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Sharing in Collaborative Systems

A Set of Patterns for Information Sharing between Co-located Users

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Problem Description

The task is in the research area of cooperation technologies. In particular the task will focus on support to co-located users. Cooperation technologies have traditionally been used to support geographically distributed users, with the exception for support in the context of meeting rooms. Ubiquitous and mobile technologies open for new scenarios and a growing number of applications are supporting cooperation among co-located users. The task is aiming at supporting designers of these applications.

The master thesis will focus on creating a set of design guidelines for information sharing among co-located users within collaborative systems. The task is expected to result in a set of design guidelines, using a structured method called patterns. These guidelines should aid designers and developers in the creation of mechanisms for the support of information sharing between co-located users in collaborative work- and learning systems. The patterns should be based on a set of re-occurring problems within co-located sharing, identified by a review of relevant literature, research and existing solutions.

Assignment given: 15. January 2010
Supervisor: Monica Divitini, IDI

Abstract

Technological advances, specifically within the field of mobile and ubiquitous technologies, hold the promise to support collaboration in work and educational environments in new ways. Within collaborative systems, it is possible to use ubiquitous technology to provide users with services to interact – for instance share information – with other users in a given environment. Over the course of this project, the authors have created a set of design principles for co-located information sharing in collaborative systems, using a structured method called *patterns*. The aim of these patterns is to provide support for designers and developers of collaborative systems to take advantage of mobile and ubiquitous technology when designing and implementing support for co-located sharing.

The patterns were based on a set of re-occurring problems identified as important for co-located information sharing between users. These problems were identified by performing a review of relevant literature, research and existing solutions on the subject. An initial set of patterns were created based on this review. The patterns themselves are written on an abstraction level that targets the human-computer interaction part of sharing information between co-located users.

The patterns where then evaluated by three experts within system engineering and collaborative systems, in an iterative process. The overall aim of these evaluations were to ensure that the patterns were easy to understand, and that they provided the information that was relevant for the problem and the domain, in order to be useful in the development process of collaborative systems. The result of these evaluations culminated in a final set of patterns for co-located information sharing. These patterns describe guidelines for: (1) How users can specify the information they wish to share and the receiver(s) of that information, (2) how users can be aware of the potential for collaboration, (3) how situated displays can be used to share information, (4) how user privacy should be protected and (5) how information should be available when the user needs it. The final set of patterns is given in chapter 6.

Preface

This is the master thesis of Terje Aasgaard and Åsmund Skjerdal in the course *TDT4900 – Program and Information Systems, Master Thesis* written during the spring of 2010 at the Norwegian University of Science and Technology (NTNU).

We would especially like to thank our supervisor, Monica Divitini, for her commitment and valuable feedback throughout the course of the thesis. We are very satisfied with the collaboration, and – just as last year – we would not have been able to complete this thesis without your good advice.

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Åsmund Skjerdal | Terje Aasgaard

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1 Introduction

The aim of this thesis is to create a set of patterns, or design principles, for how co-located users can share information using computer-mediated interaction. The task was given in conjunction with FABULA, a project group at NTNU that are looking at City-wide collaborative learning systems (city-CL systems) [8]. The problem definition of the thesis can be found in the next section. In the rest of this chapter we will introduce our problem context and patterns as a means to structure design guidelines, before moving on to our research method and research questions. The last section of this chapter contains an overview of the thesis.

1.1 Problem Definition

Technological advances, specifically within the field of mobile and ubiquitous technologies, hold the promise to support collaboration within work and educational environments in new ways. Ubiquitous computing is a vision where computers are embedded within objects situated in our everyday world [48, 42]. The aim is to shift the use of technology from device-centered to human-centered, where devices are situated in the background and become available when and where the user needs them [32]. Mobile technologies can enable persons to be connected to networks even when they are on the move. The emergence of these technologies has the potential to support flexible collaboration environments, where the collaborative activities are freed from the confines of the desktop activities [49]. This can enable collaboration to continue outside traditional situations; when and where the users desire, through exploration and interaction [5, 6].

Within collaborative systems it is possible to use ubiquitous technology to facilitate the users with services to interact - for instance share information - with other users within a given environment. There exists many examples of applications that utilize these kinds of technologies to enhance collaboration in both work- and learning settings [25, 47, 52]. Even though a lot of the research on computer-mediated collaboration focus on collaboration over distances, some also focus on collaboration between co-located users. For instance in [25], the authors explores new possibilities for people working together in technology rich spaces by augmenting dedicated meeting spaces with displays, wireless or multi-modal devices and seamless mobile appliance integration.

One part of collaboration between people is the exchange – or sharing – of information. However, there has been done little work to consolidate the information about how *co-located* users can share information through the use of computer-mediated interaction and ubiquitous technology. The aim for this thesis is to create a set of design guidelines for computer-mediated information sharing between co-located users. These guidelines will be presented using a format called *patterns*, which will be introduced in section 1.3.

In the introduction to this chapter, we mentioned that the problem was given in connection with the FABULA research group. Because of this, we will primarily use examples and scenarios based on city-CL settings when this is appropriate. City-CL will be more thoroughly introduced in the next section.

1.2 Problem Context

As previously stated, the aim of this thesis is to create a set of design principles for information sharing between co-located users. Although the principles that we are creating could possible be used in other domains where information sharing between co-located users is applicable, our problem context resides mainly within collaborative systems.

1.2.1 Collaborative Systems

The research area of collaborative systems is a field that entails research efforts on many different areas. However, research on two areas within collaborative systems stand very central, namely the computer supported collaborative work (CSCW) and computer supported collaborative learning (CSCL).

The term computer supported collaborative work was first used by Irene Greif and Paul M. Cashman in 1984, at a workshop for people interested in using technology to support their work [11]. The field of CSCW is related to the way people work together, and although primarily relevant in a business setting, it has also applications in a series of other contexts. The purpose of CSCW is to research supporting technologies that facilitate management of people, resources, communication and productivity within a collaborative unit in a workplace [21]. In a book from 1991, Wilson defines CSCW as:

> "*...a generic term which combines the understanding of the way people work in group with the enabling technologies of computer networking and associated hardware, software, services and techniques*" [50].

As such, CSCW embraces a variety of other related terms, like for instance *groupware* or *workgroup computing*.

While CSCW focuses on collaboration within a workplace, CSCL focuses on the same in an educational setting. This entails the study and development of environments and tools for students to collaboratively learn together efficiently [21]. Research within CSCL cuts across research in psychology, computer science and education in order to provide an appropriate platform for learning that is facilitated by human-computer-interaction. As an example of CSCL, we will have a closer look at City wide collaborative learning, which we previously mentioned is central to this thesis.

City wide collaborative learning (city-CL) is a form of electronic learning (e-learning) and a sub-domain of CSCL. In city-CL the focus is to transform the city into an arena for learning. Using mobile and wireless technologies, learners are encouraged to explore a city-landscape, where learning activities are supported through: *Exploration*, e.g. that learning experiences stems from real-life and authentic settings; *interaction*, for example interacting with objects and peers in the field; and *serendipity*, meaning that learning may come from knowledge that is obtained by chance or as a byproduct of the main task [5]. The vision of city-CL systems is to provide "services based upon user preferences and current environmental conditions" [6].

In city-CL, learners are encouraged to enter the city and learn through exploration, interaction and serendipity. Interaction in this setting covers both interaction with technology enhanced objects in the city, for instance statues, buildings, situated displays or other devices; and interaction with other users of the system. Both of these forms of interaction can promote learning. Today, there exist a variety of prototypes of city-CL applications that support interaction with situated objects and other users through ubiquitous techniques, for example using RFID to support information retrieval about specific objects of interest in the city [41, 32, 51, 19]. There also exist several frameworks for city-CL systems that aim to give a clear understanding of the architecture and underlying components, for instance the FABULA platform, the SUN E-Learning framework and the IMS abstract framework [28, 46, 22].

City-CL is very relevant to our work because activities between users often takes place in the field, where the users are co-located. Using information extracted from their surroundings, users participate in learning activities. Co-located collaborative activities and - more importantly for us - sharing between co-located users, are as such vital aspects of city-CL. For instance, users might meet each other in a museum or at historical site and become engaged in collaborative activities that includes sharing or exchange of information.

1.3 Patterns as a Structured Method for Design Principles

A pattern language is a structured method for describing design principles within a certain field, which consist of individual patterns that put emphasis on the context of a specific problem [44]. The idea of a pattern language was first coined by Christopher Alexander, an architect and author, in the 1960s [1]. In later times this form of design principles has become increasingly popular [44, 43, 38].

In *The Timeless Way of Building* Alexander defines a pattern as a general planning principle that explains how one can design a solution for re-occurring problems within a specific context [3, 44]. Furthermore he stated that: "*Each pattern is a three-part rule, which expresses a relationship between a certain context, a problem and a solution*" [3]. The set of patterns – or principles – together form the pattern language. However, a pattern language is more than a list of patterns. Each pattern is linked to other patterns in the language. The purpose of this link can have some variations from language to language, but the idea is that these links help tie the patterns together into a connected entity [43].

The book that one might say is responsible for the popularity of pattern languages was written by Alexander in 1977, and is called *A Pattern Language: Towns, Buildings, Construction* [2]. In this book he describes the philosophy behind a pattern language, and gives a recollection of a pattern language within the field of the design and construction of buildings and towns. The form that the pattern language is written in is later referred to as the Alexandrian pattern form. Alexandrian patterns are described using natural language, in a fairly informal style with the aim of "educating the users of patterns so that they can act like experts" [44]. In other words, the patterns are written to be easy to understand, even for people that are not domain experts. This is illustrated in table 1, that shows an example of the level of abstraction used in the Alexandrian format.

In order for the pattern to be useful, certain information should be present. This includes why the pattern should be applied, where and when it should be used, who should use it and how it should be used [43]. This information is presented in a formal structure that usually include topics such as title, problem, context, discussion and solution.

As previously mentioned, patterns have become an increasingly popular way to describe design principles within a certain field, and in our opinion there are several reasons for this. The first is the previously mentioned informal style of the patterns together with the extensive use of examples from everyday life. This enables

10. Magic of the City

Problem. There are few people who do not enjoy the magic of a great city. But urban sprawl takes it away from everyone except the few who are lucky enough, or rich enough, to live close to the largest centers.

Solution. Therefore: Put the magic of the city within reach of everyone in a metropolitan area. Do this by means of collective regional policies which restrict the growth of downtown areas so strongly that no one downtown can grow to serve more than 300 000 people. With this population base, the downtowns will be between two and nine miles apart.

Table 1: An example of a pattern from *A Pattern Language: Town, Buildings, Construction* [2]

people with little or no experience on the subject to quickly attain knowledge on the domain itself, and be provided with basic building blocks for problem-solving within the domain without extensive knowledge about it.

The second is the modular, or component based organization of the patterns. Since the patterns are so specific, it helps the designers and developers to quickly isolate the patterns they are interested in. Also, since the patterns are linked together, it is easy for the designers and developers to navigate through the language and find similar and/or related patterns that can help to solve, or partly solve the problem. Large problems can be solved by applying several patterns that often are linked together.

The third is that patterns are, to some degree, portable [43]. This means that patterns from one field can either be directly re-used or modified to address similar problems in another field. Some patterns are even so general that they give high-level solutions of problems that re-occur in many different fields.

Because of these reasons, we think that patterns are a very suitable way for describing design guidelines for specific areas or domains.

Since the introduction of pattern languages, the use of them has been adapted to many fields; including software design, user interface design, classroom curriculum and social change to name a few. In the field of software design, one of the most influential publications is *Design Patterns: Elements of Reusable Object-Oriented Software*, which is also known as Gang of Four (GoF) [44]. GoF is targeted for software designers, and therefore uses a more formal style that the Alexandrian pattern format [2]. Although we are also creating patterns for software designers, our patterns will concern how end-users should interact with the system in order to obtain the services they need. In other words, while GoF views the actual designer as the user of the software framework, we will instead look at both the end-user and the designers as users of our patterns. As such, our notion of who the users are is more in line with the ideas of Shummer and Lukosch in the book *Patterns for Computer-mediated Interaction*, which also contains patterns that are relevant to our problem domain.

The book *Patterns for computer-mediated interaction*, is a pattern language that covers the domain of Human Computer Interaction (HCI) [44]. This pattern language contains patterns that are directly connected to our problem domain. Since connectedness is an important attribute of patterns - both within a language and between different languages [44] - we will describe and relate this pattern language to our work in chapter 3. An example of how a pattern language can be connected to other languages can be found in figure 1. In this figure, the gray boxes point to clusters of patterns in the *Patterns for computer-mediated interaction* language, and the white boxes point to other pattern languages.

With this in mind, it is important to note that we only wish to create a *set* of patterns for our specific area, and not a complete pattern *language*. A pattern language would cover a wider domain, and would also have to be evaluated for completeness of the language according to the domain. Although a set of patterns would not cover a complete domain, they would essentially have the same strengths as we described above; the informal language, the component-based organization and the portability. The downside is that the set would to some degree lack the completeness to be useful when solving larger tasks. However, since patterns can be connected, it is possible to relate our patterns to other sets or languages of patterns, thereby increasing the usefulness of both our own and the connected patterns.

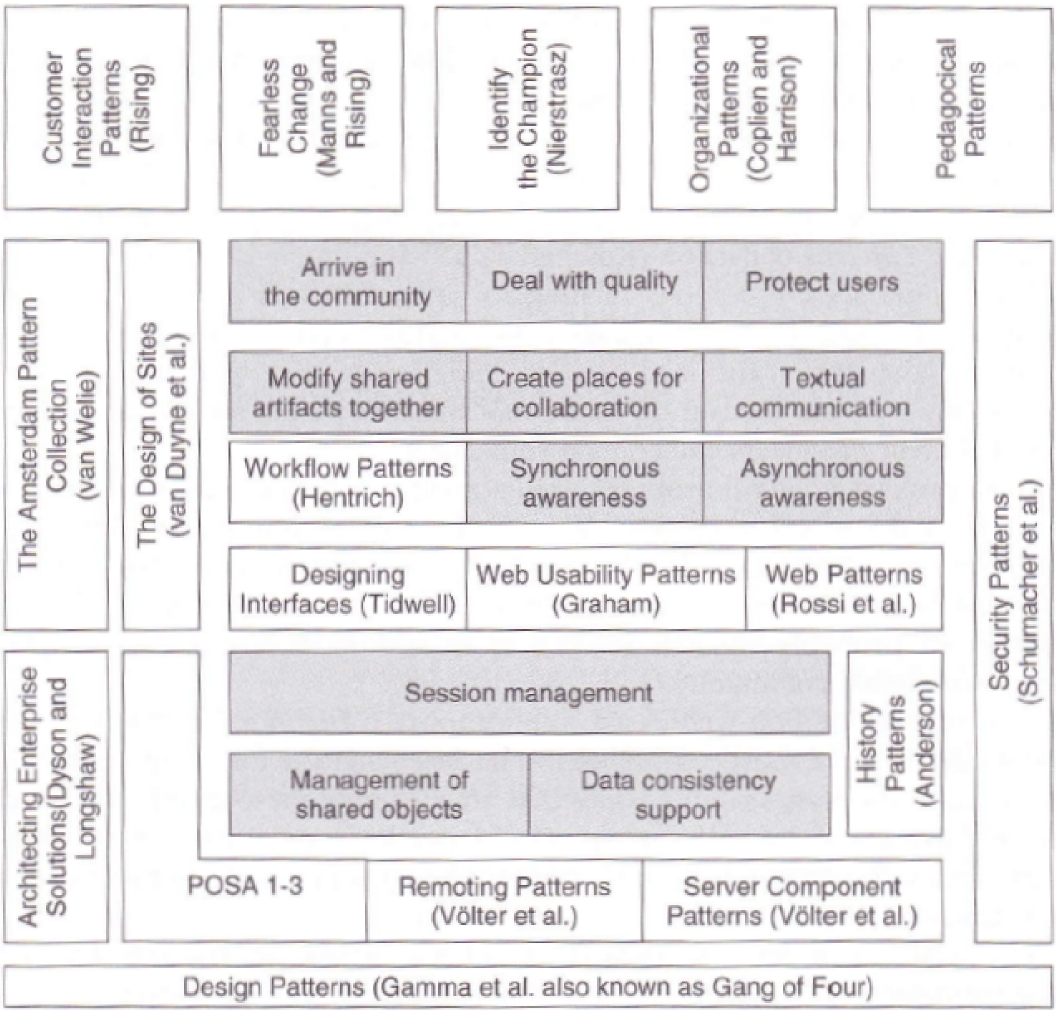


Figure 1: Other languages related to *Patterns for Computer-Mediated Interaction* pattern language. Figure is taken directly from [44].

1.4 Research Questions

The main research question that will be addressed in this thesis can be found in table 2. This table lists the full set of research questions. The sub-research questions will be explained in chapter 2, where we uncover the set of re-occurring problems within co-located information sharing that these questions address.

Main RQ	What is the set of patterns that can aid in the design of systems intended to support information sharing among co-located users?
Sub RQ 1	How can the set of patterns facilitate interpersonal interactions?
Sub RQ 2	How can the set of patterns facilitate collective viewing of information?
Sub RQ 3	How can the set of patterns take advantage of relationship among users and protect the privacy of users?
Sub RQ 4	How can the set of patterns facilitate the availability of information?
Sub RQ 5	How can the set of patterns facilitate the awareness of potential for collaboration?

Table 2: Research Questions.

1.5 Research method

In order to create a set of design guidelines for co-located information sharing between users, we will have to look at existing work on the subject. First, we will look at existing collaborative systems and other related work on the domain, with the aim of identifying a set of problems that are usually present when co-located users share information. These re-occurring problems will in turn be used as a basis for the creation of a set of design guidelines, in the form of patterns. Our aim will be to create these patterns so that they could be used by designers of collaborative systems to more effectively solve problems related to co-location in future systems.

When we have created the initial set of pattern we will conduct a series of evaluations with a panel consisting of experts within software engineering. The aim of these evaluations will be to revise the patterns, and possibly the set of problems they are addressing, based on the feedback we receive. We will conduct three different evaluations, where the first will focus on the understandability, and the second and third will be regarding different aspects of usefulness of the patterns. A more detailed description of these evaluations can be found in chapter 5, and a model of the overall research method can be found in figure 2.

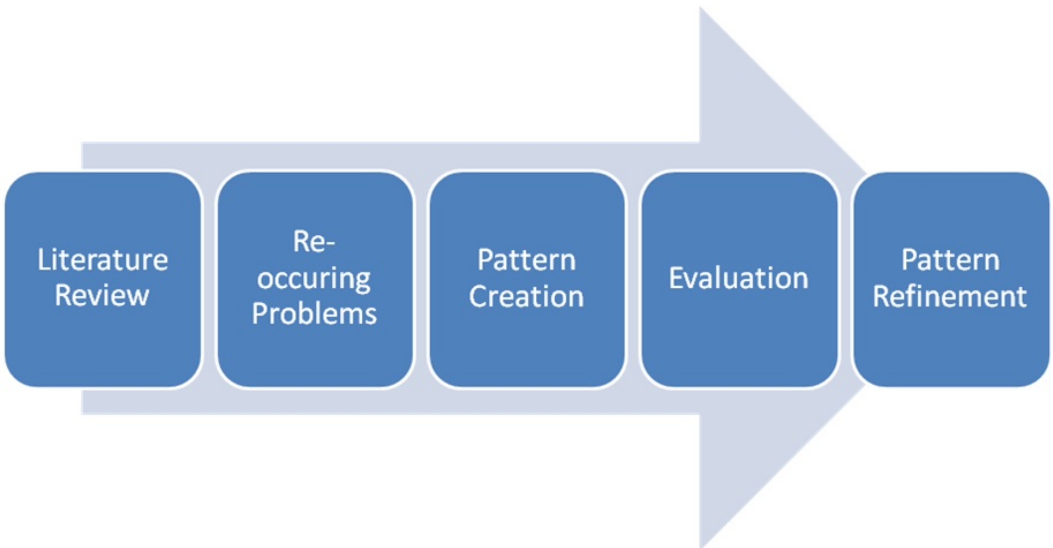


Figure 2: A model showing the research method

The evaluations will be in the form of semi-structured interviews, where we mainly focus on one of the evaluation criteria that will be introduced in section 5.1. A semi-structured interview is a form of interview where one uses a list of themes to cover and questions to ask, but reserves the right to change order of questions depending on the flow of the interview, and ask additional questions if issues that require more questions are uncovered [37]. This will allow us to focus our attention on a certain criteria, ask additional question where needed, and at the same time have the ability to investigate issues that are not directly related to the criteria, but still important to the evaluation of the patterns.

1.6 Organization of Thesis

In this section we will, briefly, describe the organization of the thesis.

Chapter 2 - Problem Refinement

In this chapter we will give a more thorough introduction to our problem and identify the re-occurring problems that the patterns should address. We will start by a more in-depth description of information sharing within co-located collaboration, before identifying a set of re-occurring problems for co-located information sharing through review of existing literature on the subject.

Chapter 3 - Related Work

In this chapter we will have a closer look at a set of patterns and a pattern language that are relevant to our set of patterns for co-located information sharing.

Chapter 4 - Pattern Overview

In this chapter we will introduce each of the patterns we created individually, and provide an overview over the set of patterns and how they are connected to each other.

Chapter 5 - Pattern Refinement

In this chapter we will present our evaluation method, as well as the results from the evaluations we conducted in order to revise the set of patterns.

Chapter 6 - Patterns for Co-located Information Sharing

In this chapter we present the set of patterns that has been the aim if this thesis. Before the actual patterns are presented we provide a short scenario, which illustrates the use of the patterns. After the set of patterns have been presented, we provide an example showing how the functionality described in the scenario can be obtained.

Chapter 7 - Conclusion

In this chapter we will conclude our work. We will present a short summary of the report, evaluate and conclude with answers to our research questions, point out contributions and discuss further work.

2 Problem Refinement

In this chapter we will give a more thorough introduction to our problem. We will start by a more in-depth description of information sharing within co-located collaboration, and use scenarios from city-CL settings to provide illustrative examples when needed. In addition we will review existing literature on the subject in order to uncover a set of re-occurring problems for co-located information sharing.

2.1 Co-located Information Sharing

Sharing has in modern culture become more and more a part of everyday life. People are connected to the Internet virtually anywhere they go, and the use of the Internet for sharing and collaboration has increased dramatically. The popularity of social networks like Facebook[1], online forums like 4chan[2], and online collaboration tools and services like for instance Google Documents[3] are a testament to how people have increasingly started sharing and collaborating with each other across the globe.

Even though technological advancements have made collaboration possible over large distances, many activities in specific collaborative environments still require people to work in close proximity with each other, in order to complete their goals. These environments are often characterized by users having a high degree of mobility, which enables them to establish face to face interactions with co-located peers [34]. Kraut et al. showed in paper from 1993 that physical proximity can in some cases be a predicator for success, and in addition documented a negative impact on collaboration when opportunities for casual interaction were reduced or eliminated [31, 30].

Issues that are often raised in collaborative environments where users are co-located concern the need to move around within the given location in order to locate peers and access information and resources [33]. In these situations people will often find themselves in the need of sharing information with other, co-located peers as part of the collaborative activity they are engaged in. Traditionally, sharing is done through conversation and with the assistance of printed documents. However, often these situations are not planned, and the information – e.g. the printed document – might not be available at hand. Also, using a printed document might not be suitable when multiple actors are viewing the same document;

[1]http://facebook.com
[2]http://4chan.com
[3]http://docs.google.com

especially when the meeting is spontaneous, and only one copy of the information is available. Using ubiquitous and mobile technologies, it is possible to support sharing of information in more flexible ways, by allowing different methods for information sharing based on the context of the activity the people are engaged in.

