Master Thesis

Attacking Location Privacy: Exploring Human Strategies

at the

Institute for Geoinformatics
Westfälische Wilhelms-Universität Münster

by

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October 2, 2012

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Münster, den 2. Oktober 2012 Thore Fechner

No one shall be subjected to arbitrary interference with his privacy, family, home or correspondence, nor to attacks upon his honour and reputation. Everyone has the right to the protection of the law against such interference or attacks.

Article 12
The Universal Declaration of Human Rights of the United Nations

Attacking Location Privacy: Exploring Human Strategies

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Abstract

The proliferation of location-based services in recent years has highlighted the need to consider location privacy. This has led to the development of methods enhancing location privacy, and to the investigation of reasons for sharing location information. While computational attacks on location privacy and their prevention have attracted a lot of research, attacks based on human strategies and tactics have generally been considered implicitly. This work addresses this knowledge gap by reporting on a user study which was conducted in the context of a location-based game. Participants had to identify other players over the course of several weeks. The results show that human strategies for deanonymization and re-identification can be highly successful and thus pose a threat to location privacy comparable to computational attacks. By incorporating real-world knowledge that is not easily available in automated attacks, human players were able to efficiently re-identify other people in the game.

Keywords: re-identification, deanonymization, location privacy.

1. Introduction

Location-based services (LBS) as a part of Ubiquitous Computing (ubicomp) have attracted a lot of attention from research, industry and the public in recent years. Applications or services such as navigation support, personalized search query results or micro blogging services incorporate the users' current location to enhance their usefulness. With the communication of location information to such services potential adversaries could establish profiles about daily routines and habits. The increasing tight integration of LBS in online social networks (OSNs) leads to even more privacy risks as private social information becomes accessible as well.

This trend towards ubicomp was already predicted by Weiser [1] in 1991. He also stated that privacy is one of the key aspects due to the intertwining nature of ubicomp and our social lives. Privacy definitions and discussion have been around for a long time. Well known is Warren and Brandeis [2] definition from 1890: "The right to be let alone." In 1967 Westin [3] describes privacy as the "claim of individuals, groups or institutions to determine for themselves when, how, and to what extent information about them is communicated to others." There are a lot more definitions of what privacy is and it is hard to settle upon just one definition since privacy needs evolve with our society or need to be adapted.

One of the more recent major privacy breaches demonstrates why. It affected over 77 million people all over the world as Sony's databases from its Online Entertainment PC games network and PlayStation network were hacked. Stolen data included credit or debit card numbers, names, birth dates and phone numbers amongst other information [4]. Most people would not feel comfortable if information about their home, phone numbers or financial status were public. While this incident is not directly ubicomp related it depicts the potential magnitude of such breaches. In a society where people have to register or authenticate their identity almost everywhere such breaches of confidentiality pose a threat; privacy is deemed a fundamental human right per Article 12 of the Universal Declaration of Human Rights of the United Nations [5].

A prominent example within Germany was the collection of 54.782 individual datasets consisting of name, address and birthdays of mobile owners as well as their movement trajectories. The collection of this data was conducted by the police and sanctioned by the court to help resolve crimes and identify persons of criminal organizations during an antifascism protest in Dresden in February 2011. The majority of the collected datasets was not related to people attending the protests but instead happened to live or work within the vicinity of the protest. Until now it is not planed to delete the data or movement trajectories of the non-related persons [6] although the Federal Data Protection Act of Germany formulates a principle of data avoidance and data economy in §3a [7].

Even if data is anonymized, pseudonymized, or only sparsely collected, research has shown that it is often possible to re-identify large quantities if only partial facts are known [8]. Collected location information needs even more careful handling.

As has been stated in the literature by Langheinrich [9], "location information is typically associated with a particular place, which in turn often implies an activity or a spe-

cific personal interest." Duckham and Kulik [10] even state that: "Our precise location information uniquely identifies us, more so than our names or even our genetic profile."

This unique nature of location information, together with the depicted incidents demonstrates the need to continue investigation on privacy in general and the role of location information in particular.

So far, research in location privacy has mainly focused on topics such as storing and processing sensitive data in a privacy preserving way, user preferences for location privacy, motivations for location sharing, and computational inference attacks [11]. Human attacks on location data are often considered implicitly – it is thus unclear what strategies and tactics people employ for successful re-identification or deanonymization. In order to understand the threat posed by human attacks and to develop effective countermeasures, further research is needed. In practice, location data is often directly exposed to the users of OSNs or location sharing applications (LSAs). While it is unlikely that the average user will employ sophisticated computational attacks, "naive" or manual attacks do not require thorough technical knowledge.

This thesis focuses on how humans deanonymize unobfuscated but selectively shared location data. For this purpose a location-based game mimicking common LSAs has been developed, encouraging location sharing, tasking players with with deanonymizing other players.

It was found that combining third party knowledge sources, common sense and people's ability to reason about spatial data can be a highly effective means of re-identification and deanonymization. Post-hoc semi-structured interviews were used to identify strategies employed by users while sharing their own locations and about their investigations on locations shared by other players. Players used three basic patterns for deanonymization depending on their social relation to the investigated player: categorization, data harvesting and exclusion. Besides, the sharing behavior was consistent among most of the players, who avoided sharing certain locations deeming them to be more revealing than others.

The remainder of this thesis is structured as follows: Section 2 discusses how this work relates to previous work in privacy research, ubiquitous computing and especially location privacy. Then the used approach is introduced, describing the developed game, its mechanics and incentives as well as giving a brief sketch of how it was implemented (Section 3). Playing this game was part of the conducted user study to find out how humans perform inference attacks on shared locations. The different phases of the study, how they were run and in which way the results were obtained are explained in Section 4. Section 5 reports on the findings of the study touching upon sharing behavior and strategies, with a detailed look upon the used re-identification strategies by the players. The novel gaming approach, study and results are discussed in Section 6, while the thesis concludes with a brief outlook on future work and a summary of key contributions (Section 7).

2. Related Work

In order to provide a clear overview over work already conducted and related to this thesis this section is organized into four sub-sections. The first one covers attacks on location privacy – algorithms and methods breaching location privacy by exploiting its geometrical nature computationally. Work discussed in sub-section 2.2 tries to prevent such breaches, mostly by using statistics. Studies and social aspects are subsumed in sub-section 2.3 focusing on reasons for sharing locations, user preferences for location sharing and the value of location information. The final sub-section covers research on gamification and crowd-sourcing, important factors for game design.

2.1. Attacks on Location Privacy

By incorporating location information obtained from a Global Navigation Satellite System (GNSS), the Global System for Mobile Communication (GSM) or Wireless-Local Area Networks through Fingerprinting (WLAN-Fingerprinting) modern smart-phones have a plethora of possibilities to enhance their services with location information [12]. While there are a lot more ways and systems available to retrieve location information in- and outdoors those are certainly the most popular technologies. Usually the user does not even know which techniques are used when e.g. the local weather forecast is requested, navigation assistance is given or a geo-tagged picture is uploaded to the web. As soon as communication with such a service is established location information is transmitted to a server infrastructure which might be compromised.

If the transmitted locations were to be recorded or are known due to other reasons, so-called inference attacks can be performed. Krumm [13] carried out such an attack upon 172 pseudonymed GPS-tracks from navigation systems of two weeks length. Simplistic algorithms and assumptions were used: The last destination of the day is a likely candidate to be the subjects home. Also a weighted median based upon dwelling times indicates a subject home location with the assumption that subject's spend most of their time there. Using reverse geocoding and a corresponding reverse white page lookup he identified 13% of the subjects home addresses correctly and 5% of their names.

In a similar experiment Hoh et al. [14] were able to create an algorithm able to find home locations in a subset of 239 GPS tracks of drivers. They identified 65 plausible homes in the traces by manual inspection (actual home locations were unknown due to privacy reasons) and applied a k-means clustering algorithm to identify frequently visited places. The algorithm was able to locate about 85% of the homes, albeit also returning a large number of false positives. Nonetheless the authors conclude that this technique can be effective for automated prefiltering, followed by manual inspection to remove false positives. Another study by Gruteser and Hoh [15] demonstrates that

datasets with no consistent pseudonyms are subject to inference attacks as well. This was shown with three day long GPS-tracks from university students and a multiple target tracking algorithm based upon a Kalman filter.

Not only GPS tracks are potential subjects to inference attacks. Golle and Partridge [16] used U.S. Census data to establish that the threat of re-identification is substantially greater if home and work locations are both known, even if the location information is intentionally degraded e.g. to Census blocks, tracts or county level.

The above mentioned techniques do not rely upon complex computations. They employ assumptions based upon common sense which anyone could make. Curiously no research seems to be available investigating upon human strategies for re-identification. Although the computational approaches are all inspired by them considering them implicitly. Humans are likely to perform successful inference attacks with similar or even better results but on a different scale in terms of data amount and time. Hoh et al. [14] even state that manual inspection is used to identify and remove false positives from their results.

A set of attributes uniquely identifying a record owner within a database, is called a quasi-identifier as defined by Dalenius [17]. Each attribute alone is not sufficient for a identification, but in combination they allow the linking to third party information to obtain the subject's identity. Using census data from 1990 Sweeney [18] demonstrated that zip code, date of birth and sex can be used to identify 87% of the U.S. population. Golle [19] revisited this study using census data from 2000 and was able to identify 63% of the U.S. population.

Bettini et al. [20] adapted the definition of quasi-identifiers for location privacy. According to them a Location-Based Quasi-Identifier (LBQID) is a "spatio-temporal pattern specified by a sequence of spatio-temporal constraints each one defining an area and time span, and by a recurrence formula." Meaning that a sequence of locations potentially used in combination with other information sources can identify a person. As demonstrated by the computational inference attacks above this is quite possible.

2.2. Methods & Techniques Protecting Location Privacy

Inference attacks on location privacy rely mostly upon exploiting the geometrical nature of the location. Methods protecting location information often use the concept of k-anonymity introduced by Sweeney [18] or obfuscate the information by degrading its quality, a technique introduced by Duckham and Kulik [21].

Obfuscation for location information can be achieved by adding gaussian noise, discretization of points onto a grid or dropping samples. Krumm [13] investigated how much obfuscation is needed to counter re-identification. He found that the degradation amount has to be quite high. Even when he added Gaussian Noise with a standard deviation of one kilometer he was able to identify some home locations in GPS tracks. Similar high values were found for discretization. If a continuous tracking system is used, the needed sampling frequencies should be considered carefully. Reducing samplings seems to have a direct effect on successful re-identification as well [14].

Sweeney [18] defined k-anonymity as achieved, if each released record has at least $(k-1)$ other records in the release whose values are indistinctive over those fields that appear in external data. This involves generalization of values or suppressing them entirely. Gruteser and Grunwald [22] adapted this concept for location privacy and it is sometimes referred to as "spatial cloaking". A reported location is k-anonym, if it is uncertain enough to be in a set of $k-1$ other locations. This is achieved by adapting the temporal and spatial resolution of location information, so that one location can be linked to multiple users.

Another method of protecting location privacy is to avoid the usage of long-term pseudonyms. Frequent pseudonym changes have been proposed by Beresford and Stajano [23] in a concept called "mix zone". Users of LBS receive unused new pseudonyms in "mix zones" where multiple users traverse but do not use a LBS (no location information is transmitted). Areas where LBS are used are called "application zones". With this approach pseudonyms cannot be distinguished by a potential attacker since users emerge from the mix zone and they could be anyone being in the mix zone at the same time.

While all methods mentioned here help to sustain location privacy they are not required by law. Simple pseudonymity is often sufficient [24, 7]. Most of the performed inference attacks used pseudonymized data. To ensure comparability of the results, this approach was used as well. Research in the area of protecting or attacking location privacy has been vivid in the last couple of years. For a more in-depth review Krumm [11] published a survey paper on the topic of computational location privacy.

2.3. Studies & Social Aspects on Location Privacy

Privacy is a controversially discussed topic with many different views, opinions and understandings. Scenarios where new technologies such as Radio Frequency Identification (RFID) are invading our privacy have been depicted and discussed [25], arguments like "I've got nothing to hide" have been examined [26] and the gap between privacy research, privacy law and legal scholars addressed [24]. Despite the continuing effort there is no concise understanding or definition everybody can agree upon.

Solove [see 27, Chapter 1] even called it "a concept in disarray." He states "there is no overarching conception of privacy. Instead it has to be mapped like terrain, by painstakingly studying the landscape."

Looking at conducted studies and social aspects on location privacy this statement seems to hold. Danezis et al. [28] found that university students from Cambridge would be willing to be tracked every few minutes 24 hours a day for 28 days for a median bit of 10£ to 20£ depending on

how often they travel. Students traveling a lot seemed to "value" their privacy more than those who did not. These bids seems to be fairly low but comparable results have been found by Cvrcek et al. [29] in a study with over 1200 people from five EU countries.

Additionally they found initial evidence that recent privacy scandals could have an considerable impact on the value of location privacy. Greek participants did not fit into the patterns of the other four countries and asked for substantially more money. Two months before the study was conducted an eavesdropping scandal involving the wiretapping of top Greek politicians has been covered by the press. Although the authors state that this result needs to be investigated more thoroughly with an additional study, it indicates that privacy perception is subject to change and hard to predict. Additionally there is a mismatch between people's privacy attitudes and actual behavior as reported by Tufekci [30]. This discrepancy has been coined as "privacy paradox" [31].

To be able to provide an appropriate setting for the study of this thesis one needs to understand why and under which circumstances people share or provide location information. Tang et al. [32] look upon reasons for location sharing and classify them into social- or purpose-driven, finding evidence that social-driven location sharing is done to attract attention and boost self-presentation. This is supported by a previous study conducted by Consolvo et al. [33] showing that people consider to whom and for what purpose before sharing location information. Public spaces with large and diverse sets of people traversing are more likely to be shared according to Toch et al. [34]. Another important factor is feedback about shared locations and who accessed it [35]. Those findings were taken into account while designing the game for this thesis.

Feedback and transparency are provided utilizing a news system which reported upon player activity enabling users to react and adapt their sharing or deanonymization activities. Elements from gamification have been used as incentives – e.g. a simple point system rewarding player activities. More detailed information about gamification research is given in the next sub-section.

2.4. Gamification & Crowd-sourcing

The incentive for participating in research studies is often monetary, be it directly paid or with some kind of prize competition. Most of the related work mentioned explicitly states how much was paid for the participation. Instead of following along those lines the approach of this thesis differs significantly.

Applications such as foldit[1] demonstrate that careful game design in conjunction with crowd-sourcing can be highly successful. Foldit players solved a long standing protein crystal structure problem through collaboration and competition. The only direct incentive of the game is a point system alongside a prominently displayed leaderboard on the homepage of top players. Khatib et al. [36] report on this and see a "huge potential in using the ingenuity of game players to solve a wide range of scientific problems."

Gamification is a term which became popular during 2010 through conferences like DICE (Design Innovate Communicate Entertain) or GDC (Game Developers Conference). Deterding et al. [37] give a first definition after reviewing the underlying ideas previously explored within Human Computer Interaction (HCI) literature such as playful design. According to them gamification or gamified applications "use game design elements in non-game contexts." This usually involves rewarding a player with points, levels, leaderboards and achievement badges [38, 39]. Nonetheless the term gamification is contested.

McGonigal [38] proposes the term "gameful" to differentiate from "playful" and Schell [40] pictures a "gamepocalypse". Both concepts envision that game elements will encompass real life by influencing decisions and interactions. But not only extrinsic rewards are utilized in their visions, intrinsic motivations are employed as well since they are known to be more engaging [41]. At the moment many "gamified" applications rely only upon extrinsic rewards and this has led to criticism from various sides. Bogost [42] even proposed to replace the term "gamification" with "exploitationware".

The combination of carefully designed games with extrinsic rewards and intrinsic motivation can work well with crowd-sourcing elements. Howe [43] stated that participants in crowd-sourcing projects "are not primarily motivated by money, and they're donating their leisure hours to the cause. That is, they're contributing their excess capacity, or 'spare cycles', to indulge in something they love to do."

Projects like foldit encompass all elements successfully. Extrinsic rewards are given with leaderboards and intrinsic motivation arises from the cause for science (purpose) and that people get better over time since the learning curve is not to steep (mastery). In addition, people form teams working together on a common goal, which is crowd-sourcing.

Drawing upon this knowledge the mechanics of the location-based game to be developed should include intrinsic motivation and extrinsic rewards to create a high engagement. Highly motivated and engaged players should allow for insights into how a determined attacker would try to re-identify shared locations. Commercially successful LSAs such as foursquare[2] utilize leaderboards and achievements since users only need to share locations. For those repetitive tasks without a high cognitive load extrinsic rewards work well [44].

[1] http://www.fold.it

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

3. Approach

In order to gain insights into human strategies for deanonymization a pervasive game was designed mimicking common LSAs. The reasons for this are twofold: First, the user experience and acceptance for sharing location information is already existing in this scenario. Foursquare claims to have surpassed 20 million users with over 2 billion "check-ins" in 2012 [45, see Foursquare About Page].

Second, the process of human re-identification of location information has yet to be investigated initially. High engagement is key for this to be able to acquire as many aspects as possible for later investigation. By designing a game around this process, participants of this study became players. Players engagement, motivation and investment into games are uniquely high [46]. Tuite et al. [47] reported that over 109,000 photos were collected in the course of six weeks in their game PhotoCity. The 45 players were motivated by the competitive nature and the purpose of creating 3D models out of photos in the game. Bell et al. [48] found similar high engagement with Eyespy, as well as von Ahn and Dabbish [49] with the ESP game.

Getting to the point, until a game "works" and participants evolve into players a lot of effort and resources are required. Designing the core mechanics, creating a theme, playtesting different iterations, overhauling incentive mechanisms, sharpening the user interface and promoting the game are just some aspects and countless ways exist where one can fail. But the return of investment is worth it. The results (see Section 5) show that engagement and motivation were a lot higher than expected – players spent an average of *ten hours* playing the game. Careful monitoring gave promising insights into how human re-identification works.

The game idea alongside its mechanics is presented in the following sub-section, while motivations for playing the game and its design are discussed in sub-section 3.2. A brief overview of the implementation without excessive technical details is given in the last sub-section (3.3) of this paragraph.

