

**Social Awareness
in a Location-Based Information System**

**Medvetenhet om den sociala omgivningen
i ett positionsbaserat informationssystem**

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Social Awareness in a Location-Based Information System

Abstract

Much of context-aware application research has dealt with the technical aspects of context capturing and how to interpret the context of a user. Little effort has been spent on the experience and usage of these systems. This thesis will present the general aspects of social awareness and present an example on how these concepts can be implemented into a location-based information system to help users navigate a potential information overload. This thesis also states that giving the users an experience of not being alone in the system increases the pleasure of using such a system. However this implies a decrease in privacy.

To demonstrate these ideas I will describe a location-based information system, GeoNotes, built by a group of researchers at SICS, the Swedish Institute of Computer Science. I will state a set of interaction requirements for how to extend the GeoNotes system with functionality for social awareness. Furthermore I will set up functional requirements for those interaction requirements to after implementation be able to conclude which interaction requirements I have been able to implement for. I will also give suggestions on how to position users in a WLAN.

The deliverable from this project is a location-based information system with functionality for social awareness. However, it was not within this project to test the system on true users. Therefore the statement that this functionality can help users to navigate a potential information overload is still just a hypothesis.

To retrieve the position of a user in a WLAN a packet is sent to all base stations in the network. In the first returning packet the mac¹ address of contacting base station is extracted. Each base station is therefore a unique position. Triangulation was discarded due to its sensitivity to noise and weather circumstances, although a system that uses triangulation would have offered a much higher granularity.

¹ On a local area network (LAN) or other network, the mac (media access control) address is your computer's unique hardware number. When you are connected to the internet from your computer, a correspondence table relates your IP address to your computer's physical mac address on the LAN.

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Sammanfattning

Den mesta forskningen på kontextberoende system har inriktats på dom tekniska aspekterna av hur man fångar in kontexten och hur man sedan tolkar denna kontext. Väldigt lite arbete har tillägnats själva upplevelsen och användandet av sådana system. Denna uppsats kommer att presentera begreppet "social awareness" och hur detta koncept kan infogas i ett positionsbaserat informationssystem för att hjälpa användare att navigera i ett potentiellt informationsöverflöd. Jag utgår också ifrån att nöjet av att använda ett sådant system ökar om användaren ges en social upplevelse.

För att demonstrera dessa idéer kommer jag att beskriva ett positionsbaserat informationssystem, GeoNotes, byggt av en grupp forskare på SICS, the Swedish Institute of Computer Science. Jag kommer att ställa upp en mängd interaktionskrav för hur GeoNotes ska förses med funktionalitet för "social awareness". Därefter kommer jag att ange vilka tekniska krav som ställs på GeoNotes för att interaktionskraven ska vara uppfyllda. Detta för att sedan kunna bevisa vilka interaktionskrav jag verkligen lyckats implementera. Jag kommer också att ge förslag till hur användare kan positioneras i ett WLAN.

Resultatet från detta projekt är ett positionsbaserat informationssystem med funktionalitet för ökad medvetenhet om den sociala omgivningen. Huruvida dessa funktioner kan komma att hjälpa framtida användare att navigera ett potentiellt informationsöverflöd är inte klarlagt i denna uppsats. Systemet måste då testas på riktiga användare, vilket inte låg inom ramarna för detta examensarbete.

För att positionera användare i ett WLAN skickas ett paket ut till alla basstationer i nätverket. I det paket som först kommer tillbaka kan adressen för närmaste basstation avläsas. Varje basstation utgör därför en unik position. Triangulering kom inte att användas pga. dess känslighet för väder och ljud. Detta trots att positioneringssystem som använder sig av triangulering skulle ha erbjudit en mycket större finkornighet.

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Table of Contents

1	Introduction	1
1.1	Motivation.....	1
1.2	Purpose	1
1.3	Method.....	2
1.4	Limitations.....	2
1.5	The Structure of the Thesis.....	2
2	Background	3
2.1	Location-Based Information Systems.....	3
2.1.1	Physical Dimensions.....	3
2.1.2	Communicatory Dimensions.....	3
2.1.3	Social Aspects	4
2.1.4	Commercialization of Public Space.....	5
2.2	Social Awareness	5
2.2.1	Translucence.....	5
2.2.2	Social Navigation.....	6
2.3	Privacy	6
3	Related work	8
3.1	E-graffiti	8
3.2	The Notification Collage.....	8
3.3	InfoScope	9
3.4	Comparison with GeoNotes	9
4	Interaction Requirements and Functional Requirements	11
4.1	The Initial Version of the GeoNotes System.....	11
4.2	General Aims	12
4.3	Interaction Requirements	12
4.4	Functional Requirements	15
4.5	Implementation.....	16
5	GeoNotes: Interaction Design	18
5.1	Main Area.....	18
5.1.1	Write a Geonote.....	19
5.1.2	Read a Geonote.....	20
5.1.3	The Overview Window.....	22
5.2	Search Area	23
5.2.1	Search on Friends' Actions	23
5.2.2	Recommendations.....	23
5.3	Settings Area.....	24
5.3.1	Signatures	24
5.3.2	Friends.....	24
5.3.3	A User's Own Geonotes.....	25
5.3.4	Saved Geonotes	25
5.4	Privacy	25
5.4.1	Actions are Stored.....	25
5.4.2	Anonymity.....	26
5.4.3	Users need to be Positioned.....	26

6	Technical Implementation	27
6.1	Positioning Service	27
6.2	Wherehoo.....	28
6.3	The Recommender	28
6.4	The Searcher.....	29
6.5	The Server.....	29
6.6	The MySQL Database	29
6.7	The Client	30
7	Results and Conclusions.....	31
7.1	Final Application contra Interaction Requirements	31
7.2	GeoNotes in a WLAN.....	32
8	Future Work.....	34
9	References	35

1 Introduction

According to Mark Weiser ubiquitous computing, or calm technology, is the new wave in computing where computers recede into the background of our lives. Instead of each person having a laptop or a stationary computer the technology we use will be embedded in our environment [1].

A group of researchers at SICS, the Swedish Institute of Computer Science, work with ubiquitous computing in their research on social mobile computing. One of their prototypes is GeoNotes, a location-based information system for public spaces [2]. The basic idea behind location-based information systems is to connect information pieces to positions in outdoor or indoor space. Through position technologies such as Global Positioning System (GPS), GSM positioning, WLAN positioning or Bluetooth positioning, the system keeps track of where a terminal (and its user) is located in space. Via his terminal, the user is allowed to enter/upload information, and the system automatically allocates a latitude-longitude coordinate to this information piece. Later, the same user, or some other user, can access this information (again via their wirelessly connected terminals) when they enter the place. Although the digital information is stored on a remote server away from the actual location, the position technology and the mobile terminals give users the impression that information is actually “attached” to the place where the user is. In this way, location-based information systems create user experiences similar to those of post-its, graffiti and public signs and posters.

A number of systems have been working with this basic concept over the last five years within the fields of augmented reality, wearables and ubiquitous computing [3,4,5,6,7,8,9,10]. Some have used goggles as access medium [11]. Most, however, work with handheld devices that may not provide the same stunning and spectacular visual effects, but still preserve the basic functionality.

1.1 Motivation

In spite of all the work that has been undertaken, none of this research has directly addressed the social and navigational implications of digital mass-annotations in public spaces, such as streets, squares, pubs, public transportation, churches, cafés, galleries, malls and libraries. SICS’s idea is to allow all users to post virtual post-its² and read others’ without restriction, in combination with powerful yet easy-to-use navigation tools, location-based information systems may potentially change public space and the ways in which it is conceived, created and consumed.

1.2 Purpose

The purpose of this work is to maximize social awareness enabling functions in a social mobile system and to investigate technical constraints and possibilities when implementing a scalable, social and location based service in a WLAN network.

² In this work the GeoNote system will be referred to as GeoNotes and the notices/virtual post-its, geonotes.

1.3 Method

Starting by reading about social awareness and information systems in general I got an overview of the research field. Thereafter I looked at the existing implementation of the GeoNotes system, which was the starting point of this work. With this knowledge I could together with my supervisors at SICS define possible interaction requirements of a social information system. To be able to say if those interaction requirements were fulfilled after implementation I stated functional requirements for those demands. Thereafter followed the actual implementation. After implementation I could compare it with the initial functional requirements and conclude which interaction requirements I had been able to implement a solution for and which I had been forced to leave. The functionality of the system was then tested with several models of positioning systems to get a hint of how it would work in larger scale deployed in the Kista OPEN WLAN.

1.4 Limitations

I used GeoNotes as my social mobile system which already had a small client written in Java. I was constrained to build on top of that.

A user study of GeoNotes followed on this work. The subjects were 400 students in Kista Open WLAN who were equipped with laptops and WLAN-cards. They were using GeoNotes during one month. There were both Windows and Linux users. The setting of this user study was known already at the beginning of my work and had to be kept in mind when implementing new functionality in the GeoNotes system. I was therefore limited to use a positioning system for WLAN. I was not supposed to write a positioning system myself but to find one suitable for this user study but still as unlimited as possible. As well as laptops, I was also encouraged to run the system on a Compaq Ipaq personal digital assistant.

1.5 The Structure of the Thesis

Chapter 2 presents a background to location-based information systems and a summary of social awareness. I will thereafter present three of these information systems in more detail in chapter 3 and also compare them to the GeoNotes system. This comparison will help to set the GeoNotes system in a perspective.