Figure 3 illustrates our definition of co-located information sharing. In this figure, we can see five users of a collaborative system. These users are equipped with hand-held devices capable of sending and receiving information. The three users on the left are co-located and collaborating, for instance within a meeting room solving a task together. The two users on the right are not co-located with the three on the left, and this is represented by the dotted line between them. For this thesis we will define co-location as:

> *Two or more people being present at the same time at a physical location that encourages communication*

Although the two users on the right are not co-located with the three on the right, they are located within the same place, for instance a workplace, and operate in the same environment. For this thesis we will assume that the people collaborating are a part of a technology rich environment. A technology rich environment is characterized by providing situated devices to support its users, like for instance projectors, displays and printers, that facilitate collaboration between users and makes it more effective. In the figure, the three users on the right take advantage of a situated display in order to collectively view and discuss the same information.

In addition, we will use both the terms *information* and *information object* equally when we refer to users sharing information with each other. We define an *information object* as any type of information that can be represented digitally, for instance an image, an audio recording, parts of a document, a whole document, several documents, or any combination of these. This term is introduced in order to emphasize that the type of information the users share with each other is not important, but that users should have the possibility to share any digital information available to them in any way or combination that they want. Our patterns will reflect this notion.

In order to share an information object with other users, the computer system must know *which* information object a user wants to share and the *receiver(s)* of the information. We therefore introduce two actions that stand central from an end-users perspective:

(1) Specify *the information object* to share.

(2) Specify *the receiver(s)* of the information.

In a technology rich environment, a receiver can either be a user (or more specifically the personal device of a user) or a situated device that can be used to view the information collectively. These are the two primary actions that must be performed by the user in order to share an information object. However, the system might also offer additional support, for instance to help protect the privacy of a user when he is sharing information. These support features are also a part of the procedure of sharing information.

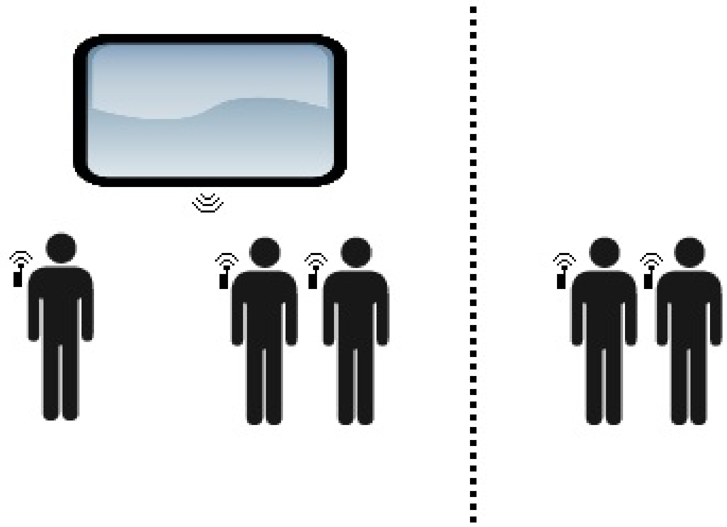


Figure 3: Co-located information sharing.

For a more practical example of information sharing among co-located users, consider the scenario depicted in table 3. This scenario describes a city-CL system where users can explore the city, and use hand-held devices in order to complete learning activities in a city-landscape. The scenario gives an example of two activities that illustrate some of the aspects of co-located information sharing.

In the first case (*action 1*), two users of the same collaborative system meet and one of them decides to exchange the information he has collected so far with the other. This is an example of how information sharing can happen informally between co-located actors. By informal collaboration we mean collaboration that happens outside a predefined schedule or place, are spontaneous or of a serendipitous nature and where the topic can change during the course of the interaction. Studies in office and educational environments have shown that informal interactions between

Sharing information in a city-CL system

The teacher has just given out a new assignment about pollution. The students have to investigate the status of their local environment. Anna, George, and Isabel are assigned to the same group and they decide to divide their tasks. Anna will cover the main street, George will cover the area around the main square, while Isabel will monitor the status of the river.

Action 1
While out in the field, George meets a class working on a similar project. By chance a conversation starts, and George decides to share the information he has collected so far with one of the other students.

Action 2
Back to school Anna, George and Isabel meet up and discuss the results they have gathered. In order to view the results while they talk about them, they share this information with each other.

Table 3: A short scenario showing co-located information sharing in a city-CL setting.

people can be important for the success of collaborative activities [13, 9, 31, 30]. This research argues that this is mostly due to the fact that informal interactions provide lightweight means for collaboration; where the parties can take advantage of the opportunities that arise in a casual setting due to physical proximity. Information sharing or exchange is often a part of this informal collaboration. For instance, Mejia et al. found that in a hospital setting, 26% of the total informal interactions that occurred had the need for sharing or exchange of information [34]. Another aspect that this scenario highlights, is how information sharing can happen by exchanging information to the personal device of another user. Using mobile technology, sharing information can be facilitated by exchanging the information using mobile devices that the users carry at all times. This stands opposed to sharing information by viewing the information collectively, that is illustrated in *action 2* of the scenario.

In the second case (*action 2*), several actors are starting a collaborative activity together, where each one has data that is considered relevant. This is an example of formal collaboration. In formal collaboration the parties involved have decided upon the content, place and time of the meeting. There is in other words a clear understanding between the members of the session concerning what the meeting is about. More importantly for co-located information sharing, this scenario serves as an example of when it could be appropriate to share information by viewing it collectively. In this setting ubiquitous technologies can be used to provide the users with situated devices in the environment that facilitate group interaction. In this example, users could use a display medium that allows them to more efficiently view and discuss the same information together.

The scenario only highlights some of the issues that must be considered when creating collaborative systems that are intended support co-located information sharing. In the sub-sequent section we will describe these and other problems that we have uncovered as relevant for co-located information sharing. We will only address problems that are related to cases where users are co-located and present at the same time. These problems will form the basis for the patterns, that in turn will serve as guidelines for how designers and developers can best support information sharing in a co-located setting. The patterns themselves will be written on a level of abstraction that targets the human-computer interaction part of sharing information between co-located users. This means that the patterns are intended to act as guidance on how to achieve the solutions to the problems we identify as prominent for information sharing in a co-located setting.

2.2 Re-occurring problems in co-located information sharing

As stated in chapter 1, patterns are solutions to re-occurring problems within a given domain. In order to create a set of patterns, it is therefore appropriate to first identify the set of re-occurring problems that the patterns should address. In this chapter we will present the set of re-occurring problems we have uncovered by reviewing existing literature on the subject.

2.2.1 Strain on interpersonal interaction

When using technology that is designed to support collaborative activities, it is important that the technology imposes the least amount of interference on the interpersonal interaction between the participants [45]. Interference with these interactions can have a negative impact the collaborative activity, by shifting focus away from the task at hand. Elwart-Keys et al. [12], points out that this is especially true when the use of technology hinders the conversation between the parties involved. As an example we point to the meeting between George and the other student in the scenario depicted in table 3. If the task of exchanging data was cumbersome and time demanding, much of the conversation between George and the other student could be about how to carry out the sharing – thereby shifting the focus away from original topic.

In order to meet this challenge when developing software for information sharing between co-located people, it is important that the interaction needed to perform the sharing is user-friendly, and takes as little time as possible. The users must therefore be equipped with light-weight mechanisms to both specify *the information object* they want to share and the *receiver(s)* of the information.

Bump, an application for iPhone and Andriod mobile phones, is an example of how users can specify a receiver. With Bump, users can obtain contact information of others, simply by touching their devices together. This type of interaction could also be used to share other types of information, and falls under the definition of *touch interaction*, which is defined as: "*The deliberate bringing together of two devices, for the purpose of obtaining services*" [7].

Additionally, a concept within ubiquitous computing called *the boundary principle* could also ease the impact on inter-personal interactions. This principle states that:

> *"Ubicomp system designers should divide the ubicomp world into environments with boundaries that demarcate their content. A clear system boundary criterion - often, but not necessarily, related to a boundary in the physical world - should exist. A boundary should specify an environmentŠs scope but doesn't necessarily constrain interoperation"*[29].

Applied to information sharing among *co-located* users, this means that we can take advantage of the fact that all possible receivers will be in the vicinity, and therefore simplify the selection of receivers by only showing those in the sharer's proximity. This can for instance be achieved by using what Dahlberg and Sanneblad called *proximity-based notification* [10]. *Proximity-based notification* is a way of allowing devices to gather information about other devices, indicating if these devices are in the proximity. As such, a similar technique could be used to present users with an overview of devices in the proximity that can receive information.

When using an intermediate device to share data with co-located peers, additional requirements are also imposed in order to support natural interpersonal interaction. Scott et al. pointed out that the use of separate, personal displays in tabletop environments could hamper certain communicative gestures – for example pointing to an object on the screen – since the other group members could misunderstand or not notice this gesture [45]. The authors of [33] seems to share this opinion, and solves it by using a large display that the users can individually remote control using their personal, hand-held devices.

2.2.2 Multiple users viewing the same information together

As stated in the previous section, co-located collaboration can often happen in environments where the actors are mobile – moving from location to location. In these types of environments, the use of hand-held devices can support data sharing between people. An example of this type of sharing can be seen in *action 1* of the scenario in table 3. Another example is the *Push!Music* system, that allows users to share music to other, co-located, users of the system [20].

However, not every collaborative task in environments with mobile users are best supported by handheld devices [33]; for instance when multiple, co-located users want to discuss a document together. A typical example of this can be found in *action 2* of the scenario found in table 3, where three people meet up to discuss data they have collected separately. One can assume that sharing the information collected between each participant would facilitate this discussion. One might also assume that gesturing to certain parts of the information would be part of this activity. However, this would not be ideal if each of the participants used their own device to view the information. In order to overcome this limitation in a hospital setting, the authors of [33] proposed the use of semi-public displays, located in strategic locations, that could be used to share and discuss information.

Other research on co-located collaboration has also come to the conclusion that the one-user/one-computer design paradigm is not well suited for multiple users. Starcey et al. list several systems that range from extensions of the standard desktop, to electronic white-boards and digital tabletop systems that support co-located collaboration [45]. Many other systems have also tackled this issue, and they usually contain displays that support multi-user interaction in one form or another [26, 40].

2.2.3 User Relationships and Privacy

There are many existing frameworks/architectures for collaboration systems. We have mentioned some already, including the FABULA platform and Sun's E-Learning Framework [28, 22]. Both of these have support for management of social configurations. This functionality allow users to create relationships between each other, for instance joining and being a part of a group, a community or other configurations that are tailored for the kind of interaction they wish to perform. One thing we can extract from this is that: When users interact, collaborate and share information with each other by using a collaborative system, the relationship between the users differs. These relationships offer both possibilities and constraints to designers of collaborative systems.

One possibility of using relationships is to create functionality that allows users to take advantage of these relationships in order to filter out other, interesting users. An example of this is shown in *action 1* in scenario 4, where a user of a city-CL system takes advantage of the relationship she has with other members of a certain group in order to filter out interesting receivers of the information she wants to share.

However, these relationships are also tightly knit to the problem of protecting the users' privacy. This is illustrated in *action 2* of the same scenario, where unintended use of the functionality results in another user being interrupted. In the case of the scenario, the user does not suffer particularly, other than being interrupted. However, there can also exist cases where such use of the functionality can become problematic. This can for instance be cases where users find themselves in an environment with a high density of devices and become frequently interrupted, or cases where the functionality is abused in order to spread malicious data. It is therefore important that the users are in control over what they receive or not.

A relevant example can be seen in an article by Hakansson et al [20]. The authors developed and tested a mobile music sharing system, that allowed users to share music with friends and strangers . In the evaluation with the users, they discovered the users mixed attitudes towards sharing with friends versus sharing with strangers. Although users had different motivations, most of them enjoyed sharing with people they knew. However, users were not so comfortable sharing music with complete strangers. One of the important factors were the feeling of *intrusiveness*. A conversation with some of the test subjects in the evaluation illustrates this [20]:

D9: "I wouldn't sit on the bus and spread music, that feels like..."
13: "...like spam"
D9: "I don't look for random contacts on ICQ either"

These issues should be carefully considered when designing collaborative systems. The system should allow users to take advantage of relationships to simplify sharing of information, while at the same time maintaining the privacy of the users and allowing them to control what information they receive.

User relationships and privacy in a collaborative system

Michelle and Sandra are two new exchange students at NTNU in Trondheim. As a part of their introduction to the university and the city, they have been encouraged to take advantage of the city-CL system that covers most of central Trondheim. A couple of days later they decide to meet a group of people they have gotten to know through the university at a café downtown. On the way there, they find an interesting historical building, and Michelle uses the city-CL system to retrieve some information about it using a mobile device. When they meet the rest of their friends at the café, she wants to share this information with them.

Action 1
Since all of her friends are part of the same group, *Exchange students in Trondheim*, she configures her mobile device to share to the devices of all group members in the vicinity.

Action 2
Paul, another exchange student which also is a part of the *Exchange students in Trondheim* group, is also at the cafe with a friend of his, but he does not know Michelle and Sandra and her friends. When Michelle unintentionally attempts to share the information with him, he refuses to accept it, because he doesn't know what it is or who it is from.

Table 4: A short scenario showing uses of user relationships and privacy in a collaborative system

2.2.4 Availability of information

Another important aspect of information sharing in general, is the availability of the information. Consider for example a scenario shown in table 5. In this example the person stores his data using a distributed data storage scheme. In a distributed setting, users have their own personal copy of data stored locally on different devices. This means that the user must ensure that he has the information stored on the device he is carrying, if he wants to show it to a colleague. A centralized approach eliminates this problem by storing the data centrally, on a server connected to the Internet or possibly some other network that the users have access to. In this setting the data is always stored at the same location – the server – and users can access this information using a device that has the ability to connect to the server. This means that the user can access his information as long as he is connected to the network. As an example of a centralized data model, we point to Google Docs, which is a very popular collaborative tool used by thousands of users all over the world [4]. Google Docs gives the users the ability create text documents, and to share these documents to other users. A user then as the ability to access his documents as long as he has a connection to the Internet.

Roger is working on a document on his personal computer. After working on it for some time, he decides to take a lunch break. On his way to the cantina he meet one of his colleagues that he would like to consort with before finishing his work. However, since he does not have the information with him on his hand-held device, they are unable to discuss the contents of the document, and this opportunity is missed.

Table 5: A short scenario regarding the availability of information

The choice of how data is stored in collaborative system will not only impact how users share information but also how they interact with the system to add new or modifying existing content. For example, in Google Doc users share a document by allowing other users access to the document, not by transmitting the document between two devices. Furthermore, the owner of a document can also allow other users to edit the document. As stated in the introduction, the aim of this thesis is to provide a set of design guidelines for information sharing between co-located people. An important aspect of this is to use a data storage model that makes information available at all times. One possible way of ensuring this is to use a centralized data storage model. However, it could also be ensured by other methods, for example by letting devices synchronize data between each other. Either way, it is important to ensure the availability of information and we must therefore take this aspect into account when creating patterns that support co-located information sharing.

2.2.5 Awareness of the potential for collaboration

Moran et al. mentions two elements that trigger collaboration between people: (1) the availability of a communication or interaction channel and/or (2) at least one of the people involved having the need or interest to collaborate with the others [36]. For co-located collaboration, and especially when the collaboration is of an informal nature, the relevant channel in (1) is the close proximity of the participants and that they thereby have the ability to instantiate face-to-face communication [34].

[4]http://docs.google.com

As discussed in section 2.1, some collaborative environments offer natural opportunities for collaboration based on the proximity of the participants. However, these environments can also face some inconveniences that lead to wasted opportunities. Mejia et al. mentions that, in a hospital work environment, this is partly due to lack of nearness and awareness of colleague because of their mobility and limitations of the physical environment [34]. An example of the limitations of the physical environment could be how people cannot see trough walls and therefore are not aware of who is physically present in e.g. a building.

Based on this, Mejia et al. stated that the systems should allow workers to be aware of other's presence, identity and location in order to facilitate informal collaboration. This notion is also part of a paper from 2005 by Jones and Gandhi, that looks at the use of people-to-people-to-geographical-places (P3 systems) [27]. In this paper the authors mention how location and availability of information can be used as a means to increase informal interactions and to coordinate interactions that reinforce existing ties between users. This is an issue that should be addressed when looking at co-located collaboration and sharing.

Awareness can also be facilitated similar to how proximity can be used in the specification of the receivers of information. *Proximity-based notification* is an example of this, which as previously stated, enables devices to gather information about other devices, indicating if these devices are in the proximity. This indication can act as an incentive for informal collaboration, which we earlier mentioned could have positive effects on collaboration. In [33], *proximity-based notification* was used to provide user with an easy way of detecting the presence of other users in the vicinity, and share information with them.

2.3 Summary

The re-occurring problems identified in the previous sections, form the basis for the patterns that will aid in the design and development of information sharing capabilities between co-located users in collaborative systems. More specifically, they form the set of basic issues that the patterns need to address. Because of this, we extend our main research question with the addition of the five sub questions, which where given in the introduction chapter in table 2. Each of these questions targets the occurrence of one of the re-occurring problems we have identified. Additionally, based on the problems identified we conclude that the set of patterns should at-least include:

- A pattern that addresses the strain on interpersonal interactions when specifying *which* information object to share, in accordance with section 2.2.1

- A pattern that addresses the strain on interpersonal interactions when specifying *who* is the receiver of the information object, in accordance with section 2.2.1
- A pattern that addresses the ability to collectively view information with other co-located peers, in accordance with section 2.2.2
- A pattern that addresses the need to protect the privacy of users, in accordance with section 2.2.3
- A pattern that addresses the availability of information when a user wishes to share an information object, in accordance with section 2.2.4
- A pattern that addresses the awareness of the potential for collaboration, in accordance with section 2.2.5

3 Related Work

As stated in chapter 1, patterns become increasingly useful when they are connected to other pattern and pattern languages. In this chapter we will have a closer look at a set of patterns and a pattern language that are relevant to our set of patterns for co-located information sharing. There are two reasons for doing this: (1) to investigate a pattern language that has similar intentions in order uncover if the formal structure is suitable for our patterns, and (2) to list patterns that we can reference to from the patterns for co-located information sharing.

3.1 Patterns for Computer-mediated Interaction

The book *Patterns for Computer-mediated Interaction* describes a pattern language which contains patterns for the design and development of Groupware applications [44]. Groupware applications are applications that use a combination of software, hardware and social processes to support interaction among a group of people, and is as such a part of CSCW [50]. The book focuses on patterns that cover the social and software technical aspects of Groupware – the computer-mediated interaction. This means the book covers requirements for both the social aspects, e.g. the social structure of the participants or the flow of information; and technical aspects, e.g. how users obtain a service or how the IT infrastructure is organized. Together these form what the book refer to as *socio-technical* requirements.

Shummer and Lukosch operate with three different levels of pattern abstraction: (1) Patterns at a high level of abstraction deal with the social aspects of computer-mediated interaction, and can often be implemented by changing end-user behavior. (2) Patterns at a medium level address problems related to human-computer interaction, and define how specific part of an application should be designed. (3) Patterns at a low level treat the technical aspects of an application, and are written for application developers. The patterns are then divided into one of three categories: Community support, Group support or Base Technology; that are analogous to the different levels of abstraction (from high to low abstraction).

Patterns in community support should be considered when social configurations have not yet been created, and one plans to use a collaborative system in a large organizational context. The patterns mostly describe social processes, but some technical implications are also raised. The patterns in community support are divided into three sub-categories: *Arrive in the community*, *deal with quality* and *protect users.*

Group support contains patterns that support small groups in their interaction. In this layer the authors assume that the participants have defined a collaboration context and that they want to perform certain tasks that are in line with the group's collective goal. The patterns are both social and technical, but in all cases describe aspects of the system that are visible to the end user. The category is further divided into five sub-categories: *Modify shared material*, *create places for collaboration*, *support textual communication*, *synchronous group awareness* and *asynchronous group awareness*.

The lowest level, base technology, includes patterns that are used to design the infrastructure of the groupware application. The patterns describe more implementation specific aspects, such as how information is exchanged and managed within the system, and are divided into the sub-categories: *Session management*, *management of shared objects* and *data consistency support*.

The abstraction level used in the two highest categories, community support and group support, matches the level we intend to use in our own set of patterns. The patterns in these categories rarely mention technical details or implementation specific aspects, and focus on areas that in most cases are visible to the end-users. At the same time, the structure used to represent these patterns are rigid enough to also support more implementation specific aspect of collaborative systems. Since the domain that *Patterns for Computer-mediated Interaction* covers is related to co-located information sharing, and the level of abstraction used is similar to our intentions, we deem that the pattern structure used in this book is suitable for the patterns that will be created in this thesis. A description of the formal structure can be found in chapter 4 in table 8.

3.1.1 Relevant patterns

Many of the patterns from *Patterns for Computer-mediated Interaction* are relevant for our patterns. A pattern is relevant when it can help to solve another pattern or if they can be used in conjunction in order to improve a certain aspect of one or both patterns. Table 6 contains the set of patterns that we have identified to be directly relevant for one or several of our patterns. These patterns will also be referenced in a section called *Relevant Patterns* for each of our patterns, along with a notion of why they are relevant for that pattern. The patterns that have been created for information sharing among co-located users will be introduced in the next chapter.

Buddy List
In order to provide the users with an overview of relevant interaction partners, Buddy List specifies that users should be provided with a buddy list where they can bookmark other users of interest. Whenever a user browses other users, this list should be initially showed.

Group
The Group pattern states that it should be possible to compose users into groups in order to develop group awareness. The group should be given a name and it should be possible to visualize the group composition. Furthermore, the pattern states that users should be allowed to manage groups and interact with a group in a similar manner as to how the interact with a single user.

Letter of Recommendation
According to the Letter of Recommendation pattern, users should be able to rate previous interactions with other users, in order to provide the community with a rating about other unknown users that are potential interaction partners. This would enable users to gain a measure of trust about users they do not know.

Masquerade
This pattern concerns the need to let users control what information is revealed about their personal details in a specific interaction context. Users should be able to filter the information that is revealed from their personal information. This pattern is specifically relevant in settings where users are monitored in order to provide awareness information to other users.

Shared File Repository
This pattern states that a Shared File Repository should be provided where users can place and retrieve files, in order to collaborate over the use of this shared content. The main reason for this, is to counteract the exchange one-time copies that can be out of date.

Active Map
Users can have problems with orienting themselves or interact with other users or artifacts in large or unknown spaces. The ACTIVE MAP pattern concern how users can be provided with a graphical and scaled representation of this space, in the form of a map that is enriched by awareness information about users and artifacts in the area.

Telepointer
When discussing visual artifacts, it can be difficult to obtain a shared focus on a specific part. The TELEPOINTER pattern states that users should therefore be provided with a visual pointer that can be placed in the information space.

Table 6: Related patterns from *Patterns for Computer-mediated Interaction*

3.2 Patterns of Mobile Interaction

The patterns that are contained in this set are design patterns that cover areas related to interaction among mobile devices, and are describe in an article from 2002 [38]. The patterns are at a fairly low level of abstraction, in contrast to the patterns presented in the categories *community support* and *group support* of *Patterns for Computer-mediated Interaction*. As such, they are more similar to the patterns contained in the *base technology* category, but with focus on aspects related to interactions in and among mobile applications. These patterns can therefore be useful for us to connect to with respect to implementation specific issues, since we will not directly address these issues in our set of patterns. Figure 4 show the organization of the patterns. Table 7 contains a short description of the patterns that are directly relevant for the patterns created for co-located information sharing. As previously mentioned, these will be introduced in the next chapter. As with the patterns we presented from *Patterns for Computer-mediated Interaction*, these patterns will be referenced in a section called *Relevant Patterns* for each of our patterns, along with a notion of why they are relevant for that specific pattern.

