Chapter One Introduction

1.1 Research Background

Information communication technology plays an important role in a large office work environment in next generation of social bonds. People know that communication and information exchange are the way for efficient work, and the face-to-face communication is the most common way during social contact. We can distribute the way of face-to-face communication into two parts, formal and informal. The formal is on schedule meetings and appointments…etc and are held in some specific places. The informal one can be happened in any time and any place in office. Informal communication is considered to compensate the weaknesses of the formal flow of information. (Schutze, 2000) Therefore, we may say informal communication may play a important role as same as the formal in human relationships. However, the formal starts by an obvious purpose and the purpose form the motivation for people to make contact, but the informal one starts from an unexpected opportunity. Mitchell provides a scenario in his book "e-Topia" page 3 (1999):

> *"Long ago, there was a desert village with a well at its center. The houses clustered within the distance that a jar of water could comfortably be carried. In the cool of the evening the people came to the well to collect the next day's supply of water, and they lingered there to exchange gossip and conduct business with one another. The well supplied a scarce and necessary resource, and in doing so also became the social center- the gathering place that held the community together. "Then the piped water supply came. Who could deny the practical advantage? It was more convenient, and kids no longer got cholera. Population grew, and the village expanded into a large town, since houses could be supplied with water wherever the pipes could run. Dwellings no longer had to concentrate themselves in the old center. And the people ceased to gather at the well, since they could get water anytime, anyplace. ....."*

The scenario pointed that we need an opportunity to start an informal social event, and people have willing to make contact to others. But, the new technology decrease physical contact social chances; even people are neighborhood. The theory of social bonds (Hirschi, 1969) gives us the idea that human has the potential desire to join social events and contact to people especially they are acquaintances. How might we support informal communications? Maybe the key point is how we can find the opportunity to support informal communications. Some researchers try to use the method of context-mediated awareness. (Bardarm, 2000; Bardarm and Hansen, 2004; Schmidt and Van Laerhoven, 2001) Back tracing to the common media in the general offices, text-based short message may be the

most frequently used in information communication. Streitz (2003) points that the media creating words and sentences to convey all kinds of information in any situations. Some situations don't need much text to explain the situation. They proposed a concept "light-weight means for communication" to represent the situation without text. They use simple figure patterns to perform light-weight means and represent different level of the social situation by different operation. From much past researches, whether distant or local information technology synchronous communication has been implemented and studied in many cases; however it has an implicit problem: the work could be obtruded to break off (M. Handel & J. D. Herbsleb, 2002). Thus, a concept of new technology, "calm technology" has been revealed by Mark Weiser (1996). The idea is to bring the periphery to central and to back quickly. Thus, the periphery must be light. After Mark's idea, lots of ambient display concerned researches become a trend (Heiner, Hudson and Tanka, 1999; Ishii et al., 1998; Prante et al., 2003; Redström et al., 2000; Skog, 2004). Their implementations all have the "calm" spirit within.

In this research, we take "context-mediated social awareness" as the start point consideration to create opportunities for supporting informal communication, and calm technology and light-weight means are our implementation principles. In chapter two, we'll discuss concepts of these domains.

1.2 Research Problems and Objectives

1.2.1 Research Problem

Lots of formal or informal meetings and chatting are held everywhere in the office environment. Most informal meetings or chatting are in the social place such as lobby, coffee corner, hallway….etc, and those who are in the place may have willing to accept others' joining with easy manners even feeling of obtrusive notification from other members. In modern work office environments, staffs usually grasp the information they want through the internet at their work seats, and they also accept other information by peripheral awareness from neighborhood colleagues, but the kind of awareness is at local and far from social places. Members at their own seats might not aware of the social events in the social place, and those social events might be the opportunity for informal communication. For example, a designer is busy in his digital art stuff. His group colleagues who have an idea chatting at the magazine zone without informing or inviting him are talking about some interesting ideas of group work. Somehow, the idea might be inspirable to the designer, but he even didn't know the chatting had happened. If he was aware of the chatting, he could choose to join or ask colleagues to get the context of chatting, or those who are in the magazine zone can be aware of the existence of the designer and invite him to join the chatting. In big office environment, colleagues may work in the same building but different levels, and they are uneasy aware the others' presence. However one of them may lose some chances to coordinate and integrate the group work or get some good ideas. Studies of organizational and office work show that 90% of brief conversations are unplanned (Whittaker, Frolich, and

Daly-Jones., 1994), A survey data shows that informal communication take 25% to 70% of the general work hours, (Kraut, Fish, Root, and Chalfone, 1993) and beyond time, informal communication is considered to compensate the weaknesses of the formal flow of information. (Schutze, 2000) G. Henn (2002) indicates that 80% of innovative ideas created in offices are a result of informal personal communication. Therefore, we may say informal communication may play a more important role than the formal one. However the contents of these social events are hard to share with colleagues who didn't join the social activities. For the reason, a mechanism of social events awareness and back sharing channel are required. Beyond the synchronized situation, in some design studios, members would have different habit of working time. In the situation, colleagues have few chances to have informal or formal meeting. In order to promote the informal conversations, the mechanism mentioned above should also support asynchronous situations.

1.2.2 Research Objectives

In this paper we describe a social awareness system conceptual framework which is based on collected multiple sensor data and context-mediated artifacts for finding the opportunity to extend informal communications.

According to the observation in office environment, we found that informal communication can satisfy people's desires, help mental rest and integrate group work. However members may not be aware of social events happened because of the bad relationships of the plan between personal seats and social places. We use two terms, "monitoring" and "displaying" (Schmit, 2002) to form the concept of computer supported system (fig. 1.2.2.a) for the social events awareness between personal seats and social places. Based on a scenario and steps in social awareness, the system is mounted three main functions: (1) Monitoring the existence of social states of the social place. (2). Displaying the light weight meanings of the group ID and activity both in personal seats and social places. (3). Broadcasting the information of public social events, given specific instant massages over network services. The main software system frame work includes three parts: (1). Multiple sensor data collecting server. (2). Social place server. (3). Personal seat clients. And the whole system can be separated into three parts: (1). Social events inference engine. (2). Communication server. (3). Context-mediated artifacts. Later, we'll use a scenario to describe how the framework works and test its implementation result with a few users to explore the possibility of further developing physical context mediator.

