IMPROVING AVAILABILITY AWARENESS WITH RELATIONSHIP FILTERING

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Abstract

Awareness servers provide information about a person to help observers determine whether a person is available for contact. A trade -off exists in these systems: more sources of information, and higher fidelity in those sources, can improve people's decisions, but each increase in information reduces privacy. In this thesis, we look at whether the type of relationship between the observer and the person being observed can be used to manage this trade-off. We conducted a survey that asked people what amount of information from different sources that they would disclose to seven different relationship types. We found that in more than half of the cases, people would give different amounts of information to different relationships. We then constructed a prototype system and conducted a Wizard of Oz experiment where we took the system into the real world and observed individuals using it. Our results suggest that awareness servers can be improved by allowing finer-grained control than what is currently available.

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This thesis is dedicated to Liam. Someday, you will do great work.

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Chapter 1 - Introduction

Informal contact is an important part of everyday human interaction. However, informal interactions are difficult in distributed organizations where people cannot interact face-to-face. In a distributed setting, there is little of the information that people normally use to facilitate informal interaction. Researchers have pointed out that there seems to be a lack of ‘naturalness’ even in rich environments such as video conferencing. One key element that seems to be missing is awareness:

> One could argue that insofar as supporting human-human interaction that telephones and videoconferencing do a reasonably good job. One can hold fairly rich conversations; see each other, judge moods, etc. So why is there still such a sense of distance between people, despite such technology? Our belief is that this is due to the fact that such technologies do not share some of the key affordances that occur naturally when people work in close physical proximity. Regardless of the fidelity of the videophone, I still have no sense of who is in when. I can't "bump into" people in the hall, know who is available and who is busy, or take advantage of synergistic opportunities when just the right combination of people happen to be at the water cooler at a particular time. Yet, in shared physical space, all of these are commonly available almost effortlessly in the background, due to our ‘peripheral awareness.’ (Buxton, 2001)

One way that awareness assists people is by helping them understand when others are available for contact. People use a variety of contextual information to help them determine another person’s willingness to engage in an interaction. For example, seeing an open door can suggest that an individual is able to answer a question or start a conversation whereas seeing that someone is on the phone usually suggests that they are not available for contact. In a collocated environment, it is easy for people to gather this information, but in a distributed setting, most of this contextual information is simply not there, making it difficult to maintain awareness of availability.

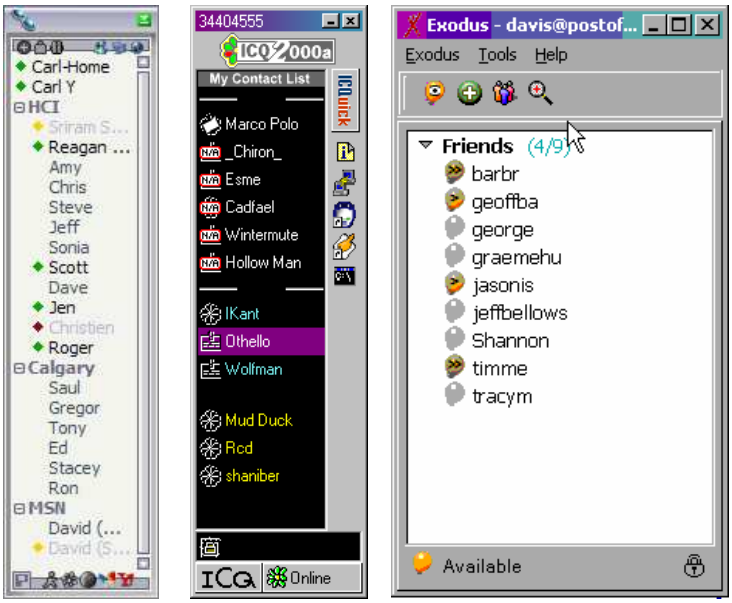

Figure 1.1 Instant-messaging systems with availability icons based on computer idle time (icons are shown to the left of each person's name). Status of the individual is represented by a singular icon to the left of their name. The first is Trillian (http://www.ceruleanstudios.com/learn/), the second is ICQ (www.icq.com), the third is Exodus (www.blarg.net/ExodusSetup).

Several computer systems attempt to address this problem by providing availability information over distance. Some systems provide information about computer use such as idle time or screen-saver status (see Figure 1.1); others provide much more detailed information using regular snapshots or through live audio and video (e.g. Borning & Travers, 1991). However, current systems have problems – difficulties that stem from a trade-off between awareness and privacy. On the one hand, systems like those pictured in Figure 1.1 do not provide much information, and it is difficult to accurately determine a person's true availability; on the other hand, many people find the more detailed audio-video systems to be intolerably intrusive, and refuse to use them because of concerns about privacy.

In attempting to negotiate this trade-off and improve the design of computer systems that support availability awareness, there are a number of problems that have not yet been solved. First, although it is plain that adding more contextual information will improve people's ability to judge whether or not someone is available, it is unclear what types of contextual data are most effective at conveying availability. Second, any addition of information reduces privacy, and it is not clear how that information should be

processed or restricted to protect an individual's privacy. This thesis is concerned with determining what those elements are, and how to use them to design better availability servers without compromising privacy.

1.1 Research Problem

The problem addressed in this thesis is: it is difficult to achieve both accuracy and privacy in distributed availability systems, since improving accuracy through additional information compromises privacy.

Availability awareness is the understanding of another individual's availability for some form of interaction. An accurate representation of a person's availability allows others to correctly determine whether or not they should initiate interaction. When a person's availability representation is inaccurate, others will incorrectly interpret their availability, and will act inappropriately. This may result in unwanted interruptions if the availability representation shows that the person is more available than they really are. Conversely, the wrong availability representation results in missed interactions if the availability representation shows that the person is less available than they really are.

Privacy is a person's ability to protect personal information, remain secluded from others, and prevent intrusions into what they consider to be their personal space. For an availability system to be accepted by users, they must feel that the system does not compromise their privacy. Attitudes towards privacy vary widely for different people, situations, and cultures, but it is not clear what factors change people's attitudes. Current availability awareness systems fail to successfully negotiate the trade-off between awareness and privacy; as a result, the systems are either not very accurate, or too intrusive. Those systems that are widely used offer only simple representations without the richness required to accurately determine a person's availability. Adding more information into an awareness system could provide more accurate availability

representations. However, this creates a new problem in that more information is not acceptable under all circumstances due to privacy issues.

One possible way to improve awareness servers is to make them more flexible – to provide explicit recognition of the fact that people have different privacy tolerances in different situations. Although this does not avoid the trade-off between awareness and privacy, it does allow a person to make use of several different points along the continuum. In this research, we explore the mechanism of filtering availability information based on the relationship between the person producing the information and the person consuming it.

1.2 Availability Servers

An availability server is a tool with which people can maintain availability awareness of friends and colleagues. Availability servers distribute information about each user, and others use this information to evaluate the user's willingness to partake in social or work interaction with others. The server can facilitate natural interactions between distributed users, and can help people cooperate more effectively by making it easier to determine when to initiate collaboration, ask for help, or engage in social conversations. Millions of people use commercial Instant Messaging (IM) systems that include simple availability servers (e.g., approximately 160 million people currently use ICQ) to communicate and to keep track of each other.

Current availability servers generate an awareness representation based on very little information about the user. This drawback leads to two usability problems: first, that a few sources of environmental information are over-valued, and second, that users must often explicitly manage their own availability representation.

The main source of information in current systems is computer idle time. Unfortunately, this measure says little about a person's availability for contact or

interruption; it is really only indicative of presence, and basing judgments about availability on this representation can often lead to problems (Tang & Begole, 2003). To combat the problem of lack of information sources, users can often explicitly set their own availability state in awareness servers. Although this can in some cases be an accurate reflection of true availability, it requires considerable effort on the part of the user, and it is common that people forget to update their representation when their availability changes. In addition, most servers have only a small set of states that represent only a few levels of availability. Users may be forced into selecting a representation that is only close to what they would like to convey to others.

Current availability representations fail to account for many of the details of human interaction, such as the information of what the relationships between individuals are. In typical social interactions, different individuals have different rights to interrupt others. For example, a supervisor may have more freedom to interrupt a subordinate than a peer would have. Current availability servers represent an individual's availability with a single and limited representation to a broad group with diverse social access rights, ignoring information about the user's relationships.

1.3 Solution

The problem of designing for both accurate representation and privacy protection can be addressed by making availability servers more aware of the context in which judgements about availability are made. Since both the requirements for information and the tolerance for intrusion vary across people and situations, availability servers can use information about context to tune the type, amount, and presentation of information about a person and their current activities. This does not avoid the trade-off entirely, but can greatly increase the number of situations where an availability server will successfully provide appropriate information to observers without compromising the provider's privacy. This thesis considers the idea of relationship type as a way to manage information flow in an availability server.

1.4 Steps in the Solution

Two main activities have been carried out in this solution. First, to collect knowledge about what information sources best represent availability in different situations, and about the factors that can alter information requirements and privacy attitudes, we have built a conceptual framework of availability awareness. This framework sets out what information sources can be used to determine availability, and how that information is affected by other factors such as relationship. Second, to determine how context awareness changes the design and performance of availability servers, we developed a prototype awareness server that adjusts information and representation based on the relationship between users and those observing them.

A more detailed set of steps is given below. The framework is comprised of the first three steps, and the exploration of relationship-based filtering is described in the final two steps.

1.4.1 Investigate information sources and the contextual factors affecting them

To understand more about awareness, it is necessary to determine what information individuals need to determine another person's availability, and what factors change the ways that information is used and interpreted. We gathered information on these sources of availability awareness in three ways: by asking people how they determined whether another person was available in everyday (non-computer) situations, by talking to users of common availability servers about their experiences, and by reviewing literature about the collection of and use of awareness information. From this data, we determined a set of information sources that are appropriate for supporting availability awareness.

We also determined that contextual factors including relationship, time, location, and activity can modify the importance and use of these information sources, and can

change people's willingness to provide the information. Relationship was chosen as an important factor to study more closely in the remainder of the research.

1.4.2 Determine how relationship affects information requirements and privacy preferences

The goal of this step was to better understand what information people wanted to use about others when determining availability, and what information people were willing to give out to others. To explore this issue, we conducted a questionnaire study that asked people to rate their interest in using different types and granularities of each of the identified information sources, and also their willingness to give that information out to others. People were asked to give responses for each of several different types of canonical relationships that are seen in work situations: Supervisor, Peer, Subordinate, Secretary, Friend, Spouse, and Anyone in the organization. This study provided an understanding of how much information people wanted to use and were willing to provide, organized by relationship.

1.4.3 Develop display principles

Once it is known what information people need, it is necessary to determine how to represent that information to observers in a useful way. The goal of this step was to devise principles that would translate the knowledge from the steps above into useful information for designing availability servers. Availability information needs to be categorized into a meaningful representation without overloading the viewer. This step involved investigating different representational approaches and determining a set of basic guidelines that allow availability information to be conveyed but still protect privacy.

1.4.4 Build a prototype availability server

The knowledge in the steps above was used to design and build a prototype availability system. The client was a small web-based application for use within a small to medium sized workgroup. The prototype was the subject of the evaluation described below.

1.5 Evaluation

Two types of evaluation were carried out in the research. The first evaluation assessed the idea of relationship as a way to filter availability information – the question of whether people do in fact change their privacy preferences based on their relationship to the other person. This evaluation was carried out using the questionnaire study described in Chapter 3.

The second evaluation assessed the usefulness of relationship as a design principle in a realistic availability server, and tested a prototype system in a real-world setting. The evaluation determined usability problems and strengths in the principles underlying the prototype, and considered to a limited extent whether people can maintain availability awareness more accurately and with less effort with the relationship-based prototype than they can when using conventional means. The second evaluation consisted of a "Wizard of Oz" experiment where a human gathers information for the computer system. We followed a participant at a local company for one week, gathering the information that was represented in the availability prototype. Four other people in the organization ran the client system and were asked to determine the availability of the observed individual at regular intervals. At the end of the study, people were interviewed about their experiences, and basic data about accuracy was compiled.

1.6 Contributions

The main contribution of this thesis is the idea that relationship can be used to mediate awareness and privacy in an availability server. Although further work is needed to better understand the generality of the idea, evidence suggests that relationship-based filtering should be considered as a design factor in future awareness systems. For many uses, it can be used to reduce privacy concerns over the disclosure of useful availability information.

There are also two secondary contributions from this work. First is the framework of availability awareness information. The framework provides a more complete understanding of what information can be used in supporting availability awareness, how one contextual factor in particular (relationship) affects people's information requirements and preferences, and how availability servers can be designed to take advantage of relationship. Second is the awareness server prototype, which provides an example and a reference implementation of how the relationship-based filtering can be put into practice.

1.7 Thesis Outline

The remainder of this thesis is organized as follows:

- Chapter two outlines background material and describes the background concepts needed to complete the research, including awareness, casual awareness, availability awareness, privacy, and distributed systems. This material is from past research in availability systems, computer-supported cooperative work, and psychology.
- Chapter three describes the investigation into how individuals in the real world gather awareness information and how they use it, specifically using a questionnaire study conducted to determine how people gather and use awareness information. This information is used to generate a framework used to design a prototype.
- Chapter four presents the design and implementation of a simple prototype availability awareness client and server used to study a real world situation. It

describes the prototype and discusses design decisions and the specific information to be shared.

- Chapter five discusses the second evaluation, of the prototype in a real-world setting. This chapter describes the study, the observational and quantitative results, and discusses some of the issues that were raised by the evaluation. The chapter also discusses the usability issues raised through the use of the prototype.
- Chapter six is a summary of the research included in this thesis, and the contributions to the research community. This chapter also discusses directions for future work.

Chapter 2. Background

This chapter introduces background concepts about awareness, casual awareness, availability awareness, privacy, context aware computing, and distributed systems, and reviews related previous research in those areas.

2.1 Awareness and Group Awareness

Awareness is knowledge of a dynamic environment, knowledge that must be maintained and kept up to date (Endsley, 1988). In the context of this thesis, we are mostly interested in *group awareness*, which involves information about the people in the groups that we interact with. Group awareness is "an understanding of the activities of others, which provides a context for your own activities" (Dourish & Bly, 1992).

Awareness information comes from the answers to the "W" questions: Who is around? What are they doing? Where are they working? When did things happen? Why have the actions happened? A system that supports group awareness needs to capture awareness information about others' interaction with each other and the shared workspace, and effectively present that information to answer these "W" questions. Gutwin et al suggests a framework of workspace awareness to address these issues (Gutwin, Greenberg, & Roseman, 1996). It presents a set of basic ideas that are central for designing awareness support, and that allow different techniques to be identified, described, and compared. The framework considers both the elements that make up people's workspace awareness, and the mechanisms they use to gather awareness information. These elements and relevant questions are:

Presence: Who is participating in the activity?

Location: Where are they working?

Activity Level: How active are they in the workspace?

Actions: What are they doing? What are their current activities and tasks?

Intentions: What will they do next? Where will they be?

Changes: What changes are they making, and where?

Objects: What objects are they using?

Extents: What can they see? How far can they reach?

Abilities: What can they do?

Sphere of Influence: Where can they make changes?

Expectations: What do they need me to do next?

Awareness information comes from people, the objects that they are working on, and the environment they inhabit. Awareness information must be maintained, and researchers have proposed a natural perceptual cycle that people use to gather information about the world around them (Hayes, 1993; Neisser & Jopling, 1997). Neisser and Jopling (1997) suggests that perception is a cyclic activity where a person's picture of the world around them directs how the environment is perceived and explored. This in turn leads to gathering new information about the environment, which in turn influences the picture of the world. In the case of awareness information, users sample their environment, gathering information, which modifies their awareness of others, which directs their attention to particular individuals and actions (Figure 2.1). The cycle starts again as users gather more information about events that they are interested in.

The three sources of awareness information (people, objects and their environment) correspond to three perceptual mechanisms; *consequential communication, feedthrough, and trace observation*. Consequential communication is the data that comes to us by observing actions or via the interaction someone has with their environment (Gutwin & Greenberg, 1996). Feedthrough is the evidence that a person's actions leaves on their environment and the objects in that environment. For example, if an object moves, it implies a mover (Gutwin & Greenberg 1999). The object that is manipulated gives feedback to the user, and others can observe this feedback. A longer-term version of feedthrough is *trace information*, where the user has left longer-lived indications of the effect that they have had on the environment (Hill et al, 1992; Ishii, 1998). For example,

if footprints can be observed in a dusty hallway, it implies that someone recently walked through.

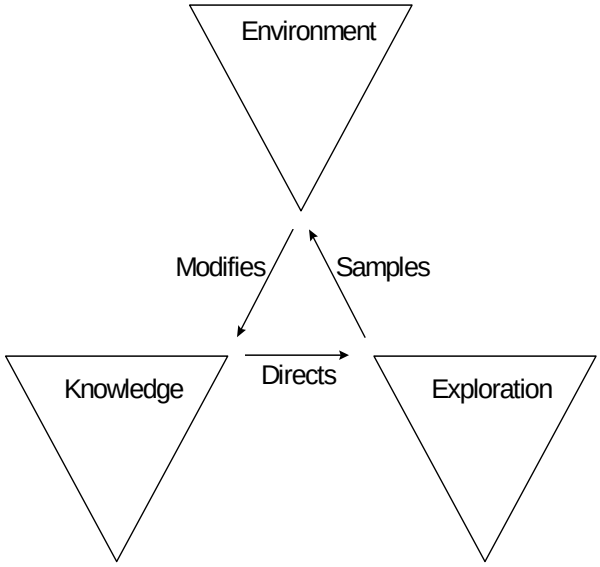

Figure 2.1 Neisser and Jopling's (1997) cycle of cognition

Individuals use awareness information to aid the coordination of tasks and resources and assist transitions between individual and shared activities. People can use their knowledge to predict others' actions, support them with their tasks, and infer shared references to objects. The benefits of workspace awareness are small in any one situation, but over the course of a collaborative interaction, they can markedly improve a group's effectiveness (Gutwin, Greenberg, & Roseman, 1996)

Group awareness comes naturally in a face-to-face situation, but it is difficult to maintain in non-collocated settings. In distributed groupware systems, people may only receive a fraction of the possible awareness information available to them. To counteract the natural lack of information, researchers have looked at adding awareness information back into groupware systems.

Figure 2.2 The Portholes client showing images of peoples' workspaces.