Synchronization
The SYNCHRONIZATION pattern describes a method that can be used to ensure that up-to-date copies are available to the users. The pattern solve this using a distributed data architecture.

VirtualWindow
The VIRTUALWINDOW pattern give readers a method for using a device to present a window of another device or computer.

Sensing
The SENSING pattern describes how a device can receive continuous sensor data, for instance location data, from other devices.

Table 7: Related patterns from *Patterns of Mobile Interaction*

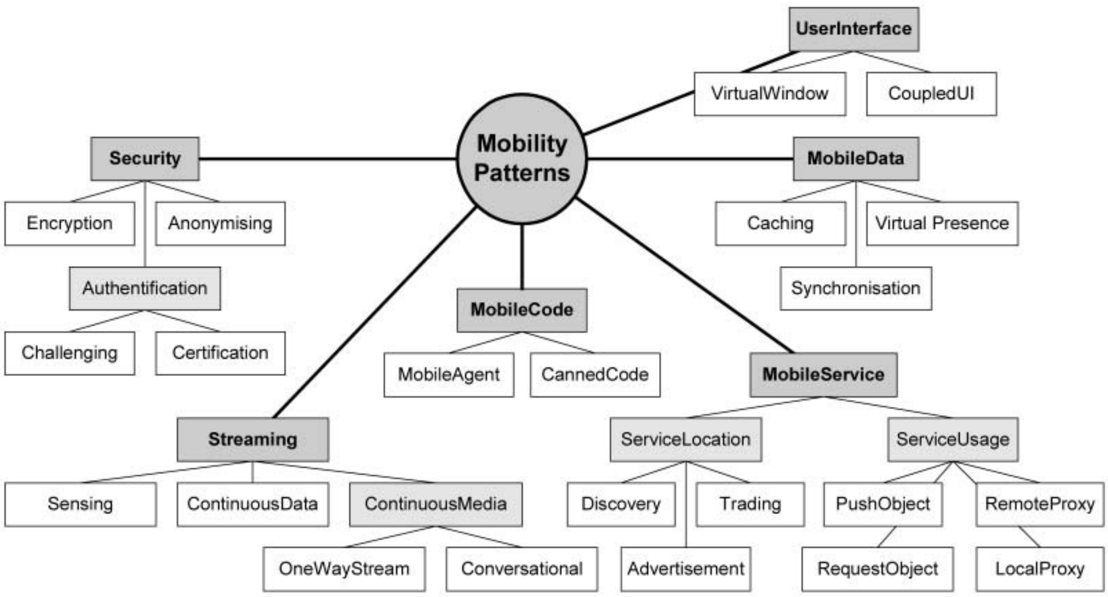


Figure 4: A figure showing the pattern hierarchy of the patterns contained in *Patterns of Mobile Interaction*. The figure is taken directly from [38].

4 Pattern Overview

In chapter 2 we looked at existing literature and identified a set of re-occurring problems for co-located information sharing in collaborative systems. These problems were used as a basis to uncover how other systems tackle these problems, that in turn were used to create a set of patterns. The patterns were then refined based on a series of expert evaluations. We will describe refinement process in chapter 5, and the revised set of patterns is given in chapter 6. In this chapter we will introduce each of the patterns we created individually, and provide an overview over the set of patterns and how they are connected to each other.

We will reference to a pattern created in this thesis by typesetting the name of the pattern in small capital letters, and the section where the pattern can be found in subscript. SHARING SHORTCUT$_{6.2}$ is an example of this, which references the *Sharing Shortcut* pattern that can be found in section 6.2. When we reference patterns from another pattern language or set of patterns, we will use subscript to indicate where the pattern can be found instead of pointing to a section in this thesis. Patterns from *Patterns for Computer-Mediated Interaction* [44] will be marked *CMI* and pattern from *Patterns for Mobile Interactions* [38] will be marked *PMI*. For instance, BUDDY LIST$_{\text{CMI}}$ is an example of a reference to a pattern from *Patterns for Computer-Mediated Interaction*, and VIRTUAL WINDOW $_{\text{PMI}}$ is a reference to a pattern from *Patterns for Mobile Interactions*.

4.1 Pattern Context

As stated in the previous chapters, the patterns that were created in this thesis aim to provide software designers with design guidelines for information sharing between co-located users. Similarly to the patterns described in the book *Patterns for Computer-mediated Interaction*, our patterns are on a level of abstraction that targets the human-computer interaction part of sharing information between co-located users. As such, they focus on issues that are visible to the end-user. In most cases we foresee that the patterns will be applied within collaborative systems, where users are mobile, and as a result often engaged in face to face meetings and informal collaboration. Examples include cases where users are mobile within a specific place, such as a hospital, or cases where users are mobile between different physical locations, such as city-CL systems used in a city landscape.

Information sharing is a big part of collaboration [34], and since users are mobile and often collaborate on-the-move, users can benefit from using hand-held devices to facilitate the exchange – or sharing – of information between each other. In addition, users can also benefit from taking advantage of situated devices in their surroundings in order to better facilitate collaboration [34, 33, 45].

To illustrate this context, we point the article *Supporting Informal Co-located Collaboration in Hospital Work* [34]. In this article, the authors present a collaborative system used in a hospital setting, where users can share information to their colleagues, either with the use of their hand-held devices or through stationary devices that are placed throughout the hospital.

4.2 Pattern Structure

As stated in chapter 1, a pattern should be represented in a formal structure that includes information such as why the pattern should be applied, where and when it should be used, who should use it and how it should be used. Our patterns were created using the structure created in *Patterns For Computer-mediated Interaction* [44]. As stated in chapter 3, this was reasonable since co-located information sharing is connected to the domain this book covers, and the patterns are written on a similar abstraction level. The pattern structure, together with a short description of each section is given in table 8.

Name The name serves as the primary identification for the pattern. Users of the pattern language should be able to use the pattern name in daily communication.
Sensitizing Picture A picture is also added to help users remember the pattern. The picture should illustrate the pattern either by an example of use, an analogy or a situation where the pattern is relevant. The users should also be able to use the picture as a quick way of remembering and capturing the essence of the pattern when looking back on them at a later time.
Intent The intent captures the core of the pattern's solution in one sentence. In our case, the intent of the pattern is what the developers are trying to accomplish by applying the pattern.

Context
The context describes the situation in which a pattern is intended to be used. This can for instance include which state users are in, which tools they use and which environment they are in. The context helps designers recognize when the pattern is applicable, and for which context the pattern was designed. However, this does not mean that the pattern can be used in other contexts as well, although it might require the designers to adapt the pattern to the context in question.

Problem
The problem describes the most important aspects of the re-occurring problem that the pattern is trying to solve.

Scenario
The scenario describes a fictional example of a real-life setting that highlights the intent, context and the problems related to the pattern.

Symptoms
The symptoms describe a set of occurrences that indicate that a certain pattern could be applied to improve the current situation. Symptoms have the form of sentences that starts with the phrase *"You should consider applying this pattern when..."*. Symptoms help users of the patterns to recognize when a pattern should be applied.

Solution
The solution section captures the core of how the pattern resolves the problem given in the problem section and the symptoms given in the symptoms section. Together with the problem section, these are the two most important parts of the pattern.

Dynamics
The dynamics section describes the actors and resources involved in the pattern, and how they interact together in order to solve the problem. Since our patterns are mostly socio-technical, this section will often contain social or group processes between users, but could also contain suggestions to how technical parts of the pattern can be addressed.

Rationale
The rationale section describes how the pattern reaches its objectives. It gives an explanation as to why the pattern works and why it is appropriate within the given context.

Check The check section poses questions that needs to be answered when the patterns is applied. The section is a list of short questions that each point to a potential problem that developers must consider when the pattern is realized. The check section is introduced with the phrase "*When applying the pattern, you should answer these questions:*"
Danger spots The danger spots section points to new problems that may arise when the pattern is applied, and possible solutions to these problems.
Known uses The known uses section provides examples of applications of the pattern. This section is especially helpful for pattern users, since it provides them with a hands-on example of how the pattern is applied, and the effects of it.
Related patterns The related patterns section list other patterns that can be used to solve or partly solve the same intent, or patterns that are relevant in other aspects and why these patterns are relevant.

Table 8: Pattern structure

4.3 Introduction to the set of Patterns

Table 9 depicts how the patterns are related to the re-occurring problems we identified in chapter 2. In this section we will describe each pattern individually, and state which re-occurring problem the pattern addresses, and describe the patterns intent and partly its solution.

Pattern	**Re-occurring problem**
SHARING SHORTCUT$_{6.2}$	Strain on interpersonal interaction when a user specifies *the information object* to share
PROXIMITY-BASED IDENTIFICATION$_{6.4}$	Strain on interpersonal interaction when a user specifies *the receiver(s)* of an information object
PHYSICAL IDENTIFICATION$_{6.3}$	Strain on interpersonal interaction when a user specifies *the receiver(s)* of an information object
	Continued on next page

Pattern	**Re-occurring problem**
SHARED VISION$_{6.6}$	Multiple users viewing the same information together
SHARING AGREEMENT$_{6.7}$	Relationship among users and privacy
ENSURE ACCESS$_{6.8}$	Availability of information
PROXIMITY-BASED AWARENESS$_{6.5}$	Awareness of the potential for collaboration

Table 9: Relationship between the patterns and the re-occurring problems identified in section 2.2

4.3.1 Sharing Shortcut

The SHARING SHORTCUT$_{6.2}$ pattern relates to the problem of minimizing strain on interpersonal interactions, with respect to simplifying how users specify the information they wish to share. The intent of the pattern is to give users a consistent way of specifying the information object to share; independent of parameters such as the type of information it is and the device they are using.

4.3.2 Proximity-based Sharing

The PROXIMITY-BASED SHARING$_{6.4}$ pattern also relates to the problem of minimizing strain on interpersonal interactions between users in collaborative systems. However, this pattern does not focus on simplifying the way users choose which information to share, but how they specify *the receiver(s)* of the information, where the receiver(s) can either be situated devices or mobile devices of other users. The pattern addresses this problem by allowing users to specify one or several receivers based on devices that are in their proximity.

4.3.3 Physical Identification

The PHYSICAL IDENTIFICATION$_{6.3}$ pattern also addresses the problem of how to minimize strain on interpersonal interactions when identifying receivers, albeit with a different approach than PROXIMITY-BASED SHARING$_{6.4}$. The intent of the PHYSICAL IDENTIFICATION$_{6.3}$ pattern is to allow users to identify receiving devices when sharing information by using a *physical motion* or a *physical contact* with another device. This allows users to identify the receiver(s) while at the same time participating in the collaboration, for instance while keeping eye-contact or participating in a discussion.

4.3.4 Shared Vision

The Shared Vision$_{6.6}$ pattern relates to the problem of allowing users to collaboratively view information together when they are co-located. The intent of the Shared Vision$_{6.6}$ pattern is to let users take advantage of situated displays in the environment in order to better facilitate collaboration between several co-located users. In addition, the pattern emphasizes that the same methods for sharing between personal devices of users should also be applicable when sharing to situated devices, like for instance situated displays.

4.3.5 Sharing Agreement (Sharing Request)

The Sharing Agreement$_{6.7}$ pattern concerns the problem of protecting the privacy of the users when sharing information to each other. The intent of the pattern is to protect both the sharer and the receiver of information. The pattern states that the receiver should be protected by have the ability to accept or deny an incoming information object. Additionally, some cases warrant the need to protect the sharer, by prompting the user to explicitly state that he wants to share the information object he has specified to the receivers he has selected. An example can be cases where the user is about to share sensitive information.

Before the second refinement of the patterns (found in section 5.7), this pattern only focused on the protection of users *receiving* information, and was called Sharing Request$_{A.1}$. The intent of this pattern was to allow users to accept or deny an incoming information object. The original Sharing Request$_{A.1}$ pattern can be found in appendix A.1.

In the evaluations of the patterns, we will therefore address the Sharing Request$_{A.1}$ pattern until Sharing Agreement$_{6.7}$ is introduced in the second refinement of the patterns, which can be found in section 5.7.

4.3.6 Ensure Access

The Ensure Access$_{6.8}$ pattern concerns the problem of availability of information when users need to share. The intent of the pattern is to ensure that information from different sources is always available when the user needs it. The pattern discusses several ways of achieving this, as well as important issues that need to be addressed when the pattern is applied.

4.3.7 Proximity-based Awareness

The Proximity-based Awareness$_{6.5}$ pattern addresses the problem of allowing people to maintain an awareness of the potential for collaboration, by providing users with awareness information about objects of interest, such as peer users and situated displays. Moreover, the patterns describes how proximity can be used to provide a user with information about which resources that are in the vicinity, and that a user should have the ability to create notifications that occur when interesting people, or devices, enters their proximity.

4.3.8 Pattern Relationship

Figure 5 shows how the different patterns relate to each other. In this figure, a pointed arrow from pattern A to pattern B, it means that A *affects* B in some way, but B does not directly affect A. As the introduction to the patterns states, the Ensure Access$_{6.8}$ pattern describes why it is important that users have access to information sources, and how this can be obtained. When users know what information they would like to share, Sharing Shortcut$_{6.2}$ can be used to select this information. After selecting an information object to share, Physical Identification$_{6.3}$ and Proximity-based Identification$_{6.4}$ describes how the receivers can be identified. Physical Identification$_{6.3}$ describes a method to identify a single user, while Proximity-based Identification$_{6.4}$ takes into account that a user might want to identify several co-located receivers at once. When users share information with each other, it is important to ensure privacy. The Sharing Agreement$_{6.7}$ pattern describes how the users should be able to protect their privacy when sharing information. In some settings a user might also wish to share information by collectively viewing it with other participants, for example by using a situated display. The Shared Vision$_{6.6}$ pattern describes how this can be obtained.

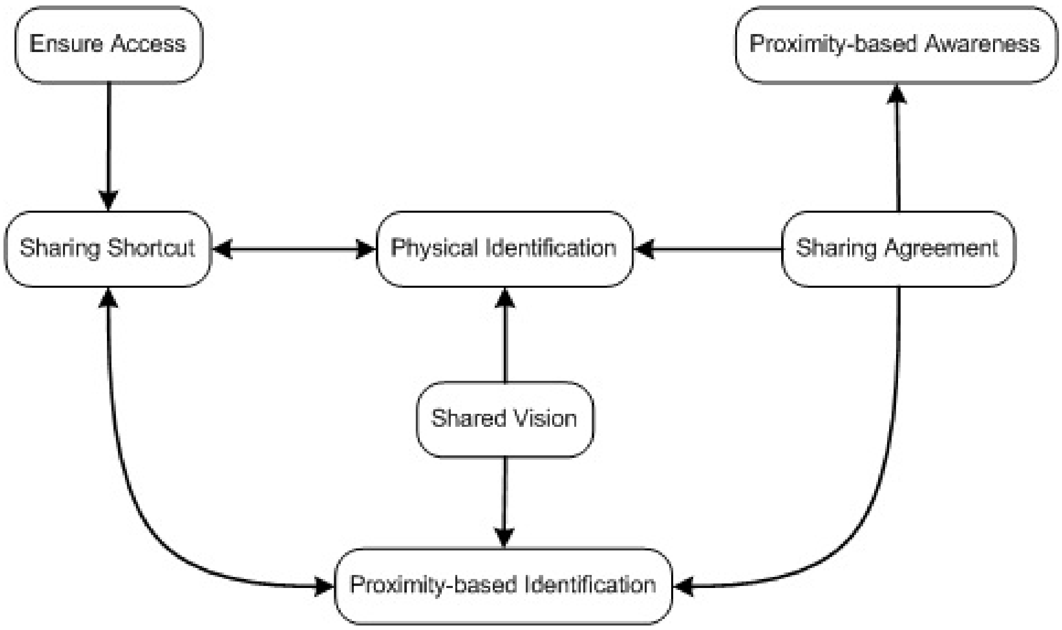


Figure 5: Patterns for co-located information sharing and how they relate to each other.

5 Pattern Refinement

In order to evaluate and refine the patterns, we conducted a series of expert evaluations. The evaluations where conducted according to a set of evaluation criteria, with a panel of experts within the field of software engineering. We then revised the patterns based on the feedback received through the evaluations.

5.1 Evaluation Criteria

In order to find a suitable set of criteria for the patterns we created, we examined how other authors of patterns had evaluated their patterns. The book *Liberating Voices*, contains a separate chapter that focuses on how individual patterns and pattern languages as a whole should be evaluated [43]. Since the aim of this thesis is to create patterns for information sharing between co-located users, which is only a part of the domain of co-located collaboration, we will not evaluate the completeness of the patterns with regards to the domain. Instead we focused on the parts that were relevant for individual patterns, and ultimately what the set of patterns together aimed at achieving. Although the chapter in *Liberating Voices* is specifically designed for their language, we have extracted a general set of criteria that are relevant for our work. These were grouped into two main evaluation criteria for the quality of a pattern, namely *Understandability* and *Usefulness*.

Understandability of the patterns

There are several aspects that could have an impact on the understandability of a pattern. The two aspects that we deemed most important were (1) that the language used in the pattern was easy to understand, and (2) that the pattern successfully conveyed the idea *behind* the pattern.

As stated in the introduction, one part of the value of patterns is that they enable readers to act as expert in a domain they previously had little or no knowledge of. As such, it becomes important that readers can easily understand the content of the pattern, in accordance with (1). Additionally, a readers understanding must be in line with our intentions of the pattern. As such, a reader should – in an unambiguous way – be able to understand the idea behind the pattern, which gives us aspect (2). This means that each part of the pattern must be written so that there is no confusion about what the authors meant, using a language that makes it understandable for the target readers. We have defined this quality as the *Understandability* of the patterns and, more specifically, this entails that the patterns should:

1. Use a language that is easy to understand and that is suitable for the target readers
2. Use a formal structure (or representation) that is appropriate for the level of abstraction used in the patterns
3. Ensure that each of the sections of the pattern is in line with the guidelines for the formal structure and that information is not redundant
4. Provide an answer to a single, distinguishable problem relevant to the domain

Because the patterns are meant to be used in the design phase of collaborative systems, it is important that it uses a formal structure and a language that all stake-holders can understand [44]. For our part, this means that potential users, the customers that require the collaborative system and the designers of the system should all be able to understand and make sense of the patterns.

For ease of use, it is also important that information given in each section of the pattern is not redundant, and that each section fulfills its specific goal. The goal of each part can be found in table 8, which also describes the formal structure that is used.

The fourth point means that a potential reader should not be confused about what problem the pattern addresses. This is important in order to give the reader a clear picture of the problem and a distinct course of action for resolving it.

Usefulness of the patterns

As previously stated, the second criteria we will use to evaluate our patterns is *usefulness*. This criterion is targeted towards the actual application of a single pattern and the set of patterns as a whole. More specifically we want to evaluate if the patterns can be helpful in the design-phase of collaborative systems. In order to be useful, the patterns should:

1. Relate to the occurrence of a real problem within the domain
2. Provide a context for the application of the pattern
3. Provide a scenario that exemplifies the context and the problem
4. Provide a non-trivial and plausible solution to the problem
5. Discuss the set of most important problems that may arise when the pattern is applied

6. Provide a set of examples from the real world that illustrates how the pattern can be applied
7. Ensure that the pattern provides a timeless answer

First of all, in order for a pattern to be useful it must target a real, re-occurring problem within the domain. The patterns created in this thesis, aims at providing solutions to problems related to information sharing when people are co-located. The context is therefore within collaborative systems, in environments where users often engage in face-to-face interactions. This means that the patterns should be targeted towards problems that arise when users are *co-located and in need – or interest – of sharing information.* In addition, the scenario should provide a clear example that illustrates both the problem and the context of the pattern.

The solution should be non-trivial and plausible. Within the structure we use to represent our patterns this means that: the solution section captures the core of how the pattern resolves the problem, the dynamics section describes this with a level of detail suitable for the target audience, and the rationale section states why this course of action solves the problem. In addition, the pattern should discuss the potential problems that could arise when the pattern is applied. In the structure that we use, this is discussed in the danger spots section, and it is important that this section contain the most important problems that can arise.

According to the original conceptualization of patterns by Alexander, a pattern should be timeless [3]. In other words, it should describe a course of action that is valid even though time changes specific elements within the domain. Evaluating the timelessness of a pattern is not a trivial matter, and it is not made easier by the fact that different domains exhibit various degrees of change over time. Additionally, some changes could also potentially redefine a domain, for instance when personal computers were first introduced in accounting. For the patterns created in this thesis, the main factor will be that the patterns are technology independent. Rather than basing a solution on a technology, they should describe an idea or a method of interaction that is on a higher level of abstraction than the underlying technology. This does not mean that technologies should not be used as examples in order to show how the essence of the pattern could be achieved. However, the solution that a pattern suggests should be technology independent, and possibly achievable through many different technologies – even some that are not yet a reality.

In addition, the set of patterns must together:

1. Provide readers with a course of action that solves the most prominent problems of information sharing between co-located people.

Liberating Voices states that *"the set of patterns must ultimately be evaluated with respect to what they are trying to achieve"* [43]. In chapter 1, we stated that the aim of this thesis is to create a set of patterns that describes what designers need to consider when implementing applications where sharing of information can occur between co-located users. As such, the set of patterns should, as a whole, be evaluated with this goal in mind.

5.2 Evaluation Method

We conducted three evaluations, where each evaluation focused on a certain criteria. As stated in the introduction of this chapter, the feedback from these evaluations was used to refine and improve the patterns. The evaluators were chosen based on their familiarity with the domain of collaborative systems and with respect to the criteria that the evaluation focused on.

Each evaluation was structured as a semi-structured interview. Before the evaluation the evaluator was given the set of patterns, the evaluation criteria and a set of guidelines, in order to prepare for the actual evolution. During the evaluation we conducted a review of each of the patterns using a limited set of pre-prepared questions to steer the evaluation towards the intended focus. These questions were based on the criteria and adapted for the focus of each evaluation. If the evaluator had other feedback, or something was uncovered that needed more elaboration, additional questions were asked. The actual evaluations were conducted with three participants: a facilitator, who performed the evaluation and asked questions; the evaluator, who reviewed the patterns and answered questions; and an observer, who taking notes during the proceedings. In the evaluation, the authors took the roles as facilitator and observer. In addition, each evaluation was audio recorded with permission from the evaluators, in case of any confusion regarding the notes taken by the observer.

Figure 6 show our overall evaluation method. *Evaluation 1* focused on the understandability of the patterns. The reason for doing this was that an increased understandability of the patterns would have a positive effect on the later evaluations. In order to evaluate the usefulness of the patterns, it was important that the readers understood the content of the pattern and that this understanding was in line with our intentions. The patterns were therefore improved based on the feedback received from the first evaluation, before conducting the two consecutive evaluations that focused on the usability of the patterns.

Evaluation 2 focused on the usefulness of the patterns. While the evaluation focused on all aspects of usefulness, there was put some emphasis on (1) the quality of the problems that each pattern were addressing, and (2) whether the set of patterns covered the most prominent problems that could arise when designing systems that supports co-located information sharing.

Evaluation 3 also focused on the usefulness of the patterns. However, this time the emphasis was on the whether the patterns provided a course of action that would be helpful under the design and implementation phase of a collaborative system, which was intended to support information sharing between co-located users.

After *evaluation 3*, we revised the pattern based on the feedback received from both the second and the third evaluation. The reason for not doing this after each of the evaluation was that we wanted to do a comparison of the feedback that we received on both these evaluation before revising the patterns.