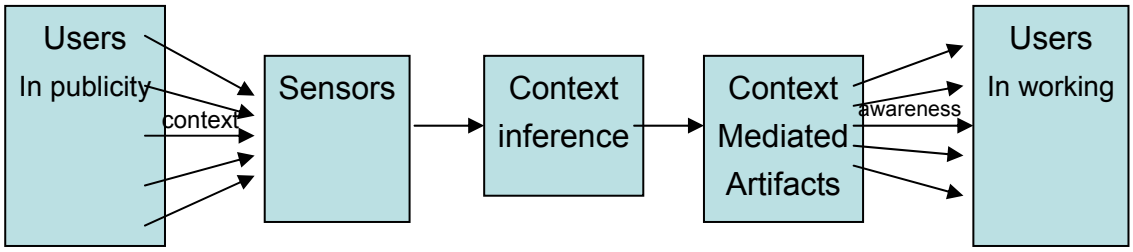


Fig 1.2.2.a Social Awareness System

1.3 Research Steps

Our approach tries to find out what social events are by multiple sensor data and offers a context-mediated channel to connect colleagues both in social places and work seats. Hence, we use a scenario to explain how the approach works and implement the approach.

First we choose an office environment to find out where informal communication or social events happen all the time. We set a suitable scenario to develop the conceptual framework, and we choose several social events to analyze them into physical cues. According to the basic framework, we implement the prototype of the framework in the scenario for studying more detail computational processes under the principle framework, and we test it with few users to get some user experience for more clues about user interface and the possibilities of further development. Finally, we will discuss some problems and issues in the system and set the future study.

This paper structures as five chapters. *First chapter* give the simple image of this paper and research problem and goal. *Second chapter* introduces the research background, formal related work and related technology. *Third chapter* plans the entire structure of the social awareness system. And based on the third chapter we implement the scenario in *chapter four*. *Fifth chapter* is the questionnaire testing, discussions, summary and conclusion.

Chapter Two Background Review

In this section, the connecting relationships of these background domains are going to be introduced. “Social Awareness System” is based on the following domains to be built. “Social Awareness System” is aimed to build in a ubiquitous computing environment to enhance the context awareness of spatial context and human interactions. Context-awareness is the central idea of pervasive computing environment, and lots of interactive mechanism is based on context-awareness analysis. The technology of pervasive computing is relied on network communications and sensor technology and is the mid-part to connect people and capture spatial context. The end-part will be a physical interface for user’s operation. To implement the awareness part, recent researches are toward ambient displays and ambient interfaces. The principle of interface design is following the domain, “Ambient Intelligence”, and the supported technology is based on physical computing and embedded system design. With these domains, “Social Awareness System” has a base knowledge to perform its basic framework.

2.1 Awareness

2.1.1 Context-Awareness

According to Webster, “awareness” is the state of elementary or undifferentiated consciousness. To define more specifically, the term refers to anything from consciousness or knowledge to attention or sentience, and from sensitivity or apperception to acquaintance or recollection (K. Schmidt, 2002). CSCW researchers are full of confident with using the term in combination with different adjectives, e.g., ‘general awareness’ (Gaver, 1991), ‘collaboration awareness’ (Lauwers and Lantz, 1990), ‘peripheral awareness’ (Gaver, 1992), ‘background awareness’ (Bly et al., 1993), ‘passive awareness’ (Dourish and Bellotti, 1992; Dourish and Bly, 1992), ‘reciprocal awareness’ (Fish et al., 1990; Schmidt, 1994; Robertson, 1997), ‘mutual awareness’ (Benford et al., 1994; Schmidt, 1994; Rønby Pedersen and Sokoler, 1997), ‘workspace awareness’ (Gutwin, 1997; Gutwin and Greenberg, 1999; Gutwin and Greenberg, 2002), etc. The proliferation of adjectives indicate that the term ‘awareness’ is vague and abstract, that researchers notice that the term is being used in different usages, and that it is in need of some additional criteria to be useful. The term ‘context-aware’ was introduced by Schilit and Theimer (1994). They defined context through giving a number of examples of contexts – location, identities of nearby people and objects, and changes to those objects. There are also works that provide analyses of context (Brown, 1996; Franklin and Flaschbart, 1998; Hull, Neaves, & Bedford-Roberts, 1997; Ward, Jones, & Hopper, 1997). These works refer context as environment, surroundings, or situation of either the user or application. From these previous works, we know that additional criterions should be set in the context we refer to. However, these previous works limit themselves to static entities. Definitions

that focus on dynamic aspects of context were also introduced, focusing on the constantly changing aspect of context (Dey, Abowd, & Wood, 1999; Pascoe, 1998; Schilit, Adams, & Want, 1994). These dynamic definition sets of context make it difficult and complex to establish the static criteria in the context we want. Dey and Abowed (2000) defined the term 'context' in their paper as "any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and application themselves." This definition points out another important aspect of context: relevance. To summarize, context has been defined as an element in the user and application's environment, including time and date, location, temperature, lighting, etc., that may constantly change. And also Dey and Abowed (2000) suggested us that use the five Ws: who, what, when, where and why to build the list of the relevant contexts.

Now, we have the idea that before applying the "awareness" we should set the relevant contexts. In this paper, we try to translate social events or human interactions into relevant physical environment contexts for applying into the application and transforming the contexts into another kind of environment contexts with simple meanings. That's the reason why we have to understand what contexts could be hide in back of social events or human interactions. But first, we have to know what social awareness is.

