1
Suggestions/Comments												
	*	*	*	*	*	*	*	*	*	*	*	*

Figure B.2: Questionnaire Combined Data 2 of 2

Game Instructions & Common Script

User Study for mLog2
Vyshantha Anantha Simha
Media Computing Group, RWTH Aachen University

You **all 4** shall be playing **together as a group**, 3 location-based quests and these are designed to be within the confines of the *park between Kirchratherstraße & Pariserring* **(50.774206, 6.051076)** in Aachen. You would require to read the **King Orders** to advance in the game or get clues on how to complete the different quests. Some of the quests require you to work individually and some to work together as a group or as sub-groups. To help you communicate during the quests the following features are available besides the walkie-talkies.

1. One can use the **Text Messaging** system which can be access by clicking on **Chat** link on the top-right on the navigation bar and then selecting the Text Field to enter text by typing.

2. On selecting the Text Field you could see a microphone like button which allows you to use the built-in **Siri** feature to convert *Speech to Text*, and this could be used to send **Text Messages**.

3. Also on the left-side of the Text Field one can see a small **Recording Spool** image which will allow you to record messages and then send them as **Voice Messages**. These messages on being received give an alert in form of phone vibration and then play immediately. One can also *replay* these messages by clicking on the latest Voice Message, which can also be accessed by clicking on **Chat** link. Recommend you to use this feature like a *walkie-talkie* and only record & send about **10 seconds** long audio for best performance. This kind of a message would take about 3-4s to reach you teammates. Use this when the actual walkie-talkies are **out of range** to reach your teammates.
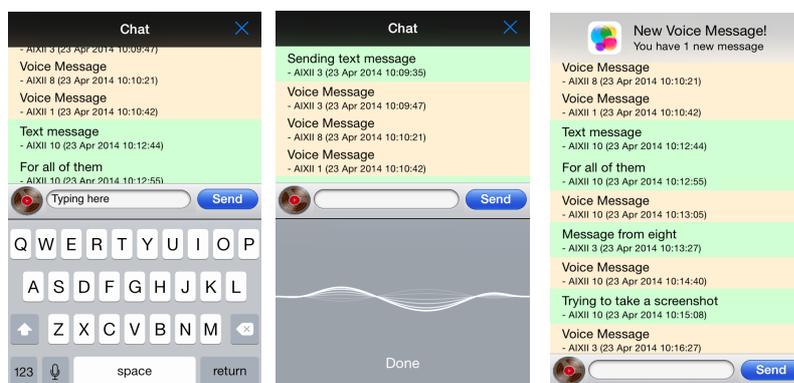
Figure B.3: Common Script and Instructions for all Game Sessions 1 of 4

Recommendation for players during the quests: Request you to **not to leave** the Game screen. Handle the *devices with caution* and *do not damage the props* on the park. You can *zoom in/out* of the Map using touch gestures. **Do not lock the screen** or **mute the phone** or **change any phone settings** at any point of time while playing the quests. During the quests its suggested to walk slowly around to let the GPS update correctly. On completing your part of the quest, request you to either **wait for a prompt** to go back to the King or go to Chat if needed. After all of you have completed their quests request you to return to **start point** for instructions for the next quest. You may use the walkie-talkie *anywhere* and *anytime*. The audio during the entire game will be **recorded**. Make sure each of you know who has which **phone number** at the back.

In the **Lost Recipe** quest you are required to abstractly move around this park to locate different archeological sites. To help you find these sites, once you are in the vicinity of the site then you will hear a *scanning beep* sound at regular intervals till you are next to/at the site, then the phone **vibrates** and a visual alert **pops** up saying you have discovered the site. After that you would see a *shovel* image. If you go away from the site then the *shovel* become partly **transparent**. You are required to click on the site to show an **info button**, on clicking that you open the archeological site, where you need to dig for the ancient scroll by **swiping** on the phone until the **scroll is entirely** visible. Once you have dug the scroll, it will be stored in the inventory. To complete the quest you need to **transfer all** the *scroll* to **one player**. This can be established by clicking on the **Inventory** button at bottom-right, then selecting the player to whom you would like to transfer and then selecting the particular scroll itself. While **transferring** make sure both players have their **inventories open**. You can see all the sites which you have discovered. Recommend **only one** player to **dig one** site.
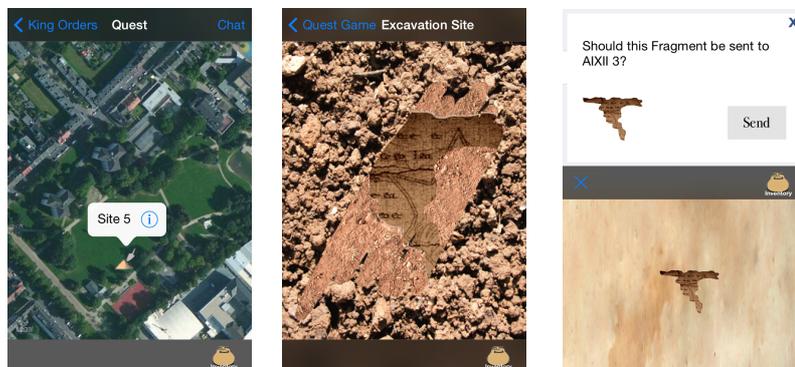
In the **Save Peasant** quest you are required to strategically move around this park to save as many peasants as possible. These guards can only save certain **number of peasants** under their influence **simultaneously**. The Peasants change colour from default **red** to **green** once you are in the **vicinity** of the Peasant and to place the guard at your location you are required to press **Place Guard** button at the bottom-middle and then press **Done**. You can also **Cancel** the placing of the

Figure B.4: Common Script and Instructions for all Game Sessions 2 of 4

guard. If you have secured a peasant but **move away** from its vicinity then Peasant would appear partly **transparent**. To save another peasants you can **reposition** your guard at any time you are within the vicinity of another peasant. On reposition you may **unsafe** a previously **safe** Peasant. Once the guard has *saved maximum* number of peasants the guard can then you need to wait until the other players have done the same. You are only provided with **one Guard** and you can not see where others have placed their guards. You may click on a Peasant to get their **current state**. Recommend **only one** player to **save one** peasant.
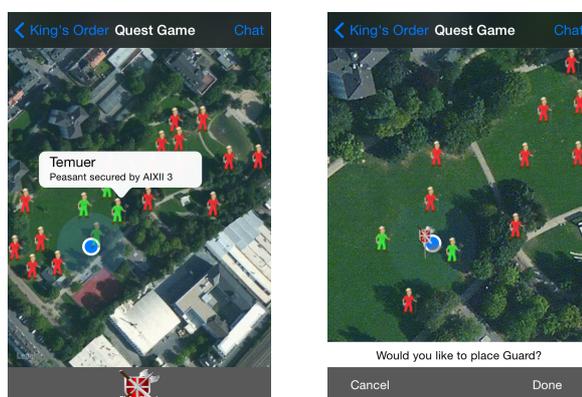
In the final **Trade and Commerce** quest you are required to abstractly move around this park to locate different shops which are located near the *flagpoles*. On locating the shop the phone **vibrates** and a visual alert **pops** up saying you have discovered the shop. After that you will see an **icon** corresponding to the shop. If you go away from the site then the *icon* become partly **transparent**. You are required to click on the shop to show an **info button**, on clicking that you open the shop. Then you can start negotiating with the shop owner to trade for particular goods by **clicking** on the goods which you have and goods which trader provides. Once a right deal is possible then you need to select the **how of many** of those goods are needed before pressing **OK**. If **no deal** is acceptable then you need to find the goods in a different shop. The trading happens in the **Barter** system type setting. Thus you would need to do multiple exchanges in order to get the required goods which the **King Orders**. Once the exchanged goods are obtained it shall be stored in the inventory. To complete the quest you need to **transfer all** the *required goods* to **one player**. This can be established by clicking on the **Inventory** button at bottom-right, then selecting the player to whom you would like to transfer and then selecting the particular good itself. While **transferring** make sure both players have their **inventories open**. You can see all the shops which you have discovered.