Researchers have supported awareness in many ways and for different purposes. Portholes provided images of peoples' workspaces (Figure 2.2) (Dourish & Bly, 1992). For example, DIVA supports perceptual awareness using a virtual office environment for individuals to see the current tasks of other group members (Sohlenkamp & Chwelos, 1994). Clearboard supported gaze awareness via the ability of users to determine the gaze location of the group member (Ishii et al, 1992). ArgoHalls supported location awareness by allowing users in a group to have a general sense of who was around for interaction (Gajewska et al, 1995). The Notification Collage supports activity awareness by allowing people to leave information for others (Greenberg & Rounding, 2001). Contact awareness is supported in the 'live addressbook' project (Milewski & Smith, 2000) where users add information to an address book allowing users to manually provide a local phone number as they are on the go.

2.1.1 Casual Awareness

Casual awareness is a person's understanding of who is nearby, and the general activities they are engaged in (Ackerman, 2000). This is the overall sense of "what's

going on" within members of a group that gather for meetings, check their mail, meet at the coffee maker, and so on. Casual awareness is the peripheral information about others that we gather as a normal part of our day. Casual awareness keeps us informed about the whereabouts and activities of our neighbours, and allows people to take advantage of opportunities for collaboration (Gaver et al., 1992; Boyle, 2001). For distributed groups, computer supported cooperative work (CSCW) researchers have attempted to restore informal awareness with awareness servers that gather, distribute, and display information about the members of a group.

Casual awareness, like other awareness information, is gathered using traces, feedthrough, and consequential communication. The difference between this form of awareness and other kinds of group awareness is that the information-gathering process is continuous, low-level, and often subconscious (Dourish & Bly, 1992). Typically, this informal communication is made possible by physical proximity (Fish et al, 1992). For example, overhearing conversations or glimpsing someone through an opened doorway can facilitate casual awareness. Often, the awareness information is not intended for the observer, and the perceiver merely picks up what is available (Gutwin & Greenberg, 2004).

Casual awareness allows people to initiate informal opportunistic collaborations. For example, valuable work often results from being able to talk to the right person at the right time and it is casual awareness that allows us to know who is around and if they are available for casual interaction. In these informal interactions, the purpose, duration, and degree of involvement of the interaction is not planned in advance (in contrast to a scheduled meeting), but is informally agreed on during the course of the interaction. Thus support for casual awareness is required for any form of informal interaction, since awareness is a prerequisite for this type of contact (Borning & Travers, 1991).

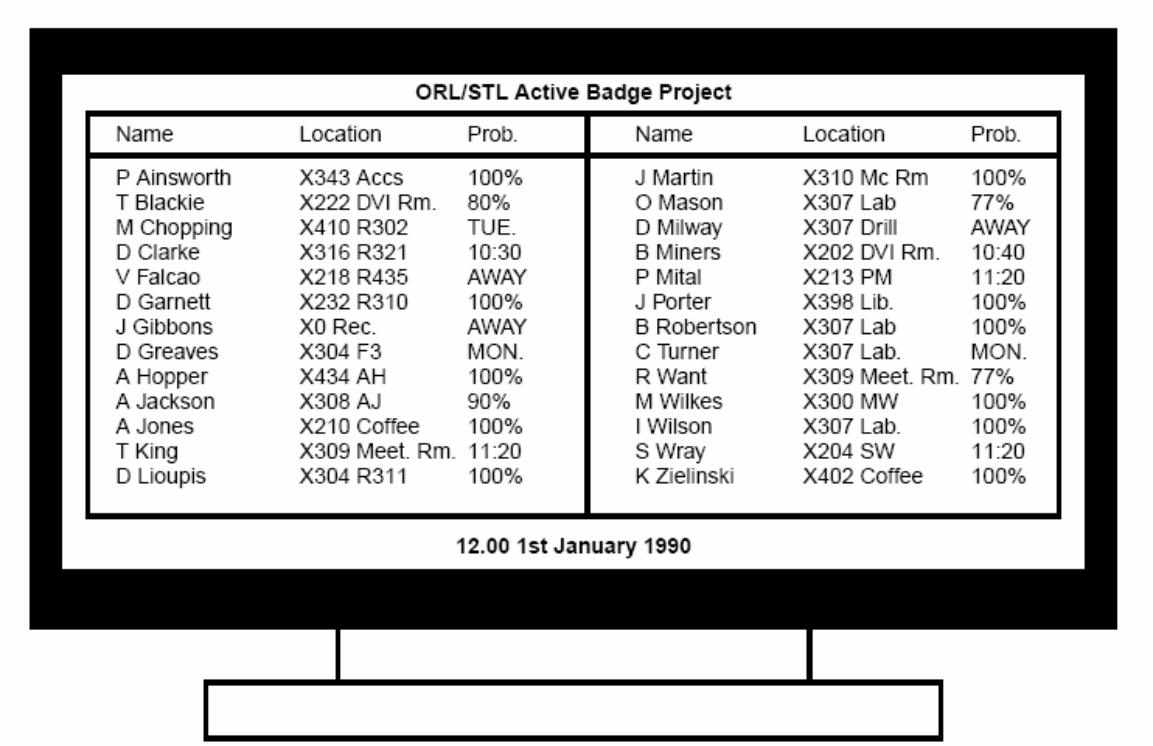

Figure 2.3 The Active Badge client showing peoples' locations and probability that they are still there.

In past research, different means have been explored for gathering useful information about others. Some researchers have developed systems that used video to observe other members of the group, such as Cruiser (Fish et al, 1992), Notification Montage (Greenberg & Rounding, 2001), PortHoles (Dourish & Bly, 1992), and CaveCat (Mantei et al, 1991). Location was used be Active Badge (Figure 2.3) (Want et al, 1992). OfficeWalker (Figure 2.4) used a virtual hallway model (Obata & Sasaki, 1998). Other research has used audio (Active Hydra (Greenberg & Kuzuoka, 2000)), , or personal information (Notification Collage (Greenberg & Rounding, 2001)) for maintaining casual awareness of others.

Figure 2.4 The OfficeWalker client showing people in the virtual hallway.

2.1.2 Availability Awareness

One particular element of casual awareness is availability. Availability refers to the level of social activity that a user is capable of based on their current situation (Jang et al, 2000). *Availability awareness* is information and understanding about the current disposition of other users for interaction (Hinds & Weisband, 2003). Availability awareness includes knowledge about the current activity, the emotional state, and the attention of the user (Gross, 2000). Availability awareness uses a background of common knowledge and shared understanding of current and past activity (Bellotti & Bly, 1996).

There are multiple sources for gathering availability awareness information. Usually, this will be some form of information that tells an observer about the environment, locale, or the activity of the person they are observing. There are a number of sources of information that could be used to determine the availability of others. This would include door state, phone state, calendar, activity, as well as visual and auditory information. There could also be a stated willingness to interact with others, a person's location, or some form of representation (an in/out board or a public calendar). This information can be broken down into formal information sources (e.g. an office phone number or a meeting calendar) as well as informal information sources (e.g. web page, web camera) (Girgensohn et al, 1996).

Parts of availability awareness have been supported in work that considers causal interaction between pairs of distant collaborators, usually through media spaces or other information displayed on a personal computer screen (Bly et al, 1993). The goal is usually that members of a distributed community can detect when others are on-line, and use that awareness to move into interaction with each other. Recent additions to the typical home personal computer have made the sharing of audio and video information across networks quite simple even for relatively slow networks. This has made it possible to envision the widespread use of such technologies to support distributed work groups. While rich connections in these technologies allow distributed work groups to function well, they are still typically not nearly as natural as working in a co-located environment (Isaacs & Tang, 1993). Outside of the research community, this has manifested itself in the use of popular on-line instant messaging programs that use some form of availability representation for others to know if the user is available for interaction (Greenberg & Rounding, 2001). Two main distinctions in the systems that have been built to support availability awareness include the types of information presented, and the way that the information is gathered.

Types of information. Past research and current software have used different information sources to provide availability awareness information. These include:

- the location of the individual, shown either visually as in the Active Badge system (Want et al, 1992) or through sound, as in the Audio Aura system (Mynatt et al., 1998).
- temporal information such as calendar entries (Tang & Rua, 1994), or in the CLUES system (Marx & Schmandt, 1996).
- full-motion video images, as used in the CaveCat system (Mantei et al., 1991), or quick glances, as used in RAVE (Gaver et al., 1992) or Montage (Tang & Rua, 1994);
- representations of the observed individual's activity within an office, such as where they are looking (Greenberg & Kuzoka, 2000);
- on-line status and idle time, as seen in PeepHoles (Greenberg, 1996) or in several instant messenger systems;
- specific information that the user chooses to share, such as a message of the day as in PortHoles (Dourish & Bly, 1992) or selected images and other data as in the Notification Collage (Figure 2.5) (Greenberg & Rounding, 2001); in addition, some systems such as ICQ allow the user to set their state explicitly.

The fidelity of the representation is also an issue. Video provides high-fidelity representations of people; abstract representations, either physical as used in the Active Hydra system (Figure 2.6) (Greenberg & Kuzoka, 2000), or iconic as used in PeepHoles (Figure 2.7) (Greenberg, 1996) provide a level of privacy for the observed individual, but require the observer to interpret the information that they received indirectly. This interpretation requires either some foreknowledge on the part of the observer, or some lucky guesswork, to get an accurate view of the observed individual's availability. Using individual indicators for different information sources (such as the state of the door, or the idle state of the computer) by themselves is useful but is not enough on their own to provide an accurate view of someone's availability. For example, Hubbub is an instant messenger that runs on a wireless Palm and a PC, using "sound instant messages," referred to as earcons that have meaning, such "Hi" or "Thanks." Users have individual sound IDs that identify their sound messages and their availability (Issacs, Walendowski, & Ranganathan, 2001).

Figure 2.5 Notification collage, availability software showing many kinds of information about its users.

Gathering mechanism. Systems that support availability awareness can be organized as to how they obtain the availability information that they present to others. This is can be divided into three types: raw information, self-selected, or machine-interpreted. Raw information is the presentation of information as collected at the source, such as video or audio information, idle time, or login status. Self-selected is the case where the user determines their availability directly. This is seen in terms of the state of the user in ICQ. However, there are a limited number of states, and most of these kinds of systems provide only one state for all users observing the individual. This fails to account for variation based on personal relationship or circumstances. Automatic is the case where the system determines availability based on an internal algorithm or preset condition. Without allowing for user intervention to change status (beyond on/off), this system expects that the availability information it is presenting is flawlessly representing the user. In the case of automatic selection based on computer use, such as idle time, this

could be thrown off by either a clever programmer writing a program that always "cheats" the idle time.

Figure 2.6 The Active Hydra system.

The idea of automatically determining availability has been explored in more detail by a few researchers. Hudson et al (2003) explored if sensor-based predictions of availability might be constructed, and which sensors might be most useful to such predictions, and how simple such sensors might be. This research sought to answer five questions:

1. Can a practical sensor-driven model reliably predict human availability?
2. How can such a model be constructed?
3. How accurate can we make such a model?
4. Which sensors are most useful for such a model?
5. What are the simplest sensors that will produce an accurate prediction?

Recordings were taken of individuals in real world environments, and participants were given an audio prompt to provide a self-report of interruptiblity at random intervals, averaging two prompts per hour. In order to minimize the disturbance caused by the prompts, the designers chose to ask only one question, and used a five point. Specifically, subjects were asked to "rate your current interruptibility on a scale from one to five, with one being most interruptible." After the study, the video of the participant's office was hand-coded to simulate the output of a variety of sensors: occupant information (speaking, writing, sitting, standing, or on the phone), interaction with objects (desk or primary work surface, other work surface, file cabinet, food, drink, keyboard, mouse, monitor, and papers) guest related information *(*number of guests present, and whether they are sitting, standing, talking to the occupant) and environment (door open or closed, day of the week, and time of day).

This study suggested that sensor driven models of human interruptibility could indeed be fashioned. A decision-tree model built from the observed data was able to accurately determine the interruptibility of an individual with 75% accuracy. However, these results were based on a 'personal assistant' job, where interaction with other people was the major component in whether the person was available (e.g. if they were talking to someone, then they were not available). For other job types such as programmer, the sensor-driven models may be less effective.

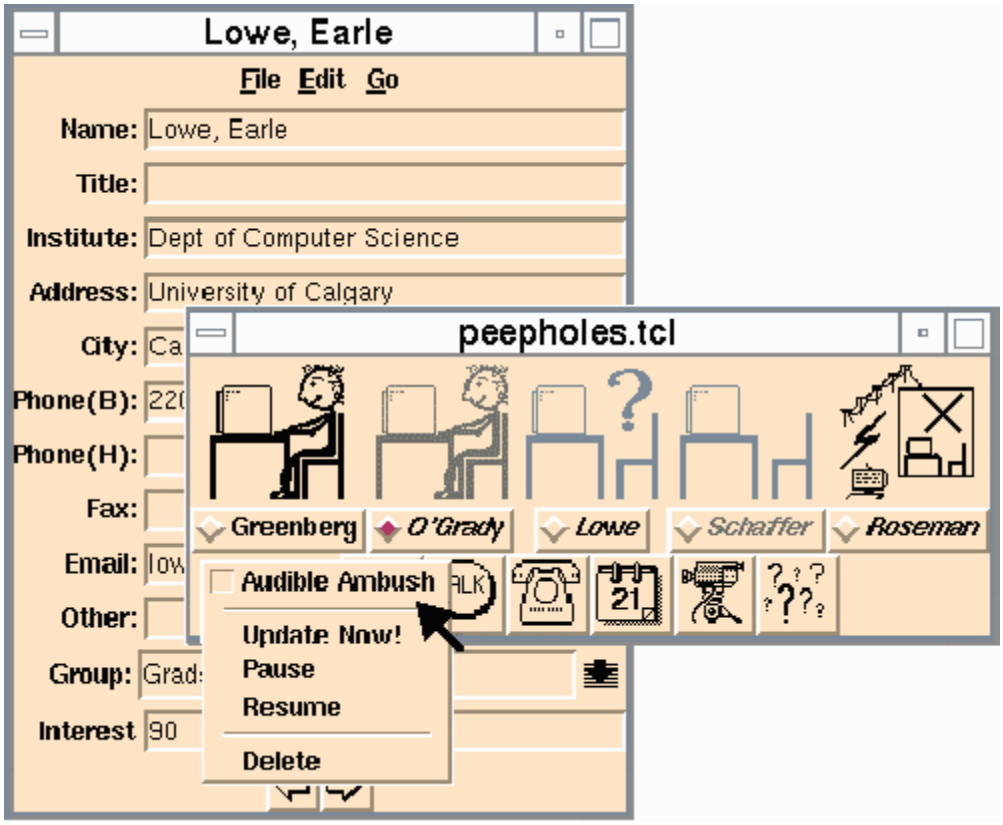

Figure 2.7 Peepholes, an example of an early availability server.

2.1.3 Availability and Interruption

It is assumed that a better understanding of another's availability will reduce interruption. The body of research concerning interruption can be split into various groups. One group contends that machines cannot properly manage interruptions (and likewise awareness perception) but must defer to users in an accessible and useful fashion (Bellotti & Edwards, 2001). Others posit that machine-learning techniques could appropriately present the information needed in a predictive fashion (Horvitz et al,, 1998; Hudson et al., 2003). Other human computer interaction (HCI) research has focused on developing guidelines for directing interruption.

A result of previous research was the discovery that people who were interrupted often benefited directly from the interrupt, with the initiator providing that benefit

(O'Conaill & Frolich, 1995). Therefore, getting rid of all interruptions is neither desirable nor explicitly beneficial; however, greater degrees of control or filtering for interruptions (by some form of intermediary, human or otherwise) are often seen as useful (Hudson et al., 2003). The real challenge is making interruptions more effective, as they may be a valuable part of teams getting work done (Hudson et al., 2002).

The type and amount of information is important to judgments of a person's availability for contact. For example, Hudson et al (Hudson and Smith, 1996) showed in a study of a professional assistant that audio was the most important information source: if the assistant was talking with someone else, then they were unavailable. However, social interaction is clearly not the only activity that reduces availability, and the value of an information source depends on the person being observed and their current work situation. In one study (Dabbish & Kraut, 2004), information about activity on the computer screen was needed to determine availability. This study also showed that the granularity and amount of information was important. The researchers showed that when observers had to interrupt a person playing an interactive game, people who had detailed information about the state of the game were more likely to wait before interrupting, and interrupted less frequently than those who had no information (Dabbish and Kraut, 2004). A similar phenomenon was seen by Begole et al (2004). They observe that many of the indicators in current awareness servers show a person's presence, but without additional information, this is incorrectly equated with availability.

2.2 Privacy

Privacy has been investigated in several contexts in CSCW, and there are several different definitions for the concept. To have privacy, a person must be able to predict how his actions will drive interactions, information access, and behaviour in chosen ways (Boyle and Greenberg, 2003). This prediction is based on the reputation and promises made by the party to which the information is disclosed. For example, privacy has been

defined as the right of an individual to have a level of freedom from interference by others, as the right of individuals to control personal information about themselves and their environment, and as the right to control who sees that information as well as how the information is presented (Weston, 1967). The definition that we use in this research, however, is based on the work of Altman (Altman, 1975), who defines privacy as a boundary control process. This definition has been used by several more recent researchers in CSCW (e.g., Palen & Dourish, 2003; Boyle & Greenberg, 2001), and it presents structures that are particularly relevant to availability awareness. In Altman's control processes, people manage the flow of information towards and away from the self, leading to two aspects of privacy: confidentiality and solitude. *Confidentiality* is control over information moving outward from the self, and affects other people's access to personal information. One aspect of confidentiality that is particularly relevant to our work is control over information fidelity – the accuracy and specificity of outgoing information. *Solitude* is control over information moving towards the self (such as requests for interaction), and determines how much of one's attention is taken by that information. Gavison (1984) adds a third privacy element called *autonomy*, the users' control over their identity, and over how they are represented to others in the world. Being aware of the environment that one is in and how that environment changes based on one's actions (and how one is perceived by those changes) determines one's autonomy.