3.1. JohnDoe – A Pervasive Deanoymization Game

The goal in designing a game was to create an experience for the participants of the study similar to other LSAs. Naturally re-identifying location based information involves looking and interpreting maps. A process which might be experienced as cumbersome if done in a traditional paper-based fashion. Extending the concept of a pure gamified LSA such as foursquare to become a complete game with a re-identification part was promising since foursquare itself is already perceived as "fun"[50].

Thus a pervasive location-based game was designed, where the goal was to identify other players based on location information they share (see Fig. 1 for a screenshot). In essence, JohnDoe could be described as a "stalking game". Players try to find out as much as possible about their fellow players by looking at previously shared locations from

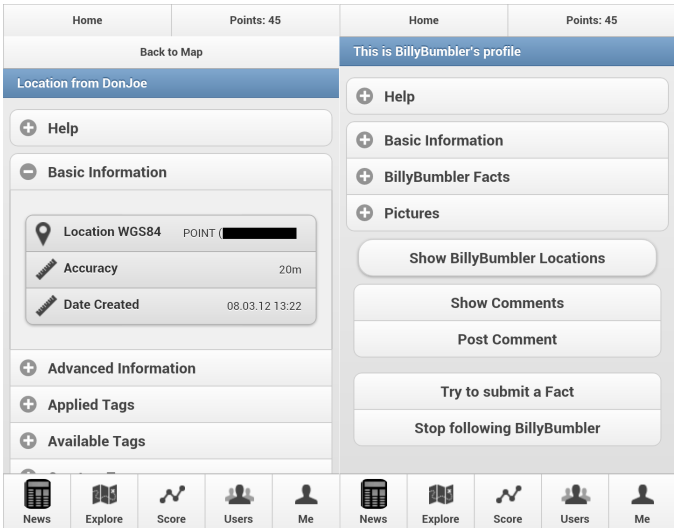

Figure 1: JohnDoe - a pervasive deanonymization game: Location User Interface and Player Profile User Interface.

other players and trying to infer details or routines about the person behind them – ultimately leading them to his or her identity. To give a hypothetical example:

A shared location late at night at a well-known pub on a weekday might suggest that a person can plan time individually without restrictions from a regular 9 to 5 job. If another location is shared at a university building on the next day it might not be far-fetched to assume that this player is a student. Further clues might be derived from shared locations at sport areas, cultural places or social gathering hubs for certain groups and much more. Re-occurring "check-ins" at places help to establish routines while movement trajectories allow for deeper investigations with information derived from OSNs or search engines.

In order to participate in the game players had to provide basic personal information during registration, e. g. first and last name, complete home address including country, date of birth, and gender (see Table 1). As Sweeney [8] demonstrated knowing only partial facts about a person is enough to re-identify them in a pseudonymized dataset. Optional facts in this study included workplace address, mobile number, facebook account and a photo. Players earned points by sharing their own location, completing their profile with optional facts and by correctly identifying different facets of other players' profiles.

Each shared location granted a fixed amount of points while points varied for correctly identified facts; e.g. the combination of zip code, gender and date of birth was worth almost six times as much as sharing one location. Other facts which could be figured out more easily like country were worth half those points. If players submitted facts and they did not match the records (ignoring case sensitivity) they lost twice as many points as earned by sharing a location. This simplistic approach encouraged sharing locations and was transparent to the players pre-

venting simple try and error guessing, since players could only submit facts if they had points.

Correctly identified facts were made public, thereby creating a crowd-sourced profile during the game. Players picked a pseudonym during a registration process, which was used as a common identifier for the shared locations of a player. Computational inference attacks on pseudonymized location data have been performed before by [23, 13, 14]. To ensure comparability of results, this approach was used as well.

Players could follow (or unfollow) certain players to receive updates on their activities, e. g. when they shared a new location via Twitter[3] or the internal news system. The interface for the exploration of locations was a basic map showing all shared locations of a player. Each location was annotated with a timestamp, the accuracy of the shared location and speed/ heading if applicable. Additionally, players could create tags for locations, or use tags of other players to label locations. The game was run for six weeks, during which three rounds of 14 days each were played.

After each turn players could re-register and pick a new pseudonym to start over, if they had been identified in the previous turn. The game logged every user action such as sharing locations, submitting facts or accessing a specific site and stored this with corresponding details such as time, player, used device, etc.

3.2. Design

Why people play games still eludes us. Since Bartle [51] initially categorized players into four different types – achievers, explorers, socialisers and killers – it has become clear that not everybody plays for the same reasons or in the same way. Yee [52] built upon this early taxonomy and created an empirically grounded model of player motivation in Massivley-Mulitplayer Online Role-Playing Games (MMORPGs). It revealed three overarching components – achievement, social, and immersion – with ten motivational subcomponents (see Table 2). Although this model was created based upon MMORPGs most of its aspects are valid for any game types.

The **Achievement** motivation subcomponents seemed most promising for JohnDoe since it builds and extends upon the ideas of available LSAs already creating motivation through badges, banners, titles or point systems (extrinsic rewards). In JohnDoe players could measure their *Advancement* through a leaderboard and progress by accumulating points through successfully revealing facts of other players or sharing locations consolidating or advancing their status.

JohnDoe's *Mechanics* are tailored in such a way that players would know how big their reward would be for a certain action. The amount of points rewarded for revealing facts (see Tab. 1) was known as well as the amount for sharing one location (10 points). Also all other rules like preventing to share locations every few meters, or multiple times in the same spot were transparent and communicated via help texts and a tutorial video on youtube[4]. This allowed for *Optimization* strategies and the analysis of sharing behaviors. Being able to learn how a game works and improve oneself is another strong motivational aspect and important for intrinsic motivation (mastery).

Table 1: Personal information players provided during the registration process for JohnDoe and points they received for uncovering one of those facts

Mandatory Facts	**Points for Uncovering**
First Name	30
Last Name	30
Birthday	10
Birth Month	10
Birth Year	15
Home Street	15
Home Street Number	15
Home Town	5
Home Town ZIP Code	15
Gender	5
Mobile Number	30
Country	5
Optional Facts	
Workplace Street	15
Workplace Street Number	15
Workplace Town	5
Workplace Town ZIP Code	15
Facebook Account	30
Photo	60

Competition is directly given through the leaderboard as well. Players wanted to be on top of it, and challenged other players through unusual sharing behaviors provoking them sometimes to guess facts and potentially lose points.

Social aspects like *Teamwork* are possible through the crowd-sourcing aspect of the game. Players could utilize a tagging system to label locations or communicate using a comment system to exchange information. Game related events such as new shared locations or previously unknown details about a player were disseminated through an internal news system, via Twitter and as Really Simple Syndication (RSS) -Feed. Hence, players were informed immediately and able to react quickly, further promoting competition.

Immersion was not on the list of top motivational elements for JohnDoe since it usually requires a rich story. Creating a quality story for JohnDoe was beyond the scope of this thesis. Nevertheless players could *Customize* their alter ego by picking a unique pseudonym and a picture to provide better identification for themselves and other players. Interestingly players did not *Role-Play* their alter

[3] `http://twitter.com`

[4] `http://www.youtube.com/watch?v=NqshRkl0S4c`

Table 2: Motivations for play in online games – from 3,000 online surveys of MMORPG players by Yee [52]

Achievement	**Social**	**Immersion**
Advancement	*Socializing*	*Discovery*
Progress, Power	Casual Chat, Helping Others,	Exploration, Lore,
Accumulation, Status	Making Friends	Finding Hidden Things
Mechanics	*Relationship*	*Role-Playing*
Numbers, Optimization,	Personal, Self-Disclosure,	Story Line, Character History,
Templating, Analysis	Find and Give Support	Roles, Fantasy
Competition	*Teamwork*	*Customization*
Challenging Others,	Collaboration, Groups,	Appearances, Accessories,
Provocation, Domination	Group Achievements	Style, Color Schemes
		Escapism
		Relax, Escape from Real Life,
		Avoid Real-Life Problems

ego and shared continuously locations for a fictive character although this was neither prohibited nor encouraged by the game. Some players did try to confuse players but only to a small extent; Section 6 discusses potential reasons.

Motivational aspects are not enough to engage players. According to Klug and Schell [53], two prominent professional game designers in the industry, players want to be able to control what happens in a game. Controlling a game means to be able to predict to a certain degree what happens next. Therefore the rules have to be known and everyone has to oblige them or the game must not allow deviations. Albeit total predictability is not wanted – a certain randomness is desired to give room for surprise, which is an important aspect of progression.

JohnDoe covers all this in a novel setup. The idea of a real-life "stalking" application or special kind of long term hide-and-seek game defines rough edges for players to operate in. The theme is derived naturally from the idea but is not forced upon players and may therefore differ. Some players described their experience using analogies from well now board games like "Scotland Yard" and found it exciting to be a "detective" and "agent" trying to stay hidden at the same time, planning their moves carefully in both roles. Others focused more on trying to re-identify players since they found this aspect most exiting. A few played the game for the purpose of helping scientific research or simply enjoyed sharing locations and earning points.

Motivations for playing a game depend on the player type and player types change and mix depending on the game which is played. Klug and Schell [53] offer a list (see Tab. 3) of nine player types used by professional game designers in the industry. JohnDoe was designed with most of them in mind and all types have been encountered during the study except "The Storyteller" or "The Craftsman" since JohnDoe did not feature a comprehensive storyline nor allowed to create new content. To ensure that the game is motivating it has been playtested early and often during its design and implementation phase. Those tests were conducted with small focus groups or individuals, collecting feedback, listening carefully and watching people interact with different iterations of JohnDoe.

The entire design and implementation process was heavily influenced and guided by the book "The Art of Game Design: A Book of Lenses" by Schell [54], a lot of talks with potential players, "hardcore-gamers" and publications from successful "games with a purpose" (GWAPs) such as Eyespy [48], PhotoCity [47], CityExplorer [55] or the ESP Game [49].

As described JohnDoe features different motivational aspects to engage different player types utilizing a mixture of extrinsic rewards and intrinsic motivations arising from the game mechanics and purpose of helping science.

3.3. Implementation

JohnDoe has been implemented as web-application (web-app) targeting as many mobile platforms as possible with one development cycle. The ongoing discussion amongst developers and designers about web-app vs. native is often happening in an idealized environment disregarding development time, cost or even intended audience and purpose. Very few attempts have been made to investigate this topic without bias looking at user interface design or conventions [56]. The following section describes briefly why JohnDoe was developed as it is – providing arguments for this specific project.

With only one person at hand developing and maintaining a small code-basis is a key element for success. Reimplementing the same functionality in different dialects and frameworks for different platforms was out of question due to time constraints. Limiting the potential audience by only supporting one specific platform would have reduced insights of the study. Due to the distributed, asynchronous nature of the game's mechanics a communication infrastructure had to be deployed as well. After taking screen sizes of mobile devices into account and previous experiences with map-based interactions on such devices it became clear that a web-app would offer a better user experience and reduce development time.

Table 3: Prominent player types used by the gaming industry for professional game design presented by Klug and Schell [53]

Player Type	Description
The Competitor	plays to be better than other players.
The Explorer	plays to experience the boundaries of the play world. He plays to discover first what others do not know yet.
The Collector	plays to acquire the most stuff through the game.
The Achiever	plays to not only be better now, but also be better in rankings over time. He plays to attain the most championships over time.
The Joker	plays for the fun alone and enjoys the social aspects.
The Director	plays for the thrill of being in charge. He wants to orchestrate the event.
The Storyteller	plays to create or live in an alternate world and build narrative out of that world.
The Performer	plays for the show he can put on.
The Craftsman	plays to build, solve puzzles, and engineer constructs.

A web-app can be used on mobile devices as well as on traditional computers giving the player more flexibility while providing one coherent user experience. The re-identification process involves reasoning on the map interface and potential investigation using the web – both tasks which benefit greatly from display size since more information can be absorbed with one glance.

With the need to deploy a communication infrastructure a centralized server encapsulating the mechanics of the game was straightforward. Extending the game-server with a mobile-capable web-portal as a lightweight interface for devices with limited computing and battery power was a well-considered design choice. This approach provided flexibility and choice of device to use e.g. mobile, tablet or desktop as only the sharing location component needed to be carried out on a mobile or GPS-enabled device. The results presented in Section 5 show that this flexibility was an important factor for the success of the study and the game.

JohnDoe was implemented and tested with latency and execution times in mind. Latency was reduced by relying upon JavaScript Object Notation (JSON) -formatted data for communication and intelligent caching mechanisms like HTML5 web storage. Also, all utilized javascript frameworks and custom code were minimized, loaded only when necessary to reduce data transfer times.

Execution times were not as critical although users have come to expect responsive user interfaces. JQueryMobile[5] has been used as the basis for JohnDoe's interface. It is an excellent framework aiming for the same user experience on all major mobile platforms, using hardware-accelerated Custom Style Sheet (CSS) transformations. The map component is built upon a custom fork of leaflet[6], a mapping library built around the same notions and technologies.

The server software was implemented relying upon Grails[7] – a Java/ Groovy framework for fast and agile web development. It combines well known open-source frameworks as Spring[8], Hibernate[9] and Sitemesh[10] with Groovy[11] – a dynamic language for the Java Virtual Machine (JVM). Grails was chosen due to familiarity with the Java ecosystem and deployment stack further reducing development time.

In total JohnDoe's development took seven months including play-testing on six different mobile devices with three different operating systems (Android, iOS, BlackBerry OS). The project's repository is hosted at github[12] and will eventually be released as OpenSource. During development 41 major bugs/ design issues were reported by the testers and fixed. JohnDoe was realized using twelve distinct software libraries, four programming languages and roughly forty-three thousand lines of code.

4. Study

Using the game described above, a user study was carried out. The goal of this study was to investigate how human players re-identify other players selectively sharing locations who used a pseudonym.

The study was split into two parts: the gaming phase, where the participants shared their location data and tried to deanonymize other players, and the evaluation phase, where semi-structured interviews with the participants were conducted to investigate their strategies and behavior during the game. A questionnaire was incorporated into the game's registration and used to collect demographic information of the participants. Semi-structured interviews were chosen due to the fact that human re-identification and denonymization strategies have to be investigated initially. Besides interviews are a lot more flexible in covering unforeseen strategies players might have employed.

Participants: In order to recruit participants, the study was advertised through various mailing lists and by word of

[5] http://jquerymobile.com/
[6] leaflet.cloudmade.com
[7] http://grails.org
[8] http://sprinsource.com
[9] http://hibernate.org
[10] http://sitemesh.org
[11] http://groovy.codehaus.org
[12] https://github.com/tfechner/tracesinspace

mouth from in- and outside of university campus. In total 26 participants registered – 24 male, two female. Their age ranged from 19 to 32 years.

Procedure: At the beginning of the study, players were briefed individually about the game and its goal, either in person or via phone. The briefing showcased the game's interface and explained the setting and timeframe of JohnDoe. Players knew that this game was developed along the lines of a master thesis, encouraged to provide feedback during the game and to report bugs. They were also informed about the interviews after the game concluded but not explicitly told what the goal of the study was. Almost all participants used their own smart phones and were therefore familiar with such devices. Two participants did not own a smart phone and were provided each with an android device.

In total six weeks (three rounds of 14 days) were played and twelve participants played at least in two rounds (see Sec. 5.1). After the game finished, nine semi-structured interviews were conducted with an average length of 20 minutes each. Five interview partners were chosen actively to cover top, medium and less engaged players. The remaining four were chosen randomly out of the pool of active players. A player was deemed active if at least two locations were shared and more than ten minutes were spent playing the game. This constraint was set to ensure that players had at least a basic idea of the game. The interviews consisted of four parts touching upon sharing behavior, investigation of locations, finding out and submitting facts, and general familiarity with OSNs, LSAs and their usage. Afterwards they could also provide general feedback about the game and make suggestions. All interviews were recorded and transcribed afterwards.

Post-Hoc Interviews: The semi-structured interview guideline for JohnDoe was created according to Helfferich [57] suggestions. Standard demographic information was present due to the player's registration for the game.

In a first step 46 questions were collected touching upon various aspect of the game and research interest. In a second iteration those questions were tested under aspects of previous knowledge and openness, and modified accordingly [57]. Afterwards the questions were categorized and sorted into aspects regarding *Sharing Locations*, *Investigation of Player Locations*, *Submitting Facts* and *Last Questions*. As a last step all questions were subsumed and reduced to create guiding questions. Tables A.6 and A.7 in Appendix A show the complete guideline in its final form. It was tested with two players of the development phase who did not participate in the final study.

A typical interview was scheduled via mail in the week after the game concluded. Participant and interviewer would meet in a quiet and private location. First the purpose of the interview was described, and legal requirements met with an informed consent. The collected demographic information of the game's registration would be checked and then the actual interview started with an average length of 20 minutes. Interviews were recorded using a stereo recorder[13]. Three of the nine conducted interviews were in German and the rest in English, although all participants were non-native English speakers.

Transcriptions were created using Kuckartz [58, p. 27] computer aided system (is explained more in detail in [59]). A translated and slightly modified version which was used can be found in Appendix B.1. Each transcription was summarized to gain a better overview about a participant's strategies regarding sharing & investigating locations, submitting facts, familiarity with LSAs or OSNs and general noteworthy statements. The summary process was similar to the qualitative summary content analysis [58, p. 91] as it paraphrases, generalizes and reduces statements. All transcriptions can be found in Appendix B.

5. Results

In the following the study's findings are presented starting with factual data from the game logs. Afterwards a novel visualization method is introduced displaying data from round two providing first insights into players re-identification strategies (Sec. 5.2). Players sharing behavior is presented in sub-section 5.3. The final sub-section 5.4 of this paragraph combines and interprets the factual data using the previously introduced visualization in conjunction with the conducted interviews investigating the re-identification strategies players employed.

5.1. Player Activity

The automated game logs show that 17 out of 26 players participated actively. They shared their location at least two times and spent more than 10 minutes playing the game. 240 locations were shared in total over the course of the six weeks long gaming phase.

Out of the 17 active players twelve were successfully re-identified with all facts sometimes including an optional picture. A player is deemed re-identified if first and last name were uncovered. Twelve players participated in two or more rounds and eight were re-identified repeatedly. 312 facts were revealed with 101 wrong attempts, see table 4 for a complete overview.

The remaining five participants were partially re-identified in at least one round revealing country, gender, hometown and one work location. The nine inactive players shared none or only one location and hence were not re-identified.