In chapter 4 I describe interaction requirements of a potential system built on the initial version of the GeoNotes system but expanded with social awareness. In the same chapter I also state what functionality such a system would require if those interaction requirements were to be fulfilled. Chapter 5 contains the interaction design of the new GeoNotes system after those requirements were implemented. A more technical description of that system follows in chapter 6.

Chapter 7 presents results and conclusions, while chapter 8 gives a short epilogue and suggests directions for future work.

2 Background

In this chapter I will describe a background to location-based information systems and also describe the general aspects of social awareness. In later chapters I will present a suggestion on how to combine these two. It will be pointed out that such a combination most often requires users to share more of their activity. Last in this chapter there is therefore a discussion around privacy.

2.1 Location-Based Information Systems

Location-based information systems are not a new phenomenon. Since the cave-paintings 30,000 years ago, humans have annotated space with imagery, figures and text to communicate with each other, and human societies have developed technologies to support this, e.g., graffiti, posters, billboards, neon signs, and paper post-its. Although digital location-based information systems need not slavishly replicate the features of their analog counterparts, these counterparts may offer design inspirations.

2.1.1 Physical Dimensions

On a *physical* level, analog annotation technologies are placed in space in a number of different ways. Glue, pins, fridge magnets, ink, and paint are perhaps the most common ways of accomplishing this, with different life spans as far as persistence is concerned. Some stay put for centuries (paint and carvings) while others wither and disappear quickly (sand beach messages or ink in the rain). Some surfaces are quite resistant to annotation. Textile materials, for instance, are not very suitable for use with post-it notes; they tend to quickly fall off. Indeed, this non-stick property is deliberately used in certain situations to prevent annotations being made. For example some public space surfaces such as house façades, metro wagons and buses are manufactured using anti-graffiti, easy-to-clean materials.

Analog annotation systems support different forms of media. Paper-based annotation systems, for instance, can display text and still imagery. Neon signs and screen-based annotation systems provide added support for moving imagery.

Furthermore, when both writer and reader share this connection to space, the message can refer to that context without any loss of understanding. For instance, attaching a post-it note to a piece of paper with the text “Peter, would you please make 10 copies of this?/Angie” is perfectly comprehensible since the position of the annotation clarifies the reference of the word *this*. The more exact the position of the annotations, the more writers can rely on deictic expressions. This, of course, also makes messages shorter and more economical, in contrast to if the message would have to keep the same meaning even if someone changed its location. Then the writer would have to express himself in more detail.

2.1.2 Communicatory Dimensions

It is essential to point out that location-based annotations have many functions. Posters and signs may *inform* about events, activities, facts and authorities’ decisions. However they may also *persuade* people to change ideologies or rethink their lives. Finally, location-based annotations also operate as effective *reminders* to oneself and others. In many cases it is much more efficient to direct reminders to places than to times (calendars and alarm clocks). A

post-it note on the door, for instance, reminds me to bring my keys at exactly the right moment (exiting the apartment before I slam the door locked). Although, this would only work as a reminder until I got used to it, then I for example would have to change the colour of the paper for me to keep noticing it.

2.1.3 Social Aspects

In addition to the physical and communicatory dimensions, *social* aspects determine how people annotate space and how those annotations are produced. The assumed target audience often affects the contents of an annotation. Post-it messages between peers, family members and colleagues take place in a shared understanding of one another's preferences, sense of humour, personality and daily routines. By exploiting and alluding to this shared context, messages can be short and yet expressive. In public spaces, the potential reader of the message may not be entirely clear, which forces the writer to deal with more general subjects. Still, many places are assumed to attract a certain clientele. In Stockholm, billboard producers can expect a Swedish audience; in a mall one can expect shoppers; and on a university campus, students and teachers will be the most likely reader of your message. In addition, since many places *physically* restrict access to large groups of people, the target audience can be clear (only family in my house, only students in the university library, only Ericsson employees in Ericsson facilities). It is certainly the case that the placement of the annotation affect the subjects chosen and the opinions expressed.

To maximize visibility, annotations are often placed in passageways where it is known that many people (of the appropriate target audience) have to go through. Examples include entrances/exits of malls, stores and metro stations, as well as traffic intense gateways into and out of cities.

If the writer's understanding of the reader affects the annotation, the opposite is equally true. In particular, the degree of writers' *anonymity* plays a role here, i.e. the extent to which readers can trace the unique identity of the writer [12]. If a writer is reassured that her identity will be maintained secret, she will not be morally or legally accountable for opinions expressed or statements made. Such situations can be liberating for many annotators since one can express what one feels, bring taboos and political incorrectness to the surface, joke about forbidden phenomena and criticize authorities – all without social reprimands. On the other hand, yielding accountability may encourage racist and sexist statements, invoking social stereotypes and lead the way for criminality and abuse of power. For what it is worth, anonymity tends to unleash the society's unconscious.

A softer form of anonymity involves anonymous signatures, in which the unique identity of the writer is unknown but its repeated occurrence in several messages indicates the same source.

Of course, making ones views, attitudes, personality and preferences known in a public setting is not something people generally avoid. On the contrary, it is striven for. Humans are social animals with deep going needs to show personal and social identity to others, and become recognized, accepted and respected for it. By articulating our attitudes to others, we “become” someone. By exhibiting what we think and are, we mark our group belonging in terms of ethnicity, gender, religion, class, social status, sport and hobby club, communities, interests groups, political parties, music taste, etc. [13]. Political demonstrations, manifestations, performance, public posters, information flyers or ‘legal’ graffiti are ways in which people express their views not anonymously, but in a fully transparent and open way. In these

cases the writer *wants* to be identified and recognized as something, in order to heighten the public's awareness concerning some issue. This relates not only to individuals but also to organizations, authorities, commercial players and interest groups. Public space is the most prominent arena to express what we are and what we stand for, not only through annotating space, but also through behaviour, clothing, hairstyles, jewellery and other consumer goods. By indulging in such 'social exhibitionism' we hope not only to be recognized, but also that other people will give feedback in all sorts of ways, acknowledging our presence, identity and beliefs. Without some form of social feedback, opening up to the socio-public space will be a waste of energy. As we shall see shortly, this has been a leading design principle in the GeoNote application.

As humans are social, this not only means that we express ourselves, but also that we are inquisitive about other people's lives, personalities, and background. We are curious of other people and public annotations provide a window into the lives and worldviews of others. A local notice board, for instance, may tell much about the neighborhood and its inhabitants.

2.1.4 Commercialization of Public Space

The growing commercialization of public space is an often debated political issue [14]. There is concern that public space is being taken over by commercial interests through messages and logos on billboards, buildings, streets, clothes, cars, and even in schools. *Branding* public space has become a multi-billion dollar industry. To become visible in public space requires a substantial amount of marketing resources. Why are some allowed to "tag" the urban environment, but not others? Who and what forces are to decide about images, messages, logos and architecture in public space? What is the right balance between buyable and non-commercial public space? How can we provide space for alternative players and messages? Underlying this political discussion is the assumption that public annotations affect not only our preferences and beliefs, but also the ways in which we act and behave.

2.2 Social Awareness

Social awareness is when an understanding of other people's activities add context to your own activities [15]. Other peoples' actions could enhance participation and quite often we also look at other peoples' actions before we make our own decisions. There are many ways in making users aware of each other in a system. There could be chatting areas, a user could be allowed to keep friends, with whom he could share more private information or there could be some kind of recommendation system between users. There could also be information about how many people have read a specific item and what they thought about it. Also if a user could see that another user was in the same place just seconds before him he would probably get a feeling of companionship.

2.2.1 Translucence

Translucence is about three things: visibility, awareness and accountability [16]. In a translucent system most people feel accountable for their actions due to the awareness and visibility of other users. People tend to use better manners when they know their actions are visible to others. I will give an example: pupils do not scribble on the bench when their teacher is looking, but looking at those benches some pupils have none the less scribbled at some point and they most often have not signed it with their own name, since it could then be traced back to them. In information systems this could be applied on the traces users leave. If they know that

these traces could be connected to themselves they will probably more carefully consider their actions, in contrast to if they were totally anonymous.

2.2.2 Social Navigation

People use other people's actions and advice for all kinds of navigational purposes. Either by indirect advice, like follow a stream of people, or by direct questions. This can be called social navigation. Here are two examples:

***The Baggage Claim:** Mr. Smith lives in a small town in Scotland and is going to London for the weekend. Since this is his first trip by airplane he is a little nervous. When he arrives in London he is unsure of where to find his luggage. However, he decides to follow the crowd from the plane (they ought to have luggage as well). Five minutes later Mr. Smith stands at the baggage claim to pick up his luggage. [17]*

***Finding the Pub:** Mr. Smith is really enjoying his first holiday in London. The city is huge and there are lots of things to look at. He is a little disappointed though, in that he hasn't found any good pubs (the ones suggested in the guide feel like poor imitations). Suddenly he realizes that his old friend from back home lives in London. Mr. Smith calls him up and asks if he knows of any good pubs. "What sort of pub?", the friend asks. "A good one", Mr. Smith replies. "Ok, like a Scottish or English or maybe an Irish pub?", the friend asks. "Ah, a Scottish one", Mr. Smith answers. The friend suggests the Old Scotsman, a pub that should be just in his taste. The pub turns out to be just what Mr. Smith was looking for. [17]*

Social navigation in a computer program could be simple, like sorting documents on popularity. A more subtle way would be a recommendation system that uses collaborative filtering. Either users explicitly tell the system what they think of things they read, or the system could try to extract this from what they do after they have read something, e.g. if they save something or delete it. The extracted "taste" is probably more reliable when using explicit voting, but most users tend to ignore "voting-buttons", because of the extra time they require and most often it is not clear how they would benefit from such action. In collaborative filtering a system stores each user's 'taste' and by matching it with others' the system could recommend a user to look at things it predicts he would like. However, the most important thing is to either reward the user for voting or to make the user understand how the system works and thereby make him feel it is worthwhile to leave these votes.

