Designing Location-Based Games

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

Hiermit versichere ich, dass ich die vorliegende Arbeit selbständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt sowie Zitate kenntlich gemacht habe.

Aachen, November 2015
Gero Herkenrath

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Abstract

Location-based games are a new, emerging genre of mobile games that use players' actual position in the real world for their game mechanics. Since the platforms capable of determining this position, often smartphones or similar mobile devices, are becoming more and more common it seems reasonable to assume that this field will grow in the near future.

This dissertation will provide frameworks and guidelines for the design of location-based games and present several prototype systems as examples for developing such games. The first three chapters will provide the motivation for this research and a better definition for what constitutes a location-based game. Due to the relative novelty of these games the terms and boundaries to other games are not always clear, so these chapters also try to establish a "common ground" for the reader to better understand the concepts explained later on.

The main part of this thesis then presents a pattern language that is supposed to help designers of location-based games with their work as well as researchers with categorizing and analyzing them. It then explains a method to gain an at-a-glance visualization of player movements, the so called geo-sociograms. Since analyzing movements, i.e. a process that occurs over time—in the case of location-based games sometimes quite a bit of time—this has proven to be a useful method to get at least a rough idea about what is happening during gameplay. From there the work concludes three types of play concepts in location-based games that perfectly extend existing, prior research, the so called "Relevance of Place Dimension".

Since especially a pattern language is strongly linked to concrete examples and applications the last chapter then presents several location-based games that were implemented over the course of this work. This section is in a way both, an evaluation of the patterns and other concepts introduced before as well as a description of how we arrived at those concepts. The patterns, geo-sociograms, and categories evolved alongside these location-based games.

Überblick

Ortsbasierte Spiele sind ein neues, sich herausbildendes Genre von mobilen Spielen, die die tatsächliche Position der Spieler in der realen Welt für ihre Spielmechanik verwenden. Da die Plattformen, die die dafür nötige Technik besitzen oftmals Smartphones oder vergleichbare mobile Geräte sind und sich somit immer weiter verbreiten, liegt es nahe, anzunehmen, dass dieses Feld in der nahen Zukunft noch weiter wächst.

Diese Dissertation stellt Frameworks und Guidelines für das Design von ortsbasierten Spielen zur Verfügung und präsentiert mehrere Prototypen-Systeme als Beispiele für das Entwickeln solcher Spiele. Die ersten drei Kapitel erläutern die Motivation für diese Forschung und geben eine bessere Definition dafür, was überhaupt ein ortsbasiertes Spiel ausmacht. Aufgrund der relativen Neuheit dieser Spiele sind Begriffe und die Abgrenzung zu anderen Spielen nicht immer klar, also versuchen diese Kapitel auch eine "gemeinsame Basis" für den Leser zu bieten, damit die später erklärten Konzepte besser verständlich sind.

Der Hauptteil dieser Thesis präsentiert dann eine Pattern-Sprache, die dazu gedacht ist, Designern von ortsbasierten Spielen bei ihrer Arbeit zu helfen, sowie Wissenschaftler bei ihrer Kategorisierung und Analyse zu unterstützen. Danach wird eine Methode erklärt, eine Auf-einen-Blick-Visualisierung von Spielerbewegung zu bekommen, die sogenannten Geo-Soziogramme. Da die Analyse von Bewegungen, d.h. eines Prozesses der über die Zeit abläuft—im Falle von ortsbasierten Spielen manchmal über relativ viel Zeit—hat sich diese Methode als nützlich herausgestellt, um wenigstens ein grobes Verständnis dafür zu bekommen, was während des Spielverlaufs passiert. Von hier aus schließt die Arbeit auf drei Typen von Spielkonzepten in ortsbasierten Spielen, die hervorragend ein bereits existierendes, früheres Forschungsergebnis erweitert, die sogenannte "Relevance of Place Dimension".

Da insbesondere eine Pattern-Sprache stark mit konkreten Beispielen und Anwendungen verbunden ist erörtert das letzte Kapitel dann mehrere ortsbasierte Spiele, die im Verlauf dieser Arbeit entstanden sind. Dieser Abschnitt ist gewissermaßen beides, sowohl eine Evaluation der Patterns und anderen, vorher vorgestellten Konzepte als auch eine Beschreibung, wie wir zu ihnen gelangt sind. Die Patterns, Geo-Soziogramme und Kategorien entwickelten sich parallel zu diesen ortsbasierten Spielen.

Acknowledgements

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At the core of the various projects so important for my thesis are a whole lot of students, who coded, tested, and maintained the hard- and software. Their work, and in several cases their own theses, made my own dissertation possible. My thanks go to Ignacio Avellino, Mariana Bocoi, Sebastian Borggrewe, Daniel Forster, Carl Friedrich Huch, Stefan Ivanov, Dennis Kehrig, Kerstin Kreutz, Dennis Lewandowski, Vyshantha Simha, Sarah Theres Völkel, Martin Wermers, and Christoph Will. Heng-Wei Chang, Paul Heiniz, Christopher Kurtz, and Xiaojun Ying were also working as students for me and although their specific projects did not become a part of my dissertation I want to thank them for their efforts.

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Most important of all I want to thank my mother, Elisabeth Herkenrath. Without her I wouldn't have been able to finish this enormous task. When I felt down, she got me up again and encouraged me to continue. Thank you, Mom.

Conventions

The whole thesis is written in American English. Throughout the text we use the following conventions.

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

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

Definition:
Excursus

Names of location-based games are written in typewriter-style text, for example `Aachen Horror` (see also chapter 6.7 — "Aachen Horror").

Pattern names (see chapter 5.1 — "The Pattern Language") are written in small capitals, for example IMMERSION.

Due to its length, the chapter describing `Aachen Horror` (6.7 — "Aachen Horror") uses additional conventions:

- Character names are written in a sans serif font (e.g. the Guilty Hero)
- (Real world) locations will be slanted in addition (e.g. the *Ehrenmal*)
- Events are formatted in a sans serif, bold font (e.g. **Oh, show me the girls**)

Chapter 1

Introduction

Economical rise of digital games

In the last few decades digital games and gaming in general have become more accepted as a form of entertainment suitable not only for children. At least among the younger generations it is not unusual for a person to spend a certain amount of income on a form of gaming as a hobby. As regards the software market this has lead to creators of computer games becoming more numerous, larger, and more influential; creating these media is not a niche market anymore. According to the Entertainment Software Association[1] the total consumer spend on games industry 2013 was 21.53 billion dollars.

Technical advancement of gaming hardware

For several years now advance has been made in incorporating more and different kinds of sensors into various kinds of computers, leading to a more manifold kind of hardware. Gaming consoles adopted sensors for direct movement and posture capture, allowing for an entirely new set of games about physical exertion. Mobile devices have not just become more mobile in terms of connectivity and battery life, they have also evolved into fully fledged computers with their own ecosystems of useful software applications, including games.

Our focus lies on the location-based games.

This work will investigate a subset of these mobile games, the location-based games. We believe the now common

[1] http://www.theesa.com

functionality of smartphones to track a user's position will enable this area to grow, like it was the case with other technologies. The kinect, for example, lead to an increase in the number and popularity of exertion games and in research about physical/gesture interaction in general.

We won't give economic predictions or advice.

Of course it is not our goal to give a prediction for economic purposes. To predict whether location-based games will become a substantial market or not is beyond our scope. A lot of factors other than human-computer interaction aspects play a role here, like development costs, cultural acceptance, or legal issues. We will address them in part in the later chapters, but the focus will be on a scientific examination of the particular design space of location-based games (see for example chapter 5.2 — "Geo-Sociograms", figure 5.5). However, the usefulness of our results will in part be influenced by how widely spread these games will or will not eventually become. If location-based games stay a niche product, only few people will apply our findings and recommendations. This means how useful this dissertation turns out to be in the future, depends on how well location-based games as a consumer product fare. Since in our opinion they *will* fare well, we hope to be of use for more than just a small group of designers of these games and future researchers.

We want to "prepare" people for designing location-based games in the future.

The reason why we join the efforts to better understand location-based games now is that we want to offer a means to avoid mistakes and problems from the start. It is always easy to spot problems in a vast amount of existing examples, but hard to predict potential pitfalls in hypothetical examples. Also, we think the already mentioned changes in computer games we see reflected in the general public indicate a high chance of location-based games eventually going to be more wide-spread.

Understanding how other technical developments changed games can help foreseeing location-based games.

A couple of examples show how improvements in technology changed gaming. The evolution of multiplayer games is one such example, i.e., a game's capability to allow more than one player to participate. PONG[2] was already a multiplayer game, allowing two players to play digital tennis. However, this required both players to stand next

[2] http://www.pong-story.com

to each other, since the PONG system was an arcade system with a separate controller for each player. Over time, the term multiplayer changed. With better connections for networked computers, it now includes games where each player runs the game on their own computer. First, the needed connectivity was established on LANs, but nowadays many games are connected via the internet for so-called massively multiplayer functionality. There are still games that can be played on the same machine, especially for consoles, but in general the internet connectivity has become ubiquitous and in most contexts multiplayer implies playing online with others.

"Multiplayer" did no longer necessarily mean "co-located players".

A similar trend can be seen in digital games for smartphones and handhelds. The term "mobile game" has become widely spread and typically refers to a game running on a mobile device. A lot of these games aim to be played while on the go. They are themselves literally mobile in the sense that they can be played while commuting to work or waiting for a plane. Designers have to accommodate for a more complex context the player might be in, they can't rely on the game being played in a living room or with certain specific controls. However, that does not mean the game "knows" or "cares" about the location and/or context it is played in. It simply tries to be playable while the player is on the go, one could say the game is actually more "portable" than mobile. With smartphones now being able to determine a user's physical location it seems reasonable to assume these mobile games will at some point incorporate this feature, in fact it might well be that a "mobile" game is not just one that *can* be played on the go, but that this mobility *has* to be executed, that it becomes a feature of the game.

"Mobile" gaming might become location-based gaming in the future.

In some way this enforced mobility would bring back digital games to traditional analog ones. A lot of children's games, e.g. "tag" or "go hide and seek" require mobility and the same is essentially true for virtually any sport, which can also be seen as a game. This again ties into the recent trend of exertion games which also focus on physical activity. It could even be claimed that these areas, outdoor games, sports, and exertion games, could merge into location-based games in the future. The only reason not to

Location-based games could "close the circle" and link to traditional outdoor games like "tag".

include mobility over a larger area in exertion games is the simple fact that systems like the kinect are still limited to the living room. Games like Zombies, Run![3] can already be categorized as both location-based and exertion.

Of course, all of this also means this work has to limit its scope. We will not go into detail about classic games or sports, even if they could be considered location-based. Instead, we will focus on digital games that incorporate the new and growing technology to track a player's physical position and use the latter in the game mechanics. We will try to give abstract criteria to sort these location-based games into categories and provide an overview of what needs to be considered when creating this relatively new kind of application.

[3] https://zombiesrungame.com

Chapter 2

Development Challenges

The real world becomes a part of location-based games.

There is a fundamental aspect of location-based games, or actually all location-based applications, that sets them apart from other software, even mobile software. By incorporating a potentially large area of the real world, or far away locations, into the system, it gets, in a sense, directly extended. The entirety of the interaction is not just defined by the user, their control mechanisms, the hardware, and the software's logic. In addition to that, the world around the user becomes part of the system as well. Not as a confounding variable, potentially disturbing or distracting the user from the system, no, it becomes an intentional influence on the experience.

Of course to some extent this is always true of other games as well. Exertion games, for example, require space to move in, often they are even meant to be played with on-lookers (see e.g. DanceDanceRevolution[1]. However, location-based games differ in that they can't be played without, well, one or several actual "locations".

Designing for real locations is hard to mock and resource intensive.

This makes it hard to develop and test them. Game designers and developers literally have to "go places" while building the game. In some cases this can be mocked in a

[1] https://www.konami.com/ddr/

lab or with software, to simulate the location changes that are needed as input for the game, but that's not always feasible. In other games, the basic mechanism is usually iteratively implemented in some way or another and after some point testing it equals tweaking it. Controls might become easier or harder depending on how well people are able to actuate them and how the game is supposed to feel.

Important aspects of locations can only be tested by really going there.

For location-based software and especially games, prototypes and mock-ups quickly become impractical. This is not just due to technical problems many location-tracking technologies might have, it's imminent in the concept itself. To figure out how it *feels* for somebody to go to a certain place, they have to actually go there. It is one thing to write a program that does something once its user reaches a certain place, like playing an audio clip, but as soon as the designer wants to gain feedback on how the player perceives this, there's no way around having users go to the location and report. The problem then is that this can't be easily done in an artificial setup. As we will describe later, there are different types of location-based games, but a lot of them result in one major activity the player has to do: walking.

Two important aspects set location-based games apart from other games.

If the location of a player is tracked and used as input to the system it means in some way the game depends on the changes of this parameter. At first glance this appears to be similar to let's say mouse and keyboard input. Many games allow the player to control a character, an avatar, by pressing keys and moving the mouse. However, there are two differences: First, the input is *player-initiated* and second, the *abstraction* for these controls is usually high.

The first aspect: *player-initiated* input

To understand what we mean with *player-initiated* input we have to look at the traditional means of controlling a game. Usually players provide input by pressing buttons, touching surfaces, etc. The common thing about these controls is that they require manual, physical interaction, very often via the hands of the player. The consequence is that every interaction requires *intent*. Players can at any point in a game simply cease to provide input by literally "doing nothing".

This is not the case with location-based games. Players, or rather humans, cannot simply stop being located somewhere. Of course they could switch off the location-tracking functionality of the device they're using, but that is more like turning off the game entirely. Also keep in mind that stopping to change one's location is not the same as stopping to provide input, it would more be like constantly pressing a button on a traditional control.

There are exceptions to this, for example many games using Nintendo's Wii Remote[2] or Microsoft's Kinect[3] capture a player's posture as input and, like with location, a human by definition always is in some kind of posture. The reason behind this is that these systems do not use a completely artificial control mechanism, but rather use a more "passive" parameter inherent in human existence.

The second aspect: less *abstraction*

The second general difference lies in the degree of *abstraction*. Traditional input methods can be highly abstract whereas using a person's location for input is less abstract. It is less that we couldn't, in theory, build a game that uses the player's whereabouts in a very abstract way, but rather that such a game would probably be pretty bad. What players perceive as a good control is usually strongly tied to the actual mapping between the control and the resulting action in the game. Moving an avatar left, for example, is naturally mapped to some form of accessing a control on the left or moving (part of) a control to the left. Again, there are exceptions, especially when the challenge of a game lies in an intentionally unnatural mapping, but otherwise this is more or less always the case. However, when moving around, there seems little else natural than to map the player's movement (i.e. the location change in the real world) to an avatar's movement in the game. A lot of the location-based games we will discuss in this work follow this principle, creating scavenger hunts, tag games, exploration quests, etc., all with a mapping between the player movement and a parameter in the game that ultimately also equals "movement" or "change of location" in the broadest sense. With traditional controls, concepts like "up", or "pressure" can easily be mapped to other factors

[2] https://en.wikipedia.org/wiki/Wii_Remote
[3] https://en.wikipedia.org/wiki/Kinect

than movement, for example "up" could not just make an avatar move forwards or upwards (even that is technically a difference), but it could also increase the level of some other game related aspect, energy to shoot something, etc. In short, when using traditional controls, there is a whole palette of natural mappings game designers can choose from besides a literal interpretation of the controls' physical manipulation. With location this seems, at least currently, to be less the case.

Additional constraints when using location as input: Real world physics.

Part of the reason is surely that actual location change is a lot more time-consuming and inflexible than simply operating a button. As stated above, one has to actually "go places". This isn't only an issue during the design of a game, but also during gameplay. If movement is coupled to a traditional control it is easy to temporarily switch it off and move an avatar programmatically somewhere else. In most cases that won't break a player's experience. The abstract mapping for moving the avatar still works after the "teleport". Once the avatar's movement is tied to one's own, it's not so easy anymore. Teleporting the avatar somewhere else can't teleport the player in the real world, after all. This would only work if the game world and the real world weren't directly mapped or the movement of the player would not move the avatar but control some other game aspect. The latter seems unnatural as stated above, and the former gives rise to a lot of different problems when designing the game, like real world constraints (players might be unable to move to a location the game would require) or the player's spatial memory ("This thing was here before, why is it not here anymore?").

Chapter 3

Location-Based Games: Fundamentals

simple hierarchy of games in general

To understand location-based games in their context this chapter will outline a simple categorization that explains their two major types and puts them into relation to the kinds of games often confused with them. A general problem when talking about these games is that the term is not strictly defined. There are several terms, sometimes used interchangeably, sometimes with slightly different connotations. Several works mentioned in 4 — "Related work" use varying terms, which is why we will define what we mean by which term in this chapter. It will also help to put location-based computer games into relation to the colloquial understanding of what constitutes a game in general.

real world games with movement as top layer

The simple definition of "game" according to Merriam-Webster[1] is "a physical or mental activity or contest that has rules and that people do for pleasure". This obviously includes location-based computer games as we described them in the previous chapters. As we deduced they require movement, which is certainly a physical activity, and they would have rules for sure, either related to the movement, i.e. where players must go, and/or related to other aspects specific to the concrete game. The more interesting question is which games fall under this simple definition, but

[1] http://www.merriam-webster.com/dictionary/game

are not location-based. If our only relevant characteristic was the movement aspect we would find many games to be location-based:

Football (American & European) Movement is certainly a very important aspect in this sport. Even in the planning phase of a match, when they players don't move, location is an important variable while planning who covers what position on the field.

Tag This simple children's game is all about movement. Not necessarily just about who runs faster, but also who moves more effectively while avoiding the person chasing them.

Chess Although certainly in the "mental" domain of the definition, *moving* the chess pieces is what players think about, their positioning defines the state of the game.

The list could go on. Limiting us to the computer would not necessarily eliminate this mis-categorization. While the physical stress is surely less if players control a football avatar on screen with a controller it could still be considered a physical activity, or a mental one for that matter. The location and movement aspects would remain more or less the same in a computer football game.

computer games that allow movement: mobile games

One could argue that the football example falls short of being a location-based game because it doesn't require the player to actually move, other than perhaps his hands and fingers on the controller. Still, there are games that alleviate this constraint and allow the player to physically move, yet we do not want them to be included in our understanding of location-based games. These games would be mobile games. Nothing prevents a developer from designing a football game on a mobile platform like a smartphone, yet uphold the general control mechanism of moving an avatar on screen with some buttons and/or cursors. Theoretically, it could be played while the user is walking around, i.e. changing her location. Mobile games have been around for quite some time in the form of portable consoles like the

Game Boy[2] or even earlier electronics. With the recent advances in smartphones they have seen a rise in popularity again. Nevertheless, it doesn't make much sense to consider every mobile game also a location-based game, since the possible change of the players' location has no direct effect on the game.

location-aware technology is key

However, that doesn't mean there isn't a differentiating characteristic found in the underlying technology of location-based games. The game mechanics must include location-aware technology.

LOCATION-AWARE TECHNOLOGY:
A combination of hard- and software that enables determination of a user's physical location.

Definition: *location-aware technology*

Note that this does not specify how exactly "location" is to be represented nor does it define what underlying method of tracking is used. Devices like smartphones, the probably most common end-user device with location-aware technology, usually use GPS and related technologies to determine their location in absolute geographic coordinates (latitude and longitude). Other hard- and/or software might determine a location from infrared emitters and corresponding sensors and simply provide an abstract identifier as a result. A location-based game in the context of this work then builds on that technological feature.

LOCATION-BASED GAME:
A digital game that uses location-aware technology as at least one control input to the game's rules and mechanics.

Definition: *location-based game*

The term "game" in this definition can be understood as in Merriam-Webster. We narrowed it further down to "digital game" for the simple reason that with the use of location-aware technology we are bound to digital/computer games in the broad sense, meaning that this aspect alone requires digital parts to work. Note that this doesn't necessarily imply that the game runs on a mobile device, although current

[2] https://en.wikipedia.org/wiki/Game_Boy

technology usually requires some portable/wearable electronics for the underlying technology to work. For the purpose of this thesis we exclude non-digital games as mentioned above, unless we refer to them for comparing certain characteristics.

digital games that require movement have two types

Location-based games as we understand them can be further subdivided into two categories. When it comes down to it, there are two abstract ways in which a given game can use the data received through the platform's location-awareness. Either it relies on absolute positioning within the boundaries of the technology or it uses a relative reference frame, i.e. the distance between ad hoc defined positions.

fixed location games

The first kind of location-based game thus uses fixed positions to trigger an event in the game, for example specific latitude and longitude data. By nature this restricts the game to be played only in a certain location, which limits the set of players to those who can reach the play field with reasonable effort. The benefit often is that the game mechanics and rules can adopt the actual real world aspects of a location, like the cultural relevance of a specific building.

variable location games

In systems of the other kind the mechanics are not tied to a certain fixed position in the real world. For these location-based games, the absolute values the location-awareness of the platform delivers are only relevant in relation to each other. As an example one might think of any type of digitally enhanced chasing game, where players have to catch each other. For the game mechanics it is not relevant where the players actually are in the real world, but rather whether the catcher is in the same spot (or near enough) to the runner.

To better distinguish between these different types of location-based games this thesis will use the following abbreviations:

Definition: *location-based⁺ game*

LOCATION-BASED⁺ GAME:
Any location-based game that is only playable at a fixed location.

LOCATION-BASED* GAME:
Any location-based game that is playable at different locations. It may require an initial set-up phase.

Definition: *location-based* game*

In practical terms the categorization of a specific location-based game into these two types might sometimes be debatable. For example, a game could include a "set-up" phase where players define the play field and tell the system about boundaries or special locations. This could even be incorporated in the game as part of the normal play. The obvious advantage would be that players all over the world can in theory experience the game and don't need to travel anywhere as long as they have the necessary technology (the platform, for example, the specific type of smartphone). However, this game design is by definition restricted in that designers can not include specific location-data into the game's rules and mechanics. For example, referring to the "largest church in the city" in the game becomes very tricky for them if they don't know where the final game will eventually be played.

limitations of these definitions

From a plain technical point of view, such a game falls into the second category. Nevertheless, one could argue that aspects of the first category could be at least partially recreated if players are required to play the game that incorporates real world aspects of locations. In the above example, the "largest church in the city" can be seen as such an aspect, because certain real world facets surely apply to all churches. Of course the designers don't have as much control over these as when they chose a specific church and limit their game to the area where that is. Still, by compromising and only relying on a specific *kind* of location, they might achieve similar results.

This means that the above technical definition isn't automatically limiting a game's experience to being either real world related or real world unrelated. To properly grasp the entire experience one has to look at the actual game mechanics. Josephine Reid introduced a design space to properly express a game's location-related mechanics besides the plain technical aspects in [Reid, 2008]. We propose an extension this "Relevance of Place Dimension" in

chapter 5.2 — “Geo-Sociograms”.

location-based games close a circle game history

The Merriam-Webster definition of game covers both, physical and mental activities. Our list of “classic” games reflects this, we intentionally put chess as well as football in it. However, if we further look into these two subcategories we can deduct an interesting aspect of many mental games, for example chess. It surely is more of a mental game, but in spite of that it stems from a very physical activity: battle. Chess is an abstraction of war, simulating various classes of fighters on a battlefield. We can see this form of abstracting from physical origins in a lot of games falling into the mental activity type of the Merriam-Webster definition. Boardgames are often an abstraction of physical aspects of real life, like gathering resources or settling new lands. The resulting game then focuses not anymore on the actual physical task, but on its mental requisites, like planning ahead or developing tactics and winning strategies.

With that in mind, it stands to reason to say that games can in many cases be considered the result of actually “dragging away” physical activities from the real world. This then ultimately means, that location-based games have the potential to “close the circle” in that development and bring games back to their physical roots.

Chapter 4

Related work

As is usually the case with a dissertation, it builds not only on previous work done by other researchers, but also includes work we did ourselves over the last couple of years. Because of this we divided this chapter in two sections. The first gives an overview on the related publications by others and the second will present work that we participated in directly.

Since the second category thus also includes previous research presenting most of our game prototypes, we will try to keep it relatively short; these systems will be described in more detail in chapter 6 — "Evaluation".

Explanation of authorship:
Usually, this dissertation uses "we" when talking about the various location-based games created at the Media Computing Group. However, that makes it difficult to explain who did what as regards the second category of related work, so for this section an explanation is needed to avoid confusion regarding authorship. All of the earlier publications listed below were diploma or master's theses. I (Gero Herkenrath) was the advising research assistant for each of the student authors at the Media Computing Group and the one defining the topic and handing it out as a thesis project in the first place. As such, I am naturally not listed as author on the theses directly. My contribution to these publications was of an advising and defining role; I ensured that

the students' work was adequately fitting into the larger topic of location-based games and of course into my dissertation.

4.1 Predecessor Research

Concepts and methods work

"A pattern language: towns, buildings, construction"

A large portion of this thesis is dedicated to providing game designers with frameworks to create location-based games. The pattern language in chapter 5.1 — "The Pattern Language" (first published by [Will, 2013], see also below) is one such framework and naturally goes back to the works by [Alexander et al., 1977]. This book is basically the origin of patterns as tools in the HCI and, by extension, the software developer communities. As such it was a base for our research, too.

"A Pattern Approach to Interaction Design"

Consequentially, [Borchers, 2001] was relevant for the same reasons, as it is one of the first books adapting pattern languages to interaction design. Its frame is not explicitly focused on games, but was still vital for our own projects, because any computer game could be considered as "a software primarily aimed at providing a good interaction for the players" (otherwise it would be considered flawed and no fun).

"Patterns in Game Design (Game Development Series)"

The third publication important to our patterns was the book "Patterns in Game Design (Game Development Series)" by [Björk and Holopainen, 2004]. As the title implies it further adapts patterns directly to the game development process. In a way, this provided us with not just an abstract methodology, i.e. an example of how to write a pattern language for games, but of course also with concrete patterns that we could use in our various location-based games.

Pervasive games and the work of Markus Montola

The books "Pervasive Games: Theory and Design" by [Montola et al., 2009] and "On the Edge of the Magic Circle: Understanding Pervasive Games and Role-Playing" by [Montola, 2012] as well as the paper "Tangible Pleasures of Pervasive Role-Playing" by [Montola, 2007] define and explain pervasive games, a form of game

> "[...] that has one or more salient features that expand the contractual magic circle of play spatially, temporally or socially."
>
> [Montola et al., 2009, page 12]

Montola's work focuses much on role-playing, but as "spatially" implies, it also touches on what we define as location-based games. What he calls pervasive games does not necessarily have to include location-aware technology, but one could argue that if that is in fact the case, a given pervasive game also qualifies as a location-aware game and vice versa. Due to this overlap his work was very influential and especially helped us to understand aspects of the players that would be participating in our games. We hope to extend this understanding further and include this into the design process of location-based games; this is for example reflected in several patterns in chapter 5.1 — "The Pattern Language".

Categorization of location-based games

Location-based games have only recently shifted into the focus of researchers. However, it is hard to specify an exact point in time, because as explained in chapter 3 — "Location-Based Games: Fundamentals" the term has not been clearly defined. Another problem is that there are a lot of games or game-like experiences that are related and have similarities to our definition of location-based game, so a lot of publications about these apply to the concept as we understand it, at least in part.
One of the first approaches to categorize location-based games in general is "Design for coincidence: Incorporating real world artifacts in location based games" by [Reid, 2008]. It is not the first research about them, but it compares several examples to arrive at generalized conclusions and concepts for designing them, excluding aspects of implementation problems with specific instances. Especially important is "the relevance of place dimension". This design space lays out location-based games according to whether they rely more on "space" or "place", a terminology devised by [Harrison and Dourish, 1996]. This concept strongly influenced our definitions of location-based^{+} and location-based* games as well as the LOCATION AS CON-

TENT and POSITION AS INPUT patterns defined in [Will, 2013]. The other important part is of course the aspect actually reflected in the paper's title, as the name of the pattern DESIGN FOR COINCIDENCE shows, see chapter 5 — "Design Frameworks" and [Will, 2013].

Theoretical concepts for location-based games: geo-sociograms

The geo-sociogram concept first introduced in [Huch, 2013] and explained in detail in chapter 5.2 — "Geo-Sociograms" built on "Proximity-based visualization of movement trace data" by [Crnovrsanin et al., 2009]. Their work actually has nothing to do with location-based games specifically, but rather demonstrates the general usefulness of relying on distance data instead of (just) direct visualizations of traces (i.e. movement tracking data). We adapted their approach for our field of research, thus hopefully extending their work as well as laying down a foundation for future analysis of location-based games.

Other conceptual foundations

As this thesis presents several projects involving the concrete implementation of location-based games, we also relied heavily on the established principles of iterative design, namely the works of Jakob Nielsen. Especially his book "Usability Engineering" ([Nielsen, 1993b]) and article "Iterative User-Interface Design" ([Nielsen, 1993a]) have to be mentioned here. Although we do not directly add much to these, chapter 5.3 — "Implementation Tools" can be seen, hopefully, as being as useful to any location-based game designer as Nielsen's work.

`Ingress` as a first example to educate people

Last but not least we want to mention Google's `Ingress` here ([NianticLabs@Google, 2013]), as it is one of the first really big commercially available location-based game out there. Especially when explaining the early concept of our work it was often very helpful to refer people to the game. Even if they didn't know it yet, describing the general principle was easy enough and they were able to find additional information online on their own later. We hope that perhaps `Aachen Horror` (see chapter 6.7 — "Aachen Horror") will perhaps become at least a bit as intriguing as `Ingress`.

Related game projects

Besides `Ingress`, several other games had an impact on

our own research, especially the pattern language in chapter 5.1 — "The Pattern Language". We list the ones with explicit influence on patterns here, since they were all part of actual research projects and as such actively contributed to the field of location-based games.