14.5 minutes were spent on average on the games website per day, summing up to more than *ten hours* per player. It was accessed more than 10,700 times during the study. Ten different devices (e.g. tablets, iPhones & Android Phones) were used with eight different browsers to view the website. Players used the map interface more often on a computer than on mobile devices due to larger screen sizes and better interfaces for searching the web (mouse & keyboard).

[13] `http://www.zoom.co.jp/products/h2n/`

Table 4: Data for active players derived from the game logs for all rounds (6.2.12 - 19.3.12). Points from round one cannot be compared to rounds two and three due to a revision of the point system (rewarding location sharing more after round one).

Participant	Round	Points	Shared Locations	Correctly Identified Facts	Incorrect Facts	Revealed Pictures	Incorrect Pictures	Re-identified Successfully
P1	R1	318	6	21	8	1	0	yes
	R2	765	7	36	8	3	0	yes
	R3	615	6	26	5	2	0	yes
P2	R1	0	0	0	0	0	0	no
	R2	140	22	3	7	0	0	yes
	R3	470	29	26	26	1	0	yes
P3	R1	260	15	15	5	1	2	yes
	R2	500	46	2	0	0	0	yes
	R3	300	3	7	1	2	0	yes
P4	R1	23	3	0	0	0	0	no
	R2	60	4	0	0	0	0	no
	R3							
P5	R1	1	1	0	0	0	0	yes
	R2	20	2	0	0	0	0	yes
	R3							
P6	R1							
	R2	985	7	87	18	3	0	yes
	R3	455	9	50	5	0	0	yes
P7	R1	113	3	0	0	1	0	yes
	R2	50	3	0	0	0	0	yes
	R3							
P8	R1	207	4	8	4	1	0	yes
	R2	215	13	13	5	0	0	yes
	R3	55	8	1	3	0	0	yes
P9	R1	18	0	0	2	0	0	no
	R2	105	9	3	1	0	0	yes
	R3							
P10	R1	101	2	10	1	0	0	no
	R2	30	3	0	0	0	0	no
	R3							
P11	R1	0	0	0	0	0	0	no
	R2	0	0	0	0	0	0	no
	R3	20	2	0	0	0	0	yes
P12	R1	62	12	1	0	0	0	yes
	R2	65	4	1	0	0	0	yes
	R3							
P13	R1							
	R2	40	4	0	0	0	0	yes
	R3							
P14	R1							
	R2	30	3	0	0	0	0	no
	R3							
P15	R1							
	R2	40	4	0	0	0	0	no
	R3							
P16	R1							
	R2							
	R3	30	3	0	0	0	0	no
P17	R1							
	R2							
	R3	30	3	0	0	0	0	yes

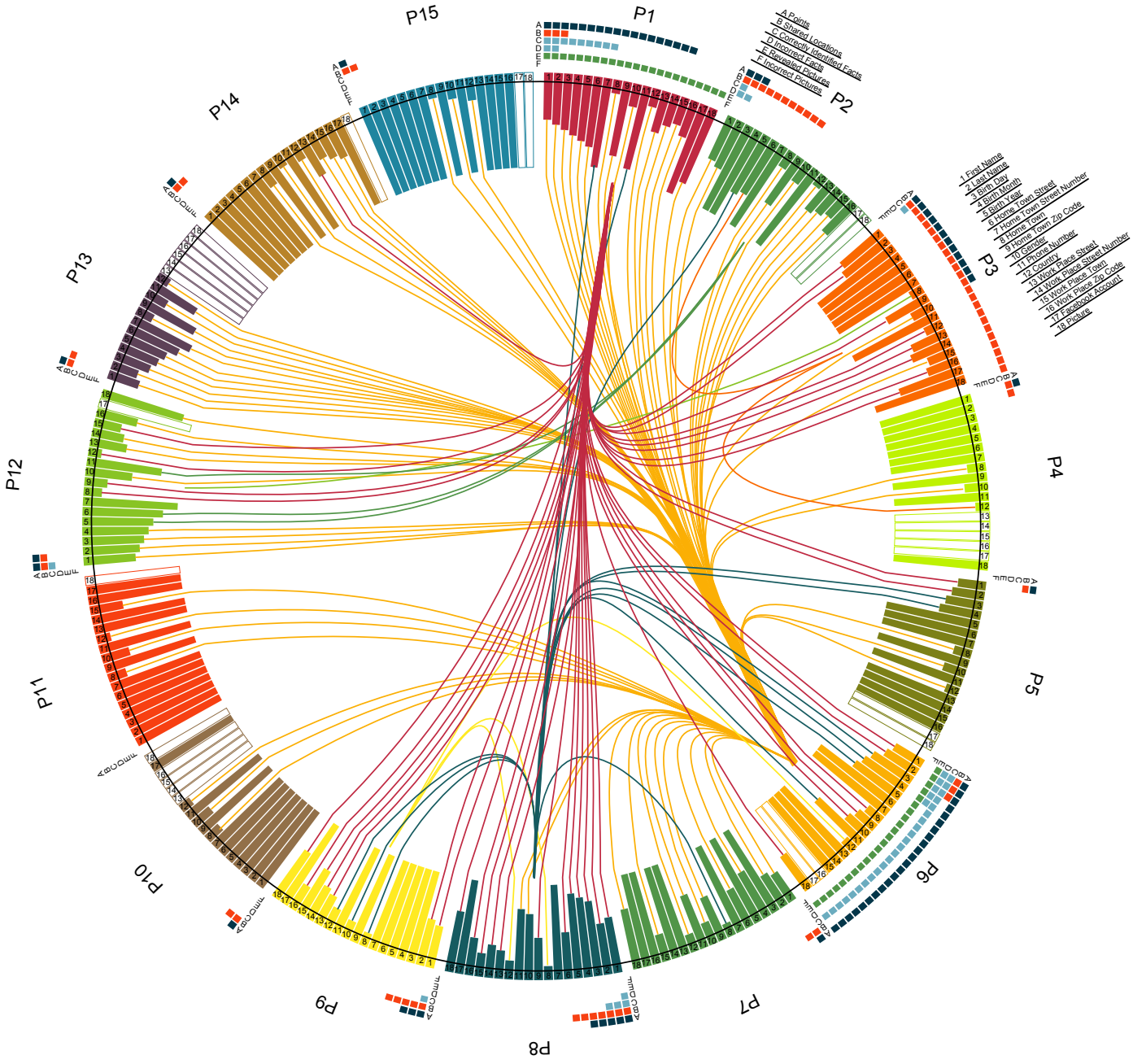

Figure 2: Circular visualization displaying logged data from round two of the game. It showcases the order of re-identification, crowd-sourced public profiles, player activity and strategies employed.

5.2. Visualization

JohnDoe's data collection mechanisms stored every player activity and interaction within the game to cover as many aspects of the re-identification process as possible. In order to understand the deanonymization process on the data level one needs to be able to answer questions like: "Who was deanonymized by whom?", "Who participated in the process?", "Which facts were the easiest to be re-identified?" and "Is there a pattern in the process?" among others. While this can certainly be done with a traditional spreadsheet it would not be efficient or well suited for the complex data available.

Therefore a circular approach is introduced capable of visualizing and exploring relationships between objects or positions. Figure 2 showcases the approach with data from round two of the gaming phase since it had the most active participation.

Each player is represented with a distinct color and annotated with P1 through P15. Every player *segment* in the most inner circle consists of 18 perpendicular *bars* labeled with one to eighteen representing the different facts of that particular player. If a bar is hollow that specific fact was not submitted and optional during the registration. The *height* of each bar represents the order (the

lowest being the first) in which the facts were uncovered but not the actual timing – a further iteration of the visualization might include this. From each player *lines* span across to other players indicating which facts have been successfully uncovered by the adversary player. The *outer ring* segments labeled with A to F display the accumulated points, shared locations, correctly identified facts, incorrect facts, correctly uploaded photos and incorrect photos. Those details are displayed in percentages that were obtained by normalizing the absolute values with the maximum value of each detail. Afterwards they were fitted into the visualization above each player. The circular approach used in this thesis was inspired by Circos[14], a visualization software package used in cancer and comparative genomics.

Figure 2 allows to grasp and interpret a lot of detail with one glance. For example different player styles can be seen: P3 gathered points almost exclusively by sharing locations, apparently enjoying this aspect of the game more than the re-identification part. P6 scored the most points mostly due to re-identifying other players, while P8 or P1 shared and re-identified on a smaller scale but still successfully. Another important aspect can be derived easily as well. The number of wrong facts is quite low – players seemed to be quite sure when they submitted facts that they were right. Crowd-sourcing happened often. For example P3's facts were uncovered by P1, P12 and P6. P9 was re-identified in a joint effort of P8 and P1.

Facts were uncovered in a certain order which is visible as well in figure 2. The strategies going alongside those orders are presented in sub-section 5.4. Before those are discussed the sharing behavior is presented in the following sub-section.

5.3. Sharing Behavior

The interviews show that players were sharing locations strategically. All players mentioned avoiding to share their home or work location as it was mentioned during registration. No one indicated specific times of the day they avoided when sharing locations. When being asked about their sharing routine most of them stated they preferred sharing locations at public places, since anyone could do so as well. P1 stated: *"I always tried to ensure that no one can identify me from this specific location, [...] when somebody was with me I assumed that this person was playing as well so that I did not share a location [...]. I always shared locations which were public."*

P8 made similar comments:*"I tried to share locations so I could not be identified – so for example I shared a location at [mentioned specific place] but I never told someone that I am going to [mentions place again]. I shared there and was happy about it. I avoided locations where I thought someone could identify me through this location – like [mentions workplace] or my home."*

P3 also reported*"I used to do it while commuting [...]. No one could really know who is the one who is seen at this place."* One player mentioned avoiding entire zip code regions since they were asked during registration. While sharing on a regular basis this player was the last to be re-identified completely (due to one shared location on a public event where he was known to be).

Two players altered their behavior to confuse other participants by sharing unusual places or home locations from other players after they were pretty sure that those were playing as well. Sharing in front of other players homes proved to be very effective in confusing other players but did not prevent re-identification in the long run. Both players using this tactic did not sustain it through the entire game.

P9 stated:*"I shared in front of [mentions player] house two times. I think people ran even into false guesses due to that."*

P3 reported: *"[...] there are many ways from my home to my workplace, so I just chose another route – this is kind of a detour. It is not that the way is longer but I did it not to take the same route every day."* Outside the location context, three players found it very useful to not have correct information about their birthdays in OSNs.

P2 said:*"That is actually a good opportunity to make the others lose points – because I have set a wrong birth date on my Facebook account."*

All interviewed players seemed to be very aware of the re-identification potential of home or work locations, as well as potential data sources like OSNs providing information about them. Participants not sharing any location stated they did not done so because a single location would reveal already too much about them or they did not like to share locations with strangers.

5.4. Re-identification Strategies

Based on the interviews and the game logs, three basic strategies can be identified that have been used in the re-identification process: categorization, data harvesting and exclusion. The selection of a strategy was heavily dependent on the social relation of the adversary player to the player under investigation.

Categorization was used as the basic approach by all players. Players who shared locations often became preferred targets for investigation. The provided map interface was used to check the latest shared location, when and where it was shared and at what speed.

P9, for example, said: *"I looked at the locations when and where it was as well as further data like speed – to be able to derive if they have been cycling, etc."*

Basic assumptions about the nature of the study helped to submit certain facts as well. Players knew that this was a game played in the context of a master thesis and figured that most of its participants would be recruited from the same city (Münster) and therefore from Germany (Country). They also assumed that most of the

[14] `http://circos.ca`

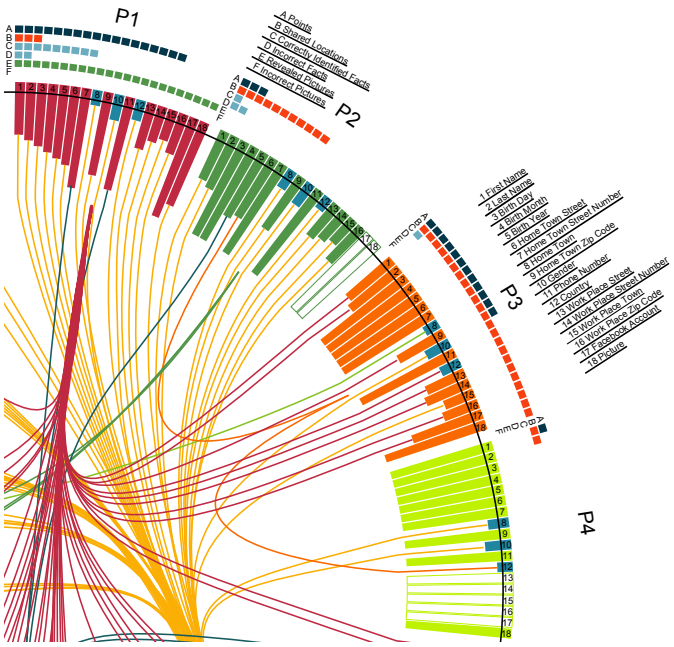

Figure 3: Bars highlighted are hometown, gender and country. Those facts were to be found first. This indicates that people assumed players to be male, from the same city (Münster) and country (Germany). Assumptions which were true due to the smaller nature of this study.

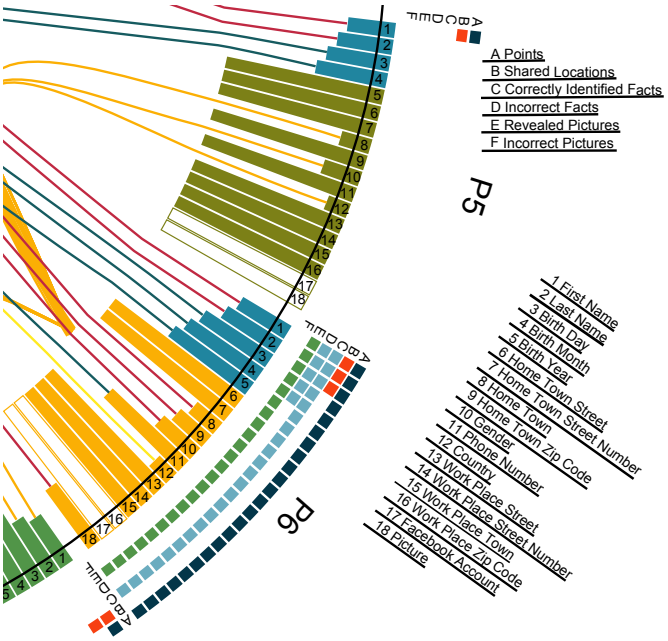

Figure 4: Bars highlighted are first and last name as well as birthday. P8 submitted the birthdays after P1 re-identified player 5 and 6 completing their profiles with third party information.

participants would be male (see Fig. 3). Most of these common sense assumptions would be correct but not always. One female player had chosen a male pseudonym and players suspected a male and were wrong. In a follow up a male player used a female pseudonym and was suspected to be female, thereby creating confusion amongst the adversaries.

Furthermore common sense reasoning was applied to figure out if someone was on the move, and whether they were walking, driving or riding a bike. The map was used to investigate points of interest giving additional insights about possible activities at this spot. Successful reasoning resulted in the creation of a tag like "doing groceries", "visiting a pub", "party", "driving a car", "cycling" or "student".

P9 reported: *"So for example if someone shared at [mentions place] I assumed that it could be a student, someone who works here or of course someone who passes by. So I tried to figure out for every location what is special about this location."* P2 also commented *"When locations were near to a supermarket – [...] then I thought okay and tagged the location 'shopping'."* This process was repeated until some location would trigger data harvesting or exclusion.

The **data harvesting** strategy was employed when a player found something curious or suspicious and started interrelating third party information such as calendars, social networks or results of search engines. Players reported this to be very difficult since it was not easy to find patterns or habits in the shared locations of other players. This is very likely a direct result of the strategic sharing behavior of some players. P4 commented *"It was pretty hard – you could see that someone was moving in the city but identifying hobbies like playing soccer was not possible for me."*

But as soon as other players revealed first and last name some gathered additional information from public sources. P8 reported: *"I tried to reveal some people, but that was not really successful. Instead I submitted additional facts to people, who were deanonymized by other players."* This strategy can be seen in figure 4 where P8 submitted birth day, month and/ or year after P5 and P6 were re-identified by P1.

If a location was considered to be re-occurring or a pattern was found indicating the investigated player might be known personally by the adversary player, an **exclusion** process started to eliminate potential candidates.

P1 described this as follows: *"I just knew that many students are at [mentions place] – if someone is there I just knew that he/ she is probably a student as well so it is important to know that this place is part of the university. If someone was at the [mentions street] I also assumed that it could be someone studying the same as I do."*

Players created lists excluding persons they knew based upon the established categories. The most common fact to further reduce the list were zip codes from work or home. Zip codes served as a regional buffer to eliminate candidates and were often mentioned in the interviews as being very useful. The deanonymization potential of zip codes in combination with age and gender has already been demonstrated by [8].