2.1.2 Social Awareness

Ethnographic studies of co-located cooperative work show that people tacitly and unobtrusively align and integrate their activities in a seamless and highly sophisticated manner without interrupting each other. The term "social awareness" has been used to describe this practice (Schmidt, 2002; Heath et al., 2002). For example, study of operating theatres (Heath et al., 2002) reveals the subtle social mechanisms, which help people adjust their own effort according to other co-located with them. Therefore social awareness helps to minimize interruptions and disturbances when engaged in cooperative work. In Schmidt's research, a phenomenon named as "appropriate obtrusiveness":

> "*In monitoring the work of others and in displaying aspects of their own work, actors exhibit great care and much skill in choosing an interactional modality is obtrusive or unobtrusive to a degree and in a manner that is appropriate to the situation at hand." (Schmidt, 2002, p. 292)*

From the explanation of Schmidt's 'appropriate unobtrusive', Jakob and Thomas defined that social awareness is a mechanism for making appropriate interruptions adjusted to the nature and urgency of current task and it is a highly active and coordinated activity (Jakob & Thomas, 2004). And in Heath and Luff's research, they use the concepts, 'monitoring' and 'displaying' to describe the mechanism of social awareness (Heath et al., 2002).

Monitoring is the action referring to actors or states actively over watched by other people or applications. The act of monitoring doesn't disturb the person monitored and is also characterized as a fairly focused process. Monitoring is the most common way to find out the specific context or relevant context. The entire process of monitoring is not only including the observation but also the understanding part. For the reason, the process is composed by knowledge and active selection part. In other words, monitoring process does not monitor the entire context, and it is the current activity of the process to decide which parts of context should be monitored (Schmidt, 2002; Heath et al., 2002).

Displaying is the opposite term of monitoring. In Heath and Luff's research, the term 'displaying' refers to the process of the transformation of an implicit signal or situation to an explicit one. Just like the monitoring, displaying is a selective process and the selection mechanism is relevant to the relevant context of what monitored. So, we can say, the current activity of monitoring decides which part should be monitored and which relevant context should be transformed to be displayed (Schmidt, 2002; Heath et al., 2002).

In briefly, social awareness is the co-sentience between human to human, not only a person's sentience. The way to arise social awareness is the process of monitoring and displaying. In this way, we have the idea of that "Social Awareness System" should have these two concepts within. Now, we can look for what is social events context and how to find its entities.

2.1.3 Social Events Context

Before the definition of social events in this paper, we have to understand the term 'social bond'. The term has been revealed by Travis Hirschi in 1969, and it refers to the mental connection between an individual and the society. The theory assumes that when an individual lacks the connection with the society or the connection is weak, the individual may have aberrational behavior. In the theory, there are four significant elements: 'attachment', 'commitment', 'involvement', and 'belief' (Travis, 1969). These four elements show the basic mental desire of that people are eager to make the connection with the other people. Depending on these basic mental requirements, people have all kinds of social events to satisfy these inner desires. Therefore, the existence of varieties of social events is due to social bond. Thus, there are some high-level criteria of the social context what we looking for in social awareness: 'attachment' and 'involvement'.

Many CSCW researches about social events focus in office environment. These social events are inclusive of the inevitable ones and unexpected ones. The inevitable ones refer to those reserved appointments or meetings which may be controlled by fixed or active schedules. These activities are not purposed to satisfy some criteria in social bond but mean to coordinate the collaborative works. Thus, this kind of social event is not what we discuss in our system. Due to the basic criteria of social bond, here, we focus on those unexpected social events. To understand unexpected social events, we can take informal communication as reference. In Steve, David, and Owen' researcher, they treat informal communications as taking place synchronously in face-to-face settings. They are distinct from

other methods of office communication such as phone, documents, memos, email, FAX and voicemail (Whittaker, Frohlich & Daly-Jones, 1994). Thereby, we know that unexpected social events might have its own taxonomy which may includes opposite subjects such as synchronous to asynchronous, face-to-face to distant, explicit to implicit, and with voice to without voice…etc. From the taxonomy, we can find that no matter what the social event is, they all have some physical elements to describe what they are and what current state they are in. How to find these distinguishing properties? Peter and his fellows give the taxonomy and examples to find distinguishing properties and metaphors in context. The taxonomy is composed of observer, actuator, container, presenter, scope, associated, and access limitation (Coschurba, et. al., 2001). Some researchers use sensor technology and inference engine to turn these physical properties into classified situations. Schmidt and Van Laerhoven offer an example to show the idea:

Situation	**Sensor Data**
User sleeps	It is dark, room temperature, silent, type of location is indoor, time is "night-time", user is horizontal, specific motion pattern, absolute position is stable
User is watching TV	Light level/color is changing, certain audio level (not silent), room temperature, type of location is indoors, user is mainly stationary
User is cycling	Location type is outdoors, user is sitting, specific motion pattern of legs, absolute position is changing

Table 1. Real world situations related to sensor data (Schmidt and Van Laerhoven, 2001)

The above example is not relevant to social events but focusing on an individual. However, it gives us an image of how describe the situation using physical world elements. As the same fundamental, co-located social events context can be described just as the way of the above example. In this paper, we use the method to find out the context of the selected social events in office environment.

2.1.4 Context-Mediated Social Awareness

Most of researches about social awareness only discuss social awareness in settings where the people in co-located social events, or at least with visual cues about what happened or what is going on. If people cooperate and work in a distributed location in same building, social awareness cannot be obtained directly except mediated by some social artifacts such as phone, mobile phone, mobile computers, email…etc. Some of them can be synchronized and some are asynchronies. For instance, whiteboards are often used to communicate and inform in hospital (Bardarm, 2000). Thus, the type of social awareness with mediated artifacts for extending time or location Bardarm used the term "mediated social awareness" to describe it. In Bardarm's research, he thought colleagues can find their co-workers' situation with different cues and basic knowledge of the work (Bardarm and Hansen, 2004). For example, co-located people have visual cues about their connection and sentience. Hence,

Bardarm gives the context-mediated social awareness a definition:

"People use 'context cues' observed in their environment to maintain some kind of social awareness. – or to put it in other words; the working context is used to mediated social awareness" (Bardarm and Hansen, 2004; p. 193)

However, the idea is not revealed by Bardarm. In 1998, "inTouch" (Brave, Ishii, and Dahley, 1998) uses two haptic devices to facilitate the interaction between two non co-located colleagues. In 1999, Gellersen and Beigl have faced the challenge of the work-awareness between non co-located colleagues (Gellersen and Beigl, 1999). In their solution, "sensor-based context-awareness" is the back-end process, and the "mediated artifacts" process the mid-end; finally, the front-end uses the concept, "ambient display". Here, from the Gellersen and Beigl's solution, we know the spiritual elements of context-mediated social awareness are just like Heath and Luff said: monitoring and displaying; furthermore, mediated-artifacts is the key to make "context-mediated social awareness" different to "social awareness".