`REXplorer` and the earliest approaches at the Media Computing Group

In "REXplorer: A Pervasive Spell-Casting Game for Tourists as Social Software" by [Ballagas et al., 2006] and "REXplorer: a mobile, pervasive spell-casting game for tourists" by [Ballagas et al., 2007] the authors describe the development of a location-based game in the city of Regensburg. Our own research group was heavily involved (in fact, Mr. Ballagas was a PhD student before I joined the group) in the work and as such the project had substantial influence on my efforts. Especially in informal ways those previous experiences were helpful for our following games. As the titles imply, the distinction between location-based games and pervasive games is not strictly defined (see also above), but the `REXplorer` relied heavily on location-aware technology. It's worth mentioning that the game preceded the heavy impact of smartphones and was implemented on a "dumb" phone connected to additional hardware. The gameplay was basically a scavenger hunt through the city to find "ghosts" narrating interesting facts about Regensburg's history. As such, the game was mainly aimed at tourists, connecting traditional guide systems with game elements and entertainment in a similar way as we would later do with the `GroupAixplorer`.

Benford's influence on our patterns and games

"Coping with Uncertainty in a Location-Based Game" by [Benford et al., 2003] describes a game called `Can You See Me Now`. It's a chase game in which people in the real world (obviously equipped with location-aware technology and connected to a network) hunt virtual avatars controlled by other players using a normal computer. As such it was in some ways inspiration for `iCatch`, but more importantly the paper deals with a very specific problem developers of location-based games have to deal with: unreliable or not precise enough location data or network connectivity. These aspects were captured by [Will, 2013] in the patterns NETWORK INFRASTRUCTURE and COPING WITH UNCERTAINTY (see also chapter 5.1 — "The Pattern Language"), but more importantly, the work showed that, re-

alistically, these problems have to be dealt with. Unfortunately, most developers tend to assume that with technology getting better they simply disappear, but our, sometimes painful, own experience indicates that even over a decade later this seems not to happen. While we can't add much to this, besides several additional games showing how to deal with this uncertainty and try to promote this with patterns, it was still influential on all our projects and increased our awareness of this aspect of location-based games.

A similar lesson was taught by "Life on the Edge: Supporting Collaboration in Location-Based Experiences" by [Benford et al., 2005]. The described game `Savannah` had children take on the roles of lions who had to hunt (virtual) prey, scent mark territory, etc. by moving over a real world school playing field. The authors address technical difficulties with location-aware technologies and network problems (especially in the context of multiple players getting correct, synchronized data), but are also very interested in the collaborative aspects of location-based games. We tried to factor their experiences into our patterns, but concepts like geo-sociograms and to some extent even our proposed prototyping tools (see chapters 5.2 — "Geo-Sociograms" and 5.3 — "Implementation Tools") also benefited from `Savannah`. In the future, the game could perhaps even be further analyzed, using geo-sociograms, adding to the more anecdotal observations the authors of the paper made so far.

The paper "The Frame of the Game: Blurring the Boundary between Fiction and Reality in Mobile Experiences" by [Benford et al., 2006] focuses on mechanics more suited for role-playing oriented games like, in our case, for example `mLoG` or `Aachen Horror`. The foundation of it is the game `Uncle Roy All Around You`, a game including online players, but also street players and to some extent just bystanders (the game "pretends" that the latter are part of the game so players believe so). Its general aim to break into social boundaries of the gameplay and blurring the perceived or real boundary between game and reality was influential for our `Aachen Horror` in particular. While we were more hesitant to include real people (i.e., bystanders or ac-

tors) into the game, we did do something similar in one scene (see also chapter 6.7 — "Aachen Horror"). In addition to this direct adaption of one of the paper's concepts the pattern APPARENT FRAME is also strongly inspired by it.

The `Interference` game illustrates the importance the social context in the real world.

In the paper "Pervasive Play, Immersion and Story: designing *Interference*" by [Bichard and Waern, 2008] the authors describe a pervasive game in which players assume the role of investigators in a mystery plot. While the actual plot has similarities with our own `Aachen Horror` (see chapter 6.7 — "Aachen Horror") the important influence of this paper was its focus on social aspects of games played in the real world, i.e. a public environment. `Interference` is not described as a location-based game as we define it, but rather as a pervasive game as, for example, Markus Montola describes the term (see [Montola et al., 2009]). While it does use a GPS device for location-awareness and players move around in the real world, it also adopts aspects of role-play (although in depth role-playing is not enforced). There's even an observing game master present. Its influence on our work was a major part in the development of patterns like LOCATION AS CONTENT, MINIMIZE SOCIAL AWKWARDNESS, EXPLORATION CENTRAL TO GAME, and several others. In our projects, especially `Aachen Horror`, we have shown how these aspects can be adopted in location-based games with less staff involved during gameplay, a criteria also more common in traditional computer games. Even in our `iCatch` game, which focuses least on a location's actual social context, similar issues (especially social awkwardness) were addressed.

Immersion related research

"The Three-Sixty Illusion: Designing For Immersion in Pervasive Games" by [Waern et al., 2009] deals with, as the name implies, IMMERSION. The paper discusses how LARPs (Live-Action Role-Plays) and ARGs (Alternate Reality Games) enable high degrees of player immersion and how this relates to pervasive games. As our understanding of location-based games classifies them also as the latter, this was a very influential approach for our work. This is not only reflected in several patterns in chapter 5.1 — "The Pattern Language", but also our own game projects, especially `Aachen Horror` (chapter 6.7 — "Aachen Horror").

Because of that, our examples can be seen as further proof of [Waern et al., 2009]'s findings, meaning that location-based games as we defined them (see 3 — "Location-Based Games: Fundamentals") would constitute another kind of games in which IMMERSION can be achieved in the ways the paper identifies.
"Design and Evaluation of Player Experience of a Location-Based Mobile Game" by [Carrigy et al., 2010] evaluates the game "Viking Ghost Hunt", a game with a similar atmosphere like our own `Aachen Horror`. It is especially noteworthy in our context because it shows that the degree of IMMERSION can vary depending on what type of media is presented to players. In their case audio content seemed to work better than video pieces that were displayed over the camera view of the used phones. It was one of the reasons why we chose not to implement this in our games.
Lastly, "Parallel Worlds: Immersion in location-based experiences" by [Reid et al., 2005] quantitatively supports the notion that IMMERSION is not only well achievable in location-based games, but also an important aspect, being correlated to enjoyment, *the* key factor of any game.

4.2 Earlier Publications

`GroupAixplorer`

Our earliest own prototype location-based game and the findings we got from it are published in "GroupAixplorer: An Interactive Mobile Guide for Small Groups" [Wermers et al., 2011] as well as "Small Group Interaction Methods on Location-Aware Mobile Audio Guides" [Wermers, 2010]. The first focuses on the results and recommendations we learned for design while the second gives a more detailed overview of the development process and system itself. Since it marks the start of our interest in the topic of location-based games, the lessons we learned had a big impact on subsequent systems and also the other publications we supervised and collaborated on. It will be described in more detail in chapter 6.2 — "GroupAixplorer".

"Movement analysis of visitors using location-aware guides in museums"

While not really a game, the master's thesis by [Borggrewe, 2013] is still related to location-based games, especially considering that much of our work was tied to the `Aixplorer`

(see 6.1 — "Aixplorer"). The work analyzes how people move through a museum, either with or without a location-aware mobile guide system. This was very important for us as we wanted to find out how movement behavior is actively changing when a person or group uses location-aware technology. The work will be discussed in more detail in chapter 6.4 — "Movement analysis of museum visitors".

mLoG

The diploma thesis "Strategies and Movement Patterns for City-Wide Location-Based Games" by [Huch, 2013] introduced the game `mLoG` and the concept of geo-sociograms, which was later further refined and published in "Geo-Sociograms: A Method to Analyze Movement Patterns and Characterize Tasks in Location-Based Multiplayer Games" by [Herkenrath et al., 2014]. The diploma thesis was done roughly parallel to Christoph Will's diploma thesis "A Pattern Language for Designing Location-based Games" (see below) and as such `mLoG` is in a way the first test for some of the patterns from a developer's point of view. It also considerably extended our experience from the `GroupAixplorer` and our more general learnings made with the `Aixplorer` system (see 6.1 — "Aixplorer"). The game `mLoG` will be described in further detail in chapter 6.5 — "mLoG" and geo-sociograms are explained in chapter 5.2 — "Geo-Sociograms".

mLoG2

"Movement Patterns in Location-based Multiplayer Games" by [Simha, 2014] was a master's thesis specifically meant to refine and verify observations of player movement we made with the `mLoG` game and as such is closely tied to the diploma thesis of [Huch, 2013]. In fact, the game, `mLoG2`, builds directly on code from the first thesis, as the name implies. It also served as a use case for geo-sociograms, as the results were also analyzed by using them as a visualization tool. `mLoG2` will be described in more detail in chapter 6.6 — "mLoG2".

Chapter 5

Design Frameworks

Designing games is hard due to the vague goal of creating enjoyment.

Unlike a lot of other software, digital games do not serve a specific task that people *need* to do. Games in general are usually intended for leisure and pure enjoyment. Sometimes players might hope to accomplish something else by playing a game, for example practicing their memory or gain some useful skill, but this is then a secondary goal. The immediate result of a game, or to be more precise a *good* game is supposed to be enjoyment, or fun.

This makes the process of creating games, and digital games along with them, hard to quantify. There is no specification of what a game must be able to accomplish. This sets games apart from, for example, a word processing application, which has a more or less clearly specified task and thus list of basic, necessary features.

Games are more an art form than an engineering solution to a fixed problem.

From that point of view designing games could be considered much more as a form of art than a way of engineering well-designed software with a more quantifiable purpose. Of course, there might be metrics for analyzing different kinds of games. Computer game magazines often even try to calculate a numerical grade for a game, but when it comes to the design process it is hard to formulate any rules to follow for designing a good game. This is not to say the same problems don't apply to non-game software as well, but to a much lesser extent. Even an application with bad performance and a badly designed user interface might, in

the end, still succeed in solving a given problem, like controlling a factory robot or the like. Users might not like a piece of software, but could still be willing to put up with it as long as it holds value to them, usually because it does its job. A game, on the other hand, only has the "job" to "be liked" by its users i.e., the players. Like a painting or a piece of music this is, if not completely then at least mostly, what it's about.

Such creative processes can be better supported with best practice collections & recommendations than abstract rules.

As a result, the process of designing games, and in our case here this means location-based games, can not be adequately supported by abstract rules. Their artistic nature and their aim to support a creative act aimed at the players' enjoyment prevents such a strict, engineering-like approach. Thus, any advice this thesis gives on designing a good location-based game can ultimately only be understood as a recommendation.

A Design Pattern Language is well suited for conveying such recommendations.

For this purpose we introduced a Pattern Language in the work of [Will, 2013]. This thesis revises these patterns and puts them into the context of several example projects in the following chapter (6 — "Evaluation"). As is usual for a Pattern Language its patterns have a varying granularity. Some focus on specific aspects perhaps not relevant for all kinds of location-based games, others are broader. Also, the various example projects had different scopes, resulting in some patterns being more often applied than others. This means that we are more confident in some patterns than others. The revision of each pattern will reflect this and we annotated the affected patterns accordingly.

Geo-sociograms as a way to visualize movement patterns.

Usually, a design pattern describes an inherent characteristic of the kind of system it is related to. That means even though a pattern is helpful in design, it should describe something that can be directly observed in a system that conforms to it. Mere design guidelines providing advice on the actual implementation work flow for location-based games are different. However, since the publication of [Will, 2013] we found a new "kind" of patterns which are hard to be directly seen in a location-based game. These characteristics are related to the specific kinds of movement players make while playing certain games. To help grasp what we mean by this the thesis introduces so-called "geo-

sociograms", a graphical representation of player movement over time (see [Herkenrath et al., 2014] and chapter 5.2 — "Geo-Sociograms"). This allowed us to grasp different ways of people's movement at a glance.

Practical Design Guidelines useful for location-based game development.

During the development of the various projects explained in chapter 6 — "Evaluation" we also gained a lot of insight into the practical issues of implementing location-based games. Complementary to the Pattern Language, these Design Guidelines are a collection of practical tips for location-based game development.

5.1 The Pattern Language

Format of the Pattern Language.

The Format of the Pattern Language for designing location-based games was not changed from [Will, 2013]:

- Name
- Design Ideal
- Design Solutions
- Trade-Offs
- Inspiration
- Related To

As [Will, 2013] explains, this format is an adaptation of the original pattern format proposed by [Alexander et al., 1977].
The "Name" is self-explanatory.
"Design Ideal" is a short description of the goal the pattern encapsulates, i.e. the intended outcome a designer would wish for when implementing this pattern.
"Design Solutions" make the core of each pattern and explain what is to be done to arrive at the design ideal.
The "Trade-Offs" are a necessary part of the pattern, since in almost every case the implementation of a pattern does not only satisfy its ideal, but it also adds side-effects to the

game.
"Inspiration" is a section specifying the sources for the pattern, i.e. existing location-based games and/or research projects that lead to the pattern. It is important to note that some of the patterns already refer to projects explained later in this thesis. These projects predate the actual definition of the pattern or were running parallel to the work of [Will, 2013], so they influenced each other.
Lastly, "Related To" puts the pattern in relation to the other patterns of the entire language.

Differences to the classic format by Alexander.

For the full rationale behind this format please see [Will, 2013]. In short, the main reason for differing from the more traditional format proposed by [Alexander et al., 1977] is the abstract nature of a location-based game as not just a physical object or arrangement of things, but as a complex activity and experience. This makes it hard to visualize the concept of a given pattern through a picture or a diagram. One cannot photograph a game as a whole. Also, these games are not very common. There are few location-based games outside academia, which means there's not much empirical background in the sense of typical, frequent phenomena one can observe in everyday life. This sets our patterns apart from Alexander's, for which there are often existing examples in the architecture and buildings in the real world.

Patterns are citations with additional annotation at the end.

The patterns in the following section are directly quoted from [Will, 2013, pp. 70–112], but we divert from the usual citation formatting style. Instead of using quotation marks we put each quoted pattern into a gray box for better readability. Otherwise the format is exactly the same as in their first publication. Since [2013] we reached new insights from our various projects (see 6 — "Evaluation") that are important for several patterns. To reflect this, we added an "Annotation" after each pattern, which is obviously *not* part of the quotation. This part puts the pattern into the context of our projects, shows how it was useful, and explains the rationale behind potential changes of it in the future. We chose against incorporating such changes at this time, because we believe such changes would be better done in a more formal process that relies on peer-reviewing and/or workshop discussions with a broader audience.

POSITION VS. LOCATION

Design Ideal:

Since the terms *location* and *position* can both have multiple meanings, there is a need to clearly define them for the context of location-based games and especially for this pattern language.

If we want to describe where a player is in terms of a data set, we are going to use the term *position*.

If we want to describe where a player is in a context, therefore giving meaning to his position, we are going to call it a *location*.

Design Solutions:

Determining a player's position and the change thereof can already be the basis for creating game-play mechanics. The game `Feeding Yoshi` for example turned unsecured wireless networks into plantations and secure ones into Yoshis. While more ideas and examples to use POSITION AS INPUT can be found in that pattern, the most important use of the player's position is to determine her location.

Observations from games such as `Feeding Yoshi` indicate that players tend to turn non-descriptive positions into meaningful (as in: having a meaning for the player) locations anyway: players would for example say a Yoshi "lived down the block".

There is obviously a possible mis-match between position and location: One position (e.g. a set of GPS-coordinates) can belong to a multitude of locations since the shape and size of what constitutes a location is variable. These variables are determined by context and meaning, which can be influenced both by the player and the game. For more information on how to deal with this mis-match and what kinds of locations one can differentiate, consult the pattern LOCATION GRANULARITY.

There are many ways to use location in games, some basic ideas for this are explained in LOCATION AS CONTENT, more specific solutions can be found in DESIGN FOR COINCIDENCE and OTHER CONTEXT OF PLAYER.

Trade-offs:

There are definitely ways to create interesting games using POSITION AS INPUT and resulting games often can be played anywhere, which is a great advantage.

However, this pattern language will focus on games that use more than just position to create a game experience, hence the name "location-based games".

We think the disadvantage of being "tied" to locations is far outweighed by the variability of gameplay mechanics, the depth of IMMERSION and the player's experience in general (e.g. through CHANGE PERCEPTION OF REAL WORLD PHENOMENA) that is offered by using LOCATION AS CONTENT in a game.

Add to this the rise of AUGMENTED REALITY technologies, which allow a great degree of interaction between virtual game worlds and real locations, and the result is a complex design space. One of the goals of this language is to help navigate this space and help with the unique challenges created by the pervasiveness of location-based games.

Inspiration:

- `Feeding Yoshi`
- `REXplorer`

Related to:

- POSITION AS INPUT
- LOCATION AS CONTENT
- IMMERSION
- DESIGN FOR COINCIDENCE
- OTHER CONTEXT OF PLAYER
- CHANGE PERCEPTION OF REAL WORLD PHENOMENA

[Will, 2013, pp. 70–71]

Annotation:

This pattern is probably one of the hardest ones, because it technically covers two aspects and not one. It addresses the same problem that was already mentioned earlier: what "location-based" means (see chapter 3 — "Location-Based Games: Fundamentals"). From the start, when [Will, 2013] was written, we were unsure whether the mere explanation of this dichotomy qualifies for a pattern, but in the end we decided to include it. So far this decision proved to have value, considering its usefulness in the games we developed since then, especially `Aachen Horror` (see chapter 6.7 — "Aachen Horror"). We didn't see any need to change the pattern either. Its main use has been to explain people, potential users/players and new developers/game designers alike, the ambiguity of the term "location".

Differentiating between the plain *technical* aspect of players' whereabouts and their *contextual understanding* of where they are has proven to ease development and discussion about location-based games in our teams a great deal. As the pattern explains we reserved the term "position" for the first option and used "location" for the latter.

In terms of hierarchy the next two patterns, POSITION AS INPUT and LOCATION AS CONTENT, are directly beneath this one and rely on the distinction of these two terms.

Since the usefulness of a pattern in development is one of its key points and this distinction is so important we saw no need to revise it. Its full name is only rarely used in general talk about a given project, unlike other pattern names. Instead, we generally used either the first or second part of its title ("Position" or "Location") to ensure everybody knew what "kind" of location we meant.

Position as Input

Design Ideal:

Information about the player's position and change thereof can be used in gameplay.

Design Solutions:

There are three basic possibilities to use the player's position as input:

- use mainly the change of position as a basis for gameplay (and not the absolute start/end position)
- with minimal setup, the game can create a game field in any suitable place
- use Other Context of Player to determine his position in a way that works in a multitude of places

Using one of these or a combination of them provides a good basis for interesting gameplay while not anchoring the game to a specific location such as a specific city or building. Some examples to further illustrate these possibilities:

- `Zombies, Run!` uses audio to give a runner the feeling of being chased by zombies. This simple idea turns a physical excercise into an immersive, story-driven experience by using distance traveled and speed of the runner as input.
- `Savannah` can be set up on on any suitable open space.
- `Feeding Yoshi` uses encryption of WiFi-networks to create plantations (not encrypted) and Yoshis (encrypted), a great example of using the Network Infrastructure to create a very diverse game experience based on where in the world the game is being played.

Trade-offs:

Since you can no longer effectively predict where the game will be played, choosing to use position this way in a game makes it difficult to use Location as Content. It is certainly more difficult in these kind of games to Design for Coincidence since it is practically impossible to scout locations for natural coincidences or fabricate coincidence using hired actors.

However, with the rise of AUGMENTED REALITY technologies it is certainly becoming feasible to provide players with a seemingly "localized" experience, even in games played all over the world (see `Ingress`).

Inspiration:

- `Zombies, Run!`
- `Savannah`
- `Feeding Yoshi`

Related to:

- POSITION VS. LOCATION
- OTHER CONTEXT OF PLAYER
- NETWORK INFRASTRUCTURE
- LOCATION AS CONTENT
- AUGMENTED REALITY

[Will, 2013, pp. 72–73]

Annotation:

This pattern ties into the concepts of location-aware technology and location-based$^+$ respectively location-based* games. It is basically the opposite pattern to LOCATION AS CONTENT, described below. As its Design Solutions imply, it refers to the games more common to the location-based* game concept, whereas LOCATION AS CONTENT fits better to the other concept of location-based$^+$ games. However, just as stated in chapter 3 — "Location-Based Games: Fundamentals" drawing a hard line between these concepts is not feasible, which is why the pattern doesn't claim it was impossible to adapt LOCATION AS CONTENT as well. It just states that doing so is difficult.

In the context of this work, the pattern also ties into the differences we see between location-aware technology as control for a game and the controls of regular (computer) games (see chapter 2 — "Development Challenges"):

- control input is less player-initiated
- control mapping is less abstract

The examples mentioned in the Design Solutions all avoid problems with these differences since they make it very clear to the players what position change does. None of these games implement an absurd mapping. The player position is always mapped to some feasible movement- or position-related game aspect. Neither do they introduce problems regarding the first point: They don't require players to perform impossible position changes or introduce mechanics where not being able to "stop inputting a current position" leads to a dangerous result.

Especially noteworthy in this context is perhaps `Zombies, Run!`, for two reasons: First, yes, having to wait at a traffic light (i.e. "inputting the same position over and over") can be fatal in the sense that the zombies "get the player" and the game/mission is lost, but that is an intentional design choice and part of its charm. From a technical point, however, this is not fatal, because it is neither a crash nor an option the designers did not consider. Second, it is one of the few location-based games that don't map the players' real world position (or rather change thereof) to (just) a virtual position.

One of our own game prototypes adapting this pattern was `iCatch`, as described in chapter 6.3 — "iCatch".

LOCATION AS CONTENT

Design Ideal:

Location-based games are played in the real world and should use it as a resource.

Design Solutions:

To quote Bichard and Waern: "The world is a vast and infinitely changing resource of content for pervasive games".
Games that use LOCATION AS CONTENT should incorporate real-world artifacts unique to those locations into the game.
The ability to merge the real world into a game world is essential in differentiating location-based games from "classic" games on PC, consoles or mobile devices. The goal in this case is to use things that are unique about a location to create an equally unique game experience which can not be replicated elsewhere.

Real-world artifacts include for example all kinds of sensory information:

- visuals: what kind of buildings, colors, lighting...
- sounds: streets, cars, people, church bells...
- smells: food, people, smog ...
- social events: regular gatherings (markets, weddings, mass etc.)
- people: tourists, locals, age groups (children, adults etc.)
- "atmosphere": time of day, lighting, weather, special occasions such as Christmas markets

Additionally, every place has a unique history and "facts" (as in: trivia) associated with it, which can be used in multiple ways in a game. For example, you could use your game to teach these things to the players, which results (ideally) in CHANGED PERCEPTION OF REAL WORLD PHENOMENA. The opposite would be to use their existing knowledge of history and trivia (e.g. in a game aimed at locals) as a basis for a gameplay mechanic where they have to use that knowledge to solve riddles.

Real-world artifacts can be used in a multitude of ways to create a great experience for the player(s) - the patterns DESIGN FOR COINCIDENCE, EXPLORATION CENTRAL TO GAME and LANDMARKS contain some of the most prominent ideas.

Trade-offs:

Using real-world artifacts in a game also introduces "real-world problems" into it - REACHABLE LOCATIONS probably being the most important one.

Additionally, LOCATION GRANULARITY needs to be considered to avoid PLAYER CONFUSION.

And finally, from a more technical point of view: NETWORK INFRASTRUCTURE can have a huge impact on what locations are actually suitable for location-based games.

Inspiration:

- `REXplorer`
- `Interference`

Related to:

- POSITION VS. LOCATION
- LOCATION GRANULARITY
- DESIGN FOR COINCIDENCE
- PLAYER CONFUSION
- EXPLORATION CENTRAL TO GAME
- NETWORK INFRASTRUCTURE
- CHANGE PERCEPTION OF REAL WORLD PHENOMENA
- REACHABLE LOCATIONS

[Will, 2013, pp. 74–75]

Annotation:

This pattern serves as the counterpart of POSITION AS INPUT. Consequently, it results in adapting games leaning more towards the location-based$^+$ type, since using the specific characteristics of locations (especially in the more colloquial sense of location as "sights") binds them to individual, absolute playing fields.

Relying on the actual semantics of a location also shifts their importance during play from "moving there" to the site itself, hence the pattern's naming. Unlike the previous pattern this also draws players' awareness away from the control issues in chapter 2 — "Development Challenges". While, technically, the change of location still triggers changes in the game, i.e. it is a form of input control, the focus typically does not lie on this aspect. To the player, a location is not a given set of input data that she can manipulate, it is part of the game's plot, or "content", like a certain area in a traditional digital game's virtual environment or a specific item.

Like POSITION AS INPUT avoids potential problems by making the limited abstraction of movement as control and the limited player-initiation of the control input obvious. This pattern avoids problems by hiding them. The down-side to this are the limitations explained in the Trade-Offs and the leaning towards location-based$^+$ game concepts.

Location Granularity

Design Ideal:

Misunderstandings between game designers, players and the game system about positions and locations must be avoided.

Design Solutions:

As described in Position vs. Location, to GPS, a position is merely a set of coordinates. To WiFi or cellular-based positioning services, position information might be a set of signal strengths and network IDs.

To players however, location can mean a lot of different things: It could be a street, a building, a room in a building, the place in front of a certain side of a building.

Furthermore, there is no fixed size for what constitutes a location: anything from which side of a table you are sitting at up to which city you are in.

Game designers need to match these two different views, the semantic, context-dependent view players have of a location and the discrete, mathematical/geometrical view computer systems have of a position.

To further illustrate the problem: Imagine a player is standing just outside of Aachen Cathedral's south wall, close enough to touch it. For some reason, let's say a quest that is part of a game based on city exploration, he should go into the cathedral. Now, to cope with uncertainty of GPS, the game assumes the player is inside the Cathedral and marks the quest as "completed". While the system might not see a difference between position X and position $X+1m$, to the player these two positions are totally different locations.

While it might be possible to predict these mismatches, the only way to be adequately sure is to do extensive user/player/beta-testing and watch out for symptoms of these problems, such as Player Confusion.

Trade-offs:

In a lot of cases, this mismatch is actually not a severe problem, one example being `Feeding Yoshi`: Players memorized e.g. that a certain Yoshi lives in front of a store. While the Network Infrastructure responsible for creating this Yoshi might not actually belong to that specific store, it does not change it's position and (presumably) always covers the front of that store.

Therefore the game experience is not always disturbed by the mismatch between player view of *location* and system view of *position*.

Inspiration:

- `Feeding Yoshi`

Related to:

- POSITION VS. LOCATION
- NETWORK INFRASTRUCTURE
- COPING WITH UNCERTAINTY
- PLAYER CONFUSION

[Will, 2013, pp. 76–77]

Annotation:

This is a pretty straight-forward pattern that might seem obvious at first. We included it in the pattern language anyways, because experience from the various games we designed (see chapter 6 — "Evaluation") showed that the different connotations of the term "location" are not always present in people's minds.

`Aachen Horror` (see chapter 6.7 — "Aachen Horror") or the `GroupAixplorer` are good examples of this. For these projects we had to gain feedback not just from potential players, but from an early point on also from the city's and the museum's staff. Often during these meetings we realized that concepts we had planned to include were harder to communicate than we originally thought. People tended to rely a lot on semantic knowledge about given places and/or changed the actual meaning of a location's name depending on context. For example, they would describe one building as being "near the city hall" in the context of routing players there. In this context that would mean several dozen meters away, maybe even where you wouldn't even see the city hall anymore. Yet, when talking about a search task, "near the city hall" would mean something different, even if it was the same person using the phrase. Suddenly it was meant to refer to the small area actually encircling the city hall itself, a much closer location.

Of course, as we had the technical background regarding the actually used location-aware technology, we would usually catch those issues when staff were proposing ideas to us, for example, giving us information about a location's history to come up with plot ideas for a game, but we realized that when we relayed suggestions to them, we never knew how they would interpret our terminology when we weren't careful.

Thus, we realized we would have to show the same carefulness when including such terminology in our games.

REACHABLE LOCATIONS

Design Ideal:

Game locations should be reachable by anyone, anytime.

Design Solutions:

If a game uses LOCATION AS CONTENT, it is important to ensure players can actually reach the game's locations.

There are many factors that can influence how and if players can actually play the game at the intended location, such as:

- opening times
- traffic
- social events (e.g. a farmer's market might restrict access to a public place)
- construction
- weather

Extensive scouting of the locations used as content has not only the advantage of minimizing the impact of the above-mentioned factors, but additionally one might notice artifacts that could be used to DESIGN FOR COINCIDENCE.

Trade-offs:

Sometimes, a certain difficulty to reach a location can actually be a part of the game, `Geocaching` being the best example for how this is appealing to players.

It is also important to note that it is not necessarily "bad" to limit the general availability of a game: Players will for example accept they can only rent and use an interactive tourist guide such as `GroupAixplorer` during the opening times of the game's location.

Inspiration:

- `Geocaching`
- `GroupAixplorer`

Related to:

- LOCATION AS CONTENT
- DESIGN FOR COINCIDENCE

[Will, 2013, pp. 78–79]

Annotation:

This is another one of the seemingly obvious patterns, yet we felt it important to "give the problem a name". The limitation to games using LOCATION AS CONTENT mentioned in its Design Solutions should be revised to address games using POSITION AS INPUT as well. Those might also hit issues with unREACHABLE LOCATIONS, after all. However, usually location-based* games don't encounter such problems in the same manner. Here it is more often a problem when setting up the game, i.e., it could even be a challenge for the players themselves (if they are required to set up the play field during an initial phase).

From our experience this is less of an issue, though, since these games focus more on physical movement and less on the meaning of specific locations. Blocking issues are thus automatically recognized by players.

For games using LOCATION AS CONTENT (which are more likely to be of the location-based+ kind) the impact can be harder. It is easy during game design to simply not choose permanently blocked locations, but as the list in the pattern's Design Solutions implies, it is varying conditions that are the problem.

It even goes beyond plain physical reachability, e.g. a farmer's market might not physically prevent players from going to a place, but make playing the game there practically impossible, or at least socially uncomfortable (see also MINIMIZE SOCIAL AWKWARDNESS).