P1 reported: *"I always tried to start with the least specific facts like country, city, zip code. If the zip code is*

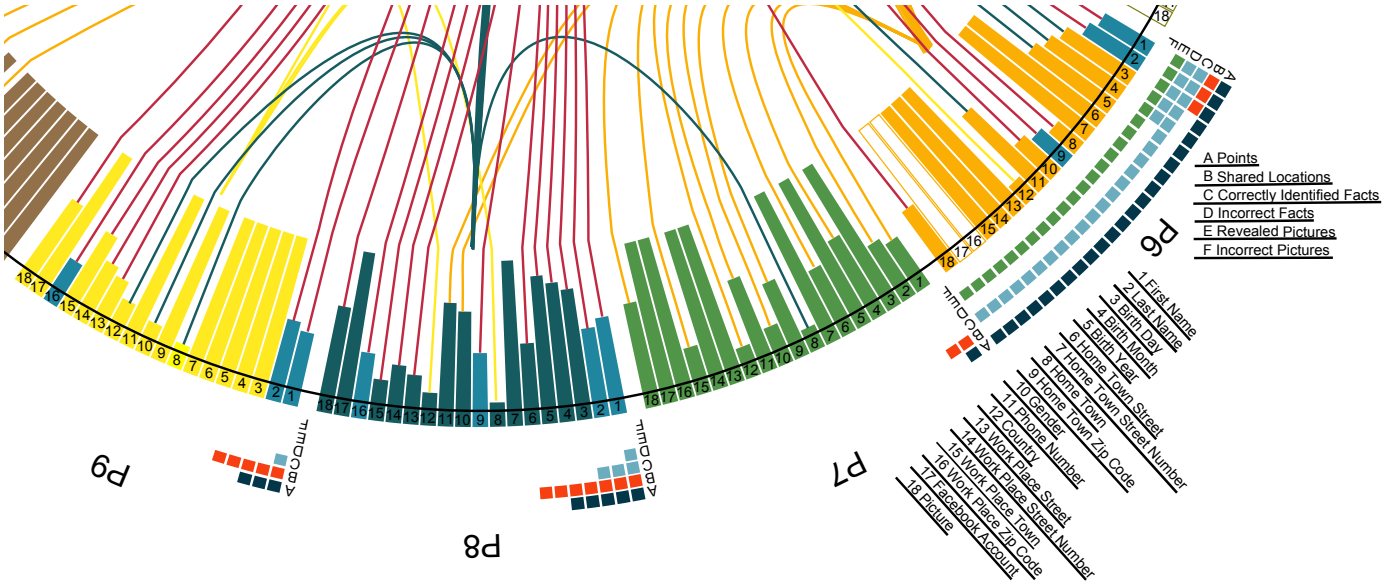

Figure 5: Bars highlighted are workplace zip code, hometown zip code, first and last name. Zip codes would be used as buffers to narrow down the target audience. Hence they were submitted previously before first and last name would be re-identified.

right but the person was wrong you always know it has to be someone living in this particular area. I always tried to increase the accuracy of the facts." Figure 5 highlights this strategy in the logged data where player one submitted workplace zip code and home town zip code before first and last name were submitted. If the zip codes of a players home or workplace were known, other players crawled employers websites in this region, used online telephone books or OSNs to harvest additional information to submit. This supports the deanonymization potential of home/ work location pairs found by [16]. P6 commented: *"Then I started to look at [mentions employer's] homepage and check the employee section – after finding the person I suspected submitting the name was easy."*

If a player's name was successfully re-identified and submitted, other players often used it to search for missing profile information. P2 described this as follows: *"When I knew the name of a player I started to search him on the web [...] I typed the name into Google and just gathered more information."*

A quantitative threshold was not found, i. e. a minimum number of shared locations for re-identification. In one case a player shared at a party, afterwards at a fast food restaurant and the next morning while commuting to work. Those locations gave enough clues to another player to re-identify that player. Another player shared over 25 locations during the game and only country and city were revealed until he got careless and shared at a social event which led to his re-identification. Players stated it was most helpful for the re-identification process if locations could be linked to a personal level of information such as routines or hobbies – if they knew other players, e. g. as colleagues, friends or friends of a friend. The most commonly used third party information source was Facebook. Some players even received friend requests during the game and rejected them to avoid giving away potential facts.

6. Discussion

Location privacy is largely looked at from a computational perspective. Most of the algorithms used for re-identification apply straightforward assumptions like dwelling times, last visited location per day or clusters of locations. Afterwards potential home and work locations are used with reverse white page or telephone book look-ups for re-identification, all tasks humans are capable of as well.

The conducted study with JohnDoe provided first insights into strategies applied by humans to re-identify location information. While the diversity and size of the participants is limited the engagement was a lot higher than expected. The discussion of this thesis is split into two major parts. First the methodology is discussed touching upon the novel gaming approach, participants, interviews and the structure of the study (Sec. 6.1). Second, the results of the study are examined observing limitations while reflecting on how to overcome them in future work (Sec. 6.2).

6.1. Methodology

Computational attacks are able to process large amounts of data efficiently in a pre-defined way but they cannot incorporate subtle clues. In the conducted study humans reasoned and applied common sense in parallel with methods like dwelling times and location clusters. Those tasks are time consuming and seem cumbersome if presented plainly. To gain insight into the human deanoymization

process of selectively shared locations a more appealing way than a traditional paper based study was chosen. With the unique context of existing LSAs employing gamification techniques a more complete game seemed promising to motivate people.

6.1.1. Gaming Approach

Creating a game is time consuming – most likely too time consuming for most research questions. It took seven month from the first design document to the finished game not counting an alpha phase with pilot testing. Early and continuous play testing is crucial to find out if the concept works. One must not be afraid to change aspects often – sometimes back and forth. Certain user interface elements of JohnDoe have been changed a dozen times in terms of information feedback, saturation and hue of the color scheme or complexity.

Game mechanics are especially challenging. Even the "simple" point system has been revised six times until the focus group found it to be rewarding. In the final deployment it got updated again between rounds one and two since the study's participants were not as engaged in sharing locations as the focus group.

Yet the time spent developing the game was worth it. Player involvement was a lot higher than expected. Ten hours were spent in average on the games website per player – 14.5 minutes a day. There is no way of knowing if players actually spent the time only on the games website or if it was just an open tab in the browser. Nonetheless it is an impressive commitment and indicates that the motivational aspects and game mechanics worked.

This motivation and engagement was created by gamification elements like the point system, a carefully crafted presentation of the game itself and its purpose. The re-identification process offered different activities for different levels of commitment. Some facts were relatively easy to re-identify (country, city, gender) while others offered a bigger challenge (first/ last name, home address,...). This balance was still intact even as the game progressed. When a person was re-identified by players with high engagement others could still earn points contributing additional facts completing the profile with e.g. a photo, facebook account or birthday information. Offering different challenges for players is vital for progression, motivation and long term engagement. Those are integral aspects of crowd-sourcing as well. Nonetheless players wanted new "content" if they played more than two rounds. Badges, banners or achievements were requested which are commonly found in many games today. Unclear is if players felt they learned everything there is to learn about the deanonymization process and needed additional incentives. On the contrary it may just be an expression of modern gaming culture to further distinguish and present one's success.

JohnDoe essentially mimicked well known and successful LSAs such as Foursquare and added a re-identification layer on top. Game elements are already introduced in this context and embraced by users [50]. Essentially its concept is perceived as known with "yet unknown" aspects and therefore benefits from a novelty bonus. Game mechanics could be tailored around the research aim fitting naturally into the theme of "stalking game".

All those aspects allowed the gaming approach in the first place. For other research questions this approach might not work. Even if it can be done it does not mean that it should be. Game design is best learned actively and needs considerable experience and commitment. The author of this thesis was very aware of both aspects and had experience with them.

6.1.2. Participants

Players were recruited from university campus by word of mouth and mailing lists. Albeit coming from different departments or institutions they often joined the game in small groups of colleagues or friends who decided to participate. With 26 participants in total and the aforementioned low diversity the exclusion strategy may have been favored. Additionally only a certain mobile "affine" user group was targeted and therefore captured (age ranged from 19-32 in the study). Most of the participants had a background in sciences like informatics, geography or mathematics with only a few participants from humanities like politics or languages. While all humans are able to reason on spatial data and draw conclusions approaches may differ. A more diverse and larger set of participants from multiple cities or cultures is needed for further insight on these limitations.

Players' engagement presented itself not only in the time spent in game. One player was not satisfied with the implementation of the location sharing aspect of the game. He liked the idea of a web-app but favored a native application for sharing locations since it would consume less battery to load a native app and be faster. After consulting with the author of this thesis he developed a native location sharing client for Android phones and contributed it to the player community. As of round two it was publicly available and actively used. This surprising request was very welcome. Moreover players reported 46 minor bugs or enhancement to the games bug tracker on github suggesting improvements or requesting features. Most of them could be integrated during the study.

This kind of commitment outside the "gaming" context but nonetheless related to the game testifies that the players really liked the game and its purpose, unveiling the potential of intrinsic motivation. Still most of them were extrinsically motivated and wanted to be on top of the leaderboard like player six: *"I wanted to get the points – I was really trying to get as many as possible."*

Recalling the different player types (see Tab. 3) these players would be "Competitors" and "Achievers" aiming for short and long term success. Such behavior created strong competitions or even in-game-rivalries. Seeing that one could kick a player of a top high score position with only a few more points motivated to share more locations

or complete profiles. Notwithstanding this can be demotivating as well if to much effort is required and no possibilities are present to compete. This was prevented in JohnDoe with facts such as uploading a photo. The reward would be higher but if the photo was wrong more points would be lost as well. "Competitive Explorer" player types were present likewise. Player three tested out the games "over sharing" prevention system to stop spamming locations in one place. This provoked other players commenting on that and focused their deanonymization efforts on him. Two players tried to disguise their identities by taking detours or sharing in front of suspected home locations of other players. They did not sustain this "performance" through the entire game but managed to elude adversaries for some time.

Figure 2 displays that the crowd-sourcing aspect worked, players' identities were revealed in joint efforts. The tagging and comment function was not used as much, instead players asked for a mechanism capable of storing notes privately to not give away their strategies. Perhaps the news distribution system made comments a bit obsolete as almost every action in game would trigger it.

6.1.3. Interviews

Post-hoc semi-structured interviews were chosen to have a certain degree of freedom exploring the used re-identification strategies. They proofed to be a useful tool to gain insights. Players spoke without being prompted often about their strategies for re-identification and sharing behavior. During the interviews they would describe certain situations which led to the re-identification of certain facts and generalize them afterwards into strategies they used. Some of them liked the interviews and derived an additional sense of accomplishment for being chosen as an interview partner. As previously mentioned nine interviews have been conducted with four randomly chosen participants and five deliberate candidates to cover different player types.

The interview time of 20 minutes was long enough to give room for detailed elaborations of players. Those elaborations were most useful to identify patterns and therefore strategies in the game data, demonstrating that players actually did what they were reporting. Without players' remarks and the freedom to further investigate certain aspects like taking detours or sharing in front of suspected player homes would not have been found. With the developed detailed interview guide (see Appendix A) the foundation for further detailed interviews is given for future work.

6.1.4. Structure

Although JohnDoe was a tested rigorously it was still a novel approach with some informed guesses. Unclear was if the game itself would be played longer than a couple of days by a larger audience. The time needed for a successful deanonymization or if one would even occur could only be hypothesized. Locations sharing, player motivation, information presentation and understanding had to come together in a complex interdependent system for a successful in-game re-identification. Considering all factors it was decided to split the gaming phase of the study into multiple parts. A two week window for one round seemed long enough to share potentially revealing locations. Additionally players could start over in a new round and were not penalized by previous mistakes. To give an example: One player picked a pseudonym he would use in online forums and OSNs and was re-identified by a friend instantly.

Table 5: Participation during the gaming phase of JohnDoe. Players are deemed active if they have at least shared two locations during the gaming phase and spent ten minutes in game.

Round	**Active Players**	**Registered Players**
Round One	11	16
Round Two	15	18
Round Three	8	10

Round one had a limited numbers of players in order to account for server stress and watch the game progression closely. In case of no location sharing or re-identification would have occurred, mechanisms were set into place to nudge players. In-game events rewarding sharing locations or re-identifying facts had been prepared but were not used. After round one concluded some adjustments were made to the reward system. Players felt they would receive not enough points. This was compensated by adjusting and raising the rewarded points by an order of magnitude – sharing locations would now grant ten points instead of one.

Participation dropped in the last conducted round (Tab. 5). Players playing more than two rounds wanted new content like badges and banners. New advertisements would have helped to reach a wider audience, but in order to gain insight into learning or evolving strategies it is advisable to include long term incentives. Asides from a two week timeframe different durations might work as well. Consecutive sharing during a typical weekday might also lead to re-identification, or split sharing and re-identification phases within one round might have an impact – all aspects which are subject for future work.

6.2. Results

The presented results are subject to certain limitations which will be reviewed in the next two sub-sections. Nonetheless they provide valuable insight into human re-identification strategies and demonstrate that they are equally possible as algorithmic attacks. Sharing behavior is looked at in the next sub-section (6.2.1) while the last one discusses the re-identification strategies (6.2.2).

6.2.1. Sharing Behavior

The majority of the players shared locations very cautiously. Most of them did not share more than ten locations during one round avoiding home and work locations.

It seems that they were very aware of the revealing potential, possibly adverted by the registration which asked to provide them. Preferred were public places while commuting deeming them less revealing than less frequented ones. Statements like player seven's were encountered often: *"I was thinking about how revealing the place was and then I shared."* These findings are directly comparable to Toch et al. [34]. Despite this awareness and mentioning during the interviews some players did share within the vicinity of their home and work locations. A possible explanation can be derived from a concept called "The Privacy Hump" by Iachello and Hong [60, page 112]. It describes the introduction of new technologies and the initial privacy concern arising with them. As time passes and no privacy violations occur or are overcome, concerns drop (see Fig. 6).

The same might be true for home and work locations. During registration they had to be provided and were introduced as facts for re-identification. As time passed players got more experienced and their concerns lowered since they were not re-identified. Due to the nature of a re-identification process one "weak link" or location suffices to uncover an entire data set or player. Yet players did not know or could only suspect what led to their re-identification and accepted that it will happen possibly as part of the game. Further iterations of the game could provide feedback e.g. by players indicating locations triggering the re-identification process. Its impact on learning and adaption strategies would be highly interesting for privacy aware LSAs aside from further insight into the entire process. At the moment it is unclear whether this contradictory behavior is due to the privacy hump or a result of the desire to earn more points quickly. Nonetheless Tufekci [30] witnessed similar contradictions. The game's mechanics did not enforce the goal to stay hidden. They reward sharing locations and finding facts. Staying hidden arose from the theme of the game.

More participants from multiple cities could change sharing behavior as well. 209 locations were shared in Münster while the remaining 49 were spread across western Germany from the coast to places near the French boarder. Participants shared outside of Münster while visiting friends or family – further clues for adversaries.

Aside from the two participants taking detours and sharing in front of suspected players homes all others wanted to stay "true" to their habits not damaging the study. This restrain may have been caused by the presentation of the game. During the registration process players were asked to fill out the registration form honestly otherwise the game would not work. This may have influenced peoples' sharing behavior, nonetheless humans are creatures of habits and do not change their daily routines lightly. This aspect can also be seen in the shared location data. Players shared often in regular reoccurring intervals while commuting to or from work, visiting pubs or during social activities. In addition, the motivation for sharing locations was purpose-driven rather than social-driven. The re-identification potential of social-driven shared locations might differ.

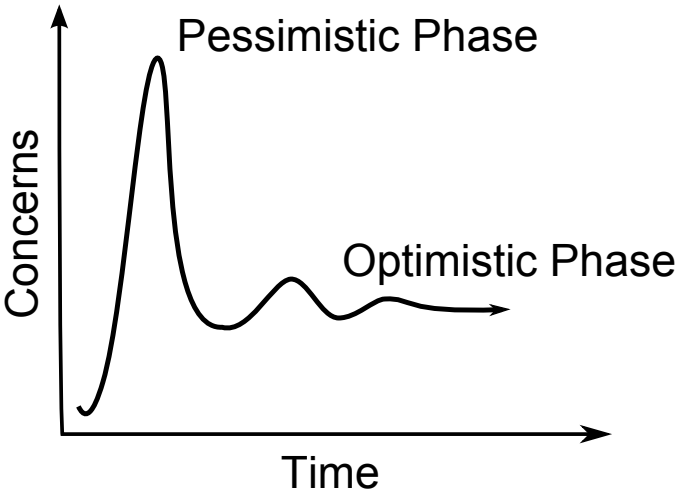

Figure 6: Reworked picture of the Privacy Hump; a working hypothesis by Iachello and Hong [60] describing users' privacy concerns about new technologies and their degradation over time as no violations occur or are addressed

6.2.2. Re-identification Strategies

The results show that determined non-experts are able to re-identify persons based upon self-determined selectively shared locations in a reasonable time. Reasoning and common sense enabled them to do so even with very few shared locations. Instead, computational attacks have been performed on GPS tracks with high sampling frequencies of several weeks length.

Players did not need continuous tracked locations to derive useful information. Albeit the setup of the game may have favored or influenced certain strategies. The limited pool of players may have favored the exclusion strategy. Close social relations and insight into colleagues or friends' lives provide certain background information which not everybody possess or had to derive first. For example routes to and from work might be known or methods of transportation. Adversaries searched for such evidence. If only one friend is known to possess a car and locations were shared on streets with speeds too high for bikes or pedestrians one can look for hints supporting this theory. One player shared carefully over 20 locations and was not revealed until the very end of round two where he shared at a social gathering with friends who happened to play as well.

Another player was deanonymized not because of his shared locations but instead of his deanonymizing strategy. He would submit country, gender and hometown for every available player to gather as many points as possible. Since this behavior was witnessed it led to his re-identification in a subsequent round. As can be seen in figure 2 player eleven did not share a single location but his work place town, home town, country and gender were still found out. These re-identifications demonstrate the

strength of the human re-identification process – the ability to use all available information drawing conclusions including subtle clues.

One might argue that the way facts were submitted could be exploited. If a submitted fact was wrong this would be reported and players lost points yet gaining additional clues. The only fact directly affected by this was gender where only two options existed. Actually players had to cope with false negatives due to spelling errors and difference in writing street names and tested different variations. The relatively total low number of 101 wrong facts compared to 303 successful identified facts demonstrates that players were quite sure before they submitted facts.

Knowing that their privacy was under attack players' awareness was raised. Data harvesting strategies led to new friend requests on Facebook. Players reported rejecting those seeing that it opens up their profile information to other potential players. Yet to be investigated is the effect of obfuscation techniques like degradation or spatial cloaking. It has been shown that algorithms are still successful when these are in place. It is likely that humans are as well since the algorithms used did not employ thorough statistics.

Beyond the analysis of the logged data and the interview other means could potentially be adapted to help understand the re-identification process. Hägerstrands concepts like Space-Time-Prisms or the Space-Time-Cube from Time-Space geography have regained some attention with advancing computer graphics [61] but are of limited use. Initial visualizations with an interactive Space-Time-Cube were promising although the concept needs serious adjustments being designed for migration movements on city or continental level in social geography. Furthermore mapping the data and interpreting it only reveals what the observer infers, hence multiple observers are needed.

7. Conclusion

The results show that a motivated person is capable of re-identifying self-determined selectively shared locations published under a pseudonym. No special training is needed nor does it take a lot of time. Basic human reasoning combined with categorization, data harvesting and exclusion strategies suffices. This is especially true if the attacker has some kind of social relation to the target. A first comprehensive overview about human deanonymization and re-identification strategies attacking location privacy is provided in this thesis. Up to know these attacks have only been considered implicitly. The work presented provides first insights for further investigations closing this research gap.