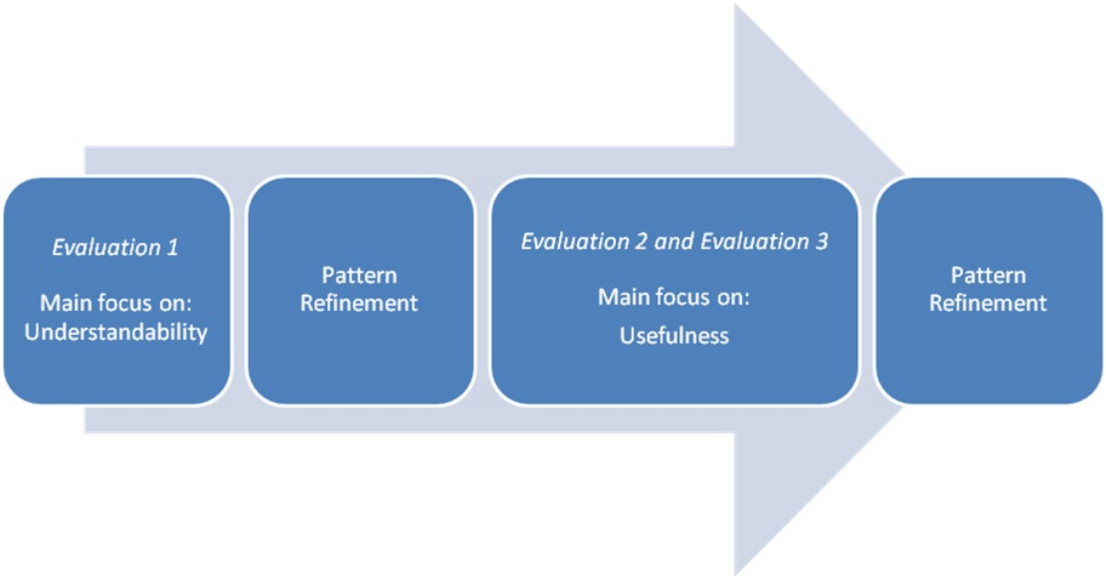


Figure 6: The overall evaluation method

5.3 Evaluation 1

The first evaluation was conducted with a PhD Candidate from NTNU that was part of the FABULA research group. The evaluator also had some familiarity with the uses of patterns in software development. The rest of this section will list the feedback we received under the evaluation. In order to reduce confusion about which evaluator we are referring to in later chapters, we will hereafter refer to the evaluator of evaluation 1 as *evaluator 1*.

5.3.1 Overall Feedback

Before looking at feedback related to specific patterns, we will first present some general findings that apply to all of the patterns. Firstly, overall we received very good feedback on the general understandability of the patterns. The language was considered not being too technical, and at a level where users with little or no experience from the domain should be able to make sense of the pattern. The level of abstraction of the patterns were also considered suitable. Although some of the pattern contained some technical details and discussions on technologies that could be used to realize them, such details were well described and not considered vital in order to understand the essence of the pattern. The structural quality of the pattern was also deemed to be good. Each section of the pattern was considered to address separate issues and the evaluator stated that "*.. no information appears to be redundant*".

We also received a lot of feedback on changes that could be made to improve the understandability of the patterns. The first was that some terms that were frequently used in several patterns needed to be properly explained either in the patterns themselves, or in the introduction to the set of patterns. An example of such a term was the use of *information objects* as a way of referencing any digital information that a user could share to another user. Another issue that the evaluator pointed out revolved around the scenarios. The evaluator stated that some parts of the scenarios were not particularly relevant for the pattern and only used to describe circumstantial details. These parts of the scenarios should therefore be removed in order to make the scenarios shorter and more concise.

5.3.2 Feedback Related to Sharing Shortcut

The overall understandability of this pattern was judged to be good, although some terms needed to be better described to make the pattern more clear. The feedback on the structural quality of the pattern was also good, and each section of the pattern was judged to provide a potential user with information that was not redundant to any other section. One comment that was mentioned for several sections was the use of the term *universal* to describe that the interaction method for the sharing shortcut should be the same throughout the system. The evaluator stated that the use of the term was a bit confusing, and that we should consider replacing it. The evaluator suggested other terms, like for instance using *consistent* instead. In addition, there were some points that could be clarified:

Sensitizing picture
The sensitizing used in this pattern was a keyboard that featured a designated

button for sharing, and is depicted in figure 7. The picture was judged to be describing for the pattern, but the evaluator also stated that having a keyboard in the picture could imply that the shortcut was intended for stationary devices. This is something we therefore should consider changing.

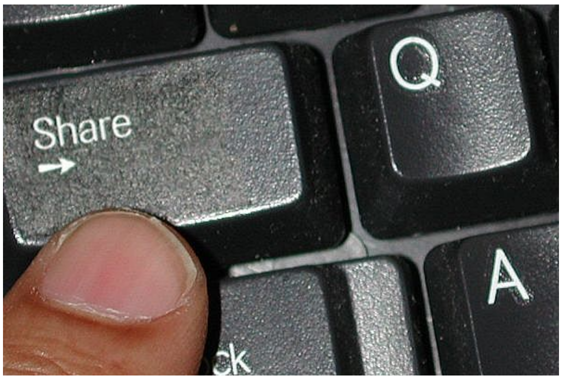


Figure 7: Sensitizing picture used the Sharing Shortcut pattern.

Danger Spots
The evaluator commented that we should explain more explicitly what we meant with the term “hidden” functionality. With “hidden” functionality we mean that the sharing shortcut could sometimes be hidden from view. As such, it could for instance be button that does not show until some information has been selected or the use of speech. The term was used without giving a thorough explanation about what we referred to with this term, and should be revised.

In this section we also discussed the difference between heterogeneous and homogeneous systems. A heterogeneous system is a system that supports many different devices and/or applications as opposed to a homogeneous system where the support for different devices and/or applications is restricted. We had argued that the pattern was not suitable in heterogeneous systems. However, the evaluator commented that this pattern was perhaps more useful in such systems, and that the discussion should be modified to reflect this.

5.3.3 Feedback Related to Proximity-based Identification

Overall, the feedback on this pattern was good, and the evaluator understood the essence of the pattern. However, there were also some specific parts of pattern that could be explained in more detail:

Sensitizing picture
The original sensitizing picture can be seen at the right of figure 8. Although

the picture used was a good illustration on several people in proximity, it could be made more obvious that the pattern is about one user identifying other users based on their proximity. The evaluator proposed that we could for instance add a signal icon that points from one of the people to the rest that within his proximity. A modified version of the picture that reflects this can be found on the left side of figure 8.

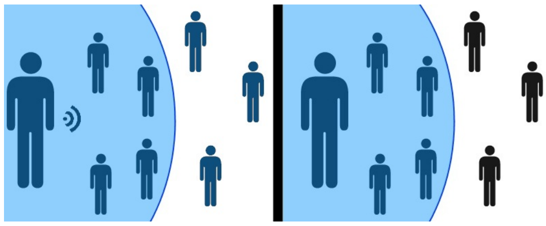


Figure 8: (Left) Sensitizing picture with a signal-icon added. (Right) Sensitizing picture without a signal-icon added.

Intent
The intent of this pattern had the wording: *Give users the ability to specify one or several co-located receivers of an information object.* Feedback on this section was that we should make it more obvious that the solution uses physical proximity of other users to make them available as receivers of information.

Solution
Even though the solution provided a reader with the core essence of the pattern, it could benefit from being more describing. The solution only stated that users should be provided with a list of users and devices in close proximity, and be able to select multiple users from this list. It should therefore be made clear that the pattern concerns the selection of a recipient of information, and that it should be possible to select one or several recipients. Also, the distinction between sharing to a user – meaning sharing information directly to the personal device of another user – and sharing information to a user by showing the information on a situated device should be clarified.

Check
Evaluator 1 had problems determining what we wanted to achieve with the check section of this pattern. The aim was to highlight that the technology used to give users a list of possible recipients in the proximity can affect the range. The section should therefore be rewritten in order to make this more obvious.

5.3.4 Feedback Related to Physical Identification

For this pattern, we received many helpful comments. The most important issue that the evaluator pointed out, was that the physical motion, which is the heart of the pattern, should be more explicitly described. Another issue that was discussed was that the pattern should be revised to reflect that when physical identification is used, this is a mutual process from both users. In other words, the sender does not just identify the receiver, but the receiver also identifies the sender since they both have to bring their devices physically together.

Sensitizing picture
The picture used in this pattern can be seen in figure 9. The evaluator stated that could be modified to make the physical motion more visible, and suggested adding arrows or a similar representation to illustrate that two people actually use a physical motion to bring their devices together. In any case, the picture should be revised in order to make it clearer that the two devices are in physical contact.

Figure 9: Sensitizing picture used in the Physical Identification pattern.

Intent
The intent had the wording: *A user want to identify another user in order to accomplish a task*. This should be rephrased in order to make it more obvious that the physical motion is a central part of the pattern.

Dynamics
Evaluator 1 commented that the dynamics section should more explicitly explain how the physical motion is used to identify a receiver. Another comment in this section was the use of “known” and “unknown” users. It was not sufficiently

explained that we were talking about the representation in the system, and not whether they knew each other socially. This should therefore be revised, in order to make our intentions more obvious.

5.3.5 Feedback Related to Sharing Request

The evaluator commented that we should make our intentions with this pattern more explicit. More specifically, it was in some cases unclear whether the pattern was intended to protect the *receiver* or the *sharer* of information. The pattern should therefore make it more obvious what it intends to solve.

Picture
It was commented that the picture does not illustrate the pattern well, or the use of the pattern. The picture used displayed a green check-mark and a red cross, and is depicted in figure 10. Although it was commented that gives the viewer a notion of the pattern having something to do with accepting or receiving, we should consider using a more illustrative picture.

Figure 10: Sensitizing picture used in the Sharing Request pattern.

Symptoms
The evaluator commented that a symptom should be added, which addressed users having different requirements when roaming between different locations. This could for instance be a distinction between how the sharing request behaves in public and private settings.

Check
Evaluator 1 stated that a check should be added which addressed the question of how much information that should be revealed to receiving users to allow them to take an informative decision about accepting or denying a sharing request.

Danger Spots
One danger spot given in this section discussed if some users should be unable to decide what they receive or not. The evaluator commented that users should always be allowed to decide what they receive, the systems role should rather

be to assist the users making this decision. Such an approach would include the system filtering out spam, warning users when they receive suspicious information, or information from users they don't know, and other similar tactics.

5.3.6 Feedback Related to Ensure Access

The feedback on this pattern was mostly positive, and the evaluator understood each of the sections. However, during the evaluation there also came to light a couple of issues that could be made more obvious.

Name
It was pointed out that there is no clear connection between the name, *Ensure Access*, and the goal of the pattern, namely to allow the same information to be easily accessible for different devices. A possible alternative that emerged during the evaluation was *Universal Access*.

Intent
The evaluator commented that the Intent section should have additional focus on the need for information to be available from *different* devices.

5.3.7 Feedback Related to Shared Vision

Concerning the SHARED VISION$_{6.6}$ pattern, the evaluators understanding of the pattern was in line with our intentions. However, there were also few issues that came to light during the evaluation.

Sensitizing picture
The feedback on the sensitizing picture was that it provided a good illustration for the pattern. However, something unintentional was also brought to our attention. At the bottom of the picture, there is a crowd gathering around the actors looking at the shared display, as depicted in figure 11. In some environments, situated displays might be used in public areas, and in these cases one might foresee situations where other people gather around someone interacting with the display. This is not a central aspect of the pattern. The picture should therefore be cropped so that the picture's only focus is on the actors that are interacting with the display.

Context
During the evaluation it was pointed out that the context section was not consistent with the dynamic section. More specifically, the context section states that "*two* or more users are co-located and equipped with hand-held devices", when in fact only one user need a hand-held device in order to share information with other

Figure 11: The original sensitizing picture used in shared vision.

users by using a shared display.

Solution
The evaluator did not have any trouble understanding the solution. However, it was pointed out that the use of situated displays to *share* information with others should be made more obvious in the solution section.

Dynamics
One part of the dynamic states that users should be able to transfer information from a situated display to other devices using an action that is similar to how a user uploaded information to the situated display. This part could benefit from an example, for instance it should explain that this could be done by using the Sharing Shortcut$_{6.2}$ pattern. It should also be made clearer why this functionality is needed.

Check
In this section there was some confusion about what the second check-point referred to. The point refereed to the fact that some situations could require functionality to manipulate the information while it is shown on a situated display. This was not very clear, and should therefore be rewritten to make it more obvious. In addition, during the evaluation of this pattern we also uncovered some new check-points that could be added. These concern: if and how uploads by multiple user are supported and if individual areas within the display, or in other words individual parts of the screen, should be supported.

Danger Spots

One of the issues discussed in the danger spot section was that not all user tasks and/or environments where suitable for situated devices. However, this was not conveyed clearly, the evaluator was confused about our intentions for this part. The paragraph should therefore be rewritten and an example should be included in order to make this aspect clearer.

Known Uses
In the Microsoft Surface example, a reference to the PHYSICAL IDENTIFICATION$_{6.3}$ pattern should be made, that exemplifies how this pattern can be used in conjunction with a situated device in order to transfer information to (and from) a device.

5.3.8 Feedback Related to Proximity-based Awareness

Overall, the evaluator's understanding of the patterns was the same as our intentions. However, some there were also some small comments to a couple of issues that could be made obvious.

Symptoms
The evaluator stated that we should add a symptom about users being in unfamiliar surroundings. This symptom is most relevant for where users roam throughout the city and often find themselves in new places, for instance a city-CL system.

Dynamics
It was pointed out that the difference between place and vicinity should be more explicitly described. In addition, since going into an "invisible" mode will not eliminate incoming notifications, the situation where a user does not want to receive any notifications at all should be discussed.

Danger Spots
The evaluator commented that the link between PROXIMITY-BASED AWARENESS$_{6.5}$ and SHARING REQUEST$_{A.1}$ should be made clearer in both patterns.

5.4 Refinement based on Evaluation 1

Based on the feedback from the evaluation, a review of the scenario section was conducted for each pattern, in order to remove any unnecessary details. In addition, changes were also made to the individual patterns, in order to reflect the feedback we received.

5.4.1 Changes to Sharing Shortcut

In SHARING SHORTCUT$_{6.2}$, the term *universal* with respect to the interaction method was removed and replaced by the term *consistent*. Additionally, the notion of a *consistent interaction method* was described in more detail in the dynamics section of the pattern.

We decide not to change the sensitizing picture used in this pattern. The reason for this, was that we wanted to see how the next two evaluators interpreted this picture. After these evaluations a new decision will be made whether this picture must be changed or not. Instead, changes where made to the context section to make it more clear that the pattern was targeted towards both mobile devices and stationary devices.

In order to clarify our meaning of the concept "hidden" functionality in the danger spots section, we added a paragraph to the dynamics section that describe this concept. This section was also updated to reflect the benefit of applying the pattern in heterogeneous systems, while still expressing the challenges designer are faced with.

5.4.2 Changes to Proximity-based Identification

Changes to the PROXIMITY-BASED IDENTIFICATION$_{6.4}$ focused on making it more obvious that the pattern addressed the selection of receivers of information based on proximity. The sensitizing picture was therefore modified to reflect the changes proposed under the evaluation.

In addition, we did a complete revision of the intent and solution sections to clarify that the patterns purpose is to provide a method to identify one or several receivers of information, where the receivers are either other users' personal devices or situated devices used to collectively view the information. Finally, we combined the points in the check section into a single point, which objective was to highlight that the technology used might have an impact on the range of proximity.

5.4.3 Changes to Physical Identification

The sensitizing picture, intent, solution and dynamics sections of the PHYSICAL IDENTIFICATION$_{6.3}$ pattern was revised to more clearly describe how a physical motion was used to specify the receiver of an information object. This included changing the picture to make the physical contact more obvious and adding text to the section to describe the interaction method in more detail.

Additionally, the difference between known and unknown users (from a systems point of view) was changed to describe how the pattern can be used to form a relationship among users, for instance adding a contact in a buddy list. In the pattern, Buddy List$_{\text{CMI}}$ was used as an example of such a relationship.

5.4.4 Changes to Sharing Request

Sharing Request$_{\text{A.1}}$ was revised to make it more obvious that the patterns purpose was to protect the *receiver* of information. The intent, solution and dynamics section were changed to reflect this by shifting the focus over to the need for a users to be in control of whether he wants to accept or deny incoming information objects.

As previously stated, the evaluator commented that the sensitizing picture did not sufficiently convey the intentions of the pattern. However, we had problems finding a more fitting picture, so we therefore decided monitor how the evaluators of the next evaluations interpret the existing picture.

Additionally, both the symptoms and check sections were updated with the issues that were uncovered during the evaluation, and the danger spot section was revised to not include fully automated decisions with respect to users accepting information.

5.4.5 Changes to Ensure Access

In Ensure Access$_{6.8}$, the intent section was changed to make it more clear that information should be accessible for different devices, in order for information to be available when a user needs to share it with other users. We also discussed changing the name, but were unsure if *Universal Access* was more fitting. We therefore decided to get more feedback on this issue from the other evaluations, before changing the name.

5.4.6 Changes to Shared Vision

Regarding Shared Vision$_{6.6}$, we decided to crop the sensitizing picture to only include the actors that where directly interaction with the display, in order to maintain focus on these people. There is a possibility that “outsiders” might stop and view the contents on the shared display when it is situated in a public area. However, this aspect is not considered central to the pattern.

With respect to the context section, we changed the content to reflect that only one user needs a mobile device to interact with a shared display in order to share information with other users. We also changed the solution section to make it more obvious that the core of the pattern is to use situated displays to share information between co-located users.

In addition, the dynamics, check and danger spots sections where rephrased and examples where added, to counteract the issues that the evaluator found confusing in these sections. We decided not to edit the *Microsoft Surface* example in the known uses section, because we wanted the focus to be on illustrating different situated displays in this section. The usage of PHYSICAL IDENTIFICATION$_{6.3}$ in conjunction with SHARED VISION$_{6.6}$ was therefore been elaborated in both these patterns, in order to make this connection more obvious.

5.4.7 Changes to Proximity-based Awareness

In PROXIMITY-BASED AWARENESS$_{6.5}$, we added a symptom that concerned the usage of this pattern when users collaborate within environments that are unknown to them. With regards to the dynamics section we elaborated on the usage of an "invisible" mode, and added that this mode should also disable incoming notifications, since the sharing of awareness information should be mutual. In addition, the connection between PROXIMITY-BASED AWARENESS$_{6.5}$ and SHARING REQUEST$_{A.1}$ was made clearer, by elaboration on their relationship in the danger spots and dynamics sections.

5.5 Evaluation 2

The second evaluation was conducted with PhD Candidate from NTNU that was part of the FABULA project, and was chosen for his familiarly with computer-mediated collaborative learning systems. The rest of this section will list the feedback we received under the evaluation. As with the first evaluation, we will hereafter referee to the evaluator of evaluation 2 as *evaluator 2*, when there is doubt about which evaluator we are referring to.

5.5.1 Overall Feedback

Overall, the feedback received from the evaluation was positive. The evaluator judged that each pattern could be useful in the design of collaborative systems, and that they all targeted the occurrence of a real problem within the domain. In addition, the evaluator had not uncovered any missing problems that the set patterns should address within the domain. However, we received a lot of constructive feedback about improvements related to the existing patterns.

On improvement related to the problem of filtering out receivers of information based on user preferences. This is a central topic in PROXIMITY-BASED IDENTIFICATION$_{6.4}$ and PROXIMITY-BASED AWARENESS$_{6.5}$, since they both present users with a list of devices in the vicinity. The versions of the patterns that were used in this evaluation each contain a paragraph on this issue, but the evaluator felt that these sections were somewhat lacking. The use of criteria to filter these lists should therefore either (1) be described in more detail per pattern, or (2) separated into its own pattern that can be referenced in PROXIMITY-BASED IDENTIFICATION$_{6.4}$ and PROXIMITY-BASED AWARENESS$_{6.5}$. The evaluator stated that both (1) and (2) would solve this issue, but also mentioned that the problem was central enough to warrant a separate pattern.

The evaluator also had problems understanding the model that we provided in addition with an introduction to the set of patterns, which can be seen in figure 5 in section 4.3.8. This model describes the relationship between the different patterns. However, the evaluator understood the model to be more of a state diagram that described the step necessary from the need to sharing information had been established to the information was ready to be transmitted. He did however point out that the model was easier to understand after reading all the patterns. He therefore stated the model, specifically how we defined the relationships, should be described in more detail, in order to make the intentions with it more obvious.

Another issue that the evaluator felt would increase the usefulness of the patterns was a scenario that described the collective use of the patterns. It was suggested that this scenario could for instance be used as an introduction to the set of patterns, in order to better illustrate the context of the patterns and their actual usage together. At the time of the evaluation, the introduction to the patterns included a short description of the context the pattern where intended for, how we foresaw their use and how the different patterns related to each other. The evaluator suggested that a scenario would provide a clearer illustration of the use of our patterns, and the addition of this should therefore be considered.

A third issue that the evaluator pointed out was the sequence that the patterns were presented in. The evaluator commented that the sequence should be changed in order to naturally suggest their relationship. This would then lead to an increase in the usefulness, since it would become easier to understand how the patterns fit together, and easier to find the pattern you were looking for. The sequence of the patterns should therefore be revised, with their natural ties in focus.

In addition, the evaluator commented that some of the patterns focused a bit much on the technology used apply the pattern. One example of this was the paragraph we used in the dynamics of PROXIMITY-BASED IDENTIFICATION$_{6.4}$ to describe how short-range radio transmitters could be used to apply the pattern. The evaluator stated that although it was appropriate to mention this, it was not directly relevant for the level of abstraction that the patterns were written on. It was therefore suitable to mention technologies when they had impact on the interactions between the users and the system, but the main focus should be on *how* designer can solve the problem and not *what* technology they can use to achieve this. This comment was mostly targeted towards the PROXIMITY-BASED IDENTIFICATION$_{6.4}$ pattern, but each pattern should be reviewed and revised based on this feedback.

5.5.2 Feedback Related to Sharing Shortcut

Under the evaluation, it was commented that the context section of this pattern was not specific enough. The first line in the context had the wording "*Two or more users are co-located and equipped with hand-held or stationary devices*". A more correct context would be that users are equipped with mobile devices and are situated in technology enriched environments, which contain stationary devices that can be use to share information with other users.

5.5.3 Feedback Related to Proximity-based Identification

Also this pattern received feedback that we should be more specific with our wording. More specifically, this feedback referred to the distinction between identifying users with the intent of sharing information and identifying *the devices of users* with the intent of sharing. As the evaluator pointed out, the pattern targets the identification of devices of users or situated devices in order to share information. It is therefore important that we are consistent with respect to this.

5.5.4 Feedback Related to Physical Identification

The evaluator did not have much to comment on with respect to this pattern. However, it was pointed out that the symptoms listed in the symptom section of PROXIMITY-BASED IDENTIFICATION$_{6.4}$ would also be relevant for this pattern and vise versa, since they address the same overall problem. The patterns should therefore be revised to reflect this more clearly.

5.5.5 Feedback Related to Shared Vision

The first thing that the evaluator commented on this pattern was the name, and questioned us as to if we actually meant *Shared View*. An extract from a dictionary defines view as *the ability to see something* and vision as *the state of being able to see*[5]. As such, both of these nouns can used to convey a sense of seeing something. However, we note that the word view might be more used in everyday speech, which we mentioned in section 4.2 as being an important attribute of pattern names. We will therefore consider changing the name of the pattern.