Since identification of a target location is often part of a game (e.g. in a scavenger hunt, or game with investigative aspects like `Aachen Horror`, see chapter 6.7 — "Aachen Horror") different reachability might also lead to players simply not recognizing a location ("They can't mean the city hall, we can't always enter that!").

Other Context of Player

Design Ideal:

Location-based games can and should use more information than just the current position of a player.

Design Solutions:

The full context of the player includes more than just information about his *position* and *location*.

Using all this information allows to create interesting interactions and gameplay mechanics.
For example, at every location you can probably find things such as:

- the sounds the player can hear
- the people he can interact with
- the ambiance (e.g. the weather)
- the buildings at the location

Incorporating these (and whatever else you can think of) allows for more variety in gameplay and content, e.g. by using these artifacts in order to Design for Coincidence.

Trade-offs:

While the context of the player can be used to greatly enhance gameplay, e.g. through Design for Coincidence, it can sometimes be hard to predict. Therefore it is important to have mechanisms in the game that can deal with unexpected errors and similar problems to avoid Player Confusion.

While variety in gameplay is great to bind players longterm and therefore great for "persistent" games such as `Ingress`, it also increases the time it takes to learn and understand a game, making it less suited for players such as commuters looking for short distraction.

Inspiration:

- `Interference`
- "Tangible pleasures of pervasive role-playing" Montola

Related to:

- DESIGN FOR COINCIDENCE
- LOCATION AS CONTENT
- PLAYER CONFUSION

[Will, 2013, pp. 80–81]

Annotation:

We haven't found any new aspects regarding this pattern since its first publication in [Will, 2013]. Naturally, it is easier to make use of a player's other context if the game designers already know what this context will be. Thus, this pattern is a lot easier to adapt for location-based$^+$ games and games that implement LOCATION AS CONTENT.

We made extensive use of this pattern in `Aachen Horror` (see chapter 6.7 — "Aachen Horror"), trying to pick "eerie" places that fit the game's mystic, ominous themes.

DESIGN FOR COINCIDENCE

Design Ideal:

Seemingly coincidental events are a great way to manipulate the APPARENT FRAME of a game.

Design Solutions:

Study the places your game will be played at carefully. Observe what kind of visual cues, sounds and social events happen regularly (and are predictable) and incorporate them into your game.
Additionally, you can manipulate the environment to create circumstances which will seem coincidental to the player.
Both require, in almost all cases, the game to use LOCATION AS CONTENT.

Player interviews in case studies of LARPs and other pervasive games often indicate that players really appreciate coincidental events that seem to be part of the game world. This is not surprising: real life is full of (perceived) coincidences while game worlds are often governed by strict rules and are strongly scripted, making them feel "artificial".

The goal now is to take an "artifact" from the real world, be it a visual cue, a person or an event and give it a meaning inside the game world. For a wider overview of what artifacts can be used in a game, see OTHER CONTEXT OF PLAYER.

A perfect example on how to achieve this can be found in the game `Prisoner Escape from the Tower of London`:
The "beefeater" guards in the Tower were given RF transmitters, while the players had devices able to detect the location of those transmitters. One of the player's goals is to "escape" the Tower, i.e. leave it while avoiding the guards. When detecting one of the guards' transmitters, the player's device would alert them and they would lose the game. As a result, the real world activity of the guards - patrolling the Tower and talking to tourists - had an additional meaning to the players of the game. Even more so since not all guards were carrying transmitters - which the player's did not necessarily know. This resulted in players hiding from guards which were just going about their everyday duties, turning a coincidental encounter into a part of the game world.

While the above mentioned guards still continued their everyday routine, it is also possible to fully fabricate coincidental events. This is often achieved by hiring actors for no other purpose than to interact with the players.

Lastly, there is one more way to blur the APPARENT FRAME - which is also the most difficult one: to use an actual coincidence as part of the game.
`Uncle Roy all Around You` achieved this by essentially gambling with probabilities. One instruction for example, given in a crowded place, was to "follow the black-haired woman". Obviously there is a decent chance that in a crowd the player will sooner rather than later spot a black-haired woman and follow her. The vague description in this case is essential to increase the probability of the player spotting someone to follow. The game constantly tracked the player's position and had several coordinated actors in place to "step in" when the game administrators suspected she might be lost or when she actually came close to where the game continued.

Trade-offs:

Designing for coincidence is obviously reliant on predicting both the behavior of the player(s) and the environment - which is definitely hard at times.
It is therefore important to have "fail-safes" in place, in order to recognize PLAYER CONFUSION and help.

Additionally, if the "timing" is off, e.g. a player is supposed to count the number a church bell rings but does not pay attention at the right time - the whole game can fall apart.
A possible fail-safe in this case could be a recording on the player's device that she could play at will after the church bells finished.

Inspiration:

- `Prisoner Escape from the Tower of London`

Related to:

- APPARENT FRAME
- LOCATION AS CONTENT
- OTHER CONTEXT OF PLAYER
- PLAYER CONFUSION

[Will, 2013, pp. 82–83]

Annotation:

As emphasized in its Trade-offs section this is one of the harder patterns to adapt in the framework. It basically demands that the designers expect the unexpected.

Generally, we see this pattern more suited for location-based$^+$ games adapting LOCATION AS CONTENT, since those are better defined in terms of what real world conditions impact the gameplay.

In practice the difficulty to implement it heavily depends on the game's concrete specifics and plot (if it has something like a plot). Since coincidences in this context are usually things that happen in the real world, regardless of the game, it must have mechanics that are relevant to them in some way. For example, imagine a bystander approaches people playing a scavenger hunt game. The players won't even perceive her as part of the game unless there are mechanics implying the interaction with a person is even a possibility. If said game was not a simple scavenger hunt, but rather a game with the objective to find an incognito opposing player the impact of a bystander approaching the players is a lot different: Could they mistake her for the opposing player they're chasing?

In our projects we found it hard to DESIGN FOR COINCIDENCE without leading to too much PLAYER CONFUSION or even not properly MINIMIZING SOCIAL AWKWARDNESS.

`Aachen Horror`, for example, actually demands the players to contact people outside of the game (who were asked to deny having anything to do with the game): Players have to book a certain location to get access. The location is used for other means than our game, too, so when exactly the players can visit depends on a booking schedule and is thus random. That's basically a coincidence in the sense of the DESIGN FOR COINCIDENCE pattern (though it touches other patterns as well, of course). During the design phase we considered setting a time-limit in which the location needs to be visited. That would have introduced even more chance to the task, whether the players could succeed or not would have been a complete coincidence depending on how much the location was frequented outside of our game.

Thus, we decided against a time-limit. It would have given us no fail-safe.

For an in-depth description of how this mechanic works, see chapter 6.7 — "Aachen Horror".

LANDMARKS

Design Ideal:

Landmarks are perfect for location-based games.

Design Solutions:

The main advantages of landmarks are:

- they are easy to spot: they might not necessarily be visible from everywhere in a city, but you can definitely see them from some distance
- they are easy to recognize: there is only a very small chance someone will confuse Aachen Cathedral with the church next to it
- they are known to locals: even if a player has difficulties finding a landmark, the local population will not

The combination of these three properties makes landmarks very useful for navigation - tourists everywhere on the world can attest to this. Through the use of landmarks, a game can help players find out:

- where they are
- where they need to go
- what way they should take to their target

To achieve this, the game should tell them what distinctive buildings (like clock-towers), features (like hills) or even social settings (a busy marketplace) they should or shouldn't be able to see.

Displaying pictures of the landmark can further reduce ambiguity and help with navigation. This is especially helpful in areas with less accurate position information (see: COPING WITH UNCERTAINTY, NETWORK INFRASTRUCTURE).

Landmarks can also help to reduce the problem of LOCATION GRANULARITY - there is a general consensus of the size and borders of a landmark. Additionally, most landmarks are buildings and as such have a front, a back and often labeled entrances, which can be very useful for precise navigation.

But while using landmarks for navigation is already great for location-based games, they are also very well suited as content for the game (LOCATION AS CONTENT). In many cases, landmarks are not only visually unique but carry additional cultural, historical or social meaning. Some ideas to use these unique properties in location-based games are:

- as reward: if players solve a quest, they recieve information about the history of a building - very useful for interactive tourist guides
- as part of a game mechanic: players might have to find out the date a church was burned down and enter it into the game to proceed
- as atmospheric background: e.g. if a game is set in 1600 a.d., playing in front of or in an actual building from 1600 increases the player's sense of IMMERSION
- as part of the game world: in a story-based game, blurring the boundary between game and reality (see APPARENT FRAME) can "transform" an ordinary church into the headquarters of a secret society

Trade-offs:

In POSITION AS INPUT, we give examples of games that do not use LOCATION AS CONTENT. Such games therefore can make little use of landmarks.

One additional trade-off is similar to the one mentioned in REACHABLE LOCATIONS: Games such as `Geocaching` draw much of their appeal from the fact that the game's locations are difficult to find.

Inspiration:

- `REXplorer`
- `Geocaching`

Related to:

- POSITION AS INPUT
- LOCATION AS CONTENT
- REACHABLE LOCATIONS
- APPARENT FRAME
- IMMERSION

[Will, 2013, pp. 84–85]

Annotation:

Usage of this pattern should be pretty self-explanatory. There's just two minor aspects that should be taken into account to properly benefit from it.

First, what constitutes LANDMARKS depends on the scale of a game, respectively its used location-aware technology. If it is an outdoor game played in a city the term can mostly be understood quite literally, in indoor games that might be a little different. For example, in the indoor game `GroupAixplorer` (played in a museum, see chapter 6.2 — "GroupAixplorer"), a LANDMARK could be a single painting or even a specific room (like the "red hall").

Second, the mentioned mitigation of problems concerning LOCATION GRANULARITY has its limits. As this pattern's Annotation explains, the context any LANDMARK is referenced in during gameplay can influence what exact area player's will assume as belonging to it. For example in Aachen, the actual area people assume to be meant by the expression "on the market" might depend on whether there's currently a farmers' market going on at the location or not. The space where the different stands are is actually less than the entire public square officially called "market place" in this case.

CHANGE PERCEPTION OF REAL WORLD PHENOMENA

Design Ideal:

Many games are appealing because the players learn something about themselves, others, and the world.

Design Solutions:

While important for and present in almost all kind of games (the work-in-progress pattern language of Björk contains a version of this pattern more focused on classic games), location-based games have a distinct advantage.
Since they are played in the physical world, they can more easily change the perception players have of the places they are played at, especially if they actively use that LOCATION AS CONTENT.

A classic example would be an interactive tourist guide such as `GroupAixplorer`, teaching players what life was like at their current location during a specific period of history.

Through role-playing, players could learn something about themselves or about characters they portrait.

AUGMENTED REALITY can be also be very helpful in achieving this ideal, e.g. by overlaying historical views on the current version of a building.

Trade-offs:

The (maybe) central problem in game design: different players like different kinds of games. Not everyone plays a game to learn something about the place they are at. E.g., for players that just want to "waste some time" and have a little bit of fun, learning about a very tragic fact about the history of their current location might be a game-breaking intrusion.

Additionally, purposefully designing to achieve this is very difficult, as Bj´ork explains in more detail in his pattern: both the players knowledge and willingness and the ability of the system to model the real world or interact with the real world have heavy influence on a successfully changed perception.

Inspiration:

- `GroupAixplorer`

Related to:

- LOCATION AS CONTENT
- AUGMENTED REALITY

[Will, 2013, pp. 86–87]

Annotation:

Besides the issues already mentioned in the Trade-offs of the pattern there are also external factors that have to be considered when trying to adapt it.

In `Aachen Horror` (see chapter 6.7 — "Aachen Horror"), for example, we intended to bring the players' attention to an especially grim historic occurrence at a location in Aachen: Right at the end of World War II, two 14-year-old boys were murdered for alleged plunder by the Nazis. Today, a memorial badge[1] indicates the location where this crime happened. We thought we could use our game to draw attention to this tragedy and educate our players. It wouldn't contradict the dark general theme of the game, so we didn't expect it to be game-breaking for the players.

However, it turned out that our historical advisors voted against the idea, not because they were against getting people to know about this dark part of Aachen's history, but because we wanted to include it in a *game*. We had been too focused on the game itself and whether real world phenomena would fit in with the game and not whether the game would fit in with them. Our advisors also pointed out that both boys' families might be concerned (we didn't know the two still had living relatives at first) with their ancestors names being used in this context. In the end we found a compromise, we referred to the incident without using the boys' names. Thus, we were still able to bring attention to the crime without disrespecting the victims or their families.

[1] http://www.wgdv.de/wege/bunkersaarstr.htm

Exploration central to Game

Design Ideal:

Location-based games should provide motivation to explore a cityscape or landscape.

Design Solutions:

The advantage of playing in the "real world" allows players to explore more than just a virtual game world.

There is no question about exploration being a great motivator for players. Be it single-player games or MMORPGs on consoles or PC, players will always use the freedom they are given to explore that particular virtual world.
Obviously, a little reward from the game for doing so is helpful, but not much is required - humans seem to be explorers by nature.

Therefore, location-based games should try to give players as much freedom as possible:

- let them choose their own path between locations
- let them choose the order for visiting locations
- lead them "off the beaten path"
- provide motivation for them to explore their environment - with all their senses

Trade-offs:

While exploration is great in order to achieve several goals, such as Change Perception of Real World Phenomena as well as being appealing gameplay, there are limitations to it.

First, there are trust issues as in described in Ethical and Legal Problems: Urban areas for example can be dangerous - it might be useful to prevent players from exploring them.

Secondly: Players might be of different navigational skill level - there is obviously a difference between exploration and simply being lost (see Player Confusion).

And in some games, exploration might simply not fit in with the overall theme or

idea of a game: a game with a strong, linear narrative and time constraints (since it may use hired actors) can not give the players a lot of freedom in choosing their way between locations in order to keep the narrative flowing at a certain pace.

Inspiration:

- `Feeding Yoshi`
- `Ingress`

Related to:

- CHANGE PERCEPTION OF REAL WORLD PHENOMENA
- LOCATION AS CONTENT
- ETHICAL AND LEGAL PROBLEMS
- PLAYER CONFUSION

[Will, 2013, pp. 88–89]

Annotation:

This pattern was heavily used in all our projects so far. One of the reasons were our ties with the city of Aachen. Since we often worked together with museums and the city's historians we received plenty of suggestions regarding places that would be worthwhile for our players. We tended to use LOCATION AS CONTENT a lot, so it seemed natural to also have our players "discover" new or at least uncommon places. The most notable example of our games adopting this pattern is `Aachen Horror` (see chapter 6.7 — "Aachen Horror"). The sheer size of the area the game takes place in (basically the entire inner city) as well as its potential length mean that players explore the city quite a bit. We also consciously designed it in such a way that would lead players to places they probably have not been to yet, or least put places they knew into a new perspective.

We think that when dealing with third parties during the design process (like historians, city officials, etc.) this pattern is one of those seen as most valuable by them. These people are often interested in reaching a greater audience with "their" locations and are likely to value location-based games of any kind as a form of edutainment. EXPLORATION CENTRAL TO GAME fits that demand very well, since, as we learned from the city staff we met, leading visitors to certain places is a key aspect they often deal with.

An additional warning to be added to the pattern's Trade-offs, however, would be this:

- In large scale games, avoid forcing players to re-visit locations without good reason

The rationale behind this is rather simple and ties in to the last paragraph in that section: A lot of games relying on a narrative, like our `Aachen Horror`, demand that players do something specific at a location. Furthermore, it is easily possible that they first have to accomplish a prerequisite at location A to do be able to do something at location B. If they find location B via exploring before they finish the prerequisite at location A, this means they have to go back to location B later. In city wide games this can quickly lead to quite a large overhead in traveling between locations and thus potentially tire the players.

In other, smaller scale games, this is less of an issue, since the additional travel between locations isn't that big a deal. Our `GroupAixplorer` is a good example for that.

PLAYER CONFUSION

Design Ideal:

Since player confusion in location-based games can have significant consequences, it needs to be prevented and alleviated.

Design Solutions:

In games played at home, players can easily turn off the game and take a break when they encounter a problem they can not solve. In location-based games, a game confusing the player could lead to her being lost in a city she might not know.

In `Uncle Roy All Around You`, the game designers kept constant track of the position of their players. When they suspected a player might be lost, they instructed one of the actors that were part of the game to intervene.

This shows one of the central challenges in recognizing confused players: it requires constant supervision, done by human observers. One of the best solutions to help confused players is implemented in all MMORPGs: Game-masters. Players can contact them if they are lost or stuck and will receive (ideally) immediate help. Additionally, the availability of game-masters provides players with an increased sense of security, even if they don't need them.

As with any device or software, a "help" function should always be available, providing the player with information on how to deal with possible problems. This help should be available off-line, i.e. even if the device is currently not connected to a network, to avoid problems of the NETWORK INFRASTRUCTURE.

Trade-offs:

As mentioned above, recognizing if a player is truly confused or maybe just enyoing EXPLORATION CENTRAL TO GAME is near-impossible from tracking data alone. Human observers can provide more accurate guesses than an automated system, but it is still mostly guesswork.

The (arguably) best solution, game-masters, require a considerable effort of money and man-power. Therefore, a good help functionality, available off-line, is essential.

Inspiration:

- `Uncle Roy All Around You`

Related to:

- EXPLORATION CENTRAL TO GAME
- NETWORK INFRASTRUCTURE

[Will, 2013, pp. 90–91]

Annotation:

It should be noted that in principle, this pattern applies to any kind of game, not just location-based games. We decided to explicitly include it in the language anyways because the consequences are potentially even bigger than in any other kind of game.

As stated in the Design Solutions, a confused player can easily be literally lost. In most other games, confusion is limited to the game itself. Just because a player doesn't understand what's going on in the game doesn't mean she's suddenly also confused about what to do after stopping to play for any reason.

In a location-based game, the confusion can easily "swap over" into real life. Not just in the form of lost orientation, but also in terms of "what is real and what belongs to the game?", depending on the use of other patterns like APPARENT FRAME and IMMERSION (the same applies to pervasive or AR games): Depending on how strong any IMMERSION is and how the game mechanics work the player might not even exactly know how to turn off the game. (Of course a game should never be intentionally designed like this.)

This then can also lead to problems with MINIMIZING SOCIAL AWKWARDNESS or even cause ETHICAL AND LEGAL PROBLEMS.

So far we always avoided the extreme consequences of PLAYER CONFUSION by giving players of our prototypes our contact information, i.e. we included game masters.

Admittedly, this might be hard in real commercial games with a large player base, but at least during the design/beta phase of any location-based game we would strongly recommend this approach. In our case any game-master was always also able to physically meet up with the players to investigate problems. This turned out to be often necessary since it was sometimes hard to communicate the details properly. Especially when it came to describing problems with finding the correct location (as in "a location the game software reacts to") players and the game-master could better discuss things in person and "on location".

ETHICAL AND LEGAL PROBLEMS

Design Ideal:

Players put a lot of trust into the game creators when they play a location-based game in a public space.

Design Solutions:

It is important to keep the social context in mind when designing a location-based game.
As an example: ten adult men chasing a woman over a marketplace may not be correctly interpreted as part of a game by bystanders.

It is therefore important to design the game-play in accordance with local laws and customs.
Even if players know some action would be unlawful, they might still rationalize completing it, e.g. by assuming the game creator acquired a permit or has otherwise coordinated the game with local law enforcement.

While staying within the confines of the law will keep players out of jail, staying within local customs is great for MINIMIZING SOCIAL AWKWARDNESS, making a game more accessible.

Trade-offs:

While breaking the law should never be part of a game, breaking local customs and social conventions can actually be very appealing to players. The pervasive role-playing game `Interference` is a good examples for this.

Inspiration:

- `Interference`

Related to:

- MINIMIZING SOCIAL AWKWARDNESS

[Will, 2013, page 92]

Annotation:

While the legal aspect of this pattern is probably immediately obvious in most location-based games, the ethical and "merely" culturally questionable (instead of outright illegal) issues are easily overlooked.

Especially when parts of the game are meant to CHANGE PERCEPTION OF REAL WORLD PHENOMENA, which could go along with changing player's perceptions of cultural rules, it can quickly happen that players behave in a way that conflicts with social norms.

This can be a good thing, but can also lead to unintended conflict or even punishment.

The example given in the Design Solutions section actually came up during a student project (for the `iCatch` game, see chapter 6.3 — "iCatch"). Students had to design a digital version of tag, i.e. players had to chase after another. The entire team, including the instructor, was so immersed in coming up with new rules and solutions for technical problems that nobody thought about the game's impact on bystanders. Only during the first trials in a park, students realized how awkward it feels to chase one another as adults. This also shows how the team failed to properly MINIMIZE SOCIAL AWKWARDNESS.

The testers were all male and during the tests nobody happened to alarm the police, but students mused that might have been different if the one being chased had been female (we didn't actually confirm that for obvious reasons). The bystanders they saw didn't immediately realize they just played a game. We believe that although people know tag as a game, they generally perceive it as a game only children play, so seeing adults play it looked suspicious. Usually, adults chasing each other is of a more serious matter.

Another example for ethical problems is the one mentioned in the annotations for CHANGE PERCEPTION OF REAL WORLD PHENOMENA.

MINIMIZE SOCIAL AWKWARDNESS

Design Ideal:

Location-based games are mostly played in public settings. If a game requires any interaction that is unusual for the public setting (such as loud verbal communication, gestures etc.), the feeling of awkwardness might discourage players from playing it. Additionally, bystanders not knowing a game is being played might further increase the feeling of awkwardness.

Design Solutions:

When designing your game's interactions, be aware of the social context the game is played in.

The easiest way to reduce awkwardness is CO-LOCATED MULTIPLAYER, especially if it involves local co-operation since this invites players to form an EPHEMERAL MAGIC CIRCLE. This circle can distinguish play from everyday behavior in the eyes of bystanders - helpful for avoiding ETHICAL AND LEGAL PROBLEMS.

In games that are played by a single player but in very public settings, in most cases it is a good idea to avoid interactions that involve expressive gestures, loud verbal interactions or role-playing, as they might make the player (and bystanders) feel uncomfortable.

Trade-offs:

Minimizing social awkwardness is important as it has a fundamental impact not only on the player experience, but also can make it easier for bystanders to understand a game is currently being played.

It seams that one of the best ways to reduce this awkwardness is CO-LOCATED MULTIPLAYER, which is great since location-based games often work better as social experiences anyways.

However, balancing social awkwardness and interesting game mechanics is not a simple process: Gesture-based interactions, for example, certainly can increase awkwardness, but they are also very appealing mechanics (especially in role-playing games, where AUTHENTIC ACTIVITY is required).

Inspiration:

- `Interference`

Related to:

- CO-LOCATED MULTIPLAYER
- EPHEMERAL MAGIC CIRCLE
- AUTHENTIC ACTIVITY
- ETHICAL AND LEGAL PROBLEMS

[Will, 2013, pp. 93–94]

Annotation:

This pattern addresses similar aspects as the previous, only with a slightly different focus. Even activities that are not directly illegal or culturally inappropriate can be problematic when displayed in public. The examples given in ETHICAL AND LEGAL PROBLEMS can be seen as relevant for this pattern, too.

Of course the easiest way to avoid any social awkwardness is to either "hide" the game within normal activities. For example, playing `Zombies, Run!` is, for an on-looker, indistinguishable from simply running.

However, a lot of games try to coax players into doing something unusual. It can be fun to overcome any slight anxieties in the context of a game. For these cases it is important to think of the OTHER CONTEXT OF PLAYER during the design phase.

In a lot of our projects this was a constant process of reducing the game mechanics. Designing a task of simply "going somewhere and do X" seemed to appear bland to us at first, at least compared to the design ideas for more traditional games' mechanics. Making use of gestures and interaction with the gaming hardware seemed essential.

Only when we took into account that our players would often be under the scrutinizing view of the general public, were we realized that "less might be more" in many cases.

Another aspect of this is the effect a location itself can have on a person. Such effects are often subliminal and thus they were easily forgotten, it "didn't show up on the drawing board". Too much interaction with the traditional game mechanics (i.e. in our cases mostly tapping on a smartphone) draws the attention away from, for example, the general eeriness of a dark alley or park. While this is not in itself necessarily causing awkwardness (depending on the place), it most certainly went contrary to our efforts to make proper use of LOCATION AS CONTENT.

EPHEMERAL MAGIC CIRCLE

Design Ideal:

In CO-LOCATED MULTIPLAYER games, help your players form a safe zone in order to MINIMIZE SOCIAL AWKWARDNESS.

Design Solutions:

When standing shoulder next to shoulder, facing inwards, players form a "magic circle of play".
This magic circle is ephemeral because it is disbanded as soon as the group starts to move again or splits up for another reason.

This helps both them and bystanders to separate play from ordinary life, reducing the social awkwardness.

Gameplay mechanics that require face-to-face communication, device sharing and similar forms of cooperation will naturally lead to the formation of such a circle.

Some case studies of pervasive LARPs indicate that role-playing feels less awkward when not done alone.

Both for the players and onlookers, a clear distinction of play and ordinary life is helpful in avoiding miscommunication and feelings of social awkwardness. The circle formed by multiple players, while not a "hard boundary" such as a closed door, is a clear signal to bystanders that a social group activity is going on. For the players, knowing they are sending a clear signal to outsiders "we are playing a game inside this group" helps them to feel secure and be more outgoing.

Trade-offs:

While this clear distinction is helpful in MINIMIZING SOCIAL AWKWARDNESS, the circle puts the APPARENT FRAME into the focus of players and bystanders. As explained in the pattern APPARENT FRAME, blurring this (perceived) boundary between play and real life is a great tool to create IMMERSION, which helps players enjoy a story-driven game.

Inspiration:

- `Interference`
- "Tangible pleasures of pervasive role-playing" Montola

Related to:

- MINIMIZE SOCIAL AWKWARDNESS
- APPARENT FRAME
- CO-LOCATED MULTIPLAYER

[Will, 2013, pp. 95–96]

Annotation:

Since most of our game projects were designed for CO-LOCATED MULTIPLAYER this pattern was often used, so we are quite confident in its importance. The observation that players' awkwardness appears to be reduced by creating a stronger group identity could also be made in our gaming sessions.

However, it wasn't apparent to us that the circle doesn't necessarily need to be a literal, physical circle for the players at all times when [Will, 2013] was written. In some cases players started a game's task at a certain location by forming a circle and debate what to do and how to do it, but then, due to the nature of the task, broke up.

`Aachen Horror`'s various quests, for example, are often designed in such a manner. The players arriving at a location first had to listen to an introductory audio and then had to split up, or at least divide into subgroups. In the case of defending against the Hounds (see chapter 6.7 — "Aachen Horror" for a detailed description of the game's concepts), it was enough that one player left the group to lure the beasts away. While technically breaking off from the circle, it seemed the player was still immersed enough in the game and did not feel left out, although we do not have hard data to bolster this observation.

Another addition to the pattern would be that even after a circle was broken, players could often be identified as a group by bystanders via the used hardware. In our case it always stood out that a group using the same smartphones at the same time belonged together, even if they were not in that close vicinity.

Lastly, we found out that the synchronized audio we used also added to the group feeling. This shared experience resulted in an atmosphere of being in a "secret society". Players would usually wear headphones, so only they could hear the sounds, emphasizing the pattern further.

NETWORK INFRASCTRUCTURE

Design Ideal:

Location-based games rely on wireless technologies - these should ideally not have a negative impact on game design.

Design Solutions:

Unfortunately, there are three ways the available infrastructure can impact a location-based game:

- the game design is (more or less) final and a fitting infrastructure needs to be chosen
- only a very specific infrastructure is available and therefore influences game design
- the game is designed based on a very specific technology

The first way can be the case of a game designed for all modern smart-phones - whatever the current standard of technology is, will probably be used in the game (e.g. GPS or Assisted GPS or maybe even WiFi-localization).

The second case if often encountered in games that use LOCATION AS CONTENT, for example interactive tourist guides and similar games. These often rely on custom-build devices that can be rented at the location where the game is played (such as `GroupAixplorer`). These devices may use standards like GPS (if available at their location), but often additionally use custom systems for indoor-localization.

A perfect example for the third case would be `Feeding Yoshi` which utilizes the difference between unsecured and secured WiFi-network access points as a basis for gameplay.

Furthermore, it is important that network infrastructure is not limited to the localization technology, but also includes data down- and up-links and device interconnectivity.

When designing a game, the available technologies need to be carefully evaluated, especially on how they try to cope with uncertainty. In “Coping with Uncertainty in a Location-Based Game”, Benford et al. show that very high error rates can create game-breaking scenarios, ruining the player experience.

Special attention should be paid to the impact of network connection on player behavior: in their game `Savannah`, the researchers noticed that a player would often stop immediately when notified that she reached a game location, i.e. at the edge of this location. This would sometimes cause the players following this player to stop outside of the detection radius of this location and therefore not being able to help with the players "quest".
To tackle this problem, the researches suggest to separate game locations into two zones: trigger the "quest" only when a player enters the inner zone, so that players in the outer zone can also be given the quest and help him.
Another way to help with this is to have players project a "personal aura" around them. If a player triggers a quest, all players in his vicinity should be able to collaborate with him, even if they are not perfectly inside of the game location.

Trade-offs:

Currently, indoor localization is not in any way standardized or even available which makes it near-impossible to use in games that can not rely on custom-build hardware.

It is also important to realize that even if localization works well, data connectivity can be bad at a location. If a game relies on exchanging information, e.g. between a client device and a game server or between devices (mainly in multiplayer games), this can also create game-breaking problems, for example in the form of "lag".

Inspiration:

- "Coping with Uncertainty in a Location-Based Game" Benford et al.
- `Savannah`

Related to:

- LOCATION AS CONTENT
- COPING WITH UNCERTAINTY

[Will, 2013, pp. 97–98]

Annotation:

This pattern turned out to be one of the most obvious ones, but at the same time also one of the most underestimated. Every new member of any of the various project teams that designed the games described in chapter 6 — "Evaluation", assumed technology to be more advanced than it turned out to be for our purposes. Even laymen we presented our ideas to (city officials, beta testers, etc.) often believed this.