2.1.5 Computer Supported Collaborative Work

In the idea of computer supported cooperative work (CSCW), many approaches and researches had been developed for solving the network supporting groupware or workspaces. In the early 1990s, the experience of email as a part of network groupware had been recorded. (Y. Goldberg, M. Safran, and E. Shapiro, 1992) Network bridges the virtual communications to establish the collaborative works. NIT Human Interface Labs developed a co-drawing system via video conference to stimulate the creative ideas through co-thinking (lshii H., Kobayashi M., and J. Grudin, 1992). The examples are too massive to list here, and many successful researches are turned into consumer products. The research trend is very successful, however some implicit problems had been discovered into explicit. These problems include that distant connection may not satisfied social bond requirements. Thus, the next trend of the CSCW researches focus more on the co-located colleagues, or groups. These researches are more and more close to the context mediate social awareness.

2.2 Pervasive Computing Environment

2.2.1 Introduction

The idea, “Pervasive Computing” was revealed in the book, “The computer for the twenty-first century” for over a decade ago (M. Weiser, 1991). Mark has a vision which describes the style of computers in twenty century. He predicts that all computers will be disappeared, distracted and still computing in every part of an environment. This abstract idea can be thought as two parts. (1) Integrating physical I/O interface into environment design. (2) Network communications between computing nodes. Some developers think the idea can build intelligent environments. More than the idea, learning from science fiction novels, developers think intelligent environment should have an agent to integrate and void conflictions in network communications. Project “Oxygen” (project, “Oxygen”, 2002) and project “Aura” (project, “Aura”, 2002) both used voice reorganization technology for communicating with the agent to control environment computing. Microsoft Research-Vision Group revealed their research achievements contouring the Easy-Living environment.(project “Easy-Living”, 2003) The most different with the above projects, they use sensors (camera, pressure sensors…etc) to make the environment sense some specific users’ movements and then computers do the correspond events.

As the personal computing leads the trend in recent years, researchers put their eyes on combining the wireless networks, mobile devices and ubiquitous computing. Stanford University tries to use this kind of combination to build a ubiquitous computing environment. (A. C. Huang, B. C. Ling, J. Barton, A. Fox, 2001) The research group tries to explore a vision of an appliance computing world where users move data seamlessly among various devices. The whole project has set three principles. (1) Bring devices to the forefront. (2) Keep the number of user-controllable features users must learn to operate a device to a minimum. (3) Place the software required to accomplish tasks in the Internet infrastructure. These principles may be the basic ideas of this type of researches. Some principles here are quite similar to those in the Sony computer research lab. Jun Rekimoto implements the idea: add a button to easily build communication between mobile devices and local devices. The same idea is also the vision of NFC (Near Field Communication [W1]) (Fig. X.) technology — physical and simple to connect just like pushing a button.

Fig. X. NFC [W2]

With Near Field Communication (NFC) enabled devices, you will make your travel reservations on your PC and download your tickets to your mobile phone or PDA, just by bringing it next to the computer, and then you will check in for your trip by touching your handheld device to the departure gate kiosk -- no paper, no printing needed.

After many development and design works in ubiquitous computing and tangible devices, researchers are trying to find rules and paradigms of designing the architecture for such cases. Xerox Palo Alto Research Center offered five questions for designers and researchers. (V. Bellotti, M. Back, W. K. Edwards, R. E. Grinter, A. Henderson, C. Lopes, 2002) The five questions are made from the analysis of human-human communication that are mundanely addressed by traditional graphical user interface designs. These five questions are: (1) when I address a system, how does it know I am addressing it? (2) When I ask a system to do something how do I know it is attending? (3) When I issue a command (such as save, execute or delete), how does the system know what it relates to? (4) How do I know the system understands my command and is correctly executing my intended action? (5) How do I recover from mistakes? These questions are quite important to considerate when we design GUI or SUI (spatial user interface).

2.2.2 Related Cases

Information accessing and changing play important roles in pervasive computing environment; many researches work on the information changing architecture for forming the infrastructure of pervasive computing environment. **AIPIS** is such a project with two main purposes: (1) provide users with a hands-free computing environment that automates much of the drudgery associated with the use of computers; and (2) require human attention for only critical aspects of task execution that require their input (Thayer and Steenkiste, 2003). This project is also the pre-work of project Aura. The relationship also tells us that the architecture of pervasive computing environment is very complex. To minimize the drudgery of development and costs, Gupta and Moitra suggest us to use the existing information technology and existing infrastructure to evolve a suitable one (Gupta and Moitra, 2003).

Before the whole integrated pervasive computing environment, many big projects use the distributed manner to develop its sub-projects. Project "**Roomware**" is the typical one (Streitz, Gelβler and Holmer, 1998). **Roomware** had been set with three components at initial stage. The three components are "**DynaWall**" – and interactive electronic wall, "**CommChairs**" – mobile and networked chairs with integrated interactive devices, "**InteracTable**" – an interactive table. Later, with the support and connection of the cooperative hypermedia framework COAST (Schuckmann et al., 1996), the integrated project "**i-LAND**" (Streitz, et al., 1999) had been built. The same research group starts another similar project of pervasive computing environment named "**Ambient Agoras**" (Prante, et al., 2004). The project also contains three sub-projects: "**InfoRiver**" (Fig. X.), "SIAM", and "**Hello.Wall**" (Fig. X.). The much different concept capering with "**i-LAND**" is the human-computer interface design principle.