Humans were able to re-identify twelve out of 17 players only using the very few selectively shared locations, although the exclusion strategy may have been favored due the relatively small size of the study. Twelve players played in subsequent rounds and eight of them were re-identified repeatedly. The novel gaming approach was successful. Careful game design with proper incentives led to a high commitment towards the study. Essentially people liked to participate and told their friends to join. Players spent on average 10 hours on the games website throughout the study, without being motivated by money. An aspect – if performed carefully – worthwhile to look at for other research questions which benefit from human ingenuity and crowd-sourcing.

A novel visualization method has been introduced showing data from the most active round, highlighting and confirming the results of the conducted interviews. This combined approach reduces uncertainty in the findings as the logged data confirms to a large extend what players reported.

Participants were aware of the deanonymization potential of certain locations but awareness dropped throughout the game. Since participants were actively sharing locations as well as trying to re-identify others their sharing behavior most likely differed somewhat from standard LSAs.

Nonetheless findings from related work for sharing behavior could be confirmed. Additionally home and work locations have been confirmed as sensitive to privacy attacks, as well as zip codes. Facebook was perceived as "best information" source for the game. A questionable award for an Online-Social-Network of this magnitude.

Obfuscation techniques and their impact on the re-identification performance of humans are left for future work. Additional studies with more diverse participants are likely to deepen the understanding allowing for insights on learning, adaptation and evolution of strategies. Future work might also include a version of the game where players indicate locations/ patterns triggering the re-identification process. Providing this feedback to other players would create a transparent system. Sharing behavior might be influenced, while a knowledge base is created useful for designers of location-based services.

The need to understand location privacy manifests itself with every iteration of modern ubiquitous devices. Smart phones and service providers incorporate location information to enhance the user experience. Each data theft or database breach reported in the news perpetuates the need further. Understanding how such attacks are performed enables us to delay or prevent them. Privacy in its various forms concerns us all and the journey to understand and respect it is far from over.

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Appendix A. Semi-Structured Interviews

Table A.6: Semi Structured Interview Guide for JohnDoe Part A

Guiding Question/ Prompt to narrate	**Check - Was this mentioned?**	**Concrete Questions - ask at appropriate time (could also be in the end) using this formulation**	**Continuation and Steering Questions**
Part I - Sharing Locations			
Tell me about sharing locations in JohnDoe.	"Special structure /attitude" in sharing locations Avoiding / sharing specific locations Avoiding / Sharing at specific times Steps to confuse other players (taking detours, sharing unusual locations,...)	If somebody did not share locations: Why didn't you share locations?	Tell me more about... Explain this in more detail please. And then? How did it turn out?
Part II - Investigation of Player Locations			
Please tell me a bit on how you investigated the locations of other players.	Determining which players to investigate Usage of existing information: temporal, speed, heading	Did you use the page primarily on a mobile device or on other platforms as well?	
What have you found while looking at the shared locations in the game?	patterns, habits, structures Re-identified high value facts coupled to a particular location OR Combination of multiple locations Usage of tagging system Usage of third party information Reasoning on locations		
Did you miss anything while you investigated the locations?	Highlighted last shared location Trajectories Path/ Lines		

Table A.7: Semi Structured Interview Guide for JohnDoe Part B

Guiding Question/ Prompt to narrate	**Check - Was this mentioned?**	**Concrete Questions - ask at appropriate time (could also be in the end) using this formulation**	**Continuation and Steering Questions**
Part III - Submitting Facts			
Tell me about submitting facts.	Started to submit facts when... Starting Facts Hardest Facts Knew the player personally Third party information / combination	If no facts where submitted: Why didn't you submit facts?	Tell me more about... Explain this in more detail please. And then? How did it turn out?
Have you had any specific structure or order for submitting facts?	Being sure about a fact or just "testing" it		
Have you collaborated with other players?	Comment Function Tagging Function		
Part IV - Last Questions (Informative)			
Are you familiar with Online Social Networks (OSNs)?	Facebook, Xing, LinkedIn,...		
Are you using OSNs?			
Are you familiar with Location Sharing Applications (LSAs)?	Foursquare, Gowalla, Brightkite, Google Latitude,...		
Do you use LSAs?			

Appendix B. Transcribed Inteviews

Appendix B.1. Transcription System

The transcription rules used for this study from [58] – translated with slightly changed naming and highlighting conventions.

1. Transcriptions are literal, not summarizing. Dialects are not transcribed.
2. Language and punctuation are slightly adjusted for readability.
3. The interviews are anonymized, removing all details allowing re-identification.
4. Distinct pauses are marked with (...) and short pauses with a dash.
5. Agreeing sounds like "Mhms", "Ahas", etc. of the interviewer are not transcribed if they did not interrupt the interviewee.
6. Interjections of the other person are in brackets.
7. Supporting or clarifying sounds of the interviewee like laughing or sighing are noted in brackets.
8. Passages of the interviewer are denoted with "I", passages of the interviewee with a distinct abbreviation like "P1".
9. New passages are indented to enhance readability.

Appendix B.2. Participant 1

Part I - Sharing Locations

I: Tell me about sharing locations in JohnDoe.

P1: I always tried to ensure that no one can identify me from this specific location, because for example only one person was with me at for example the Mensa I assumed that this person was playing as well so that is a factor that I didn't share a location. Also I didn't share locations at my home because most of the people know where I live. One of the persons would have tried – so I always shared locations which were public.

I: Did you avoid sharing at specific time frames?

P1: No – I think I shared at a very broad range of times from 5 pm to very early in the morning.

I: Did you employ any strategies or tactics to confuse people?

P1: I once shared a location where nobody knew that I was there (doctor) – I was just there and had time to share. No one would assume that I was there.

I: So you did not take detours or traveled to another location in the city to share something?

P1: No.

I: Did you like the point system / rewards?

P1: Yes - but they were not the main emphasis. The focus of the game was finding out where and who other people were and not to share locations.

Part II - Investigating Locations

I: Tell me a bit on how you investigated the locations of other players.

P1: Of course I used the map function and looked up when the location got shared and speed (...) I looked up speed, time and place and I always tried to figure out for each location what has this person to do with this special location. So for example if someone shared at [mentions place] I assumed that could be a student, someone who works here or of course some who passes by. So I tried to figure out for every location what is special about this location – can I conclude form a location to a person and if there were enough locations it was often possible to do stuff like that.

I: You said "if there are enough locations" so could you explain a bit more?

P1: Enough locations which are connected to people – if someone just shared a location somewhere in the middle of Münster it often was very difficult to combine this information with something else to get to the player – everyone can be there – it was much easier if a position was in Gievenbeck (Distric of Münster) where I think that most of the students live or at the Institute for Geoinformatics where I can assume that people are students here.

I: Okay you kind of used knowledge which you had previously? So like Background information - what kind of Background information mostly?

P1: I just knew that many students are here - if someone is here I just knew that he is probably a student as well so it is important to know that this place is the university. If someone was at the Robert-Koch Straße I also assumed that it could be someone of the Institute of Geography or Landscape Ecology.

I: So one could say you did some kind of reasoning on the locations try to combine what you know of the place with the people who are usually around that place and find out who that might be in terms of reducing the possibilities - categorizing it, this could be a student or teacher.

P1: Yes.

I: What have you found while looking at the shared locations in the game? You already answered that. Found out about special places, reasoning, categorizing, patterns, structures and stuff like that. Did you miss anything while you investigated the locations?

P1: Well I think from the location we got everything we needed, place, time, speed - everything there.

I: Missed anything from the map interface? P1: Would be nice to see the order of the locations. Which locations were shared the latest.

I: Did you use primarily on a mobile device or on other platforms as well?

P1: When I tried to explore the locations of the player I more or less used always the desktop computer because of larger screen. Of course location sharing was always done on mobile phone.

I: When you looked at the locations which where shared did you find out habits from locations which were shared?

P1: One could always see if a position was shared at different times could assume that it is maybe a part of the road to the workplace and that was also nice (...) that you have the speed value – while driving a car or a bike –

while someone shared a location while he drives you could always assume that it is pattern.

I: Have you found any particular interesting locations or funny things while you looked at the locations which would might give it away?

P1: Well I think there was one location at a prison – where I don't know if the location was actually on the road and the accuracy was to low or anything like that. You don't really know what people are doing there. I think one person was very far in the north of Münster and I don't have any clue what he or she might have done there so it was always a bit curious.

Part III - Submitting Facts

I: Tell me about submitting facts.

P1: I always tried to start with the least specific facts like country, city, zip code. Just because if the zip code is right but the person was wrong you always know it has to be someone living in this particular area. I always tried to decrease the accuracy of the facts.

I: So narrow the potential candidates down?

P1: Yeah.

I: Have you had any specific structure or order for submitting facts? Obviously.

I: Have you collaborated with other players?

P1: Well I think the tagging functions was at some time helpful – where some person said driving in a car and someone else said its buying some groceries. It helped a little bit. But most of facts I figured out myself.

I: So what where the hardest facts?

P1: Phone number, because if you don't know the person very well you don't have a phone number and you can't guess a phone number. You have to know it or you can't submit the fact.

I: And the names or where one was living?

P1: It is a bit more easy because you often know a street or names of some persons. Of course if you don't really know the person you can't submit a name.

I: So most or all of the players you were submitting facts about you knew somehow?

P1: Just persons I knew from the university, friends of friends, but also close friends.

Part IV - Last Questions

I: Are you familiar with Online Social Networks (OSNs)?

P1: Yeah I have a Facebook account, had StudiVZ – I sometimes shared locations on Facebook but not as often as in JohnDoe. I am very familiar with them.

I: So you use them as well?

P1: Yeah.

I: Are you familiar with Locations Sharing Applications (LSAs)?

P1: Like Foursquare? Yeah I know them but I did not use them. I used Facebook as I said to share a special location one or twice – on a party or something like that but I never shared at home or at work.

I: Why don't you use them?

P1: Don't see the point in using them sharing locations for everybody. I can tell my friends or tell them directly. But if you play it as a game of course there is a motivation.

Appendix B.3. Participant 2

Part I - Sharing Locations

I: Tell me about sharing locations in John Doe.

P2: I was pretty new to a mobile device or smart phone and I couldn't use the information right away and I needed a little help from some other persons. I tried to download the application that [mentions a player] had developed and it worked fine. Sometimes the site said "the website has cached the location and you cannot submit your location" that was a little bit annoying and I did not know how to solve it and I just restarted the smart phone. That was it about the technical part and then the tactical part was:

I avoided to submit any location in my neighborhood. The zip code was also some information to find it out from me. I also tried to avoid this one in my zip code area where I live or where I work. By accident it happened that I visited my parents who do not live in Münster and I went there by train so I had many opportunities on my way to share information which cannot be connected to me right away. It was last weekend that I had to wait for a train for about twenty minutes and I used this time cause otherwise I would just stand there and wait to go around the train stop and share location on the one end of the train stop and to the other and one player was complaining about that. He was written a comment about it that it might be cheating – but it was just – it shorted my waiting time. Also when I was on my way back from work to my home or the other direction I submitted points when it was in between the zip code areas of those two areas.

In the last game it was obvious cause we went to an event with most other player and I shared a location there and after I shared a location there my identity was found out.

I: So you knew the people you were playing with?

P2: Aehm, yeah cause some of them were already re-identifed.

I: So you would say as you walked around the main station that was on purpose?

P2: Yes.

I: So you could say you tried to make as many points as possible there or did you want to confuse somebody?

P2: Actually it was about winning points. And it was for each location you submit you gather 10 points. As the "leader" the game leader with the most points was a 100 points ahead I tried to reach him by just submitting 10 locations. It was not to confuse the others cause if they had a look at the map they knew I was at the train station and so they could easily derive from the position that I was waiting for a train I guess. So it did not make any sense to have the intent to confuse them – it was more like winning the game.

I: So you had some kind of special attitude and structure while sharing. So you told me you avoid special places – did you avoid also certain times during the day?

P2: Aehm – no – cause the question at the registration from was where I would spend the most time between a certain time interval and this location was my working place. And whenever I was at a certain other location and not at my working place between this time period I tried to share as many points as possible when I was not at home of course.

Part II - Investigating Locations

I: Please tell me a bit on how you investigated the locations of other players.

P2: So finding out where the other players have been? Okay – so that was really hard. Cause I thought or in this game this might be obvious to have the same tactics as I did. So I thought I could not get that much information about the other players. But only the city the city they live in at work at. That was sometimes wrong anyway when I guessed that. Guessed that someone was working in Münster. But he or she was not. So and some of the other locations of the players where at the train station - actually most of them or pretty much all of the player locations where at the train station and that showed me that they either had to ride home with train or also visit relatives or something like that. Aehm – then there was another player just in the current game who shared locations in two other towns then Münster. What should I guess about that? Maybe one of the towns would be his home town and another one would be his working place or he would (...) he would just went there to the cinema or to visit some friends I don't know. I think it was really hard. When sometime points where near to a supermarket – and I also thought it would be a good opportunity when I go to a supermarket to share a location – aehm (...) then I thought okay I tagged the location "shopping" But actually from the location I could not gather any information. When the location was at this known building where I work at and I knew or guessed that some players were also working here or were colleagues of mine then I thought okay as soon as they publish information here around the ifgi that their working place would be ifgi. To be honest from the locations I did not guess that much.

I: Okay - because there were to few? Or would you need more?

P2: They were to spread and to confusing. Ahem – yes some of them were in Münster but spread all over Münster and other locations where in a town – in Hamm for example – one player submitted certain locations in Hamm. Then I guess that his or her working place would be in Hamm. So I lost 40 points that was pretty much (...). And then I tried to say his home town was Hamm and that was also wrong, so I did not try to make any attempts about this town as soon as not all of the points where located in Münster.

I: So you didn't use or did you use the additional information like temporal information, the speed and the heading? Which were provided by the location? Did you check them out?

P2: No I didn't.

I: So did not know that that you could tap on a location and an info window would pop up telling you certain things?

P2: Whenever I tapped on the location on the mobile device I was invited to tag it.

I: But there were also other parts where you could see the time, speed and heading ? Perhaps you don not recall it or have not seen it.So it was hard to find patterns or habits in the shared locations?

P2: Yes, it was very hard. You had one location in eastern Münster and one in western Münster and then suddenly in Osnabrück. So no location in the train station. And another player tagged the location in Osnabrück that the player that submitted that location could have possibly a car. But what could tell this to me – but I don't know – most of the people in the world have a car. So (...).

I: Did you miss anything while you investigated the locations? Any certain feature in the game or perhaps vital additional information one could display.. anything?

P2: No. Nothing comes to my mind. Cause what you need from the location, you need x and y – latitude and longitude – the time you have shown the location on a map anyway.

I: So you wouldn't be interested in seeing the last shared location highlighted perhaps or a trajectory?

P2: Yeah – if you say that – maybe to cluster the points somehow – yeah that were submitted in a certain time period – cluster them by hour, last three to five locations. And the direction – I haven't realized that. That would be very good to find out a player work place and home. So from my tactic it would be pretty obvious when I always share a location in a park when was going towards ifgi in the morning and towards my home in the evening I live somewhere near to that point (...) so heading (...) yeah (...) that would be nice if I knew that before.

I: Did you use the page primarily on a mobile device or on a other platform as well?

P2: Also on the computer.

I: For what?

P2: For guessing facts about other players. Cause it is subjective and I don't like this tipping with one finger.

Part III - Submitting Facts

I: You have already told me a lot of stuff about that – but anyway. Tell me about submitting facts.

P2: When I submit facts or when other players submit facts about me?

I: You about other players.

P2: Okay so - there was one tactic when the game starts. It was pretty obvious that most of the players come from Germany. But I thought that were easy points. So there were just 5 points for each guess. So I'd rather share three or four locations in the right place. But that actually was a pretty interesting part when you played the game more than once. Cause I played the second round. In the end of

the second round it was obvious that that one player who was already identified – his name or identity – he made use of that opportunity of those easy points. He submitted the facts that where obvious – everyone was living in Münster and living in Germany – and so he also did that right in the beginning of the third game – and I thought hey who is he.

And I just guessed his name and of course it was right and it was him. And (...) that was one strategy and the other facts – so I did not know how to find out any facts from only the location.

I: So all facts are pretty hard?

P2: Yeah facts where really hard. Where should I get the date of birth from? Where? When not Facebook? And yeah it was really funny – actually I did not want to be friend of those guys in Facebook – when I can't see their date of birth – they also could not see mine. And that what was some players did – I got some – when my name was known in the second run of the game – I got some invitations on Facebook to be a friend of the other players. Or possibly the other players. Right after my name was known (...) that was interesting – but to submit facts about the other player from only the location – I mean I know that some of my study colleagues where playing the game and here is a room where some of the information like birthdays are noticed in the "Fachschaft-Raum" and I went there and I tried to find out the telephone number and I tried to find out the birthday and that was successful of course. But the other players I didn't know them are not anywhere (...) I didn't know. I even tried – when I knew the name of a player I stared to search him on the web – that was interesting – cause it was that player that submitted the points in Hamm and I thought that – when I typed his name into Google I just gather more information.

And then I found out a page saying where he went to school actually - to the Gymansium and I tried to (...) cause his working place was not known before – to type in this name. And I thought okay he went to school and his parents might live there – and it is not that far from Münster – his working place could be there if it is not in Münster. But that was wrong anyway. I started to stop guessing (...) cause 40 points (...) you had to share 4 locations) I thought it is really hard.(Actually it is twenty points – you had to share two locations to compensate) The birthday or street number – you can't gather it from the web – or I don't know how.

I: You could try to use telephone books or something like that.

P2: I tried to (...) it is not in the internet (...) most of the students are even not listed there. Telephone books – "Das oertliche.de" and Google (...) yeah and Facebook. Cause Facebook is known to say really much about a person. But guessing other facts it was really hard. There were other player whos name I haven't even heard before (...) and to find out their birthday. Or where they live (...) that was impossible for me at least. And I've also observed that as my name was known to the other players – they did try to submit guessings about my birthday cause they did not know me. And it was not written anywhere in the web. And also they did not know my house number. Where I live. Also they identified me not by making conclusions they did it by trial and error (brute force). They first thought I was another player (...) that was that situation where we visited the brewery and they tried out the other players that where at the brewery and I was one of the third or fourth they tried (....)it was just brute force to find out who I was.