We believe the reason is that mobile devices have become very ubiquitous. Most people own smartphones or tablets by now, or are used to taking their laptops when working or traveling. However, the tasks in which they use the location-aware features of their devices, differ greatly from using games. Using a map application for orientation works pretty well, since it follows a request-response paradigm in terms of user interaction. The user "asks" the device about her whereabouts and the device then answers. People are usually willing to wait a few seconds for this and the UI (User Interface) typically shows a gradual progress (the "uncertainty circle" in the UI gets smaller). In a game the location-tracking is often meant to be done in the background, so latency plays a bigger role.

The same is true for the mentioned data links. More standard-like tasks like loading a simple, informative web page or downloading emails are not as badly affected by latency, so people are not aware of how big the delay is.

Our systems showed that in a plain cellular network there can be latencies of over 500 ms, even more if the user is so unlucky as to hop between two different cellular towers. This had catastrophic impact on our initial designs. Even as comparatively tech-savvy individuals we had underestimated this problem, hence we're now emphasizing how important this pattern is.

Of course, future improvements of underlying technology will soon alleviate many of these problems, but especially for games that could be played anywhere the designers should really be aware of these issues. Rural areas, for example, often take a long time to catch up with the latest improvements in infrastructure.

In a future version we might also split up this patterns into one detailing the network connectivity (especially as regards multiplayer games) and one tackling the problems with location-aware technology. At the moment these two are strongly intertwined for many technologies, so it seems reasonable to keep them in one pattern.

COPING WITH UNCERTAINTY

Design Ideal:

Technical limitations and problems should not have a negative impact on the game experience.

Design Solutions:

Technologies like GPS and WiFi-networks have levels of uncertainty. The accuracy of the location information can for example depend on many factors and range from a few meters to several hundred meters. Wireless technologies have different levels of connectivity and can experience considerable delay.

Three elementary techniques to cope with this are:

- *avoid*: design game mechanics etc. so that they don't need accurate measurements (e.g. use LANDMARKS for navigation)
- *reveal*: explicitly tell players the current level of accuracy so they can make an informed decision
- *hide*: design game mechanics and interfaces so they work even with lower degrees of accuracy

Obviously, this is all heavily influenced by the choice of a NETWORK INFRASTRUCTURE.

Revealing uncertainty is a great way to reduce the impact of technical problems on PLAYER CONFUSION. However, it requires both that the information (e.g., how much latency there is in milliseconds) to be displayed in a clear and concise manner and that the player actually possesses the technical knowledge to understand what kind of impact this will have on her experience.

Hiding uncertainty is often done by trying to catch all foreseeable errors - one example for this, from `Can You See Me Now`, might be to exclude all "impossible" (such as a pedestrian standing in the center of a lake) locations from reporting.

Trade-offs:

While revealing uncertainty is great to avoid PLAYER CONFUSION, in games that

rely on narrative and IMMERSION, hiding the uncertainty might be more desirable.

In any case, if your game uses LOCATION AS CONTENT, it is very useful to scout those locations with the kind of device you wish to use in your game. In `Can You See Me Now`, for example, the researchers found that urban landscapes have a significant effect on GPS accuracy.

Inspiration:

- `Can You See Me Now`

Related to:

- LOCATION AS CONTENT
- LANDMARKS
- PLAYER CONFUSION
- NETWORK INFRASTRUCTURE
- IMMERSION

[Will, 2013, pp. 99–100]

Annotation:

This pattern is strongly connected to the previous one and has a similarly underestimated importance.

Since our projects were mostly using LOCATION AS CONTENT and tried to achieve a high degree of IMMERSION into a narrative story we had a lot of problems implementing it.

For the most part we tried to avoid and hide the uncertainty, for example in `Aachen Horror`: In our original designs it was important that a group of players at a location would hear synchronized audio to give the impression of a ghost talking to them. The problem with this was that either players were not all in the defined region for that event (as described in NETWORK INFRASTRUCTURE) or that their devices took a different amount of time to properly track their location correctly. Because of this we couldn't simply start the audio as soon as players got to the location. Also, after the introductory talk of the ghost, we wanted players, or rather just one of them, to send a signal for the discussion to go on. This meant one player's device had to basically trigger the continuation of audio on all other devices. Ad hoc connections between devices turned out to be too unreliable, so we used a central server structure: The trigger would go to the server and from there to all devices. Because of the aforementioned latency issues, all potentially different between players, this lead to the audio not being in actual sync.

It turned out that this was okay, i.e. we designed the game with this latency in mind, actually even implementing code to ensure stability over latency. After all, the players were wearing headphones, so even if the various devices' audio streams would have a latency of one second, players wouldn't really notice it much. Of course, the dialog had to be written accordingly, avoiding sudden stops or requiring immediate interaction (basically anything that would make it obvious to a player that her peer wasn't done yet or done already with listening).

The downside of this approach in general is, of course, that certain game mechanics can't be used. In many cases it is impossible to avoid or hide uncertainty, especially with very noisy signals in the location-aware technology employed by the game. We ran into this several times and in hindsight would recommend game designers to openly communicate such problems to the players. If they can see how, for example, the GPS takes a while to narrow their location further down (like most map applications do), they won't take any action that makes the problem even worse (walking away from the correct location "because it isn't working").

APPARENT FRAME

Design Ideal:

The apparent frame is the player-perceived boundary between real world and game world. Manipulate it to achieve IMMERSION.

Design Solutions:

Benford et al. call the boundary the player perceives as separating real world and game world the "apparent frame" of the game.

Manipulating this frame can be done primarily by either shrinking it or extending it:

- To illustrate "shrinking the apparent frame", imagine a hired actor behaving like a bystander towards the player. The player perceives him as outside of the game's frame, thus shrinking it.
- Involving a "true" bystander in the game therefore would be extending the apparent frame, since players would perceive him as part of the game

More detailed examples can be found in `Uncle Roy all Around You`, which uses both techniques to immerse the player in a narrative/story.

The appeal of this and other techniques leading to IMMERSION is unquestionable, considering how many people immerse themselves everyday in virtual game worlds. These games are often judged by how "alive" their virtual world feels to the player.
The implication for location-based games is: if we sufficiently blur the apparent frame, the player will experience the game world as part of or maybe as an extension to everyday life. Since "real life" is, after all, the most "alive" world imaginable, this allows location-based games to create very immersive game worlds. See the IMMERSION pattern for more on this.

Trade-offs:

The apparent frame can never be completely blurred, akin to how complete IMMERSION can never be obtained: while the player willingly suspends her disbelief, she still knows she is playing a game, setting limits to how far you can (or should) blur it.

Additionally, interacting with bystanders is opposed to MINIMIZE SOCIAL AWKWARDNESS.

Both the willingness to suspend disbelief and how much social awkwardness is tolerable are also strongly influenced by the player herself: extrovert, experienced role players probably will not have problems talking to actors or bystanders as if they were part of a game, but more introvert people, who maybe just want to do some interactive sight-seeing, have a completely different mindset.

Inspiration:

- `Uncle Roy All Around You`

Related to:

- IMMERSION
- MINIMIZE SOCIAL AWKWARDNESS

[Will, 2013, pp. 101–102]

Annotation:

This pattern's Design Ideal should be extended to stress that the mentioned perceived boundary is not just relating to physical aspects directly defined by the game. Otherwise this border would be only defined by the game's hardware, the location it is played at, and whether there would be bystanders or not. Instead, elements of the plot or even the UI (if there is one) influence it, too. Additionally, even traits of the players themselves can impact the APPARENT FRAME (as noted in the pattern's Trade-offs).

The actor example is perhaps an extreme one, especially since it is not easily affordable for commercial games to hire staff for participating in the gameplay all the time.

Especially in `Aachen Horror` (see chapter 6.7 — "Aachen Horror") we tried to extend the APPARENT FRAME quite a bit. To illustrate a few more options on how to do that we could include them in the pattern:

- We wrote the dialog with NPCs (Non-Player Characters) in a way that required simple answers and wove player's limited ability to further communicate with them into the game's narrative.
- The UI of our "ARIADNE" devices was designed without any meta elements that explained it (because the plot made it unrealistic to have such additional explanations).
- We required players to interpret hints by using real life information sources.

The first point worked like this: Players were told that the so-called "ARIADNE" devices they got were able to detect signals from a fictional "ghost plane", called the labyrinth, an invisible dimension existing parallel to ours. While the devices would convert these signals into audio for them to hear, they would simply lack the capability to directly transform real life audio back into signals in the labyrinth. They would only provide a very basic functionality of sending a sine tone into the labyrinth instead, basically enabling players to send in Morse. The encountered NPC understood that players ability to communicate was limited and would phrase eventual questions accordingly ("Are you ready? Please send me a sign if you are!").

For similar reasons we did not include any meta information in the device's UI. If people really found any prototype device for a very specific purpose in real life, it is unlikely there would be an included help function (the narrative explicitly told players the "ARIADNE" devices were prototypes).

The last and perhaps the most tricky part was that we decided to rely on real world information systems for players to be able to understand hints given by NPCs. For example, they were told to find a place "where the name of one of Charlemagne's scribes is still respected". This was supposed to lead the player's to a school in Aachen named after Alcuin of York (actually several solutions were possible), an information relatively easily found on the Internet. Since we presumed this to be quite uncommon in most games we instructed players to pretend they encountered these riddles in real life. We anticipated that once they encountered such an obstacle this would have them use "real world" information systems (a step people in real life usually undertake when confronted with a similar problem). A more detailed description of this can be found in chapter 6.7 — "Aachen Horror".

IMMERSION

Design Ideal:

Location-based games can achieve great levels of immersion.

Design Solutions:

Almost all location-based games fall under Montola's definition of "pervasive games" by extending the "magic circle of play" locally.
This allows them to use LOCATION AS CONTENT, which sets them apart from traditional games, especially if they use OTHER CONTEXT OF PLAYER. However, they also can use virtual resources of all kinds: images displayed on a screen, audio files played into headphones or even AUGMENTED REALITY technologies.

The combination of the real world and a virtual world allows them to create an immersive game world, providing a unique experience for players. There are however a few things to consider when trying to create an immersive experience:

- it is futile to attempt what is called a three-sixty illusion, i.e. a fully immersive experience
- certain techniques are absolute musts if you are trying to achieve immersion
- the degree of immersion heavily depends on the player(s)

The first point is quite obvious: players will always know they voluntarily suspended their disbelief, therefore a complete immersion is impossible.

In case studies it was observed that some things can be very immersion-breaking if not done correctly. One of these is blurring the APPARENT FRAME of the game: no player seriously expects there to be *no* boundary at all between real world and game world - but if this boundary is not even slightly blurred, no amount of willing disbelief can immerse the player.

The second major problem mentioned in several case studies is if AUTHENTIC ACTIVITY is not correctly implemented. If the activity is repeated often in the course of the gameplay, it will disrupt the immersion every time.

Trade-offs:

Immersion is great to increase the game experience in a game with a strong narrative.

This however implies: If the game does not have a strong narrative, it is more or less impossible to immerse the player in a game world. Speaking of game world: without a certain level of detail, e.g. provided by believable characters, it will not serve a purpose in telling a story. Furthermore, the game world has to have common ground with the real world, or it would be to hard to role-play characters - for example: a game world with inverted gravity would be very hard to depict overlapping with reality.

And, as mentioned above, immersion strongly depends on the player: to truly immerse herself in the game world, she needs to role-play a character in that world. This does not necessarily require LARP-levels of role-playing, but a certain mindset ("What would my character do" instead of "What would I do") is certainly required. Therefore immersion works well in games targeted at audiences interested in role-playing and similar experiences, but will often be "wasted" on audiences not willing to suspend their disbelief and act out a role.

Inspiration:

- "Tangible pleasures of pervasive role-playing" Montola
- "The three-sixty illusion: designing for immersion in pervasive games" Waern et al.

Related to:

- LOCATION AS CONTENT
- APPARENT FRAME
- AUTHENTIC ACTIVITY
- AUGMENTED REALITY
- OTHER CONTEXT OF PLAYER

[Will, 2013, pp. 103–104]

Annotation:

Since the publication of [Will, 2013] we found that the term IMMERSION itself might need a bit more explanation, so this pattern's Design Ideal section should probably provide more detail on that.

In simple terms, it describes the feeling of people to be "in the zone" and according to [Björk and Holopainen, 2004, page 206] can be divided into sensory-motoric, cognitive, and emotional immersion.

This pattern focuses strongly on the emotional type of immersion, since we don't see how location-based games are particularly different in achieving the other kinds compared to traditional games. That is not meant to say location-based games might not achieve them as well, but we believe that would then be orthogonal to their location-based nature (i.e. anything done to achieve those aspects are not in conflict with the location-based nature).

Another addition to the pattern would be referring to the so-called uncanny valley in its Trade-offs section. From our projects (e.g. `GroupAixplorer`, `Aachen Horror`, `mLoG`) and other research (e.g. [Ballagas et al., 2007] and [Carrigy et al., 2010]) we found that caution is necessary when using new technology that tries to mimic a "real" effect and gets close, but doesn't entirely succeed in doing so. This is true even if the desired effect wouldn't involve an actually possible thing (like seeing a ghost), the point is that if it doesn't manage to match the players' expectation of how something should look, feel, or sound, but misses this by just a small notch, it can appear repulsive and break the immersion.

AUTHENTIC ACTIVITY

Design Ideal:

To achieve IMMERSION, actions in the real world should closely imitate the actions they represent in the game world.

Design Solutions:

As stated in the paper "The three-sixty illusion designing for immersion in pervasive games" by Waern et al.: "A game offers authentic activity when every game action is represented by the identical player action".

Something important to consider when trying to achieve IMMERSION in a location-based game: a lot of virtual activities can not be represented because of ETHICAL AND LEGAL PROBLEMS. The obvious example would be any kind of violence such as sword fights or similar scenarios.
There are two major techniques to cope with this problem:

- symbolic activities: instead of swinging a real sword, the player presses the button labeled "swing sword" on the touchscreen of his device
- (almost) authentic activities: replicating the game action as close as possible.

While the first technique is often possible, it just does not provide the same experience to the player as a truly *authentic* activity.

The second technique takes advantage of very recent developments in consumer technology. It is nowadays very common to have tilt and gyroscopic sensors in smart-phones and similar devices, allowing to track what motions or gestures the player performs with the device, for example used in `REXplorer`.

To realize the possibilities, imagine children play-fighting with imaginary lightsabres, and you have a perfect example of how to use this sensory information to replicate the game action as closely as possible with comparatively little effort.

Trade-offs:

While the technological advances allow to implement authentic activity, there are still a major factor at play that might reduce the IMMERSION created by this: the player.

First of all, if the game is played in a public setting, activities such as imaginary sword fighting are very much the opposite of MINIMIZED SOCIAL AWKWARDNESS - as all public role-play is.

Secondly, the player still needs to suspend his disbelief to a certain degree, therefore only specific target audiences will receive the full effect of IMMERSION (and enjoyment) out of this.

Inspiration:

- `Interference`
- "Tangible pleasures of pervasive role-playing" Montola

Related to:

- IMMERSION
- MINIMIZING SOCIAL AWKWARDNESS
- ETHICAL AND LEGAL PROBLEMS

[Will, 2013, pp. 105–106]

Annotation:

An addition to this paper would be to recapture the authentic activity of walking. As described in chapter 2 — "Development Challenges", location as input is usually mapped in a very non-abstract way to a game mechanic. As a matter of fact, any traditional game involving movement (of, e.g., an avatar) typically relies on a quite abstract mapping for this. One could say that using player movement as an AUTHENTIC ACTIVITY to represent movement within the game is precisely the key part of the definition of a location-based game.

From that point of view this pattern would be automatically implemented by any location-based game, even if no other mechanics were implemented in that way. However, that does not mean no caution has to be paid when designing how exactly the movement is to be performed. There is a difference between simply strolling through a city or museum and running around. The example given in ETHICAL AND LEGAL PROBLEMS respectively its annotation shows this problem as well: Chasing another person might be an authentic activity for a game, but bears the danger of getting players into conflict with bystanders or even the police.

Lastly, the pattern should mention in its Trade-offs that achieving IMMERSION is not simply a question of using AUTHENTIC ACTIVITY as much as possible. First and foremost the game needs to offer a plausible reason for it to require a fitting activity. If the game has a narrative, the activity should fit to that. If it is meant to help in exercising, it should chose according activities. From our experience it is a bad approach to choose an activity based on how it can be implemented, and then try to construct a game around that.

Augmented Reality

Design Ideal:

Augmented reality (AR) technology provides great possibilities for location-based games.

Design Solutions:

While they have not yet fully arrived for consumers, devices capable of augmenting reality with visual overlays are definitely on the horizon. These devices will enable location-based games to:

- provide an experience of Immersion for players
- have more variety in gameplay

`Ingress` provides examples for both these major points, although the execution is still limited by available technology - mobile phones not yet being fully able to provide a constant visual overlay. The arrival of Google Glass later this year might be the first step towards comfortable, fully AR-capable glasses in the near future.

First of all, `Ingress` immerses the player deeply into the game world by showing him elements of the game world that are part of the narrative. While imagining such elements when given a description is second nature for experienced role-players, other players might need engaging visuals to immerse themselves into the story.

While `Ingress` also enhances gameplay through AR, a better example for the possibilities of this would be `Bitstars Jump'N'Run`: just as in classic jump'n'run games, the player needs to avoid and traverse obstacles. However, these obstacles are virtual elements, only visible through the "lens" of AR.

Trade-offs:

While AR technologies will offer great opportunities for location-based games, the technology is as of now still limited in both its capabilities and its availability.

Inspiration:

- Ingress
- Bitstars Jump'N'Run[2]

Related to:

- IMMERSION

[Will, 2013, pp. 107–108]

Annotation:

This pattern is one that would have to be revised constantly alongside the improvements of the technology it refers to. Since [Will, 2013] was published we have made the experience that people introduced to AR concepts often misjudge its usefulness in games.

The problem is mainly that the technology, no matter in what form, is still relatively new to most people and they are often *impressed* by it. Unfortunately that doesn't necessarily mean it is always conducive to a positive gaming experience, because in this context it has to serve a purpose and provide functionality.

Especially video overlays, i.e. a mixture of real and artificial scenery in a game can be prone to this, like [Carrigy et al., 2010] pointed out.

While even non-tech-savvy people can appreciate the feature of displaying an artificial image in the real world (whether through a "magic lens", i.e. a mobile device, or otherwise) that doesn't mean it's easier for them to suspend their disbelief and immerse themselves in a game world. Audio can often be realized in a more successful way, as that paper and our own `Aachen Horror` game indicate, but is easily forgotten as another possibility for AR elements.

Another aspect of these issues is the aforementioned uncanny valley (see IMMERSION).

All in all, this pattern should be used in a similar way as AUTHENTIC ACTIVITY. AR can be a good way to improve IMMERSION and gameplay in general, but is in itself not a guarantee for good games.

CO-LOCATED MULTIPLAYER

Design Ideal:

Meaningful interactions between multiple players in the same location offer unique opportunities for location-based games.

Design Solutions:

First of all we want to stress the difference between playing *with* another player in contrast to playing *alongside* another player: the latter is already possible in almost all mobile games, the former is what can provide unique appeal for location-based games.

To illustrate the general idea, consider `GroupAixplorer`: In this game, players (generally) move as a group and solve quests through co-operation.

While it certainly is possible to create appealing location-based games that are geared towards single players or competitive experiences, most existing games seem to be both co-operative and co-located, although in different degrees. It seems that location-based games are great at enhancing or augmenting activities that are already mostly experienced in groups of people anyway.

Consider these examples:

- `Feeding Yoshi` - many of the players played at work or met up to play with people from their team
- `Interference`, `Conspiracy for Good` - LARPs or ARGs are predominantly constructed as group experiences
- `GroupAixplorer` - research has shown that most people explore museums in groups
- `Geocaching` - most players will go out in pairs or as groups to find caches

Since location-based games are often played in public settings, they are inherently social experiences. It seems natural to support these social aspects by encouraging players to play together, which can be done easily by introducing a common goal and co-operation.

Competitive co-located gameplay carries more possibilities for bad experiences than co-operative, in order to achieve a successful competitive experience it is first

and foremost important to have clear rules. How unclear rules can negatively impact an experience can for example be seen in `Conspiracy for Good`.

As seen in `GroupAixplorer`, COMMUNICATION CHANNELS are not obsolete in co-located multiplayer games. Groups will temporarily split up, and even a comparatively small building such as the city hall of Aachen can make it difficult for group members to find each other.

One of the main beneficial aspects of co-located multiplayer: it can MINIMIZE SOCIAL AWKWARDNESS, especially through the EPHEMERAL MAGIC CIRCLE.

Trade-offs:

Obviously, having a game rely on co-located multiplayer severly impacts what people will play it and how they will play it. If, for example, a game allows group sizes of 3 or 4 people, any group below or above that number of members will not be able to play it.

Additionally, if the game augments an existing group activity, the consequence might be that only people already interested in that activity will play it. Concerning this point however: `GroupAixplorer` was able to provide a great experience even for people who, according to their own statements, "never" use audio guides. This could indicate that location-based games can be the necessary "gamification" which can interested new user groups in these activities.

Inspiration:

- `GroupAixplorer`
- `Conspiracy for Good`
- `Feeding Yoshi`

Related to:

- COMMUNICATION CHANNELS
- MINIMIZE SOCIAL AWKWARDNESS
- EPHEMERAL MAGIC CIRCLE

[Will, 2013, pp. 109–110]

Annotation:

As all of our own projects ultimately adapt this pattern we are quite confident in its usefulness.

A lot of general recreational activities already involve forming groups.

Non-computer games as well as sports often require several people, but even if they don't (e.g., golf), people might join each other for company.

We see a similar trend in computer games, too. It could even be said that the big number of single player games in the past was in part a result of the lack of interconnectivity of computers. Today even games that are technically single-player might strive to provide players to connect with other players in some way.

In the context of this pattern it is important to stress that it is meant to encourage players to play *with* each other, as stated in the Design Solutions.

An addition to that section should be that games building on an already existing group activity (like `GroupAixplorer` did) need to be careful not to include elements that break the group experience. If, for example, co-located players are forced to individually interact with the game device for too long, they in fact play less with each other, but with the device instead.

Communication Channels

Design Ideal:

Players in multiplayer games want to communicate.

Design Solutions:

If your game enables players to collaborate or to compete, give them a way to communicate with each other. This is especially important if your game requires players to cooperate or coordinate while in different locations.
In competitive scenarios, the option to communicate is appreciated, e.g. for friendly banter.

Since most location-based games use devices like mobile phones, text-based and voice-based communication are very intuitive and easy to provide. However, creative and unusual ways to communicate can create more appealing gameplay.
One example would be visual "breadcrumbs" which could be left by one player (who's responsibility is to scout ahead) for a group of other players.
Another example might be simplified, iconic signals: Maybe the device just has a button "come to me" that sends a signal to all other players. Using Augmented Reality technology, the other players would then have to check the sky for a virtual signal flare to find the source of the signal.

Additionally, communication about the game often happens outside of the actual game, the `Geocaching` community being a very good example of this: Players provide feedback about caches after returning home, primarily via online forums. Often, multiplayer games also have a "lobby" or similar system, whose primary function is communication while not actually playing the game, e.g. in order to exchange strategies or arrange parties.

Trade-offs:

First of all, players should by default be identified via pseudonyms to limit privacy concerns. Secondly, when communication is not an absolute neccessity for "beating" a game, players should be able to turn it off. Both these points are useful in order to Minimize Social Awkwardness.

In competitive scenarios, communication needs to be regulated: friendly banter might turn less friendly or players might try to collude/cheat.

In all cases, it is important to support natural communication: Your game should not force players to use mechanics such as the "signal flare" described above if

they are already standing next to each other, i.e. in games with CO-LOCATED MULTIPLAYER.
If your game uses custom devices, this communication channel might be a lot easier to create than e.g. in the case of a game playable on all kinds of mobile phones. While communication channels are available in that scenario (text message, E-Mail, Phone), they are probably going to cost the players money.

Providing external communication such as lobbies carries the inherent dangers of players exchanging information that might negatively impact a new player's experience. For example, a discussion about plot twists could ruin the enjoyment of a well-crafted story, while unwanted tips or help could reduce the joy of solving a puzzle.

Inspiration:

- `GroupAixplorer`

Related to:

- CO-LOCATED MULTIPLAYER
- AUGMENTED REALITY
- MINIMIZE SOCIAL AWKWARDNESS

[Will, 2013, pp. 111–112]

Annotation:

This pattern is based on one of the earliest findings we found in the practical design for the `GroupAixplorer`.

The fact that players in most games need, or at least want, a form of communication is nothing new. Traditional games offer various methods for this, as is implied in the pattern's Design Solutions.

For location-based games, however, designing this can be a little more complicated. To illustrate this consider the following example for a traditional game: A real-time strategy game in which players or teams of players compete for victory in battle between simulated armies. As the Design Solutions mention, these games often provide a lobby for players to decide on teams and perhaps find opponents. Since the needed exchange between them isn't that time critical, a text chat is sufficient.

During gameplay, this might change, since player's can't type and use the keyboard controls for the game at the same time. Voice chat could be preferred here.

Compare that to the COMMUNICATION CHANNELS in our `GroupAixplorer`. Since the players were CO-LOCATED in a relatively small building they could mostly talk directly to one another. When they were in the same room, they would simply walk over or signal via hand waving for a team member to please approach them. When they weren't in the same room, they could send each other a simple "please come to me", with no additional free text. This option allowed for a very quick sending of messages. They would freely switch between these two COMMUNICATION CHANNELS depending on their relative position in the building.

In contrast to the above example of a real-time strategy game there was no UI-inherent cut between the two communication methods, there was no "set up" and "start the actual game" phases.

Of course in a larger scenario, more elaborate messages would be needed. The reason why players were content with a simple "please come over" notification was that even if it turned out not to be of much interest to them (for example because they had already been where their comrade was and knew about whatever was relevant at that location) they didn't have to invest much in terms of walking over. Had they been forced to walk across the city they'd probably get frustrated if there wasn't anything to gain for them at the new location. They'd want their peer to be able to tell them beforehand why they should come over.

5.2 Geo-Sociograms

Movement patterns versus design patterns

As explained earlier we found a completely different kind of pattern in our various projects. These are not design patterns as proposed by [Alexander et al., 1977], but literal patterns in the movement of players participating in a location-based game. This means they are not an abstract concept helping in the design process or explaining a generic concept, but observable phenomena during gameplay.

We noted that players seemed to move differently depending on what a game's goals were. By that we don't mean their way of movement as in running compared to walking, but their planning of where to go, or whether to split up into smaller groups or not. Sometimes they would move as a group and in a more directed way, sometimes they would split up completely and stroll around an area without much visible planning. The interesting aspect of that was that these patterns in their movement weren't simply matching the most efficient way of movement in the sense that they would result in the game's goals be reached as fast as possible.

The first works taking a closer look at this were [Huch, 2013] and [Borggrewe, 2013], although the latter did not research a location-based game directly, but a museum guide system with location-aware technology.

Since one of the key components of location-based games is player movement, we wanted to be able to not just give design recommendations and conceptual criteria for categorizing games, but also to understand how these games would actually be played. Player movement is naturally a big part of every location-based game (and even of many traditional games).

Geo-Sociograms capture the distance between players over time

Unfortunately it is in some ways also an aspect that is hard to measure and observe. Different location-based games are played in different areas, so it is hard to figure out what movement is actually influenced by the game's mechanics and demands and what is a natural way to move around in an area. Because of this we decided to look at distances

instead of absolute coordinates of a given game. This approach is similar to the proximity-based visualization proposed by [Crnovrsanin et al., 2009].

We published a first definition of the term geo-sociogram in [Herkenrath et al., 2014], but since then have slightly revised it to the following form:

Definition: *Geo-sociogram*

GEO-SOCIOGRAM:
A geo-sociogram is a $(n-1) \times (n-1)$ lower triangle matrix, where n is the number of players and/or points of interest. Each of the $\sum_i = 0^n - 1$ elements in this matrix is a graph of the distance over time between a pair of players or a player/point of interest pair.

In our projects so far and in [Huch, 2013] respectively [Herkenrath et al., 2014] we didn't yet consider the distances between players and other elements of the game, i.e. points of interest. This was mainly because we focused on CO-LOCATED MULTIPLAYER games and were mostly interested in how players moved in relation to each other, but there's nothing that speaks against analyzing their movement in regards to stationary objects important in the game as well.

An example visualization

Figure 5.1 shows an example for a geo-sociogram taken from [Herkenrath et al., 2014]. Note that it already displays some annotation marks that are not strictly part of a geo-sociogram as required by the definition. The visualization lends itself to annotations, which made analyzing movements a lot easier for us. In this particular case the distance patterns seen in the pairs of players show that the group of four split up into two subgroups.

Geo-Sociograms can hint to strategies players use in a game

Of course a similar observation could be made from various other means. The most obvious way of visualizing movement data is plotting it on a map.

Figure 5.2 illustrates this, it is also taken from [Herkenrath et al., 2014]. The paths of the four players also seem to indicate a split into two groups, but on closer inspection that isn't necessarily the only conclusion this map view allows.