Fig. X. InfoRiver (Prante, et al., 2004)

Fig. X. Hello.Wall (Prante, et al., 2004)

Many pervasive computing researches are trying to make the environment smarter. Thus, the type of "**smart house**" researches or projects are had been developed in many companies and university such as Panasonic, Philips, Microsoft, MIT…etc. The project, "**house_n**" had been started in the Architecture Department of MIT (starts in 1999). Here is the web introduction:

> *House_n research is focused on how the design of the home and its related technologies, products, and services should evolve to better meet the opportunities and challenges of the future.* [W3]

The project is aimed at the future, and this shows the same ideas as the other institutes. Philips Research put the emphasis on their smart house with distributed smart consumer electronics. The **eHIII House** is another smart house project. It is the most recent enhancement of the **HII** (Home Information Infrastructure) house developed and implemented by Japan's Matsushita Electric Industrial Co., Ltd (a member of the ECHONET Consortium [W4]). The main concepts of the project are "**e-living**" and "**e-business**". Through it closed in March 2002, but some of research results have been transferred to the Panasonic Centre (starts in September 2002). (More smart home project information shows here: [W5])

Why smart house can be smart? The reason probably will be the varieties of sensors. Physical sensors play significant role in pervasive computing environment. In the project "**Easy-Living**", researchers use cameras to catch where the user is in the room and use the pressure sensor to detect whether a user had a seat or not (project "Easy-Living", 2003). In the project "**Hello.Wall**", RFID module is used as the identification sensor (Streitz, et al., 2003). And sound sensor is used in project "**Aura**" (project, "Aura", 2002) and project "**Oxygen**" (project, "Oxygen", 2002). Actually, various types of sensors are used in different cases. A research studied the typical sensors needed in pervasive computing show the quantitative data of varieties of sensors used in applications and in sensor nodes. Whether the data is the type of application or sensor nodes, the rate of using movement sensor is the highest and the pressure sensor is the second (Beigl, et al., 2004).

The idea of using physical sensors in pervasive computing is similar to context-mediated social awareness. However pervasive computing is more complex then context-mediated social awareness. Although the way how sensors were used in both types of research is the same, the purpose and properties of the follow steps are quite different. After all, context-mediated social awareness militates in more than two people, and most of the time, pervasive computing focuses on an individual. To certain extents, context-mediated social awareness still uses some basic ideas of pervasive computing.

2.3 Ambient Interface

As we mentioned before, the system in this paper we use the ambient interface as the concept and principle to implementation the mediated interface between users and the system. This section is going to introduce the concept of this domain.

Ambient interfaces go beyond the classical graphical user interface and use the whole environment of the user for the interaction of between the user and the system. Since the idea, “calm technology” has been revealed by Mark Weiser in 1996, ambient interface becomes a new design principle for information awareness environment.

2.3.1 Calm Technology

The concept of the term “ambient” comes from its property, “periphery” which has been mentioned as a significant property of “calm technology” (Weiser, 1996). In much earlier, Brown and Duguid give the term “periphery” a definition: *we use “periphery” to name what we are attuned to without attending to explicitly* (Brown and Duguid, 1996). It also can be explained by an example given in Weiser’s article: *Ordinarily when driving our attention is centered on the road, the radio, our passenger, but not the noise of the engine. But an unusual noise is noticed immediately, showing that we were attuned to the noise in the periphery, and could come quickly to attend to it.* The idea is much common as the term “peripheral awareness” in CSCW researches (Gaver, 1992; Bly et al., 1993; Benford et al., 1994). So, in Weiser’s idea, a calm technology will move easily from the periphery of our attention, to the canter, and back. The concept becomes the basic principle of ambient interfaces. Another feature of calm technology is to enhance periphery reach by bringing more details into the periphery. Weiser thinks that the result of calm technology is to put in a familiar place to acquaint us what happened around us, and so also is going to happen, and what has just happened. Thus, Weiser also points an important key of where calm technology should exist to function well and help our lives. The idea also reminds us the relationship between calm technology and our memories. Calm technology aims to be embedded in the environment or artifacts that we are familiar with. That’s the reason why it can bring the periphery to center efficiently.

The main key of how calm technology performs its information is subject of information visualization technology. And the way how it performs, the physical type of how it performs and the variation how it transform become the discussion points of ambient display.

2.3.2 Ambient Information Display

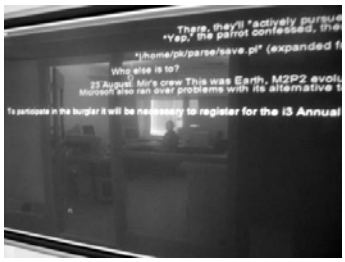


Fig. X. ChatterBox (Redström et al., 2000)

Fig. X. Water Tank (Heiner, Hudson and Tanka, 1999)

The most common ambient display example is inner office windows (Weiser, 1996). The example shows a phenomena which describes that when walk through a corridor we can see others' motion behind inner windows peripherally. In recent years, ambient display is not showed in traditional media but all kinds of new media such as plasma, projector images, light patterns, bubbles patterns, and even transformed traditional media. Much of cases used plasma or projector images to show their information in ambient way. The project "ChatterBox" (Fig. X.) is an informative art ambient display using LCDs or plasmas to show the art (Redström et al., 2000). "Activity Wallpaper" uses changing projection images to show activity information (Skog, 2004). In "ambientROOM", most of interactive images are projected on the wall (Ishii et al., 1998). Despite most cases using computer images as the contents of the ambient display, some researchers more like to use some physical elements to symbolize the contents of ambient display. A research implements the possibility of using bubbles in pipes as the elements to form different visual patterns to be information display (Heiner, Hudson and Tanka, 1999) (Fig. X). Except bubble patterns, project "Hello.Wall" uses light patterns to differentiate the information of ambient display (Prante et al., 2003). Some conventional media such as lights, sound or some actions of artifacts are also good materials for ambient display. "Networked Emoticon Device" is an ambient light display to show the status of msn log in [W6]. Ambient sound is also implemented in many researches (Hallnäs and Redström, 2001; Ishii et al., 1998 Marinis, 1999). In so many cases, we found that no information is published directly in form of complete sentences such as "Someone eyes on you." or "You are running out of gas." Ordinarily, the context of information will be displayed after being simplified and facilitated in ambient display. The reason comes form its properties of calm technology: bringing the periphery to the center and to back efficiently. For the reason, ambient display has to be equipped with familiarity and light-weight means (Streitz et al., 2003). For another observation, most of the style of status changing of ambient display is gradational. The concerned point may mean to be unobtrusive.