The evaluator also pointed out an issue with the solution. In this section we should assume that situated display, which can be used to view information collectively, already exists since we have already stated in the context that the environment is technology rich. The pattern should therefore explain *how* to take use of these display, instead of stating that such displays should be *introduced*.

5.5.6 Feedback Related to Sharing Request

The feedback on SHARING REQUEST$_{A.1}$ was that it should cover both incoming and outgoing information. In the version that was used under the evaluation, this pattern focused solemnly on the need for users to able to accept or deny incoming information. However, as the evaluator pointed out, there could also be cases where users should be able to confirm if they are sharing the correct information. This would for instance be appropriate when sharing sensitive information or when sharing to a public display.

Also, the evaluator commented that the solution section was lacking on the use of accept or deny. For instance, the section could discuss different methods for obtaining this, such as automatically accepting information based on certain filters. The use of accept or deny should therefore be elaborated in order to improve the usefulness of this section.

5.5.7 Feedback Related to Ensure Access

The evaluator stated that the intent of the pattern should be clearer, namely to reach once private resources from different devices. This should also be reflected in the other sections of the pattern. In addition, he suggested that we should clarify the difference between private and public data.

[5]The definitions used here where taken from the Oxford Dictionary of English found at http://ordnett.no/

5.5.8 Feedback Related to Proximity-based Awareness

Comments on this pattern were positive, and the evaluator did not mention anything specific that needed improvement. However, the evaluator did point out a relationship between PROXIMITY-BASED IDENTIFICATION$_{6.4}$ and PROXIMITY-BASED AWARENESS$_{6.5}$ that we were previously unaware of. While PROXIMITY-BASED IDENTIFICATION$_{6.4}$ discusses how proximity should be used to actively specify the receiver of information, PROXIMITY-BASED AWARENESS$_{6.5}$ describes how proximity can be used pro-actively send users information that could further collaboration. These two patterns are therefore two different applications of the same underlying mechanism. The evaluator suggested that these two patterns should be presented consecutively in order to make this relationship more obvious.

5.6 Evaluation 3

The third evaluation was also conducted with PhD Candidate from NTNU that was part of the FABULA project. However, this evaluator was chosen for his familiarly with the technical and implementation specific aspects of computer-mediated collaborative learning systems. As with the first and second evaluation, we will hereafter referee to the evaluator of evaluation 3 as *evaluator 3*, when there is doubt about which evaluator we are referring to.

5.6.1 Overall Feedback

Overall, the feedback received from the evaluation was good. The evaluator judged the patterns to be useful for designers and developers of collaborative systems. Specifically, we received a lot of good feedback on the *Check* and *Danger Spots* sections. We deem these sections especially important for designers and developers of collaborative systems, because they provide useful information about the dangers and pitfalls which designers should avoid. In addition they also provide guidelines for how they should be avoided, general enough to be independent of the technology the designers decide to use when applying the pattern. The evaluator also suggested some additional points in these sections that should be considered. In addition, the evaluator found the *Known Uses* section very helpful when depicting potential implementation of the pattern. He commented that this section is very helpful for people who are more technically and practically oriented, which is more than often true for system developers.

In the second evaluation we mentioned that *evaluator 2* suggested that we should provide more information about how users can filter lists of users in the Proximity-based Sharing$_{6.4}$ and Proximity-based Awareness$_{6.5}$ patterns. This was also the case for this evaluation. The evaluator suggested that we should elaborate more on this filtering, and discuss how this possibility can enhance the patterns.

An additional issue that was mentioned in both the second and third evaluation was that the set of patterns could benefit from an overall scenario before the actual patterns are presented. The aim of this scenario would be illustrate the use each pattern, how the different patterns relate to each other and how they together address a set of important issues within information sharing among co-located users. The scenario would introduce readers to the patterns and give them something to keep in mind while reading the patterns individually. Because this scenario was lacking, we experienced that the evaluator misunderstood some aspects of a couple of patterns. After discussing the issue at the end of the evaluation, the evaluator agreed that such a scenario would help to clear up potential misunderstandings, since the reader would already have some knowledge of the usage of the patterns. In addition, parts of the patterns that can be interpreted ambiguously should be revised in order to minimize misunderstandings. Another thing we learned from the evaluation was that in order for a reader to best understand the patterns the first time they read them, they should be read as a whole, and not partly. In other words, readers should first properly get to know each pattern, before using them as a reference.

5.6.2 Feedback Related to Sharing Shortcut

The most important feedback regarding this pattern was the ambiguous use of the word *interface*. In the version used in this evaluation, the solution section read: *"Provide the user with an interface so that every information object that the user can select is sharable by a universal and simple interaction method"*. The evaluator pointed out that this could be interpreted as adding a separate interface for the shortcut that uses could access, which was not intended. The intention of the pattern is to provide the shortcut as an integrated part of the interface on the device. The pattern should therefore be revised in order to make this clearer.

5.6.3 Feedback Related to Physical Identification

The evaluator stated that he would like a different name of the pattern. He commented that he understood the name, *Physical Identification*, as the physical components, e.g. hardware, identifying two devices and instantiating a communications channel for sending data. After discussing this issue after the evaluation, the evaluator commented that a scenario illustrating the use of all the patterns before reading them should help to minimize these kinds of misunderstandings. In the introduction to the patterns we should also be more specific on the abstraction level and intended use of the patterns.

5.6.4 Feedback Related to Proximity-based Awareness

Feedback on this pattern was good, and the evaluator did not have any specific issues with the pattern. He stated that he found the *Known Uses* section very helpful, because they provided good examples of use that were easy to understand.

5.6.5 Feedback Related to Proximity-based Identification

As previously mentioned, the evaluator suggested elaborating on the aspect of filtering the list of possible receivers, based on different criteria for this pattern. It was also suggested that we should mention that developers must carefully consider the capabilities of devices used in the system when implementing the pattern.

5.6.6 Feedback Related to Shared Vision

The evaluator commented that the scenario section of this pattern should elaborate more on the interaction capabilities of the situated displays, and the constraints and possibilities connected to these capabilities. We should therefore consider revising the pattern with this in mind.

5.6.7 Feedback Related to Sharing Request

With regards to Sharing Request$_{A.1}$, the evaluator commented that the ability for users to control what he receives was an important aspect. He also stated that the pattern could have elaborated more on the aspect of trust levels between users, which could be used to automatically receive information from users above a certain trust level.

5.6.8 Feedback Related to Ensure Access

During the evaluation, the evaluator stated that the aspect of *transparent* access to information should be a bigger part of this pattern. In this setting, transparent access to information is understood as the users not having to concern themselves with where the information is actually store, since he accesses the information in the same manner independently of the device he uses. Aside from this issue, the evaluator stated that the pattern concern an important aspect of information sharing.

5.7 Refinement based on Evaluation 2 and Evaluation 3

In both evaluations, the evaluators commented that an overall scenario connecting the patterns together was lacking. A scenario was therefore added as an introduction to the patterns, in section 6.1, in order to give the reader a general idea the usage of the set of patterns. In addition, we added a section after the patterns are presented, that illustrates how the functionality described in the scenario can be achieved when applying the patterns. This can be found in section 6.9.

Based on feedback from the second evaluation we also changed the sequence of the patterns. This was done because evaluator 2 stated that a more natural ordering of pattern could improve the overall readability of the set of patterns. The first pattern to be introduce is the SHARING SHORTCUT$_{6.2}$ since this is usually the first step a user takes when he wants to share a certain information object. Then PHYSICAL IDENTIFICATION$_{6.3}$ and PROXIMITY-BASED IDENTIFICATION$_{6.4}$ are presented because of their relationship with SHARING SHORTCUT$_{6.2}$. The third pattern in the ordering is PROXIMITY-BASED AWARENESS$_{6.5}$ since it uses same underlying mechanism as PROXIMITY-BASED IDENTIFICATION$_{6.4}$. Finally, SHARED VISION$_{6.6}$, SHARING AGREEMENT$_{6.7}$ and ENSURE ACCESS$_{6.8}$ are presented in that order, because that are considered dependent on the previous patterns.

In addition, we decided to rewrite the whole SHARING REQUEST$_{A.1}$ pattern. In the first evaluation, evaluator 1 stated that it was not clear whether the intention of SHARING REQUEST$_{A.1}$ was to protect both the receiver and the sharer of information, or just one of the parties. As stated in section 5.4.4, we therefore decided to focus the pattern on the protection of the receiver. However, in the second evaluation we received additional feedback that this pattern should protect both parties involved in the sharing of information. Based on this, we decided to rewrite the pattern to include protection for both the sharer or the receiver. As previously stated, the original SHARING REQUEST$_{A.1}$ pattern can be viewed in full in appendix A.1.

5.7.1 Changes to Sharing Shortcut

Based on feedback from the second evaluation, that stated that the context section should be revised to make the difference between mobile and situated displays more obvious. The context section was therefore changed from: "*Two or more users are co-located and equipped with hand-held devices*", to:

"*Two or more users are co-located and equipped with mobile devices in a technology enriched environment. One of the users wants to share information with one or several of the other users. In order to achieve this, the user has to select the information he wants to share*".

Additionally, we received feedback from evaluator 3 about the possibility to misunderstand the use of the term "*Provide the users with an interface...*". Evaluator 3 observed that this could imply implementing a separate interface that can be used to share information. However, the intention with the pattern is that this sharing shortcut is available wherever the user can interact with information. We therefore changed the wording in the pattern to state that there should be a sharing shortcut wherever the users can interact with an information object.

5.7.2 Changes to Physical Identification

Since the problem with the name of this pattern was address by introducing a scenario that illustrated the use of the patterns, the only changes made to this pattern was to the symptoms section. As stated in evaluation 2, PHYSICAL IDENTIFICATION$_{6.3}$ and PROXIMITY-BASED IDENTIFICATION$_{6.4}$ addresses the same overall problem, namely to minimize the strain on interpersonal interaction when a user specifies *the receivers* of an information object. The only difference between them is the interaction method used, and that PHYSICAL IDENTIFICATION$_{6.3}$ can only specify one receiver concurrently. The symptoms section was therefore revised to include the symptoms mentioned in PROXIMITY-BASED IDENTIFICATION$_{6.4}$, while keeping the differences between them intact.

5.7.3 Changes to Proximity-based Identification

Based on feedback from evaluation 2, we moderated the focus on technologies that can be used to obtain the functionality described in the pattern. Originally, this focus was part of the pattern in order to highlight the impact technology can have on the range used populate the list of possible receiver. This is still mentioned in the pattern, but the focus is now shifted on all aspects that can impact the appropriate range used, and to make sure that the technology chosen supports this.

As evaluator 2 pointed out, we needed to be more consisted with the use of identifying *the device of a user* as opposed to identifying *the user*. Identifying a user can be interpreted ambiguously. More specifically, it could entail that the user does not know who he would like to share information with, and therefore needs to identify this user. Since the aim of this pattern is to identify the device of a user in order to specify that user as the receiver, we decided to consistently use *identify the device of a user* in this pattern.

This pattern was also revised in order to put more emphasis on how the user could filter out interesting devices within their proximity, and thereby simplify the list of possible receivers. This was an issue that was raised in both the second and third evaluation. We addressed this issue by adding a paragraph to the dynamics section, which described the use of filtering on the list of potential receiver using different criteria.

Additionally, we added a check in the check section that conceded the need to consider the capabilities of the devices that the system would support. This issue was raised by evaluator 3, and is important because developer must be certain that all devices supported by the system can use the technology that is chosen.

5.7.4 Changes to Proximity-based Awareness

There were not many changes made to this pattern. However, similar to the PROXIMITY-BASED IDENTIFICATION$_{6.4}$ pattern, this pattern was also revised in order to put more emphasis on how the user could filter out interesting devices within their proximity. The use of filtering in this pattern could for example be to only show situated devices or to only receive notifications from members of a certain community.

5.7.5 Changes to Shared Vision

Based on feedback from the second evaluation, it was suggested to assume that the situated devices was part of the context for the pattern. The pattern was therefore revised to assume that situated displays are a part of the technology rich environment the users find themselves in, and the pattern changed focus from introducing these displays in the environment, to how users can share information to other, co-located users by showing the information on these displays. The solution and dynamics sections were therefore also revised to make it more clear that users should use the same methods to show a information object on a situated display as the would use to share information to another user's personal device.

5.7.6 Changes to Sharing Request

As mentioned in the introduction, this pattern was completely rewritten. The pattern was changed to include protection for the users who share information, in addition to the users who receive information. Because of this, we decided to the name of pattern to SHARING AGREEMENT$_{6.7}$, in order to signal that it concerned both parties of sharing.

The intent section was changed to state that the patterns intention was to protect the privacy of *users*, and not just receivers of information. More importantly, the solution section was revised in order to specify that some cases may warrant the need for the sharer to explicitly specify that they want to share a specific information object with the selected receiver. This change was also reflected in the dynamics section, where we also added examples to clarify when this could be appropriate. One example of this, could be when users are sharing information to a public display, and therefore risk not being able to control who sees the information.

Additionally, the symptoms, check and danger spots sections were revised to reflect that the pattern now included protection of the sharer, as well as the receiver of information. The most significant of these, were the addition of a danger spot that discussed the danger over-protecting the sharer by requiring him to always specify that they want to share the selected information object with the selected receiver(s). This also led to the addition of a paragraph in the dynamic section that stated how users should always be able to modify the behavior of privacy protection.

5.7.7 Changes to Ensure Access

The overall intention of this pattern was maintain. However, based on feedback from evaluator 3, we added the concept of *transparent access to information*. This concept entails that users should be unaware of where the information is actually store and consequence be able to access the same information from every device. The sections intent, solution and dynamics were therefore heavily revised to reflect this. In addition, the dynamics section were also revised to be more specific on the difference between private and public information. This was done by focusing on accessing information that the user had captured, while also mentioning that public information could be made accessible in the same manner.

6 Patterns for Co-located Information Sharing

The patterns found in this chapter have been revised based on the feedback that was received during the three consecutive expert evaluations. Before presenting the actual patterns, we will present a short scenario in order to illustrate the usage of the patterns.

6.1 Scenario

At the university in the city of Trondheim, the students have started using a city-CL system in their education program. One day, the teacher gives out a new assignment about pollution, and the students are encouraged to investigate the status of their local environment. The students are organized into groups, and are asked to split up and investigate different areas of the city. One of the students, George, is assigned to investigate the area around the main square.

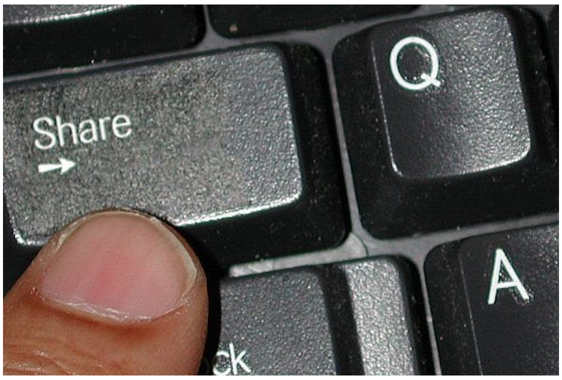
After having spent some time collecting data, George meets a class working on a similar project. By chance, a conversation starts with one of these students called Tim, and George decides to share the data he has collected so far with him. Since they are both users of the same city-CL system, George can use his hand-held device to share the data. With the use of a SHARING SHORTCUT$_{6.2}$, George quickly selects the document containing the data he has collected. Once George has done this, he specifies Tim as the receiver of the information by bringing his mobile device in physical contact with Tim's device, as described in PHYSICAL IDENTIFICATION$_{6.3}$. This results in Tim getting a request on his device, that gives him the ability to preview parts the information and the possibility to accept or deny the file, in accordance with SHARING AGREEMENT$_{6.7}$. Tim accepts the request, and the information is transmitted to his device.

Later that day George meets up with the rest of the group, Anna and Isabel, in a meeting room at the school campus, in order to discuss the results they have gathered. George is the first to present his findings, and he think it would be a good idea to use the display situated in the room to provide a SHARED VISION$_{6.6}$, so they can view the results he gathered collectively. He therefore uses a SHARING SHORTCUT$_{6.2}$ to specify that he wants to share the file containing the results, and selects the display as the receiver in a list provided by PROXIMITY-BASED IDENTIFICATION$_{6.4}$. As SHARING AGREEMENT$_{6.7}$ suggests, this results in Georges getting a request where he is asked if he wants to show information on a public display. George accepts and the information contain in the file is automatically displayed on the situated device.

While discussing the result from the fieldwork, Isabel is reminded of a figure she once saw in an article she read, which she has stored on her personal computer at her office on the other side of the campus. According to the Ensure Access$_{6.8}$ pattern, this information should be available through all of Isabel devices. Thinking it might be useful for the whole group to see the figure, she shares the figure using the same method that was used to share the results from the field trip.

After they finish the meeting, George remembers that he has forgotten about an article that has some criticism of the figure Isabel shared with the group. As specified by Proximity-based Awareness$_{6.5}$, George should be able to tag Isabel so that the next time she enters his vicinity he will get a notification. In addition George connects the article to this notification, in order to be reminded about the purpose of the notification and to provide easy access to the article next time he meets Isabel.

6.2 Sharing Shortcut



Intent

Give the users a simple and consistent way of specifying *which* information object they want to share.

Context

Two or more users are co-located and equipped with mobile devices in a technology enriched environment. One of the users wants to share information with one or several of the other users. In order to achieve this, the user has to select the information he wants to share.

Problem

Identifying information objects to share can interrupt interpersonal interactions (e.g. conversation) between participants of a collaborative activity. Interfering with these interactions can have negative effects on collaboration.

Scenario

The teacher has just given out a new assignment about pollution, and the students are encouraged to investigate the status of their local environment. George decides to investigate the area around the main square.

While out in the field, George meets a class working on a similar project. By chance, a conversation starts with one of these students, and George decides to share the data he has collected so far with him. Since they are both users of the *same city-CL system, George can use his hand-held device to share the data. He therefore opens the document containing the data. However, George does not find a mechanism to share the document from this screen, and he therefore start to look for an alternative mechanism to share the document using the device. This causes the conversation to shift from the original topic to how the sharing can be performed.*

Symptoms

You should consider using this pattern when:

- The act of sharing interferes with the underlying activity or interaction that the participants of the collaborative session are engaged in. More specifically:
  - Users become sidetracked by the act of sharing information.
  - Participants suffer from communication breakdowns when sharing information.

Solution

Wherever the users can interact with information objects, provide them with a simple interaction method to select an information object in order to specify that they want to share it. This interaction method should be used consistently, and it should be possible to select multiple information objects when this is applicable.

Dynamics

The SHARING SHORTCUT$_{6.2}$ pattern states that the users should be provided with a simple and consistent interaction method in order specify that he wants to share a specific information object. The method should only consist of a single step, and be consistent regardless of the type of information object the user wants to share, the device that is used and the software used to manage the information. This means that the interaction method should have similar placement, look and behavior independent of these parameters.

The way that the shortcut is implemented should be tailored to the system. The most standard approach would be to present the user with a button with the same look anywhere users can share information objects. The button could be a part of the graphical interface presented to the user, or be a physical button on the device. This would allow users to specify that they want to share an information object with a single action. We will label this *visible* interaction methods, meaning that the user is able to physically see the shortcut as the part of an interface or as a physical button. However, other possibilities include using *hidden* interaction methods with different modalities, like for instance using speech recognition, physical movement or buttons that only appear when the users performs a certain action. An example of physical movement can be that a users *shakes* his hand-held device when he wants to share a selected information object.

SHARING SHORTCUT$_{6.2}$ concerns the method used to specify *which* information object to share. The pattern should therefore be implemented in conjunction with a method to specify the receivers of the information selected, for instance using the PHYSICAL IDENTIFICATION$_{6.3}$ or PROXIMITY-BASED IDENTIFICATION$_{6.4}$ pattern.

Rationale

The SHARING SHORTCUT$_{6.2}$ pattern provides a universal way of initiating sharing of all types of information with a minimum amount of interaction with the system. This allows users to continue their current activity with little or minimal interference from performing the sharing.

Check

When applying the pattern, you should answer these questions:

- How should the sharing shortcut be presented to the users?
- Do the users understand the use of the sharing shortcut?
- If the shortcut is a "visible" interaction method, is the appearance of the shortcut and the expected outcome of using the shortcut universal for all information objects?
- When using "hidden" interaction methods, how do you make the users aware of the use of the functionality?

Danger spots

An important danger spot for this pattern is making the shortcut have a similar look and functionality independent of user, device and other parameters. The users should always know how to use the shortcut and what they achieve by doing it. This is especially important when the shortcut is a *hidden* interaction method, like for instance using speech or movement recognition. The designers must carefully consider how to make the users aware of such functionality.

Making the shortcut consistent could also be a challenge. If the collaborative system is heterogeneous, meaning that the system allows the use of a wide range of external applications to access information from a large verity of devices, the Sharing Shortcut$_{6.2}$ can be difficult to apply for the system as a whole. However, it is in these systems that the users can benefit the most from a consistent shortcut for sharing information. We will therefore urge system designers and developers to carefully consider the cost of applying the pattern in comparison with the benefits for the users before making a decision of adding the shortcut or not. We also argue that since the solution given by this pattern affects every part of the system where users can access information, it is important that the patterns is considered as early in the design phase as possible.

Known Uses

Internet Explorer: In Internet Explorer 8, developers added a button that shows up when users marks a text passage of a web site. An image of this is shown in figure 12. By clicking this button, users gain access to a range of different actions that can be performed using the selected text. This includes for instance automatically adding it to an e-mail and sharing it to a friend or contact, among other things.

Digg.com: Another example of the use of a shortcut to share information is web sites that provides an option to the users to share articles, pictures and similar information to social networks - like twitter or facebook – with the push of a button. A concrete example of this is the webpage *www.digg.com*, which let users post news articles, pictures and videos from other websites within a range of categories, sorted by the users voting the posts up or down. At digg.com's front-page every post has a share link that enables users to share the article using twitter, facebook or e-mail. This is shown in figure 13.

iPhone OS: When viewing a photograph using the built-in application, it is possible to share the photograph by pressing a link contained in the interface. Pressing this button brings up a short menu that contains different methods for sharing the photo. The same link can also be used when viewing an overview of all the photos taken. Pressing the button in this context will cause the application to enter a mode where it is possible to select several pictures that can then be share.

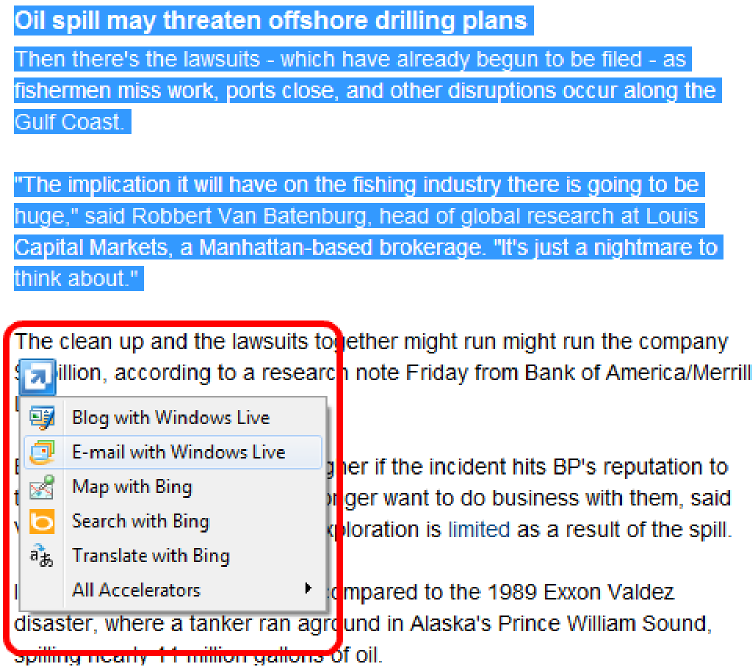


Figure 12: A screen-shot of Internet Explorer 8 showing how users can share parts of an Internet page using a shortcut that become visible when text is selected.