Figure B.5: Common Script and Instructions for all Game Sessions 3 of 4
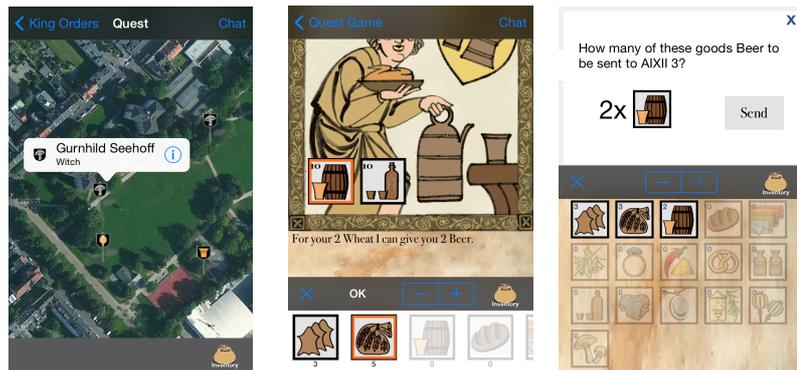
Figure B.6: Common Script and Instructions for all Game Sessions 4 of 4

Questionnaire

User Study for mLog2
Vyshantha Anantha Simha
Media Computing Group, RWTH Aachen University

User Study Group ID: ___

Participant background

1. Age: ___ , Sex: F ❑ / M ❑

2. Occupation: University Student ❑ / Internship ❑ / Job ❑ / Others ❑

3. Have you played a location-based game before: Yes ❑ / No ❑

Take on the features

1. How often did you use the Text Messaging with Siri
Often ❑　　　6 - 10 times ❑　　　3 - 6 times ❑　　　Barely used ❑　　　Didn't use ❑

2. Text messaging is easier with Siri
Agreed ❑　　Rather applies ❑　　No Idea ❑　　Not really applies ❑　　Disagreed ❑

3. I prefer the Voice Messaging (not walkie-talkie) over Text Messaging
Agreed ❑　　Rather applies ❑　　No Idea ❑　　Not really applies ❑　　Disagreed ❑

The Game Aesthetic

1. I felt the movement in the quests were limited or constrained
Agreed ❑　　Rather applies ❑　　No Idea ❑　　Not really applies ❑　　Disagreed ❑

2. The Beacons props on the ground in the Lost Recipe (first) quest acted better as a visual clue rather than the beep sound
Agreed ❑　　Rather applies ❑　　No Idea ❑　　Not really applies ❑　　Disagreed ❑

3. Was the Lost Recipe quest too long
Agreed ❑　　Rather applies ❑　　No Idea ❑　　Not really applies ❑　　Disagreed ❑

4. Was the Save Peasant quest too long
Agreed ❑　　Rather applies ❑　　No Idea ❑　　Not really applies ❑　　Disagreed ❑

5. Was the Trade and Commerce quest too long
Agreed ❑　　Rather applies ❑　　No Idea ❑　　Not really applies ❑　　Disagreed ❑

Figure B.7: Questionnaire for Users 1 of 2

_____

Strategy Involved in the quests

1. I intentionally separated from my teammates
Agreed ❑   Rather applies ❑   No Idea ❑   Not really applies ❑   Disagreed ❑

2. We strategized to go together as sub-groups
Agreed ❑   Rather applies ❑   No Idea ❑   Not really applies ❑   Disagreed ❑

3. I prefer the individual quest rather than the group strategizing
Agreed ❑   Rather applies ❑   No Idea ❑   Not really applies ❑   Disagreed ❑

4. Total walking was
Too short ❑   It was short ❑   Just right ❑   It was long ❑   Too long ❑
_____
Rating each quest and the complete game

1. **Lost Recipe Quest**
Very good ❑   Good ❑   Average ❑   Bad ❑   Very bad ❑

2. **Save Peasant Quest**
Very good ❑   Good ❑   Average ❑   Bad ❑   Very bad ❑

3. **Trading Quest**
Very good ❑   Good ❑   Average ❑   Bad ❑   Very bad ❑

4. **The Game**
Very good ❑   Good ❑   Average ❑   Bad ❑   Very bad ❑
_____
Suggestions/Comments

Figure B.8: Questionnaire for Users 2 of 2

Solomon Agreement

Evaluation of Movement Patterns in Location-based Multiplayer Games

DIRECTOR OF STUDIES: Vyshantha Anantha Simha
                         Media Computing Group
                         RWTH Aachen University
                         Telephone: 0049-176-4704-5961
                         E-Mail: vyshantha.simha@rwth-aachen.de

Goal of this study: The aim of the study is better understand influence of location-based game on movement patterns of the participants playing the prototype location-based game App on a mobile device. The interactions with the devices and players locations are evaluated in the analysis.

Procedure: The players asked to play a three part quest driven game, which involves them to move around in the confines of the *park between Kirchratherstraße & Pariserring* in Aachen. On completion of the study there will be a brief questionnaire on use of features in game, strategizes used and your thoughts on the game itself.

Risks & Problems: It is possible that you are not completely ready to participate in the study, you need not worry as during the studies there will be enough time to recover or take additional breaks if needed. If the task or questionnaire is strenuous, you could opt to end it immediately. In case of unintentional or malicious movement of props used by non-participants at the study location, then the study could recover or restart or cancel depending on the situation.

Benefits: The results of the studies are available under the evaluation section of the Master Thesis. This is a voluntary participation so you are free to cancel when you like. As a token of appreciation the participants as a group shall receive goodies worth of 25€ at the end of the whole studies.

Confidentiality: All the information collected during the study phase will be kept strictly confidential. No publication or reports from this studies will include personal information which are presented by participants. If you commit to agree to be a participate in this study, please sign below.