Mikko Laakso did the rich case studies about ambient displays (Laakso, 2004). She epitomized these cases as some presumptions:

- The data to be displayed must be continuous.
- The data to be displayed must be (mostly) non-critical.
- Changes in the data must be quite slow.
- The data to be displayed must be simple enough (2-3 dimensions at most).
- There should be an intuitive mapping from the data to the display.
- There is usually no interaction at all, just passive receiving.

Follow these presumptions; we can say that the key element “display” in context mediated social awareness can be implemented as ambient display. However the last presumption is not suitable for us to implement the ambient display, because we need not only just display but also an interface to communicate with colleagues.

2.3.3 Design Method

Ambient displays present digital information through subtle changes in the user’s physical environment such as variations of light, sounds, or movements. Ambient interfaces capture natural interactions of the user with physical devices such as switches, buttons, or wheels and translate them into digital commands (Gross, 2002; Wisneski et al., 1998).

Most of ambient devices have only the function of display. Actually, ambient interfaces include two parts: display and control. Despite the researches focus on the control part is not much; we still can find several great cases. Some cases use the natural sense of touch as the ambient control interface (Chang et al., 2002; Poupyrev et al., 2002). And some cases choose to combine the control part into display part. In “ambientROOM”, “clock” has its display part on its surface and the control part is embedded with its hands prompt (Ishii et al., 1998). The bubble patterns in the information percolator also can be changed by gestures caught by camera (Heiner et al., 1999).

Here are the guidelines for the design of ambient interfaces:

- Ambient interfaces should be effective.
- Ambient interfaces should be efficient.
- Ambient interfaces should be safe.
- Ambient interfaces should have good utility.
- Ambient interfaces should be easy to learn and remember.
- The functionality of ambient interfaces should be visible.
- Ambient interfaces should give the users adequate feedback.
- Ambient interfaces should provide constraints.
- Ambient interfaces should provide an adequate mapping.
- Ambient interfaces should provide consistent functionality.
- Ambient interfaces should be adequate or the target domain.
- Design and development should be participatory. (Gross, 2003)

With these guidelines we have some referential rules to follow and implement the needed mediated artifact which should be equipped both ambient display and ambient control interface.

2.4 Sensors and Physical Computing

Like the previous mentioned researches, this paper tries to use multiple sensors to capture the context cues of social events. Thus, we have to realize what physical context can be captured by what kind of sensors. First, we need to understand how sensors work in basic circuits. There are so many groups who implement so many platforms on sensors or sensor networks such as “tinyOS” [W7], “Moteiv” [W8], “Smart-ITs” [W9] ... etc. These hardware designs are all contain three parts: microcontroller, sensor board, and communication board. However, some of these products or open operating systems are hard to get. For replacement, we use a fast and cheap method to implement our prototypes.

2.4.1 Sensor Technology

Actually, sensor technology has been quite used in consumer electronics such as air-conditioner, electronic pot, and micro oven…etc. However the technology has not been used broadly in other domains until the rise of ubiquitous computing (since Weiser, 1991). Another promotion might be contributed by smart home projects. Despite how complex these projects are, the basic sensor circuits are quite simple. Here is the sample [W10]:

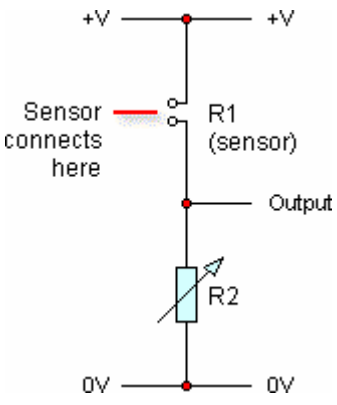


Fig X. Basic Sensor Circuit Unit

In this circuit two resistors (R1 and R2) are connected in series across the power supply rails (+V and 0V).

R1 represents the resistance of the attached sensor.

The total resistance of the potential divider can be calculated by using the formula for resistors in series:

$$R_{total} = R1 + R2 + R3 + ...$$

From this you can then calculate the output signal voltage by using the potential divider formula:

$$V_{out} = \frac{R2}{R1 + R2} \times V_{in}$$

From the above basic idea, we found most of sensors perform as potentiometer, and the sensed value can be count by the formula. However, there is still some sensors can’t be treat as a potentiometer, and these sensors should be redesigned in more complex way. No matter what kind of sensor is used, they all have to be read through analog to digital process into the computing units. Most of sensors output as analog signals, we have to use an analog to digital IC or a microcontroller with analog-to-digital function to read the changing value into computers. Except the analog-to-digital component, there is

still a needed part: communication module. The choice of communication module depends on what I/O interface of your implementation. In past cases, RS232 is a quite common I/O interface, but recently, more and more modules use USB (UAART), WIFI or LAN. In the next two chapters, we will introduce an easy module that we use to implement the sensor module that we used.

2.4.2 Physical Computing With Microcontroller

Most of appliances or consumer electronics are labeled as “smart” or “fuzzy”. They can be labeled as smart not because they are really intelligent but have combo-functions with few operations or automations. And these appliances are all equipped with more than one microcontroller which controls the logical computing part and the function combos for the correspondent operations. In the other words, microcontrollers are the cores of the most appliances, and it is just like CPU-to computer. Most microcontrollers are combined with the communication modules as a central control module. In the book, “Physical Computing” (O’Sullivan and Igoe, 2004), some microcontrollers are recommended as an easy way to access physical computing, and the module “BS2” [W11] has been used as samples to implement examples in the book. However BS2 is too expensive for us to implement multiple sensors in different places, we have chosen another module, “IRX2” [W12] to connect sensors and implement ambient interfaces. Next figure shows the idea of physical computing.