I: Have you collaborated with other players to find something out?

P2: If you are active and someone is finding out the name of another player you can jump on the same train and submit other facts about this player right away. I actually started to tag some locations of other players – but I really had to concentrate on one player (...) I couldn't multitask and tag the other players as well, but I had to concentrate on one player. So that was really hard cause the other players were not concentrating on that player I thought if everyone would be concentrated on one player that might be a little easier. So okay (...) there are five of us (..) and we try to find out who that player is (...) so I used the tagging function (...) and the comment function just one time when I was accused to be cheating (...) and I actually it did not work because I send the message to early (...) my mobile device skills are not that good. I am pretty new to it.

Part IV - Last Questions

I: Are you familiar with Online Social Networks?

P2: I am familiar with Facebook, StudiVZ – I used it too. I tried to hide as many information as possible. That is actually a good opportunity to make the others loose points (...) cause I have set a wrong birthdate on my Facebook account. And I also have not submitted my real name other users could not find me and gather information about me right away. They just add me if they knew who was hiding behind that particular user name. Some other players who knew me better that know my birthday is wrong.

I: So you are using them as well?

P2: Yeah.

I: Are you familiar with location sharing applications like Foursquare and Gowalla, ...?

P2: No I am not.

I: Okay you are not using them either.

I: Anything to add?

P2: No – actually I enjoyed to play, really – it was really interesting you had just the motivation to gather points but that was okay and even if you are not (...) the points where one motivation (...) it was interesting. This case I have told you before (...) when I identified that person who made those easy points right away I think he was very angry about that. And he thought I could make a good game (...) and maybe a cool function would be to see in the end who has submitted stuff about that fact.

From that you might see the relations who submitted the birthday, street number, zip code (That was in the game the news system).

Appendix B.4. Participant 3

Part I - Sharing Locations

I: Tell me about sharing locations in JohnDoe.

P3: The concept is to share location to get points for it – so this makes the game really attractive for me and so I tried as much as possible but still it was aware to never share a location near my workplace or my home. I did it always on the way. Most likely I did it at the Coesfelder Kreuz cause I know of many other participants crossing that area (...) sharing that location (...) I would be still anonymous and no one could really know who is the one who is seen at the hospital there. Yeah I tried to do it on a daily basis (...) once per day – if I was somewhere else then at my work or home location.

I: So one could say that you avoided sharing specific locations?

P3: Yeah.

I: And you had a special structure/ attitude for sharing locations?

P3: Yeah I tried to anonymise my personality – so no location which can give other people direct hints who I am.

I: Did you avoid sharing at specific time frames?

P3: No.

I: Have you taken any steps to confuse other players - taking detours, sharing unusual locations?

P3: Sure. Yeah one time I went like 200m of my usual why from home to work so that it was just in the middle of the big hospital - the uni klinkum here in Münster and otherwise I was not really detour but I mean (...) on the one hand it was not really a detour but on the other hand – there are many ways from my home place to my workplace so I just choose another way so this is kind of a detour. It is not that the way is longer but that I did not pass every way the same way.

I: So you altered your usual behavior?

P3: Yeah exactly (...) that it is. Yeah and if at the weekend was something special and I knew no one of the other participants (...) as far as I know who is in the game (...) did not know about it I shared a location. For instance I was with some friends – some other friends – which were not for sure in the game we were driving on the motor way – I shared my location.

I: Okay you said you kind of knew who was playing the game – how? P3: Yeah cause many other guys of the Fachschaft were involved in the game and (...) yeah just by talking.

I: So you did not know who exactly they were in the game but that they probably playing the game?

P3: Yeah (...) I had no connection to a specific avatar in the game.

Part II - Investigating Locations

I:Tell me a bit on how you investigated the locations of other players.

P3: First of I have to say that interface for the investigation is quite simple you (...) first of all you have to think about which player you want to know more about – you have to choose a specific player and you have to choose (...) this was (...) to say it more in the right order: I first looked at the news and I saw this player is quite active and shared several locations so I picked up this guy on the map which reveals the locations and then I selected several locations looked at the date and tried to get more specific details like the speed if shared his location while being on a vehicle or just standing somewhere. And this can give some few additional clues. That was my basic approach. The problem was that you have to do it for every player so many clicks (...) or I did not try to reveal players location (...) just I think the most active or when it was interesting and there were maybe some facts already been known about this player.

I: So you looked at additional information provided by the location like speed – and the other things?

P3: Exactly. So speed, heading – but I did not try to make any clues with the heading but at least I knew that he was on the move.

I: Did you also use the temporal information provided? Like when on a day?

P3: Yeah sure, sure – in the first round this gave me a big clue case two guys at a party shared the same location and I think it was between (...) quite late in the evening (...) and I knew for sure that these guys where at a party but they did not know each other shared a location (...) I got know afterwards (...) but that was a big help.

I: What have you found while looking at the shared locations in the game?

P3: You mean which clues I got? People share location all across Münster. Like me no one was sharing his location at home or most of time not here at the Institute of Geoinformatics (...) from what I knew most of the people where from here (some – not all) and no one shared a location here (not true). Yeah my other clues were that when they were just cycling or for example at a weekend then there was the carnival here in Germany (...) and when they slept at other places for partying or not sleeping maybe.

I: So you found certain patterns or habits..?

P3: Not so much maybe I had to guess for single shared location for a specific time what he was doing, but in total there where not so many patterns I discovered. It is not like that I was sure about what they were doing sometimes I guessed, sometimes I tagged the location and I tried to guess what they were doing and looked how other people tagged the shared location.

I: How did you learn about certain facts about people?

P3: Some facts were just general statements. I knew for sure that there were probably all from Germany that was so obvious. I did not reveal so many players (...) after some facts are known and I knew the persons I could easily

submit other facts. If one guy just submitted the name and the surname was easy (...) and finding a picture was easy.

I: So you "jumped on the train when somebody discovered something" and you were like "I know him as well" and I can submit facts now?

P3: Exactly (...) actually I took over the train.

I: And how exactly did you get this additional information, how did you get birthday, mobile number, zip code, ...?

P3: Some I know by heart, some are stored in my mobile and most of the other facts I wanted to know (...) either if it is work location same like me at ifgi here (...) Facebook is a big help. It is a good information source for birthdays and if you want to have a picture (...) sometimes even home address. Not all of them share this kind of information there.

I: Lets go back to locations and investigating locations. Did you miss anything while you investigated the locations?

P3: Yeah (...) a better interface to see all the shared location of one player with all the detailed information at one time – so on a map you see just the markers, showing the locations he shared it would be so interesting to see when he shared the location otherwise (...). It is like you have to click on a single marker, click on details (...) and then you know when this one was shared / tagged. If you see them all together it would be way better to investigate what they were doing. When they shared their locations. Maybe even have advanced query mechanisms that you can ask for several player at the same day. Otherwise you have to click there, there, to get every single information for one player but never several information for several players for same time, for one query.

I: So you are quite familiar in dealing with spatial information?

P3: Yeah.. that's for sure.

Part III - Submitting Facts

I: How did you submit facts.. had you any particular order,...?

P3: First of all you try the easiest one (...) like town and country and workplace (...) after you got some clues and shared locations it is just trial an error. You try several names, and you try several first names and one fits. I knew there were not so many guys in the game and then it was just easy if this name isn't working you would have that player. (He actually did not do this; he submitted very few facts, only completing information)

I: So the game for you was mostly about re-identification and not about points?

P3: Not so much (...) just for finding out facts that was my strategy (...) most of the points I got from sharing locations. Trying to guess who is who (...) I tried it not in an advanced stadium (...) and some of the facts (...) If I have enough clues then I would just trial and error but I did not do it so many times.

I: Did you employ any kind of third party information, you already mentioned Facebook any more information on that?

P3: Facebook as a source for facts (...) especially if you knew the name but not the exact spelling, then it is a good one and I told you already my mobile (...) with the contacts that is it of what I used of third party knowledge.

I: Did you collaborate with other players?

P3: During the game not so much (...) I know one session for sure that was during the first time I played the game. It was on a Thursday and everyone was here and many people involved in the game gather in the room of the Fachschaft and we were talking about the game and then I talked to another guy and asked him if he is in the game or not and then we exchanged some information (...) yeah I cannot reconstruct the session but we talked to much about the game and there was so much information (...) and one guy told me I will reveal that fact and in the game you know that the guy who revealed that fact just stated it before (...) he is going to do it (...) that was some kind of collaboration (laughing).

I: So you used that info.

P3: Yeah after many of the guys where revealed I sat together with another guy and we tried to guess about the remaining player who remained anonymous and who they are and just looked at every piece of information they shared and together guesses what they were doing there at that time.

Part IV - Last Questions

I: Do you know Online Social Networks?

P3: Yeah like Facebook or like Google+ or the former big one in Germany like StudiVZ.

I:So one could assume you used them as well?

P3:StudiVZ I am not using any more.. Former times a lot. Facebook several times a day to gather some news (...) statements about friends. Google+ not so much, I am more passive in that network.

I: Do you know Location Sharing Applications?

P3: Yeah heared about Foursquare. And Facebook wants to know always my GPS-position when I am turning on my Facebook app. But I don't know which information they are using in detail.

I: So you are using them or not?

P3: No I am not using them.

I: Why?

P3: I don't like the idea just to say yeah guys I am here. I don't like the idea of sharing my locations and telling them I was here at that time. When I look at Facebook I think it is more for people who pose that they want to say they were at a particular club or special university.

I: Any additional comments?

P3: About the game? First of all for the game (...) for me it is only working if you know some of the other players (...) personally (...) otherwise it is quite a hard to submit facts about them beyond the level of country and maybe town. So you get to have enough players to be motivated to be in the game. And yeah I would appreciate

a more sophisticated interface to gather information about the other players I already told you about the advanced queries.

Appendix B.5. Participant 4

Part I - Sharing Locations

I: Kannst Du mir über deine Erfahrungen mit dem Teilen von Orten berichten?

P4: Mein Handy hat Probleme mit dem Teilen von Orten. Wenn ich im Bahnhof im Zug gesessen habe, ohne dass der Zug überhaupt gefahren ist hatte ich keine Chance den Ort zu teilen mit meinem Handy. Ansonsten hab ich mglichst geschaut das ich Orte teile wenn ich unterwegs bin, also nicht immer an der gleichen Stelle.

I: Hattest Du irgendwie eine spezielle Strategie zum Teilen von Orten?

P4: Ja, wenn ich irgendwie unterwegs war (...) weil jetzt Semesterferien sind hatte ich keinen richtigen Alltag und wenn ich dann mal irgendwo längere Strecken gemacht habe und mit der Bahn gefahren bin habe ich geteilt.

I: Du hast zum Beispiel Orte in Hamm und in Köln geteilt.

P4: Genau schön weit weg.

I: Warum schön weit weg?

P4: Fand ich dann interessanter als wenn ich es immer zuhause mache. Außerdem kann man mich zu Hause wahrscheinlich am schnellsten identifizieren.

I: Dich hat im Spiel soweit ich weißkeiner identifiziert. Also du warst in 2 Runden dabei und es hat keiner rausgefunden wer du bist.

P4: Wundert mich jetzt nicht. Ich habe versucht nicht immer so eindeutige Orte geteilt. Außerdem glaube ich das nicht so viele mitgespielt haben die mich kennen und über mich findet man relativ wenig im Internet mit Facebook und Co.

I: Man kann also zusammenfassend sagen Du hast eine Strategie gehabt um Orte zu teilen möglichst an öffentlichen Orten und hast bestimmte Orte vermieden.

P4: Ja

I: Welche wären das gewesen?

P4: Zum Beispiel meine Wohnung. Oder ich hab zum Beispiel auch da, wo mein Elternhaus ist Orte geteilt, aber das war wieder an einem Bahnsteig, da könnte man denken da wäre ich Zug her gefahren.

I: Also du hast Dir bewusst überlegt welche Orte du teilst.

P4: Ja, Münster Bahnhof da kann jeder hergehen.

I: Hast Du bestimmte Zeiten vermieden um Orte zu teilen?

P4: Nein - darauf habe ich nicht geachtet.

I: Hast Du irgendwie Schritte unternommen um Leute zu verwirren? Zum Beispiel dein Alltag verändert oder bestimmte Orte besucht oder so?

P4: Nein ich hab wirklich drauf geachtet, dass es ein Ort ist wo ich sonst normalerweise nicht bin.

Part II - Investigating Locations

I: Erzähl mir bitte etwas über das herausfinden von Fakten.

P4: Ich hab es ein bisschen gemacht. Tags und so was angeschaut. Ja, da fand ich (...) als ich nachgeschaut habe, da hatten Leute noch nicht so viel geteilt. Da fand ich das sehr schwer. Aber man konnte bei einigen sehr klar heraussehen, dass sie sich hauptsächlich in Münster bewegen. Da hätte man schon mal den Ort herausfinden können. Bzw. der war meistens schon rausgefunden, wenn ich geschaut hatte. Oder Orte wie die Uni immer abklappern, vielleicht dads er bei der Uni arbeitet oder studiert. Solche Sachen konnte man gut raussehen dadurch. Ja (...) sonst die Karte – teilweise habe ich mir die Koordinaten nochmal in anderen Karten angeschaut, weil dann fand ich das wenn man die Gebäude dazu sieht.. das war ja eine relativ grobe Karte – das man das dann feiner sieht – besser rausfinden könnte wer dahinter steckt.

I: Hast Du dir auch weitere Informationen zu den Orten angeschaut die mit angegeben waren?

P4: Angeschaut schon, aber nicht so viel nicht daraus interpretiert. Vielleicht aus der Zeit wenn es nachts war und vorm Schloss ein Ort war. Die haben da vielleicht Flunkyball gespielt (...) nicht viel aber so was.

P4: Hast Du irgendwie Muster oder Hobbies erkannt?

I: Ich hab die Karte nicht so oft benutzt, aber großwas rausgelesen, dass wer Fußballspielt habe ich nicht gesehen.

I: Hast du irgendwas vermisst wenn Du die Karte benutzt hast?

P4: Ich hätte es gerne genauer gehabt. Eine genauere Karte, aber das habe ich mir dann selbst anders angeschaut.

I: Hast Du die App primär auf dem Handy genutzt oder auch auf dem Desktop?

P4: Auf dem Handy, die Orte und die News, die Karte hab ich primär auf dem Desktop angesehen, war eine größere Karte einfacher schneller.

Part III - Submitting Facts

I: Hast Du versucht bestimmte Fakten über jemanden rauszufinden und submitten?

P4: Nein. Also, ne glaub ich nicht. Ich wollte mal die Orte angeben, aber dann habe ich festgellst, dass die schon alle angeben waren. Die waren alle bekannt. Habe dafür wohl auch nicht oft genug geschaut.

I: Du hast dann wahrscheinlich auch keine spezielle Struktur gehabt?

P4: Nein, aber den Wohnort wäre wohl relativ schnell gegangen, aber den Namen da hätte ich nicht gewusst wie ich den hätte rausfinden sollen und so weiter. Hätte nicht gewusst wie ich da hätte rangehen sollen und extra einen fake Facebook Account anlegen da ich da nicht bin (...) und selbst da wüsste ich nicht genau wie ich die Informationen nutzen sollte.

I: Also war es tendenziell eher schwierig etwas über die Leute herauszufinden?

P4: Ja bis auf so Sachen wie Wohnort die scheinbar offensichtlich sich, das Land auch, das ist ja ganz einfach.

Genau diese Informationen habe ich dann auch versucht zu vermeiden bei mir, also nicht so offensichtlich zu machen.

I: Hast du versucht mit anderen Spielern zusammenzuarbeiten oder zusammengearbeitet?

P4: Ich hab glaub ich mal was getaggt, ansonsten habe ich mir auch Tags durchgelesen aber nicht persönlich.

Part IV - Last Questions

I: Kennst du Soziale Netzwerke?

P4: Twitter, Facebook, StudiVZ. Bei Twitter bin ich selber – bin allerdings dort privat. Freund von mir benutzt Foursquare, da ist es dann ja einfach was über die rauszufinden.

I: Kennst Du die ganzen Location Sharing Applications?

P4: Ja, Foursquar, und Facebook wollte so was ja auch mal machen.

I: Aber du benutzt die nicht? P4: Nein, auf keinen Fall.

I: Warum?

P4: Weil ich da relativ viel über mich preisgeben müsste. Ich mein ich bin sowieso nur in Twitter unterwegs, da tweete ich privat. Der Anbieter kann dann ja trotzdem meine Daten abgreifen dadurch, ich gebe jetzt zum Beispiel nicht an bin jetzt hier und hier mit dem und dem, oder ich gebe nicht an was ich gerade mache. Ich teile dadurch nur links die ich wichtig finde und selten persönliches. Ich versuche mit solchen Daten sehr sparsam umzugehen.

I: Hast Du noch irgendwelche Kommentare, Hinweise?

P4: Cell - ID hast du nicht drin?

I: Indirekt.

P4: Mh, das habe ich öfter das das mit meinem Handy nicht ging.

Appendix B.6. Participant 5

Part I - Sharing Locations

I: Tell me about sharing locations in JohnDoe.

P5: At first I was a bit confused about the sharing part, at first it was just a browser interface and playable via the handy browser and I found that confusing because most of the games in this direction like foursquare are a native app. In the later stages I found it great that we had an app version that was great.

I: Could you explain a bit more how you shared locations?

P5: I did share locations but nearly enough I think, it was a bit hard for me to share locations. I had the feeling every time I could share locations people I knew already in real life – that played this game as well – would directly acknowledge me. They knew where I live and my hometown and origin home town. I am not really from Münster and because of that and it was played in the semester break I found it hard to share locations because I thought I would be directly recognized.

I: So you avoided sharing specific locations?

P5: Exactly.

I: Did you also avoid sharing at specific times?

P5: Not really time specific – if I were at a location that I thought I could share without directly giving myself away.

I: Where the locations you shared public for example?

P5: If I was going shopping for example on the way to the supermarket I thought about the specific location. I tried to share a location on a bridge over the lake because I thought it is a direct route. Almost everybody could have shared this location so I guess you can say I made thoughts about that.

I: So you had a specific structure?

P5: Yes you could say that.

I: Although you did not share many locations – did you try to confuse other player with detours and such?

P5: Not really I guess I kind of think that would be cheating. I was a little bit too lazy for that.