2.3 Privacy

When information systems are no longer just cave paintings and graffiti but computer systems where the information is stored in databases and where the authors and readers are interrogating with various computer systems to reach this information, there is an increased concern around privacy. Even a writer that chooses to be anonymous might wonder over the potential

identification of his messages. This identification might not be displayed in the interface, but could perhaps be found in some other way, by system personnel or hackers.

Furthermore if the system will use some kind of collaborative filtering to recommend pieces of information to its users, the taste of each user will be stored somewhere and displayed to other users. Perhaps the recommendations will be displayed anonymously but still be connected to its true user somewhere in the system, and if things like a user's taste are stored what other actions that the user performs are also located and stored?

Users are also reluctant of being located in space. However, most people are used to this notion from mobile phones. They know that it is possible to tell their position if necessary, but most accept the convenience a cell phone provides as long as it remains a difficult thing to do.

Aspects like these will most likely create concerns; therefore it is of high importance to make also background issues of a system visible to its users.

3 Related work

The rest of the thesis will be mainly focused on the GeoNotes system, but before I start to expand on the functionality of GeoNotes I will describe a few other systems along the same concept. Hopefully this will give the reader knowledge of the thoughts around the GeoNotes concept and how the GeoNotes system differs from systems produced by other research groups.

3.1 E-graffiti

E-graffiti is maybe one of the systems most similar to GeoNotes [18]. It is a context-aware application that detects the user's location on a college campus and displays text notes to the user based on his location. It also allows the users to create notes that they can associate with a specific location.

The producers of E-graffiti released their system to fifty-seven students using laptops in a campus wireless network. Their experiences are vital to SICS's user study. Most of the students in their user study did not understand the concept of location and messages, instead they thought of the system as a bad alternative to email and SMS. The producers of E-graffiti pointed out a few reasons to this, they had not bootstrapped the system with any messages to point out models of usage, they gave too little information about their user study and they allowed users to direct their messages to specific friends. Users only contributed with twenty-six public notes.

The people behind E-graffiti have now taken the experience they got from this study and developed CampusAware [19], a campus tour for Palm Pilots which uses GPS to find the user's location and then beeps to alert users when information related to their location is available.

3.2 The Notification Collage

The Notification Collage is a groupware system where distributed and co-located colleagues comprising a small community post media elements onto a real-time collaborative surface that all members can see [20]. People post items they believe will be interesting to others, such as desktop snapshots and vacation photos. New collage items are always placed on top. The general idea is that the members detect when others are online, and use the awareness to move into interaction with each other.

The producers' experience was that the messages people placed on the Notification Collage differed from those over systems like ICQ. Since all users could see the collage items, the conversation could be overheard. This became an opportunity for casual interaction where others would join the conversation. Seeing incoming items also meant that people in the laboratory could tell others about messages directed to them, when they did not notice the notes themselves. People also used the Notification Collage to inform about group events, as well as a place for general queries that could be answered by anyone.

In contrast to E-graffiti the producers of the Notification Collages said that the success of their study was mostly due to the fact that they had not directed the usage. They provided a system and let the users come up with ways of using it.

3.3 InfoScope

InfoScope is a system where users can see information associated with a building, or a place, overlaid onto real scene images on their PDA's display [21]. The system combines a color camera, a global positioning system (GPS) receiver, and a wireless modem with a PDA. Its purpose is for people to get necessary information about what they are seeing around them. Users can point their PDA to a building or a place where they would like information and the colour camera captures the scene. The user then selects the item he wants information about by drawing a bounding box around it in the picture. The system uses colour-similarity based computer vision techniques in combination with position to recognize the building. Information about that building is then inserted into the bounding box.

The system has two purposes: to function as a city guide for tourists and like a realtor guide. In the tourist guide there is mainly information about museums and other tourist events while the realtor guide admits users to get price information about houses for sale.

The main problems for the InfoScope producers were about the speed of wireless communications, and processor power of available PDA's. InfoScope is mainly about pictures, either to be sent to a contacting server or to be stored locally, which are well known as resource requiring.

3.4 Comparison with GeoNotes

GeoNotes is probably most like E-Graffiti with mainly one important difference; GeoNotes does not allow directed messages, this was also one of E-Graffiti's major disadvantages according to its producers. During their user study they only got twenty-six public notes and the users seemed to have got the impression of a system similar to email or SMS. Both the Notification Collage and the Infoscope do not allow directed messages.

The Infoscope on the other hand does not allow the users themselves to contribute to the system. This is allowed in both E-Graffiti and the Notification Collage and it is an essential functionality of the GeoNotes system. The GeoNotes system is also to be deployed in an open network and not as E-Graffiti and the Notification Collage that are deployed in a campus network and between colleagues in a small community.

E-Graffiti and the Infoscope system are similar to the GeoNotes system as they work with context awareness. The messages are positioned on locations in the users' surroundings. GeoNotes is to be deployed as E-Graffiti in a WLAN network where the users have laptops with WLAN cards, but GeoNotes is also supposed to work on a pda, like the Infoscope system, although, they used Bluetooth and had problems with the speed of their wireless communication. GeoNotes is going to use WLAN communication and will hopefully not get that problem. However, both Infoscope and the Notification Collage let their users display pictures and files as well as plain text but GeoNotes will to begin with only allow plain text.

In this chapter I have described three location-based information systems and compared them to the GeoNotes system. The next chapter will explain new functionality that could be added to the GeoNotes system after this comparison and after the litterateur study presented in chapter 2.

4 Interaction Requirements and Functional Requirements

My task was to maximize social awareness enabling functions in a location-based information system like GeoNotes. I could have done a user study to find out what potential users required. However, this was not possible since I had no prototype to let them look at and the thoughts around these systems are still just research and not familiar to common IT-users. The GeoNotes system is also not supposed to be a further development of email or ICQ, which could happen if I would have let IT-users of today state the requirements. Therefore my supervisors at SICS and I set up the following interaction requirements. This thesis work has been followed by a user study that started in April (2002) with 400 students from KTH Kista. Among other things that study was to tell us which of these requirements that turned out to be true requests from real users, and then the next step would be to build a system on **true** user requirements.

By reading about similar systems (chapters 2 and 3) and about social awareness in general (chapter 2) I got an overview of how to introduce social awareness in a location-based information system. With this knowledge I could together with my supervisors at SICS first state the general aims for what we wanted to accomplish with social awareness in the GeoNotes system. Thereafter we expanded these aims into the more precise interaction requirements and finally I stated what functional requirements that would be needed if all interaction requirements were to be fulfilled. After implementation (which will be described in chapter 5 and 6) I was able to say which of these functional requirements that were fulfilled and with that knowledge I could draw conclusions about the interaction requirements. I will state these conclusions in chapter 7.

I will start this chapter with a description of the initial version of the GeoNotes system and thereafter I will present the suggestions for redesign, by first presenting the general aims followed by interaction requirements and functional requirements. Last in the chapter are guidelines for implementation.

4.1 The Initial Version of the GeoNotes System

The GeoNotes client I initially inherited had functionality for reading, writing and searching for geonotes at specific locations. The system worked in combination with the computer game Quake [22], from where it got its positions.

A user could compose a geonote with a title, a message and with either his name or the word anonymous as the signature. He also had to categorize his message into one of eight categories and then attach it to current position. He could also see all geonotes on that location in a list of geonotes where each listing consisted of the title and the signature. By double-clicking on one of these he got to see its full message. It was possible to search for the content of geonotes, either as a continuous search over all passing positions or just on current position. There was also an idea about a place labeling system. Although, not implemented yet. The idea was to narrow a widely grained positioning system by letting the users attach names of objects in sight to their messages. This to create a feeling of post-it notes that are attached to objects [2]. The idea would be helpful even with more precise positioning. Imagine if the au-

thor of a geonote wants to attach it to a whole house instead of one of its corners that might be the user's current position, then the place label 'the red house' would help to widen the attachment.

4.2 General Aims

These aims I stated with the help of my supervisors at SICS. We wanted to create a feeling of companionship between users. We wanted the users to experience that other users read and reacted to their material, this in order to encourage them to write more geonotes. We also wanted them to help each other in finding interesting geonotes in a potential information overload. However, we knew that the users would not know each other and would therefore not find it straightforward to ask each other for advice. Therefore we decided to use collaborative filtering, described in section 2.5.2, which basically means that a system can recommend material to its users by searching all users' likes and dislikes for similarities. If a user says he liked the same three geonotes as another user who has also stated a fourth geonote he liked, the first user would probably like to read also that geonote.

However, according to privacy in section 2.6 users are hesitant of being located in space, having their actions stored and also if they choose to be anonymous they are afraid that someone still can trace their actions. Due to the fundamental aspects of social awareness, with openness and recommendations, total privacy is difficult to accomplish but should still be thought of when implementing the new functionality in the GeoNotes system.