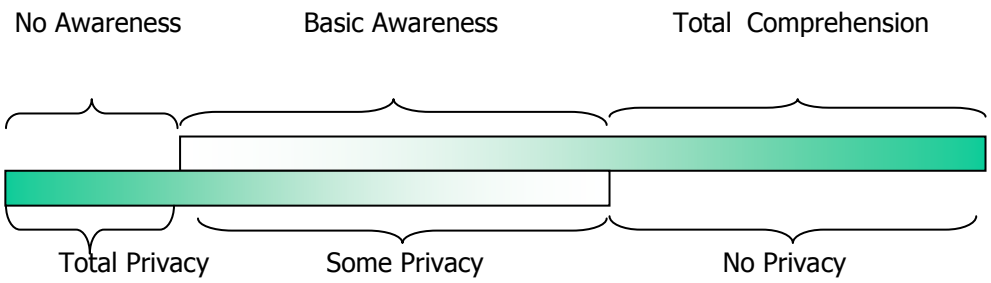

Figure 2.8 The awareness/privacy spectrum.

The common ways of managing privacy depend on the nature of the environment surrounding us and the means that present them to provide us with a sense of privacy.

This includes the effect of introducing distance between ourselves and others or closing doors to create private spaces. We also have a reasonable expectation of others in our space to act according to behavioral norms regarding touch, eye contact, personal distance, and other standards (Altman 1975). HCI research has begun to look into the privacy concerns within spaces where information technology has become pervasive (Palen & Dourish 2003). For ubiquitous computing, Bellotti and Sellen (1993) determined that users experienced problems in a digital environment that combined computer, audio and video networking with individual tracking and control technologies due to the disjoint of activity and its effects.

Grudin (2001) has suggested that changing attitues to privacy as a result of new technologies might be understood as a "steady erosion of clearly situated action" and that a person's control over how public information is used in different contexts and times is less than what would be expected in collocated situations. Dourish (1993) also researched privacy issues that exist in media spaces and pointed in particular to the "organizational situatedness of appropriate solutions." Clement (1994) investigated privacy concerns raised by these technologies and paid particular attention to the effects that an organization and its standards of behavior would have on forms of activity and control would have on the use of such systems.

Agre (1995, 1997, 1999, and 2001) has written extensively on privacy concerns and new technologies. His focus has been on technical discourse surrounding privacy within the context of information technology. His goal has been to discern individuals' assumptions within the workplace (Agre 1995, Agre 1997). He advocates an approach that casts privacy as an issue not simply involving the needs of the people affected by new technologies, but as an issue that results from the social roles and relationships within organizations (Agre 2001).

There are three ways to address privacy issues in an electronic transaction: through law, self-regulation, or technology (Spiekermann, Grossklags, and Berendt, 2001). In each model, a privacy policy can be used to embody the commitments and guarantees that a vendor makes to protect personal data provided by the consumer. In the current worldwide web, governments, industry, and independent global consortiums have encouraged companies to define their practices for handling and sharing personal information, including reasonable communication of these policies to individuals.

Privacy, and the tradeoff between privacy and awareness, has been widely recognized as important issues for media spaces and groupware systems. In a shared physical space societal protocols exist to deal with issues of privacy. For example, the distinction between a public and a private space is normally immediately clear, and most adults know how to adjust their behavior for each with little effort (Hudson & Smith, 1996). However, in a virtual space, it is often the case that the normal cues of public versus private spaces are absent. Helping people maintain availability awareness requires sharing information that may intrude on the privacy of the individual. There is consequently a trade-off between providing awareness information and preserving privacy (Hudson & Smith, 1996; Boyle & Greenberg,, 2003) (Figure 2.8). Having cameras in the office, one-way connections, or long-term monitoring of public spaces makes surveillance and monitoring a possibility. Clearly there is a need to protect privacy in awareness information systems including availability awareness systems, without losing the benefits of awareness itself. There are three main issues in managing this trade-off: 1. understanding the risks of privacy intrusion, 2. user control, and 3. social convention.

1. Privacy risks. Any information that is required to present the availability of one person to another requires an exchange of privacy for accuracy. Simply stated, there is a fundamental tradeoff involving the information sent or received between individuals. The more information sent by a person the more their co-workers can be aware of them. However, the more information one sends, the greater effect this can have on one's

privacy (Hudson & Smith, 1996). If the information is necessary, then we have to ensure that it is not overly intrusive. Protecting privacy requires that the user is comfortable with what information others can see about them. The user must also feel free from surveillance, where people are collecting the information from the user for purposes other than gathering availability information (Kawai et al., 1996). Finally, the user must feel free from the threat that the information will be misused. If the information were being collected for the purposes of a performance evaluation, then users would be less likely to want to use the system.

2. Types of user control. The user must have the ability to control the outgoing awareness information and stop the flow if necessary (without fear of judgement). Without this control, individuals would be less likely to use an awareness system. In some systems, people physically manipulate data gathering devices such as turning the camera away in Portholes (Dourish & Bly, 1992), while other systems use software to exercise user control, such as software determining that the user has put his hand over the camera in Nanana (Boyle et al, 2000). One way to mediate the amount of information being produced is through reciprocity, in systems such as OfficeWalker (Obata & Sasaki, 1998) or Montage (Tang & Rua, 1994). Reciprocity is an enforced sharing of data between users. If one person A can see person B, then Person A knows that Person B can see them as well. This way, limiting availability information to that which the users are both willing to share protects privacy. The system must also allow the user to have control over the storage of the information. This way, the user can eliminate the concern over long term monitoring for improper purposes. For privacy to work within the context of an awareness server, a person must be able to know that the system will respond to his or her wishes when information is shared (Boyle & Greenberg, 2003).

3. Social conventions. The information channels used need to be rich enough to allow the user to use existing social conventions (or adapt or build new ones) for interactions with respect to privacy (RAVE). In a shared physical space we have a well-established set of social protocols for dealing with issues of privacy (Hudson & Smith,

1996). Therefore, any system that we would develop to support casual awareness would need to support these social protocols. For example, most people realize that reading someone's mail over their shoulder without permission is improper, therefore a screen shot of someone's desktop with their personal email open would effectively duplicate the effect. It is important to remember that privacy is not only a social phenomenon; it is also a co-operative one. A person will sometimes do things that help others respect his own privacy, such as disclosing more information to enable others to make better decisions about interruption (Boyle & Greenberg, 2003). While privacy violations occur regularly, gross privacy violations seem to not occur as often as the environment permits. This is mostly due to our understanding of societal norms that define a measure of freedom and the ability to work with others' needs for privacy, which then ensure future opportunity to interact.

Within the context of this research, it is vital to have the user be assured that the data that they are sharing with others remains confidential to that set of users who have access to it, that they do not lose personal autonomy due to the sharing of that data, and that they maintain control over their interpersonal interactions regardless of the interpretations others have regarding their availability information. In distributed awareness systems, control over information is reduced. It has been suggested that because awareness and privacy cannot both be satisfied using existing mechanisms, better control over information is required. However, they also recognize that user effort is a crucial factor in the success of the control process:

> There are few fine-grained yet lightweight strategies for controlling video media spaces… Heavyweight and coarse-grained privacy control interfaces prompt an "all or nothing" trade-off [and] as a result, people often do not make changes when appropriate, and often end up configuring the system to grant all others either full access at any time, or no access whatsoever (Boyle, 2001a).

Traditionally, we understand privacy as a state of social withdrawal, Altman instead sees it as a dialectic and dynamic boundary regulation process (Altman 1975). We

perceive privacy regulation as a mix of socieital expectations and experiences, and by the expectations of others with whom we interact. Being a dynamic process, privacy is under continuous negotiation and management, with the boundary that distinguishes privacy and publicity refined according to circumstance. Privacy management is a process of give and take between and among technical and social entities—from individuals to groups to institutions—in ever-present and natural tension with the simultaneous need for publicity. We are concerned with how this process is conducted in the presence of information technology (Palen & Dourish, 2003).

2.3 Networking architectures for availability servers

Availability servers are distributed groupware systems that gather and distribute awareness information to a group of people. For such a system to work users must be able to access and update shared data, and be aware of changes to the data; the first issue concerns shared data repositories, while the latter concerns notification mechanisms (Ramduny, Dix, & Rodden, 1998).

Any awareness information system will require that the individual programs (referred to as clients) have some form of information sharing via underlying network architecture. Common architectures used for information sharing are peer-to-peer networking or client server computing. Peer-to-peer architectures are independent agents capable of performing useful work without a central authority, and client server (specifically event-based notification) architectures which are loosely coupled, highly dynamic systems that listen for notifications and then take action (Taylor, Hoek & Dashofy, 2001). Obviously, a hybrid system of these is also possible (Baehni, Eugster, & Guerraoui, 2002). The client-server model allows for central control, generally has a lower use of bandwidth, and allows for quicker data collection, but is vulnerable to shutdown. Peer-to-peer is more robust against node failure, conceivably has better protection for privacy, as data is not located centrally, but lacks an overall control point. Peer-to-peer connections may create heavy use of bandwidth when multiple client programs try to talk to each other.

Awareness information systems have used both of these technologies. Rendezvous (Patterson, 1991) uses multiple lightweight processes transferring data between machines independently. Coordinated efforts are scheduled according to their priority. Again, by keeping the processes lightweight, the need for a great deal of centralized processing power is removed. The Notification Collage (Greenberg & Rounding, 2001) uses a shared dictionary server that maintains a string-based key/value pair, a client-side library that handles all communication with the server, and a simple interface for programming clients. This allows the individual computer to only gather the data, while the centralized point interprets it for other computers or users.

Interoperation is another means of sharing awareness information (Kantor & Redmiles, 2001). Interoperation allows separate tools to share information allowing users of these tools to route awareness information to different types of awareness tools that might better suit their work styles. In interoperation, software components send out events that other software components have subscribed to, thus being able to react quickly to the arrival of the event. That way, components only handle information that they are specifically looking for and information that other components explicitly share. This methodology supports a "polling" approach to notifications by which clients can request the events that occurred over the last time period which is useful when the goal is to support human awareness. Users need to be able to select from various awareness sources so that they can use awareness information in a manner that best suits their needs. Awareness tools should support an awareness style appropriate to an individual's work practices (Kantor & Redmiles, 2001).

2.4 Social and organizational characteristics

The design and use of an application meant to share awareness information may be influenced by social and organizational characteristics in the groups it is designed for.

When designers do not account for such characteristics, the target users may fail to use the applications to their fullest extent (if at all). Defining the design factors involved can be difficult, but several approaches have been developed to help address these issues. We discuss social and organizational characteristics in the next two sections. This is a significantly large area of study, and we are only going to touch on a couple of relevant prior projects.

2.4.1 Social characteristics

The social characteristics of groups should be considered when designing software for sharing awareness information. According to Kling (1991), "fundamental and sometimes subtle social processes in work strongly influence the ways in which CSCW applications are adopted, used, and influence subsequent work". The dynamic nature of social relationships introduces variance in the activities of the individuals using awareness information systems that is hard to manage. Kling (1991) continues on to say that "in practice, many working relationships can be multivalent with and mix elements of cooperation, conflict, conviviality, competition, collaboration, commitment, caution, control, coercion, coordination, and combat".

Discerning the impact of internal social structures and behaviors is difficult for someone external to the group to account for in the design process. As Grudin (1994) points out:

> Groupware may be resisted if it interferes with the subtle and complex social dynamics that are common to groups. The computer is happiest in a world of explicit, concrete information. Central to group activity, however, are social, motivational, political and economic factors that are rarely explicit or stable. Often unconsciously, our actions are guided by social conventions and by our awareness of the personalities and priorities of people around us, knowledge not available to the computer. Tacitly understood personal priorities are tactfully left unspoken, yet unless such information is made explicit, groupware will be insensitive to it.

Making this internal information available to the designer requires involving the users in the process of developing the system. This process of "cooperative design" puts

the users into contact with the designers to expose the “tribal knowledge” using mockups and prototypes and having users simulate work situations as part of this process (Kyng 1991).

2.4.2 Organizational characteristics

Individuals typically operate as groups within organizations (whether they are loosely or tightly coupled). The structure and culture of an organization will augment how people interact, and likewise should augment how we design groupware systems (Orlikowski 1992). Just as failing to account for social factors will reduce the usefulness of an application, failing to account for the nature of an organization will result in reduced effectiveness of an awareness information system (Preece et al. 1994). It should be noted that the use of such a system may change how the system operates, changing the very factors that we tried to account for in the design (Collins 1995).

As with groupware design, awareness information systems have an implicit design problem. How do we determine the important factors in the organization we are designing for, and how do we account for the changes brought about by the introduction of the new system to the organization? Grudin describes three adoption and design issues that should be accounted for in creating groupware:

- The application fails because it requires that some people do additional work, while those people are not the ones who perceive a direct benefit from the use of the application.
- The design process fails because our intuitions are poor for multi-user applications—decision-makers see the potential benefits for people similar to themselves, but don’t see the implications of the fact that extra work will be required of others.
- We fail to learn from experience because these complex applications introduce almost insurmountable obstacles to meaningful, generalizable analysis and evaluation.

Research in the past has indicated that there are several methods to use in analyzing organizational characteristics as a means of improving the groupware design. Designers may pilot new designs amongst a group, then expand the system’s usage once

the effects of the system have been observed and understood (Orlikowski 1992). Ethnography is another means to account for organizational characteristics since long term observations of groups may provide significant detail on organizational aspects of group work (Shapiro 1994; Blythin et al. 1997; Hughes et al. 1994). However, the long term nature of ethnographic analysis conflicts with the typical short timelines of software development. Hughes et al. (1994) suggest several practical approaches for incorporating ethnography into system design to help address organizational issues:

- *Concurrent ethnography*: where design is influenced by an on-going ethnographic study taking place at the same time as systems development
- *Quick and dirty ethnography*: where brief ethnographic studies are undertaken to provide a general but informed sense of the setting for designers.
- *Evaluative ethnography*: where an ethnographic study is undertaken to verify or validate a set of already formulated design decisions.
- *Re-examination of previous studies*: where previous studies are reexamined to inform initial design thinking.

2.5 Summary

This chapter introduced and discussed awareness, casual awareness, availability, privacy, and some architectural issues. Within this discussion, various sources of information and areas of concern have been defined. The focus of the thesis is on availability awareness and how to present it in distributed groups. This will be the topic of Chapter three.

Chapter 3. How People Use Availability Awareness Information

The goal of this chapter is to find out how people in the real world gather and use availability awareness information. The chapter reports on two studies. First, an interview study looked at how people gather awareness information and the sources they use to gather it. Second, a questionnaire study investigated people's willingness to use and share specific types of availability information with others. This study asked people what level of information from six different sources they would be willing to disclose, and also what level they would like to see about others, across seven canonical workplace relationships. These two studies are used as the basis for an availability awareness framework as presented at the end of the chapter.

3.1 Interview Study

The purpose of the interview study was to find out what kinds of availability information people gather, and how they use it when interacting with others. we wanted to know what sources of information individuals used (conventional and unconventional) and how important these sources were from the perspective of the individual gathering the information. From past research, we knew that location (Want et al, 1992), visual information (Mantei et al, 1991), and calendar information (Tang & Rua, 1994) could be useful. The interview study was carried out to determine if these sources were used in the real world, how this information was gathered, and what other information sources could be used in an awareness system.

3.1.1 Methods

The interview asked participants to think about a variety of situations where they had to contact a person in their organization. Participants were asked how they found that person and how they determined that the person was available for interaction. Twenty

people in various working situations were interviewed (ten men and ten women). The age range of the people involved was 20 to 40 years old. The participants came from several backgrounds, including students (five), accounting (six), manufacturing (four), information technology (two), and human-service work (three). The specific questions discussed in the interview are shown in Table 3.1. Data was gathered by the interviewer taking notes. These people were selected by random. They were recruited through the HCI lab at the University of Saskatchewan.

Table 3.1 Questions asked during the interview study.

1. If you need to discuss something with your supervisor face to face, what steps do you take to determine where this person is in the building?
1a. Does this change based on how urgent the situation is?
1b. Are there specific tasks that your supervisor would be involved in that would preclude any form of interruption?
1c. What requirements must be met to consider interrupting your supervisor regardless of the activity your superior is engaged in?
2. Apply the same questions to a co-worker. Do your answers change?
3. Are there specific clues in the environment that you use to assist you in answering these questions?
4. How do the different times of the day (or days of the week) influence your answer?
5. Can you think of specific instances that illustrate the process you follow to determine where an individual is and how available they are for interaction?
6. Turn the question on yourself now. Are there “signposts” in your world that people can use to determine your availability?

3.1.2 Results

The goal of the interviews was to uncover sources of availability information and mechanisms people used to gather that information. Therefore, we analyzed the results to look for commonalties in information sources, lists of factors that changed their use of

the sources, and variability across groups of people. From this, we discovered three main threads. These are: the importance of environmental feedthrough, the relationships between the individuals as it relates to the granularity of the sources of information, and the importance of using multiple sources.

3.1.2.1 Environmental Feedthrough

Feedthrough, as discussed in Chapter 2, is feedback information that can be used by others to determine a person's presence and activity. From the interviews, we discovered that people frequently use information about the objects surrounding an individual; these objects provide clues for people to form an opinion of others' availability. For example, one person stated that finding their boss required looking to see if his mobile phone was in its cradle. If it was not, she knew he was in the building, but she would need to page him through the external public address system.

People said that they got clues from specific objects that individuals used. This includes personal items (coats, bikes, cars, lunch boxes) and generic objects (phones, chairs, and doors). These items provided information about the status of the individual based on tool usage. Often these tools were primary sources of information (computer status, phone status). Obviously, people have learned to read our availability through the objects that are in our environment. If someone's coat was on the coat hook in their office, but they were not there, it is likely that they are in the vicinity. This has also been extended to instant messaging systems in the workplace. For example, one person knew to check if their co-worker was on line using one of two specific instant messaging services. If the user was on line, then it was safe to assume the person was in the office. If they were using a different service, then the person was logged in from home.

The space around the individual was another source of information, including details such as light levels, sound levels, location, and time of day. These details give information about the state of the individual with respect to their common places of

reference. For example, several participants stated that they knew if someone was in or not by the lights being on their office. For people in cubicles, lights cannot be used to determine presence, but other clues were used such as sound level. Other indicators included location in an office, specific location (in a meeting room), or day of week (weekends created different impressions of availability than weekdays). For example, one person told the story of looking for their supervisor at work. Since this person worked in a common lab where lights were always on, the participant instead checked the location in the parking lot where their supervisor usually parked. By determining that their vehicle was not there, the participant knew that they would not be able to find the supervisor in the building at that time.