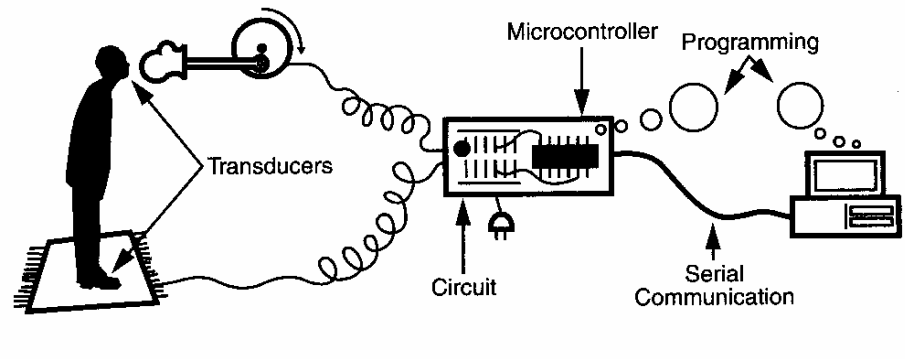


Fig. X. The system of physical computing (O’Sullivan and Igoe, 2004; p. 25)

In this paper, we try to make a few different approaches with the previous studies. First, we’ll try to collect the context cues of some social events in our environment. Second, to keep the privacy, the available connection has been changed the arena from individual-to-individual to public places-to-individuals. In the next chapter, we are going to introduce few models of our system frameworks.

Chapter Three Conceptual Framework

In this chapter, we try to set the principles of the framework and the basic mechanism of our context mediated awareness. Following the required function, first, we have to find the relationships between physical sensors, social events, and social places.

3.1 A Scenario for Social Awareness System

We set a specific scenario of informal communication in design office environment. The scenario shows the conceptual idea of the operative mechanism of the context-mediated awareness.

The scenario also had been set for a purpose: Most of time, great design idea comes out of unexpected informal communication. Base on this idea, we use the awareness system to set the scenario about helping increasing the triggering times of informal communications. For the purpose, the social events will be focused on informal communication such as chatting and discussion.

3.1.1 The Scenario in Design Office Environment

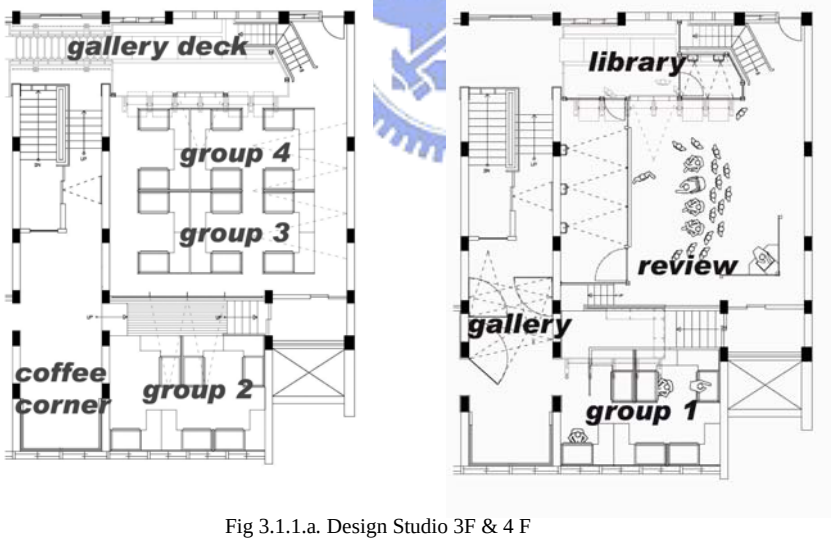


Fig 3.1.1.a. Design Studio 3F & 4 F

The fig. 3.1.1.a shows a design studio with four design group and several social places such as review room, little library, gallery and coffee corner.

Scenario 1. Awareness of Social Events Running and Join It

Mary is a member in group one and has colleagues, Ted, Greg and Jean. One day, during reviewing, Mary went back to her seat after her turn finished. After review, Ted, Greg and Jean went to the coffee corner at second floor and had an easy talk with nice coffee. While they were talking, the

coffee corner had sensed their ID as colleagues of group one. As the same time, the ambient device showed the flickering red light to draw the heed of the colleagues of group one. Greg was aware of the red light flash from a decorative orb near the coffee machine and touched the orb. After orb touched, an illuminated orb in front of Mary's desk faded into red color, and the slow change had draw Mary's heed. Then, Mary was aware of the social event may happened in the coffee corner and she decided to take a look and try to ask if she can join the talk. She touched the orb, and the orb faded into green color to show she would like to join the talk. On the other side, other colleagues also had noticed that the decorative orb had faded into green one. They know that Mary wants to join them, and Greg asked others if they want to wait for Mary. After others agree, Greg touched the decorative orb again and the orb turned into blue light. At this moment, Mary noticed the illuminated orb had turned into blue light, and she knew that they could be waiting for her. After a minute, Mary went to the coffee corner and joined them with a nice conversation and they decide to go to the lunch.

Scenario 2. Creating the Chances of Informal Communication

Following the scenario mentioned above, what if Mary didn't touch the orb (She didn't want to join the talk), she still known the social event had happened. After the conversation, if she saw others, she can ask a colleague what the contents of the conversation. Otherwise, if Mary had not been at her seat at the moment while other colleagues' talking, the illuminated orb still would fade into red colour. When Mary came back her seat, she would know the previous social events. If she had the interests, she can ask Ted, Greg or Jean for contents of the talking. On the other hand, if Mary had been at her seat and didn't notice the message of the social awareness, other colleagues still knew that they had sent the invitation of the social awareness, and after the social events, if one of them bumped into Mary, he or she can tell Mary that the social events had happened and what they had talked about.