4.3 Interaction Requirements

I will divide the requirements into writing geonotes, reading geonotes, writing and reading comments, handling information overload, feedback, remote control of others' and own geonotes, recommendations, friends, search mechanisms and notifications, starting with writing geonotes.

- **Writing geonotes** - The previous version of GeoNotes supplied functionality to write geonotes with a title, a message, a signature and a category.

Most often users are less afraid of expressing themselves if they can be anonymous in doing so. However, a signature like 'Woman 34' can add context to a message like 'Looking for a partner', but still preserve the author's anonymity. Having users write more geonotes and having users help each other in finding interesting geonotes are two of the general aims of introducing social awareness. Therefore, new functionality would be to be able to sign a geonote with a pseudonym. Users would then probably like to be able to add new pseudonyms and to reuse old ones. This concept of adding new if nothing of the previously used is suitable is also useful when adding the concept of place labels described previously in this chapter. When adding a geonote to a location the author will most likely want to see which place labels that have been used before; perhaps he will use one of these or add a new one.

Another way of users helping each other in finding interesting geonotes is to make it possible for users to tell for how long a geonote shall be stored, or to completely remove a previously inserted geonote.

- **Reading geonotes** - Functionality for reading geonotes was implemented in the previous version of GeoNotes.

Geonotes are listed as headers containing their title and signature. A double-click on one of those headers shows the whole geonote. Continuing on the concept of users helping each other in finding interesting geonotes in a potential information overload would be to give some more information about a geonote in these headers. There could be information about how many other users who have read it, when it was last read and the number of comments that are attached to the geonote. This would not only be helpful for the specific user but also for the recommendations. Since the system will recommend geonotes based on users' actions (look under recommendations) it is important that an action such as reading a geonote is an intended action and not so much based on luck.

When reading a geonote users probably want to see when it was written and the place label it received, which was not implemented for in the initially inherited version.

- **Writing and reading comments** – Another way of having users write more geonotes was to let them know how other users reacted to their material. Users should therefore have the possibility to comment on each other's geonotes. In a way comments would be much like geonotes but with one major difference there has to be a connection to its parenting geonote. If comments would be displayed as ordinary geonotes the readers would not get the whole context, and would also be even more overloaded, which is totally in contradiction with the general aims. However, if the author of a geonote decides to remove his geonote he will then decide over the life of that geonote's comments. Therefore it cannot be allowed to remove a geonote if it is the key to one or more comments. But still the similarities to geonotes are extensive. When writing comments users should have the same possibility of using pseudonyms as when writing geonotes. As well as a comment's readers probably also would like to see the time when it was written. There should also be possible to comment on other comments.
- **Handling information overload** – There are more direct ways of handling potential information overload than to get extra information about all geonotes at a location. There should be functionality for a user to tell the system not to show him geonotes from specific senders, who he finds non-interesting or maybe even offensive. It should also be possible to choose not to see specific geonotes again. However, it is important for privacy issues that data about rejected senders is stored on each client and sent to the server as arguments, and not stored on server side where it is reachable to all users.

These actions can also be used as indicators to a user's taste when implementing for collaborative filtering.

- **Feedback** – I have previously mentioned that it was important to let users know if their material was written or not. Perhaps not all readers will write a comment when they have read something, but still it would be encouraging for the author to know that his geonote is a popular geonote in the terms of number of readers.
- **Remote control of others' and own geonotes** – To read geonotes in the GeoNotes system users need to be at the location those geonotes. However, it should be possible for a user to save a geonote so that he can read it again and keep track of new com-

ments regardless his current position. By also storing own geonotes authors can receive feedback and read comments without having to walk back to where they inserted that geonote.

The action of saving a geonote could be regarded as a positive indicator for that geonote when implementing for collaborative filtering.

- **Recommendations** – A general aim was to let users help each other in finding interesting geonotes to read. Previously I have mentioned that the GeoNotes system is not a system where all users know each other and where they explicitly can recommend geonotes to each other. Therefore it is stated in the general aims that collaborative filtering should be used. However, reading chapter 2 users are quite resistant to voting-mechanisms. For example, if a user does not benefit from leaving a vote on a geonote or if he does not understand why he should do so he will most probably skip this notion. One suggestion would be to combine this voting with more straightforward actions like closing or opening a message. The system would then know that the user at least has glanced the geonote. A way to say if he has read it or not could be to trace if he uses the scroll bar or if he keeps the geonote open for more than a few seconds. However, actions like saving or deleting geonotes would probably contribute more when deciding a user's taste.
- **Friends** – The notion of collaborative filtering is one way of having users help each other in finding interesting geonotes. Another way would be to use knowledge from the real world about other users, like their taste and humour, and with that knowledge in mind search for other user's actions on specific geonotes. For example if I know I have the same taste in films as a friend of mine I could choose to read geonotes about films that my friend has previously read and then saved. A notion from similar information systems is to authorise friends, who are allowed access to things that the user wants to keep private from all users. An example of this could be the actions he takes in the system or in the GeoNotes' case, his connection to a specific pseudonym.

Most likely a user wants to see a list of all other users whom he has chosen to be friends with. He probably wants to be able to add new friends and to stop people from opening friendships with him. It also has to be possible to close a friendship.

- **Search mechanisms** - From the old version of GeoNotes it was possible to perform two kinds of searches, search at present location or create queries. Both were searches on the content of a geonote, like a word in the title or the message, the signature etc. New functionality would be to add social parameters. Examples of social parameters that already has been mentioned would be; geonotes a friend has saved, deleted or written, the popularity of a geonote or recommended geonotes.

In the old version of GeoNotes, created queries were not stored from one session to another. An obvious user request would therefore be to store these queries for future sessions of GeoNote usage, but then provide functionality to delete them, deactivate them or only to turn off the notification for them. The geonotes a query finds when the user moves around in space must be collected, listed and stored somewhere for the user to look at either in current session or in a later session of usage. The user must be able to look at these geonotes even though he is no longer at the location of the listed geonotes.

- **Notifications** – The old version of GeoNotes supplies notifications for query results. It will probably be interesting for users to choose to also be notified when people read or comment on their geonotes. To keep track of all these notifications it should be possible to choose between different notification signals. There has to be ways to turn off these notifications though, one at a time or all of them.

Those were the interaction requirements, now I will describe the functionality that has to be there if the interaction requirements are to be fulfilled.

4.4 Functional Requirements

Network connection is essential for nearly every action in the GeoNote system, like writing, reading or searching for geonotes. The only material that can be accessed without network connection is the material that is stored on each client. An argument for client storage would be to save processing time for the server. However, the server needs to store all shared material like geonotes and place labels so that it can be accessible to all users. Users' actions that are to be shared between friends should also be stored with the server. If they because of privacy concerns were to be stored with each client, friends would have to be online at the same time to be able to search each other's actions. Furthermore, the recommendation system used for collaborative filtering will use all actions to decide users' tastes. Therefore it is most convenient to store all actions once and for all on the server. In conclusion, all material that is only interesting to the user himself will be stored on the client to save processing time at server side, and all material that will be shared between two or more users will have to be stored with the server.

When a geonote is added the time and the identity of the true user need to be stored as well as the actual text filled in by the author. It has to be possible to update a previously stored geonote so that the number of readers and the last time it was read can be increased. The header of a geonote needs to contain the time when it was last read, the number of readers and the number of comments as well as the initial information, the title and the signature.

Somehow the system has to tell a user's position so that the right list of geonotes and place labels can be sent to the user, and so that his added material will be connected to the right lists. However, it is important that the server sorts out geonotes that the user has chosen not to read so that a pda for example, which is low in memory capacity, does not receive a huge amount of unnecessary information. To sort out geonotes each geonote needs to have a unique identity. This identity can also be used when a user wants remote access of a specific geonote. If the user were to save the location key he would receive the whole list of geonotes at that location.

Comments should not be reached without having read a superior geonote or comment. Since geonotes are found by location, comments should not contain any connections to location. Instead they should contain connections to superior geonotes or comments. When the server receives a position from a user it should only find geonotes. The server finds a comment if the user sends a request for comments connected with a geonote id or the id of another comment, since comments also could be comments to other comments. Apart from the location comments will have to contain all the items of a geonote like time, signature, identity of its true user etc.

It also has to be possible to remove all connections to a specific geonote so that it can be deleted from the system. If users have saved a geonote there is client storage of that geonote, that will have to be deleted. Comments to that geonote need to get location connections so that they can be reached without their superior geonote. If it should be possible to give geonotes and comments expiry dates the server needs to always look for 'old' geonotes and delete them from the system.

There have to be ways to send messages between two users so that users can authorize new friendships. To receive a message a user has to be online and, as previously mentioned, it is impossible to wait for two users to be online at the same time. Therefore these messages will have to wait at server side until the receiver goes online. Being friends involves an exchange of an identity key to open up the possibility to search for each other's actions and to tell the true user behind specific geonotes. If a user wants to be deleted from a friend's friends list the server will have to make sure that the friendship is deleted in both directions, so that no user is allowed to search for another user's actions without that user being able to search for his.

There has to be a choice of different notifications stored with the client for the user to choose from. A user needs to be online to be notified when someone reads or comments on one of his geonotes. The server will have to store also these notifications until the user goes online.

To handle some of the privacy concerns stated in the general aims the server should not keep any storage of which users that are online or their individual locations. Each client will have to keep track of its own position and send it as an argument to the server when the lists of place labels or geonotes should to be updated.