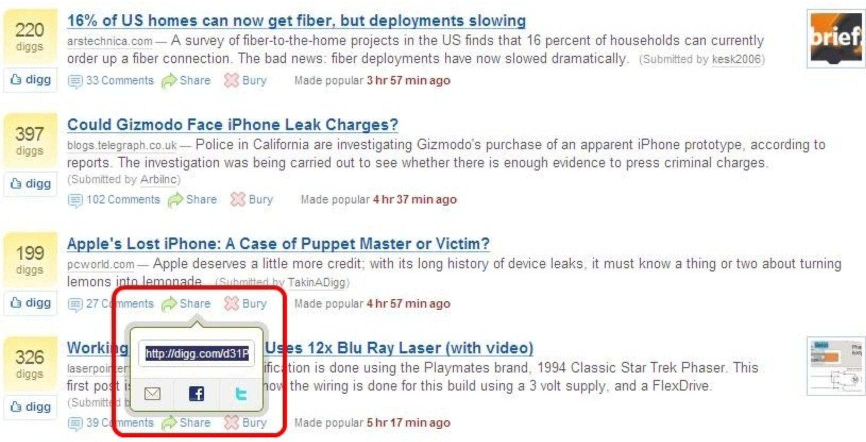


Figure 13: A segment of the *www.digg.com* front-page that shows the option to share an article using facebook, twitter or e-mail.

Related patterns

PROXIMITY-BASED IDENTIFICATION$_{6.4}$ describes how short range radio technology can be used to provide the user with a list of devices in the vicinity. The

Proximity-based Identification$_{6.4}$ pattern can be used in conjunction with Sharing Shortcut$_{6.2}$ to provide the users with a list of possible recipients.

Physical Identification$_{6.3}$ describes how a physical motion can be used to identify a receiver. This pattern can be used together with Sharing Shortcut$_{6.2}$ to provide the users with a means of identify the recipient of the information that was specified using the Sharing Shortcut$_{6.2}$ pattern.

Shared Vision$_{6.6}$ describes how users can share information with several co-located peers using situated displays. The Sharing Shortcut$_{6.2}$ pattern can be used to select the information that the user wants to share using such a display.

6.3 Physical Identification

Intent

Give users the ability to identify a co-located receiver of an information object by using a physical motion.

Context

Two or more users are co-located and equipped with mobile devices in a technology enriched environment. One of the users wants to identify another device with the intent of sharing information. The device can either be another user's device or a situated device which can be used to facilitate collaboration.

Problem

Specifying a receiver with the intent of sharing information, can interrupt the interpersonal interactions (e.g. conversation) between the participants of a collaborative activity. Interfering with these interactions can have negative effects on collaboration.

Scenario

Michelle and Sandra are two new exchange students at NTNU in Trondheim. As a part of their introduction to the university and the city, they have been encouraged to take advantage of the city-CL system that covers most of central Trondheim.

They decide to meet at a café downtown. On the way there, Michelle finds an interesting historical building, and uses the city-CL system to retrieve some information about it. When she meet Sandra at the café, she wants to share this information with her.

Symptoms

You should consider using this pattern when:

- Users are often on the move with hand-held devices and informal collaboration frequently occurs
- Users are spending a lot of time adding each other as contacts and entering contact information
- The act of sharing interferes with the underlying activity or interaction that the participants of the collaborative session are engaged in. More specifically:
  - Users are sidetracked by the act of sharing information
  - Participants suffer from communication breakdowns because sharing of information is too tedious

Solution

Allow a user to physically bring his device together with another device in order to identify the receiver of information. The receiving device can for instance be the personal device of another user or a situated display in the environment.

Dynamics

The Physical Identification$_{6.3}$ pattern allow users to identify a device as the receiver of an information object by using a physical motion. The user identifies the receiving device by physically moving his device within close proximity (approximately 1-10 centimeters) of the device he wishes to share information to. The receiving device can either be a user's hand-held device or a situated device in the environment, like for instance a shared display which can be used to facilitate collaboration between several participants. A user can for instance use the Sharing Shortcut$_{6.2}$ to select an information object to share, identify a situated display by using Physical Identification$_{6.3}$ and share this information to other co-located users by taking advantage of the Shared Vision$_{6.6}$ pattern.

Another example is to use Physical Identification$_{6.3}$ to exchange contact information with other users. The identification can also be used to create a relationship between two users in the system, like for instance adding each other as contacts in a Buddy List$_{CMI}$ or a similar structure. The Buddy List$_{CMI}$ is used to store information about other users, so that they are easier to reach and share information with later.

When sharing between co-located users occur, the intention of sharing often originates in social processes, for instance discussions between the users. In such cases, the users have already verbally agreed on sharing information with each other, but the system is unaware of this social agreement. However, since the PHYSICAL IDENTIFICATION$_{6.3}$ pattern requires a physical action from both participants, it can in some cases be fair to interpret this motion as both the users agreeing on the transmission. This means that the receiver can automatically receive the information without accepting for instance a SHARING AGREEMENT$_{6.7}$ when identifying the user this way. Still, we will stress that this will not apply in all cases, but that this indirect agreement can be assumed in small systems with users that know each other well. We will discuss this further in the Danger spot section of this pattern.

In addition, the sharing itself does not necessarily have to be done using the same technology as the identification. PHYSICAL IDENTIFICATION$_{6.3}$ can also be used to establish a wireless connection between two users, which have a much higher bandwidth than short range communication technologies.

Rationale

Mobile devices often have small screens and are not always user friendly, requiring the user to devote all his attention to the device instead of the collaboration. When users have to pay attention to their device in order to add a new contact to their contact list or select the receiver of something he wants to share from a list of users, it is easy to loose track of an ongoing activity.

The PHYSICAL IDENTIFICATION$_{6.3}$ pattern lets users to keep eye contact and continue to participate in the current collaborative activity, by enabling them to use a physical motion instead of having to focus on the interface of the device. In addition, when the users are faced with the task of selecting the correct user out of a large list of users by using their mobile device, this can easily become time demanding, and consume time that should have been used on something else.

Check

When applying the pattern, you should answer these questions:

- Which technology should be used when implementing the pattern?
- Do all the devices in the system support this technology?
- How do you make the users aware of the use of this functionality?

Danger spots

When applying PHYSICAL IDENTIFICATION$_{6.3}$, one of the most important danger spots is security, in other words avoiding unintended use or abuse of the functionality. This is particularly important if the developers also include automatic acceptance of incoming information. In such settings, developers must be *absolutely* sure that the pattern identifies the correct receiver and that there are no malicious users that can take advantage of the functionality. Although we would in most cases recommend to apply this pattern in combination with the SHARING AGREEMENT$_{6.7}$ pattern, there can be cases where automatic acceptance is suitable, for instance in very small systems with well known users, or if the pattern is used in conjunction with the SHARED VISION$_{6.6}$ pattern.

In addition, designers must carefully consider how they should make users aware of these types of “hidden" functionalities. The functionality is useless if users are not aware of it or does not know how to use it.

Known uses

Bump Bump is an application built for mobile devices. The Bump application allows users to use a physical motion in order to share information, for instance contact information or pictures, compare friends or interact on Facebook. Recently, PayPal cooperated with the Bump team and developed an application that allowed users to instantly transfer money to friends and contacts by using the technology behind Bump.

Bump uses a wireless connection and a matching algorithm in order to find the correct match, that being the person you bumped. The algorithm is based on different criteria, one of them is location. Since Bump is only uses a wireless connection, any two mobile devices that run the Bump software can transfer information between each other. A picture of Bump for iPhone in use can be seen in figure 14, and more information can be found on Bump's web page [4].

Microsoft Surface Another example of PHYSICAL IDENTIFICATION$_{6.3}$ can be seen in Microsoft Surface. When using Microsoft Surface as a part of a co-located collaborative session, users can place their hand-held devices on the table, and the table will automatically recognize the device and establish a wireless connection to it, if the device is capable. It can then be used to drag information objects from the table into devices, automatically initiating the transfer. This can be seen in figure 15, where Microsoft Surface is used to transfer pictures from one users digital camera to another users mobile phone.

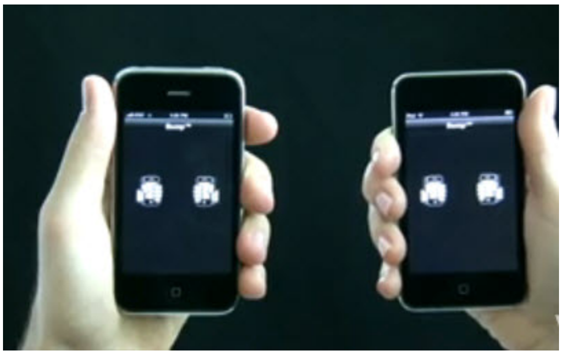


Figure 14: A picture showing two people using Bump

Figure 15: Sharing between devices using Microsoft Surface

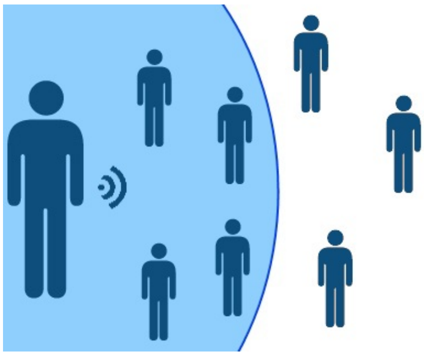
Related patterns

Sharing Agreement$_{6.7}$ should be applied in combination with Physical Identification$_{6.3}$. This pattern avoids negative consequences of unintended use or abuse by letting the user accept or deny incoming sharing requests.

Sharing Shortcut$_{6.2}$ can be used as means for identifying the information object to share, before using Physical Identification$_{6.3}$ to identify the receiver.

Shared Vision$_{6.3}$ Identification and transmission of information to situated devices can be done using Physical Identification$_{6.3}$. This allows users to share information to other co-located users by using these devices, for instance a situated display.

6.4 Proximity-based Identification



Intent

Give users the ability to identify one or several co-located receivers of an information object based on their proximity to the user.

Context

Two or more users are co-located and equipped with mobile devices in a technology enriched environment. One of the users wants to identify the device of one or several users, or situated devices, with the intent of sharing information.

Problem

Identifying receivers of an information object can interrupt interpersonal interactions (e.g. conversation) between participants of a collaborative activity. Interfering with these interactions can have negative effects on collaboration.

Scenario

Michelle and Sandra are two new exchange students at NTNU in Trondheim. As a part of their introduction to the university and the city, they have been encouraged to take advantage of the city-CL system that covers most of central Trondheim.

A couple of days later they decide to meet a group of people they have gotten to know through the university at a café downtown. On the way there, Michelle and Sandra finds an interesting historical building, and Michelle uses the city-CL system to retrieve some information about it using a mobile device. When they *meet the rest of their friends at the café, she wants to share this information with them.*

Symptoms

You should consider using this pattern when:

- Users need the ability to specify one or more receivers concurrently.
- Users spend a lot time specifying the receivers of an information object because the system only provides them with a list of all devices in the system.
- The act of sharing interferes with the underlying activity or interaction that the participants of the collaborative session are engaged in. More specifically:
  - Users are sidetracked by the act of sharing information
  - Participants suffer from communication breakdowns because sharing of information is too tedious

Solution

Allow users to retrieve a list that contains devices of users and situated devices that are within his proximity. The user can then use this list to select one or several receivers of an information object.

Dynamics

Proximity-based Identification$_{6.4}$ states how the proximity can be used to simplify identification of receivers of an information object. When a user wants to select a receiver, for instance after an information object has been identified using Sharing Shortcut$_{6.2}$, this pattern states that the user should be provided with a list that contains the devices that are in proximity and that are capable of receiving information. These devices can either be other users' personal devices or situated devices in the proximity that can be used to facilitate collaboration. The users can then select one or several of these devices as receivers of an information object.

To further simplify the list of potential receivers, the list could be filtered based on certain criteria. One example of this would be to filter the potential receivers based on existing social configurations between users, for instance by only showing receivers that is part of a specific Group$_{\text{CMI}}$ or part of a Buddy List$_{\text{CMI}}$. If the list provided can be filtered on specific criteria, it is imperative that the users is able to control what filter is applied. They should therefore be provided with a method to quickly change between the different filters.

The appropriate range of proximity that is used to acquire the potential receivers may vary based on (1) the environment the system is used in and (2) on the intended use of the feature. In addition, some limitations in the range will also be imposed by the technology used. It is therefore important that the designer carefully considers these two factors together when deciding on an appropriate range of proximity and choose a technology that reflects this choice. For example, when the pattern is used in an environment with a high density of devices the appropriate range would be shorter than when used in an environment with a low density of devices. This will reduce the risk of over-populating the list with uninteresting devices.

Rationale

When several users are part of a co-located collaborative session, there often occurs situations where a user wants to share information with several others at the same time. Showing only users and devices in close proximity reduces the risk of over-populating the list of potential receivers, and there also is a higher possibility that these users are more relevant as receivers of the information the sender wants to share. This enables users to spend shorter time on identifying receivers, that in turn reduces the risk of inferring with the inter-personal interactions of a collaborative activity.

Check

When applying the pattern, you should answer these questions:

- What is the appropriate range of proximity and which technology should be used in order to achieve the pattern?
- Are users comfortable revealing that they are in the proximity to other users?
- What are the capabilities of the devices that the system supports? Do these devices have the necessary requirements needed to apply the pattern?

Danger spots

In some environments it might not be appropriate for users to see every device in the vicinity. For example, if the environment contains a lot of devices in a small areas or the system has a large number of users, the list of possible recipients can become overwhelming for a user. In these cases, users should be able to filter out users and devices in the vicinity based on a criteria, as mentioned in the Dynamics section.

Users also might not be comfortable knowing that other users can see if a person is in within proximity or not. However, since the pattern created for co-located information sharing, Proximity-based Identification$_{6.4}$ is primarily targeted towards users which are already part of a co-located collaborative session. The pattern aims to aid users with identifying other users which are a part of this session or devices nearby that can be used to facilitate the collaboration. The range of proximity should therefore be chosen to reflect this.

Known uses

Bluetooth An example of how Proximity-based Identification$_{6.4}$ can be implemented, is by using Bluetooth technology. Bluetooth is an open wireless technology standard for exchanging information over short distances using short length radio waves. Bluetooth lets users share any information like music or pictures from any device that has Bluetooth built in, this can be printers, mobile phones, portable music players and similar [18]. Any Bluetooth-enabled device can share to other Bluetooth-enabled devices. In order to share information using Bluetooth, a user is provided with a list of nearby devices and must choose the receiving device. Bluetooth is divided into three different classes, which have different ranges. Class 1 has a range of approximately 100 meters, class 2 is 10 meters and class 3 is 1 meter. For users in a collaborative system, class 2 is the most appropriate to facilitate co-located collaboration, although there might also be cases where class 1 would be more suitable.

Related patterns

Sharing Shortcut$_{6.2}$ can be used together with Proximity-based Identification$_{6.4}$ to provide the user with a method to select which information object he wants to share.

Shared Vision$_{6.6}$ describes how situated displays should be used to share information with co-located peers. Proximity-based Identification$_{6.4}$ can be used to specify a situated display as the receiver of an information object.

Sharing Agreement$_{6.7}$ should be applied in combination with Physical Identification$_{6.3}$. This pattern avoids negative consequences of unintended use or abuse by letting the user accept or deny incoming sharing requests.

Buddy List$_{\text{CMI}}$ and/or Group$_{\text{CMI}}$ can be used in combination with Proximity-based Identification$_{6.4}$ to filter out users and devices in the proximity, in order to show relevant receivers to the user.

6.5 Proximity-based Awareness

Intent

Allow users to maintain an awareness of interesting users and situated devices in the proximity.

Context

Users are equipped with hand-held devices, and the environment or activity the users are engaged in requires them to move between locations.

Problem

Even though co-location offers natural opportunities for collaboration and face to face interactions, some opportunities are lost – wasted – due to lack of awareness of peers and devices that can be used to facilitate the collaboration.

Scenario

While in exploring the area around the main square for a school project, George finds some interesting information about an old historical statue, something he knows that his friend, Isabel, is very interested in. He retrieves the information and wants to share the information with Isabel the next time they meet.

Back at school George and Isabel meet up in the schools cantina and discuss the results they have gathered. However, George has forgotten that he wanted to share *the information about the statue with Isabel. In addition, in an empty meeting room just by the cantina there is a situated display that can be used to collectively view the information they have gathered. Unfortunately, none of them knows that the display is in the meeting room, and miss the opportunity of using it.*

Symptoms

You should consider using this pattern when:

- Users are mobile, or solve tasks that require them to be mobile
- Users often find themselves in unfamiliar environments and therefore have:
  - Problems reaching and locating other users of interest
  - Problems locating - or are un-aware of - situated devices that can facilitate co-located collaboration

Solution

Provide users with awareness of other users' identity, presence and location; and awareness of situated devices that can be used to facilitate co-located collaboration.

Dynamics

Users should be able to see information about which other users or devices that are within his/hers vicinity, for instance by using a map or showing a list of these users. The users would then be constantly updated on other users and devices in the vicinity, which would encourage collaboration. Collaboration could be further facilitated by allowing a user to *tag* interesting users, and also possibly associating this user with an information object. The system could then notify the user when an interesting user is in the vicinity, and provide the user with a reminder of which information object he associated with this user.

In order to protect the privacy of users, the pattern should be implemented in combination with SHARING AGREEMENT$_{6.7}$. If a user requests to share location information with another user, the receiver of this request should have the ability to accept or deny sharing this information through a request. Sharing of location information between users should preferably be a mutual agreement, there should rarely be cases where only one user share location information and another user does not.

Users should also have the ability to state whether or not they are available, or that they do not wish to be interrupted. This can for example be obtained by allowing them to enter an "invisible" mode or to change between a set of statuses, giving other users a clue whether or not someone is available. By entering a "invisible" mode, other users are unable to see this person. When this is used, it could also be appropriate to make the invisible user unable to see information about other users, in order to uphold the fact that sharing location information should be mutual. Setting one's status can be implemented by allowing users to manually to set their status, or by allowing the system to set a users status automatically based on his/her context. In the later case, a user should still have the option to override the action taken by the system. If the pattern is applied within a tightly coupled social structure, e.g. within a GROUP$_{CMI}$, the SHARING AGREEMENT$_{6.7}$ step can in some cases be skipped. However, allowing users to manage their availability is important for them to be comfortable sharing information about their location with others.

The users should also be able to filter out who they receive awareness information from, based on certain criteria. One example of this would be to filter users based on existing social configurations between users, for instance by only receiving information from members that are part of a GROUP$_{CMI}$ or BUDDY LIST$_{CMI}$. If filtering is used, it is imperative that the users is able to control what filter is applied. They should therefore be provided with a method to quickly change between the different filters.

The range of proximity that is used to trigger when a user or device is in the vicinity or not must be carefully considered, and is dependent on the intended use of the collaborative system. However, it should reflect the ability for users to engage in face to face meetings, since the aim of the pattern is to provide users with information that facilitates co-located interactions among users. In some systems it might be appropriate to extend the range of the information provided to cover a specific place. In these cases it should be a distinction between when users enters another's vicinity, and when they are just located at the same place.

When information is provided for a location, user should be able to actively look up information about the position of a specific user or device. For instance, a user could be in a situation where he needs to locate another user in order to discuss a particular topic, or in need of a situated display in order to provide a SHARED VISION$_{6.6}$ with several peers. The user would then look up this information in the system so that he could locate this specific user or device.

Rationale

Proximity-based Awareness$_{6.5}$ can be applied to make users aware of other users and devices in their surroundings. Sharing this information will facilitate informal collaboration between users, since users have the ability to be aware when people are close by and therefore possibly available for a face to face meeting. The application of this pattern can also increase the use of situated displays if users are operating in unknown environments, since it allows users to also be aware of interesting devices in the surroundings. This in turn can be used to facilitate informal collaboration by using Shared Vision$_{6.6}$ between several peer users.

Check

When applying the pattern, you should answer these questions:

- Are the users comfortable revealing their location to other users?
- Are there strong social ties among the users that can be used to support automatic sharing of location?
- How should users manage their availability? Can a user's context be used to convey this?
- What range of proximity is appropriate, based on the intended use of the system?
- Is it appropriate to allow users to look up other users within a specific place?

Danger spots

The most important danger spot for this pattern is creating a useful feature while still maintaining user privacy. Many users might not be comfortable with sharing information about their location to others, and if the pattern is to be useful, users should be able to share location information with other users without feeling constantly watched or supervised. Because of this, mechanisms should be in place that allow the user to continuously modify when and to whom this information is shared. Users should therefore at least be able to control *when* and to *who* information about their location is shared.

When choosing *when* location information is shared with others, a common approach is to allow the user to switch between modes, for instance by having a *normal mode*, where the user share their location with others, and an *invisible mode*. When a user enter the invisible mode, other users can no longer see his location and are no longer notified when this specific user is in the vicinity.

Users should also be able to control *who* they share their location information with. This can for instance be done by implementing PROXIMITY-BASED AWARENESS$_{6.5}$ in combination with the SHARING AGREEMENT$_{6.7}$ pattern as described in the dynamics section. When a user want to share his location with another user, he sends a request that the receiver must accept. The receiving user can then choose to accept or deny this request. If the user accepts the sharing location information should be a mutual agreement, meaning that the each agree to share this information between each other. If the users denies the request, location information is not shared between any of them.

Known uses

Proxy Lady is an application of proximity-based notification developed by Dahlberg et al. in *The use of Bluetooth enabled PDAs* [10]. Proxy Lady was intended to support opportunistic interaction by allowing users to associate "information items", like e-mails, documents or tasks, with other users, which they called "candidates for interaction". When a "candidate for interaction" was detected to be in the proximity, Proxy Lady notified and provided the user with the information item he had associated with the specific candidate. If suitable, an informal co-located collaboration session could be the result of such a notification. Proxy Lady also allowed users to enter an "invisible mode". This mode hid the user from other users, so that they did not receive any notification when he or she were nearby.

Google Latitude is a service developed by Google that let people see where their friends are using Google Maps. People add each other as friends and must agree on sharing their location with each other before they can view this information. Google Latitude can also be used with an additional application called Location alerts. Location Alerts lets a user receive and send automatically generated alert notifications if Google Latitude friends are nearby when the user somewhere interesting or unusual. Alerts use location history to send notifications only when they are most likely to be interesting to you and your nearby friends. This means that location alerts are not fired when people are at a routine place with the usual friends, but when a user meets friends at unusual locations or at an unusual time. Privacy settings in Google Latitude include a "hidden mode" like in Proxy Lady, but it also allows users to set their position manually. A picture of Google Latitude is shown in figure 16.