❏ I have read and understood the information on this form.
❏ The instructions on this form have been clarified.

_____   _____   _____
Name of Participant   Signature of Participant   Date

                                    _____   _____
                                    Signature of Director of Studies   Date

If you have any questions about this study do contact the Director of Studies.

Figure B.9: Solomon Agreement: Participants required to sign

Notes for Observer

User Study for mLog2
Vyshantha Anantha Simha
Media Computing Group, RWTH Aachen University

User Study Group ID: ___

Time Noted at beginning of Game: on   __-__-____   at: __:__

Time Noted at end of Game: on   __-__-____   at: __:__

Grouping/Strategizing Happening between participants (whom, when, where and context to be noted):
Lost Recipe:

Save Peasants:

Trade and Commerce:

Any technical issues with the App/props itself:

Any non-technical issues to be noted (with weather related, etc.):

Figure B.10: Notes to be taken during game session by Observer

BITTE, NICHT BERÜHREN!

PLEASE, DO NOT TOUCH!

STUDENT PROJECT/PROJEKT

MEDIA COMPUTING GROUP

Figure B.11: Sign present on all props to inform bystanders

Appendix C

Data analysis

The URL for all the Google Earth based tracking collected from each of the devices all groups for all quests combined :

> #### File: Google Earth Tracking for Groups[a]
> ———————————
> [a]http://hci.rwth-aachen.de/~simha/thesis/Google_Earth_Tracking_Groups.zip

The URL for all the Google Earth based tracking collected from each of the devices all groups for quests-wise :

> #### File: Google Earth Tracking Quest-wise[a]
> ———————————
> [a]http://hci.rwth-aachen.de/~simha/thesis/Google_Earth_Tracking_Quests.zip

The URL for all the Proximity-based Plots for the quest *Lost Recipe* :

> #### File: Proximity Plots for all Archaeological Sites[a]
> ———————————
> [a]http://hci.rwth-aachen.de/~simha/thesis/Proximity_Plots_Sites.zip

The URL for all the Proximity-based Plots for the quest *Save Peasant* :

> #### File: Proximity Plots for all Saved Peasants[a]
> ———————————
> [a]http://hci.rwth-aachen.de/~simha/thesis/Proximity_Plots_Peasants.zip

The URL for all the Proximity-based Plots for the quest *Trade and Commerce* :

File: Proximity Plots for all Shops[a]

[a]http://hci.rwth-aachen.de/∼simha/thesis/Proximity_Plots_Shops.zip

The URL for all the quest-wise Geo-sociogram Plots:

File: All Quest-Wise Geo-Sociogram Plots[a]

[a]http://hci.rwth-aachen.de/∼simha/thesis/Quest-Wise_Geo-Sociograms.zip

The URL for all the individual Geo-sociogram Plots :

File: All Individual Geo-Sociogram Plots[a]