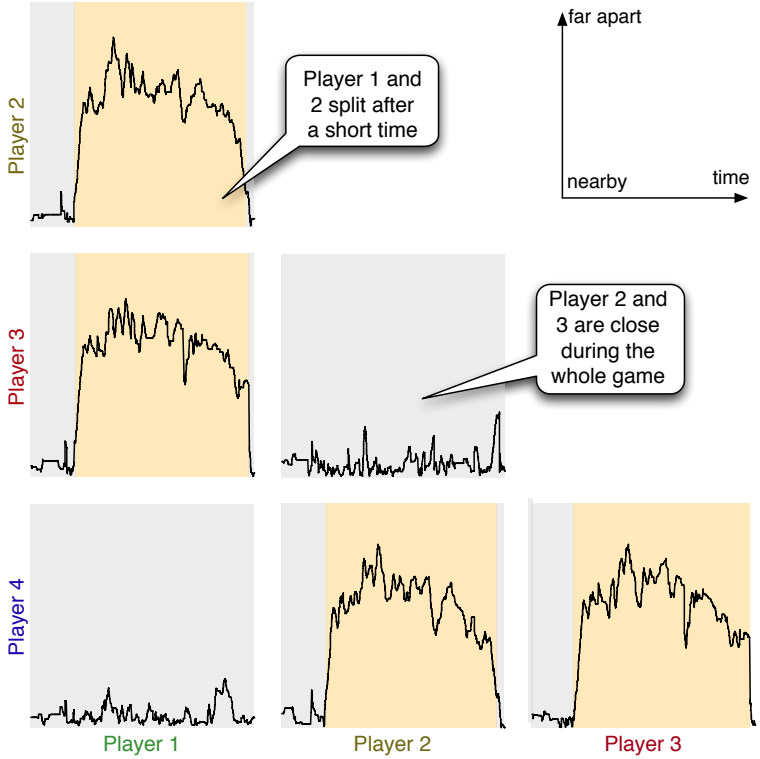

Figure 5.1: An example of a geo-sociogram. The data it's based on is from [Huch, 2013], the image is from [Herkenrath et al., 2014].

Since it does not provide any information about when players were at a specific coordinate, it might very well be that they simply got there after each other. To ensure this wasn't the case one would have to split up the image into different time frames, which essentially equals video analysis. The benefit of a geo-sociogram in comparison is the at-a-glance overview. Video analysis usually demands a much higher effort than this. Especially when investigating various groups or settings it is much easier to compare two geo-sociograms than comparing what would basically be a series of videos.

different game mechanics result in different player movement strategies

A good example of this are the findings in [Huch, 2013] and [Herkenrath et al., 2014]. In Carl Huch's prototype game `mLoG` players had to solve different distinctive tasks, called quests (for a more detailed description of the game see also

Figure 5.2: An example of a traditional map based view of movement patterns. The data it's based on is from [Huch, 2013], the image is from [Herkenrath et al., 2014].

chapter 6.5 — "mLoG"). The first of these quests had the players look for virtual excavation sites, they needed to find various pieces of an object central to the game's plot. They only knew the general area those sites would be found in, but did not have any clues for their exact position. The second quest required them to visit several virtual traders. Each trader was positioned next to a real world shop on a market place and a shopping street and the game required them to go through a series of exchanging virtual goods to finally purchase a specific set of things.

By looking at the corresponding geo-sociograms we were able to see a distinctive difference in the movement patterns. While the ones from the first quest seemed rather noisy in all distance graphs (see, for example, figure 5.3), the ones from the second looked all more or less like figure 5.1. Overall, it appeared that the requirements of the second quest resulted in players forming subgroups instead of splitting up entirely, even if that wasn't the most efficient strategy. In contrast, the first, more plainly exploratory quest lead to them randomly sweeping over the relevant area, not caring much about where their team mates were going in general.

In our cases we focused on the players' movements in relation to each other. If a game has certain points of interest it is clear that the distance would eventually shrink, since by definition a point of interest is something that needs to be visited in most games.

Geo-Sociograms lead us to categorize the usage of space in games

We believe that this different behavior visible in geo-sociograms points to a principal characteristic of different mechanics related in location-based games. Or to put it differently, some types of location-based game will result in players mostly just randomly sweeping around an area while others will have them follow a more distinctive movement pattern. Put in a more abstract way, we think there are three different ways in which a location-based game can make use of an area:

- Area exploration: The game area has to be examined to find virtual objects related to a game task.

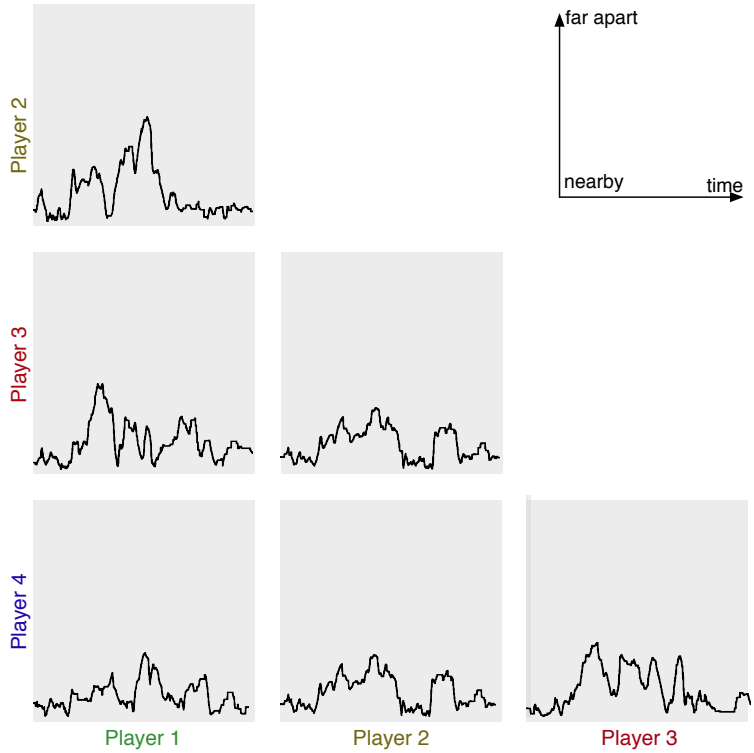

Figure 5.3: Geo-sociogram displaying a pattern typical for the site excavation quest in mLoG. The data it's based on is from [Huch, 2013].

- Route planning: Several locations in the game area have to be visited, potentially in a certain order, to achieve a goal.
- Area coverage: Players are given a means to influence a certain part of the game's area and must minimize or maximize a form of territory.

The last of these points was implemented in mLoG's successor mLoG2, implemented and evaluated in the work of [Simha, 2014]. It should also be pointed out that in any given location-based games these points might overlap, in fact mLoG's plot had a logical explanation why the first kind of play and then the second was necessary.

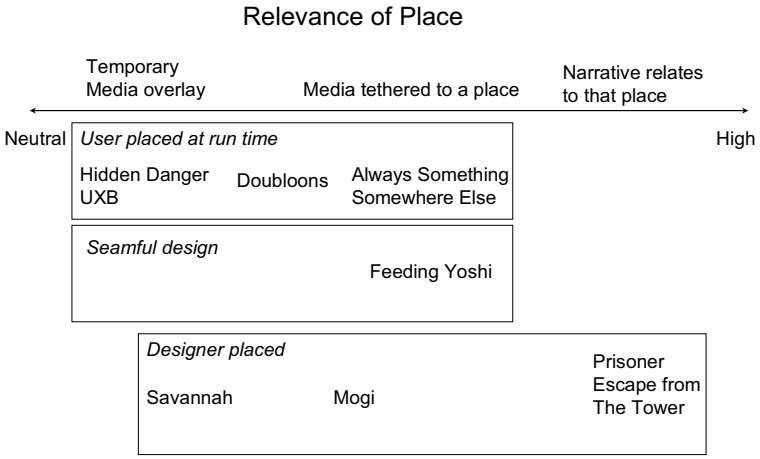

Figure 5.4: The Relevance of Place Dimension, image taken from [Reid, 2008]

Area usage extends J. Reid's "Relevance of Place Dimension"

This insight into how location-based games can use the area they're played in perfectly extends the "Relevance of Place Dimension" proposed by [Reid, 2008] in "Design for coincidence: incorporating real world artifacts in location based games". The three categories we found by comparing geo-sociograms of various game settings would be orthogonal to that dimension and could describe a game in addition to it falling to the "User placed at runtime", "Seamful design", or "Designer placed" categories. Figure 5.4 shows Reid's original dimension chart with her chosen example entries. Since our categories don't necessarily fall into a specific scale it makes little sense to put them on the y-axis, instead we chose a color coded marking for each category. The proportion of each color is in proportion to each category's importance for each game. The result is shown in figure 5.5.

No causal relationship between patterns in geo-sociograms and game mechanics found yet

So far we have not been able to reliably find a general type of geo-sociogram that is causally connected to each of these three types of games. Due to the big effort each location-based game played in the field faces we were unable to attain a large enough data set to properly counterbalance all the various disturbing variables influencing movement behavior. Besides, a plain visual categorization wouldn't suffice to properly prove a causal relationship between a cer-

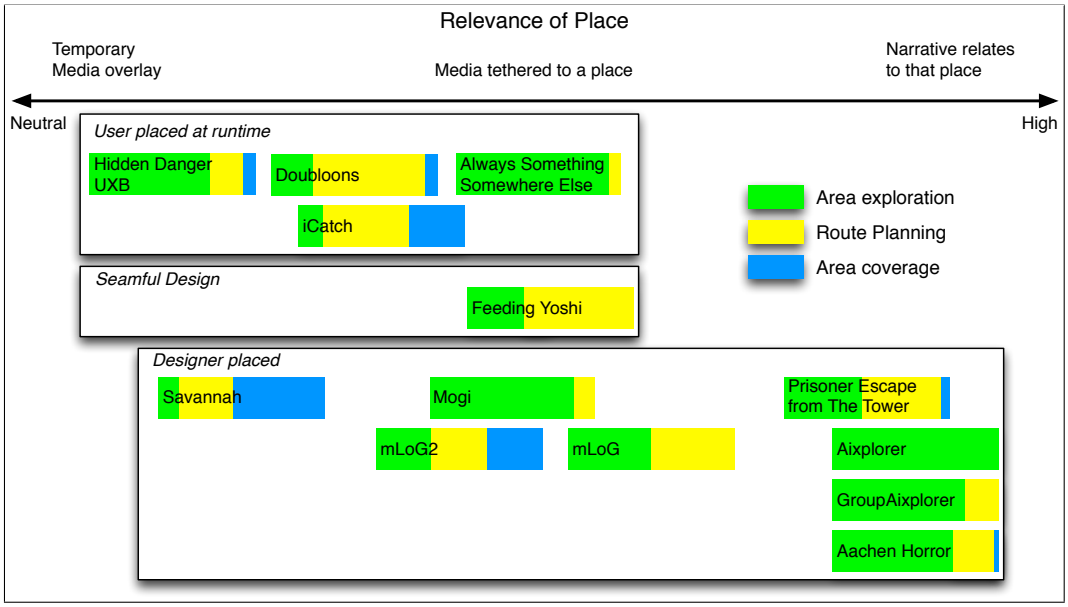

Figure 5.5: The Extended Relevance of Place Dimension. The three different ways to use the game's area are color coded.

tain form of geo-sociogram and a certain game mechanic. This would require, most of all, a well-defined convention of what a game mechanic is in this context for a large number of location-based games.

Things that geo-sociograms won't show

In their current form geo-sociograms are not meant to replace other means of analyzing movement patterns of players. By reducing the information about players' absolute positions to a distance metric and omitting map data, they naturally exclude information from analysis in favor of a quick overview. Especially concerning specific topological aspects of an area where a game is played, this is a problem. After all, it is very well possible that players keeping a certain distance from each other is simply a result of them being physically constrained to specific paths through an area. Walls or temporary obstacles like bystanders are not visible in a geo-sociogram unless they're specifically listed as a point of interest.

Another aspect to keep in mind is a meaningful normalization for the distance graphs' axes. Maximum distance as well as playtime are probably influenced by the game or

even the individual session. In mLoG, for example, different groups solved the two tasks described above in different times, skewing the time scale. The possible maximum distances between players was also not constant between both conditions, as they were played in slightly different areas. We tried to accommodate for the latter point in mLoG2 by playing both tasks in the same area (see [Simha, 2014]), but encountered different topological problems making it hard to gain conclusive results.

Movement patterns seen in geo-sociograms are not how they are laid out

Additionally, one must be careful when using a geo-sociogram as an example to illustrate a specific movement pattern, like we did with figure 5.1. The actually visible "pattern" of the distance graphs for players one and four, respectively players two and three indicating small distances over the entire task and the rest being relatively high (after an initial phase) is *not* the pattern we mean. Since player numbering and the labels on the geo-sociogram are random, a different layout, i.e. different visual pattern of distance graphs, could still represent the same abstract pattern that denotes the forming of two subgroups. Had, for example, players one and two (respectively players three and four) been in a subgroup, the low distance graphs would be in a different position in the geo-sociogram, making it visually slightly different from the one depicted. This actually happened, of course, but the player behavior in regards to distance from each other was still a lot easier to deduct than from analyzing videos.

5.3 Implementation Tools

Low-fidelity prototypes need to be adapted for location-aware systems.

As described in earlier chapters the implementation of prototypes for location-based games can be hard. A lot of low-fidelity prototypes focus on displaying a basic UI concept and test users evaluate that, delaying location-aware aspects. Interaction is then simply described, or sometimes mimicked in one way or the other, and there are various ways to have the prototype "react" if the designer needs it for the current test session's goals.

Paper prototypes, for example, can convey things as form

factors or layout of UI elements very well, especially for mobile devices. Interaction is then either described ("I would now tap that button"), or acted out on the paper directly. The resulting action can be mocked by then simply showing a different paper with a changed UI.

A user's location change cannot be easily abstracted.

While these techniques are great to design layouts, proper UI transitions, and more traditional mechanics in location-based games, the core aspect of player movement is hard to mock with such a prototype. After all, there's not really a physical control the players manipulate to change location, they simply *do* change it. A prototype can hardly provide various levels of abstraction for this, because this act in itself lends to just little abstraction when it comes to the connection to a game's mechanics as we described in chapter 2 — "Development Challenges".

Care is needed when mocking big movements for the final system by adapting small movements in a lab.

Pretty much the only thing that can be done in terms of mocking player movement is to have players act it out on a different scale. If the game is positioned towards the right side of the Relevance of Space spectrum (see figures 5.5 and 5.4) that typically means having players pretend to take locations in the lab or test area for the actual locations in the real game area. The problem is that this quickly leads to too much scaling down of the distances. If the game is city-wide but the prototype requires them to just move around a single building (e.g. a school), the results will hardly give a proper impression of how players move and act in the final system. In our own projects we have seen that often times people are not completely aware of this. They underestimate how walking longer distances can break the game flow and make the experience less enjoyable, not to mention the aspect of simply getting exhausted or even frustrated.

5.3.1 Paper prototypes suited for location

Prototypes need to be mobile.

Pen and paper drafts of a system can hardly catch the "look and feel" of actually going to a certain place, yet really going to a location makes it difficult to provide certain kinds of paper prototypes at all. A core requirement these pro-

totypes must satisfy is thus mobility. Even if the location-based game's scale is small enough and its position on the Relevance of Space spectrum more towards the left (i.e. it doesn't need very specific places for its narrative and falls more into our location-based* category) this is important. Testers should carry the prototype around just as they would, whatever device will be used in the final setup.

Scale up any mocked location-tracking.

This alone will mostly provide feedback on the parts of the design not directly related to location-change. Form factors and practicability are things to be looked upon instead. In terms of actual movement, we would recommend a step-by-step increase of scale. At first, it might not be necessary to have the testers actually move around, but instead have them voice any intended changes in their location in the context of the game. As stated above this has to be done carefully and keeping in mind that people might underestimate the effect exhaustion and pauses have on their experience.

Use markers to have users run their prototypes.

The next level of mocking location-awareness would be markings in the area the test play is done in. Our own projects like `GroupAixplorer` (see [2010] and [2011]) or `mLoG` (see [2013]) used this technique a lot. Even though the final systems would be played in a much larger and fixed area in or around a city hall, both systems first tested concepts in the lab by marking areas on the ground. Players would then be given flip-book prototypes with a key what page to flip to for what marking. Part of the idea here was also to keep the sessions manageable for the experimenter (both systems were multiplayer games).

5.3.2 Location-tracking simulator

Modern mobile development cycles allow for quick testing of standard UIs during development.

In our systems we quickly shifted to medium-fidelity prototypes on real mobile devices. This offered an easy way to have testers carry around the media they were supposed to be getting by arriving at a certain spot and at the same time confront them with the real look and feel of the place. We typically developed these prototypes on the same platform that was also our designated target for the final game, usu-

ally iOS. Development on that platform is relatively easy, so in spite of the technology level being a lot higher compared to other medium-fidelity prototypes, we could create and alter prototypes rather quickly. A normal application can easily be compiled and run either on a device or a simulator, so the most obvious bugs or wrong UI behavior is seen and fixed with little implementation overhead.

Testing location updates is not as well supported as e.g. touch gestures.

Unfortunately, things are different when it comes to the location-aware aspect of iOS applications. XCode (the Apple's default development application for iOS) allows to simulate location updates, i.e. essentially send fake GPS updates to the device (or iOS simulator), but this requires more effort than testing regular interaction. The developer has to create a file containing the positional data (basically latitude & longitude) and has to use the debugger to cause the running application to be notified of the according updates. More importantly, the functionality results in perfect location updates, i.e., the developer defined coordinates are sent to the application as is, with the best accuracy. Also, a list of coordinates is simply handled one after another, resulting in an update each second. It is thus not possible to define a location update to occur, for example, two minutes after the previous. Single coordinates are treated as constant updates, a behavior different from the way iOS handles naturally occurring updates (which only happen when the device's position changes).

Especially the right side of Relevance of Space spectrum can't be tested easily.

All this results in a rather difficult prototyping process. Of course, any form of providing faked coordinates to an application is flawed in the way that the developer doesn't really know whether the coordinates are really accurate unless she checked them herself at the actual location. Getting this data from maps or databases can result in offsets. This can be especially problematic for games on the right side of the Relevance of Space spectrum, i.e. games more likely to be location-based$^+$ and adopting LOCATION AS CONTENT.

The existing tools treat location updates as singular, relatively rare & simple system events.

XCode's way to simulate location updates is essentially suited for relatively simple and rare events. An application that uses them extensively, like a location-based game, requires a considerable amount of work to prepare a simulation, effectively raising the question to skip that and test

at the real location in the first place. This is a big difference to how other interaction with an application can be tested. Touch gestures, for example, can be tested directly on the device or even the simulator: The developer can simply perform them on the fly and see whether the application responds correctly. Note that we're not talking about testing in the sense of doing user evaluations. Instead, the problem lies in the creation process already, where such testing for simply correct functionality has to precede handing the prototype out to users.

An example scenario illustrating problems with the current simulation

To properly illustrate the potential shortcomings of a simple location-update simulation consider the following scenario: A location-based$^+$ game emphasizing on area exploration and with a narrative tethered to real world places requires the player to visit certain specific spots to find virtual items. One such item is located in the front of a church, another on the same church's side. For the narrative it is important in which order those items are found and ideally there would be a time gap between the player finding them (i.e. they wouldn't find them both at once).

Any developer familiar with such a situation will see the problem: Depending on the size of the area around the church it might happen that the player is at the second location, the church's side, but the mobile device's location-aware technology might not deliver precise enough results, at first or at all, to make a safe distinction between the two locations. This could be countered by for example only using results with high enough accuracy values, but even that is not reliable. By adopting COPING WITH UNCERTAINTY and choosing to reveal these problems to the player the designer could solve this problem, for example the interface could display static noise until accuracy gets better, informing the player that "something" has been found, but the game is still in the process of "narrowing it down".

This scenario is more elaborate than just reacting to a simple location update with a correct coordinate. To see (during development) if the chosen UI elements and behavior are feasible and, more importantly, even work at all, the developers would need to implement the prototype and then actually go to the desired locations, maybe even logging

the location-tracking data alongside running the prototype to see what exactly brings the interface to behave in what way. It would be a lot easier if, for this simple functionality and UI concept tests, the developer could just feed faked location updates into her prototype, like the simulator allows to do for, e.g., pinching gestures.

An avatar & map based approach for location simulation.

Of course creating such a fake data stream of location-updates is a little more complex than creating touch gestures. Then again, it wouldn't be that hard to move around a kind of avatar on a map. We would suggest an application integrated into the development platform, for example XCode, that provides a map where the developer can drag around a marker, i.e. a simple avatar representing a user's location. The resulting artificially created location-data would then be sent to the development device or the simulator so the developer can see how her prototype behaves.

There are certain criteria a location-simulator should have.

Of course the proposed location-simulator would need additional controls to cover the various parts of location-data. A map would be able to provide coordinates, but as stated above accuracy etc. are also very important. Building on top of how iOS works, i.e. what data a location update on the platform actually consists of, the following criteria need to be considered in an application to simulate location updates:

1. Coordinates (latitude, longitude)
2. Altitude (and in some cases potentially the floor level)
3. Accuracy (horizontal and vertical)
4. Potentially a timestamp (for routes, see below)

The first point is already realized in the current way XCode allows location-simulation, although in the explained rudimentary way only. Thus, the first improvement would be the possibility to allow for additional "faking" of the location data structure (CLLocation). However, a proper location-simulator should offer more. Instead of simply relying on a list containing the fake data that is blindly

parsed, a complete UI to construct it and then send it to the application to be tested would be desirable.

A design proposal for a simulator or emulator extension

Figure 5.6 shows a sketch for such a UI. It would work in the following way: The map on the left side works pretty much like a standard map view in most similar applications. The developer could zoom and pan it around to focus on the relevant region the tested (part of the) game prototype takes place in. Double clicking would create a new location to be used for simulating location-updates later, represented by a dot.

The complete data of such a "fake" location can be seen in the five upper right fields. This structure reflects the data type used on iOS devices, CLLocation. Newly created locations would have the actual latitude, longitude, and altitude values from the real world location indicated by this dot and have default values for accuracy, floor, and the other fields. Changing latitude or longitude would then of course also move the dot on the map around.

Note that the "Accuracy" value is also reflected on the map by a surrounding ring. This allows to immediately see whether two locations might overlap when taking into account their accuracy.

The "Delay to next" and "Absolute Time" fields are not directly part of the resulting CLLocation objects that are simulated in the game prototype, but work in conjunction with the locations marked as "Routed" in the table below. The idea here is that all locations marked as such are part of a route that can automatically be played back with the "Play route" on the bottom right (the "Stop route" button becoming active while it runs and serving an obvious function). The "Previous" and "Next" buttons allow for shifting the selection of a location to the previous or next according to the route (skipping over non-routed locations, which would need to be selected manually in the table or map). All locations part of a route are connected with a line in the map with the first location having a small arrow indicator. In the depicted image that is the top most location, named "Start quest" in the table. Note you can also select locations directly on the map and that the dots there also reflect that

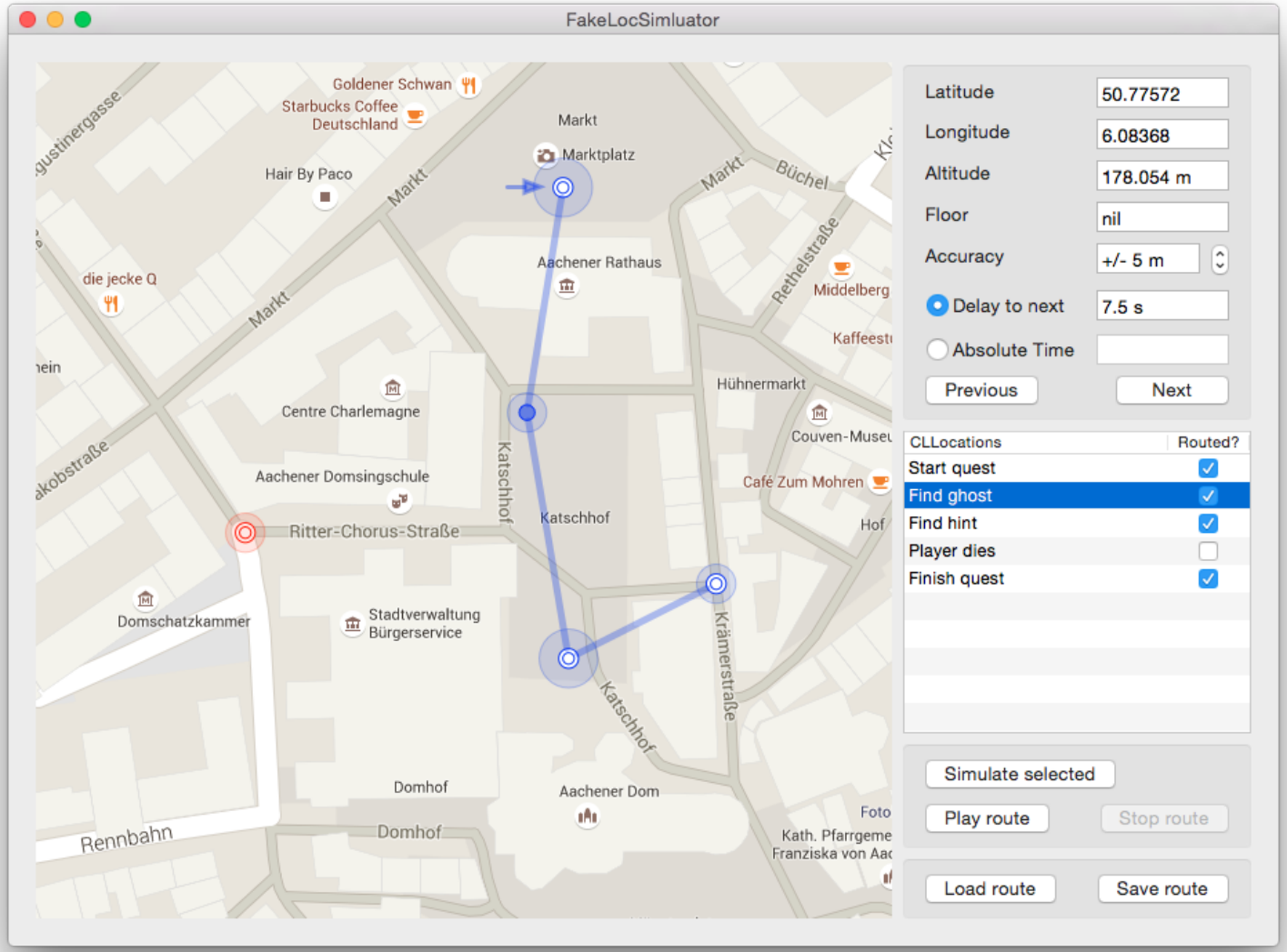

Figure 5.6: A UI proposal for a location-simulation application. It would run on a computer connected to an iOS device or in parallel to the iOS simulator. CLLocation objects for location updates would then be sent to the location-based game prototype running on the iOS device.

(a full dot representing the current selection).

Locations that are not part of the route are colored in red on the map, but behave like routed ones except that for them the "Delay to next"/"Absolute Time", "Previous", and "Next" buttons and fields are greyed out.

The "Simulate selected" button immediately sends a faked location update to the game prototype, "Save route" and "Load route" allow to save the current set up to a file and load it from one respectively.

How the location-based prototype handles the location updates generated through this depends, of course, on how it is implemented. In many scenarios on iOS devices a delegate would be informed of the new location and simply go from there, but it is also possible that the program only monitors so-called "region changes", i.e. specific delegate methods are called if the device enters or leaves a certain region (this is also called geofencing). This then doesn't necessarily involve using the faked location data explicitly. From the tested application's point of view, there should be no difference between faked and real location updates, for every purpose it should "think" the device it runs on was actually at the location indicated by our location-simulation application.

The proposed location-simulation application is only a first idea.

It's important to stress that we haven't actually developed anything like this for our own projects. The reason was that we underestimated the need for such a tool, given that XCode does provide some form of location-simulation already. At first we believed the effort to create a more elaborate tool wasn't worth the benefit. Only through its painful lack during the various projects we were convinced otherwise.

It is not meant to replace paper prototypes.

Neither would the tool be a replacement for any low-fidelity prototypes like the paper/flip book prototypes described above. It is meant to be used in later phases of development, when concrete technology is used besides or instead of simple paper. As we said earlier, location-based games, and location-based applications in general, might require a shift to using a higher level of technology, i.e.

a concrete form of location-aware soft- and hardware, because tracking a user's location is hard to mock. However, one needs to be careful to then not move towards higher-fidelity prototypes too quickly. Keeping interfaces simple and "paper like" would be better to have test users still focus on high level concepts instead of concentrating on how, for example, the UI on a mobile device looks.

The location-simulation application could also be used for Wizard of Oz like prototypes.

Besides making the developer's life easier during implementation of a location-aware prototype software, the proposed location-simulation application could also be used in test runs directly. This would also allow for reducing the concrete UI on the mobile device, preventing too much focus on that and stressing high level concepts. For example, an experimenter overlooking the test users could send location triggers to them even when the test is not done at the final location the game is supposed to take place. This would avoid having the players having to take care of operating parts of their prototype themselves, like flipping to a certain page of a flip book prototype for a given location. Instead, they would experience how it is if the device suddenly informs them of having "found" something, an important aspect that is not covered in simpler prototypes.

Chapter 6

Evaluation

Our location-based game projects were developed in parallel with our design frameworks.

This chapter lists the various location-based games we developed during the course of this dissertation. In a way, they served as a form of evaluating the design concepts we introduced in the previous chapters, but of course they at the same time inspired these concepts. Also, they were started before all design paradigms were fleshed out, for example, the `GroupAixplorer` (see [Wermers, 2010], [Wermers et al., 2011], and chapter 6.2 — "GroupAixplorer") was completed before the pattern language existed. Due to its nature that doesn't mean that said pattern language had no influence on it, actually several patterns were in a way already adopted. Thus, most projects were influenced by our design frameworks just as much as they influenced them.

A common structure for presenting the projects to compare them against relevant design concepts.

To emphasize this parallel development we will use the same structure to present each project:

- Project's name followed by a general description
- The context and time-frame for the project
- Aspects (for example, patterns) the project influenced
- Aspects from our projects that were intentionally adopted to validate them

The projects will be presented in chronological order, except for Aachen Horror, the project that ran for the longest time. It should be noted that this doesn't mean that sometimes newer projects influenced older ones. This happened due to their different size; several times the idea for a bigger project was already there, but it started at a later time because of available resources at the chair.

6.1 Aixplorer

The Aixplorer is not a game, but a tourist guide system.

Technically, the Aixplorer is not a game, but a location-based multimedia guide for tourists. For the most part it has been used as an indoor system in the city hall of Aachen (which is also a museum). Visitors would rent devices and then stroll through the museum on their own with the guide offering context dependent information on the various exhibits. We list the system here, because for a lot of the other projects we were able to use it as a test and development platform. The location-tracking parts of the software were implemented by the chair, so we could reuse those in our location-based games. Also the devices themselves could be used in our test runs, the museum allowed us to lend several of them for extended periods of time.