Part II - Investigating Locations

I: Tell me a bit on how you investigated on the locations of other players?

P5: Not really – have not done that. I found it hard to get interested in that.

I: Could you explain why?

P5: Part of it was I was I had to learn a new interface and observe nearly daily changes. Was too was lazy – maybe if it were a little bit more like a native app and a you get notification(...) or popus (...) but you get the drift. 00:06:21-8

I: At some points the game started to twitter did you see that?

P5: No, but that is great. Twitter would be great. And people check twitter daily (...) at least I do it.

I: Have you seen the temporal information or speed or did you disregard that part of the game completely?

P5: Disregarded it completely.

I: Have you found anything interesting?

P5: I did not check it.

Part III - Submitting Facts

I: Tell me about submitting facts if you have done it?

P5: I did not do that on this part I think that I don't understand it fully (...) most of the players knew each other. If I had one fact I most certainly would have everything so I found it hard to take the game seriously in this direction.

I: So you did not submit facts because you were not interested in that?

P5: Exactly.

Part IV - Last Questions

I: Are you familiar with Online Social Networks?

P5: Yes, I think I know them all but I am not a hardcore user of them.

I: Do you have a Facebook Account or something like that ?

P5: I have a Facebook Account and Google+ Account but I use more in a twitteresque way – to follow people.

I: So to stay informed?

P5: Yes.

I: Are you familiar with location sharing applications?

P5: On the surface.

I: Have you used them?

P5: No but I get exposed enough I think.

I: Could you elaborate a bit more on that?

P5: Most of my colleagues in the university use them daily, hourly sometimes excessive.

I: And you don't like the notion of them?

P5: At least here in Europe in I don't see the merit in that. I know from a friend in the USA that in the USA you get discounts from being in a top location in Foursquare for example at Starbucks you get 10 %. And then it would make sense. Currently I think you just give away your personal information and have nothing fruitful coming out of it.

I: And if that were the case you would be willing to share your private information? Yeah (...) it is difficult for me (...) private information is a valuable good.

I: So you would think really hard about that?

P5: Yes.

I: Have you any other suggestions or something you just want to say?

P5: It is a good idea. I am thankful to get information about it and if you say you developed a twitter integration. I find that great. I guess a native app would be a lot nicer.

Appendix B.7. Participant 6

Part I - Sharing Locations

I: Erzähl mir etwas über das Teilen von Orten in JohnDoe.

P6: Ich hab danach entschieden – ich hab versucht mich in die Lage der anderen Spieler hineinzuversetzen und dadurch versucht so wenig wie möglich von meiner Wohnnähe zu sharen. Das ist mir aber in der ersten Runde relativ schlecht gelungen – dann habe ich drei Mal in einer parallel Straße eingecheckt – dadurch wurde ich dann entlarvt. Man checkt auch nicht ein wo die Leute wissen, dass man da ist. Man muss auch ganz genau überlegen was man den Leuten dann im Nachhinein erzählt wo man dann war – denn das war der Fehler bei [nennt einen Spieler].

I: Man kann also sagen das du bestimmte Orte vermieden hast und Dir Gedanken gemacht hastet welche Du teilst?

P6: Genau.

I: Hast Du versucht Zeiten zu vermeiden?

P6: Die Zeiten waren für mich irrelevant.

I: Hast Du irgendwelche Schritte unternommen um Leute zu verwirren – also längere Wege nach Hause oder ungewöhnliche Orte geteilt?

P6: Nein – die Idee kam mir erst zu spät – als ich schon aufgeflogen war.

I: Was hättest Du denn dann geteilt (...) also was hättest du getan?

P6: Ist gerade weg – vielleicht fällt er mir noch ein. (...) Eine lustige Verwirrungstaktik, die ich nicht mehr anwenden konnte weil ich aufgeflogen war, war folgende: Bei irgendeiner Person "versuchen" den Vornamen rauszubekommen und einfach den eigenen Vornamen als Versuchsnamen benutzen. In der Theorie müssten die anderen Spieler dann davon ausgehen, dass man selbst gar nicht die Person sein kann dessen Vornamen man versucht hat bei einem anderen einzugeben. Verstanden (lacht)? Und meine Freundin hat mich vorhin noch an was lustiges erinnert. Als ich mit ihr unterwegs war und bei JohnDoe Orte geteilt hab, habe ich ihr verboten an selbigen orten bei Foursquare einzuchecken! Sie hat teilweise dieselben Freunde bei Foursquare wie ich, somit hätten die 1 und 1 zusammenzählen können.

Part II - Investigating Locations

I: Wie hast Du die Orte von andern Nutzern untersucht?

P6: Wo fange ich da am besten an? Wir waren ja bei Rohling – da habe ich bei den News gesehen, dass da ziemlich viele Leute geteilt haben dann wusste ich ja wer bei der Besichtigung dabei war. Dann hab ich mir jeden Spieler einzeln vorgenommen – versucht bei Foursquare zu schauen ob zeitgleich oder zeitnah jemand eingecheckt hat – während der Besichtigung hat [nennt einen Spieler] mit [nennt einen anderen Spieler] drüber geredet das er in Hamburg war. So habe ich den einen Spieler als [nennt den ersten Spieler] identifiziert weil ein Spieler auch in Hamburg war. Seine Adresse rauszubekommen war etwas schwieriger, da musste ich in alten Emails nachsehen.

I: Also hast Du auch Informationen aus dritten Datenquellen genutzt?

P6: Ja die beste Quelle dafür ist Facebook. Wenn ich den Namen hab dann ist er komplett aufgeflogen. Also die meisten haben da ja ihr komplettes Geburtsdatum angegeben – Straße und Hausnummer kann man dort ja nicht verbreiten- - aber mit [nennt den ersten Spieler erneut] hatte ich vorher in einem Fach eine übungsgruppe und da haben wir uns dann alle bei Ihm getroffen.

I: Also Du kanntest die meisten Spieler?

P6: Ja – die meisten kannte ich – sonst hätte ich die nicht rausfinden können.

I: Weil?

P5: Weil da sonst komplett die Anhaltspunkte fehlen würden, vielleicht hätte man den Arbeitsplatz bei andern rausfinden können, aber (...) ja.

I: Und dann hätte man dort zum Beispiel auf der Homepage gucken können?

P6: Ja so habe ich das zum Beispiel beim [nennt einen dritten Spieler] gemacht – er war auch einer von denen die bei der Rolinck Besichtigung dabei waren. Und bei Ihm hatte ich schon rausgefunden dass die Person im ifgi arbeitet und dann habe ich auf der ifgi Homepage bei den Mitarbeitern geschaut (...) und hab dann gesehen ach ja der [nennt den dritten Spieler] war ja auch dabei und hab ihn so entlarvt.

I: Also du hast quasi so eine Art Data Mining gemacht und viele Datensätze angesehen?

P6: Ja, also wenn ich Punkte haben will und die machen will, da versteife ich mich da echt.

I: Hast Du irgendwelche Hobbies oder Muster entdeckt?

P6: Also wie es mir aufgefallen ist, haben die meisten weit weg von zu Hause geteilt – also auch abstruse Orte geteilt – zum Beispiel der [nennt einen vierten Spieler] war irgendwann mal in der Warrendorfer Straße und ich konnte mir nicht ausmalen was er da gemacht haben soll.

I: Also Du hast also gefunden das es fast keine Muster beim Teilen gegeben hat – also bewusst alles abstrus und konfus war?

P6: Also bei [nennt den vierten Spieler] wirkte es eigenartig.

I: Du hast also auch auf alle Orte geschaut von einer Person und gewartet bis du einen gefunden hast der dir mehr sagen konnte?

P6: Genau.

I: Hast Du mit anderen Spielern zusammengearbeitet?

P6: Nein – also als ich und andere Aufgeflogen waren, da haben wir über das Spiel geredet aber nicht zum Entlarven.

I: Hast Du das Tagging System oder die Kommentare genutzt?

P6: Ja teilweise.

I: Findest Du das sinnvoll?

P6: Naja das sieht man auch auf der Karte – aus jux und dollerei habe ich das gemacht.

I: Wenn es Punkte gegeben hätte dafür – hättest Du es mehr genutzt?

P6: Vielleicht, aber man muss ja bedenken, wenn man das nutzt dann läuft man Gefahr das man anderen Leuten das dann zum enttarnt nutzen – dann klauen se einem Punkte. Also ich hab ja z.B. den [nennt den dritten Spieler] enttarnt in dem Wissen das andere die Punkte kassieren. Ich kannte seinen Wohnort nicht usw. Habe seinen Facebook Account nicht rausgefunden und auch bei Google nichts. Aber über Google konnte ich noch ein Bild herausfinden. Immer wenn ich gesehen habe, wenn jemand einen Ort geteilt hat habe ich mich ran gesetzt und geschaut, ob ich etwas herausfinden konnte. Habe die Twitter Integration genutzt.

I: Hat dir irgendwas spezielles gefehlt?

P6: Naja es wäre gut, wenn es gleich chronologisch sieht, wenn man allgemein das Datum am Ort sehen würde. So musste man zu viel klicken. Die zeitliche Information war ziemlich wichtig. Geschwindigkeit und Ausrichtung nicht – bin davon ausgegangen das die meisten eh mich Fahrrad oder zu Fußunterwegs sind.

Part III - Submitting Facts

I: Erzähl mir da etwas drüber ob Du eine Strategie gehabt was zum Beispiel als erstes submitted hast?

P6: Geschlecht, ist relativ wichtig, Land, Stadt am Anfang immer – immer versucht erst mal beim Arbeitsplatz die Hausnummer versucht. Da können die Spieler nichts falsch machen - bei Straßennamen können sie was falsch schreiben - um sicher zu gehen dass ich nicht zu viele Punkte verliere. Da war ich mir sicher, dass es der Arbeitsort war dann kann man bei der Straße nochmal eine andere Version probieren. Dann Name und Vorname ging dann relativ schnell wenn man den Ansatz hat wer es ist. Dann Geburtstag – da musste man dann nachforschen, aber außer bei Facebook findet man die dann nicht.

I: Du hast noch andere Fakten geteilt - oder rausgefunden?

P6: Die Mobilnummer – das war in der ersten Runde lustig – da war ich noch nicht enttarnt und konnte deshalb meine Freunde nicht fragen ob Sie mal die mobil Nummer von [nennt den vierten Spieler] haben – ich hatte auch mal bei WhatzApp gefragt aber keine Nummer bekommen.

I: Ich hab gehört das andere Spieler Facebook Freundschaftsanfragen bekommen haben – hast du das auch gemacht?

P6: Nein das war ich nicht.

I: Du hattest aber eine spezielel Struktur beim submitten von Facts?

P6: Ja – ich war mit immer relativ sicher beim submitten – wollte nicht so viele Punkte verlieren – außerdem ist Trial und Error nicht dem Sinn des Spiel entsprechend.

Part IV - Last Questions

I: Du kennst soziale Netzwerke?

P6: Facebook, Jappy, WhatzApp, (...)

I: Du benutzt die auch?

P6: Ja.

I: Du kennst Location Sharing Applications?

P6: Ja - nutze Foursquare.

I: Warum?

P6: Ja, nen richtigen Grund gibt es nicht – weil es das gibt einfach und man kann auch mehr oder weniger Punkte sammeln. In Verbindung mit JohnDoe habe ich das so gut wie gar nicht mehr benutzt.

I: Interessant - Warum?

P6: Weil die Leute mich dann schneller rausgefunden hätten – [nennt drei Spieler] – die habe ich bei Foursquare drinn die hätten da garantiert was rausgefunden.

I: Hast Du noch Kommentare, Fragen?

P6: Ist der Admin auch [nennt Spieler]?

I: Ja – aber der hat andere Profildaten – sonst noch etwas?

P6: Nein, das wärs gewesen.

Appendix B.8. Participant 7

Part I - Sharing Locations

I: Erzähl mir etwas über das Teilen von Orten

P7: Teilen von Orten – da gab es einen Unterschied im Interface von der ersten Runde die ich gespielt habe zu der zweiten. Der Unterscheid war daran das in der zweiten eine genauere – was heißt genauere – eine etwas verbesserte Anzeige dem Ort und der Position gab und erst eine Suche, bevor man die Location sharen konnte, man musste erst einen fix bekommen bevor man teilen konnte. Das fand ich auf jeden Fall sehr gut. Ich hab das soweit ich weißnur auf meinem Handy ausprobiert, was nicht immer so gut funktioniert hat wie ich es mir vorstellen könnte. Es war ein HTC Desire auf Android 2.2. Da hat das teilweise gesagt Entfernung noch 1000 Meter, das hat etwas gestört, teilweise aber auch direkt

gefunden, also ich weißnicht woran das genau gelegen hat – kann auch am Gerät gelegen haben. Ansonsten super einfach- - tippst auf share und dann wird geshart – und alles war gut. Ich hab glaub ich mal ausprobiert 2 mal direkt hintereinander eine Location zu sharen – ich meine das hat auch funktioniert. Ich weißaber nicht ob das auch gezählt wurde.

I: Ja da hat sich auch etwas verändert von Runde 1 zu Runde 2.

P7: Ich glaub ich habs in Runde zwei probiert, hab kein Feedback bekommen – vielleicht wars in Runde eins (...) weißich nicht mehr genau.

I: Hast du eine spezielle Struktur gehabt beim teilen von Orten? P7: Meinst du den Workflow, wie ich das gemacht hab (Das oder auch...) oder nur an bestimmten Orten geteilt habe, wenn ich mich da aufgehalten habe?

I: Ja.

P7: Es war eigentlich eher so, dass ich mal so zwischendurch immer mal wieder drann gedacht habe das so eine Testrunde läuft, und das ich einen ort sharen könnte, dann aber wieder gedacht habe – okay wenn ich jetzt hier share dann ist das ziemlich offensichtlich, zum Beispiel wenn ich zu Hause war, oder sowas. Deswegen habe ich meistens versucht irgendwie unterwegs war und losgefahren bin, oder wenn ich mal hier war mit vielen Leuten.. das ich dann mal auf share gedrückt habe. Ich habe nicht dirket ein Muster verfolgt wo ich gedacht habe so findet man mich am wenigsten, sondern so das ich eher zufällig dran gedacht habe und dann das hier ist ein guter Zeitpunkt und ein guter Zeitpunkt um zu sharen.

I: Okay also Du hast drann gedacht, und dann überlegt der Ort hier könnte zu viel über mich preisgeben oder das passt.

P7: Genau, genau.

I: Alles klar. Hast du bestimmte Zeiten, weil du die Zeit gerade genannt hast, vermieden?

P7: Ne, ich bin nicht nach Uhrzeiten gegangen.

I: Okay, hast du irgendwie (...)

P7: Was heißt ich bin nicht nach Uhrzeiten gegangen, ich bin – ich sag mal klar es macht mehr Sinn auf einer Fachschaftssitzung die von 18-20 Uhr Mittwochs ist sich einzuchecken wo viele Leute sind und sich einchecken. Da kannst Du schon nach Uhrzeit gehen und sagen ja das macht das schon Sinn gefharlos hier am ifgi einzuchecken. Aber wenn ich das heute morgen gemacht hätte wo man mich über die Webcam hätte sehen können (lacht) - ne das ist halt - da wäre man schon eher nach Uhrzeit gegangen, so hab ich nicht wirklich was gemacht, so sehr drauf geachtet.

I: Also war es meistens eine Kombination aus Ort und Zeit. Hinter dem Gedanken das möglichst viele an diesen Ort hätten teilen können.

P7: Ja, ja – aber ich habe mehr auf den Ort als auf die Zeit geachtet.

I: Hast Du irgendwelche Schritte unternommen um andere Leute potentiell zu verwirren?

P7: Ne das habe ich nicht.

I: Irgendwelche ungewöhnlichen Orte geteilt?

P7: Was heißt ungewöhnlich? Ne - eher weniger, nix was ich nicht mit anderen Leuten zusammen gemacht hätte.

I: Dann sind wir mit Teil 1 auch schon durch.

Part II - Investigating Locations

I: Kannst Du mir dazu was errzählen?

P7: Auf jeden Fall. Das erste was mir dazu einfällt. Man hatte keine dirkete Möglichkeit, eine Karte zu sehen mit allen Orten von allen Spielern. Ich sag mal bei vielleicht 40 Spielern die 10 mal am tag einchecken wäre das auch etwas Overkill gewesen. Aber es hat auch keine Möglichkeit gegeben direkt zu sehen wo ein Spieler ist. Man musste dem erst folgen und dann konnte man sehen wo der ist - das fand ich etwas Umständlich, das hat mich etwas genervt, hat mich auch nicht unbedingt dazu angeleitet so sehr hinter den Leuten her zu sein. Ich hab mir mehr oder weniger Leute ausgepickt denen ich wirklich gefolgt bin - hatte keine Lust bei 20 Spielern auf folge mir zu klicken. Das hat die Dynamik etwas gedämpft - rausgenommen. Mehr Filteroptionen wären schön gewesen. Für die denen du gefolgt bist wars schön einfach - aber nur für die.

I: Da hat sich in Runde zwei auch was getan - man konnte dann von jedem Nutzer aus zu den Orten und auf die Karte springen.

P7: Ja - das meinte ich.

I: Hast Du irgendwas Interessantes gefunden, Hobbies, Muster?

P: Naja was natürlich aufgefallen ist is das jeder hier mal am ifgi eingecheckt hat. Naja aber ansonsten – man versucht natürlich Muster von seinen Freunden herauszufinden und da weißwas die in Ihrer Freizeit machen – z.B. auf einen bestimmten Geburstag sind und drei Leute da einchecken da kann man dann schon so ein Muster erkennen. Da hab ich schon versucht etwas hinter zugucken mit dem was ich über die Leute weißtatsächlich, abgesehen von dem Spiel. Da hab ich schon ein Muster versucht zu erkennen und wer wer ist.

I: Also hast Du quasi Wissen was Du hattest eingesetzt?

P7: Genau, genau.

I: Hast Du noch irgendwas anderes gemacht? Facebook oder Google bemüht?

P7: Nein - das habe ich alle versucht mit meinen eignen Erfahrungen zu lösen.

I: Was hast Du für Infos angesehen als Du die Orte untersucht hast - Du hattest die Zeit erwähnt, Geschwindigkeit und Richtung auch?

P7: Geschwindigkeit und Richtung - ne da bin ich ich überhaupt nicht nach gegangen.