[a]http://hci.rwth-aachen.de/∼simha/thesis/Individual_Geo-Sociograms.zip

Following are the Geo-Sociograms for all groups in grid form
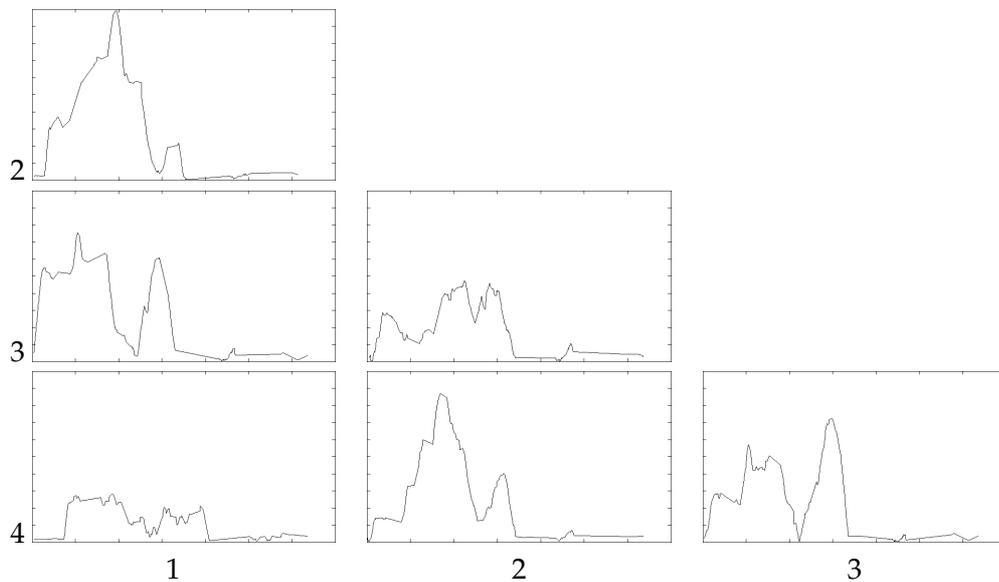
Figure C.1: Grid based Geo-Sociogram Group 1 in Quest 1
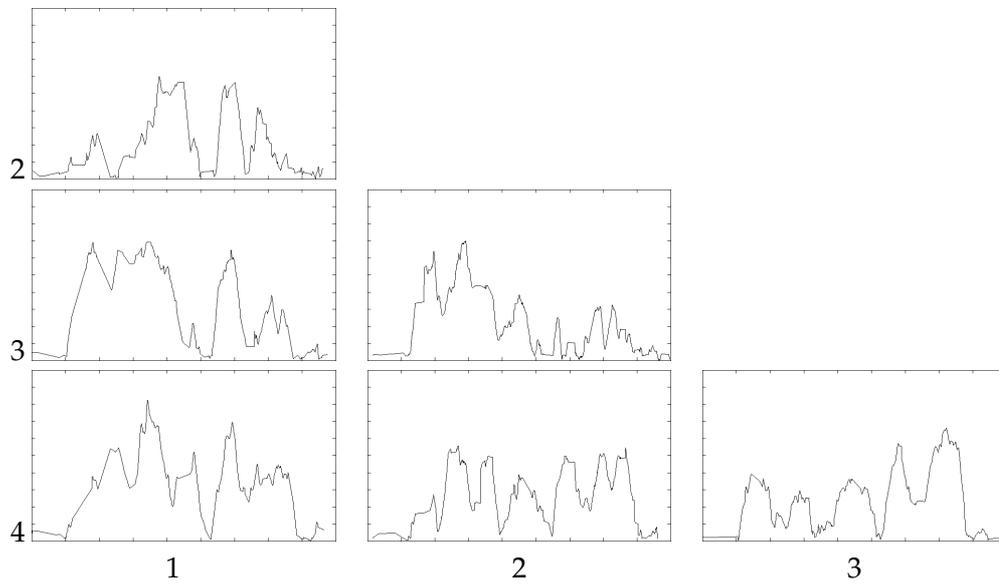
Figure C.2: Grid based Geo-Sociogram Group 2 in Quest 1
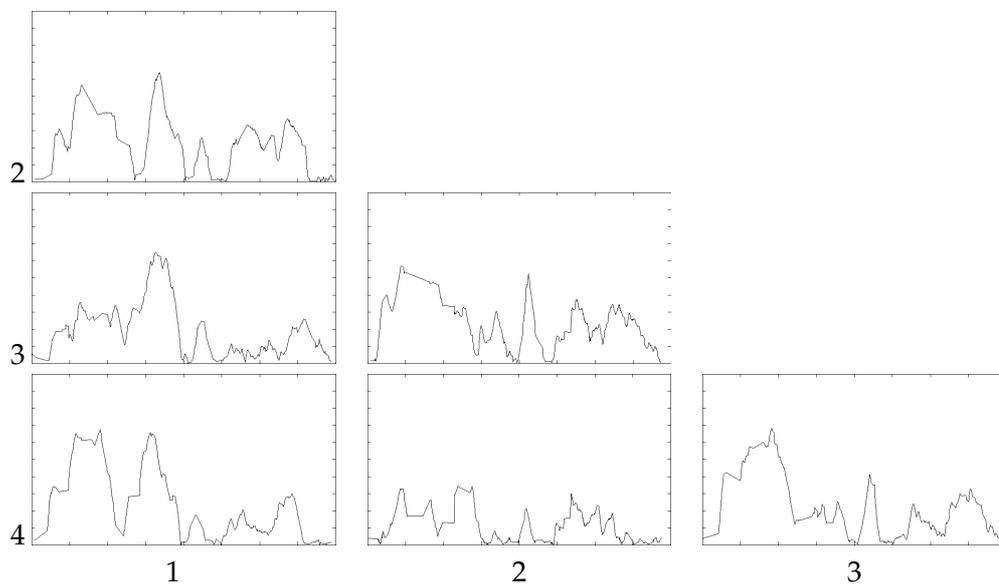
Figure C.3: Grid based Geo-Sociogram Group 3 in Quest 1
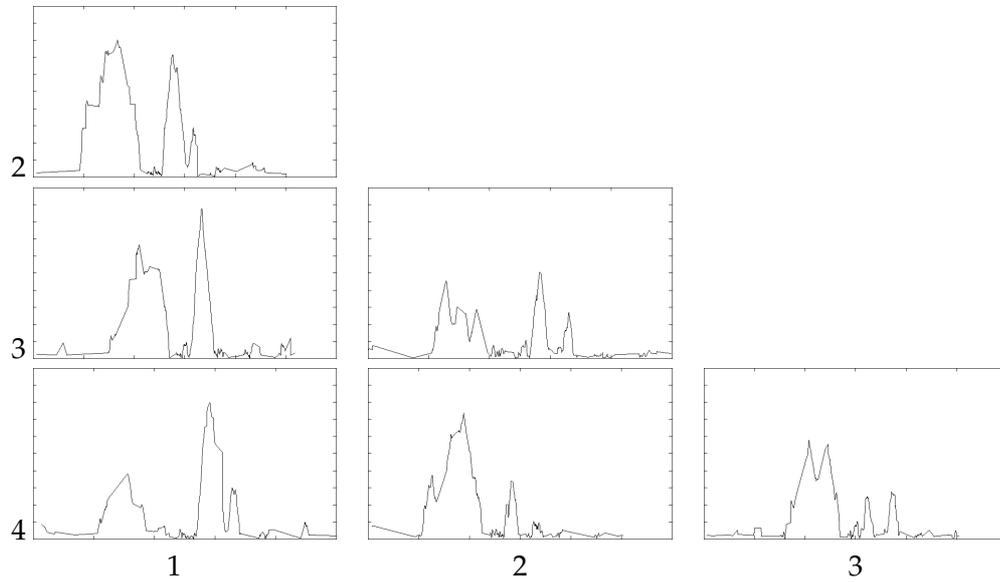