Future plans for the Aixplorer

At the time of this writing, the Aixplorer is still in use in Aachen's city hall, a second version has even been deployed in another museum in Aachen, the Centre Charlemagne[1]. For the future it is planned that an umbrella application, potentially as a download for people's own smartphones, will function as a combined indoor/outdoor guide system connecting several museums.

Context and time-frame

Two versions of the Aixplorer were relevant for our work.

For the location-based games presented in the following, two versions of the Aixplorer are relevant. The first one ran on iPhone 3G devices embedded in a custom casing; it is shown in figure 6.1a. Since the devices were constantly in use they wore out and new hardware needed to be deployed in the city hall. We chose iPhone 4s for that pur-

[1] http://www.centre-charlemagne.eu

Figure 6.1: Both versions of the `Aixplorer`. Left (**a**): The version that was used in Aachen's city hall. Right (**b**): The new version that is used in the Centre Charlemagne.

pose and although the software wasn't changed immediately with that switch, the newer hardware allowed for our other projects to make use of additional features (like Bluetooth 4.0 technology). The custom casing didn't fit on the new iPhones, so they were clearly recognizable as such. By now, a new casing is in use, shown in figure 6.1b.

Tracking technology.

The original `Aixplorer` used wifi-tracking as approach for location-awareness. The city hall was outfitted with several access points, even directional antenna were used to create a different signal pattern for each room. We then used a machine learning algorithm (using libSVM[2]) to be able to distinguish between each room in the two-story building. Most rooms are approximately seven by seven meters and divided by rather thick walls, so the results were quite reliable.

The newer version of the `Aixplorer` and the one now

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

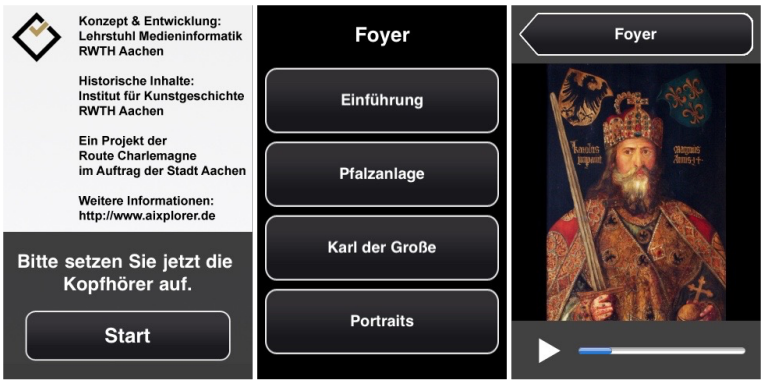

Figure 6.2: The first `Aixplorer`'s UI flow: Left (**a**): The welcome screen with an introductory audio. Middle (**b**): The up to four topics that can be selected (here in the museum's foyer). Right (**c**): One topic is selected and audio & slideshow are played.

also deployed in the Centre Charlemagne uses Bluetooth 4.0 proximity beacons (called "iBeacons"[3]) instead of WiFi access points, but under the hood the same machine learning approach is used with those different radio signals.

Of course for our larger, outdoor systems, we also made use of the iOS APIs' out of the box location framework for location-tracking, CoreLocation.

The original `Aixplorer`'s interface and user concept.

Since the multimedia guide was designed to basically be a one-time usage application for a broad user base its interface is very simple. The language settings are performed by the city hall's staff, so the actual user's don't have to bother with any controls for that. They are presented with a first welcome screen where they can play back an introductory audio message (see figure 6.2a). After that, the device will always display a list of up to four buttons that changes depending on which room the visitor is in (see figure 6.2b). Clicking on any of these buttons presents the user with a slide show accompanied by an audio message explaining one of the exhibits of the room (see figure 6.2c). Note that there is no further information where exactly in the room the exhibit or the user herself is, due to the small size of

[3] https://developer.apple.com/ibeacon/

the room it was sufficient to simply provide an image for orientation.

The newer Aixplorer's interface concept.

The Aixplorer released in the Centre Charlemagne had to use a different UI concept, because that museum isn't as conveniently divided into separate rooms of relatively small size. Instead, it consists of a big entrance area followed by a large, triangular room. The middle of that triangle is constructionally and thematically different from a path around its walls, so the architecture softly guides visitors to walk around it along its outer sides, but that way isn't enforced. People can freely stroll through the entire area. Thus, the UI shows a map that automatically pans to roughly the section the user is currently in (determined with the same algorithm used in the older Aixplorer). A marker indicating a more exact position was omitted, because the tracking isn't precise enough to reliably place that. For the city hall an updated version more similar to that in the Centre Charlemagne is planned as of this writing.

The Aixplorer is still in use.

The entire project started in 2009 and is, as said, still running. This is worth mentioning because back then smartphones weren't as widely spread as they are today, resulting in people being less familiar with location-aware software, especially for indoor locations.

Influenced work

The Aixplorer influenced our later works a lot, but in an indirect way.

By spending time in the museum for maintenance and general support we learned a lot of how people perceived the system's functionality. Although we initially didn't do a lot of explicit research with the platform, those experiences strongly helped us during all of our other, gaming-focused projects. This can be concretely seen in several concepts found in the pattern language described in [Will, 2013] and in chapter 5.1 — "The Pattern Language". Since the Aixplorer is not a game, we decided against listing it in any of the patterns' inspiration sections; besides, the influence was a lot more indirect than our later works and other actual location-based games.

Nevertheless, the following patterns can be said to be found in a prototypical way in the Aixplorer:

- LOCATION AS CONTENT:
  The `Aixplorer` as a guide system offering context-aware information for a museum is strongly bound to the Aachen city hall and builds on the actual meaning of its characteristics and exhibits.

- REACHABLE LOCATIONS:
  Since the Aachen city hall is not just a museum, but also still in use as a city hall, sometimes rooms were closed or access was otherwise temporarily obstructed. This was part of why we did not, for example, enforce a certain order for the various points of interest and kept everything optional.

- LANDMARKS:
  Because the tracking wasn't precise enough to figure out which exhibit the visitor would stand in front of, we used images on the device as landmark representations for her to further orient herself.

- NETWORK INFRASTRUCTURE:
  The city hall had only a very restricted WiFi infrastructure for us to use, so we quickly learned that it is very important to design with according care in that regard.

- COPING WITH UNCERTAINTY:
  As said for the LANDMARKS, our tracking technology was not always totally precise, so we had to make sure that even wrong tracking results would not disturb the visitors' flow.

- CO-LOCATED MULTIPLAYER:
  The `Aixplorer` itself was designed as a single user experience, but we quickly learned that most people visit a museum in small groups. Our system would then actually split these up, especially since the headphones, in a way, physically isolated people. Our interest in designs better suited for multiple users was sparked by this, so all our following systems were created accordingly.

Besides patterns, our informal observations also motivated the creation of the GroupAixplorer, presented in [Wermers,

2010] and [Wermers et al., 2011]. As the name implies, we wanted to investigate ways to make the experience more suitable for groups of people, but it was also our first step into location-based games as the GroupAixplorer was a gamified version of the multimedia guide. Thus, the Aixplorer also influenced Aachen Horror, the largest location-based game we had in mind pretty much from the start to be developed on the "Aixplorer-platform".

Otherwise, the fact that the Aixplorer allowed people to freely follow their own path through the museum sparked the work of [Borggrewe, 2013]. With this we wanted to find out whether being in a group or not and using a guide system or not affect movement behavior.

Influencing work

Since the Aixplorer was pretty much the first thing using location-aware technology we tackled, we couldn't rely on own experiences with similar projects. However, a previous doctorate student at the Media Computing Group had done a similar project, the REXplorer (see [Ballagas et al., 2006] and [Ballagas et al., 2007]). So besides the usual related work, we were able to rely on previous experiences at the chair with a similar system more directly.

6.2 GroupAixplorer

The GroupAixplorer was developed for the diploma thesis of Martin Wermers, [2010], and later published as a case study in [Wermers et al., 2011]. The general game concept was that of a scavenger hunt for groups of up to five people. Several quests making use of the Aachen city hall's exhibits and historical aspects were designed, either in the form of so-called *interactive riddles* involving device interaction or of so-called *discussion quests* focusing more on interaction between the players.

The GroupAixplorer was our first quest oriented location-based+ CO-LOCATED MULTIPLAYER game.

It was the first location-based game we actually implemented and tried out, once the Aixplorer was sufficiently stable and we had the experience and know-how to use it as a platform for further research. As such, the concept stayed in the museum, the game's content was still providing information about various exhibits and the history of the place. All quests, i.e., tasks within the game were built on facts that were collected from museum guides and historians we had worked with during the development of the Aixplorer.

Context and time-frame

The various steps to solve a quest

Each quest had three audio files that could be found in the museum, an introduction, a task description, and a final solution.

The first clip could be found by individual players, the idea here was that they would split up to scout to find the various quests. This introduction always gave a hint where the quest's actual objective was located, so players then had to look for that once the quest was accepted. For technical reasons the GroupAixplorer only allowed one player, the "group leader", to accept quests, other players were only given a button to call that leader over (with a predefined text message, see below). However, as soon as a quest was accepted, all players were given the chance to listen to the introductory audio, regardless of their whereabouts.

When a player found the actual task in the city hall, they were supposed to call all missing players over. The group leader would then start the task and an audio file would be played for all participants in sync; they all had to be present for this. Depending on whether the quest was an *interactive riddle* or not, they then had to interact further with the device, for example, they had to decode a number hidden in a painting and enter it on the screens of their devices to complete the quest. Contrary to that, the *discussion quests* simply encouraged (in their audio) to discuss a certain exhibit, for example, why a character in a painting had three hands. These quests were open and no device interaction was necessary; once the group decided to have discussed enough, the group leader could press a button to play back the final solution audio for everybody in sync.

The GroupAixplorer's COMMUNICATION CHANNELS

Since the game actively encouraged splitting up and scout the museum, yet each quest was supposed to provide a team experience during its solution, the players needed some means to easily communicate while being apart from another. The easiest and least obtrusive way seemed to be a simple messaging mechanism. Voice and/or video chat seemed unsuited for a museum, besides there were technical limitations due to bad NETWORK INFRASTRUCTURE. In the end, the system offered only pre-defined messages, which turned out to be sufficient as well as easy and quick to use.

Time and potential for a permanent museum installation.

Since it was designed for a diploma thesis, the GroupAixplorer's development cycle was under six months and we sadly did not have the resources to have it set up permanently in the city hall. The overhead for doing so would have required special staff to lend out and explain the game, which wasn't available at the time. Instead, the game was only played during the actual evaluation phase in [Wermers, 2010]. Besides, we included concepts, like the group leader, that were likely not suited for a permanent set up. The rationale behind that was that we simply wished to see how those worked out, but there were also technical limitations.

Influenced work

Like the regular Aixplorer offered a basic set of experience for the pattern language presented in [Will, 2013] and in chapter 5.1 — "The Pattern Language", the GroupAixplorer influenced several patterns as well.

Patterns directly influenced

In some cases there was a direct impact on the patterns; the system is listed under the Inspiration section of those:

- REACHABLE LOCATIONS:
  Besides the system being designed for a rented system bound to the museums opening times as mentioned in the pattern itself, one of the quests lead players into a part of the city hall (the council hall) that occasionally was unavailable (because it was used by the city council). The system, or more precisely the actual runs, needed to be scheduled around that.

- CHANGE PERCEPTION OF REAL WORLD PHENOMENA:
  A big goal of the `GroupAixplorer`'s content was to provide the players with information they would otherwise hardly get. It was made from specific anecdotes obtained from local tour guides to better teach players how people in the past perceived various things about paintings or historical events.

- CO-LOCATED MULTIPLAYER:
  As stated earlier the `GroupAixplorer` was the first implemented location-based game we did and as such was specifically designed to investigate group behavior. We also wanted to find ways to explicitly prevent the "forced" splitting up of groups that we observed in the `Aixplorer`.

- COMMUNICATION CHANNELS:
  The city hall's characteristics and the game's quest structure lead to us considering the possible ways to design inter player communication during the game and ultimately brought us to the insight that voice or even video chat might not necessarily be always preferable over simpler methods (see also above).

Patterns indirectly influenced

The following patterns were not directly influenced by the final system itself and thus, Christoph Will did not list them in the respective Inspiration sections. However, our experiences during development and testing in general provided valuable experience that is reflected in some of the patterns in a more informal way.

- LOCATION AS CONTENT:
  Obviously the `GroupAixplorer` is specifically designed for one location, the Aachen city hall. Its content is bound to that museum and it incorporates the real world artifacts found there. It is a location-based$^+$ game as stated above.

- LANDMARKS:
  As an indoor game the `GroupAixplorer` obviously doesn't use landmarks in the literal sense, but it uses the museum's architecture like stucco as well as

paintings, etc. as explicit marks for the players to look out for. Basically, this fulfills a similar purpose on a smaller scale, so it had an indirect influence on the larger scale pattern. As mentioned in that pattern's Annotation in chapter 5.1 — "The Pattern Language" it should probably be updated accordingly.

- EXPLORATION CENTRAL TO GAME:
  In its original version this pattern was focused on outdoor games, so the only reason for the `GroupAixplorer` not to be listed in its Inspiration section is that it was a smaller scale, indoor game. Nevertheless, it *did* have a certain influence, since after all the `GroupAixplorer` *is* a game focusing very much on exploration, in its case of a museum.

- NETWORK INFRASTRUCTURE:
  This pattern does not have a direct connection to the `GroupAixplorer` other than the latter was the first project that made us realize how important a functioning network structure is and how hard it still is even these days to ensure a proper network connection with roaming devices. The game itself doesn't lend to be explicitly noted in the pattern, since we did not conduct further research into this problematic aspect during development besides solving the issues we encountered.

In terms of projects that were influenced by the `GroupAixplorer` there is pretty much every other project from the following sections. An exception would be `iCatch`, as it differed from the concept and was of a smaller scale designed during a seminar.

Reducing device interaction was a general influence to all following projects.

The biggest lesson we learned from the `GroupAixplorer` for our other location-based games was to tone down the interaction with the hardware responsible for the location tracking. While this is reflected also in several of the patterns (e.g., OTHER CONTEXT OF PLAYER, APPARENT FRAME, IMMERSION, and others), the results from the `GroupAixplorer` evaluation lead us to keep that in mind from very early on. We were surprised that players rated the quests encouraging simple discussion amongst them

higher than those that had a much more riddle-like character, involving finding a concrete and correct answer that could be verified by the system. While this might also be true for non-location-based games, we consider this especially important now for our kind of games since it adds to the impact a given location has on the players' experience. It seems too much device interaction holds them from fully appreciating a location as well as interaction with fellow players (potentially sharing that appreciation, especially if the game adopts LOCATION AS CONTENT).

`GroupAixplorer` was from the start a preparation project for `Aachen Horror`.

It should also be said that we already had `Aachen Horror` as a much bigger game in mind when the `GroupAixplorer` was built. Right from the start we considered it as a small-scale test to collect experience with location-based games.

Lessons learned for multimedia tourist guides.

One of the goals of the `GroupAixplorer` was to find a way to prevent a system from isolating its users. Of course part of our solution to this was the entire quest mechanic enforcing interaction between the players and coming together at various points in the museum, but this was also accompanied by simply giving them mono-headphones, so that even when listening to audio, they would not be totally acoustically cut off from the rest of their surroundings. The synchronized audio also seemed like a viable option that could be implemented in a tourist guide system. So far we did not have the chance to do the latter, but at least the mono-headphone idea was adopted by the newer versions of the `Aixplorer` as of our recommendation.

Influencing work

`Aixplorer` and `REXplorer` were the strongest influence on the project.

As the name already implies, the `Aixplorer` had the most direct influence on the project. Since we had quite a lot experience with the design of this multimedia tourist guide and were familiar with its location, the Aachen city hall, it seemed natural to gamify it into a location-based$^+$ game. Also `REXplorer` was an important predecessor since it was also a potentially CO-LOCATED MULTIPLAYER location-based$^+$ game.

Testing for `Aachen Horror`

As we said above the `GroupAixplorer` was specifically meant to try out a first, smaller scaled location-based game

before we started with development of Aachen Horror. Naturally this also means the general idea for that larger game influenced the project, though only to a smaller degree. While it was already clear we wanted Aachen Horror to become a much longer game and even the genre was partially decided, the ideas weren't fleshed out in the slightest and we didn't realize concrete things in the GroupAixplorer just to test them for the bigger game. Nevertheless, the influence was there in both directions.

6.3 iCatch

The iCatch[4] location-based* game is the smallest project we did over the course of this work. Its general idea is that of a tag game with scavenger hunting elements and team mechanics. From that point of view it is also a CO-LOCATED MULTIPLAYER game, but some of the mechanics actually have avoiding other players as a goal, effectively forcing players to *not* be co-located to win. It is the only game we designed so far that focuses on a much more rapid game flow, similar to Savannah (see [Benford et al., 2005]). Our other games usually didn't require fast movements or planned player versus player tactics, but focused on a location's cultural or social impact, relying on the places and not the game mechanics to provide to the atmosphere.

iCatch is the smallest project and strongly differs from our other games' concepts.

Context and time-frame

iCatch was part of a practical lab for students taking place in 2011/2012. Most students were relatively unfamiliar with location-based games, so we had to spend some time on teaching the basics. Additionally, the class's aim was to also teach a basic understanding of network programming, resulting in the time-frame reserved for the actual game being more limited than in our other projects.

The constraints of the lab limited the available time for implementation.

It should be noted that the game's concepts were largely devised by the participating students. We only "set the stage" and introduced them to generic location-based ideas and

The project nevertheless tried to explore various design ideas.

[4] https://hci.rwth-aachen.de/icatch

methods like brainstorming and paper prototypes to iteratively shape the idea of a scavenger hunt and tag-like game.

`iCatch` is about competing teams

The result became a mechanic for two or more teams to compete for *points* and virtual *money*. Those could be earned by either so-called "runners" or "hunters" respectively in each team, with a third role, a single "operator" per team, acting as supervisor and coordinator. "Runners" would be assigned by the "operator" to collect points from randomly appearing checkpoints within the play-field and bring them back to a (secret) base, while "hunters" would try to stop enemy "runners" from doing so, earning the virtual money depending on the number of points that enemy "runner" was carrying.

The final interface concepts for `iCatch` so far

The "operator" would actually not use a mobile device, but instead coordinate their team using a map based interface running on a regular computer. This would show the appearing checkpoints, the own team's base as well as all "runners" and "hunters" (enemy and own team). "Runners" would use a mobile device showing a map also, whereas "hunters" would only see an interface giving directions and distance to the next assigned enemy "runner". Once they were close enough, they were given the option to steal that "runner's" points and convert them to virtual money.

The development process itself offered insights although the game did not reach a production level.

The students developed this interface over various paper prototypes and conducted preliminary field tests to get a feeling for the gameplay before implementing any of the needed functionality. This process gave us several insights regarding what developers might overlook or underestimate when developing location-based games. They came up with even more advanced ideas, for example a leveling system for the teams or upgrades an "operator" could buy for the collected virtual money and distribute them amongst their team, but due to the scope of the project we were unable to fully implement or explore these options. Other than a final presentation at the end of the class we did not conduct any real user tests, so in the end the project can be seen as a case study showing relatively new developers approaching the field of location-based games.

Influenced work

iCatch gave us personal experience and insights for following projects to properly assess location-based game specific issues.

As a practical lab project, iCatch had a rather indirect impact on our other projects, creating personal experience and anecdotal evidence rather than published results. However, especially those personal experiences and seeing other designers, in this case our students, face the same issues with location-based software that we encountered in our design sessions and brainstorms were very valuable. Worth mentioning is, for example, the pattern MINIMIZE SOCIAL AWKWARDNESS, something we didn't pay much attention to until the students trying our the "hunter" roles in an early prototype reported their own awkwardness of chasing after each other in a public setting (see also the Annotation section for that pattern in chapter 5.1 — "The Pattern Language"). The same experience was also incorporated into the pattern ETHICAL AND LEGAL PROBLEMS, as is mentioned in its Annotation section as well.

It also is our only project focusing on POSITION AS INPUT.

As said earlier, iCatch is also our only project not predominantly adopting the LOCATION AS CONTENT pattern but its counter part. The reason for this may be the fact that is is not tied at all to the Aixplorer guide system, which is, although not a game, in a way very centered around the actual meaning of locations and thus related to the LOCATION AS CONTENT pattern.

Technical lessons learned from the game

A more technical aspect for the game design was realizing the importance of tackling roaming problems. Christoph Will also collected this in the NETWORK INFRASTRUCTURE and COPING WITH UNCERTAINTY patterns later, but the game development showed us how special the demands in this regard are for game applications on mobile devices. This wasn't immediately obvious, as for the lab we had to make do with only WiFi, our mobile devices didn't have SIM cards to be used in the cellular network. So at first we thought that in our later projects we would be able to tackle these problems with connecting our hardware platform (mostly iPhones) to the cellphone network, but when we saw that this doesn't always yield in better results we had to fall back on lessons we learned in iCatch.

Influencing work

The Aixplorer was the only influencing project.

The practical lab was, as stated above, also aiming to teach more technical skills to the students, like network programming. Because of this we did not extensively build upon previous research, besides introducing the Aixplorer, the participants were not required to read through specific related work. For us, it was especially interesting to see how people not yet very familiar with the concept of location-based games would adapt to it and which design ideas they could bring to the area.

6.4 Movement analysis of museum visitors

We wanted to see how museum visitors move as a means of comparison to location-based games.

The work of Sebastian Borggrewe, "Movement analysis of visitors using location-aware guides in museums", [Borggrewe, 2013], is not about designing a location-based game, as the title implies. We decided to include it here anyways, because it was conducted in parallel to the design of mLoG and had a similar goal in terms of understanding movement behavior. Our original observations from the Aixplorer, which had influenced the GroupAixplorer as well as mLoG, were simply informal observations we made while working in the city hall. This made it hard to properly refer to them when explaining why we did things the way we did in our games. Thus, Sebastian Borggrewe's task was to properly track visitors in the museum and try to uncover any movement patterns.

Context and time-frame

We wanted to track people with and without the Aixplorer.

The master's thesis was done over a course of six months and largely focused on obtaining reliable, exact tracking data from the city hall. A problem was that the Aixplorer was only able to distinguish between the various rooms with its tracking algorithm and even that was, in rare cases incorrect for a few seconds. Besides, we wanted to analyze the movement of people not using the guide system as well to see whether they moved differently. Another comparison was meant to be done between people visiting the museum in a group and those who came alone, but only four

of the participants came alone (all using the `Aixplorer` system), so we could not make any statistically reliable conclusions in that regard.

A video analysis approach was chosen to obtain reliable tracking data.

The final approach to properly track people, especially those without the guide system, was a video analysis. Since the city hall in Aachen is not that big but has high ceilings, we were able to mount several cameras in the rooms, except for the staircase and the council hall. The resulting videos were then hand annotated on a special iPad application to mark the visitors' movement paths. Relying on markers placed on the rooms' floors we were then able to translate the path coordinates to a floor plan of the building.

Privacy concerns and camera failure hindered data aggregation.

In compliance with the museum's and city's privacy policies we were required to not just ask each participant for permission to be filmed, but also had to immediately stop any recordings should another visitor enter the museum and decline permission. A large sign had to be put up to let people entering the museum know about the experiment, too. Additionally, the cameras turned out to have a faulty firmware, resulting in the loss of several film files.

Concerning our game projects existing assumptions were verified.

A full discussion of the resulting heat maps and paths that were gained from the video analysis, see [Borggrewe, 2013]. regarding the impact on our game systems, we saw our assumptions about group behavior verified. It appeared that people in groups tended to stick together. Only larger groups (seven people and up) seemed to split up and form sub-groups that would then behave like their smaller counterparts. Individuals did sometimes walk ahead, but would then either wait for the rest of the group or even go back to places they had already seen to stick with their peers. This observation matched the one we had seen during the `GroupAixplorer` tests and reminded us of an "amoeba"-like movement, the faster people in a group went on ahead while the main "body" of the group would then follow, like an amoeba would send out protrusions or "arms" first before moving to a new position. We believe that at least for exploratory scenarios this pattern appears, with visibility between group members defining how far individuals might go ahead to new areas.

Influenced work

All in all, the work by [Borggrewe, 2013] can be seen as a more formal approach to verify assumptions that we made when designing the `GroupAixplorer`. Because of this, its impact on the location-based games presented here is little and similar to that of the `Aixplorer`.

Influencing work

As stated above, the general idea was to verify ideas that had already impacted our games, so from a practical point of view the most influence on the project were our informal observations from administrating the `Aixplorer` system in the city hall. The games we already had designed or that were queued up or in the middle of being implemented motivated it, but a concrete influence from them was not given.

6.5 mLoG

`mLoG` continued the `GroupAixplorer` by moving the experience outdoors.

`mLoG` was a game developed by Carl Huch for his diploma thesis "Strategies and Movement Patterns for City-Wide Location-Based Games" (see [Huch, 2013]). It was the logical continuation of the `GroupAixplorer` in that it relocated the playing field to an outdoor area. Although the quest approach was kept and the game's content was not as tightly bound to the various locations' cultural or social relevance, it still predominantly adopted LOCATION AS CONTENT and was in the end a location-based$^+$ game. Adapting it to a different area would be possible without changing the game's experience, but that would mean additional implementation effort.

Context and time-frame

The game was written in parallel to the pattern language.

As explained above the game was developed as part of Mr. Huch's diploma thesis, i.e. it was developed and evaluated in approximately six months. It built upon the findings from the `GroupAixplorer` as well as from our general past experience and since Christoph Will wrote his pattern language (see chapter 5.1 — "The Pattern Language" and [Will, 2013]) at the same time so there was quite a bit of "cross-pollination" between the two projects, too.

mLoG had an extensive prototyping phase.

Nevertheless, mLoG's design process included extensive prototyping, similar to the GroupAixplorer. We decided to keep the general quest approach, i.e. have certain tasks that the players would need to accomplish for winning the game. However, the "edutainment" aspect was reduced, meaning that the game would still follow the local theme of "Charlemagne" often encountered in Aachen, but the actual gameplay would not include actual historic facts to teach the players. Instead, the plot in mLoG would refer to the historic figure, but fabricate a clearly fictional story to embed the various tasks in. Theoretically, a different plot or story could serve this purpose as well.

Our goal was to further analyze how players would move.

We had already developed the GroupAixplorer with player movement in mind. Since it was thematically closer to a tourist guide and we had observed museum visitors typically coming in groups, it had been designed to encourage players to split up and come together again. Indeed, the GroupAixplorer showed that this specific group movement was well received by the players. With mLoG, we wanted to look at how exactly players would move and what aspects of the game could potentially lead to a specific way of group movement.

Two of the game's three total tasks were location-based in the strict sense.

In its final implementation, mLoG consisted of three different tasks for a four player team, so it adopted the CO-LOCATED MULTIPLAYER in a collaborative instead of competitive way. We will only give a rough overview of the gameplay here, for a full explanation of how it worked please see [Huch, 2013]. The first task required the players to scour a certain area, the Katschhof in Aachen, for "recipe pieces", i.e. for several virtual items relevant to the game's plot. The second task would then have the players visit several virtual "traders" to exchange a set of goods to another set of target goods. Unlike for the first task, players could see the locations of these traders (not what trader it was, though) and Mr. Huch tried to map them to real world locations that were similar in theme (an "herb trader" was located near a pharmacy and so on). The last task was a "mixing game" without ties to any location; it served as a satisfying finish to the game's narrative.

These first two tasks later lead to creating the categories "area exploration" and "route planning".

Both location-based quests in mLoG are pretty much archetypes for the first two categories for area usage we described in chapter 5.2 — "Geo-Sociograms". At the time, however, we hadn't realized those categories yet, as a matter of fact, the evaluation of mLoG later gave us that idea. However, we did intentionally include both tasks as very different, to see whether people would behave differently, movement-wise.

Player movement did not follow an efficiency-focused strategy.

The interesting thing about this was that players apparently did not just adopt the most efficient way to move as a group. Both tasks were designed in a way that would automatically yield in a different strategy, if efficiency was the main objective for the players. When looking for the virtual objects, for example, it would have been best to divide the play field in distinct areas and split up accordingly. The other task could have been solved with a slightly similar, but different approach: First split up and scout the various traders to figure out what could be traded where, then figure out the route between relevant traders and do the exchanges. Instead of this, players more or less randomly scouted the area during the first part of the game and while they did mostly split up completely, they did not necessarily cover the place in the best possible way. They would occasionally revisit certain parts of cross paths with other players. During the second part of the game, it seemed players were reluctant to even go out completely on their own, most of the times they preferred to stay in teams of two. There was also not a specific distinction between scouting the traders and then doing the exchange, the sub-teams of players would instead simply "risk it" and do trades while they were at a specific trader.

Movement kinds were hard to measure and confounding variables prevented quantifiable results.

The above observations are of a qualitative nature. Geosociograms helped us with visualizing how the players moved and especially how they split up over time, but we did not find a way to mathematically distinguish between the kind of movement in each quest. After all, mLoG was also meant to be an enjoyable game, so for the sake of a good narrative and engaging, non-repetetive gameplay the different parts of the game used different areas (the first quest the Katschhof and the second the nearby Krämerstraße). This introduced several confounding vari-

ables (size and topology of the areas, visibility between players, maximum distance between them, etc.) to the tasks and while we do believe that in the end it was for the most part the difference of the tasks themselves that lead to the different movement, it's hard to say what exactly was part of each task and what was a confounding variable. There was no other approach to this, however, because as we explained before we started without even knowing what to look for. In the end, we consider the project a great success, since it lead us to the concept of categorizing movement for tasks and to the tool of geo-sociograms as a means to provide an at-a-glance overview of player movement.

Influenced work

Geo-Sociograms were a direct result of our observations in mLoG.