4.5 Implementation

Looking at the initial implementation of the GeoNotes system there was no client storage. If the GeoNotes client is to run also on ipaq's such a storage has to be kept minimal, but still be easy to update. The most suitable solution for this was XML-files, which are easy to update and requires minimal storage but still provide a searchable structure of the data.

In the initial implementation geonotes were stored in a search system³ built by Rickard Cöster at SICS where it was not possible to update previously stored geonotes. Also the syntax of the geonotes had to be changed with new items like time and place label etc. However, the search functions of this system were too complex and superior to get elsewhere therefore the simplest solution was to edit this search system to suit GeoNotes purposes.

Furthermore the server side storage had to be extended. The Searcher only stored geonotes but there also had to be storage for all user's actions, place labels, user identity keys, messages between users etc. Rickard Cöster at SICS had also built a system for recommendation⁴ which could be used for all user's actions and the rest of the server storage had to be placed in a MySQL database.

Finally, I had to look for some kind of client-based positioning to fulfil the requirements concerning positioning stated in the general aims.

³ In this text referred to as the Searcher

⁴ In this text referred to as the Recommender

In this chapter I have listed interaction requirements that were set up to introduce social awareness into the GeoNotes system. I have also stated the functionality that was required for those interaction requirements to be fulfilled. Furthermore I have given a short explanation on how to implement this functionality into the initial GeoNotes system. All this work was done before the actual implementation. In the next two chapters I will describe GeoNotes after I had tried to implement as much of that functionality as was possible in reality. The next chapter will be from the presumed user's perspective while the second will present a more technical description.

5 GeoNotes: Interaction Design

The major aim of this project was to create a feeling that no user was alone in the system. Each user should get the feeling that there are also other users in the system who both read and respond to their inserted material and who can be helpful when navigating through a potential information overload. By reading about social awareness and other systems similar to GeoNotes I set up interaction requirements together with my supervisors at SICS that perhaps would accomplish these aims (see chapter 4).

Interaction design in this case is not about creating the user-friendliest interface, but to set up functionality for the interaction requirements described in chapter 4. However, the interface must be kept simple and easy to comprehend.

I have divided the interface into three windows, the main area, the search area and the settings area. My intention is that novice users should learn the main window first. They might be happy with the basic functions of this area and perhaps not explore the rest of the system. More advanced users could also make use of the more complex search area. There is also a subpart to keep a user's personal settings, like used signatures, friends etc. The user can alternate between the different parts of the system by a menu tab that can be found in all three areas, see figure 1.

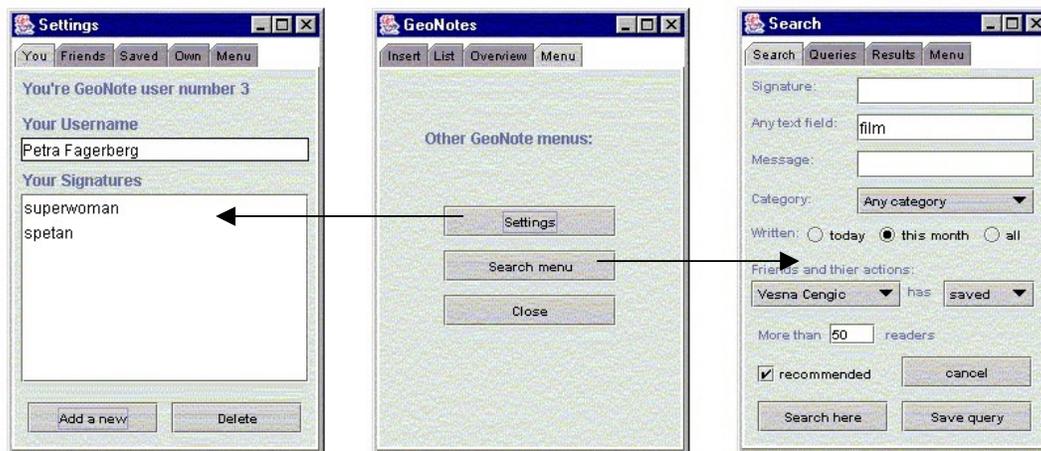


Figure 1 – Use of menu tab to switch between areas

This chapter will describe the GeoNotes system from the user's perspective. A more technical description will follow in chapter 6.

5.1 Main Area

In the main area the basic functions are to read and write geonotes. Figure 2 presents the window for inserting a geonote, but a click on one of the other tabs takes the user to the window for reading, the overview-window or to the menu-window (Figure 1), where he can navigate to the search area or the settings area.



Figure 2 – The main area

5.1.1 Write a Geonote

The write window (the insert tab) appears first since it is important that users will not only read but also write geonotes. It is obvious that the system would not be anything if its users were only lurkers. When writing a geonote a user can submit a title, a message, he can choose a signature, a category and a place label. I will go through each of these in further detail.

For the signature, the default option is the username. Since the username is thought to be a user's real name, this would be the least anonymous option. A user could also choose to write under a pseudonym, one that he has used before or a new one. His trusted friends would then be the only ones who could tell that he was the actual author of this geonote. The last option is total anonymity. When the user chooses to place what he has just written the system composes a geonote from this together with some background information, like the author's system ID. His friends keep this ID also, which is the reason why they can trace his geonotes no matter what the signature is. The only exception to this is when he takes the choice of total anonymity, then this ID is set to 0 and could therefore not be traced.

Since I have not succeeded in finding a perfectly grained positioning system (Section 6.1), my supervisors at SICS and I decided to use place labels to narrow the positions. Each position is for now one base station's coverage and within such an area there can be several objects for the user to write about. I have talked about post-its as a metaphor for geonotes and to create this feeling for the reader it is important that the writer specifically states where he wants to position his message. When entering a new position not only geonotes placed on that location but also created place labels will be pushed to a user's client. If he then chooses to write a geonote he could choose an already existing place label or he could create one that more perfectly suits his preferences. This place label system could expand in a dynamical labelling system filled by its users. It is possible that also other systems will find use for these place labels and then a lot of users from all kinds of systems will use and enter place labels. Currently all created place labels are shown in a scrollable menu. This would not be possible in a

community of users, where this list could be extremely large. A way to get around this could be to have the ten most popular labels appear in the list. This will also solve the problem with meaningless place labels that otherwise could create confusion. With a more fine-grained positioning system the system can show not only place labels from current position but also place labels from nearby locations. By giving the geonote the position of the chosen place label instead of the user's actual position, the geonotes would with this system be even more exactly located and the user would not need to be on that exact location to position a geonote.

5.1.2 Read a Geonote

Under the second tab there is a list of geonotes placed on the present location. The user can see the title and the signature of each geonote. The user can then double-click on a title to read that geonote or he can get some extra information before he definitely decides to read it ('Get status' in figure 3). That information would contain when the note was last read, how many people that have read it and how many comments those readers have left (Figure 3). If there are many geonotes in the list this could help the user to decide which geonotes he is actually going to look at.

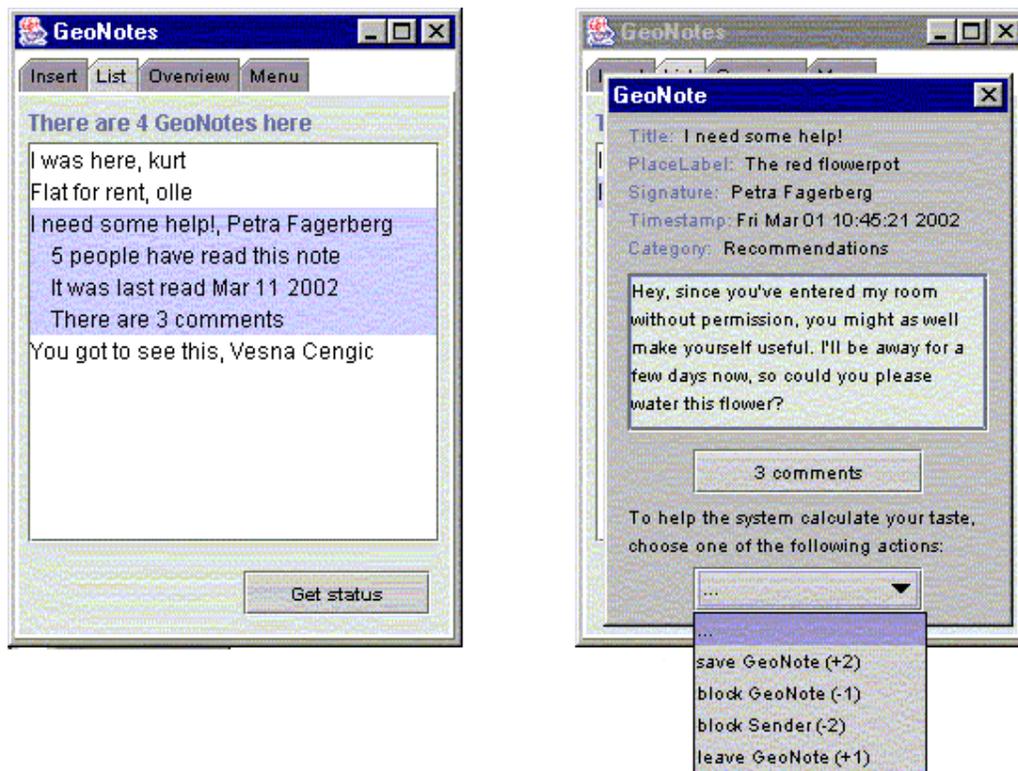


Figure 3 – A geonote

A reader of a geonote will have the opportunity to leave a comment or to read other readers' comments. This is done in a separate window, much like newsgroups. The comments are displayed in a list, where each segment is the time when the comment was placed and the signature of the person who wrote it followed by the comment itself.