**Figure C.4:** Grid based Geo-Sociogram Group 4 in Quest 1
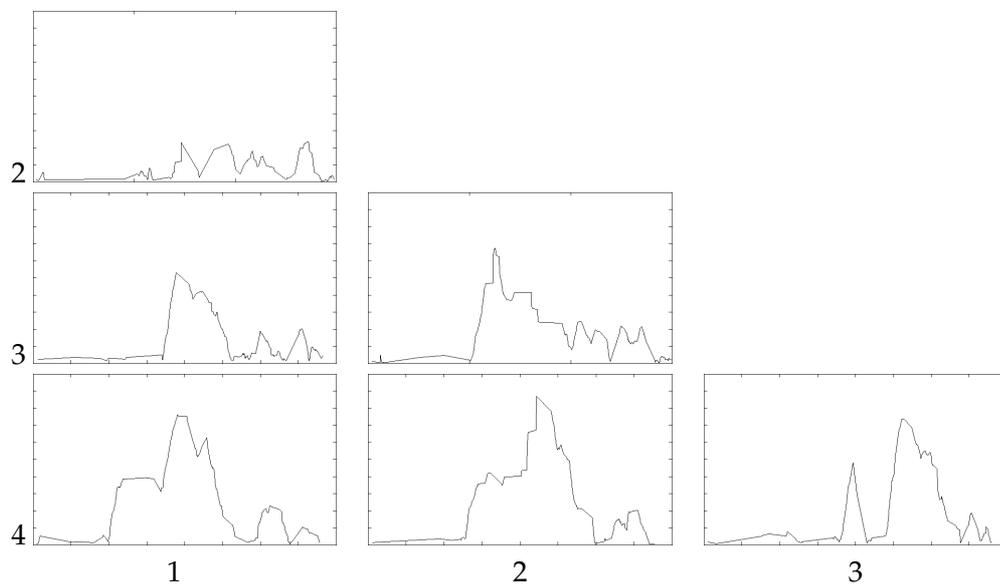
**Figure C.5:** Grid based Geo-Sociogram Group 6 in Quest 1
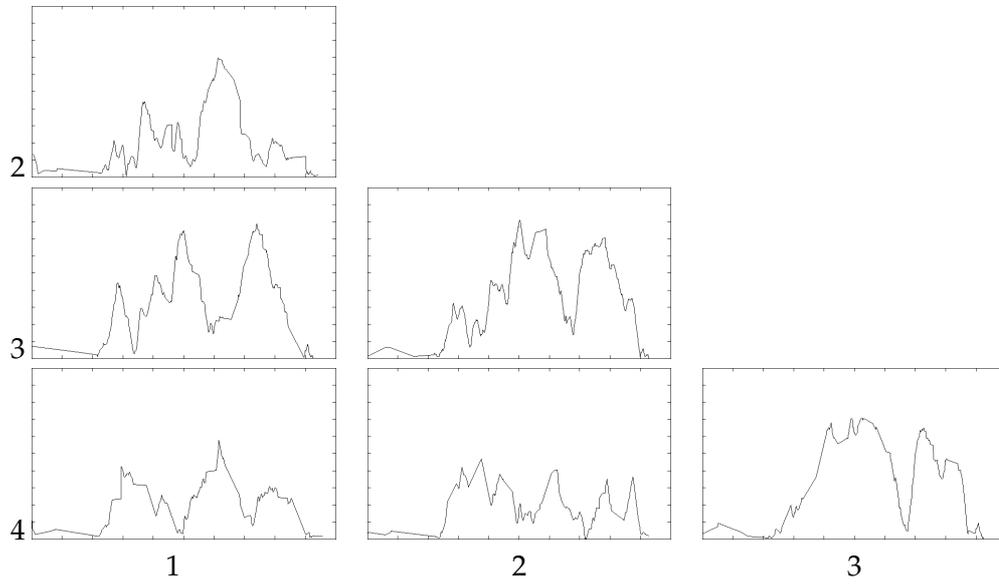
Figure C.6: Grid based Geo-Sociogram Group 7 in Quest 1
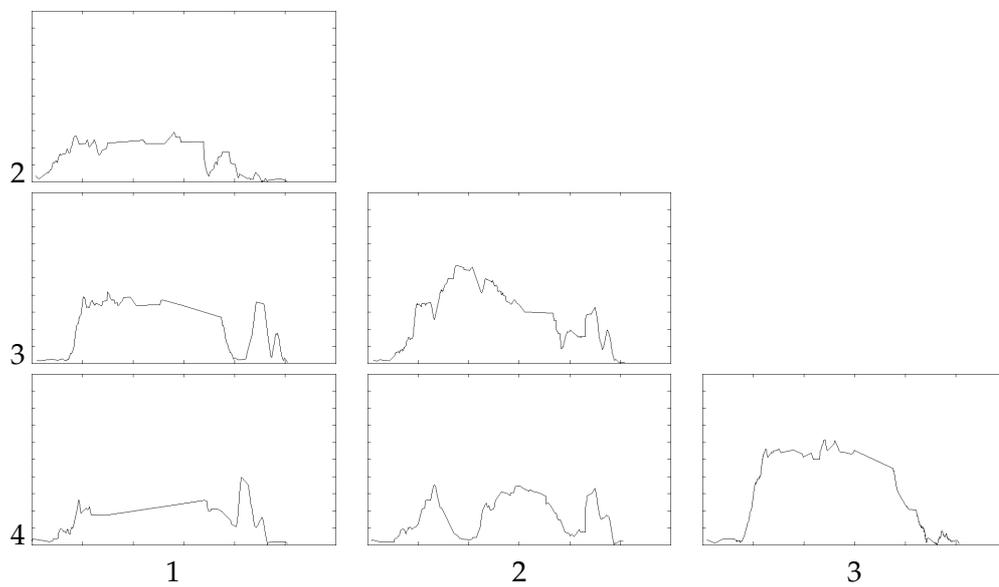
Figure C.7: Grid based Geo-Sociogram Group 1 in Quest 2
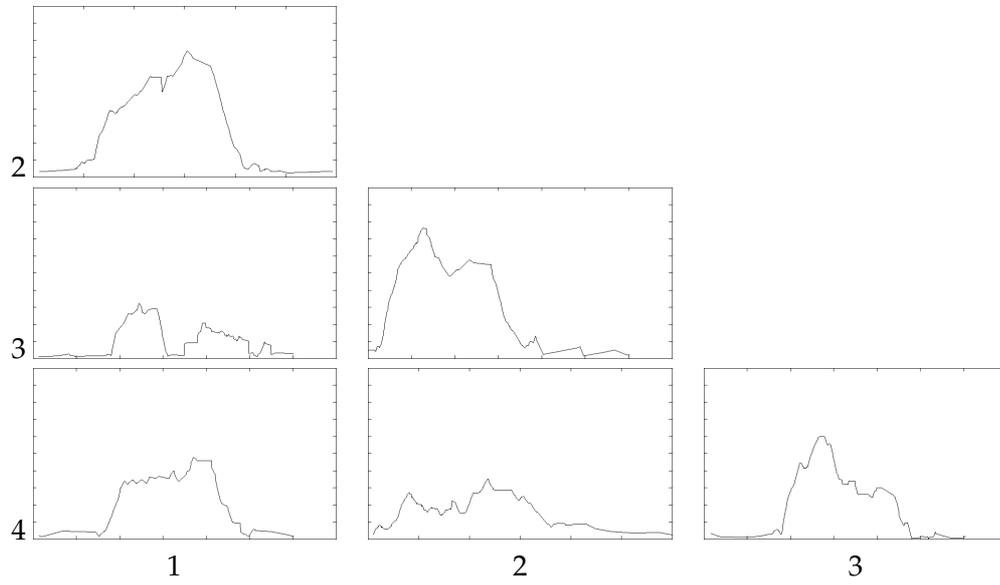
Figure C.8: Grid based Geo-Sociogram Group 2 in Quest 2
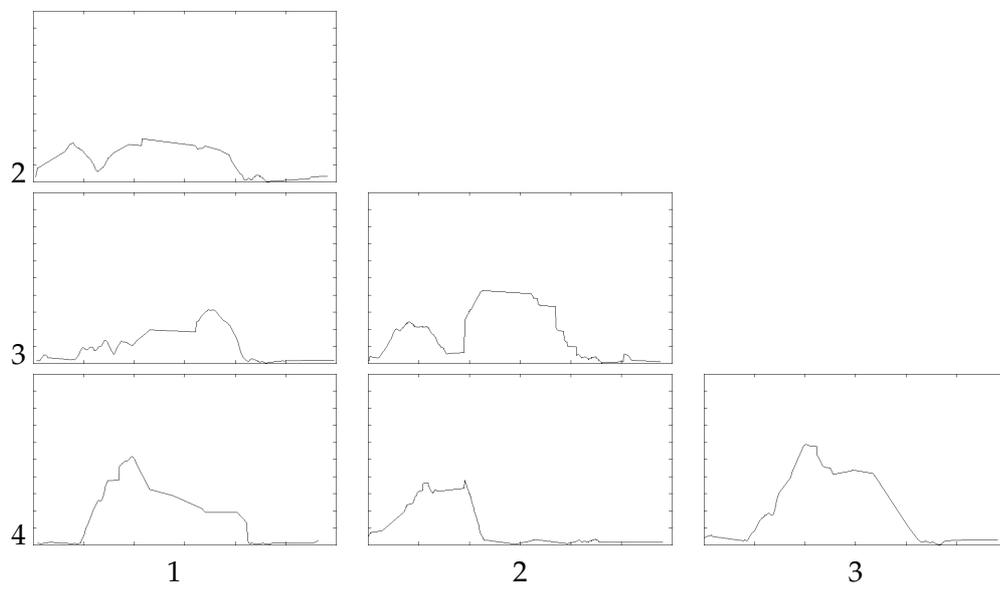