Related patterns

SHARING AGREEMENT$_{6.7}$ can be used to allow users to control who they share location information with. If a user receives a request from another user he can

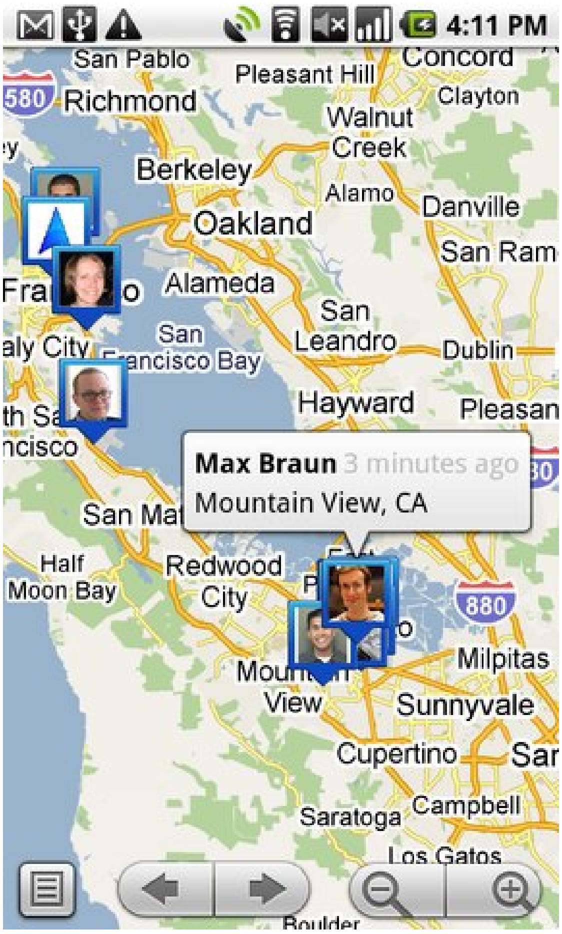


Figure 16: Google Latitude in action

either accept, to mutually start sharing location information, or deny the request.

Buddy List$_{\text{CMI}}$ and/or Group$_{\text{CMI}}$ can be used in combination with Proximity-based Awareness$_{6.5}$ to filter out users and devices in the proximity, in order to show relevant receivers to the user.

Masquerade$_{\text{CMI}}$ As mentioned in the dynamics and rationale sections, users should be able to control what information that is revealed about them, and when they do not wish to be monitored by other users. This can be achieved by applying the *Masquerade$_{CMI}$* pattern together with Proximity-based Awareness$_{6.5}$.

Active Map$_{\text{CMI}}$ can be used together with Proximity-based Awareness$_{6.5}$ in order to provide a graphical and scaled representation of the users space, enriched with awareness information of resources (users and situated devices) in the proximity.

Sensing$_{PMI}$ describes a technical solution for devices to receive continuous sensor data, for instance location data, from other devices. This can be used to provide awareness information to users about other devices in the proximity.

6.6 Shared Vision

Intent

Let co-located users share information through a situated display.

Context

Two or more users are co-located in a technology enriched environment. At least one of the users is equipped with a hand-held device and wants to share information with the other users.

Problem

The one-user/one-device design paradigm does not effectively enable co-located users to collectively view information when they are collaborating [45].

Scenario

The teacher has just given out a new assignment about pollution. The students have to investigate the status of their local environment. Anna, George, and Isabel are assigned to the same group and they decide to divide their tasks. Anna will go out and collect data in the main street, George will cover the area around the main square, while Isabel will monitor the status of the river. In order to facilitate this work, each individual is equipped with a hand-held device that communicates with a city-CL system.

Back to school Anna, George and Isabel meet up and discuss the results they have gathered. They have booked a meeting room in order to facilitate the activity. However, this room contains no devices to view the information, and the three participants are therefore forced to use their hand-held devices to view the different data collected while they where out in the city. This makes is difficult to discuss specific parts of the results, since the participants are unable to see what part others are currently pointing to.

Symptoms

You should consider using this pattern when:

- Users often have a need to collectively interact with a shared information object.
- Users often meet and collaborate together at specific locations.
- In order to collaboratively view information, users have to simultaneously view it on each of their own devices.

Solution

Allow users to share information to other users by showing the information on situated displays located in the environment. The methods used to specify that an information object is shown on a situated display should be identical to how users share information with other users.

Dynamics

The SHARED VISION$_{6.6}$ pattern enables users to collaborate collectively using shared displays in places where users are often present together or that are often used for collaboration. Users share information with other users by transferring the information from their personal device to the situated display and should be able to use any capabilities the situated display might offer to interact with the information.

Users should be able to use the same methods to transmit and show the information on the display as they use to share information with other users. For instance the information object could be specified using the SHARING SHORTCUT$_{6.2}$ pattern, and the PROXIMITY IDENTIFICATION$_{6.4}$ or PHYSICAL IDENTIFICATION$_{6.3}$ pattern to identify the display as the receiver.

Users should also be able to transfer the information back to a mobile device, or to share the information to other users' devices, by using methods that are similar to how they transmitted the information to the situated display. The users could for instance be enabled to select the information they wish to send by applying the SHARING SHORTCUT 6.2 pattern, and specify the receivers with either PROXIMITY IDENTIFICATION 6.4 or PHYSICAL IDENTIFICATION 6.3. This can be especially useful in cases where information is modified collaboratively by using the screen, and the users want to store and updated copy of the information on their personal devices. However, this can also be a useful feature when interacting with situated display that's only purpose is to show the information, for instance if one of the other users wants a personal copy.

If this pattern is applied in conjunction with the ENSURE ACCESS 6.8 pattern, it could also be possible to let users identify themselves with the device, and access the information directly. In this case PROXIMITY IDENTIFICATION or PHYSICAL IDENTIFICATION could still be used to identify a user.

Rationale

SHARED VISION 6.6 gives users the possibility to view the same information collectively, and thereby have the ability to use body language and other interpersonal interactions to facilitate the collaboration, since every participant is viewing the same screen. Different devices can also support the interaction with the information in different ways. By sharing the information to the device, and then letting users interact with that device, SHARED VISION 6.6 serves as a general solution to the problem of letting co-located users collaborate collectively.

Check

When applying the pattern, you should answer these questions:

- Which locations are strategic for the placement of shared displays?
- Should the situated display provide any mechanisms for interacting or modifying the information which is displayed?
- What communication capabilities should the situated device support? Do these capabilities match the capabilities of the users' devices?
- What should happen when several users upload information at the same time to the device? Should the device support the display of multiple information objects concurrently?

Danger spots

If the nature of the collaborative session or the participants are mobile, situated devices might not always be suitable. This can for instance be cases when users collaborate while on the more between location - e.g. on a train, or if they rarely work in the same place. In cases like these you should rather let users share information directly between the hand-held devices of other users.

Also, if the location that houses the situated display is better facilitated with the participants using remote tools to interact with the display, or the display itself does not support interactions, you could consider letting users remote control the simple display using their hand-held device. For example, the VIRTUAL WINDOW$_{CMI}$ pattern describes how users can use their personal hand-held devices in order to present a window on another device.

Known uses

Microsoft Surface: One example of how multiple users can collaborate using a share display is to provide access to digital media on a tabletop system. Microsoft Surface is an example of such a system that is a multi-touch computer with a large, horizontal user interface [35]. Using Microsoft Surface multiple users can is around a tabletop and interact simultaneously with the information presented on the display. The system also supports object recognition, which means that it is for example possible place a mobile device on the tabletop in order to transfer data to or from it. To achieve its functionality, Microsoft Surface is equipped with cameras, and uses image recognition in the infrared spectrum to identify object such as fingers, tagged items and shapes. The input is processed by the computer and the resulting interaction is then displayed using rear projection.

IBM BlueBoard: The BlueBoard is a 1.3 meter plasma touch screen designed to support lightweight, fast encounters and simple collaboration meeting of serendipitous nature [17]. The system provides the users with methods to show information on the screen that they can then interact with and share information between users [39]. Users can for example send documents to the device through email, which are automatically showed on the screen. The system also provides the users with the ability to identify themselves with the BlueBoard, which are then display on the screen by an icon. The users can then access personal content stored on a central server, or share the information showed on the screen to the users that are identified by using a drag motion [17].

Figure 17: (Left) An image showing an application running on Microsoft Surface. (Right) Four representatives from Microsoft interaction with Microsoft Surface.

Figure 18: An image showing the BlueBoard in use by two participants. The main part of the screen contains an image that the participants have annotated using the touch screen capabilities. On the left one can see the icons of the two persons who have identified themselves with the display.

Related patterns

SHARING SHORTCUT$_{6.2}$ can be used together with SHARED VISION$_{6.6}$ to provide the user with a method to select which information object he wants to share.

PROXIMITY-BASED IDENTIFICATION$_{6.4}$ describes how short range radio technology can be used to provide the user with a list of devices in the vicinity. The PROXIMITY-BASED IDENTIFICATION$_{6.4}$ pattern can be used in conjunction with SHARED VISION$_{6.6}$ to provide the users with a list of devices that can receive information.

Physical Identification$_{6.3}$ describes how a physical motion can be used to identify a user or device. This pattern can be used together with Shared Vision$_{6.6}$ to provide the users with a means of identifying themselves or their device with a shared display in order to transfer information.

The Telepointer$_{\mathrm{CMI}}$ pattern describes a way for users to obtain a shared focus of a specific part of a piece of information shown on a large screen. The pattern states that users should be equipped with a visual pointer that can be used to indicate at which part of the information collaborating users should focus their attention.

Virtual Window$_{\mathrm{PMI}}$ describes a way for users to show a window of a specific device on a second device. This can be used together with Shared Vision$_{6.6}$ in order to allow users to show a window of their personal device on a situated display to discuss information stored on the personal device.

6.7 Sharing Agreement

Intent

Support users to protect their privacy when sharing information.

Context

Two or more users are co-located and equipped with hand-held or stationary devices that enable them to share information with each other, in a technology enriched environment.

Problem

In collaboration systems where users frequently share information with each other, there can often be cases where unintended use or abuse of sharing functionality occurs.

Scenario

Michelle and Sandra have decided to meet several of their friends at a café in Trondheim. On the way there, they find an interesting historical building, and Michelle uses the city-CL system to retrieve some information about it using a mobile device. When they meet the rest of their friends at the café, she wants to share this information with all of them. She therefore configures her hand-held *device to share the information to everyone in the vicinity, also people in the café she does not know.*

Symptoms

You should consider using this pattern when:

- Users are loosely connected to each other
- Users frequently share information to several recipients at the same time
- Users frequently share information to the public, for instance using a public display
- Users frequently share sensitive information
- Unintended use or abuse of sharing functionality often occurs
- Users often roam between public and private locations with different users and settings

Solution

Users who receive information should have the ability to control what information they receive. In addition, in some cases the users should be prompted to explicitly specify that they want to share a specific information object with others.

Dynamics

Sharing of information can sometimes be unintended, or abused by malicious users. The system should therefore help users maintain privacy when sharing is performed. The SHARING AGREEMENT$_{6.7}$ pattern solves this problem by introducing additional support for both users who share information with other users, and users that receive information.

When users receive information from other users, the system should be configured to prompt the receiving user with a request before actually receiving the information. This allows the receiver to be in control of which information he receives. The user should be presented with a simple notification on the screen of his device, which states that a user is trying to send him something, for instance *Bill is trying to send you meeting-agenda.doc*. The user should then be allowed to accept or deny this request based on the information provided. The system could also allow the receiver to view a sample or a preview of the information, before deciding to accept or deny the request.

In most cases when users share information with other users, the act of specifying the information object to share and the receiver(s) is sufficient to state that they want to share the information. However, in some cases an additional layer of protection should be added, which require the user to explicit state that he wants to share the information with the receivers he has specified. These cases are for instance when users are about to share information using a public display, share with unknown users or when they share information that the system regards as sensitive. This additional agreement will help users maintain their privacy, reduce the impact of unintended use of sharing functionality, and prevent other users being interrupted by irrelevant sharing requests.

Additionally, users should be able to modify the conditions for these agreements. Examples include cases where a user wants to automatically receive information from one or several specific trusted users, or when he don't need an additional reminder when he publicly shares information. We recommend that the system defines a default setting for these agreements, and provide controls for the users to customize them as they wish.

Rationale

The SHARING AGREEMENT$_{6.7}$ pattern decreases negative effects of unintended use or abuse of sharing functionality by putting the user in charge of what information he shares and receives. Users should primarily only share and receive information from users he knows and trusts. Users should be careful when sharing information publicly, and in cases where the information can be regarded as sensitive. In addition, a user should never receive information from unknown users or information he suspects to be malicious.

Check

When applying the pattern, you should answer these questions:

- In which cases should a user be asked to verify that he wants to share a certain piece of information?
- What should be the default configuration for sharing agreements?
- How much information should be revealed about the sender?

Danger spots

When applying this pattern, developers must consider the cases where it is relevant to use SHARING AGREEMENT$_{6.7}$. As mentioned previously, we have mentioned cases where users share information publicly, or when sensitive data or unknown users are involved in the sharing. Developers must carefully consider these issues, and create an appropriate default setting for the cases where users have to agree on sharing or receiving information.

If a users always have to explicitly state that they want to share an information object after selecting the object and the receivers, one can run into the risk of users not paying attention and therefore blindly accepting the agreement. System designer must therefore carefully consider when the system should post this agreement, and allow users to modify these setting, in order to fit with their behavior.

In addition, system designers must consider how much information the receiving user should be allowed to know about the sender before agreeing to receive the information. When sharing to other users, the system should never reveal details that can be judged as sensitive about the sender, but at the same time the receiver should be presented with enough information to be able to decide if the incoming data could be malicious, for instance a computer virus or similar threats to a computer system.

Known uses

Windows Live Messenger Windows Live Messenger (formerly named MSN Messenger) is an instant messaging client created by Microsoft. Windows Live Messenger lets users add other users to their buddy list, in order to chat, share, or play games with each other. In figure 19, *User X* wants to share the document *meeting_agenda.pdf* with another user. As you can see, the receiver is provided with three options, *accept*, *decline* or *save as...* *Accept* means that the user accepts the transfer, and the document is stored at a pre-defined location on his local hard drive. If the user *declines*, the document is rejected and not transmitted. *Save as..* lets the user choose the location to store the document.

Figure 19: A sharing request in Windows Live Messenger

Related patterns

User should be able to agree before they receive information from other users. *Sharing Agreement*$_{6.7}$ is therefore relevant when applying both Proximity-based Identification$_{6.4}$ and Physical Identification$_{6.3}$. In addition, users who share sensitive information or share with unknown should also be asked to explicitly agree to share this information.

In the Proximity-based Awareness$_{6.5}$, a *Sharing Agreement*$_{6.7}$ should be made between two users who want to share their location with each other.

If the display used in the Shared Vision$_{6.6}$ pattern is public, users who share information could be prompted with a *Sharing Agreement*$_{6.7}$ before they share information to this display.

Letter of Recommendation$_{CMI}$ can be used in order to let rate other users based on previous interactions. This can be used to provide additional information about certain users that are especially helpful or knowledgeable, or users who should be avoided or have malicious intentions.

6.8 Ensure Access

Intent

Ensure that information captured using different devices is easily available when a user wishes to share this information with other, co-located users.

Context

The environment or activity that the users are engaged in requires them to be mobile and information is captured using a range of different devices. In addition, users want to share information with co-located peers by transferring information between hand-held device or through a situated display.

Problem

Mobile devices are not appropriate for some of the tasks users might be engaged in, for instance writing long documents or painting graphics. When data is distributed among many devices and the users are mobile, they might not have the relevant information available at the time they wish to share it.

Scenario

The teacher has just given out a new assignment on pollution; and Anna, George, and Isabel are assigned to the same group.

The next day, Anna meets up with a fellow student, Christine, for a lunch break at school. While eating, they discuss the current school assignments they each are engaged in. Christine is doing an assignment about greenhouse effect and its local impact, and Anna thinks that some of the work might be used in the assignment she is writing together with George and Isabel. She therefore ask if Christine would be willing to share the work she has done so far, so she can take a look at it before meeting the rest of the group to continue their work. Christine agrees to share the work, but unfortunately she has an appointment downtown, and she has left her laptop, which contains the work, at home. She therefore says that she will send Anna an e-mail once she is home and done with the appointment.

However, it takes some time before Christine is done with her appointment and gotten back home. In the mean time Anna, George, and Isabel have already completed their assignment, without integrating information from Christine's work.

Symptoms

You should consider using this pattern when:

- Users capture and access data using more than one device.
- Users have problems finding the correct copy of information.
- Users miss the opportunity to share information with others because the information is not available.
- Users have to delay the sharing of information to a later time because they did not have access to the information.
- Users have to delay sharing information and forget to share it later.

Solution

Allow users to place and retrieve information in a way that enables them to access information independently of how the information is distributed among different devices. Additionally, access to information should be transparent to the users.

Dynamics

In order to apply Ensure Access$_{6.8}$, the system should use a data distribution architecture that facilitates a user with access to his information independently of the device he currently uses. Additionally, it should be transparent for the user where the actual information stored. This means that the information should be presented to the users in a manner that makes it irrelevant which device he used to capture the information. If the system internally houses information that is public to it's users, or a subset of the user, this information should also be accessible in the same manner.

Ensure Access$_{6.8}$ can for example be obtained by using a central server where the information is stored or by basing the system on a peer-to-peer architecture that enables them to access the information stored on each of his device. The users could then either access the information directly from the source, or have the ability to synchronize local copies to the device they want to access the information from.

Rationale

Ensure Access$_{6.8}$ states that information should be available regardless of which device was used to capture the information and which device the user want to access the information with. Introducing a data distribution architecture that enables this, ensures that information is always available when the users wants to share it with other co-located users.

What type of data distribution architecture the collaborative system uses will most likely have impact on other areas of the system, for example how users store information and how information is shared between distributed users. However, making sure that users have easy access to information sources is especially important for information share between co-located users. This is mainly due to the often serendipitous nature of co-located collaboration, where short face to face meetings can spur a need for the participants to share information. When designing a system that is intended to support information sharing between co-located users it is therefore important that they have easy access to the information at the time an interaction with peer users is established.

Check

When applying the pattern, you should answer these questions:

- What type of data distribution architecture are you going to use in the collaborative system?
- How are you going to control access to the data storage?
- What type of device shall the collaborative system support?

- Are you going to provide the users direct access to the data or provide tools to synchronize local copies with the data storage?

Danger spots

How the system allows users to access the same information will depend on what data distribution architecture the system uses, as such it is imperative that this pattern is applied in a way that fits with the overall use of the collaborative system. It is also important that this issue is taken into consideration at an early stage in the design phase, so that it fits in with the devices the system supports and how co-located users share information.

If the system contains information where privacy is an issue, it is important that the users are provided with methods to ensure that information does not go astray, especially when information can potentially be accessed from different devices. The security measures that the system has in place for this, is not a direct consideration with respect to co-located information sharing. It is, however, important that the security measure taken imposes the least amount of stress on co-located information share, so users still can carry out the sharing in a lightweight and fast manner. At the same time, it is also important that users are aware of what information they are sharing, in order to not accidentally share confidential or sensitive information.

If a peer-to-peer architecture is used, one might run into the risk of devices being unreachable when they are not turned on. It should therefore be considered whether the devices used by users are usually off-line or not, before settling on this type of data distribution architecture.

Known uses

Dropbox: Dropbox is an online file storage provider that is specifically designed to allow users to access information from different devices [15]. Using a client application on the user's device, Dropbox integrates with the native file system on this device, providing a special folder where users can store information they wish to access from other devices. The contents of this file is then synchronized to a central storage server hosted by Dropbox. If the user wants to access these files from other devices, they simply install the client application, and the information is automatically synchronized to the device. Users can also access the information in a web-interface using a regular internet browser. Dropbox is available for the Windows, Mac and Linux, including any device running the Android or IPhone operating systems.

Google Sync: Google Sync is an application that runs on mobile devices and is used to synchronize a user's mail, calendar and contacts between the device and the Internet based *Google Apps* tools [16]. The synchronization happens automatically each time the uses accesses the information. This enables users to always have access to the same information, even though changes are made using different devices. Although Google Sync only provides synchronization of specific types of information, it serves as a good example of how information is available when the users needs it.

Related patterns

Sharing Shortcut$_{6.2}$ describes how users can specify the information object they wish to share.

Physical Identification$_{6.3}$ Describes how users can specify the device of another user or a situated display as the receiver of an information object.

Proximity-based Identification$_{6.4}$ Describes how users can specify several receivers of an information object concurrently. The receivers can either be devices of others user or situated displays.

Shared Vision$_{6.6}$ Describes how a situated display should be used to facilitate information sharing between co-located peers.

Shared File Repository$_{\text{CMI}}$ One application of Ensure Access$_{6.8}$ is to provide a Shared File Repository$_{\text{CMI}}$ for the users. This repository gives users the ability to place and retrieve files on a shared storage space, facilitating collaboration over shared content.

Synchronization$_{\text{PMI}}$ This pattern describes an application of Ensure Access$_{6.8}$, which uses a distributed data architecture instead of a centralized data architecture.

6.9 The Patterns Applied

The scenario presented in section 6.1 gives an overall illustration of how the patterns can be used to provide support for information sharing among co-located users. In this section we will go into more detail, and provide an example of how these patterns can be applied in order to achieve the intended functionality of this scenario. To simplify the example, we will only focus on the aspects of the system that are directly relevant for the information sharing. In addition, the example is simplified to highlight certain aspects of the functionality, a fully working system should therefore also implement other aspects of the patterns that we do not directly focus on in this example. We assume that users are equipped with mobile devices, which are supported by the system, and that have wireless connection, Bluetooth and Near Field Communication capabilities. The environment is also populated with situated displays that can be communicated with using a wireless connection or Bluetooth.

The first step towards the support of information sharing between co-located users in a city-CL system is to provide the users with an interaction method to select – or specify – which information they want to share. According to the SHARING SHORTCUT$_{6.2}$ pattern, this interaction method should enable users to quickly select the information they want to share in a manner that is consistent wherever they have the ability to interact with information within the system. In order to achieve this, a web-portal to the system is created, where they can reach the information that they have stored as a list of files. For a selection of file-types the system supports, users can also access a specific file in order to view or edit the contents. By selecting a specific file, users are promoted with a message box, where one of the options is entitled “share...”. Similarly, when browsing a specific file, users can select a passage of text or an image in order to be prompted with the same message box. A mock-up of the graphical interface can be found in figure 20.

Once users have the ability to specify *the information object* to share, the next step will be to specify the *receiver(s)*. Once the user has selected what he wants to share and pressed the button entitled “share”, a list containing users in the proximity appears as described in PROXIMITY-BASED IDENTIFICATION$_{6.4}$. The list is populated using Bluetooth technology that detects mobile devices and situated devices in the proximity. Furthermore, it is possible to select one or several receivers from this list and to filter the list to only show users that share a relationship with the sharer in the form of a group. Additionally, once the “share” button is pressed, users can specify the receiver by bringing their device in physical contact with the device of the receiver, in accordance with the PHYSICAL IDENTIFICATION$_{6.3}$ pattern. This functionality is obtained by using the NFC capabilities of

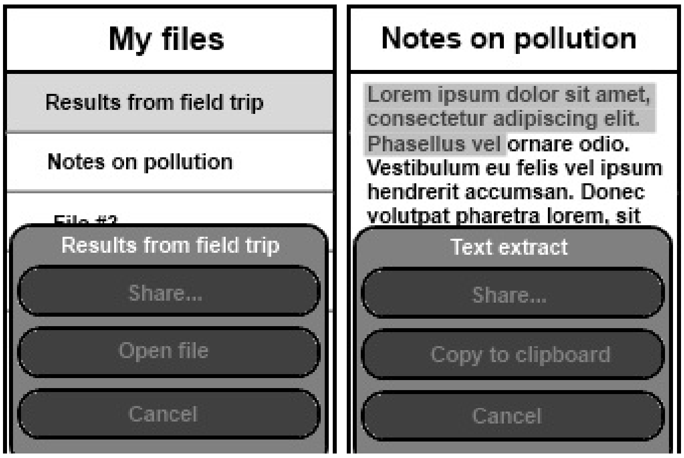


Figure 20: Mock-up interface with a sharing shortcut. (Left) Used in a list of files. (Right) Used within a text document.

the devices to recognize when two devices are in contact. In order to transmit the information, short-range technologies (Bluetooth and NFC) could also be used to negotiate a wireless connection between the devices, which usually have a much higher bandwidth than short-range technologies.