The most notable influence is of course the concept of geo-sociograms, explained in chapter 5.2 — "Geo-Sociograms" and previously published in [Herkenrath et al., 2014]. We used them to visualize the movement patterns in the six evaluation sessions and saw that they apparently displayed a different structure for both quests. As stated above, this ultimately also lead to out categorizations of "area exploration" and "route planning" for location-based games. Other than that, mLoG is the direct predecessor of mLoG2, presented in Vyshantha Simha's master's thesis "Movement Patterns in Location-based Multiplayer Games", [Simha, 2014]. We intended to deepen our understanding of geo-sociograms and these categories further with that work, see further below for that.

mLoG was developed in parallel to the pattern language.

Additionally, the work was conducted in parallel to Christoph Will's work (see [Will, 2013] and chapter 5.1 — "The Pattern Language"), so several of the patterns were either influenced by mLoG or vice versa. Since mLoG wasn't finished at the time it is not listed as Inspiration for any patterns. This is also the case because the influence often was of a more general nature and in the form of informal discussions between the authors.

Some observations during mLoG gameplay surprised us.

Nevertheless, we saw things that would eventually be addressed in patterns that we hadn't thought of before evaluating mLoG. For example, the pattern EPHEMERAL MAGIC CIRCLE was not yet conceived and thus mLoG wasn't intentionally designed to encourage players to behave in such a

way, we saw them form the described "circle" often. The fact that they were reluctant to completely split up in the second quest can be said to also relate to that.

Influencing work

Even though the patterns weren't written down during most of mLoG's development, concepts covered by several of them were also known to us, so we wanted to include those in the game to see how they could work out. We will list them in the following by referring to the according patterns for easier readability.

- LOCATION AS CONTENT:
  Like most of our games, mLoG treats the data received from its location-aware technology (iOS's CoreLocation) setting a focus on locations, the movement itself does not play much role in the game mechanics. As a continuation of the GroupAixplorer we stuck to the game mechanics adopting this approach.

- LOCATION GRANULARITY:
  Part of the challenge in designing the first two quests was to find a balance between enough points of interest to be searched or visited to make the game interesting and fitting them all into the available area without introducing overlapping due to bad tracking data. The chosen areas provided relatively high accuracy values, but it was still an issue, for example the number of virtual items in the first quest couldn't be larger as to not clutter the Katschhof too much.

- OTHER CONTEXT OF PLAYER:
  Right from the start it was clear that players would walk around in the open. The chosen areas were deliberately in a pedestrian zone to avoid players getting into trouble with traffic, etc. Besides, the location offered a fitting atmosphere for the game's narrative (the Aachen city hall was part of the residency of Charlemagne, who was used as the virtual character tasking the players with the game's quests).

- LANDMARKS:
  Especially the second quest made use of this, if maybe

not in as strict a sense as the pattern implies. As mentioned above, the various virtual traders were located near real world stores fitting to their profession.

- EXPLORATION CENTRAL TO GAME:
  In both location-based quests it was central to find out "what is where".

- MINIMIZE SOCIAL AWKWARDNESS:
  Unlike the `GroupAixplorer`, players would be acting in a completely public space. Inside the museum it was relatively common for people to see others interact with a location-tracking device (regular visitors could rent the `Aixplorer` even during the evaluation runs of the `GroupAixplorer`). `mLoG`, however, was played outside and onlookers could easily see that "something" was going on. One passerby actively inquired if he could take part in the game, having immediately understood what `mLoG` was. Because of that, the game did not require the players to perform things they might feel uncomfortable doing in public, like chasing around or doing elaborate gestures with the devices.

- CO-LOCATED MULTIPLAYER:
  Since the `GroupAixplorer` was a cooperative multiplayer game as well and `mLoG` was meant to be a conceptual successor it was only logical to keep this concept as part of it.

- COMMUNICATION CHANNELS:
  Quite a bit of work was put into offering a more elaborate way for players to communicate once they were farer away from each other. Since the game would be played over a bigger area, simply asking somebody to come over seemed insufficient. Depending on what needed to be said this could have been a waste of effort considering the increasing walking distances. For that reason `mLoG` got a chat system instead of just the pre-set text message snippets that were used in the `GroupAixplorer`.

The GroupAixplorer had the most significant influence of all our earlier projects.

As explained above, the main influence regarding projects was of course the GroupAixplorer. Logically, the Aixplorer also played a role, but since mLoG conceptually left an "edutainment" approach behind the influence of actual historical facts is less prominent than it was in its predecessor.

6.6 mLoG2

The project continued right where mLoG ended.

With the mLoG2 game we aimed to expand on the findings we made when testing mLoG. For this purpose Vyshantha Simha expanded the software in his master's thesis "Movement Patterns in Location-based Multiplayer Games", [Simha, 2014]. One of the biggest problems we saw in the evaluation of the original mLoG was that the two different location-based tasks were completed in differing areas, raising the question whether the observed differences in movement behavior were due to that or due to the varying nature of the quests.

Context and time-frame

mLoG2 built directly on the code of its predecessor, so the initial prototyping phase was shorter.

As mentioned the project was undertaken as part of a master's thesis, so it was again conducted over roughly six months. Since we wanted to address very specific issues in mLoG the plan was to directly work with the source code from that project. The goal was to relocate the gameplay to a different area and use the same play field for all of the location-based tasks. mLoG's third task was stripped from the game, as was most of its narrative. This left the "area exploration" and "route planning" tasks, both to be played in the same play field and with as little difference other than their individual specifics as possible.

A new task was added to cover the third category of area-usage.

When stripping the quests from everything but their core concept and redesigning the software accordingly it became clear that the mentioned categories were not the only possible ways to use an area in a location-based game. As a result we decided to add another task to mLoG2 that would cover what we had previously not thought of. "Area coverage", as explained in chapter 5.2 — "Geo-Sociograms". In

the context of the game that meant to have players place so-called "guards" that would cover a certain radius of space in the play field. Additionally, several markers were distributed over the field beforehand, and the goal was to include as many of these as possible with the area defined by the "guards". To complete the task successfully, a certain threshold of those pre-distributed markers needed to be achieved.

Real world hints were given as needed using small flags.

Of course this new task and the original "route planning" task (the one that demanded players trade goods with several virtual traders) needed visible markers in the real world to denote where a point to protect or a trader was. Leaving those out and relying on virtual markers to be seen on the mobile device was not an option, because we wanted to stick with using LOCATION AS CONTENT for those tasks. The locations would admittedly not really have any real-world related content since we used abstract flags, but stripping the game of the needed interaction with the real world (looking around for orientation, mentally connecting the virtual map with the surroundings, etc.) too much would have resulted in a game completely different from mLoG. The result would have been a probably rather dull location-based game that uses POSITION AS INPUT as a mere means to move a marker on a screen.

To increase tracking results, Bluetooth beacons were used together with iOS's CoreLocation (GPS).

We decided to attach small Bluetooth senders to each flag so that the used iPhones would easily register coming close to them. This eliminated the problem of only relying on GPS and thus having to place the flags very exactly to avoid a drift between the device tracking and the real world coordinates.

Communication channels were widened to include voice chat.

Another thing that was changed in mLoG2 compared to mLoG referred to the COMMUNICATION CHANNELS pattern. Since the play field became potentially larger (at least compared to the area used for the "area exploration" quest in mLoG) we wanted to provide the players with a voice chat system instead of just a text based messaging functionality. To avoid wasting time on the relatively elaborate implementation of such a feature, we simply gave radio equipment (i.e. in-ear receivers and wearable senders) to the players.

Area selection was difficult.

A major problem for mLoG2 was our intention to use the same area for all three tasks in the game. While the original mLoG used a pedestrian zone in the center of Aachen that added to the game's atmosphere, it also brought several confounding variables to the game, for example a high architectural complexity, bystanders obscuring the view of things, and a varying quality of mapping between real world shops and their counterpart traders in the trading task. For mLoG2 we thus needed a field large enough for us to do the tasks in (due to GPS accuracy of +/- 5 meters at best it needed to be quite large to hold all traders, etc.) that was accessible and relatively even in its topology (i.e. no obscuring buildings or the like). Our first choice, the Kennedy park in Aachen, turned out to be suitable from its general properties, but unfortunately the neighborhood was problematic. Our placed flags and the Bluetooth senders were vandalized during our first experiments, even although we brought additional staff to watch over them. The area turned out to be too big to be able to constantly have an eye on every single marker. In the end we were forced to compromise on the location and chose another play field, we moved to a park between Kirchraterstraße and Pariserring in Aachen (see also [Simha, 2014, pp. 50]).

These problems reduced the number of test groups we could handle.

The result of this organizational overhead was a relatively low number of test players we could fit in the project's time frame. However, we could show that there, again, seemed to be a different movement strategy involved in solving the different tasks. Surprisingly, the the sub-grouping pattern we saw in mLoG's trading quests did not occur.

A classification algorithm to verify differences in the geo-sociograms was used.

The graphs of the geo-sociograms themselves were not as easy to analyze with the plain eye, which is why we adopted a classification algorithm (a support vector machine, or SVM) to try and see whether the differences we saw were in fact relevant. This showed us that there was a difference between the "area exploration" and "route planning" tasks as well as between the "area exploration" and the "area coverage" tasks. Of course this approach has its problems due to the mentioned low number of trials we could do. A part of the data had to be taken to train the SVM, so even less data would then be tested for a difference according to that trained classification model (for a full de-

scription of the approach please see [Simha, 2014, pp. 72]). Still, we believe the results indicate at least a high probability that certain tasks lead to specific patterns in players' movement.

Influenced work

mLoG2 put the geo-sociogram idea to the test.

Since mLoG2 was designed as a second iteration of mLoG its principal influence is similar. The concept of geo-sociograms was tested as a kind of evaluation tool in its test runs and proved to be of significant use. Most notably is of course the extension of the area usage categories by "area coverage", a way to use the available area in a location-based game we hadn't previously thought of.

No new patterns were written based on mLoG2, but their usefulness can be seen as further verified.

Due to mLoG2 omitting an elaborate prototyping phase and instead pretty much directly extending its predecessor we did not conceive any new patterns. However, this also means we can see the patterns that are adopted by both games as having been further verified. For example, EPHEMERAL MAGIC CIRCLE can be seen as, again, occurring naturally, i.e. without us having consciously worked towards the game lending itself to this phenomenon. Patterns like LOCATION AS CONTENT and LANDMARKS were not strictly in the game anymore (since the relevant points of interest in the game did not really incorporate any aspects of the real world and our flag-markers were not given, culturally meaningful characteristics of the landscape) were in a way abstracted. Still, it would be easy to change that in a real, non-prototypical game by, for example, weaving real world meanings of a location into the exploration quest and connecting the traders to real world locations hinting at their in-game role like mLoG did.

Even negative aspects turned out to be reflected in a pattern.

Even the bad experience we made with the heavy vandalism in the Kennedy Park can be pointed out as one aspect of the ETHICAL AND LEGAL PROBLEMS. While this is of course a bad thing, the problematic neighborhood could be seen as a local "custom" that we underestimated as potential influence on our game. In fact, we knew the Kennedy Park might be a questionable area, but did not expect that much hostility (one or two "casualties" in terms of flags or Bluetooth senders would have been no big issue, but constant and willful destruction turned out to be too much).

Influencing work

As successor of mLoG the same patterns were adopted by mLoG2

As stated above, mLoG2 was a second iteration of mLoG, so the same patterns were adopted in its design. Due to a more formal setup though, LOCATION AS CONTENT, OTHER CONTEXT OF PLAYER, and LANDMARKS were only included in an abstract manner. These patterns require the use of a place's semantic meaning to be somehow included in the game, usually by weaving it into the narrative. Since we intentionally stripped out any narrative to eliminate the confounding influence a specific point of interest might have (for example because it was perceived as more attractive to go to), mLoG is a bad example to showcase these patterns. Its predecessor, however, shows how that change could be easily reverted.

6.7 Aachen Horror

Aachen Horror game is the largest project so far.

Aachen Horror was the biggest location-based+ CO-LOCATED MULTIPLAYER game prototype we built so far. Other than heavily relying on location-aware technology it roots in classic (as opposed to electronic) role-playing games (for an easy explanation of the term see for example Wikipedia's article[5] on it). This means that its appeal is meant to come from an interesting narrative for the most part, not from its game mechanics.

The following paragraphs will be finer structured than for the other projects to better explain the game.

Due to the relative complexity of the game and the fact we did not yet publish anything about it (for the reasons see below) the following subsections will be further divided, outlining the various aspects of the game, including its plot.

Context and time-frame

Aachen Horror is also the oldest of our location-based games in regards to the general idea.

The first ideas for a location-based game running in smartphones came up in 2009 when the Aixplorer was developed. Due to the guide system and other projects, work on Aachen Horror did not progress continually or planned, but the general concept hasn't changed from those first thoughts. The first notable progress wasn't made until 2012

[5] https://en.wikipedia.org/wiki/Role-playing_game

when we organized the project's budget (which was part of the Aixplorer's EU funding), acquired an author for the game's plot and held a workshop to gather first design ideas for story, mechanics, etc. Over the next three years, due to other projects again with interruptions, the game was prototyped and developed.

Problematic aspects of role-playing games lead to the game's conception.

Interestingly, the motivation wasn't sparked from the Aixplorer's location-aware aspects only, but also from personal experience with traditional pen & paper role-playing games. These kinds of games are usually relatively time-consuming and require a group of players to regularly schedule sessions to play. This can be difficult to plan around people's working hours, especially including the overhead of meeting in one place. The so-called "game master" required in most traditional pen & paper role-playing games has an even higher overhead since she is required to plan the session, i.e. the played scenario. Since most people have smartphones, i.e. mobile devices, the initial idea for Aachen Horror was to "synchronize" people's normal days and the fictional days their role-play avatars experience.

We wanted to create something different from other computer role-playing games.

Using computers to run the game and thus effectively eliminating a game master (who usually plays non-player characters and enforces any rules) is would also reduce this overhead; this approach is not new. There are also computer games called role-playing games, but there's often quite a difference in the concept. As said, the non-player characters are played by the game master, i.e. a human (in so-called LARP[6]s there can even be several humans fulfilling the role of side-characters, or background actors). While digital technology can easily present a fictional character with adequate multimedia, the interaction between such a character and the players is limited by the computer's inability to really react like a human (in a way an "AI-complete" problem). Many computer role-playing games thus rely on just offering pre-defined interaction methods in these cases or focus on more action-oriented mechanics such as fighting. Story or plot is often just conveyed in a more cinematic manner through video clips and similar means. From the start we wished to make Aachen

[6]https://en.wikipedia.org/wiki/Live_action_role-playing_game

`Horror` different in that we strove to provide as close an experience to pen & paper role-playing games as possible. We wanted to have as much IMMERSION in it as we could manage (although this was a while before the pattern was written, the term was of course already known to us).

Several constraints for the game resulted from this intention.

This goal would influence `Aachen Horror` from the start and also define several constraints on the game mechanics and genre. First of all it was clear that we would need a narrative scenario that could be played along through several "paths", i.e. the plot needed to have a general outline that would unfold depending on the choices players would make. Second, our plan to quite literally merge the players' avatars movement with their own movement through the real world meant that the genre of the game would need to fit to a modern city for the most part. Otherwise, so we feared, we would demand too much from the players' ability to suspend their disbelief, emphasizing the APPARENT FRAME too much and hindering IMMERSION (see also [Benford et al., 2006]).

Character role-play would be limited as well.

The second point also meant that, unlike in pen & paper role-playing games, players would basically have to "play themselves". A plot set in a modern city that also adapts to players' movement, potentially even if it's not even related to the game alone or at all (for example on their way to work) would not provide a means to fully immerse in role-playing any sort of character. Although this is a diversion from traditional forms of role-play (where it is often a major aspect to display a character or respectively a personality different from one's own) we believe the experience is still comparable. "Pretending" to actually be in a fictional situation and act accordingly is the same, whether taking into account how a fictional character would act or simply acting on one's own, normal decision process.

We decided on a mystic, slightly scary genre with a strong connection to the city and its real history.

A fantasy or far-future science fiction narrative would not meet these demands, especially the second. This meant we had to construct a plot playing more or less in the present city of Aachen, but it would not prohibit any fictional or supernatural aspects at all. Having this option would allow us to construct believable excuses around some technical difficulties later (see below), so in the end we decided to

choose a horror or mystery themed genre for the game. We wanted a feeling comparable to serious, but slightly dark stories, like for example found in TV shows like "X Files" or the short stories of H. P. Lovecraft. A classic pen & paper role-playing in that genre is "Call of Cthulhu" a system based on the short story by H. P. Lovecraft of the same name. There is also a similar board game with this setting called "Arkham Horror" (Arkham is a fictional city in Lovecraft's stories), which is where `Aachen Horror` got the Inspiration for its name.

We hired a professional writer for the plot.

Although we had run several role-playing sessions in the past, some also with self-written scenarios, we decided to opt for a professional writer familiar in that field, especially since we did not just want a convincing narrative, but also a proper inclusion of real historic events if possible. After contacting several candidates with the help of game publisher Pegasus Spiele[7] Carsten Schmitt accepted to work with us. The plot of `Aachen Horror` was thus written by him; he also did the necessary research for fitting historical aspects hinted at in the game. Progress on this was done iteratively, thankfully Mr. Schmitt was willing to revise ideas constantly with us, so he would not include things that resulted in mechanics we wouldn't be able to properly implement in accordance with our patterns and intentions.

Once we arrived at the point of needing proper multimedia files in the game, we hired more professionals for that, too.

Interface development in the traditional sense happened relatively late; we focused on what players would have to do around the city. Instead, we simply decided, in consultation with Mr. Schmitt, what the interface would be needed to do, not yet deciding on how any graphical representation would look like. Eventually, of course, we needed a real interface, so we outsourced the necessary design to Peîra[8]. They were also tasked with creating the actual audio for the game, including atmospheric background sounds as well as the dialog for our non-player characters (see below).

Interaction with characters.

Since we aimed for a high IMMERSION we wanted to make the game as realistic as possible. This didn't just mean that the supernatural aspects in our narrative had to be believable and consistent in themselves, but we also wanted

[7] http://www.pegasus.de
[8] http://www.peira-kollektiv.de

to avoid common problems computer games involving a complex narrative often suffer from: Interaction with non-player characters. As explained above this is a tricky part and in terms of the experience for the players often the biggest difference between a computer role-playing game and a pen & paper role-playing game. Designing a game on a mobile device, i.e. a computer, we of course could not overcome that restriction. Any interaction would be limited to players "talking" to the characters by simply providing pre-selected options. To make this believable, we constructed the narrative in a way that gave an explanation for this limit. As will be described below, all non-player characters would be "ghosts" trapped in a kind of "parallel dimension". Players were given a device, called "ARIADNE" (really iPhones) that allowed them to perceive this "parallel dimension" and hear the ghosts. However, we told players that since the devices weren't originally expected to be used in that way, "receiving" was a lot better suited than "sending", i.e. although they would be able to listen to what the ghosts told them, they could only send back very rudimentary signals. Effectively, they could only produce simple tones for the ghosts to hear. Most non-player characters would then understand it and offer a simple convention for answering them, like "Please beep once if you agree".

The plot of `Aachen Horror`

We needed to prevent players from finding out the plot beforehand.

The plot of `Aachen Horror` is principally comparable to a crime story, albeit one with supernatural and mystic aspects. This meant that its appeal relied greatly on surprise and secrecy. As one mechanic in the game would be that players had to research information using every day means like search engines (see below) it was vital to not spoil the plot by making it accessible to people online. For this work that means we can't point to an available version of the script for reference (and it would be too large for the appendix, too). Instead, we will provide a detailed overview of the various tasks players had to solve to win `Aachen Horror` and hope this thesis won't spoil the fun for eventual future players.

Special formatting for the following sections

To make it easier for the reader to differentiate between the various locations, characters, and events we will format their names in the following specific way. Character names

(or short descriptions) will be in sans serif font, real world *locations* will be slanted in addition, and **event** names that we used as references in our script will be in sans serif, bold font.

The true core of our background story

As is typical for role-playing games, the story in `Aachen Horror` contains a number of events that took place before the point at which the players get involved in the game. In our case this ties into real historical events revolving around Charlemagne, the Carolingians, and their predecessors, the Merovingians. The true historic facts are that the royal line of the Merovingians ended when their majordomo servants (holding the offices of "mayor of the palace"), the Carolingians, de facto already leading the Franks, fully took over the kingdom in the 8th century. The last Merovingian king and his son were placed in a monastery. It's important for our story to note that the Merovingians claimed to be descendants of an old sea god or monster.

Our "believable" fabrication of additional events after the end of the Merovingians.

Even today there are open questions about these historic events, which allowed us to make up a believable story involving the last Merovingian (believable in so far as a story with supernatural concepts can be believable in the first place). In the world of our game it continues like this: The last Merovingian's son, Theoderich, had a child which was raised in secret by a monk from the monastery. This child became a student under Alcuin of York, the actual historic figure, leader scholar and teacher at the Carolingian court. Unfortunately Theoderich's son learned of his past and studied ancient lore to transform himself into a monster, something possible due to his (in our game world actually true) monstrous heritage. Eventually he took on the name Merowech and succeeded with the ritual, in spite of Alcuin trying to intervene. Alcuin then performed another ritual to banish the so-called Quinotaurus into a "parallel dimension".

The parallel dimension "labyrinth"

We call this supernatural world "labyrinth", simply because it holds the Quinotaurus prisoner similar to the Greek mythology of the Minotaur on Crete. Of course when we say it's a "parallel dimension" we mean it in the common, non-scientific way that is often found in fiction. The

labyrinth is a dark place where not only the last Merovingian is trapped, but also other "lost souls" who got caught accidentally in it and are doomed to stay in this purgatory. Some of them have gotten used to it and almost enjoy living in it while others suffer and have almost gone insane. Additionally there are immaterial beasts roaming this world which we call the Hounds. For 1300 years the Quinotaurus has tried to escape and slowly the barrier between his prison and the real world crumbles.

Prof. Dr. Theo Seuß and the events immediately before the players enter the stage

The first (fictional) person in modern times finding out about the labyrinth is Prof. Dr. Theo Seuß, a professor for communications engineering at RWTH. More as a hobby, he built the ARIADNE devices, originally to disprove the existence of "Tesla waves". Surprised, he found out that he could detect signals from an invisible plane and even from sentient beings living in it. Afraid to be called insane he didn't immediately report his findings and instead sent several backup ARIADNE devices to random students for the case that something happened to him (an admittedly clichéd but common plot device). Of course he then vanished and the students, our players got their devices with an explaining letter (which is actually a physical printout they get), suggesting them to try out the ARIADNE at the *market place* in Aachen.

First steps and meeting the Hounds

At this point the actual gameplay starts, players are now supposed to investigate the supernatural events surrounding the disappearance of Prof. Seuß, the labyrinth, and the Quinotaurus/Merovech. If they follow the advice in the letter they will be able to find Prof. Seuß trapped and panicked in the labyrinth, waiting for them at the *market place*. To talk to him they will need to fend off the Hounds (for the actual game mechanics see the section below). This will be a common thing throughout the game, so it is vital for the players to get used to doing it. From the professor they learn that he was somehow trapped in the labyrinth by a monster (the Quinotaurus, of course) and that he needs their help to get out again and stop the monster from escaping. He also gives them hints where to look next, which basically also serves to introduce a typical pattern of the game.

The Guilty Hero and the Nameless

These following steps concern two locations not far from

the *market place*, one at the *Ehrenmal* and one at a nearby former *bunker* from World War II. The players meet two ghosts there, a soldier at the *Ehrenmal* who killed a teenager under martial law and his victim at the *bunker*. The soldier, we called him the Guilty Hero in the script, is guilt ridden and asks the players to ask the initially nameless teenager for forgiveness. Both ghosts are bound to their respective location and can't move within the labyrinth. By mediating between the two the players help them to gain at least some degree of redemption and peace. As a reward, they get a hint for where to go next and a method to calm down the Hounds later in the game. How exactly players can decipher this hint is described under game mechanics below. Woven into the dialog of the Guilty Hero are several other allusions to the game's plot which the players may or may not understand; perhaps even just after they progress far enough and think back. The setup between the Guilty Hero and the Nameless is based on true historical facts: Two teenage boys were shot by the Wehrmacht at the end of World War II near the *bunker*, a plaque there commemorates this tragedy. We did not use the real boys' names out of respect, intending instead to raise awareness of this dark historic fact in the players (see also the annotation for CHANGE PERCEPTION OF REAL WORLD PHENOMENA in chapter 5.1 — "The Pattern Language").

Mandatory & optional events

Because of this mechanism of hints and subtle mentioning it is difficult to define an exact path that players will follow. So to give an overview of the plot we will instead point out the major tasks they have to solve to win the game. Some of these stations must be found and visited, although not necessarily in a certain order. Others were optional, not strictly necessary to finish the game, but providing additional information and opening up different or even better ways to solve the mystery.

The overall task consisted of three objectives.

At the *Alkuin-Realschule* the players find an echo of Alcuin, presenting them with a letter that is read to them. This explains the background to them and leads them to the *Katschhof* in Aachen where they will learn what to do to keep the Quinotaurus trapped in the labyrinth. To succeed with this, three major objectives needed to be achieved:

1. Find a suitable location for the ritual. This would be the *Langer Turm* and to figure this out the players needed to visit the *Marschiertor*.

2. Learn the melody to be played during the ritual. This would be taught by a lost soul at the location where Alcuin himself performed the first ritual, on the *Lousberg*.

3. Find a soul as a necessary ingredient of the ritual. This soul would basically be bound to the new labyrinth (see also below).

Naturally the various hints to these locations were hidden in the dialog again and players have free control over where to go first. If they, for example, do not completely understand a hint, but assume it has to do with the *Langer Turm* and the *Lousberg*, then blindly decide to go to the *Langer Turm* first, they will find themselves unable to do anything there. They have to learn the melody on the *Lousberg* first. With all requirements met, players can visit the *Langer Turm* and perform the ritual, winning the game. The tower is actually a student dorm and since the players have to enter the building to perform the ritual, they have to contact its residents to arrange access. The dorm has a room that can be rented for festivities and the students living in the tower were informed by us beforehand to avoid any confusion, see also the game mechanics below. A special aspect of the three requirements is the last one, the soul. In a potentially unexpected revelation it turns out that Prof. Seuß is actually already dead, although he is unaware of this himself. If the players figure this out in one of the optional tasks (see below), he also learns about his fate and willingly participates in the ritual to get revenge on his murderer, the Quinotaurus. If the players do not figure this out, they still need to include his soul in the ritual (he basically is "sucked in" by accident), enabling them to win, but leaving a maybe bitter aftertaste behind.

Side tasks and optional hints

As mentioned above, several experiences are optional for the players to find. Their main purpose is to enhance the atmosphere and increase IMMERSION, giving the narrative more depth. However, they can have impact on the main

storyline, i.e. the outcome of the game. Most notably players can learn that their original motivation to rescue Prof. Seuß is impossible to achieve. To do that, they need to investigate the main train station in Aachen, where they then find a sort of "echo" of Prof. Seuß's death. This is admittedly hard to find, as nothing in the game actually requires the players to go there, but there are several hints implying that the professor is already dead. In his first dialog with the players he tells them that *on his way to the train station* he received a strong signal with his ARIADNE device. Several other characters also hint at him being dead, including the Guilty Hero. The following meetings were optional, but either hinted at what was going on or the background of the game. We gave each event a name in the script to be easily identified, but of course these names were never told to the players.

- **The train station**: See above. Once the players witness the professor's death he approaches them and automatically remembers.
- **Merowech's mother**: Players can randomly meet the mother of the Quinotaurus, who roams the labyrinth, grieving over her son's and her dynasty's demise. This doesn't help directly and serves to emphasize the tragic aspects of the story.
- **Allow me, name's Whisperer**: One lost soul is simply called the Whisperer. He is a mocking trickster, actually enjoying his life in the labyrinth. In his first appearance (happening only after the players have already solved the problem of the Guilty Hero and his nameless victim and not done anything else for eight hours) he hints at Prof. Seuß being dead and at the *Alkuin-Realschule*.
- **Oh, show me the girls**: Only accessible after the players met the Whisperer, this event takes place near the *Antoniusstraße* (a formerly famous red light district in Aachen). The Whisperer suggests a bargain: If the players lure away The Pimp and the Hounds long enough for him to visit "his girl" (dubbed The Whore), he'll give them a hint. Should they choose to do so and succeed, he gives them a phone number of all things. With this

they can actually call the *Langer Turm*, so basically it hints to the importance of the location.

- **Stone of the Goddess**: Located on the *Lousberg* near the place where the players learn the melody used in the final ritual, the stone is simply a location where they can recharge their ARIADNE devices (see game mechanics below).

- **Belvedere**: Located on the *Lousberg* as well, this interesting looking building (a former water tower, now a café) is a red herring, i.e. in the game's context a place that looks relevant, but actually isn't. Players have nothing to gain here and will instead simply be attacked by an ongoing pack of Hounds.

- **So I'm dead?**: This isn't a location, but a scene that's automatically triggered after the players found out that Prof. Seuß died at the train station (see above).

- **Update from Theo**: Like the previous event, this is not triggered by going to a specific location, but by the game's other events. If the players have not found out about Prof. Seuß's fate but are close to the game's finale (i.e. they met the first two main objectives, location and melody) it occurs on its own (once the players turn their devices on). Prof. Seuß urges the players on, telling them the labyrinth might crumble soon and he teaches them the method to call him to them. From then on, players will be able to do so during the finale (which is actually the only point in the game when Prof. Seuß can help them).

- **Filler dialog for Theo**: Again, this is not location- but event-triggered. If the players call Prof. Seuß (after they have learned to do so) somewhere else than in the *Langer Turm* (during the finale) he informs them that he can't help them at this moment. To avoid too much repetition we included several fitting audio files from which one is selected randomly. Unfortunately, this is pretty close to the way other computer role-playing games treat these circumstances and tends to be immediately recognized by the players as meaning "this is a dead end in the plot", but we couldn't avoid it in this case.

- **Granusturm**: Like the stone of the goddess this is a location to recharge the ARIADNE devices.