Figure C.9: Grid based Geo-Sociogram Group 3 in Quest 2
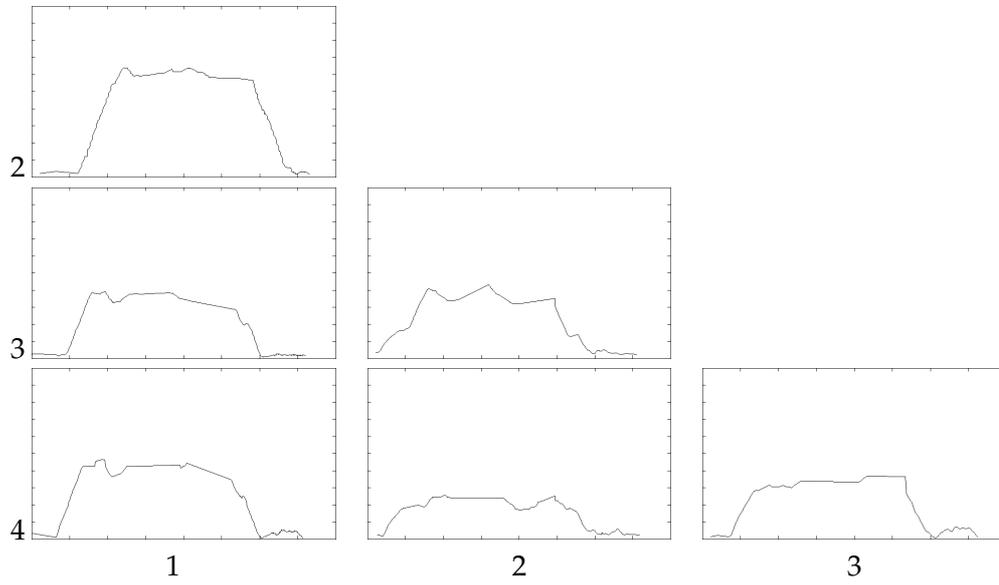
Figure C.10: Grid based Geo-Sociogram Group 4 in Quest 2
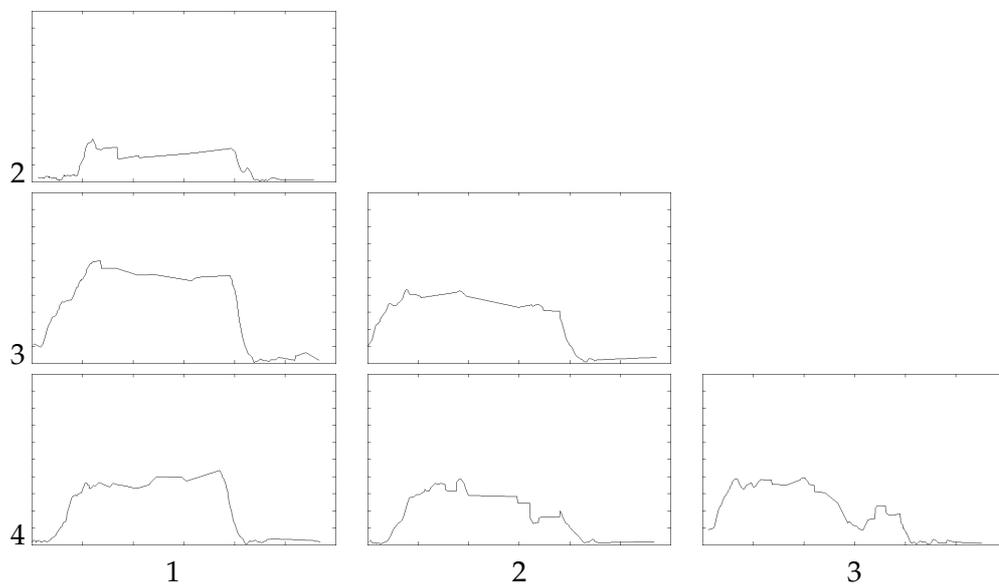
Figure C.11: Grid based Geo-Sociogram Group 6 in Quest 2
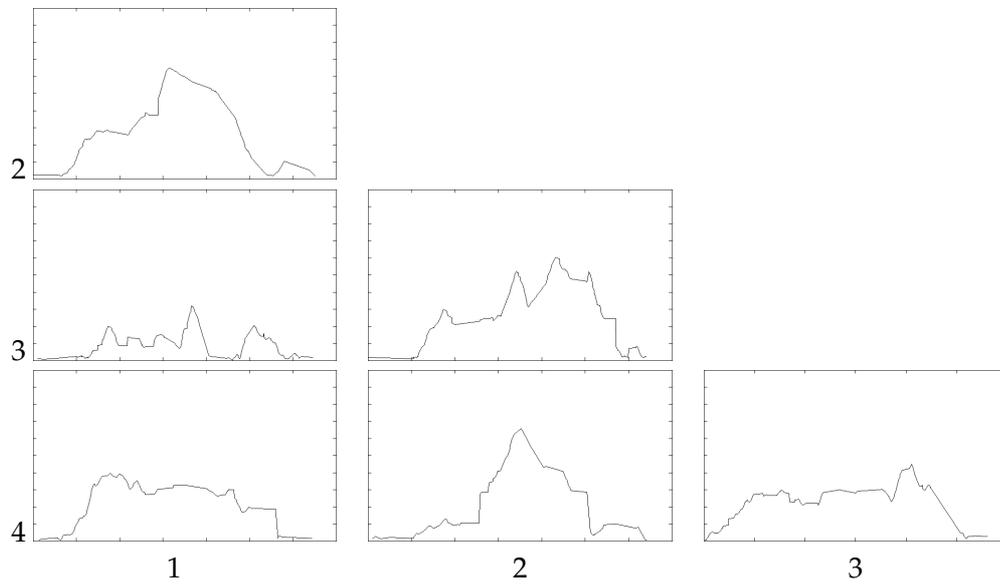
Figure C.12: Grid based Geo-Sociogram Group 7 in Quest 2
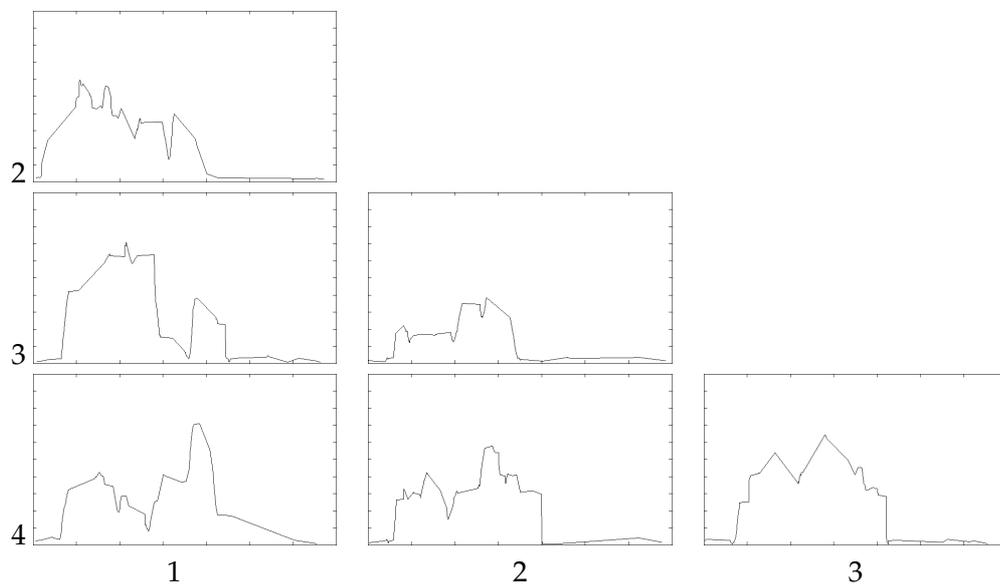
Figure C.13: Grid based Geo-Sociogram Group 1 in Quest 3