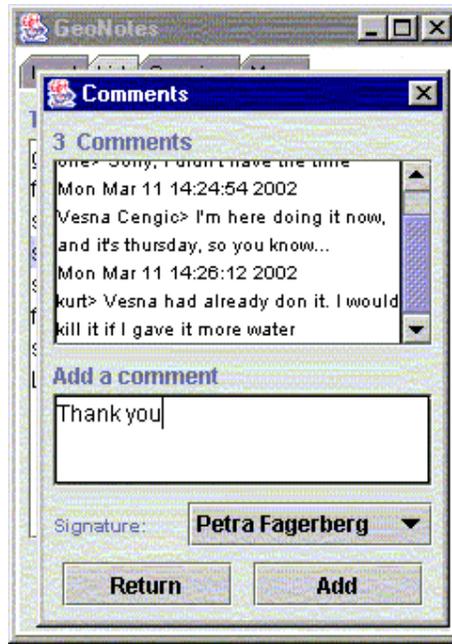


Figure 4 – The comments' interface

The comments are much like geonotes themselves but with a main difference, they are connected to an already placed geonote or comment. This can be displayed in a GeoNote-like manner with a list of comments connected to each parenting geonote, instead of the current newsgroup-like window. This would allow users to search not only for the content of geonotes but also for the content of comments since comments would then be individually unique items, exactly like geonotes (see section 5.2 about GeoNotes' search functionalities). By a double-click on one of the comments in such a list the user would get access not only to that comment but also to another GeoNote-like window with a new list of comments, this time comments on the comment. However, this would create a system where the user can be more than five clicks away from the main window (Figure 5). Therefore comments are not individually unique and users will not be able to search for the content of comments.

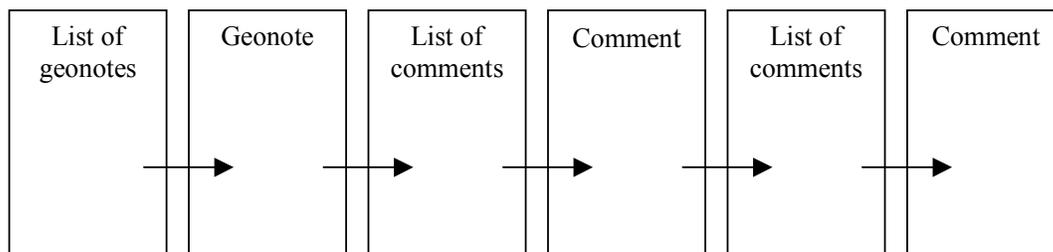


Figure 5 – A bad example of structuring comments

As I wanted to use the notion of collaborative filtering, I had to make users in some way say what they thought about each geonote they read. Most users tend to skip buttons like “grade this geonote” since they do not believe they benefit from such actions, so I therefore extract this information from the action they take when they leave a geonote. If they just leave it there in order to also see it the next time they enter that same position I will say they have read it which is for me a bit more positive than not reading it, because of the information they got

before they double-clicked on it. A user can also save a geonote or block it, so as not to see it again the next time he enters that same position; or he can block all that author's geonotes. There are four actions that can be performed on a geonote that are stored and used to calculate a user's taste. Which one a user chooses grades that geonote in the Recommender system. If a user saves a geonote I imply he really likes it and therefore saving a geonote gives the highest grade. The lowest grade is if the user chooses not to see any of that author's geonotes again (block sender in figure 3). In between those two there is 'choosing not to see that specific geonote again' (block geonote in figure 3) or just 'leave it there in order to see it the next time at that position' (leave geonote in figure 3), the first implies a lower grade than the second.

Saving a geonote is the only way to get to read a geonote remotely. A user can save a geonote because he wants to follow the discussion that goes on in the comments' window without having to walk back to where that geonote was placed, or maybe the geonote just contains some valuable information that he wants to remember.

5.1.3 The Overview Window

The main area also contains a pie chart, with the percentage of geonotes of each category at the present location. This is for the user to get a quick overview of the locations he passes. If he keeps this view open when moving around in space he will notice the different distributions at different locations.

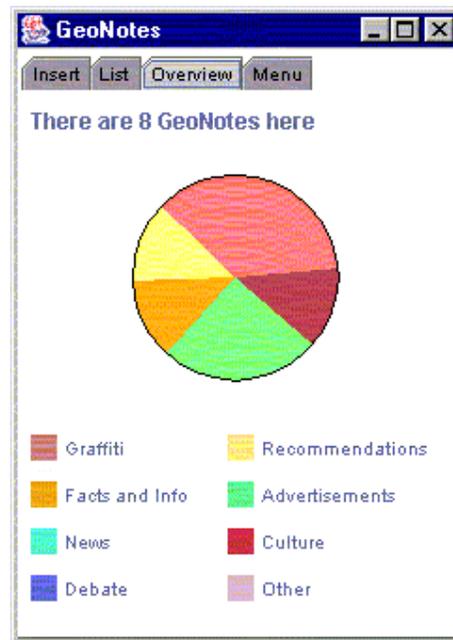


Figure 6 - The Overview window

5.2 Search Area



Figure 7 – The Search area

The second area is the search area where the user can perform highly advanced searching. He has available both social aspects of a geonote as well as its content, and from this he can perform all kinds of combinations (Figure 7). However, there are two ways in how to conduct a search. A user can search on present location or save the entry as a query that searches for geonotes on each location the user passes. A created query will have the options active and notify. If a query is active but notify is not set, the resulting geonotes will be placed in the result list but the user will not be notified when this happens.

5.2.1 Search on Friends' Actions

Since users' actions when they have read a geonote are stored in a database, called the Recommender system (Section 6.3), the GeoNote's server will know exactly what each user has done at each location. To be someone's friend⁵ in the GeoNotes system involves being able to look at that person's actions. From real life I am quite certain of my friends' tastes and humor etc., maybe I want to search for geonotes about film that a specific friend of mine has saved as valuable information, since I know we have the same taste in films. Or maybe, my friends tend to use pseudonyms instead of their real usernames when they write their geonotes, and I want to know which geonotes that are actually my friends'. Another example of this can be if several users use the same pseudonym and I know that one of those users is a friend of mine. I then perhaps want the possibility to check the authenticity of geonotes with that signature.

5.2.2 Recommendations

In the search area there is also an option to search for recommended geonotes, which is done by collaborative filtering, described in chapter 2. The actions users take after they have read a geonote, like saving or deleting it, set up their taste and are stored in their profiles in the Re-

⁵ I will talk about keeping friends in section 5.3.2

commender system (Section 6.3). The Recommender system sets up clusters of users that has the same taste, and can within these clusters recommend geonotes that users from the same cluster have read and liked but that are new to the user that requires the recommendation.

5.3 Settings Area

The Settings area is where the user keeps his personal settings. The data presented in this area are stored locally and is therefore available even without network connection, however with a few exceptions, which we will see later in the text.

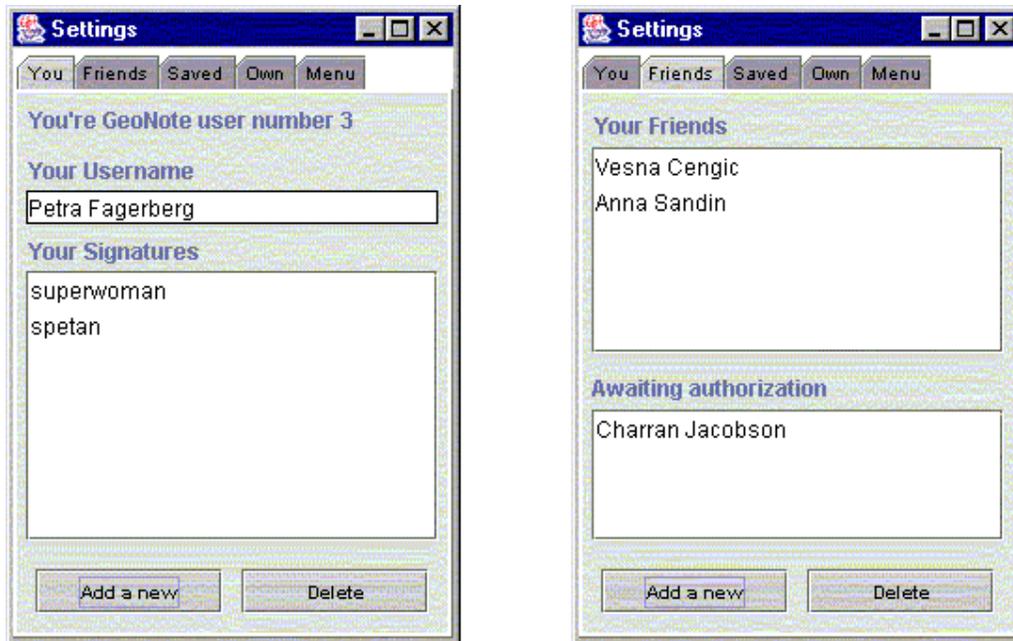


Figure 8 - The Settings area

5.3.1 Signatures

Apart from the window insert-a-geonote (Figure 2) the Settings area is where the user keeps track of his signatures (you on tab, see figure 8). It is possible to create new ones or to delete old ones. Composing a geonote and signing it with a signature involves anonymity to everyone but your friends.