Participants also said that the activity of the individual was important. If the person was occupied in a task, interacting with others, or in motion, these cues told them a great deal about their availability. So, if a person could see someone was on the phone, they knew that they were not immediately available. Facial expression told people a great deal, as did the context of the person's current activity (walking down a hallway with a specific object in hand). Other indicators included mode of dress, proximity to others, and intensity of activity (yelling indicated less availability than laughter). For example, one student relayed the story of looking for a professor on our campus. From the hallway, he saw that the professor had a stack of papers and was walking towards a photocopier; from this he determined that a task within some idle time was about to take place, and so it was a fairly safe time to approach.

3.1.2.2 Effect of Relationship

People described that they had different sources of information available to them based on their relationship to the other person, usually with a closer relationship meaning that there was more willingness to share information. It appears that this closer relationship results in more information, allowing the observer to better determine if the person is available for a specific kind of interaction (for example, whether they could be

interrupted for a quick chat based on who they were). The observer was allowed to make that determination only because of the relationship they had to the person they were looking for. The closer the relationship between individuals, the more information people were willing to share. For example, one individual related the story of taking a leave from work. The company electronic calendar listed her as away with leave; the group calendar for her section at work listed her as away for educational leave; and the people that worked with her on a daily basis had contact information for her should the need arise to call her. As this story illustrates, when we have clear relationships with individuals, we give information that more clearly defines where we are, what we are doing, and how available we are.

Likewise, the closer the relationship was, the better a person was able to interpret the information. Different people share different amounts of information. Some people were willing to allow others to know a great deal of information about them (one person intentionally left their door open all the time, while another person put a web cam up in their office for their wife to watch them at work) while others are less willing (one person instructed their secretary to not tell anyone where he was if he was not in his office). However, most people said that the rules about how much information they shared depended on the identity of the person looking for them. For example, one participant related the story of how they use their door as a means to indicate their availability. A closed door would generally mean that someone does not wish to be disturbed (in the context of the participant's workplace), but that others can still knock on the door. However, the people in the participant's department knew that he only closed his door to complete personnel reviews with others, and therefore, regardless of one's relationship to him, one would not disturb him when the door is closed. However, the knowledge of the individual that came about from the shared relationship would clarify the reasoning behind the decision.

This information implies that granularity of information increases with a closer relationship. Not only do we get to know more about others based on a well-defined

relationship, we are more capable of interpreting that information in a correct manner. For example, going back to the person who had taken leave from her work, when there was an issue that required her attention, only those close to her were able to contact her. Knowing the state of her work and her reasoning for the time away, they were able to determine what did and did not require her, thus avoiding some unnecessary interruptions. Further, the closer the relationship and the clearer the information, the more someone's privacy would be protected by a natural reciprocity of sharing. For example, individuals who mentioned using an availability client (ICQ) were able to determine someone was on line or not using a flag that marked them as on line but not available. If others were looking for them, they would see the flag for not available and be able to direct others away from them, preserving the information sharing without intrusion.

Finer granularity of the source also increases the ability of others to accurately determine availability. When there is sharing that is bi-directional, the accuracy of the information increases due to the increased granularity of the information as well as the ability of the individuals to interpret the information. In normal human interaction, people that we know well often have access to more sources of information and a finer granularity of sources of information about ourselves. Supporting this will provide people with a more natural form of interaction with the awareness information that they would have.

3.1.2.3 Multiple sources

The interviews showed that some people are able to determine others availability very effectively, and that it is a natural process for all of us. However, single sources of awareness information were often not enough for people to consistently determine availability. Different people determined availability using a wide variety of sources. For instance, for one person it was not enough to know if someone's office light was on, but this information combined with whether or not their vehicle was in the parking lot was enough to determine their presence. Similarly, participants stated that more sources

provided more clarity. Having additional context for availability information allowed people to more correctly interpret information. For example, knowing that one person preferred to turn out the main lights in their work area allowed his co-workers to determine that even when the lights were off, they should use other sources of information to complete their assessment of his availability.

More sources provide redundancy, and provide context for the other sources. For example, some people observing others usually told them what they needed to know, since they could interpret the data based on their own experience. Most people can determine someone's availability based on the simple knowledge that the person they are observing is in conversation with someone else. However, knowing that someone is in the building (location), combined with an assessment of his or her schedule (calendar) as to their being free or busy, and knowing that their phone is in use provides individuals with refined awareness information. Each individual source informs on the others to provide a clearer sense of another person's availability.

How people ascertain availability using multiple sources varies greatly. For example, one person just looked in someone's office for clues, while another person would also ask others for information of the person's whereabouts. Another participant stated that they would walk into the office of a co-worker, see their coat rack, their computer monitor, and the position of their chair, and make a decision about the availability of that person for interaction. Another would also check the calendar information for that same individual and make their determination. Here we see both environment and state information being useful.

It is also important to realize that people sometimes use explicit mechanisms to provide information to others. For example, when a specific person wanted privacy, he would simply close his door. In a cubicle set up, people have started using signs to pass on status information explaining their situation. This implies that people should be able to

control the output of whatever environmental sensors are being used to show their availability.

3.1.3 Conclusions

The main findings of the interview study were that people use information from the environment around a person, they use multiple sources, and they change the way they interpret the sources based on who the other person is and what their relationship is to them. In addition, when these sources of information are combined, people use them differently based on the fidelity and granularity of the source; thus, a more detailed source of information provides more insight into another's availability.

From the interviews it appeared that relationship was a clear factor that affects the gathering and use of availability awareness information. To explore the idea of relationship more carefully, and to get more detail about how people would use different sources and different levels of granularity, we created a questionnaire and conducted a second study as described below.

3.2 Questionnaire Study

Based on the information from the interview study, we created a questionnaire to answer four research questions:

1. Do people differentiate information disclosure or information gathering by relationship? Do some people differentiate more than others?
2. Are there differences between disclosure and gathering, and do people differentiate differently depending on direction?
3. Do people differentiate by information source?
4. Are there differences between fidelity levels?

The information-source issues were chosen because they are not part of current awareness systems. The relationship issue was chosen because the interviews suggested

that relationship is a strong factor in understanding the clues about others' availability; this has also been suggested in prior work on video media spaces (Boyle, 2001a). The actual choice of information sources has been looked at in detail in previous research, and the interviews also informed us about reasonable choices for which sources to use. Therefore, we focused on relationships in the second study, considering the effect of relationship on both disclosure and gathering of information.

We looked at this interaction by using canonical workplace relationships:

a *supervisor* represents any direct superior in the organization,

a *peer* represents someone with the same organizational status,

a *subordinate* is a person on the same project who would report to the participant,

a *spouse* represent a partnership relationship external to the workplace, but where interactions are common at work,

a *secretary* represents individuals with an expectation of knowledge about the whereabouts and activities of the individual in the workplace,

a *friend* in the workplace represents people that share a closer personal relationship beyond those defined by the organizational structure,

an *acquaintance* is any other employee in the organization that has no explicit relationship to the participant.

The study also looked at six different information sources (video, audio, telephone, location, computer activity, and calendar information). Within the individual sources, we examined different levels of granularity of information for each source, as shown in Table 3.2.

A sample of the questionnaire is shown in Table 3.3 (the complete version is shown in Appendix A). The questionnaire considers the relationships we were looking at by the types of information we were asking about at different levels of granularity.

Table 3.2 Sources and granularities used in the questionnaire study.

Source	Level 4 Fine granularity	Level 3 Medium granularity	Level 2 Low granularity	Level 1 Coarse granularity
Video	Full motion video	Clear images every 30 seconds	Fuzzy images every 30 seconds	Heavily distorted images every 30 seconds
Audio	High quality sound link	A muffled sound link (words not clear)	A sound level indicator only (constantly updated)	Sound level indicator updated every 60 seconds
Phone	A sound link to the phone (with identity of members of conversation)	Displaying the name of members of phone conversation	The type of call (long distance, internal, conference call)	Phone on or off the hook
Calendar	Calendar for the whole day	Current calendar entry and free/busy for whole day	Current calendar entry	Person is busy or free currently
Computer	High-resolution picture of screen	A low- resolution picture of screen (where they could see what application was running but not understand the data)	Idle time only	Active or idle
Location	Moving dot on a map of building (updated in real time)	A person's room location	Type of room the person inhabits	In/out of the building

We also considered including urgency as another factor in the questionnaire. However, during a pilot round of testing with the questionnaires, we asked individuals to indicate their willingness to use sources of information based on their sense of urgency to contact an individual. We also asked them to relate how willing they would be to allow others to see their information based on their level of activity. It became apparent that the individuals did not change their answers very much (if at all) based on urgency. When questioned about this, the participants declared that they were willing to share information equally whether they were busy or not, and that they felt that the necessity to

find someone else did not increase their willingness to use specific sources of information. Therefore, this factor was left out of the questionnaire.

Table 3.3 A sample of the questionnaire used in the study.

	Friend in the workplace	Project supervisor	Peer on same project	Subordinate on project	Spouse	Secretary	Any other employee
Part 1. Visual information							
Level 1: Live video (20 FPS)							
Level 2: Regularly-updated image (every 30 seconds)							
Level 3: Fuzzy still image (identity visible but not action) (every 60 seconds)							
Level 4: Motion detector only (every 60 seconds)							
Part 2. Auditory information							

3.2.1 Methodology

Sixteen participants (six women and ten men) were recruited from a variety of work and organizational settings (software development, engineering, management, sales, teaching, and research). Participants' ages ranged from 25 to 42 years. All participants were regular users of computer systems for their work, and all were commonly in situations where they had to determine the availability of someone in their organization. These people were recruited through the HCI lab at the University of Saskatchewan to participate.

The questionnaire was given to each participant, asking them about what information they were willing to disclose, and what information they would choose to

use, in a number of different situations. People marked an X on the questionnaire cells where they would be willing to disclose/use information. Participants were told that leaving all cells blank for a particular column meant that they would not disclose/use any information at all.

As introduced above, the questionnaire was organized by four factors:

- Information source: video, audio, telephone, location, calendar, and computer use;
- Information fidelity: four different fidelity levels, from a binary indication to the richest available for that information source;
- Relationship to observer: peer, supervisor, subordinate, secretary, friend, spouse, or acquaintance (any employee not in the other six groups);
- Direction: whether the awareness information is being disclosed (outgoing) or gathered (incoming).

3.2.2 Results

Results and analysis from the questionnaire are organized by the following research questions:

- Do people differentiate the type of information they are willing to disclose (or gather) by relationship?
- Are particular relationships consistently given more or less information?
- Do people differentiate by information source?
- Are there differences between fidelity levels?

3.2.2.1 Do people differentiate by relationship?

For each person, we calculated the maximum fidelity they would give to (or use from) each relationship, for each information source. The number of differences within each information source is a simple indication of differentiation, and indicates whether a person would use different settings for different relationships in an awareness server. we report first on results for disclosing information, and then for gathering it from others. In addition, we analyzed the data using two separate groupings. First, we tested all

relationships (including the 'acquaintance' category), which corresponds to an availability server where everyone can see each other (e.g., an internal company directory). Second, we also considered the data without the 'acquaintance' category, which corresponds more closely to current IM systems, where people specifically choose which people to include in their system.

Disclosure. In our data, people differentiated their disclosure more than half the time (Figure 3.1). When considering all relationships (i.e., including acquaintances), people would disclose different amounts to different relationships for 61% of the information sources. When considering only personal and professional relationships (i.e., friend, spouse, supervisor, peer, subordinate, secretary), people differentiated with 54% of information sources.

Gathering. People differentiated much less in their preferences for gathering information. As shown in Figure 3.1, people only indicated a relationship-based difference in about 25% of cases. Since there was so little differentiation, our analyses in the next section focuses on disclosure only.

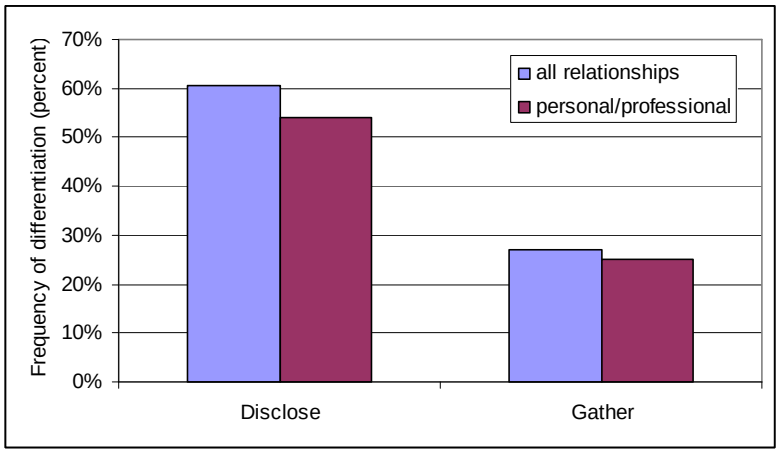

Figure 3.1 Histogram showing frequency of differentiation, for both disclosing and gathering.

3.2.2.2 How much do people differentiate?

We considered both the amount and the magnitude of differences. To measure the amount of differentiation, we counted the number of differences from the majority answer for each information level. For example, if a person indicated one fidelity level for four of the relationships (e.g., spouse, friend, supervisor, and peer were treated the same), and different levels for three (e.g., secretary, subordinate, and acquaintance were different from the four above), we recorded that there were three differences from the majority.

Figure 3.2 shows the amount of differentiation for disclosing information, and again considers two groupings of the data (all relationships, and professional/personal relationships only). Although the largest category has no differentiation, a large proportion of cases (more than 40% when considering all relationships) show more than two differences per information source.

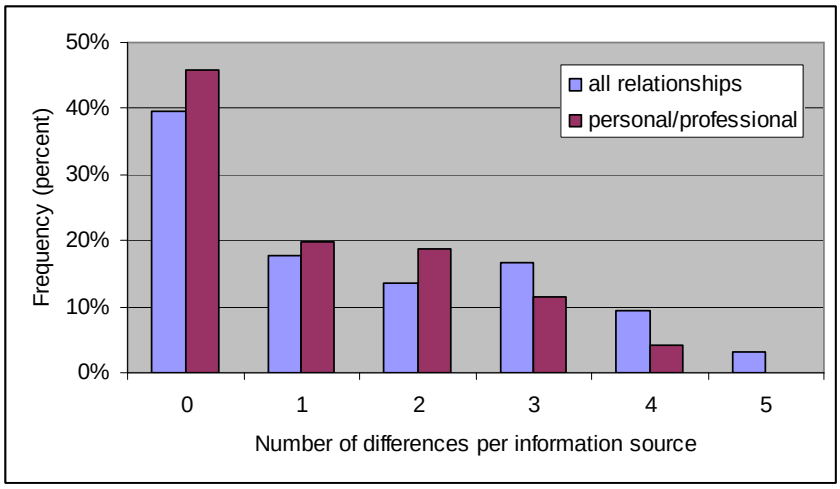

Figure 3.2 Histogram showing amount of differentiation per information source, in terms of the number of differences from the majority.

Finally, to measure the magnitude of the differences, we recorded the difference between the highest and lowest fidelity levels for each information source. Figure 3.3 shows that in several cases, there were fairly large differences. For example, in 30% of cases (considering all relationships) there was a difference of three or four between the highest and lowest fidelity levels. This means that in a substantial minority of cases,

people are giving some relationships the highest level of fidelity, and others the lowest level.

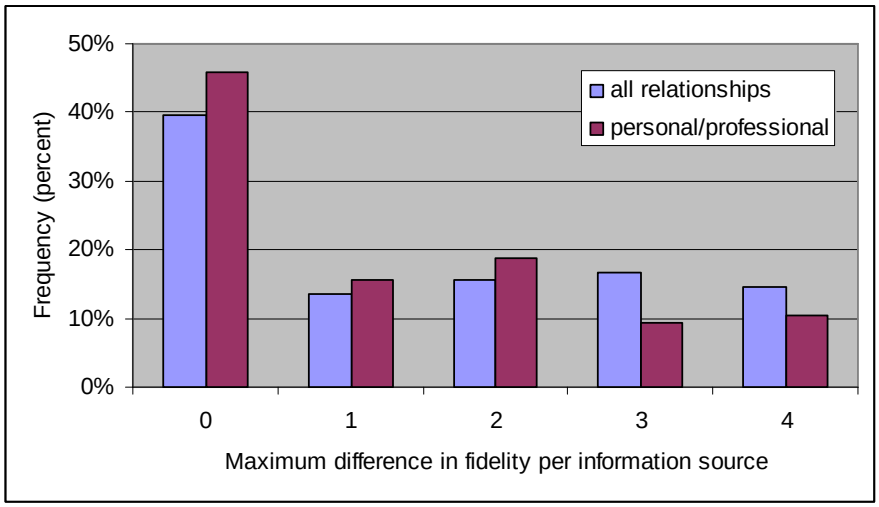

Figure 3.3 Histogram showing magnitude of difference between highest and lowest fidelity levels.

3.2.2.3 Are there differences between relationships?

Using the measure of maximum fidelity, we looked at whether people treated certain relationships differently. Disclosure and gathering were again analyzed separately.

Disclosure. For disclosing information, there was a significant main effect of relationship on maximum fidelity ($F_{6,10}$=5.26, $p<0.001$). A post-hoc Tukey test was carried out to look for individual differences between relationships. There was only one significant difference found: participants were willing to disclose significantly less fidelity to the 'acquaintance' relationship than to any the others (all $p<0.01$). No other differences were found between pairs of relationships (see Figure 3.4).

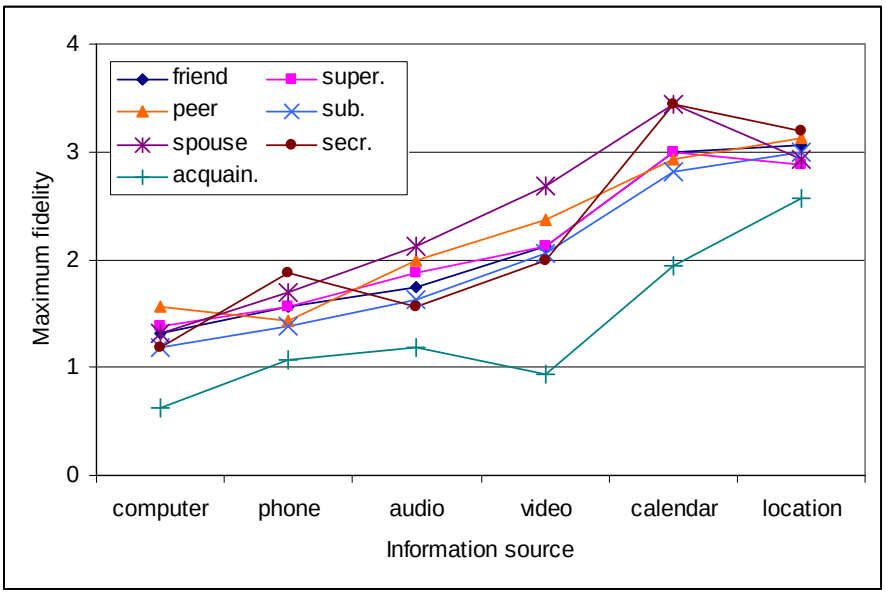

Figure 3.4 Mean maximum fidelity participants would disclose for each relationship type, by source.