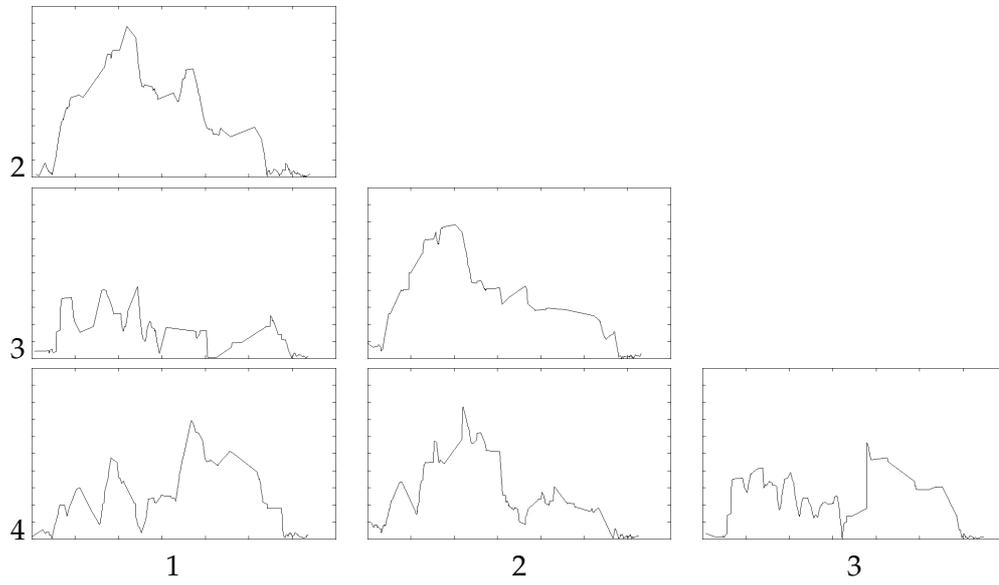
Figure C.14: Grid based Geo-Sociogram Group 2 in Quest 3
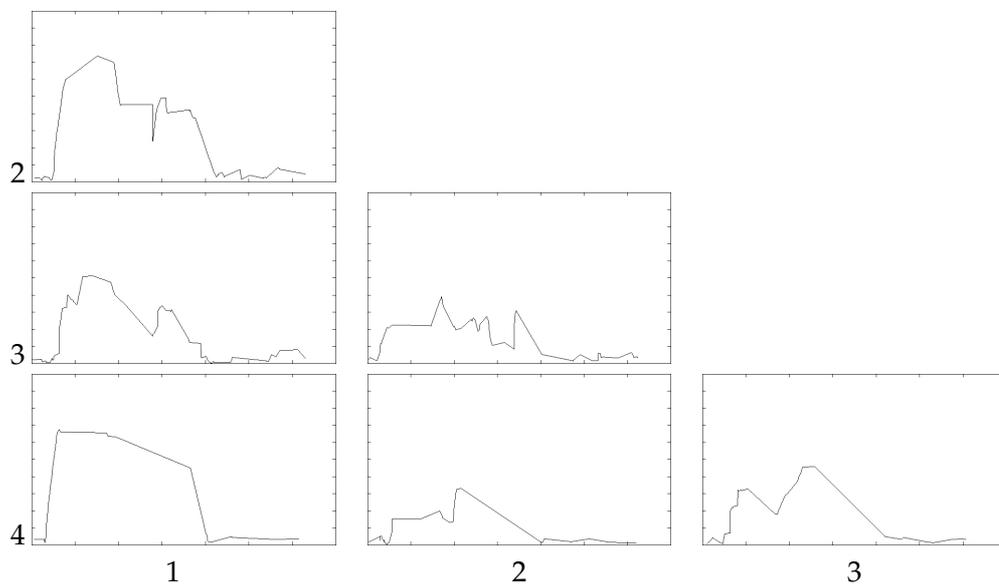
Figure C.15: Grid based Geo-Sociogram Group 3 in Quest 3
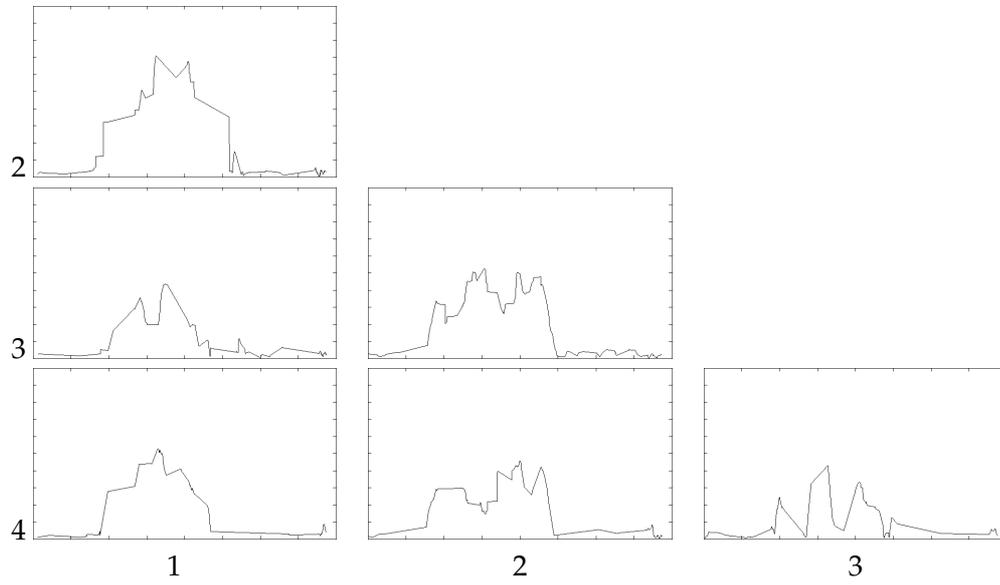
Figure C.16: Grid based Geo-Sociogram Group 4 in Quest 3
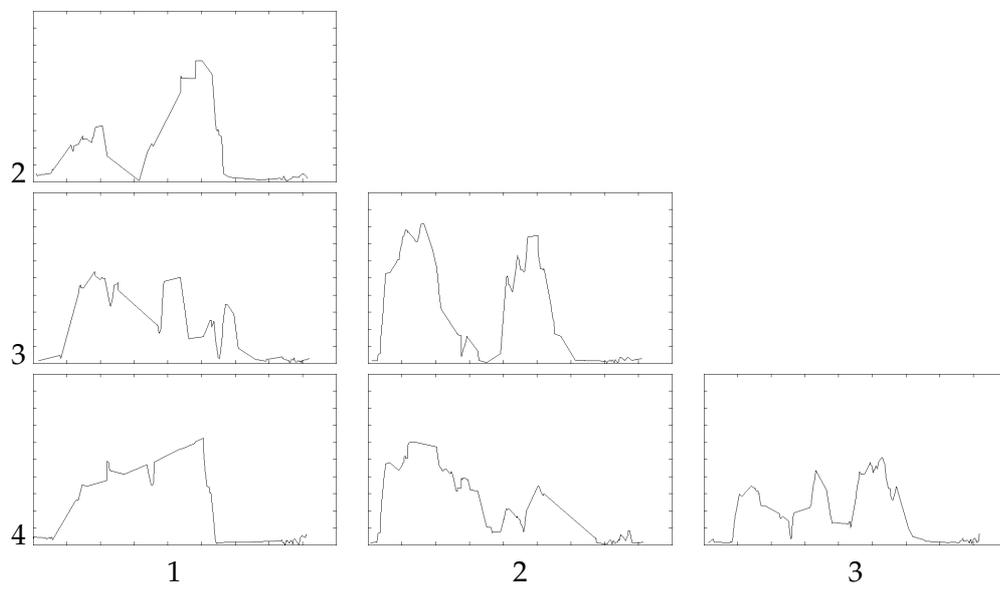
Figure C.17: Grid based Geo-Sociogram Group 6 in Quest 3
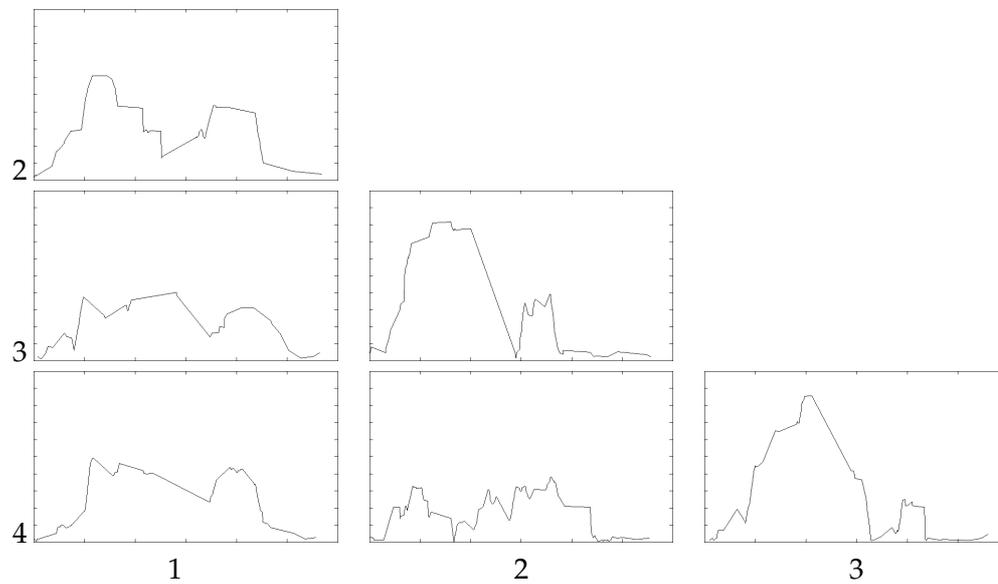
Figure C.18: Grid based Geo-Sociogram Group 7 in Quest 3