Before users receives the incoming information, they are prompted with a message that tells them that someone wants to share information with them, in accordance with the Sharing Agreement$_{6.7}$ pattern. This message includes the name of the sharer, the type of information object and the name of the information object. The users can then accept or deny the incoming information. A mock-up of this message box can be found in figure 23. In addition, users have the ability to state that certain information from this user will always be accepted. This option can also be changed in the options of the application.

The system also supports Proximity-based Awareness$_{6.5}$, where users can associate an information object with a user and get a notification when this user enters their proximity. Figure 22 shows a mock-up interface of how users can specify the user he wants to track, the associated information object and the actual notification he receives. The feature is based on the same underlying technology that is used to populate the list used to provide Proximity-based Identification$_{6.4}$. However, before users can track each other, they must both agree to share each others location. This is done by applying the pattern Sharing Agreement$_{6.7}$, where one user requests to share location information with the other, and the receiving user accepts or denies this request. In addition, the users have the ability to disable the tracking feature by going into a “invisible” mode that can be accessed in the options of the application.

Figure 21: Mock-up of an interface with a sharing request.

As stated in Shared Vision$_{6.6}$, the list of possible recipients when using Proximity-based Identification$_{6.4}$ is also populated with situated displays that can be used to collectively view information. In the user environment, situated displays are equipped with RFID and wireless connection capabilities and situated in meeting rooms and public recreation areas. In addition they provide the users with simple interaction mechanisms to highlight specific part of the screen and to close the active file using touch screen interaction. The devices are identified as receivers using the same methods as the mobile devices of users. When a situated display is specified as the receiver, an application running on the display automatically shows the information. When users share information to a public display, they are requested to explicitly agree to publicly share this information, as suggested by the Sharing Agreement$_{6.7}$ pattern.

The system also provides users with a lightweight application that they can install on any device they use to communicate with the system. This application works in a similar manner as *dropbox*, and gives users a specific folder that is automatically synchronized to a central server each time information is modified. By installing and logging on with their user credentials, users can access the information that is stored in this folder from any device that has the application installed. If, for some reason the centralized server is unreachable, the users get a warning about this, and the changes to the folder is applied as soon as the server is reachable again. This enables them to have the information available when they would like to share it, in accordance with Ensure Access$_{6.8}$.

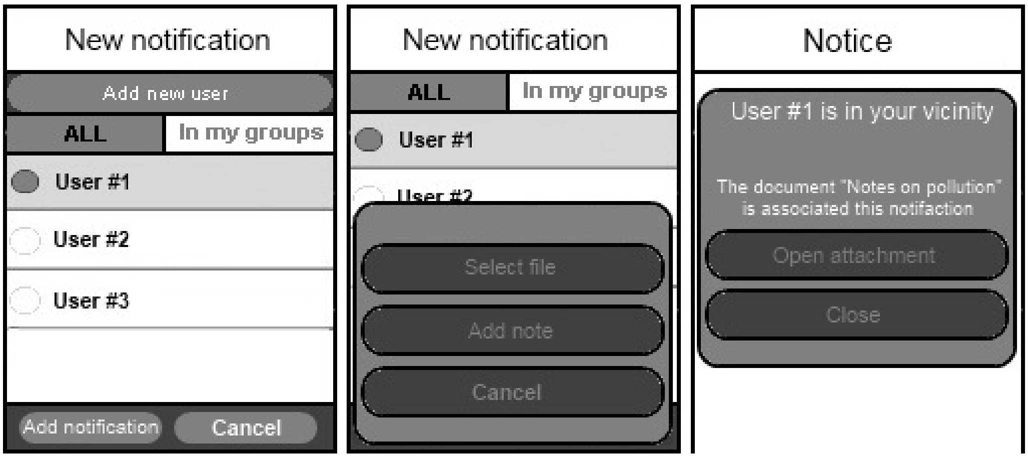


Figure 22: Interface mock-up of awareness feature (Left) Specifying the user. (Middle) Specifying associated information. (Right) Notification when user is in the proximity.

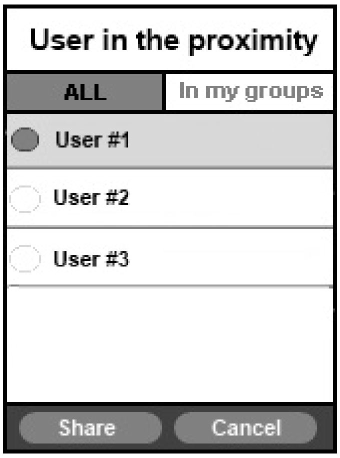


Figure 23: Mock-up interface with a list of recipients in the vicinity.

7 Conclusion

7.1 Summary

In this thesis we have looked at how users of collaborative systems can be facilitated by technology to share information with each other. We have developed patterns, from an end-users perspective, aimed at providing useful guidelines to designers and developers of co-located sharing mechanisms in collaborative systems.

As mentioned in the Introduction chapter, a pattern is a general planning principle that explains how one can design a solution for a re-occurring problem within a specific domain [3, 44]. In order to uncover these re-occurring problems, we performed a literature study which resulted in a set of re-occurring problems that we needed to address with our patterns. An initial set of patterns where then created based on the problems we uncovered, and evaluated and refined over the course of three expert evaluations. A figure showing the overall evaluation method is shown in figure 6 in the Pattern Refinement chapter. The evaluations and refinements resulted in a final set of patterns for co-located information sharing, which are given in chapter 6.

7.2 Contributions

This thesis contributes to the field of collaborative systems with a set of design principles, using the structured method *patterns*, for co-located information sharing between users. The patterns were developed based on existing research and practices within the field. They provide guidance for how to take advantage of mobile and ubiquitous technology to give users of collaborative systems the ability to share information with co-located peers, effectively and safely. The intended readers of the patterns are therefore all parties that are involved in the development of such systems. This will primarily be system designers and software developers that are tasked with the design and implementation of the system, and any other stake-holders of the system, which includes users. Additionally, students or researchers might also find use for these guidelines in order to aid them in further work or research on information sharing between co-located users.

Each pattern contributes by addressing a specific problem identified as important for co-located information sharing. The SHARING SHORTCUT$_{6.2}$ contributes with a method of specifying the information object a users wants to share. The pattern states that a shortcut, which can be used to select an information object to share, should be present wherever the users can interact with information.

Both Physical Identification$_{6.3}$ and Proximity-based Identification$_{6.4}$ addresses the need to specify the receiver(s) of information and describes how this can be obtained. Physical Identification$_{6.3}$ uses physical motion or contact to specify the receiving device. This means that users should be able to specify the receiver of an information object by touching or placing their device close to the receiving device. Proximity-based Identification$_{6.4}$ takes advantage of proximity, in order to simplify the list of possible receiver to only show devices in the vicinity.

The Shared Vision$_{6.6}$ pattern, describes how users can "share" information to a display situated located within the environment, in order to view information collectively.

Sharing Agreement$_{6.7}$ describes how users - both sharers and receivers - should be protected in order to limit the effects of misuse and malicious behavior by other users. The scope is limited to information sharing between co-located users, in order to address issues that are specific for a co-located setting.

Ensure Access$_{6.8}$, describes why it is important that information is available when a user need to share it, and how users should transparently access information. The aspect of transparency entails that users should be able to access information without concerning themselves with where the actual information is stored, so they can focus on what is important, namely to specify the information they want to share.

Lastly, the Proximity-based Awareness$_{6.5}$ pattern describes how users can share awareness information with each other. The pattern focuses on providing users with awareness information about users and devices within their proximity. This awareness can be used to discover the potential for collaboration with co-located peers.

7.3 Evaluation

The relationship between the main research question and the sub-questions is that the sub-questions individually target the re-occurring problems that were uncovered in chapter 2, while the main research question targets the set of patterns as a whole. We will therefore start by identifying how the patterns address each individual sub-question. Once this has been done, we will look at the set of patterns as a connected entity, and evaluate how they answer our main research question.

7.3.1 Sub-Research Question 1

How can the set of patterns facilitate interpersonal interactions?

Sub Research question 1 concerned the need to minimize the strain on interpersonal interactions between co-located users, when they are sharing information through a computer-mediated channel. As stated in section 2.2.1, this is important in a co-located setting because sharing is often part of a collaborative activity between the users involved. The use of computers to share information should therefore minimize the impact on these activities. From a sharers point of view, there are at least two actions that are needed in order to share an information object with other people; (1) specify the information and (2) specify the receivers. Thus, a user should be able to carry out both these task, while suffering a minimum amount of strain on the social interactions. We address this question with: Sharing Shortcut$_{6.2}$ which focuses on (1); and Physical Identification$_{6.3}$ and Proximity-based Identification$_{6.4}$ which both focus on (2), albeit with two different approaches.

Sharing Shortcut$_{6.2}$ was based on how mobile systems, for instance the iPhone OS, conveniently place a shortcut where one browses certain information, which can be use to instantly share this information. The pattern takes this concept further, and states that a shortcut should be placed wherever the user can interact with information within the system, and that the shortcut should have consistent appearance and behavior wherever it is applied. This allows users to specify the information object they wish to share using a minimum of step, in order to focus on the social interactions they are engaged in.

Physical Identification$_{6.3}$ is based on two different commercial technologies, *bump technologies* and *Near Field Communication*, which use the same underlying interaction mechanism. A white paper on NFC sums up this interaction mechanism as:

> "*... [it] allows people to use the simple act of touching or placing their device close to something to initiate the desired service. This makes using any form of electronic "service" and other interactions more accessible to more people, whatever their age or ability*" [24]

The use of this interaction method will as such enable users to quickly identify the receiver of an information object with the use of a motion that people are familiar with, thus reducing the need to spend time identifying a virtual representation of a user. Another aspect this is beneficial of this interaction method is the added layer of security when using physical contact to initiate a service [14]. In some systems it might be appropriate to only allow sharing between users that have a relationship with each other, like for instance people that are in each others buddy list. This means that an additional step is needed when a user wants to share an information object with another person, which he has not yet added to his buddy list. However, with Physical Identification$_{6.3}$, this step is not necessary, since instead of using a list to specify the receiver, a physical motion is used.

A limitation in the use of Physical Identification$_{6.3}$ is that users need to repeat the interaction method several times in order to specify several receivers. In addition, certain environments – for instance if users are situated around a large table – entails that users need to move around in order to specify the receivers. In order to address these issues, we created the pattern Proximity-based Identification$_{6.4}$. This pattern was based on the concept *proximity based notification* and the concept *Boundary principle* [29], which were introduced in chapter 5. Taking advantage of proximity, this pattern solves the limitations in Physical Identification$_{6.3}$, but at the same time loses the advantages gained by using a physical motion in order to specify receivers.

Together, the three patterns Sharing Shortcut$_{6.2}$, Physical Identification$_{6.3}$ and Proximity-based Identification$_{6.4}$ suggest how the strain on interpersonal interaction can be minimized while using computer-mediated interaction to share information. Although, Physical Identification$_{6.3}$ and Proximity-based Identification$_{6.4}$ address the same task, they both have areas or conditions that makes one of them more suitable. They are therefore intended to be used in combination. However, ultimately designers of the intended system must consider what best support the users and fits best with the environment, before deciding on the interaction methods to use.

7.3.2 Sub-Research Question 2

How can the set of patterns facilitate collective viewing of information?

The second sub research question concerns the need to be able to collectively view information in certain collaborative tasks. The use of large situated displays has been the focus on several systems within research on ubiquitous technology

[25, 47, 39]. As stated by Inkpen et al., this will enable users to work more closely and by extent, exhibit more on-task communication [23]. The research question is addressed by the SHARED VISION$_{6.6}$ pattern, which is based on research and existing solutions that use large, situated displays. The pattern focuses on how user can *share* information through situated display, in order to provide the users with the ability to collectively view and interact with the information.

A central risk one might run into when using situated displays, is the straining of interpersonal interactions between users when specifying that a certain information object should be viewed on a certain situated display. However, this issue is counteracted by stating that: "*The methods used to specify that an information object is shown on a situated display should be identical to how users share information with other users*". In order to achieve this, the pattern suggests the use of SHARING SHORTCUT$_{6.2}$ and PHYSICAL IDENTIFICATION$_{6.3}$ or PROXIMITY-BASED IDENTIFICATION$_{6.4}$.

7.3.3 Sub-Research Question 3

How can the set of patterns take advantage of relationship among users and protect the privacy of users?

Sub Research question 3 concerns two aspects, (1) taking advantage of relationships among users in order to simplify sharing and (2) protecting the privacy of users. We first intended to have a separate pattern on each of these issues. However, due to the limited scope of (1), we decided to incorporate this into the patterns where it is relevant, namely PROXIMITY-BASED IDENTIFICATION$_{6.4}$ and PROXIMITY-BASED AWARENESS$_{6.5}$. These section where also extended, based on feedback we received during evaluation 2. During this evaluation we also discussed the benefits of creating a separate pattern that targeted different methods of filtering the list of possible receivers. However, since this would only impact the patterns PROXIMITY-BASED IDENTIFICATION$_{6.4}$ and PROXIMITY-BASED AWARENESS$_{6.5}$, and because the use of filtering is not entirely identical in these patterns, we decided to keep this issue within the respective patterns. However, this means that the concept of filtering has to be copied to every pattern that can the advantage of this if the set of patterns are extended. As such, the creation of an individual pattern that concerns the use of filtering, should be considered if the set is extended with additional patterns that can take advantage of the concept.

The second aspect, was initially addressed by Sharing Request$_{A.1}$, which described how to protect the privacy of a receiver of information. However, during the first evaluation it was hinted that the pattern should also include protection for the user sharing the information. This was further substantiated in the second evaluation, where we got direct feedback on example of situations where the sharer's privacy should be protected. Based on this feedback, we decided to include how the sharers privacy should be protected in this pattern. In order to make it more obvious that the pattern describes solutions for both sides involved in sharing, we also decided to change the name of the pattern to Sharing Agreement$_{6.7}$.

Because Sharing Agreement$_{6.7}$ received such drastic changes after the evaluations, there is a risk that the understandability is not of the same level as the other patterns. To counteract this risk, we retained as much as the original pattern as possible and instead added the parts concerning the sharer of information. However, this new pattern should optimally have gone through the same iterations of evaluations.

7.3.4 Sub-Research Question 4

How can the set of patterns facilitate the availability of information?

The forth sub research questions targeted the issue of availability of the information when the user needed to share this information, and is addressed by Ensure Access$_{6.8}$. As stated in chapter 2, not all task are easily achieved using mobile devices, and as such not all information is captured using mobile devices. When users are moving between different locations and participates in collaborative activities, it is important that the information the users wants to share is available. The pattern was therefore revised during the second refinement process to put more emphasis on this aspect.

A risk concerning Ensure Access$_{6.8}$, is that the pattern's suggestions will have impact on other areas of a collaborative system aside from information sharing among co-located users. However, this pattern only describes issues that are directly relevant for information sharing among co-located users. As such, the actual usefulness of this pattern may be influenced by, or have an impact on other requirement of the collaborative system. However, we deem that the availability of information is especially important in a co-located setting, because sharing will often happen by the use of mobile devices. Since users often capture information using other, perhaps stationary device, it is important that the information is available from the device the users *currently* is equipped with. We therefore deemed that it was an important aspect of co-located information sharing, and supports the creation of the pattern. The risk is also highlighted in the danger spots section of the pattern. However, the only method to investigate this further, would be to look at the actual use of the patterns when developing collaborative systems.

7.3.5 Sub-Research Question 5

How can the set of patterns facilitate the awareness of potential for collaboration?

Our last sub research question concern the last re-occurring problem which we identified in chapter 2; the need to facilitate the awareness of potential for collaboration. In environments where users are roaming between locations, this will become an important issue because it can enable users to be aware of what resources – both other users and devices – are currently within their vicinity. We address this research question with the pattern PROXIMITY-BASED AWARENESS$_{6.5}$, which is based on the concept *proximity-based identification* and research people-to-people-to-geographical-places systems.

Perhaps the most important aspect of sharing awareness information is that the users are comfortable with how the system uses the information. As such this pattern focuses on two aspect: (1) how and why awareness information can be shared, and (2) how the *privacy* of users can be protected. In order to protect the privacy, PROXIMITY-BASED AWARENESS$_{6.5}$ describes how SHARING AGREEMENT$_{6.7}$ should be used to specify that two users accept sharing awareness information between each other. In addition, there are also aspect related to the protection of user's privacy that are specific for the sharing of awareness information. Since this only applies for PROXIMITY-BASED AWARENESS$_{6.5}$, we decided discuss this issue within the pattern. However, if the set of patterns are extended, it should be considered whether these issues can create an individual pattern that can be referenced throughout the set.

7.3.6 Summary of the Sub-research Questions

The previous paragraphs show how each sub research questions is addressed by the patterns contained in the set of pattern for co-located information sharing. While most of the sub questions are addressed by a single pattern, there are also cases where the re-occurring problem has been divided into smaller parts, which are addressed by individual patterns. The only exception to this, was the decision to include the issue of taking advantage of existing users relationships in the relevant patterns.

Each pattern has been based on existing solutions and research on the problems we have identified. Additionally, through three evaluations conducted with experts within system engineering and collaborative systems, these patterns were individually evaluated with respect to the evaluation criteria presented in section 5.1. The overall aim of these evaluations were to ensure that the patterns were easy to understand, and that they provided the information that was relevant for the problem and the domain. As stated in chapter 5, we therefore revised the patterns based on the results from these evaluations. Although the patterns could benefit from additional evaluations, we argue that the three evaluations that were conducted was sufficient to identify the most prominent issues. We base this claim on the results for these evaluations. Another aspect that we would like to point out with regards to the evaluation of the patterns is the need to evaluate the patterns based on *real* use [43]. As mentioned in the Problem Refinement chapter, the book *Liberating Voices* states that "*the set of patterns must ultimately be evaluated with respect to what they are trying to achieve*" [43]. In our case, the patterns were evaluated using three experts from different relevant fields. These evaluators provided feedback that was used to improve the patterns based on how they imagined they would be used in practice. However, we are unable to properly evaluate the patterns until we have obtained substantial feedback on how the patterns are actually used in practice. However, this is considered out of the scope of this thesis. We therefore claim that each sub-research question is adequately answered by the patterns that address the individual questions.

7.3.7 Main Research Question

What is the set of patterns that can aid in the design of systems intended to support information sharing among co-located users?

Our main research question concern the set of patterns which are needed to aid in the development of systems that will support information sharing among co-located user. As previously stated, the patterns individually address a set of re-occurring problems that have been identified through a review of relevant literature and by looking at existing solutions and research. During the evaluations, each pattern has been identified as addressing the occurrence of a relevant problem within the domain. Additionally, aside from the problems we identified through reviewing existing literature, not other problems where identified during these evaluations.

We find it worthwhile to mention that there are additional problems relation to the actual implementation of the functionality described in the patterns. However, the set of patterns are written on an abstraction level that targets the human-computer interaction part of sharing information between co-located users. Additionally, this thesis does not claim that the set of patterns is complete, rather the aim was to identify a set of patterns that would *aid* in the support of information sharing among co-located users in collaborative system.

Based on the review of literature and the evaluations conducted on the patterns, we argue that the set of patterns address the set of problem that are relevant for the level of abstraction the patterns target. However, this claim can only be fully answered by obtaining feedback on how the patterns are used in practice.

7.4 Further Work

The aim of this thesis has been to create a set of patterns that act as guidelines for the design and development of co-located interactions in collaborative systems. As stated in the previous section, there are some limitations in the evaluation of the patters.

Therefore, to further improve the patterns, more evaluations have to be conducted. Further work may include performing an evaluation where a set of system designers and developers utilize the patterns when solving a fictional task in a test environment, and discussing the usefulness of the patterns afterwards through a series of interviews or similar evaluation methods. However, one can discuss the reliability of tests created to evaluate *real* use, since there is difficult to create tests that recreate the real conditions these patterns will be used in. An additional approach is therefore to perform these tests under real circumstances, with real tasks. In order to achieve this, one would have to collaborate tightly with a suitable company willing to allow scientists into the workplace.

Another approach is to publish the patterns for public use, and provide possibilities and encourage users to give their feedback on the patterns when using them.

Patterns can then be evaluated in real settings and improved based in this feedback.

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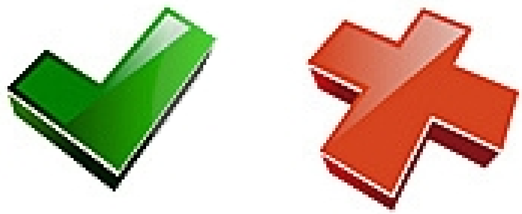
A Appendix

A.1 Sharing Request



Intent

Allow users to accept or deny an incoming information object that another user want to share with him.

Context

Two or more users are co-located and equipped with hand-held or stationary devices that enable them to share information with each other.

Problem

In collaboration systems where users frequently share information with each other, there can often be cases where unintended use or abuse of the system occurs.

Scenario

Michelle and Sandra have decided to meet several of their friends at a café in Trondheim. On the way there, they find an interesting historical building, and Michelle uses the city-CL system to retrieve some information about it using a mobile device. When they meet the rest of their friends at the café, she wants to share this information with all of them. She therefore configures her hand-held device to share the information to everyone in the vicinity, also people in the café she does not know.

Symptoms

You should consider using this pattern when:

- Users are loosely connected to each other
- Users frequently share information to several recipients at the same time
- Unintended use or abuse of sharing functionality occurs
- Users often roam between public and private locations with different users and settings

Solution

Configure the collaborative system to always prompt the receiver(s) with a request when a user want to share information. Allow users to have control over what they receive by letting them accept or deny this request.

Dynamics

When users have chosen what information they want to share and who to share it to, the system should be configured to always prompt the receiving users with a request before actually transmitting the information. The user should be presented with a simple notification on his screen, which states that a user is trying to send him something, for instance *Bill is trying to send you meeting-agenda.doc*. The user should then be allowed to accept or deny the request based on the information provided. The system could also allow the user to view a sample or a preview of the information, before deciding to accept or deny.

Rationale

The Sharing Request$_{6.7}$ pattern decreases negative effects of unintended use or abuse of sharing functionality, by putting the user in charge of what he receives. From then on it is the users responsibility to only accept requests from users he know and trust, and deny other requests, especially requests witch contain suspicious files.

Check

When applying the pattern, you should answer these questions:

- How much information should be revealed about the sender?

Danger spots

System designers must carefully consider how much information the receiving user should be allowed to know about the sender before accepting or denying a request. When sharing to other users, the system should never reveal details that can be judged as sensitive about the sender, but at the same time the receiver should be presented with enough information to be able to decide if the incoming data could be malicious, for instance a computer virus or similar threats to a computer system.

Known uses

Windows Live Messenger Windows Live Messenger (formerly named MSN Messenger) is an instant messaging client created by Microsoft. Windows Live Messenger lets users add other users to their buddy list, in order to chat, share, or play games with each other. In figure 24, *User X* wants to share the document *meeting_agenda.pdf* with another user. As you can see, the receiver is provided with three options, *accept*, *decline* or *save as...* *Accept* means that the user accepts the transfer, and the document is stored at a pre-defined location on his local hard drive. If the user *declines*, the document is rejected and not transmitted. *Save as..* lets the user choose the location to store the document.

Figure 24: A sharing request in Windows Live Messenger

Related patterns

Both the Proximity-based Identification$_{6.4}$ and the Physical Identification$_{6.3}$ pattern should in most cases be applied in combination with the Sharing Request$_{6.7}$ pattern. This is the most secure, and also most common approach in systems and applications that allow sharing between users.