Gathering. A similar analysis of variance was carried out for data from the gathering scenario. As can be seen from Figure 3.5, the relationships were treated similarly, and no significant effect of relationship was found ($F_{6,10}$=0.48, p<0.82).

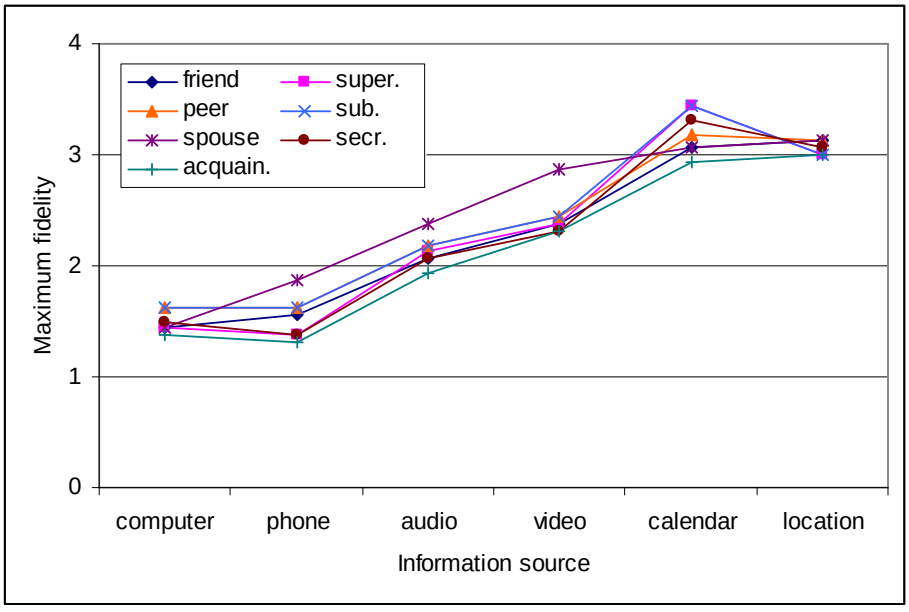

Figure 3.5 Mean maximum fidelity that participants would gather for each relationship type, by source.

3.2.2.4 Are there differences between sources?

We also used maximum fidelity level to look at whether people had different preferences depending upon the source. It should be noted, however, that fidelity is an inexact measure when comparing sources, since scales are relative to the source. For example, level two fidelity for video is not the same amount of information as level two for a calendar. Nevertheless, the scales all range from a binary representation to the maximum amount of information possible for that source, and therefore, we believe that the measure can be still used to indicate broad differences.

Disclosure. Figure 3.6 shows mean maximum fidelity for each information source. Analysis of variance showed that there was a main effect of information source ($F_{5,11}$=15.42, p<0.001).

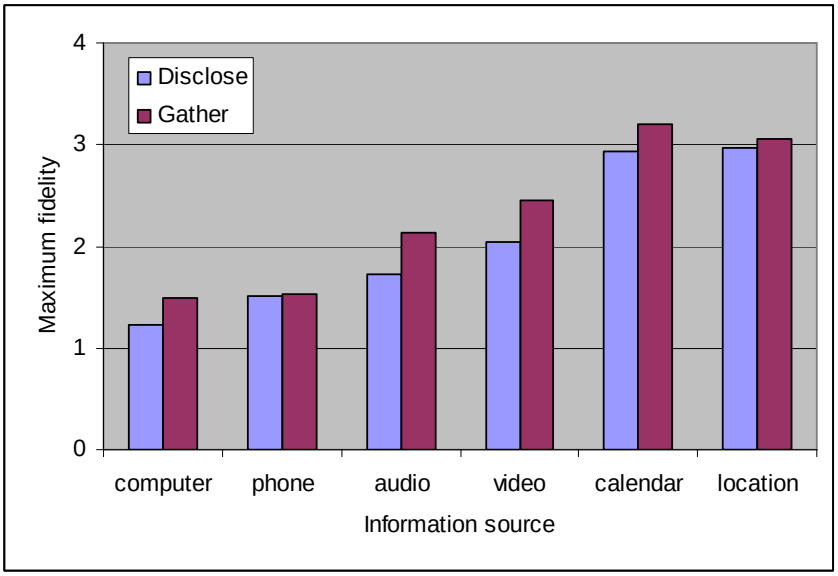

Figure 3.6 Mean max fidelity for disclosure and gathering, by information source.

A post-hoc Tukey test showed several significant differences between individual sources (see Table 3.4). This test suggested that the sources can be divided into three main groups: people are willing to disclose the least fidelity for computer and telephone,

significantly more for audio and video, and significantly more again for calendar and location.

Table 3.4 Tukey pair-wise comparisons (disclosure data). Statistic value above the diagonal, significance below.

	Computer	Phone	Audio	Video	Calendar	Location
Computer		-2.52	-4.43	-7.12	-14.86	-15.12
Phone	n.s.		-1.91	-4.60	-12.34	-12.60
Audio	p<0.05	n.s.		-2.69	-10.43	-10.69
Video	p<0.01	p<0.05	n.s.		-7.73	-7.99
Calendar	p<0.01	p<0.01	p<0.01	p<0.01		-0.26
Location	p<0.01	p<0.01	p<0.01	p<0.01	n.s.	

Gathering. There were also clear differences between sources in the data from the gathering-information scenario (see Figure 3.6). There was again a main effect of source on maximum fidelity level ($F_{5,11}$=17.23, p<0.001). Follow-up tests divided the sources into similar groups as those discussed above.

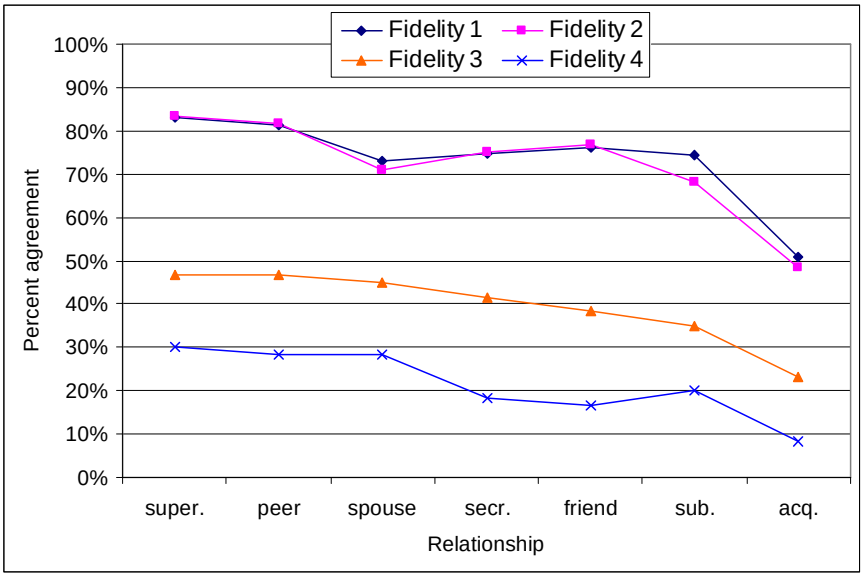

Figure 3.7 Disclosure: percent of participants agreeing to each fidelity level for disclosing information.

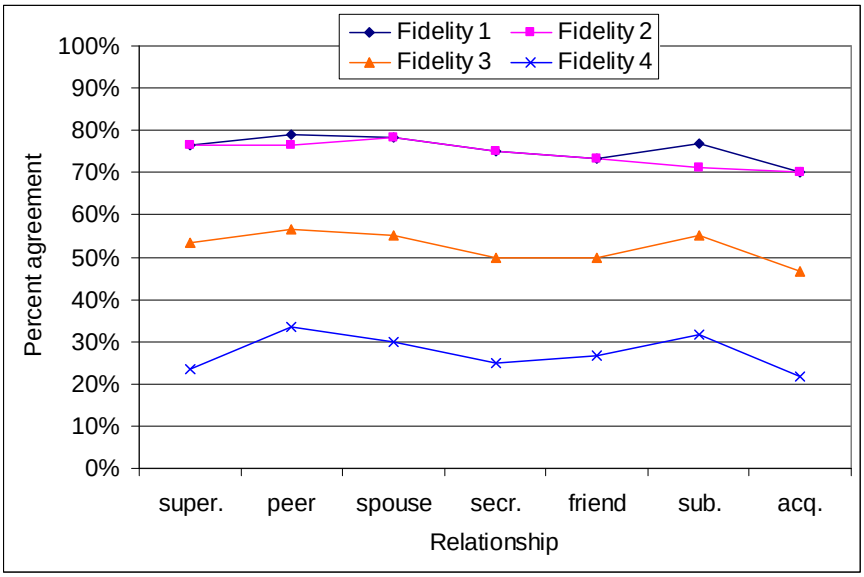

Figure 3.8 Gathering: percent of participants agreeing to each fidelity level for gathering information.

3.2.2.5 Differentiation by fidelity

As expected, people were less willing to disclose higher-fidelity information, and were less interested in seeing it about other people (see Figure 3.7 and 3.8). Significant main effects of fidelity level were found for both disclosure ($F_{3,13}$=40.03, $p<0.001$) and gathering ($F_{3,13}$=17.78, $p<0.001$). However, in both cases, level one and level two information was treated almost equally.

3.3 Discussion

The questionnaire study provides four main results:

1. People differentiate information disclosure by relationship for more than half of all information sources;
2. The only difference within relationships is that people would reveal less to acquaintances than to personal or professional relationships;
3. People were willing to reveal higher fidelity information about their locations and calendars than they were about their computer use, telephone conversations, or office audio;

4. Most people (76%) were willing to disclose lower levels of fidelity, and a smaller percentage (24%) was willing to disclose the highest level.

In the following paragraphs, we consider explanations for these findings and make recommendations for the design of awareness servers.

3.3.1 Explanations of questionnaire results

We were not surprised that people differentiate by relationship, but it was at first surprising that only the 'acquaintance' relationship was consistently different. However, the similarity in personal and professional relationships can be explained by simple variation within the participants: each of them has had different experiences with relationship types, and so different people would be likely to treat them differently. We also expected differences between fidelity levels, but were interested to see the similarity between levels one and two. We heard several comments from participants that level one information would not be particularly useful, so it may have been the case that people really did want to find a suitable level of information for the task.

Second, the differences in disclosure between sources appear to reflect the degree to which the information is already public. People were willing to disclose less information about computer and telephone use, activities which are usually private (it is seen as rude to look at a person's computer or listen in on a phone call without invitation). People were willing to give out more information about location and calendar. Location is already public information (at least for people who are nearby); calendars are less so, but electronic versions are often made public within the organization for purposes such as scheduling meetings. Several participants mentioned that they had no problem disclosing information about their calendar because it was already available in their organization.

3.3.2 Lessons for designers of availability servers

Several lessons can be taken from the questionnaire study. First, the study suggests that awareness servers should provide a means for differentiating information disclosure. Relationship appears to be an attribute that people use in this process, although further study is needed to determine whether other attributes (or customizable groups) could be more appropriate in some situations.

Second, awareness systems should make it possible to disclose at least the amount of information represented by level two of the four fidelity levels. This level was acceptable to a large majority of our participants, and the additional information could help people to make better decisions about availability. Since level two and level one were treated so similarly, it is possible that the lowest level of fidelity may not even be needed in awareness servers; however, since the lowest level lends itself well to on/off type displays that fit into a small space, it may be necessary to retain it regardless of whether anyone will actually limit disclosure to this level.

Third, fine-grained control over disclosure seems to be more important than finer-grained controls for the fidelity of incoming information. Control over outgoing information should be easily available in the interface and quick to use. The reason that controls for incoming fidelity are less important is that the amount people are willing to disclose is almost always lower than what people would be willing to see about others – that is, few people are going to receive too much information. The controls should be made available, but do not need to be as ready to hand as controls over disclosure.

Fourth, awareness servers should allow differentiation by information source. As a default, these systems should provide less information about computer and telephone, and more about location and calendar. Again, however, the ability to change these defaults should be provided.

3.4 Design Framework

The information gathered from the two studies can be put together into a basic design framework for the design of availability awareness systems (see Table 3.5). The framework specifies information sources and how each is affected by relationship. The information from the interview study, as well as data from previous research, suggests that the six information sources used in the questionnaire study are reasonable starting points for providing awareness information about an individual (see Table 3.5). Other information sources exist, but could be considered too specific to a situation (bike rack camera, door sensor) or too intrusive (facial expression camera, computer desktop image).

For the shared information, the availability information others receive will be predetermined by the person under observation. Each of the sources should have a base representation that answers a single yes or no question. Audio information should answer the question "Is the person talking to someone?" Video information should answer the question "Is there motion in this person's office or workspace?" Phone status should answer the question "Is the phone on or off the hook?" Location should answer the question "Is the person in the building or not?" Calendar information should answer the question "Is this person booked into an appointment of some type at this moment?"

It appears that each source of information should be separately represented, and not amalgamated into a single representation. Current availability awareness systems have single representations that may include additional data. Usually these are limited to online or not. Some (such as ICQ) offer more options for what someone's status is, but the interview study suggested that some people ignore these single status representations. Others allow specific information to be encoded in naming (MSN messenger) where the client software is running. Whereas these clarifications are assistive, they fail to provide the raw data that people need to make informed evaluations of others availability. Also, the sources they do represent are provided without the context of other sources. Multiple

sources will inform on each other to provide a greater context for understanding availability awareness.

Table 3.5 Information sources and effects of relationship

Sources	Relationship
Absolute location	Different people know that they can react or interact differently based on where you are. They also know that they can attach or unattach social rules based on location based on their relationship to you. It is more likely that someone who knows you personally could more accurately determine your availability from your location based on knowledge of personal habits. For example, knowing an individual is in a meeting room can inform clearly to many people their ability to interact socially
Phone status	People are more willing to allow others more information about what kind of call is being made with individuals who might know that information some other way (a secretary). Further, they are willing to let people know if they are on the phone or not
Audio information	People are potentially more willing to let those they know be aware of conversations they are in. As a general rule, they were willing to share that there was sound in their space with anyone they had a defined relationship with
Computer use	People were more willing to let others know the idle time of their computer for people that would be considered "close" in a relationship. For all defined groups, sharing information was acceptable
Calendar information	People were willing to allow others to know if they were free or busy. No one in the work environment was allowed to view his or her entire calendar. It appears that we must not allow high granularity information to be freely available
Visual information	Close friends or coworkers could see pictures of individuals refreshed every 30 seconds. Most people could see a base representation of motion in a person's office space. No one was allowed to see a full motion video

3.5 Summary

In this chapter, we reported on two studies that investigated the kinds of information people use to maintain availability awareness, and looked at their willingness to disclose information to different relationships. These studies provided information about which sources of information we should use in an availability awareness client, the granularity of data we should present, and how the data should be filtered based on

relationship. Using these criteria, a prototype was designed and tested; the prototype is introduced in Chapter four, and the evaluation of the prototype is discussed Chapter five.

Chapter 4. Prototype

This chapter presents the design and implementation of a simple prototype availability awareness client and server. The prototype was built to test some of the earlier findings in a real-world setting. In the questionnaire examined in Chapter 3, we determined that individuals were indeed willing to share information with each other when certain conditions were met, and that relationship between individuals influenced the information that individuals would share with each other. Next, we wanted to determine if relationship is really a determining factor in real world situations. In addition, since previous research has indicated that certain sources of information are useful for determining availability, we needed to know if these sources would be useful in practice. The investigation into these issues is covered in Chapter 5. In this chapter, we focus on the design and implementation of the prototype. The prototype was functional enough for evaluation, but by no means was it a production level system. Some information that the users observed was predetermined data. However, the design was complete enough to allow the design issues to be explored and provided a platform for testing.

4.1 Basic Design Goals

The prototype had to show user information, indicate identities, and allow for interaction so that additional availability information could be shown. It also had to allow the individual under observation to determine what information he/she would share and with whom. There were three factors considered in creating the layout of the prototype: size, simplicity, and clarity. The size of the client that individuals use should be small, roughly the size of a typical instant messaging client. This is to ensure that the client does not consume valuable screen space. We also wanted to make the interface very simple to allow users to quickly determine what information is being presented. Simplicity would also reduce the cognitive load on users and (hopefully) make the system generally more useful. Clarity means that each source should be independently represented from the

others. This is done to allow the user to evaluate the sources separately and then to amalgamate the information in light of their knowledge of the person observed to formulate an accurate picture of their availability.

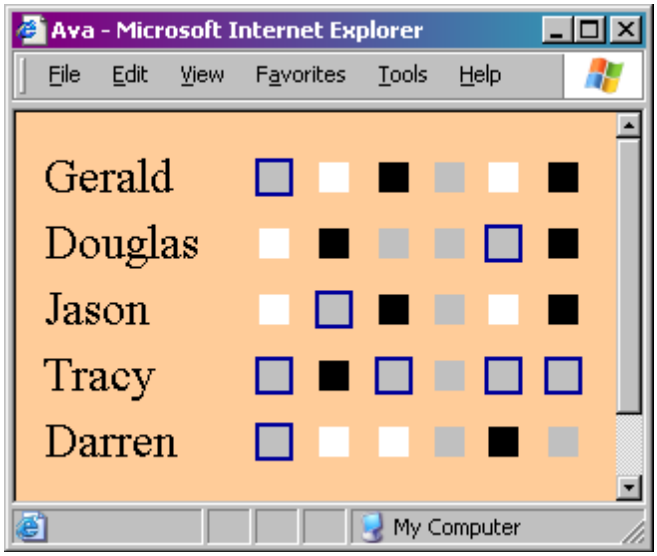

Figure 4.1 The final client prototype with multiple users represented.

The goal was to represent the availability of an individual through six sources of information with six binary visual indicators. The sources were chosen to match those that people would be able to obtain if they were physically near the other person, or that are used in common sources of publicly available information.