I: Weil das eher irrelevant für Dich?

P7: Da habe ich generell noch keine Erfahrungen mit gemacht, mit Richtung und Geschwindigkeit zu arbeiten bei GPS Sachen.

I: Hast Du die Seite primär auf dem Mobilgerät genutzt oder auch auf anderen Plattformen?

P7: Also wenn Du das IPad als Mobilgerät bezeichnest dann ja - daraufs läufts ja wie Du selber weißt auf iOS noch mit am besten, ansonsten klar mit meinem Handy mit dem

GPS Empfänger, der findest noch am besten auch wenn es am Anfang immer etwas gedauert hat.

I: Du hast mir auch schon erzählt was Du vermisst hast – ein etwas stärkeres Interface (...).

P7: Ja was die Karte angeht ja.

I: Fallen da auch so Sachen drunter wie der letzte geteilte Ort – das der eine andere Frabe hätte oder so?

P7: Ne zeitliche Abfolge wäre nicht verkärt mit einer Farbabstufung – oder das man das zumindest so einstellen kann. Oder bestimmen Benutzern Farben zuordnen kann.

Part III - Submitting Facts

I: Kannst Du mir dazu was erzählen?

P7: Dazu muss ich sagen, das habe ich selber nie gemacht (lacht). Soweit bin ich nie gekommen das ich wen herausgefunden habe - da kann ich Dir nich so viel zu erzählen. Ich fand nur - ja - die Kategorien - ob die so passend waren - mir fällt aus dem Stehgreif aber nichts besseres ein.

I: Welche Kategeorie fandest du denn unpassend?

P7: Zum Beispiel Work Adress und Home Adress war bei mir zu dem Zeitpunkt beides gleich - ich habe von zu Hause aus gearbeitet. Ich denke, dass es bei vielen auch einfach das ifgi gewesen ist - weil die hier angestellt sind. Solche Informationen sind relativ irrelevant oder trivial.

I: Gut - Du hast also keine Fakten herausgefunden, aber Du empfandest eine als relativ einfach.

P7: Ja klar sicher - Land oder sowas war halt (...)

I: Du kanntest einen Teil der Spieler persönlich? Als gute Freunde, Freunde von Freunden, Bekannte?

P7: Joa - doch so 90% als Freunde - naja so gut kenne das ich sagen könnte ich könnte durchaus ein Muster erkennen.

I: Hattest Du ne spezielle Struktur gehabt um Fakten zu erkennen? P7: Hätte ich eine gehabt (...) wenn jemand am ifgi eincheckt das hätte man wohl erkannt, das war ja trivial. Ich glaube auch nicht das jemand sagt ich share jetzt 5 mal hier an diesen Ort und dann erkennst Du direkt die zu Hause Adresse - ich glaube das haben gar nicht so viele Leute gemacht. Da - also wenn das jemand gemacht hat das hätte ich wohl erkannt – das der da zu Hause ist. Wenn Du die Leute gerade kennst – das findet Du leicht raus. Das würde ich erkennen. Oder natürlich ein Muster wo ich sehen kann – jemand hat einfach an denselben Orten wie ich eingecheckt in den letzten 3 Tagen wie ich. Dann wird das wohl jemand gewesen sein mit dem ich zusammen unterwegs war.

I: Also alles auf eine sehr sehr persönliche Ebene übertragen?

P7: Ja, ja ich habe das ganze auf eine sehr persönliche Ebene übertragen. Einfach mit den Sachen die ich über die Leute weiß.

I: Hast Du mit anderen Spielern zusammengearbeitet?

P7: (zögert) Nicht direkt zusammengearbeitet aber drüber unterhalten. Im Sinne von (...) also bis auf die erste Runde die wir gemeinsam beendet haben. Wir haben eher über Verbesserungen gesprochen, wenn man enttarnt war. Nicht so konkret überlegt der könnte der oder der sein.

I: Hast Du die Kommentar oder Tagging Funktion genutzt?

P7: Die Tagging Funktion habe ich einmal genutzt um sie auszuprobieren.

Part IV - Last Questions

I: Du kennst wahrscheinlich Soziale Netzwerke.

P7: Ja.

I: Benutzt Du auch welche?

P7: Jo.

I: Welche?

P7: Facebook – ansonsten keine. Google+ kannst Du noch mit aufschreiben, aber da gehe ich selten rein.

I: Kennst Du Location Sharing Applications?

P7: Ja – Foursquare und alles was drauf aufbaut, an irgendwelchen Spielen.

I: Benutzt Du die auch?

P7: Bis auf Foursquare nix.

I: Warum nutzt du Foursquare?

P7: Spaß– meine Freunde machen das auch und das war so eine Zeit ein Hype den man einfach mitgemacht hat und es war ganz witzig zu sehen wer am meisten Punkte bekommt. Hat aber echt nachgelassen in letzter Zeit.

I: Also wegen deinem Freundeskreis, war eher sozial als für einen bestimmten Zweck? P7: Genau, das wars. Deswegen wäre das auch ne Frage ob man das nicht auch in so ein soziales Netzwerk einreihen kann. Also wenn Du willst kannst Du das da auch mit reinschreiben, oder nicht wenn das nicht reinpasst in deinen Fragebogen.

I: Hast Du noch Kommentare, Hinweise, Meinugnen an mich?

P7: Ja also, was nicht nur mir persönlich sondern im Freundeskreis mit den Leuten die mitgespielt haben - was uns aufgefallen ist ist im Grunde es ist kein kontinuierliches Spiel. Das wirft man nicht einmal an und es läuft für immer. Ist jetzt wie in dieser Testphase gelaufen ist - es gibt immer wieder verschiedene Runden bis alle gefunden sind. Ist jetzt nich so das immer wieder neue Leute hinzukommen auch wenns vielleicht so gedacht ist. Irgendwann gibt es einen Gewinner der hatte dann mit den meisten Punkten gewonnen. Ich weißnicht inwieweit das so von Dir gedacht war.

I: War ein Versuch - ich ging davon aus das die Runden - was heißt Runden - das Konzept der Runden hat sich so ergeben und ich ging davon aus das das Spiel relativ kurz ist am Anfang. Ich ging davon aus, das die Leute am Anfang direkt Orte teilen und das es nach dem zweiten Tag schon bei der Hälfte gereicht hätte. Das war dann nicht so.

P7: Ja klar - das hätte auch sein können.

I: Manchmal hats 4 Tage gedauert, manchmal dann ne Woche oder 14 Tage bis die Hälfte bekannt war. Da hast Du dann auch gemerkt das die aktiv waren und Spaßhatten, aus welchen Gründen auch immer, die haben aufgehört es gab weniger zu tun, es gab keine neuen Features und so weiter.

P7: Ich finde die Idee total geil – also das in einem abgeschirmten Freundeskreis zu spielen mit deinen Leuten. Und das dann dann 3 Tage laufen zu lassen und zu schaun wer am Ende die meisten Punkte hat, oder überhaupt noch da ist. Dafür ist es wirklich geil und lohnen das noch weiter zu entwickeln und zu verfoglen mit z.B. nativen Apps. Das fände ich schon cool wenn das in die Richtung geht und Entwickelt wird.

I: Was war deine Hauptmotivation hier mitzuwirken?

P7: Naja war halt ein Spiel und als solches Konzipiert und ich bin offen für sowas. Klar wollte ich Dir auch mit deiner Masterarbeit helfen, aber ja.

Appendix B.9. Participant 8

Part I - Sharing Locations

I: Tell me a bit about sharing locations.

P8: I tried to share location so I could not be identified – so for example I shared locations near the Mensa – but I never told some that I am going to the mensa. So I shared there and was happy about it. Also I avoided locations where I thought that some could identify me through this location (...) like ifgi or my home.

I: One could say you had a special structure or attitude in sharing locations?

P8: I would not say so because I knew about the game (...) and then I said well now is a good time to share and why don't I share here. So I shared here. In the first round I shared here at ifgi and near my home when I was buying some food (...) but in the second and the current round I have not shared here and near my home (...) so yeah I could say it is a tactic. The goal for me is that I am not deanonymised so I can play longer.

I: Did you avoid sharing at specific times?

P8: No.

I: Did you take steps to confuse other players like detours?

P8: Yeah as I said I shared at the mensa so I never (...) I did not tell anyone. So when I was here at ifgi at six o'clock and I would go to the mensa and shared there and eat.

I: But you did not alter your behavior?

P8: No – but I thought about it – so just to go to gievenbeck and share something there or sometime I thought about sharing at [mentions player] place on my way home but I did not do it (...) I stood there at the traffic light and thought mh no.

Part II - Investigating Locations

I: Please tell me about that.

P8: I used the built in map view in the web app (...) but personally I find it very difficult to use it. You see all the markers on the map but there is no indication on how old these locations are or how the accuracy is. I would find it better if there were some indications about the date, so the markers would be grayed out in the current locations. So I could get the additional information (...) but there were too many clicks (...) it was not very convenient or comfortable. I had to remember all this (...) it was an old location (...) and also nicer analysis functions. Currently there is a comment feature but I did not use it because the tags were not easy to find. I have to click on a lot of items to reach it.

I: What have you found while looking at the shared locations? Like patterns, habits?

P8: I have not looked closely at the patterns. I looked at the locations and tried to guess who the persons where.

I: Okay and how did you proceed?

P8: I memorized that this person or this username was there and there (...) I put together an own map in my mind from the locations – I tried to reveal some people but really I have not found out (...) I put additional facts to people which were deanonymized from other people.

I: So you filled in additional information, surname, address and stuff like that?

P8: Yes that is it.

I: So the easiest facts for you where country, and (...)?

P8: But I find these facts for the small scale not very good. Because they were too easy. Because in all three rounds the participants came from Germany and Münster and are male, or most were male. I could have done what [mentions another player] in the current round but now - that is not what this game was about. I thought this is like cheating. Not because of the points but because of exploiting the mechanics of the game.

I: Did you use the tagging function?

P8: Yes I used it. I put some tags in like ifgi or eating.

I: Used you some kind of third party information?

P8: No, no.

I: So you did not use Facebook or something like that?

P8: Okay Facebook, but I did not google persons, like [mentions another player] who googled the birthplace to gather additional information to put it in. Just looked some stuff up in my personal calendar.

I: You knew most players personally?

P8: Yeah friends, colleagues that correct.

I: Did you use the page primarily on the mobile device or on e.g. the desktop as well?

P8: I would say 50 - 50. Because the analysis I did on the desktop and the sharing on the mobile phone.

Part III - Submitting Facts

I: Tell me more about submitting fact

P8: As I said I used the desktop (...) I filled in the blanks.

I: So you were gathering points by filling in the blanks and sharing locations?

P8: Yeah. Also I have not submitted a picture of someone to gain points.

I: Why?

P8: Because the persons had not submitted a picture themselves or there was already a picture submitted.

I: What would you deem the hardest fact to find out?

P8: (...) Yeah not easy to answer. Because when (...) when nothing is known – maybe the first or last name. Because from country or city you could derive the first or

last name. So I statistically seen if you have enough points you could find out the birth month by just testing values from 1 - 12. I tried to reveal some people – but I was not right I did not gain points. I lost points (laughs).

I: So it was really tough to derive identifies from locations?

P8: Yeah.

I: Did you collaborate with other players?

P8: No – because I think the game is built like that you are on your own. If you share something and tell someone that I was yesterday at [mentions place] so other people would know. I spoke to other people. But really collaboration did not happen. So it is too revealing. So I did not do it.

Part IV - Last Questions

I: Do you know Social Networks?

P8: Yes – Facebook, Twitter (...) perhaps World of Warcraft (...) [both laugh] (...) Mh, kind of a social network with a nice interface.

I: So you use Facebook for what primarily?

P8: Mh – just for stalking people, gather information. Just to know what the others are about.

I: Do you share private data in those networks?

P8: No – false name and birthdate in Facebook. And I never have shared my location on Facebook. When someone tries to send a request (...) for example this guy is my brother (...) I decline such requests. Also I decline requests like he was with me at this particular place.

I: Do you know Location Sharing Applications and are familiar with them?

P8: Yes.

I: Do you use them?

P8: No – I do not want to reveal my location and I do not see the benefit of sharing locations. If want to tell someone where I am I just send a like from Google Maps or my address (...). If it not really sharing – if I want to tell someone there are other ways.

I: So you share purpose driven there has to be a reason?

P8: Yes.

I: Any last hints questions additions?

P8: Yes - maybe implement the JSON interface (...) so I can build a native android client. Perhaps make the web interface nicer or faster. It is really a great game I had some fun while playing it.

Appendix B.10. Participant 9

Part I - Sharing Locations

I: Tell me about Sharing Locations.

P9: I think I know the whole intention of the game – from the developing aspect it was a method for research. That you want to figure out persons by their location. Spatial deanonymization – and for that you to need to have locations that people shared – like in foursquare or in Google Latitude or what so ever – and to get people sharing their location you need to give them a benefit – in the game you did it with points. Every time you share a location you get points for that. Which was you personal benefit – you would get as many points as possible to win the game – that was the intention. From the technical aspect – I mean from the interface it was easy to do – there where some technical constrains I ran into like caching mechanism (...) one I time a shared a location which was in a total different spot. So it wanted to take the spot from the morning. I don't know I empty the cache of the browser – and then it worked fine. It was amazing to see how fast it was to determine the position even without GPS enabled so it was good.

I: So did you share locations actually?

P9: Yes I did. So I did it not constantly. Since the aim of the game was to be re-identified. So for example I did not share a location in the institute to not limit the attention to a certain focus group. I also avoided my home in the evening or in general since it would be likely that it would be my home if I shared there at after 9 o'clock in the evening. So I avoided those things. Most of the time I shared locations in between – when I was still quite far away (...) or in totally different spots. One time I was driving on the other side of the [mentions well known street] on the other side of the train station where I am usually not and I guess no one of my mates would knew that (...) that I was driving around to get things done. So I thought that is a good spot to share because this is not one of my unusual habits. Also shared spots like supermarkets (...) because everybody has to go to the supermarket.

I: So you avoid specific locations?

P9: Yes.

I: Did you avoid also specific times?

P9: In correspondence with locations yes – one time when I was visiting a friend – you – I shared in front of your house two times. I think people ran even into false guesses due to that. I did not fake shared my location but I shared locations in front of other persons houses.

I: Did you take steps to confuse other players?

P9: Yes.

I: How did you got to do this?

P9: It was like a co accident – I just knew some of the other players (...) one of the players lives close to a traffic light which I pass every morning so I shared there and his home is right at this crossing. I did it in the morning and the evening. I think he got kinda pissed about that.

I: Did you also alter your behavior?

P9: I think I did it once (...) but had technical troubles (...) at least I started it (...) I wanted to do it.

Part II - Investigating Locations

I: Please tell me on how you investigated the other player locations?

P9: I looked at the players (...) but I don't know any really personally (...) just the faces (...) I did not know any further things (...) aside the basic things. So country and city I guessed (...) I also lost points due to different languages (...) due to text based comparison. So I have chosen one player checking if he shared locations (...) and it was demotivating that player would share so less (...)

and you had to check all of them. A map with all of the players would have been nice. If they shared location - I checked the bigger picture (...) like if they shared in multiple cities and then if they shared in Münster I looked at the points. When and where was it and further metadata like speed, heading to be able to derive if they have been cycling,etc. And then the combination of space-time. If they have been in the supermarket, in the mensa, in at the institute or at home. If they have been checked a location around 8 o'clock and not the weekend (...) it was most likely at home. If it was at 6 pm on a Wednesday in the Robert-Koch-Straße or the Weseler Straße it was most likely a guy from the student union since they have the regular meetings then. So you could derive such things from their calendars. And then it would be very likely that they belong to them. It it would be after 10 pm if they were in the Jüdefelder or some other street with bars. Then it would be likely that they would be a student. So you could derive that (...) very easily. Also if they have been at a crossing at the side line or stopping at a traffic line. Just by the location and accuracy and the map.

I: So you did some kind of reasoning - with personal knowledge and what you could see?

P9: Yes, both – this kind of abstract knowledge like student's union stuff on Wednesdays and pubs on Wednesdays and the personal knowledge. I have not re-identified one user but I guess that was due to lack of time.

I: So you would not say it is too hard but you did not spend enough time with the game?

P9: Well I guess I did not know the community that well - I figured that most of the persons have been identified due to excluding. They knew each other and therefore something happened like this one could be it and this one that. And I had not this knowledge. But I could categorize them.

I: Have you found patterns or habits? 00:17:13-9

P9: Not really they have not shared enough to say they have a daily, or weekly pattern. If they would share every morning and during the day it would be easier but as most of the players have shared irregularly it was not so easy.

I: Did you miss anything while you investigated the locations?

P9: An order of the locations like the most up to date ones first. But as they only shared very few points you could do that on your own.

Part III - Submitting Facts

I: Tell me about submitting facts.

P9: As I already mentioned – I did the country and city thing. In the first game it was more trial an error - but as the penalty was raised in the second game I stopped that because I would loose so many points (...) that was harsh. But it is a good way to get people to share locations.

I: Did you employ any third party knowledge like Facebook or googled someone?

P9: No, lack of time and community knowledge. I think I would have played the game more if I had more time. Sharing locations was much easier (...) and less time consuming. Finding out who someone is is really time consuming. If it would be obvious okay (...) but there were not enough locations for that.

I: Did you collaborate with other players?

P9: There where the talks in the student union room during lunch breaks. But I mostly listened there.

I: Have you used the comment or tagging functions?

P9: Yes to state mostly stuff like that someone is cycling. It is easier. And there was no penalty.

Part IV - Last Questions I: Are you familiar with Online Social Networks?

P9: Yes.

I: Do you use them and if yes which ones?

P9: Facebook, Google Plus, EGEA [student geographers community in Europe] - yeah that's it.

I: Do you know Location Sharing Applications?

P9: Yes.

I: Do you use them?

P9: Rarely.

I: Which ones?

P9: Google Latitude – but it was to annoying and obstructive. I want my location on the map when I need it. But not send it anytime automatically. And for me it was a bit scary to see my location with my face on the map so – this is you – I don't asked you to do it, so don't do it. So I removed it from my phone. Started using it out of curiosity.

I: Any comments or hints?

P9: Good luck with your research. The best thing to change would be the usability on the map. Select several players, that you could say okay the other guy had similar tags, so that you could compare. That you could do some further reasoning.