In signature-window the user can also see his username and how many users have downloaded geonotes before him. Each user will get a number when signing up as a GeoNote user. This number is not used for anything today but could perhaps be displayed on geonotes a user writes. Readers will then see if one of the early users of GeoNotes or a more novice user authored the geonote they are reading.

5.3.2 Friends

The Friends-window is where a user will keep the names of his trusted friends (Figure 8). Being friends in GeoNotes involves being able to trace each other's actions, like which geonotes a user saved, deleted or wrote (geonotes signed with username or pseudonym, not anonymous geonotes).

To start up a friendship a user needs to know which username his friend from real life uses. The server then stores a request for authorization until the receiver goes online (sends a request to the server).

When someone wants to stop a friendship he deletes that name from his list of friends, and when the deleted user goes online the server deletes the friendship also from his list. Since that is something that is done automatically as soon as the second user goes online he will not be able to trace any of the first user's actions even though the names were not deleted at the same time.

5.3.3 A User's Own Geonotes

The twenty most recent geonotes that a user composes are stored in a list. All of a user's own geonotes will not be saved since there is a limitation in memory on an ipaq, although, it could be an alternative on the version of GeoNotes for laptops. A user could also delete more recent geonotes to make room for older but more important geonotes.

As with saved geonotes (Section 5.3.4), a user's own geonotes can be read remotely as well as their associated comments' boards. However, the comments are not stored locally since other users can edit them, and they can therefore only be reached when network connection is established. When the user has network connection he will be able to follow the discussions on his own geonotes and thereby get feedback on what he wrote no matter his present location. He will also be able to see how many readers he has got on his geonotes and when they were last read.

5.3.4 Saved Geonotes

Each user will be able to save twenty geonotes on his ipaq. As with the user's own geonotes (Section 5.3.3) he will be able to follow discussions and the number of times these saved geonotes have been read no matter his present location. He will have the possibility to delete geonotes from this list to make room for new ones, since he can only keep twenty. As mentioned before, there could be another version of GeoNotes for laptops to make use of the larger memory space, where the list of saved geonotes could be as long as the user wants.

5.4 Privacy

Implementing for privacy in an open information system like GeoNotes is nearly impossible. All the user's actions are traced and stored for recommendations and for a user's friends to look at. Is it possible that they also will come in the hands of other people? Users might also wonder about to what extent one is really anonymous when signing a geonote with the word anonymous. Finally, each user needs to be located, which might lead users to think that they are being traced.

5.4.1 Actions are Stored

A user's actions, like reading, writing or deleting a geonote, are not visible to other users, only to trusted and accepted friends. However, all actions are stored in the Recommender system (Section 6.3) and used for recommendations. This notion could worry users if they do not understand where the recommendations come from and how they are calculated. Therefore, it is of high importance to make these notions as clear as possible when setting up the real user interface for GeoNotes.

5.4.2 Anonymity

An author can choose to be anonymous when writing a geonote; in this case not even his friends can trace the message back to him. Being anonymous when authoring a geonote could encourage users to write things they would not dare to write under other circumstances. However, even when being anonymous users might not write exactly what they want since they will not know about the system background. A system might log some other identification that someone can trace back to them. The GeoNotes system does not. When a user chooses to be completely anonymous this identification is set to zero for all users. In contrast, when using a pseudonym this identification is set to a user's system ID, so that his friends can identify the geonote, but stay anonymous to the rest of the user group. However, if he uses the same pseudonym over and over again people will know that for example Kilroy wrote a geonote but they will not know Kilroy's real name as his friends and the system staff will.

5.4.3 Users need to be Positioned

Since GeoNotes is reliant on a user's position the user could get the feeling that the system keeps track of where he is. This is not the case in the GeoNotes system. Each user will be connected to a base station and that user only will know which one. The position is only sent to the server when the user requires a new list of GeoNotes or place labels; it is never stored at server-side. However, in a WLAN the owners of such a network will always be able to trace their users.

In this chapter the main focus has been on the presumed user experience of the new GeoNotes system. In the next chapter I will give a more technical description of the system background.

6 Technical Implementation

In the previous chapter I described the GeoNotes system from a presumed user perspective. I will now describe the implementation from a more technical point of view. Looking at figure 9, the Recommender, the MySQL database, the positioning service and the XML-files were all added within this master project. However, I will briefly describe also the Searcher and the Wherehoo database.

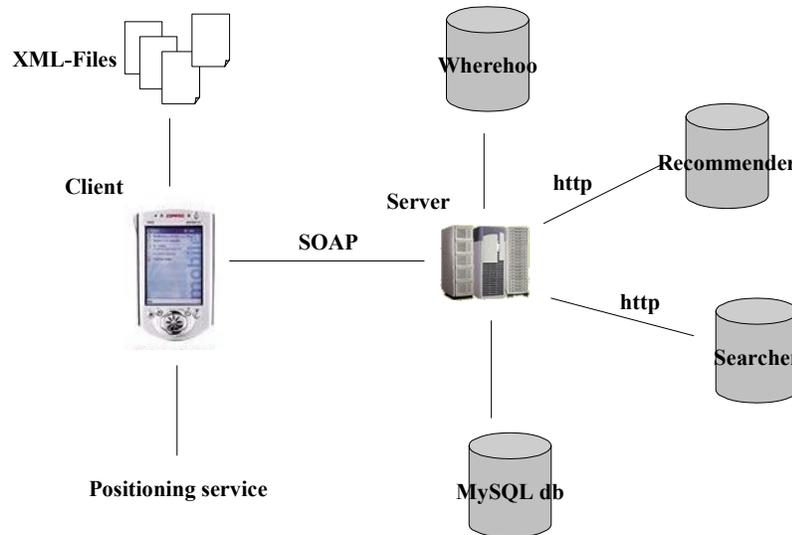


Figure 9 – The technical structure of the GeoNotes system

6.1 Positioning Service

There are several ways to position users in a WLAN, although not all of them suit our purposes. SICS wanted a system that used either triangulation on connecting base stations strengths, or in the worst case a system where the strongest connecting base station's position became the present position. To obtain the connecting base station there has to be some unique information of the present base station on each client. If the users had been using Linux this would not have been a problem, since Linux provides system commands for getting the mac address from the present base station. However, in Windows this information is not provided with a reachable API.

To determine which system to use I read about several systems and stated their pros and cons. Because of privacy concerns (Section 4.4) and limited budget I decided to look for a client-based positioning system that did not require any extra hardware. The students who were going to take part in the following user-study already had laptops and WLAN-cards. I also wanted to find a dynamic positioning system that did not require any initial record over which base stations the users could possibly run GeoNotes from. With dynamic positioning the GeoNotes system would not have any geographical boundaries.

First I looked at a system called Nibble created by a group at UCLA [23]. Nibble is based on triangulation, which means registrations of all base stations' strength and with that knowledge calculates where in the network a user is located. However, this involves calibration of base stations' strength at all positions in use and up to ten times per position, due to the signals' sensitivity to noise and different weather circumstances. Because of this sensitivity and the restriction to an initial set of base stations the Nibble system was discarded, although it would have given the GeoNotes system highly grained positioning.

A system I implemented and tested was the Alipes positioning system [24]. This system required administrator rights over the base stations in use, which SICS was not allowed to have in Kista KTH's WLAN, which was the set up for the user study that followed on this work. However, the Alipes system is a system where each base station is one position. Each client sends his mac address to the system when he wants to know the present position. The system checks each base station to find out which one he is connected to and sends back that stations lat-long. Not only does this system require administrator rights but also it is quite slow. It takes up to a minute until the position updates. There is also a problem with the rubber band effect; when a stronger base station keeps hold of a user despite him being closer to another station. Due to this, base stations could overlap in their coverage areas and therefore the base station that the user is currently connected to might not always be the closest.

Finally I found a configuring tool built by Jon Sevy at Drexel University [25]. This tool was primarily developed for network personnel to help them in configuring their base stations. However, by extracting the functionality of a broadcast to port-192 discovery I could use this system to get hold of the mac address of present base station. This port is supported by the majority of base stations and is readable for anyone connected to the network. Network personnel need administrator rights to configure the base stations since they also need to write to them. The broadcast that is sent out from the client has to pass the currently connected base station before it can reach other base stations in the network, and consequently, this base station will therefore be the first that answers back to the user. Moreover, if a user is connected to a base station that was not in the initial set up, the GeoNotes server only needs to fake a unique key for that new mac address and the geographical boundaries of the GeoNotes system are expanded. If that user adds a geonote to that new location the next user on that same location will receive the same mac address that is now recognised by the GeoNotes server and with that mac address he will have the key to the added geonote. Since Sevy's code is free this method provided the GeoNotes system with a free, client-based and dynamic positioning. The draw back is the crude positioning where each base station sets up a location.

6.2 Wherehoo

Wherehoo is a service created at MIT, Massachusetts Institute of Technology, where strings of text can be stored on lat-longs [26]. It is possible to search for data located at a specific position and within a specified radius away from that position. This is ideal for the GeoNotes system since users will not only receive geonotes and place labels from the exact position but also from positions nearby.