Table 4.1 Sources of awareness information used in the prototype client and the basic level of granularity represented.

Information source	**Binary representation**
Visual information	User in office
Audio information	Sound present
Location information	User in the building
Phone status	Phone on or off the hook
Calendar information	Calendar marked free or busy
Computer usage information	Computer in use or not

The use of one box (representation) per source allowed the users to differentiate between sources easily. Since individuals would quickly learn the meaning and location of each representation, no labels were used to save space in the client. The prototype has six boxes for the six sources.

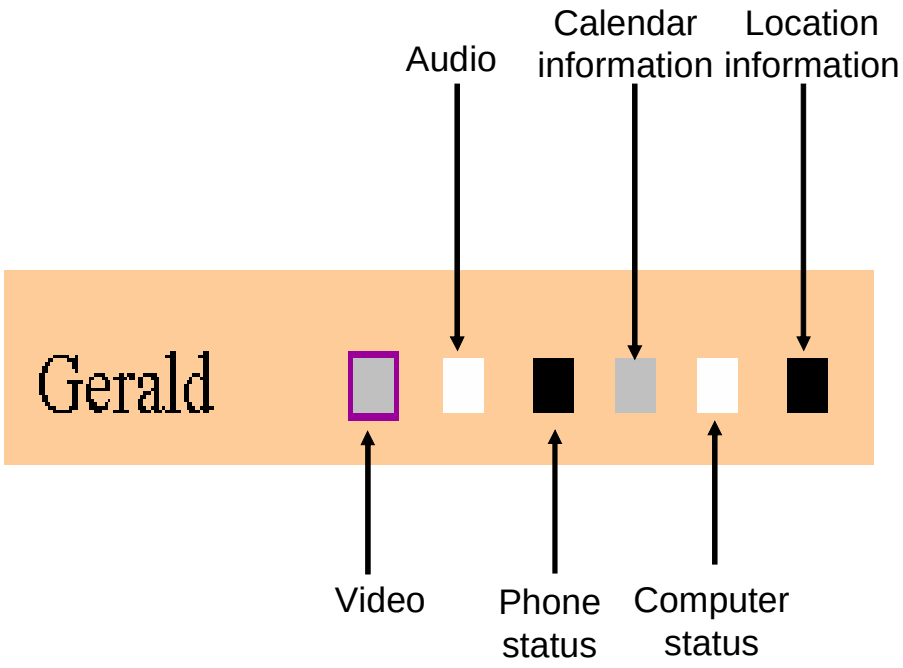

Figure 4.2 A close up of the prototype of the awareness client showing one individual's availability information. Each individual has several individual sources represented by individual boxes.

4.2 Representation of availability awareness information

The representation (Figure 4.3) has three variables for data about a user: information shared or not shared, an individual's being available or not available, and (when data available), more data or only the basic data. A grey box indicates both that user data is shared and availability condition indicates opportunity for interaction (e.g. their phone is on the hook, the calendar is marked free, the computer is in use, there is motion in the person's office, or the person is in the building). If this grey box has a coloured outline

that means that clicking on that box will allow the observer to gather more data about the individual. A black box indicates that user data is available shared but the condition is negative (with respect to the person being available (e.g. the phone is in use, the calendar is marked busy, the computer is not in use, the person is not in the office, the person is not in the building, or there is a conversation taking place in the person's office). A white box indicates that the user's information is not being shared. To assist the users to remember which representation was which, we provided flyover tags for them to both quickly realize what they were moving their mouse over as well as provide more information on the spot. In Figure 4.4, we see that the observed individual is in his office (from the tag).

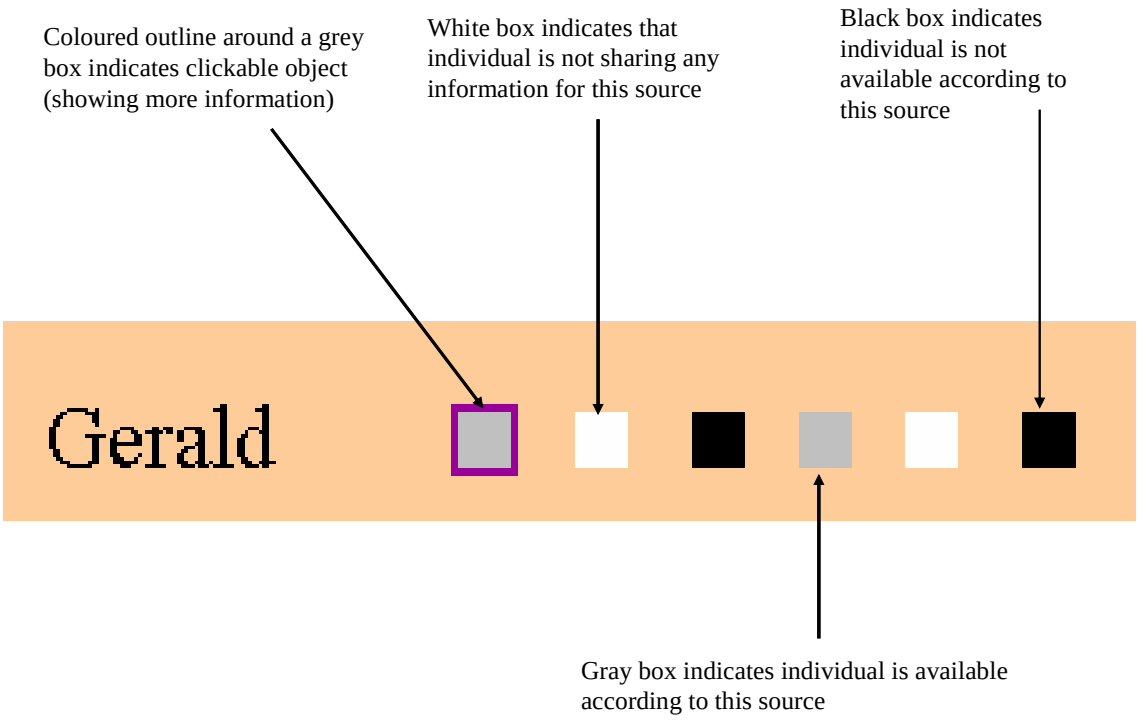

Figure 4.3 A close up of the information sources for each individual.

We used the lowest available level for each source in the client to provide a compact representation that was consistent between users. In addition, only a subset of

the availability levels used in the questionnaire were used in the prototype since some levels of information were deemed too intrusive (full audio in a person's office for example). Other availability levels were combined to simplify the study (reducing the options of frequency of the fuzzy image from either every 30 seconds or 60 seconds to only every 30 seconds).

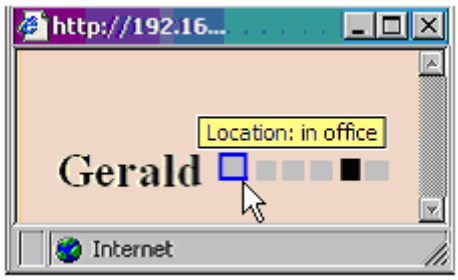

Figure 4.4 Close up of the flyover help for a single window to provide context for the label.

The basic representations shown were used because they were either the lowest or nearly the lowest fidelity, and were therefore simple to understand. This also meant that they were generic enough to be used across a wide range of circumstances and still be able to provide some meaningful information. To get the higher granularity information, the user clicked on the low level representation and automatically got the highest level available. The higher level representations used were the highest allowed by the observed individual. It seemed most natural to use the highest available as the second level as this represented the amount and kind of data people would receive in collocated situations.

When allowed, users could get more information for a particular source by clicking on the box. This would open a new browser window with the higher fidelity representation of the information source. For example, in Figure 4.5, we see the result of clicking on the lowest level representation of video, which shows the user in his office working. In Figure 4.6, the result of clicking on the user's calendar representation shows a section of the person's daily calendar. Note that for the study, calendar data was entered

and updated manually; the prototype does not communicate with calendar programs, although this would be the goal of a production system.

Figure 4.5 Results of clicking on the Video box on the client opens a new window with a self-refreshing web cam image.

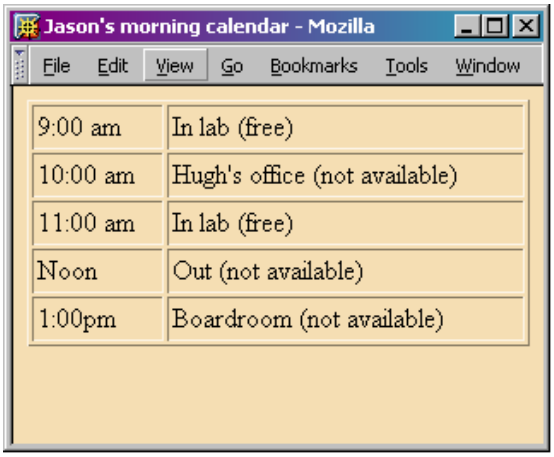

Figure 4.6 Results of clicking on the Calendar button on the client opens a new window with a listing of the person's calendar for part of the day.

4.3 Controlling disclosure

A web interface was created for the user to set and update their disclosure preferences. This interface allowed the user to determine how much information they

would share to different groups of people based on the categories determined in the questionnaire study (friend, subordinate, superior, spouse, co-worker, acquaintance).

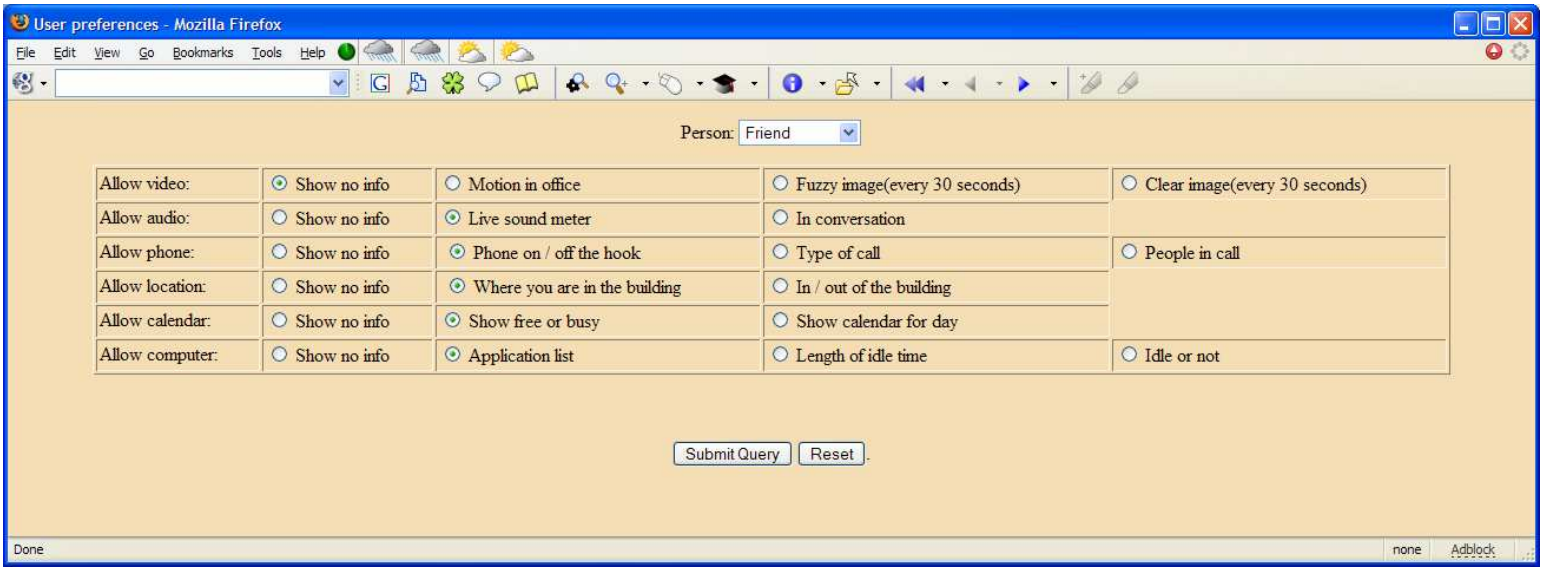

Figure 4.7 Web page for the user to set their disclosure preferences.

The user sets a maximum level of information for the observer to see and then the system filters the data that the observer receives at their console. This way, if the individual sharing the information is comfortable allowing a friend at work see an image of them, but is not comfortable with his or her superior seeing the image, the system passes the data on to the one user while restricting it from the other.

4.4 Architecture and implementation

The prototype is a simple client-server system. The clients gather information about a user, forwarding it to a server, which then allows others to access that data based on their relationship to the individual under observation. A server program listens on a socket for incoming data from a client program. When it receives new data, it updates the database with the new rules for the information about for the user it references. Based on those rules, it then creates a new html document that it saves to a directory in the file system served by a pre-existing web server. Included in this html document is a directive

to update the page from the server every 30 seconds. For the video images, an ftp client on a PC with a web cam forwards an image every 30 seconds, overwriting the previous image file. For fuzzy video (and for the blurry image), a second webcam was used and the focus was manually set wrong to ensure the quality of the video was poor. Since this was only a prototype system, the video (both clear and fuzzy) was on a slight time delay of 10 seconds, which allowed the cameras to take a picture, then record video, while a simple ftp program forwarded the data to the server.

The server acts merely as a relay of the data that the user pushes to it, rather than retrieving it when the observer issues a request. Since the data was only updated every 30 seconds, any attempt to force a refresh from the observer's client would only give data at the predetermined rate. There is also no storage of historical data that users can retrieve, although for the purposes of this study, the data was stored to compare against the observers' data later.

The prototype server was implemented in C on a Linux server. Since its job was to act as a relay for the data, all it really had to do was ensure that it forwarded the proper data for individuals, and that it was receiving data from the cameras and from the prototype client information gathering tool. Every 30 seconds, it would check the user preferences, then it would rebuild a webpage for each different set of observer preferences, and change the images (or video clip) that had been uploaded via ftp. For serving the data, the same Linux server was running Apache 1.3.19 which allowed users to browse to the information wherever they were at in the building.

The prototype client was a terminal program written in C (also targeted for Linux). A user simply had to telnet into the Linux server from the computer that was used to gather the data (in this case, a windows laptop) and update the information for location, audio levels, phone status, and computer status. Calendar information was written to a file at the beginning of the day that the server would read once and use for the rest of the day. Each time the status of the individual under observation changed, a file would be written

with the appropriate information. The server program would read this file to generate the HTML that it then saved for the Web Server to provide to the observers.

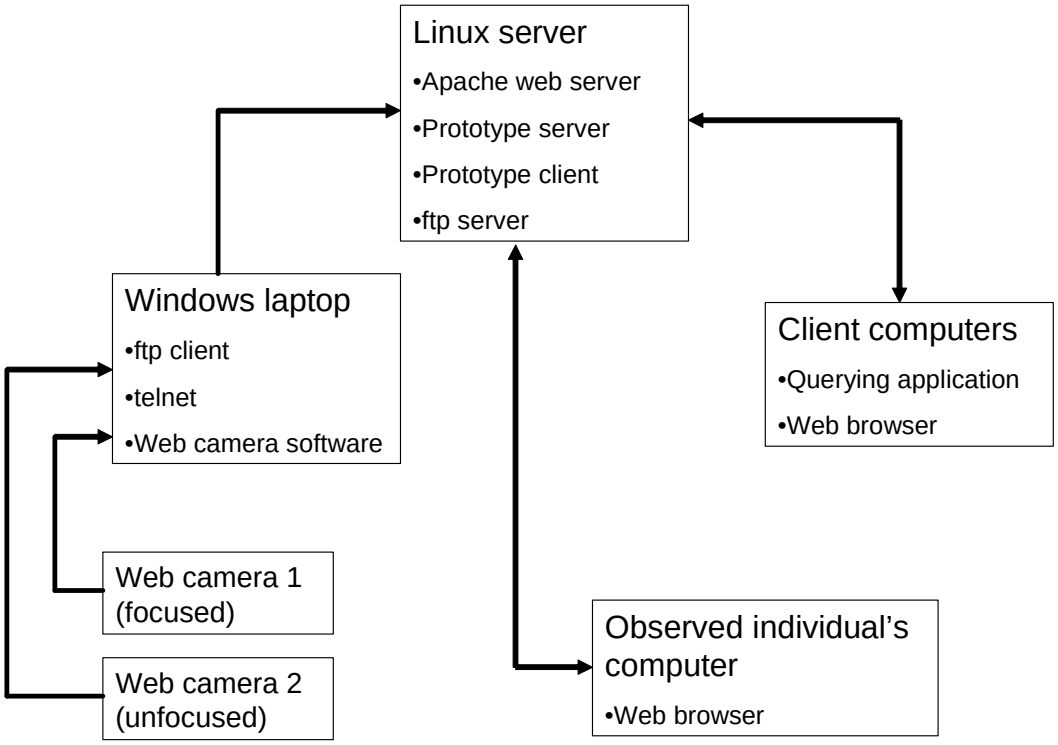

Figure 4.8 Diagram of the Wizard of Oz system

To gather information from the observers, an application was written to pop up a window on their computer every five to twenty minutes and ask them whether they though the observed individual was available for interaction or not based on the information he had chosen to share with them. Since these individuals were running Windows computers, and we did not need the data in real time, a simple Visual Basic application was written to allow the users to answer a simple question ("Is the observed individual available or not?") and log their answer. At the end of the experiment, we collected the resulting log file to use for our evaluations.

4.5 Summary

This chapter reviewed the prototype that was developed for use in an experiment testing the framework developed in Chapter 3. The prototype was used in the field trial that is discussed in the next chapter.

Chapter 5. Evaluation

This chapter reports on a field trial of the multiple-source, relationship-based prototype that was introduced in Chapter 4. The field trial used a Wizard-Of-Oz methodology to gather awareness information about one individual in a local organization, over several days. A Wizard-of-Oz methodology takes place when a system is simulated by an individual acting as an autonomous agent. The awareness information was distributed to four observers who regularly reported on their understanding of the individual's availability. In the following sections, we discuss the goals of the study, the study setting, the participants, the Wizard-Of-Oz methodology, and our findings about how relationship was used, how the multiple sources of information were used, and the overall usability of the prototype.

5.1 Field Trial Goals

There were three goals for the field study with the prototype. We wanted to explore our earlier findings about sources of information and relationship-based disclosure in a more realistic setting than the questionnaire study. We wanted to test whether multiple sources of information were valuable in a real organization, and determine how relationship-based filtering worked in practice. To do this, we needed a real location with individuals that worked closely together, interacted often, and had a variety of relationships.