The URL to the combined group data excel sheet :

File: Group Data Combined[a]

[a]http://hci.rwth-aachen.de/~simha/thesis/Group_Data_Combined.zip

This table C.1 giving details of how the data was filtered and collated from the device logs and combined into Group Data Combined Excel sheet.

Group(@) Member(#)	Values of @ [1 to 7] and Values of # [1 to 4]
Found undiscovered Site (count and site #)	Filter under type kPlayerFoundExcavationForThe-FirstTime in G@.#.*.sqlite files
Enter discovered Site (count and site #)	Filter under type kPlayerIsInExcavationOuterZone in G@.#.*.sqlite files
Scroll exchanges count	Filter under type kPlayerGivesScrapsToPlayer in G@.#.*.sqlite files
# attempts placing guard (count of cancelled)	Filter under type kGuardHasBeenPostedToSecure-Peasants (kGuardPostingHasBeenCancelled) in G@.#.*.sqlite files
# of peasant safe zones entered	Filter under type kPlayerEntersPeasantSafeZone in G@.#.*.sqlite files
# of peasants safe guarded	Filter under type kPlayerSecuresAPeasantWith-Guard in G@.#.*.sqlite files
# previous secure peasants	Filter under type kPreviouslySecurePeasantIsNot-Secured in G@.#.*.sqlite files
Found Traders count	Filter under type kPlayerFoundTraderForTheFirst-Time in G@.#.*.sqlite files
# of shops entered (including revisited or found)	Filter under type kPlayerOpensTraderDetailView in G@.#.*.sqlite files
# of Trades	Filter under type kPlayerTradesWithTrader in G@.#.*.sqlite files
# of transfers of goods to others	Filter under type kPlayerTradesWithPlayer in G@.#.*.sqlite files
Time(hh:mm:ss)	Add the times from following columns Q1, Q2, Q3
Time(Q1)	Filter under type kQuestActiveNotification in G@.#.*.sqlite files and calculate time difference
Time(Q2)	Filter under type kQuestActiveNotification in G@.#.*.sqlite files and calculate time difference
Time(Q3)	Filter under type kQuestActiveNotification in G@.#.*.sqlite files and calculate time difference
Distance(m)	Using questdistances.py script note distance travelled for the entire Game from G@.#.kml
Q1(m)	Using questdistances.py script note distance travelled from G@.#_Q1.kml
Q2(m)	Using questdistances.py script note distance travelled from G@.#_Q2.kml
Q3(m)	Using questdistances.py script note distance travelled from G@.#_Q3.kml

Table C.1: Filtering and Collecting Data From Device Logs

The URL for all Python scripts used to extract and collect data :

> ### File: Python Scripts[a]
> _____
> [a]http://hci.rwth-aachen.de/~simha/thesis/Python_Scripts.zip

The URL for the Matlab scripts which were used to do the data analysis :

> ### File: Matlab Scripts[a]
> _____
> [a]http://hci.rwth-aachen.de/~simha/thesis/Matlab_Scripts.zip

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Index