The last location

The grand finale of `Aachen Horror` takes place at the *Langer Turm*, an old tower from the 14th century. As mentioned above, the tower serves as a student dormitory these days, i.e. several people live there as permanent residents. To finance necessary repairs of the building, they rent a large room for festivities on the ground floor. Thus, the players are supposed to use that room for their ritual. The tricky part about this is that we asked the tower residents to pretend not to know anything of the game to keep it realistic. Otherwise the players would have immediately figured out that the location was important to the game, even if they hadn't yet arrived at the point where they can perform the ritual. Obviously we arranged payment for the room beforehand; we simply asked the residents to tell the players that for their case they wouldn't be charged (the ritual would not take as long as the usual events the room is used for).

The actual finale and possible outcomes

Once the players had secured access to the tower, they could perform the ritual to rebuild the labyrinth and win the game. This takes place in the evening and at least four players needed to be present. The ritual consists of drawing a symbol on the ground (which we did not test for and assumed players would simply do), standing around it and then using the ARIADNE devices to play the melody learned on the *Lousberg*. During the process the Quinotaurus and the Hounds show up and try to stop the players. They do so by interrupting the person currently playing the melody, but since all players are protected by the symbol (and inadvertently form a EPHEMERAL MAGIC CIRCLE) this is all they can do. A different player then has to take over playing the melody to continue the ritual. Should the players be too slow with that too often, the ritual will fail and they lose the game. Otherwise, the ritual will succeed after a while and they will win. The players also need to call Prof. Seuß before or during the ritual, he encourages them and warns about imminent attacks from the Quinotaurus. In the end, the ritual and thus the entire game has three possible outcomes:

- **The sacrificial lamb**: This occurs if the players succeed with the ritual but did never figure out that Prof. Seuß is dead and beyond rescue from the labyrinth. They save the world from the Quinotaurus, but have to live with the fact they doomed the poor professor to stay in the purgatory and guard the monster, his murderer. His last words accuse the players and he swears revenge on them.
- **Theo the hero**: If the players succeed with the ritual and Prof. Seuß knows that he is dead, his stance on the issue is completely different. Effectively the outcome is the same for the players, but his last words are ones of praise. He shows understanding that the players could not rescue him and is glad he was at least able to help keep the Quinotaurus imprisoned, at least until someone else will have to take his place in the, hopefully, far future.
- **The failure**: In case they do not manage to successfully complete the ritual, the Quinotaurus will destroy the labyrinth and escape the very moment the players fail. They can hear how he destroys Prof. Seuß, then he shouts out how now the world will have to bow to him (this being the only time he actually speaks). The players lost the game.

Game mechanics

Limited testing due to funding problems

Naturally, the details of the plot evolved over the entire time the project was conducted. For example, letting Prof. Seuß die was not part of the story from the beginning. The same is true for the mechanics, since they would have to fit to the plot. We had to figure out what was possible to do and adapt plot ideas accordingly, but at the same time it was important to inform our author of potential game mechanics so he could use them as inspiration for story ideas. From that point of view we had several iterations over these technical aspects of the game, even before we implemented any prototypes in software. For example, the idea of the ARIADNE devices having a "charge" (see below) was slightly changed several times. A downside of this was that we could only start to test with real users relatively late into the project. While the individual scenes and

their relevant mechanics were implemented and tested by us to ensure technical functionality, finding a group of players willing and able to participate in such a long-term game was harder than we expected. Unfortunately, the funding of the project ran out before we were able to have a group of people play the game all at once, so our testing regarding the entire game, especially its atmosphere and general "feel", was severely limited. The following sections will describe the game mechanics as they are intended and implemented, but it is important to keep in mind that they were only tested on a more individual basis.

Not all game mechanics refer to the interface.

A big part of the gameplay consists of understanding hints to figure out what to do next. `Aachen Horror` basically has no distinguishable interface for the most part. The ARIADNE devices the players get are rooted in the game's narrative and do not have any "meta" controls, i.e. every control only serves a functionality (if at all, see below) in the game's own pseudo-reality. Since according to the plot Prof. Seuß built the devices to scan for the weird, alien signals, there's no "hint" or "help" button or any kind of on screen explanation. In fact, we designed the devices with an intentionally bad usability, because in the story, he simply built them as prototypes.

The ARIADNE user interface

Figure 6.3 shows what the ARIADNE user interface looks like. The style was deliberately different from a standard iOS application since they players were supposed to pretend that it is not really a smartphone, but a hand-built prototype device made by Prof. Seuß. The numbered elements marked with the overlay have the following functionality:

(1) On/Off-Switch: This does not turn the game (i.e. the application) on or off, but rather the (pretended) ARIADNE device. If it is in the "Off" position, no signals from the labyrinth can be heard, including the Hounds, lost souls, or background noise. However, this also means the devices won't lose the virtual "charge" that is needed to stay "connected" to the parallel dimension. If players enter a special region in the labyrinth in this state, an alarm noise is played and the indicator (4) blinks to denote they should turn the switch to "On".

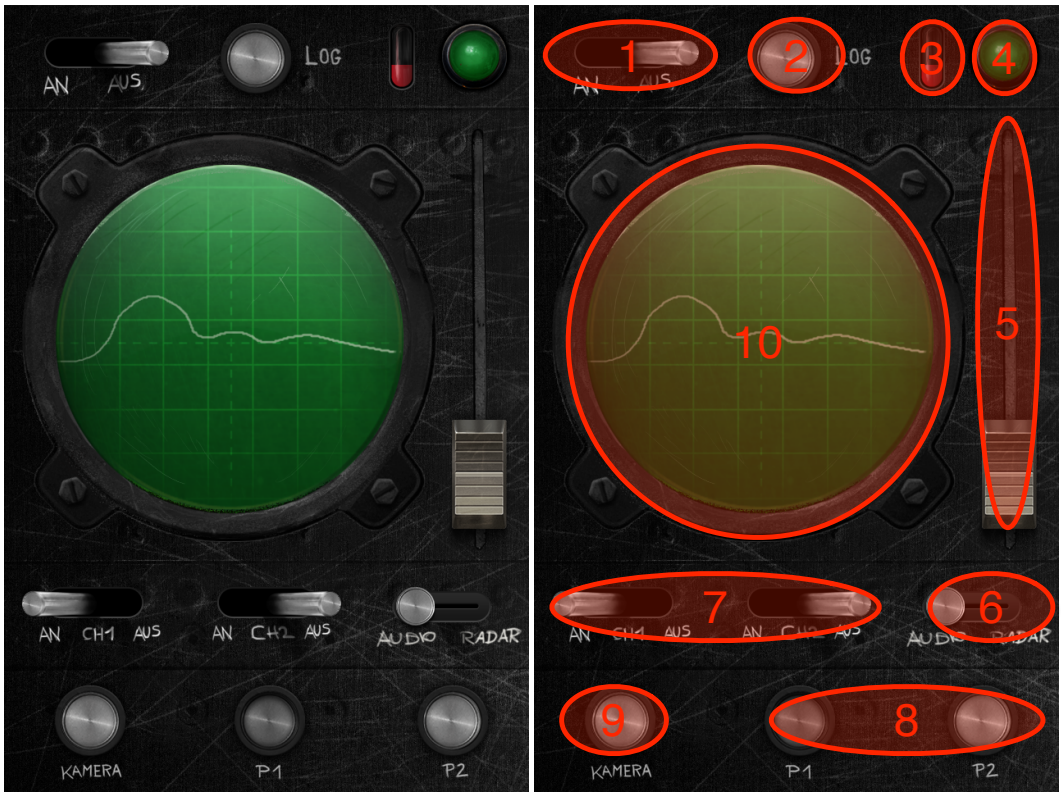

Figure 6.3: Left: a plain image of the ARIADNE UI; Right: the same image with an overlay identifying the controls, see the text for a full description.

(2) Log-Button: Originally we intended to provide the device with a (virtual) "printer", similar to an old-fashioned stock market ticker. This would technically have violated our "no meta UI" paradigm, but since most information to the players is given as transitive audio (dialog from lost souls) we thought it necessary to offer them a way to save it to re-read later in case they had trouble. Due to the funding for the project ending and limited time we didn't implement it in the end, but decided to leave the button in as a "dead end" (Prof. Seuß simply did not connect it to a meaningful feature).

(3) The "Charge"-Indicator: Once the ARIADNE is turned on and players can thus interact with the labyrinth, this gauge constantly goes down. Only at special places, for example the **Granusturm**, players would be able to "recharge" the ARIADNE. Attacking Hounds or even the

Quinotaurus would deplete this energy further and more quickly.

(4) The alarm signal: As explained above, this lights up (and an audio signal would be played as well) once players enter a game relevant region, even if the ADRIADNE is turned off.

(5) The "Tone-Modulator" slider: If the ARIADNE is turned on (1) and at least one channel is selected (7) this slider produces a tone "in the labyrinth". The higher the slider goes, the higher is the pitch of that tone (also audible for the players through their headphones of course). This is used to either lure away the Hounds or to send rudimentary signals to lost souls in the labyrinth (as mentioned above this provides a reason for the limited communication within the game's reality).

(6) Oscilloscope mode switch: This switch changes between displaying a map on the oscilloscope screen (10) or the regular oscilloscope view that visualizes sounds from the labyrinth (including the tone produced by (5)).

(7) The channel selectors: These switches basically enable (5) to work. If both are off, the slider does nothing, if at least one is on, it produces a varying pitch tone. The base pitch is defined by the channel and there are three modes: only channel 1 on, only channel 2 on or both channels on.

(8) Preset buttons: These two buttons were originally planned to act as "recorder buttons". Players would be able to press and hold them while the device was turned on and was receiving a signal (for example a tone modulation produced with the slider) and then later replay the same signal with a simple press. This turned out to be too complex so we compromised that important sounds (like the melody used in the final ritual) would be automatically recorded and playable.

(9) The camera button: This toggle button (intentionally not in the form of a switch to illustrate the prototype character of the device) would switch the oscilloscope screen (10) to a view of the iPhone's camera. We originally had the idea to use that to check for the cor-

rect symbol drawn by the players during the final ritual, but then decided against it (following one of the design guidelines we had already established with the `GroupAixplorer`).

(10) The oscilloscope: Depending on the switches (6) and (9) this would show either a map, the camera's view, or an actual oscilloscope connected to the audio played by the device (be it a tone produced with the slider, a lost soul, or regular background noise).

The players' perception when using ARIADNE

Besides this visible interface and the controls, the ARIADNE rely heavily on audio. According to the plot, they transform signals from the labyrinth into sounds, so naturally a big part of the interface and thus the application design is centered around audio. Once the device is turned on with (1), players will always at least hear a "background noise" from the labyrinth. There are two sets of audio for this, both conveying a mystic, dark, and slightly threatening atmosphere. The first is used in the city and mimics a subterranean dungeon with water droplets and echoes reflected from the walls of long hallways. Over that sighing and mourning can be heard, but there are no distinguishable voices and everything is slightly distorted. From time to time, the Quinotaurus can be heard striding and grumbling threateningly through the labyrinth's distance. The other set is suited for a more rural environment like the *Lousberg* (with fewer buildings and trees instead). Sounds like eerily blowing winds and rustling vegetation replace the dungeon-like audio and the occasional crow or unknown animal can be heard in an ominous way. Specific scenes have their own audio, of course, but sometimes the background sounds are still audible. Sounds produced by the players with the slider (5) are also mixed directly into the audio-scene.

General usage to communicate with characters

Basically, all interaction except switching the ARIADNE on and off is done with the slider (5). Players typically use a single, short "beep" (i.e. turning any channel combination on and then moving the slider up and down again) to signal a lost soul within the labyrinth. In all cases this is treated as a "keep going" signal by the ghosts, so a given scene continues (typically the character will then explain what is

going on). If the players want to provide negative feedback (i.e. they do not wish to deal with the character), they can simply ignore him or her.

Fighting the Hounds

Besides this, the main interaction is fighting the Hounds. In many cases, these ghost-animals try to keep players from interacting with a lost soul, for example in the first scene with Prof. Seuß, they attack the players and him (though it is unspecified whether they can actually hurt him, he doesn't intend to stay next to them to find out). If the players stay near the Hounds for too long, their ARIADNE charge is quickly depleted, preventing them from doing anything in the labyrinth. However, there is a tactic (explained by Prof. Seuß in the first scene) to counter that. The Hounds apparently seem to react especially violently towards a high pitched noise, which is exactly what the players can produce with their ARIADNE (by selecting any channel and keeping the slider up constantly). A player doing that will be the preferred target of the Hounds, so she can lure them away from the rest of the group. Technically, of course, the Hounds don't really have a location, they're simply represented by distorted, loud, and angry barfing of dogs on the devices. The volume depends on a complex points system and can be decreased by walking (giving the illusion of walking *away* from the Hounds). Producing a high pitch, on the other hand increases the number of points (as does any labyrinth interaction, even just switching the ARIADNE on as long as there is no "preferred target" player; the slider just gives a lot more points), so the volume increases, i.e. the Hounds stay close. In the end, one player usually has to lure away the beasts so that the rest can interact with the lost soul of the scene. This forces players to collaborate as a team, since the luring player will later have to be informed about what was learned from the character in question and what needs to be done next.

Deciphering hints without ARIADNE

As mentioned above, this information about where to go next after a specific scene is usually only hinted at by the various characters. These hints in the game are non-obvious, players need to research to understand them. For example, the Guilty Hero tells them that it was the scholar of Charlemagne who imprisoned "him" (i.e. the Quinotaurus) in the labyrinth and that they should investigate the "lo-

cations where [that scholar] is still remembered". This is a hint to the *Alkuin-Realschule* (an actual school in Aachen's Alkuinstraße), but the players have to decipher that on their own; i.e. to find out who the scholar of Charlemagne is they have to rely on sources outside the game (e.g. online). Such a concept is not common in games, so before the game started, we told players to always act "realistic" when finding hints. Of course, we couldn't give away too much information, so this instruction had to stay vague, but the few tests we were able to conduct showed that the idea worked. Players were able to figure out they could use search engines and the like to translate the given hints and get the name of the new location. The example above and the hint leading to the *Katschhof* worked just fine. The finale at the *Langer Turm* is probably a bit more problematic, since, as described above, it involves not just obtaining information from outside the game, but actual interaction with bystanders (as said the residents of the tower were asked to pretend not to know about the game). Several scenarios are possible:

- Players might suspect the residents know something and thus try to coax more information from them.
- Players might simply tell the residents that they needed the party room for a game and explain the entire issue, assuming the people living in the tower know nothing about it.
- Players might even try to stay completely "in game" and not tell the residents anything, renting the room without further commenting on it.

How players would approach this is one of the open questions of `Aachen Horror`.

Influenced work

Early, rough ideas inspired other projects.

Since `Aachen Horror` was the longest running project, basically existing parallel to all others, it had a significant influence on them all. However, during the beginning it was not as well defined, neither plot nor concrete game mechanics were decided in detail. This was ac-

tually advantageous for our other games like, for example, the GroupAixplorer, because concepts we didn't include in Aachen Horror in the end could be adapted to those games in a different form. The quests in the GroupAixplorer are an example for this. They were a lot more educational and relied on very different game mechanics than their equivalent in Aachen Horror would become, but the idea was "sparked" by the latter.

Patterns were strongly influenced by Aachen Horror and vice versa.

The most notable influence, however, would be the relevance for the pattern language by [Will, 2013], because the growing complexity of our plans for Aachen Horror was a big part of the motivation for the language. We wanted to catch our experiences and collect the knowledge about location-based games in a more formal way. As with most of the other games we designed, this lead to a two-sided relationship: The patterns, in a way, influenced Aachen Horror just as the game itself influenced the patterns. Of course, since it was far from done at that point, Mr. Will collected other games in the various patterns' Inspiration sections backing up the described concepts. Pinning down specific patterns would result in the following list:

- LOCATION AS CONTENT*
- LOCATION GRANULARITY
- REACHABLE LOCATIONS
- OTHER CONTEXT OF PLAYER
- DESIGN FOR COINCIDENCE
- LANDMARKS*
- CHANGE PERCEPTION OF REAL WORLD PHENOMENA
- EXPLORATION CENTRAL TO GAME
- ETHICAL AND LEGAL PROBLEMS*
- MINIMIZE SOCIAL AWKWARDNESS*
- EPHEMERAL MAGIC CIRCLE
- COPING WITH UNCERTAINTY

- APPARENT FRAME
- IMMERSION
- AUGMENTED REALITY
- CO-LOCATED MULTIPLAYER*

Patterns marked with a * were not explicitly mentioned in their Annotation sections, but their relevance should be clear in the context of Aachen Horror.

Other projects were motivated by Aachen Horror.

As can be seen in the patterns, Aachen Horror played a significant role in our entire research about location-based games. Thus, the various other games we made can be seen as "spin-offs", in a way. Often, we wanted to test out concepts for Aachen Horror in them, since the larger project was not ready yet or simply too big to easily adapt it for new concepts. For example, every location-based game we initiated so far was designed as a CO-LOCATED MULTIPLAYER game, since we wanted to collect as much experience with this type as possible. While single player games can also be location-based, having more than one player didn't just seem more interesting, it was also important for Aachen Horror to familiarize ourselves with as many different ways to do that as we could.

General lessons we learned

Of course the game also resulted in more general findings that are not connected to the other projects directly. For example, we saw that the result we deducted from the GroupAixplorer about the importance of player-player interaction being more important than player-device interaction verified in Aachen Horror as well. Many times we backtracked with interaction concepts, remembering that almost all scenes already had several players involved who would discuss with each other and interact in the context of the game's narrative. Also, players' ability and willingness to go beyond the content provided by the game alone when deciphering hints is a valuable lesson for game designers. This is especially important to consider during design if a game is already utilizing a smartphone (i.e. gives access to the "regular Internet"). Unfortunately we were not able to properly use our geo-sociograms on a scale covering the entire Aachen Horror due to our limited test-

ing (see above). So far it seemed players were a lot less willing to approach scenes (for example the ones involving the Guilty Hero and the Nameless) while being split up in subgroups, but we only have our own, informal observations for that. This hesitation might be due to the long-term aspect of the game and the relative high effort needed to go to places. Players might deem a scene "too important" to miss out on it. On the one hand this is a good thing, since it hints at a big interest in the game's narrative and, potentially, its atmosphere, on the other hand that means it can't be played casually alongside a regular day as we intended. The overhead planning for meeting up, which we initially wanted to lessen by using a mobile device and its location-based technology, would then still be part of the game.

Influencing work

`Aachen Horror` was source as well as result of other project's experiences.

As said in the previous section, the project spanned all our other games, meaning that it is, again, hard to distinguish between what it was influenced by, and what it influenced itself. The biggest influence that *all* other games had on `Aachen Horror` was experience. As we explained before, we "tried out" ideas in smaller games that were then indirectly used in `Aachen Horror`. Good examples of that are the patterns MINIMIZE SOCIAL AWKWARDNESS and IMMERSION (or AUGMENTED REALITY). We wanted to create games that "suck in" the players and give them a fun experience, but don't make them feel awkward. At first, we believed this to mean designing interesting interactions on the device (see also chapter 6.2 — "GroupAixplorer"), but we quickly learned this can be uncomfortable when done in a public setting. In the end, `Aachen Horror` did not include much beyond audio as a means to create an immersive atmosphere, the interaction staying mainly with walking around (as is done when, for example, luring away the Hounds). The ARIADNE interface itself is, thus, pretty simple. A similar approach was tested in `mLoG` and `mLoG2`, where the on-device interface only consisted of standard controls that only fulfilled very minor tasks for the game mechanics. Most was achieved by the players movement (in all quests). To be honest, we were sometimes surprised that this was still perceived as a fun game concept by our various test players.

Chapter 7

Summary and future work

This work has presented several design tools and example projects for the field of location-based gaming. The approach we used is very hands-on and oriented for practical use, i.e. game designers will probably find the most benefit in it. Since location-based games are not a widely spread kind of entertainment (yet) compared to other computer games, the basis for definite and certain scientific theories is thin and it is hard to judge their relevance for any location-based games being developed in the future. Games in general are mostly meant to be played for enjoyment and are a form of entertainment, so which ones are the most "important" ones will always be a matter of society's "general taste", something that is hard to predict. Because of this we believe our work's focus on providing mostly practical guidelines for development is best suited at present. In the future, with a broader basis of existing location-based games that have not just been developed for research projects in the first place, a more thorough scientific analysis seems more adequate.

7.1 Summary and contributions

Obviously, that doesn't mean that this work doesn't also introduce new insights into location-based games from a more scientific perspective.

In chapter 1 — "Introduction" we highlighted how interconnectivity of digital devices and then their emerging ability to sense a user's location closes a loop in the history of games in general; in a way they return to having movement as a central physical element of play.

Chapter 2 — "Development Challenges" then discusses the topic from a developer's perspective. Our own experiences made us realize that this is especially important, since a lot of the common problems tend to get overlooked, even though they seem to be obvious in hindsight.

We proposed a strict definition for the terms "location-aware technology" and "location-based game" in chapter 3 — "Location-Based Games: Fundamentals", the latter being further dividable into location-based^{+} and location-based* games. This makes it easier to categorize these games and discuss them, especially since the we tried to stick close to the colloquial understanding of the term "game".

Chapter 4 — "Related work" lists all foreign contributions to the field of location-based games that were relevant for our thesis and the various game projects we conducted. In a way, many of the proposed concepts by other authors can be regarded as having been tested in our location-based games, hopefully extending their insights and verifying their work.

The next chapter, 5 — "Design Frameworks", presents the theoretical basis we built with and for our various prototype games. This constitutes the one part of our main contribution. The annotated and revised pattern language (first published in [Will, 2013]) offers a practical guide for location-based games and is a tool that can be either used to develop them, or analyze existing ones. Geo-sociograms

at the moment are more suited for such analysis and provide a means to easily research player movement behavior in location-based games. With them we were also able to extend the "Relevance of Place Dimension" proposed by [Reid, 2008]. Lastly, we introduced a practice oriented tool for the actual implementation process for location-based games (and by extension for any application involving location-aware technology).

Lastly, in chapter 6 — "Evaluation", we listed all the location-based games we advised during development over the course of this thesis. They basically served as case-studies and test grounds for our proposed design methods and patterns, while at the same time being a great inspiration to figure out and define new concepts for our design frameworks.

7.2 Future work

The aforementioned practical character of this work means that it leaves some open ends for more theoretical research. Especially the geo-sociograms warrant an expansion. So far we mainly used them as a visualization tool and roughly categorized our location-based games or their subtasks according to various patterns we saw in their geo-sociograms. It would be even more useful to have an automated, mathematically sound way to do so. Of course this would probably also mean that a lot more and different location-based games needed to be analyzed with geo-sociograms. So far we haven't yet proven that there is a causal link between certain geo-sociograms, i.e., certain movement patterns, and any kinds or categories of location-based game tasks (like the categories we propose). In fact it seems questionable whether such a causality can be shown. However, for practical reasons a statistical correlation would serve the same benefit in terms of enabling game designers to plan ahead in their location-based games, i.e., plan for specific movement behavior. This would require collecting a large amount of geo-sociograms over as many location-based games (categorized accordingly) as possible, something not feasible with the current number of real, non-prototypical

games that exist at the moment.

Developing the implementation tools, as described in chapter 5 — "Design Frameworks", is probably not that worthwhile for the research community, as it is likely that the increasing amount of applications using location-aware technology (not just games) will yield in the creation of fitting tools as part of the common, commercially available development environments in the long run anyways. It should be noted, however, that short term projects might still benefit from investing time and resources into this creation, to hone the design of these tools on the one hand and simply to avoid running into similar problems we sometimes faced.

Lastly, the pattern language itself is meant to be an evolving framework, so we hope that future researchers will contribute to it. Since its first publication we already adapted several of the patterns, as is visible in the Annotations sections. It should be noted that most of our own location-based games focus strongly on cooperative multiplayer mechanics (i.e., adapt CO-LOCATED MULTIPLAYER) and are of the location-based^{+} kind (mostly adapting LOCATION AS CONTENT). Because of this we see great potential extending the framework with regards to games diverting from this. Although we are confident that patterns such as POSITION AS INPUT cover location-based* games quite well, there might be more patterns specific for those games. Also, some of the existing other patterns might be further altered to better include location-based* games.

Apart from follow-up research based on this work we believe it would be really worthwhile to further develop `Aachen Horror`. As explained before, the end of its funding and the complexity of running user tests put a stop to the project. However, we think its concept, plot and general value as an entertaining, rich game warrants further effort and development. It has the potential to become a successful game, maybe even with the potential to be commercially sustainable for the city of Aachen or some maintainer. A lot of our resources were already spent on it, and the base, including its multimedia content, is already there and it would be a shame to just leave it at that.

Appendix A

Aachen Horror Artwork

Since our largest location-based game `Aachen Horror` relies heavily on audio it turned out to be quite difficult to explain to people joining the development team or becoming otherwise involved with it. This was especially true for its atmosphere and "feeling". Simply playing the, actually often quite eerily sounding, audio wasn't an option in many cases, especially if we wanted to avoid spoiling the plot.

Because of this we had several graphic artworks made that were based on the plot. We used these in presentations, printouts and so on to convey the tone of `Aachen Horror` to people. Although these works of art do not bear any scientific importance for this work, we think it's adequate to present them here, so this appendix simply showcases the images.

Like the ARIADNE user interface graphics and the game's audio they were produced by Peîra[1].

[1] http://www.peira-kollektiv.de

Figure A.1: Alcuin of York in front of a window, contemplating what to do.

Figure A.2: An ancient book, perhaps describing an important aspect of the ritual.

Figure A.3: Another book, probably detailing what the "labyrinth" in and around Aachen is.

Figure A.4: The *Ehrenmal* in Aachen, drawn in a way that catches the atmosphere players hopefully feel when visiting it for the game.

Figure A.5: A creepy medieval hallway, perhaps the "labyrinth" looks like this for its denizens.

Figure A.6: The Hounds in `Aachen Horror`. The players will often have to lure them away.

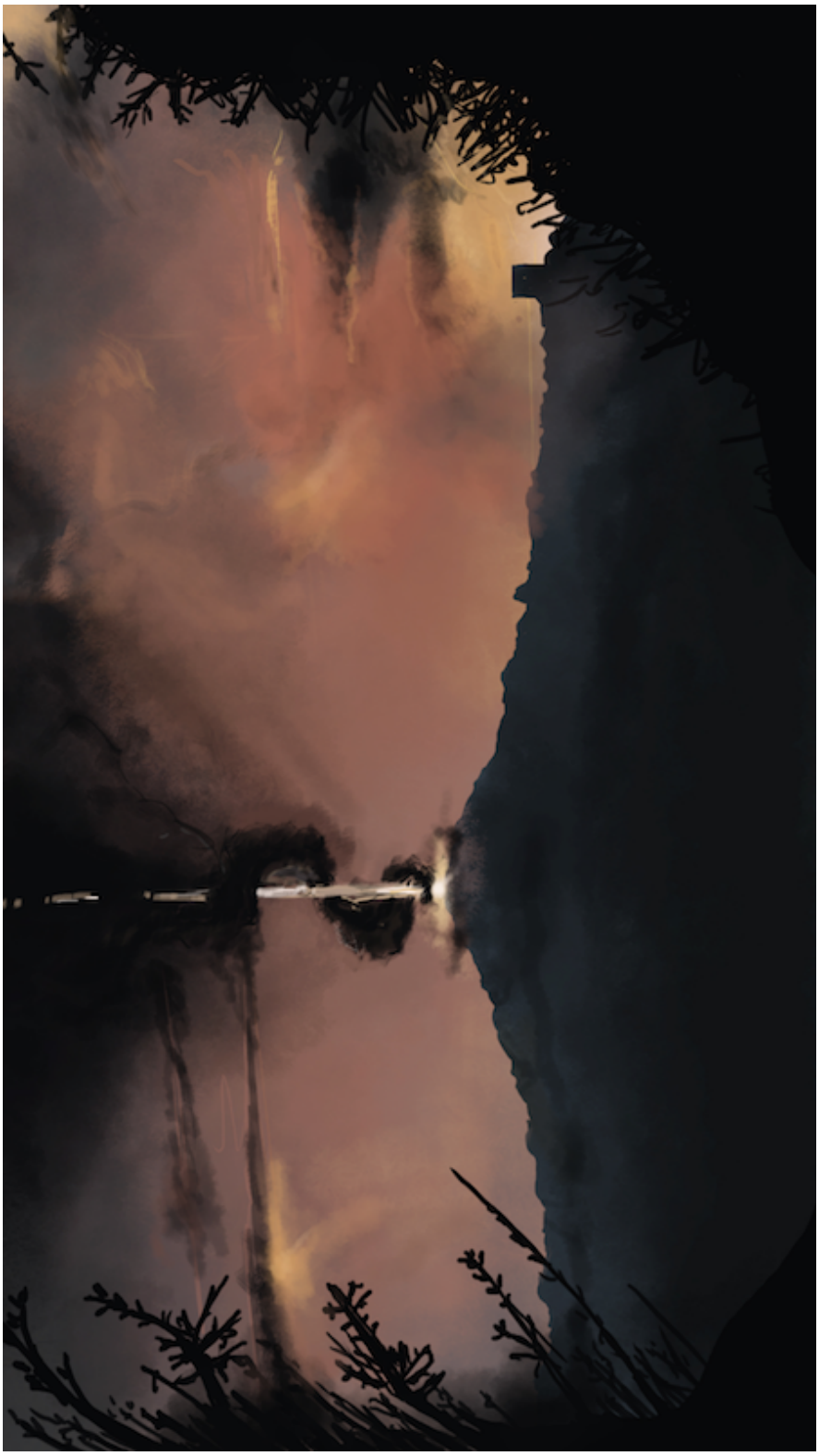

Figure A.7: The *Lousberg* in Aachen. The first ritual here might have looked like this.

Figure A.8: A closer look at the *Lousberg* and the ritual that took place here.

Figure A.9: The players' enemy, the Quinotaurus.

Figure A.10: Notes left behind by Prof. Seuß.

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