5.2 Setting

A local company allowed us to use their facilities and personnel, and assisted by participating in the experiment. What follows is a description of the setting of the

company, the department the observed individual works in, and the space where most of the testing was done.

This company is a telecommunications design and production facility. At the time of the study, there were about 230 people employed in the company. The research and development group is comprised of 30 individuals, while the manufacturing and administrative staffs comprise roughly 200 staff members. The research and development staff occupies 30 percent of the floor space on the upper floor of the building, while the physical manufacturing group is located on the lower floor (manufacturing support and administration occupy the rest of the building). Whereas the organizational structure of the company is hierarchical for the most part, the research and development group has a flatter structure, with a single individual acting as the department head. It is an workplace with a very flat heirarchy where any individual is free to talk to anyone. For our experiments, the an important individual within the R&D department acted as the test subject.

The R&D department (where the experiment took place) is comprised of thirty-five offices and cubicles surrounding a development lab. The development lab is a series of workbenches around the edges of an open space. Each of the lab benches is equipped with a computer and several pieces of test equipment. The benches are large enough to allow researchers to work together in pairs, and conversation between individuals at different benches is common. The area outside the perimeter of the lab is a walkway between departments. The test subject primarily works in the development lab beside the perimeter walkway to allow others to meet with him casually as the need arises.

The company that allowed us to undertake the field trial is divided into separate activity units. These include production support, manufacture, marketing, information technology, and research and development. Each has a slightly different model of management, but at the corporate level, the company strives to treat all employees

equally in terms of communication of information and freedom to interact with members of other departments. A sense of egalitarianism exists based on the sense that each person is important in the activity of generating products and revenue. This has lead to a sense that any sort of hierarchy can be avoided in terms of restriction of interaction. This means that our experiment did not require people to create new lines of communication between the observers and the individual under observation. This also means that people did not inherently have a sense of "violating" personal space in a new way by gathering information about the individual under observation. We do not believe that this changes the value of the results, but it does indicate that our results may differ somewhat from a more rigidly hierarchical workplace.

5.3 Participants

The test subject allowed us to have four mornings to track him and use his availability information. Four individuals who work with him at some level acted as observers. What follows is a description of the people involved and the roles they played in the field study.

Participants were recruited by word of mouth within the organization. It was made clear that participation was voluntary and that they could stop at any time. We were fortunate enough to have the members participate in a "real world" situation, and the personal knowledge that the individual conducting the trial had of the individuals' within the study provided opportunity to ask more relevant and useful questions. Care was taken to ensure individuals realized that there were no requirements or expectations for the individual's to approve of the system being tested in the field trial, and that no repercussions would result from people either disliking the system or benefit would accrue from approving of the system.

As indicated the test subject that was observed is an important individual in the company. His place of work in the development lab is directly beside the perimeter walkway so that people can observe where he is and meet with him casually as the need arises. His activities touch all facets of the creation of new products and development of future directions for the company. Further, in his executive role, he is involved in

management of the facility. His insight and experience make him a vital resource to all departments within the company. It is not unusual for much of his day to be taken up with informal meetings and he is often found meeting with one set of people while another set of individuals are waiting to speak with him. Often he is looked for in the development lab prior to being paged on the public address system simply because he is usually found there. There are times that he finds it necessary to work outside the building to get work done simply because he is constantly interrupted (consistent with Hudson et al.(2002)).

Four observing individuals were asked to view the representation of the test subject's availability information on a regular basis during the four days, and form a decision on each occasion as to whether the observed individual was available for interaction or not. These observers were other employees in the organization. One individual was in administration, one was in marketing, and two were in R&D. These individuals were people that interacted with the observed individual as a peer (referred to below as ADMIN), friend (R&D1), subordinate (R&D2), or acquaintance (MRKT). Two of the individuals were people who interacted with the observed participant at higher frequencies and for longer periods of time in the course of their daily work (ADMIN and R&D2). One person interacted with the observed participant occasionally (R&D1), while the other (MRKT) interacted with the observed individual infrequently. Their normal course of work at the time of the field study would take them through the observed individual's work locations at least occasionally as a part of their day. During the experiment each of the observers was involved in some capacity on some project with the observed individual.

The field trial was conducted by a member of the same company that all the participants of the study were a part of. The individual conducting the experiment recruited the observers and the individual being observed. Although we did try to recruit more individuals to participate in the field trial, we were only able to gather four individuals to act as observers. While this does leave us short of the full complement of relationships we would have preferred, the use of the four different relationship "types"

allowed us to evaluate the usefulness of the concepts that we had determined were of interest in the questionnaire study.

5.4 Methods for Data Gathering

5.4.1 Wizard-Of-Oz Data Gathering

This section is an explanation of the tools and techniques that we used to gather the data. For passing data to the observers, we used a Wizard of Oz methodology. To simulate the sensors that would be necessary for a fully functional system, the experimenter followed the observed individual during the experiment. The data was collected and manually entered into the system via a simple command line interface that directly communicated with the server. The experimenter carried a laptop computer and followed the observed individual around the building for the term of the experiment and updated the data for the clients as it changed in real time. For the video interface, a web camera was set up to allow people to view the office space of the individual being observed and the image was updated every 30 seconds. The calendar information was entered for the full day at the beginning of the day (remained static). Other information was updated manually during the trial. If the status of the individual changed, the collector would issue a change status command to the server, which would update a web page provided to the observers. The next time the observers' window of information (a web browser) refreshed, the representations would be updated (this updated every minute automatically, or the user could request a refresh).

The information sent to the server on a regular basis was updated every five minutes or on a series of defined events. The defined events were something that the observed individual did that changed his status or the entry of some effect into his space that would change his state (someone entering his workspace, change in volume of the surrounding sounds, in one instance, someone turned off the lights in his area). In addition, the observed individual directly signaled the collector when he was and was not available. If the observed individual went for a longer period of time without his state

changing, the collector would ask him if he was available or not every 15 minutes. When he was not available, the collector made note of it in the data log.

5.4.2 Gathering Data from Observers

The four observers ran the prototype display client (see Chapter 4) that showed availability information about the observed individual. In addition, each observer had a separate application running that would ask him or her to evaluate the observed individual's availability. This ran on a random timer that asked if the observed individual was available for interaction every 5 to 20 minutes, and their answer was recorded in a text file that was used for later analysis.

Users could follow the status of the observed individual regardless of where they were in the building (as each had a computer in several locations) but the recording of availability only happened on their main computer. This did not have much impact, however, as the observers were at their main computer nearly all the time during the study.

5.5 Procedure

There were two parts to setting up the procedure. The first was preparing the observed individuals' data for presentation, and the second aspect was preparing the observers to receive and interpret the information.

Observed individual. The observed individual was told about the study and about the methods that would be used during the four days. The Wizard-Of-Oz methods, in which the experimenter followed the individual around and entered data into a laptop computer, were demonstrated. Finally, the idea of relationship-based filtering was explained, and the individual stated his initial disclosure preferences. We asked the observed individual to place the four observers into the appropriate category (friend, peer,

co-worker, subordinate, superior, or secretary). Once the observed individual had done this, we then asked him create a starting database for the kinds of information that he was willing to share with the people in the classified groups.

During the set-up of the observed individual's preferences, there was initially some differentiation based on relationship, but after an initial trial run of the system, he decided that everyone should see the same data. After his preferences were entered, we demonstrated the info that was shared about him and he approved. He had decided to share information as follows:

computer use: computer in use or not (lowest fidelity)

phone use: phone in use or not (lowest fidelity)

video: clear image every 30 seconds (highest fidelity used in the prototype)

location: room in the building (highest fidelity used in the prototype)

calendar: if his calendar was marked free or busy

audio: whether he was talking to someone or not (highest fidelity used in the prototype).

Table 5.1 A listing of the choices of data to share made by our individual under observation.

Source	Levels		
Video	Motion in office	Fuzzy image (30 sec)	Clear image (30 sec)
Audio	Live sound meter	In conversation	
Location	Where you are in the building	In or out of the building	
Phone	Phone on / off the hook	Type of call	People in call
Calendar	Show free or busy	Show calendar for	

		day	
Computer	Idle or not	Length of idle time	Application list

Observers could click on the "in office" button (when he was shown as “in office”) to see a live web cam of his office (displaying a still image that updated every 30 seconds). The phone use indicator merely told observers if the phone was on or off the hook. Computer use was whether he was at the computer and using it or if he was logged out. The computer use information did not inform as to what software was being used at the time or for how long the computer had been idle. For audio information, the client indicated that the test subject was in conversation, but did not indicate to whom he was talking, although it was possible that the interaction could be viewed on the web cam. This level of information was chosen to match Hudson et al (2003), and also due to the high level of ambient sound in the area. The calendar function was limited to whether a previous appointment was booked or not. Location information told observers if the test subject was in the building, and clicking on the representation gave a section of the building the test subject was in (lab, admin, meeting room, office). After the trial, the observed individual was interviewed to find out his opinions on the system, and on the idea of relationship filtering.

Observers. Observers used the client interface and separate query system as described above. For each observer, the study was explained, and the different parts of the interface were explained. Two of the users then participated in the test of the system for four hours each morning for three days, while the other two used it for two mornings each. During this time, we watched them go through the decision process on several occasions and asked them how they were determining availability. After the trial, we debriefed the individuals as to their process of determining availability from the information that they had. we also asked them to tell me which information they used, which they had not found useful, and how they would use such a system in daily usage.

5.6 Results

In this section, we will discuss the results of the study as they relate to our theories about multiple sources, the use of relationship filtering, and the results relating to usability. We organize the results in terms of the main research questions we were investigating, as follows:

- Multiple information sources:
  - Were people more accurate with multiple sources?
  - Which sources were most valuable?
- Relationship filtering
  - How the observed individual did and did not use relationship filtering
  - Why relationship was not used more?
- Usability
  - Were observers able to use and interpret the client?
  - Was the observed individual able to understand and use the system?

Although a more structured environment might introduce increased variance in the results, it is likely that similar results would take place, as similar relationships can form regardless of hierarchy or structure in an organization. It would seem likely that stratification may lead to people being willing to share less, but that same functionality could appear based on individual preference as well. Where we think that the results may be consistent in similar organizations, they could have arisen from the particular culture at this company, and more study is needed to generalize these results across other kinds of organizations.

5.6.1 Results about using multiple sources

We theorized that multiple sources should make determining availability more accurate. First we will discuss whether people were more accurate in determining availability when they had multiple sources, and then we will discuss which sources were most useful

5.6.1.1 Were people more accurate with multiple sources?

There are three specific results that indicate that that people are more accurate in determining availability when using multiple sources.

First, there was an increased ability to determine availability, compared with more traditional displays such as IM windows or in/out calendars. There were 77 individual observations taken by individuals using the awareness client and these were accurate 72 times for 93.5% accuracy. As a comparison, the traditional means of using an in/out calendar was right 133/232 times, for 57.3 % accuracy and current availability awareness servers, where "on line" is the usual measure, had an accuracy of 65.1%. The person representing the friend in the study (R&D1) had an accuracy of 93.8%, whereas the subordinate (R&D2) had an accuracy of 87.5%. The peer (ADMN) had an accuracy of 95.5%, and the person representing the "any" category was perfect (100%). Since each had the same representation, it is not possible to draw conclusions based on different data for different people, but the accuracy is high enough to consider the prototype to be far more successful than single representations of either in/out or online. Fogarty et al (2003) found that a "conversation sensor" had an accuracy of 75% for determining availability. This is more accurate than the "in/out" or "online/offline" measure, and slightly less accurate than our Wizard of Oz experiment.

Second, despite the sources of information shared at the granularities he chose, the observed individual did not feel as if his privacy was intruded upon. We were concerned going into the testing that the level of privacy that the user would desire would not be adequate for others to gather useful information about him. Since he concluded that he was comfortable with the shared information, and the accuracy was reasonably high, it would be safe to assume that the design adequately covered both the observers' and the user's needs.

Third, the observed individual claimed no undesired interruptions by the observers during the test period, even though several were involved with him on different projects and his time was at a premium. The friend interrupted approximately 10 times, the administrative person (peer) interrupted twice a day during her testing (6 times), marketing interrupted twice in three days, and the any person interrupted once. This removal of "bad" interruptions is especially desirable since a goal of the design was to reduce interruptions that would be deemed inappropriate. Since the observed individual has had such a high number of interruptions in the past, finding a means to reduce the number of undesirable interruptions by any amount is a positive result.

5.6.1.2 Which sources were most valuable?

The results from the testing suggest that two sources of information are more important than the other four, and of the other four, one was virtually meaningless to the observers. Audio and video were considered the primary sources of useful information. If the observers knew the observed individual was talking to someone he was not immediately available. However, if they determined the identity of the person that was talking to the observed individual (via the web camera), they could determine if they could potentially interrupt. The observers treated phone status much like audio information. Calendar and location were used to inform and expand upon other information, but were clearly secondary. Computer use was virtually ignored. The observers implied that if someone is using the computer, they could be interrupted. We were wondering if the use of the computer was not meaningful for the individual under observation, but the observed individual is essentially using a computer at all times at work, even when he is working in the lab.

5.6.2 Results about using relationship filtering

We will now discuss how the observed individual used relationship to filter the data he shared and discuss why relationship was used the way it was

5.6.2.1 How the observed individual did and did not use relationship

The use of relationship wavered during the course of setting up the test, and the preferences also changed at the end of the experiment. What follows is an overview of how the observed individual used relationship in the data that he shared with others.

When we first demonstrated the system to the observed individual he separated out some sources and granularities based on relationship. However, after the first trial run he then changed his preferences so that all people saw the same information. He did not change his settings during the experiment. The observed individual felt that the differences in relationship were minor, and if someone needed to find him, they should have access regardless of the relationship. He was aware of who was viewing the information, so he did understand the relationships to those individuals. However, after the testing was complete, he then suggested he would change his disclosure preferences.

5.6.2.2 Why relationship was not used more?

There are two possible reasons that the observed individual did not use relationship more. These reasons follow with a discussion of how we could have changed our approach.

First the lack of data differentiation by relationship may have been a personality issue. As we mentioned before, the observed individual is quite egalitarian in his approach to people. Further, the observed individual knew the people watching at some level. We could have used less well-known people, but that would have deterred from the use of relationship as a filter. We did question the individual during the study to find out if he would like to modify his information sources, but he declined to do so. While he was ideally interactive enough to study (that is, he is a person that many people seek out during the day), he desires to treat all people the same (a personality trait which came out in the study). After the study he did start differentiating somewhat and he suggested that

he would provide more information to others based on relationship should the study continue.

Second, we believe that true determination of the information that is to be shared is an evolutionary process that might take quite some time to finalize. we believe that longer-term use of such a system would start to show the relationship filtering in his case (after he used the tool for four days, he changed his answers as to what he would share with others). This indicates to me that some people may start by thinking all information should be equally shared, but experience and usage would show them the efficacy of sharing different information with others. A further study would be to again let him use the tool, or let others use the tool and monitor how they change their use over an extended period of time. This indicates that the training time on such a system should be longer than a single day.

We maintain that the questionnaire was valid enough to show that many individuals do wish to differentiate; the study shows, however, that individual differences between different people can be large, and that we did not pick a candidate for a short-term test that would allow us to investigate relationship-based filtering in detail. There were also several people in the questionnaire study who did not differentiate at all; the field trial suggests that more research with a broader sample of people is needed to determine how the questionnaire results translate into real-world preferences.

5.6.3 Results about usability

In the field trial, we were also interested in finding out if users were able to use and interpret the client, and whether the observed individual was cognizant of and comfortable with the information shared and how the system used that data.

5.6.3.1 Were observers able to use and interpret the client?

After a short training session, the four coworkers were able to use and interpret the client and the data being presented. As part of post experiment interviews, we asked the observers two questions. The first question was to find out if after the brief experience with this they would use a system like this in daily use, to which each of the observers answered ‘yes’. We also asked if the information provided to them was adequate evidence to determine the observed individual’s availability, to which they also answered ‘yes’. The observers had commented that they felt the system could reduce interruptions and assist in determining when people were more generally available for interaction. They said that the system was simple to understand and that they could quickly form notions as to the availability of the observed individual. While the users did not have any problems viewing the states as displayed using the "black, white, grey" scheme implemented in the prototype, each did mention that some form of iconography (e.g. different icons for different sources) would be advantageous. As a group, they ignored computer use information after first couple of uses. Each of the observers indicated that the primary data sources used were video and audio.

5.6.3.2 Was the observed individual able to understand and use the system?

The observed individual was clearly able to understand what the system was doing and was able to manipulate the data he was sharing (even though he eventually chose to give the same information to everyone). At the start of the testing, he did ask to see what information was being shared, so we let him view his representation for a period. At the end of the study, the test subject had several comments. He suggested that we add a ‘do not disturb’ flag to declare when the normal means of information gathering did not adequately inform people as to his need for undisturbed periods of time. He felt that more information could be gathered, but he was unsure as to its usefulness (that is, more sources could be used, but he was not sure what good they would be). Regarding privacy, he stated that he found that none of the sources was too intrusive. When asked if he sensed that people in the experiment used the information appropriately he responded that he was interrupted at appropriate times by the observers.

5.7 Discussion

In this section, we compare our results to previous research, make our recommendations regarding the use of multiple sources, discuss the divergence of the questionnaire data from the prototype experiment, discuss the relevance of relationship as a filtering method for availability data, and discuss possible future research topics.

5.7.1 How do the results about sources compare to other research?

Any system has to capture information from the environment and display it in a form that allows others to determine one's availability. The results from our study indicate that some types of information (or situations) are more valuable for determining awareness than others, as has been seen in other research as well (e.g., Johnson & Greenberg, 1999). Sensor-based systems (e.g., Hudson et al, 2003; Horvitz & Apacible, 2003) are not a new concept. The idea of passing through uninterpreted information is not unusual either (e.g., Peepholes let you see a person, Traces displayed real data). By adopting these concepts, we came up with a fairly accurate system. If you compare our results to that of Fogarty et al (2003), our accuracy is higher with our multiple sources where the user determines the availability of another individual. In Fogarty et al's approach, availability could be determined correctly about 75% of the time.