6.3 The Recommender

The system that is used for recommendations was initially built by Rickard Cöster for the Kalas study, another project at SICS [27]. In this system all users have a profile containing all

the items they have graded. The Recommender then uses collaborative filtering on these profiles to cluster users into groups of taste. When a user asks for a recommendation the Recommender looks at what other items users in the same cluster have liked and that the first user has not graded yet. For the GeoNotes system each item is a geonote and the grades will come from the actions readers take after they have clicked on a geonote header. These actions are to save a geonote, which is the most positive alternative (+2), to block a geonote (-1) and to block all geonotes from that author (-2) (Figure 3). If the user just leaves the geonote he has at least read it, which is a bit more positive than not reading it and a grade of +1 will be entered into the Recommender.

The Recommender is also used when a user searches for a friend's actions. If the user wants to see geonotes a friend of his has saved the GeoNotes server will look for geonotes in that friend's profile that are graded a 2. Being friends involves an exchange of system IDs, since users need these to have access to each other's profiles.

There is a problem with collaborative filtering. Before a user has started to fill up his profile, before he has read any GeoNotes, there will be nothing for the server to build its recommendations on. This could be solved by instead of using collaborative filtering for recommendations use the overall most popular GeoNotes, until that user has read a certain amount of GeoNotes. This will have to be implemented in the future.

6.4 The Searcher

The Searcher was also built for the Kalas study with a few alterations for the GeoNotes project. The system stores the geonotes as XML-files, which allows for content search. An example of a search string could be 'all geonotes with the category set to debate'. However, the Searcher can only perform positive searching. This is, for example, a problem when the server is sorting out what a user does not want to read. Therefore the search interface in GeoNotes is also set up for only positive searching.

6.5 The Server

The server handles the contact between the different databases and the clients. It does not keep track of user's online or their individual positions. Therefore it cannot tell users which other users that are online which means that the GeoNotes system cannot be used as a friend-finder or handle synchronous chat as the server looks today. In the meantime messages between users are stored in the MySQL database.

Furthermore the server sorts the lists of geonotes for unwanted material before they are sent to the clients. This takes up processing time but saves memory space with the clients.

6.6 The MySQL Database

The MySQL database stores information about all users; their password, their friends as well as their messages. The messages could be about starting up a friendship, accepting or denying a friendship request etc. This message storage is also used to deliver messages from the server to all users, like a request to download a new updated version of GeoNotes for example.

When Wherehoo (Section 6.2) is not in use place labels are also stored in this database. This could only work when each base station is a position, and not for triangulation, since the labels in the MySQL database will be stored on exact position and it will not allow for searches on labels within a surrounding area.

6.7 The Client

The client keeps track of the position and stores XML-files with all of a user's settings, like used signatures, geonotes he does not want to see again, friends etc. There is also a copy of each user's friends-list on the server, since this information is mutual and would therefore create a problem if deleted on the client. The user with his friends-list intact would then be able to look for what his friend had done in the system but his friend would not be able to perform that search on his actions. It would be inconvenient for the user to lose his signature-list for example but it would not create the same injustice.

The connection between the server and the client is built on SOAP⁶, which means that each client at start-up creates its own server object. If this object is incorrectly created the first time, for example as a null object, it will not be created again because of SOAP's remembering features. Therefore it is of high importance that the client checks for network connection before it creates its server object. When network connection is established and the server object is correctly created the client can send and receive geonotes, place labels, search queries etc. There is a loop that constantly checks for movement. If a user changes location the client has to request a new list of geonotes and place labels. These lists are also updated if the user interacts with the interface. Every now and then the client also checks for new messages from other users. If there are queries running the client also has to notify when a resulting geonote is found.

On an Ipaq a Java-os (Savaje) has to be installed to run the GeoNotes client. Thereafter it is possible to look at the lists of geonotes as one moves around in space. However, there is still a bug for inserting geonotes from an ipaq. There is something to do with writing to the XML-files that do not work correctly on an Ipaq.

⁶ Simple Object Access Protocol

7 Results and Conclusions

The two aims for this project were to maximize social awareness in a location-based information system and to find a method for how to position users in a WLAN. In chapter 4 I listed interaction requirements and functional requirements that were set up to accomplish these aims. Then in chapter 5 and 6 I presented the new GeoNotes system, first from a user's perspective and then from a more technical point of view. I will now present the comparison between the functional requirements and this new version of GeoNotes and the conclusions about which interaction requirements that were fulfilled. Thereafter I will summarize my experiences from WLAN-positioning.

7.1 Final Application contra Interaction Requirements

The functional requirements were stated in section 4.3. The first statement there was about network connection and server- and client-storage. In the GeoNotes system, as it is today, there is a network connection check before the user is able to start using his client. This ensures that he will be able to reach the server-storage where all shared material is located; geonotes, place labels, users' actions, messages between users etc. Furthermore there is a client storage which saves processing time for the server where all personal information is located, information that does not need to be reached by other users.

The next statement in functional requirements was about the necessity to update previously stored geonotes. This is now implemented as well as the newer syntax of geonotes. There is also a client-based positioning system for each client to get hold of his position and send it to the server to get new lists of geonotes and place labels. The server takes care of the sorting of those lists so that the clients do not need to receive unwanted material. Each geonote now has a unique identity to handle both remote access of that geonote and to connect it to its right position. However, the comments to a geonote are stored collectively and cannot be reached when searching for material on a location. As stated in the functional requirements, comments can only be reached by knowing the parenting geonote's unique identity.

It is not possible to remove all connections to an inserted geonote. Users might have saved it, commented on it or listed it as a rejected item. If a geonote was to be deleted also comments to that geonote would be gone from the system, due to the fact that a comment can only be reached through its parenting geonote. To remove a geonote would then allow users to decide over other people's material which is not acceptable. If those comments would gain the status of a geonote and get a unique identity connected to a position they would still have lost their context and probably only confuse future readers. Furthermore geonotes do not have an expiry date for the same reasons as stated above.

To implement for friendships it was stated in the functional requirements that there has to be an exchange of a system identity key to allow users to get hold of each other's actions. This is now implemented for as well as the server-storage for messages between users.

The final functional requirement describes a selection of notifications for the user to choose from. This is not implemented for, due to time constraints.

The interaction requirements were divided into ten groups; writing geonotes, reading geonotes, writing and reading comments, handling information overload, feedback, remote control of others' and own geonotes, recommendations, friends, search mechanisms and notifications (Section 4.2). According to the discussion above there are two of these groups where the requirements are not completely fulfilled. To begin with it was stated in 'writing geonotes' that users should have the possibility to give their geonotes expiry dates and also explicitly delete them from the system. These requirements are not fulfilled; entering a geonote is an irrevocable action similar to when people send sms or email. Furthermore the requirements stated in "notifications" are also not implemented for. However, since all requirements in "feedback" are fulfilled users will still be able to look at the popularity of their geonotes but they will not get a pushed notification.

7.2 GeoNotes in a WLAN

To find a grained, free and dynamic positioning system without any server-storage of each person's location turned out to be quite impossible.

First I studied the Nibble system, which is based on triangulation and therefore could produce highly grained positioning. However, the system requires constant calibration and is also limited to an initial set of base stations. My supervisors at SICS and I therefore decided to use each base station as a position. The method would not be granular but we thought that since each laptop in a WLAN already was in contact with its closest base station it would be easy to get hold of some unique information that could be used as a position key. On a Linux computer this is done in no time, such information is reachable through a simple system command. However, on a Windows computer (which was what the students were going to use) such information is locked up in graphical interfaces and not reachable without extensive programming.

Therefore I looked at the Alipes system, where each user has to tell its own mac address and send it to a server that looks through the initially stated base stations and their connected-users-lists. This system requires administrator rights over the base stations in use as well as an initial set of base stations.

Thereafter I found a configuring tool that could be used to get hold of unique information from contacting base station. From this system I extracted a broadcast functionality that contacts the 'discovery'-port at the base station, which answers with a list of unique information. Because the broadcast needs to go through the contacting base station first to get out on the network, this will be the base station that answers first. Taken in use this system works surprisingly well, although, it only works on the majority of base stations. If contacting base station does not support packages to this port the broadcast will reach another base station on the network and the user will receive an incorrect position key.

In conclusion the new GeoNotes system has during the time of this project both received functionality for social awareness and means to position its users. However, it was not within this project to test the system on true users. Therefore the statement, that there is now a maximum of functionality for social awareness, is still just a hypothesis that has to be proved. It could be argued that I would be closer to such a proof if I would have based chapter 4 on true user requests. My argument for not doing so is that common IT-users of today are too familiar with systems like email and ICQ, on which they would most likely base their requests. With the help of my supervisors I wanted to create something new, and not a further

development of already existing systems. However, I do think we should have had an easier task to state these interaction requirements if we at least had directed our work to a specific user group. Furthermore, it could be argued that we are also 'common IT-users of today' and that we also are stuck in old concepts. Future research on location-aware community systems will have to show if we are on the right track or not.

8 Future Work

Since this thesis work the GeoNotes system got a new interface and was deployed in Kista KTH's WLAN. During one month 78 students inserted 182 geonotes and 101 comments. However, there is still functionality that could be added. Still a friendship in GeoNotes involves being able to trace each other's actions. Later on being friends could be extended to several things. Since GeoNotes involves a positioning system, users could maybe be notified if a friend were nearby, although, this would require a decrease in privacy not only between friends. The server then has to keep track of which users that are online and their individual positions. A graphical interface, like a map, of where the geonotes were located would probably add a whole new dimension to geonotes as post-its located in space. The user study also showed which social functions that were understandable and which were not, which means that yet another user interface could be implemented. When the GeoNotes system has received a user interface where all the functions are understandable another user study could be performed to evaluate users' experiences of social awareness and location-based information systems.

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