One of our findings was that if someone was in the midst of a conversation they were usually unavailable, matching Hudson and colleagues (2003). Fogarty et al (2003) points out that audio and video are accurate for determining availability greater that 76% of the time for unknown individuals. Specifically, Fogarty found that using a "conversation sensor" allowed people to understand others' availability with 75% accuracy. However, our participants added a new twist to this finding, in that they would check the video image to see who the individual was talking to. Thus, in some cases, being in conversation did not automatically mean that the individual was not available.

Video information on its own was also used as a primary determinant for availability. Whereas Johnson and Greenberg used video snapshots alone for determining availability (Johnson, 1999), our results suggest that people can accurately use multiple sources as well. The failure to account for computer use is consistent with Fogarty's finding that computer use is not a deterrent to other people interrupting each other (a colleague who is quietly browsing through email would seem to be relatively available). It seems that location (as used in the Active Badge project (Want et al, 1992)) can be superseded by a new set of sensory data (video and audio, specifically conversation). It may be that computer information does not matter because people do not care about sharing it. It is somewhat low level in terms of privacy invasion in the work place (generally speaking, people in the workplace are informed that the computer is a work tool, so high levels of privacy are not expected), so giving up that information probably doesn't affect the sharer that much. Our management of the fidelity of the sources matches Greenberg and Kuzuoka (2000) where they provided video of lower fidelity to balance privacy and awareness in their Active Hydra surrogate. Fogarty et al (2003) suggests that systems might share information when a person is available but become stingy with context information when a person is more interested in solitude, which matches our finding that the observed individual wanted a 'do not disturb' sign.

Fogarty et al's position (2003) that people make decisions based on their own availability and their own desire to communicate, rather than considering a colleague's interruptibility seems to be outside the information in our findings. Obviously, there must be some desire to communicate to cause the interaction where interruption takes place. We could say that people do still understand that sometimes there are reasons not to interrupt people, but people can ignore those cues and reasons if they so chose. Providing more information appeared to reduce people's inappropriate interruption level in our study. However, we can suggest that here there is accountability for inappropriate interruption (Erickson & Kellogg, 2000) that results in less interruption (a social balancing that naturally takes place). Perhaps the multiple sources are one way to implement the "continuum of availability" from Hudson (2002) and could make

interruptions more effective. Dourish's (2001) concept of embodied interaction points agrees with our desire to create a means of sharing presence.

5.7.2 Final recommendations regarding multiple sources

Our selection of sources agrees with other research projects, particularly MyVines (Fogarty et al, 2004). We presumed that since these sources of information were historically what were used in availability research, they were likely to be of greater importance. We also tuned them in terms of granularity based on the questionnaire and the interview study. What was interesting is that audio and video overwhelmed all other information shared. This may be since these sources are the ones most naturally occurring in daily interaction. We would suggest that the other sources are not useless, but rather they inform more completely about the status of the individual in addition to the audio and video information. The one we found most surprising is the computer information, and people's lack of use of that data. In an environment where people were tied to their computers, this source was ignored. we suspect that this is due to the fact that computer work is easy to stop and start, whereas phone conversations, meetings, and personal activities are things we are conditioned not to interrupt.

The people in the study stated that they used audio and video as primary sources. If the observed individual was not in conversation with someone, then video informed as to availability by itself. Extrapolating this information outward, we think we can say that we usually determine direct availability (e.g., is someone available right now) of someone based on whether they are talking to someone, but we measure our ability to interrupt based on whom they are talking to. Therefore, we recommend that designers focus their designs on passing video and audio information, and use other sources (in this case, calendar, location, and phone status) to inform further about people's availability.

We would make three final recommendations regarding multiple sources:

1. Audio and video should be considered the primary sources of information

2. Phone, location, and calendar are useful for gathering additional information when the other sources need clarification

3. Computer use is not a very valuable source

5.7.3 Why the divergence between questionnaire and field trial regarding relationship?

In this section we need to look at two possibilities as to why we had a difference between what we expected for relationship and what was found in the trial. We need to address if the questionnaire was incorrect or if the field trial was flawed.

5.7.3.1 Possibility 1: the questionnaire study was incorrect

We believe that the questionnaire provides an accurate picture of people's initial preferences. However, it was clear from the questionnaire that there is a wide variance in what people think regarding the value of differentiating between relationships. There are number of other issues that could be considered to clarify the questionnaire results in future work. Perhaps we need to more closely review other means of filtering than relationship (e.g. using arbitrary groups, or project groups). The use of the data from the questionnaire to create a relationship filter might have been correct, but other parts of awareness need to be supported as well to test relationship filtering. Since the space of the problem of availability is so large, we may need another series of ethnographic studies to clarify more of the space of the solution. In the end, we would suggest that the questionnaire was not wrong, but may need refinement to clarify what else we need to know such as what factors affect a relationship in sharing data. We should also review whether the relationships that we chose were canonical. Although friend, peer, subordinate, superior, spouse, and acquaintance would seem to be comprehensive, there may be subtleties that these categories fail to capture. There may also be other factors (e.g., type of work, current level of activity) that interact with relationship. The question that arises is can we not consider relationship (the "who" in availability) without considering other factors? we maintain that availability awareness filtering can be done by relationship, there are clearly individual differences in the general population.

5.7.3.2 Possibility 2: the field trial was incorrect

It is likely that we would have got more varied results if we had run the experiment with more subjects, or if we had run the experiment for a longer period of time. We chose someone who was willing, available, and important in their organization; but the person also has personal notions of fairness that may have been an issue. Perhaps if the person did not know exactly who was observing them, that might have changed the sources shared and we would have different results. However, since the individuals do match the relationships in the system, and for those relationships to exist, there must be some form of interpersonal knowledge. One clue that we are on the right track is that user did point that they might change the information that they shared with others in the future.

In the end, we suspect the user would probably find a long-term set of settings that would differ on relationship if unwanted interruptions occurred based on the system's information. Perhaps people had already adapted to the observed individual's availability and simply extended the social requirements appropriately, but through longer term testing privacy concerns might eventually surface. In subsequent interviews with the test subject, he stated that even though people know he is busy, if he is working in the lab, he is considered available for interruption. Social requirements of waiting for conversations to end are observed, but he still finds that presence is equated with availability. Perhaps social re-orientation is required in the study environment to assist in normal interaction, and designers need to figure out what we need to tell people to not interrupt

5.7.4 Is relationship still a useful principle?

We would contend that relationship is still important and make four specific recommendations for using relationship as a method of filtering information

1. People will specifically only share data with certain people in particular situations (as in the questionnaire)

2. We cannot consider relationship out of its context (where expectations differ person by person)

3. Relationships between people matter in the real world. We are trying to represent real world information between individuals; therefore, relationships must matter.

4. Relationships are a more important filter for certain people and in certain situations. In the workplace we studied, where egalitarian principles rule, it might be less important.

5.7.5 Further studies

There are two possible approaches for going forward from this point: one is to expand on the current field trial, and the other is to consider other ways of looking at the same questions. Using the current study there are four possible ways we could continue the research using the same study method:

1. We could continue the field study with more people, and people in different organizational roles.

2. We could extend the study to see if more time does change preferences.

3. We could select another individual who is less willing to share information.

4. We could introduce more people into each canonical group and see if there is more variation between individuals.

There are also three other types of studies we could conduct to look at the questions about awareness and availability:

1. We could try to determine if the motive for people determining each others' availability augments how people gather information from each other

2. We could move outside the workplace into a more socially oriented atmosphere

3. We could change the client program to allow the do not disturb button and see if people still disturb the person

5.8 Other issues

There is some disagreement between the field trial and our earlier studies. We claim from our questionnaire that people want to differentiate by relationship. However, differentiating by relationship tends to give more information to people who are more important to the person and less to those on one's social periphery. More information means that an observer can make an informed decision about whether it is appropriate to interrupt or not. Less information means that you increase the opportunity to make a poor decision, but also that you are held somewhat less responsible for the bad decision. That is, if we know that you're in conversation, and you know that we know, then we cannot interrupt you without looking rude. However, if we do not know that you're in conversation, then we can interrupt (e.g. phone you) without appearing rude. This means that we are enabling people who are less important to the person to have more opportunity to interrupt.

It has been suggested that people with more information about others' workload intentionally tried to reduce the amount of disruption that they caused when they were asking questions (Dabbish & Kraut, 2003). Likewise, it seems that if we provide enough awareness information, people are selective enough to determine how to appropriately interrupt others. Conversely, if someone has less information and that lack of information results in an inappropriate interruption, this may cause the individuals to change the amount of information that they are sharing. In our research, we see people were able to appropriately interrupt the observed individual, reducing unwanted interruption. This would suggest that the increased density of information was at least appropriate for the

situation, and that other individuals could tune the information that they are sharing to their situations.

We can suggest that some individuals have less need to contact or need be contacted by members of the acquaintance group, reducing the unwanted interruptions that might occur from reduced clarity in the shared information. However, the possibility does remain that interruptions are increased through too much information being shared. The answer may lay within Boyle's work on privacy considering privacy in terms of solitude (that is, the ability to achieve privacy without requiring interaction). Perhaps we could consider a mix of interaction where solitude is the goal, forcing people to not contact others without express indication of the identity and need. We could encode a limited response via control of availability by relationship and responsibility. This is a further area of research that could be considered in the future.

5.9 Summary

The results from our testing showed us that multiple sources of information could result in higher accuracy in determining other's availability. Although we had some useful results from the Wizard of Oz testing, we were unable to completely determine the efficacy of relationship as a filtering method. Although relationship could still be used to assist in filtering the sources and granularity of user data, it seems that more work must be done in this area.

Chapter 6 Conclusions

The problem that has been investigated in this thesis is that it is difficult to achieve both accuracy and privacy in distributed availability systems, since improving accuracy through additional information may compromise privacy. Our investigation involved a review of approaches seen in previous literature, two studies to gather data about how people maintain availability awareness and how they would use relationship to differentiate disclosure, and a field trial of an awareness prototype that allowed fine-grained control over outgoing information. This chapter summarizes this research and provides conclusions and future work for this project.

6.1 Summary of the research

We started by determining the types of information that should be gathered about people to let others determine their availability. Previous work suggested a wide range of information sources; specifically, we were able to see how people used visual information to view others, and location and computer-use information to determine their status. Using this previous research, we carried out an interview study asking people what they did to determine others' availability, from which we learned that people used environmental information (e.g., are the lights on in the office), historical patterns (e.g., is the car in the lot at a certain time), personal patterns (e.g., is the mobile phone in its cradle), and direct observation (e.g., where is the person going, who is she talking with) to determine availability for interaction.

After the interview study, we focused on the issue of relationship as a way to control disclosure of information. We generated a list of relationships and sources at several levels of granularity that we deemed to be both important and useful. We summarized this into a questionnaire that we presented to a group to provide us with their willingness to share the data sources with people in the selected relationships, as well as their desire to see the same information about others. We discovered that people do differentiate disclosure by relationship, although not everyone differentiates in the same way.

We learned several lessons from the questionnaire study. First, the study suggests that awareness servers should provide a means for differentiating information disclosure. Relationship appears to be an attribute that people use in this process, although further study is needed to determine whether other attributes (or customizable groups) could be more appropriate in some situations. Second, awareness systems should make it possible to disclose at least a minimum amount of information from a variety of sources. This was acceptable to a large majority of our participants, and the additional information could help people to make better decisions about availability. Since low fidelity levels were treated similarly, it is possible that the lowest level of fidelity may not even be needed in awareness servers; however, since the lowest level lends itself well to on/off type displays that fit into a small space, it may be necessary to retain it regardless of whether anyone will actually choose it. Third, interfaces for controlling disclosure are much more important than controls for the fidelity of incoming information (other than to control solitude as discussed above). Control over outgoing information should be easily available in the interface and quick to use. The reason that controls for incoming fidelity are less important is that the amount people are willing to disclose is almost always lower than what people would be willing to see about others – that is, few people are going to receive too much information. The controls should be made available, but do not need to be as easily accessable as are controls over disclosure. Fourth, awareness servers should allow differentiation separately for each information source. As a default, these systems should provide less information about computer and telephone, and more about location and calendar. Again, however, the ability to change these defaults should be provided.

We also concluded that it is possible to form a framework that could be applied to the needs of users and observers to assist in balancing awareness and privacy. Based on this framework, a prototype was developed and tested to determine the accuracy of the results as applied to a practical design. This prototype was then used in an experiment where four observers received data about a single test subject over four days. In that experiment, we were able to observe people create their strategies for determining the availability of the test subject, use the sources, and ascertain how accurate the prototype was.

Our subjects in the field trial related that they used audio and video as primary sources; audio as to whether or not someone was talking with the observed individual, and video to inform them of whom. If he was not in conversation with someone, then video informed them as to overall availability. Extrapolating this information outward, we can suggest that people usually determine direct availability (e.g. is someone available right now) as a measure of whether they are talking to someone, but we measure our ability to interrupt based on who they are talking to. Therefore, we recommend that designers focus their designs on transmitting video and audio information, and use other sources (in this case, calendar, location, and phone status) to inform further about people's availability.

We made three final recommendations regarding multiple sources of information:

1. Audio and video should be considered prime sources of information

2. Phone, location, and calendar are useful in situations where the other sources need clarification

3. Computer use is not a very useful source

We also looked at reasons for the differences between the questionnaire study and the field trial, and concluded that more study is needed to determine how relationship filtering will work in a real-world situation. For example, the trial could be run again for a longer time period, with a more varied group of people.

6.2 Future Work

This research focused on only one aspect (relationship) of a complete understanding of availability awareness. Within that context, we were able to determine some general rules about availability awareness when relationship is used as a filter for information. From here, it would be interesting to determine how other factors – such as activity, urgency, and social situation – affect availability disclosure. It would also be interesting to see how the other factors are used as filters for the information sources. As much as possible, we tried to use discrete values for representing the sources of information. It would be of interest to apply filtering as a continuum to the sources to determine if a sliding scale would be useful for exactly determining what information people are willing to share with others.

This research has only begun the process of looking into the ways that privacy can be protected in availability systems. Other work going forward needs to more deeply explore other aspects of privacy in the context of availability awareness. We need to discover how solitude needs to be protected in such systems, and what factors lead different people to feel comfortable with these kinds of systems. Other future work could include other forms of filtering of data. We examined relationship as a filter for source, but other work could examine motivations for contact (critical versus non-critical communication). The prototype designed and tested worked with a specific set of sources. Other sources may become available in the future; for example, a model that allowed a "dictionary" of sources to be included with the information transactions could expand and allow people to customize their sources to the specific circumstances they are in. We used very simple representations for the sources and the granularity levels in the prototype. Further work could also include the usefulness of iconography in such systems, and try to determine if the need to interpret these visual representations unreasonably increased the users' cognitive load.

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Appendix A – Availability Information Questionnaire

What follows is what was presented to the individuals who completed our availability awareness survey.

Availability Information Questionnaire

Scott Davis, University of Saskatchewan
May 22, 2002
Participant number : _____

Some information about yourself:

Your age:_____

Gender: _____

Position (description/title):_____

Do you use ICQ/AOLIM/MSNMessenger (or other instant messaging client)? Yes ____ No _____

In your workplace (past or present), what tools have people used to determine if someone is available for interaction (notes on door, calendar, etc…)

Part 1

Introduction

Two basic workday scenarios are presented below. For each scenario, there is a table that lists several types of information sources (at left) and several types of people (at top). In each square of the table, please indicate whether you would be willing (Y), not willing (N), or maybe willing (M) to let the person at the top of the column gather the information about you, assuming that they had decided that they needed to contact you.

Scenario 1: a typical morning

It is a typical workday morning, immediately after coffee break. You are at your desk, and have no immediate time constraints (meetings, expected phone calls, pressing deadlines, etc.).

	Friend in the workplace	Project supervisor	Peer on same project	Subordinate on project	Spouse	Secretary	Any other employee
Type 1. Video							
Live video (20 FPS)							
Regularly-updated image (every 30 seconds)							
Fuzzy still image (identity visible but not action) (every 60 seconds)							
Motion detector only (every 60 seconds)							
Type 2. Audio							
High quality sound link							
Muffled sound link (words not understandable)							
Sound level (updated every second)							
Sound detector only (every 60 seconds)							

Type 3. Location							
Moving dot on a map (updated every second)							
Room and location							
Type of room (meeting room, office, etc)							
In/out of building							
Type 4. Telephone							
Sound link to phone call (with names of callers)							
Call in progress (with names of callers)							
Call in progress (with type of call – toll/local)							
Call in progress only							
Type 5. Calendar							
Entire calendar for today							
Current calendar entry and booked/free for entire day							
Current calendar entry							
Booked or free currently							
Type 6. Computer activity							
High resolution screen shot							
Applications and idle time							
Idle time only							
Active/not active only							

Scenario 1 comments:

Part 2

Introduction

For this scenario, there is a table that lists several types of information sources (at left) and several types of people (at top). In each square of the table, please indicate which you would be most willing to use to determine the availability of the person at the top of the column.

Scenario 2: a typical morning

It is a typical workday morning. You need to speak to the person listed at the top of the column about a issue that is not very pressing, but does need their input. You have determined that you need to talk to them within the next few days.

	Friend in the workplace	Project supervisor	Peer on same project	Subordinate on project	Spouse	Secretary	Any other employee
Type 1. Video							
Live video (20 FPS)							
Regularly-updated image (every 30 seconds)							
Fuzzy still image (identity visible but not action) (every 60 seconds)							
Motion detector only (every 60 seconds)							
Type 2. Audio							
High quality sound link							
Muffled sound link (words not understandable)							
Sound level (updated every second)							
Sound detector only (every 60 seconds)							
Type 3. Location							

Moving dot on a map (updated every second)							
Room and location							
Type of room (meeting room, office, etc)							
In/out of building							
Type 4. Telephone							
Sound link to phone call (with names of callers)							
Call in progress (with names of callers)							
Call in progress (with type of call – toll/local)							
Call in progress only							
Type 5. Calendar							
Entire calendar for today							
Current calendar entry and booked/free for entire day							
Current calendar entry							
Booked or free currently							
Type 6. Computer activity							
High resolution screen shot							
Applications and idle time							
Idle time only							
Active/not active only							

Scenario 2 comments:

Questions

Would having this information charted over time be useful to you?

Would you allow these sources of information to be charted over time by your

supervisor
peer
spouse
subordinate

Would you allow compilation and playback of this information for

video

audio

location information

phone status information

What possible changes in how busy you are change the information you are willing to share?

What possible changes in how urgent you need to contact someone changes what information you would gather about them?