3.1.2 Discussions of the Scenario

From the design studio plan, we can obviously see that every work group or social place has a block and had been separated by the plan limitation. In this way, designers in one group have few chances to know the situation of other groups, and also know few about others work. Sometimes, even colleagues in the same group can't know others situation. And of course, we don't mean that they have to know everything about others. In the scenario, social awareness plays a mediated role to create another social event beyond the original one and try to connect more people. We pick up a most common social event, chatting to be intersected the awareness with two reasons: first, chatting often happens in design studio, and sometimes the contents are associated with the design work. Second, chatting is the simpler social event and can be easily joined by others with easy manners. The scenario also mentioned the conceptual operative mechanism of the context-mediated artifact, "decorative orb" or "illuminated orb". It uses light color changing to show the simple message and draw users heed from

central work to peripheral. But the situation in the scenario is too rough to explain the entire image of the context-mediated artifact. We will describe it clearly in next sections.

3.2 How to Sense the Context Social Events

Before social awareness, the system has to do the “monitoring” on the states of social places. States include all social events happened in social places. In the section, we propose several usual social events conditions in common office environment. These proposed examples are not proved as successful method. We use these examples to derive the basic way to find the context of social events. And these examples will be tested after the system completed in the future.

3.2.1 Social Places and Social Events

Before setting which social places, we give the definitions of social places a few limitations. First, informal or formal communications often happened in these pleases. Second, these places can be accessed in any work time. We select these places as the representation: lobby, meeting room, coffee corner, and corridor. And we observed these places to find out what social events happened in the places in a week. Table 3.2.1.a shows the results.

Social Places	Lobby	Meeting room	Coffee Corner	Corridor
Social Events	Chatting; Exhibition; Waiting;	Lecturing; Discussion; Review;	Chatting;	Chatting; Exhibition; Waiting;

Table 3.2.1.a social events in social places

These social events are all connected with more than one people and the lasting time is over five minutes. In the next section, we propose an approach using multiple sensors to try to distinguish these social events.

3.2.2 Physical Elements in Social Events

As the examples in table 2.1.3.a we know that it is possible to find someone’s state via his/her spatial value of physical elements. For example, someone is typing in front of his computer. The elements are inclusive of sound of hitting the keyboard, a hot cup of coffee may be put on the table, and the chair might be pressed. According to the idea, we also can find some elements from social places or interacting people to deduce what social events they are doing. In the table 3.2.2.a, we simulate the descriptions that proposed by Schmidt and Van Laerhoven (2001) to describe the above social events as physical conditions.

Social Events	Descriptions
Chatting	There are over two people in the places and the voices contain more than one person. Their existence in the place last over few minutes.
Discussion	There are over two people in the places and the voices contain more than two person. Their existence in the place last over ten minutes.
Exhibition	People come and go and stay not too long. Projectors are more than usual. There should be many exhibits.
Lecturing	Many people stay in a room for long time. In most time, there is only one man's voice. The room might be dark if a projected media is in using.
Reviewing	Many people stay in a room for very long time. The room is lousy. The room might be dark if a projected media is in using. And there might have claps.
Waiting	The place contains one or more people. It is silence in most time.

Table 3.2.2.a social events descriptions

From the above descriptions in the table, we know the way to define or to distinguish social events is almost impossible. There are too many exceptions and other disturbance to change the descriptions. However, these descriptions can be improved in a specific work office by long time observations. In this paper we had not done so far.

To analyze these descriptions we find out some very important elements connected tightly with human and spaces. First, the existence of human is the most important to check. There are several attributes within: lasting time, quantities, voices, and who. Despite the human factors, some environment factors are important too. These are sounds, lights, temperatures, and objects. In the table 3.2.2.b, it shows what social events have what attributes.

Social Events	Attributes
Chatting	Human(quantities, voices, who); sounds;
Discussion	Human(lasting time, quantities, voices, who); sounds;
Exhibition	Human(lasting time, quantities); sounds; lights; temperatures; objects;
Lecturing	Human(lasting time, quantities, voices, who); lights; temperatures;
Reviewing	Human(lasting time, quantities, voices); lights; temperatures;
Waiting	Human(lasting time, quantities); sounds;

Table 3.2.2.b social events and attributes

After gathering the sensor data, the inference engine will activate the trigger of context mediated artifact. In the next section, the mediated part will be introduced.

3.3 The Mechanism of Mediated Awareness

We have given a brief concept of context mediated awareness in chapter two. In our system, context mediated awareness is the most important part. Those contexts of social events in social places will be mediated to ordinary individual seat. We plan to use a global artifact as the mediated artifact to achieve the purpose of making people be aware of happening of social events. Thus, the context to be transferred is the triggering moment of social events. The key of this section is discussing how to transform the implicit context to explicit signs.

3.3.1 Context Mediated Artifacts

As mentioned before, context mediated artifact is used to transfer the context. It is not like telephone or other direct communication devices using an obtrusive way to do communication, and those devices don't focus on context but remote communications. If we only had to achieve the goal of awareness, the things will become simple. We just need to design an ambient display artifact for every individual seat and social places. As we know, most awareness systems or ambient displays didn't offer the mechanism for the next step (ex. communication) after offering awareness, because most of cases aim at co-located work environment; thus, people can respond the awareness in short time locally. But our focused context is the initial moment of social moment; that means: although most social events we focused are not so urgent that need people respond immediately, people still have chance of joining the social events. The joining types can be separate as "without asking permission", "with permissions" and "an appointment". For example, if a review is just starting, and the context is broadcasted to every mediated awareness artifact, people who see the message may join the review or not without any feedback information (ex. "I'm going to the review."). An opposite example: if an office staff is still preparing his work for review while review has already started, through the mediated awareness artifact he can knows that the chairman decides not to wait. Somehow, he may use a simple way through the artifact to inform the chairman that he is ready when he completes the work. Social events should be related to community communication; therefore, social context awareness also should be related to community communication. Hence the social mediated awareness artifact should not only be equipped with "display" but also "communicate".

Unlike the direct communication, since the context focuses on the initial stage, we don't plan to interrupt the whole process of social events in not polite manner; thereby, the meaning of the communication should be simple, and the operation of the artifacts should be effective. In the chapter two, except the "ambient display" we also reviewed the "ambient interface". We will use some design principle for implementation of the artifacts in chapter four.

3.3.2 Mediated Communication Activation and Channel Creation

After context retrieval and inference, how can the result activate the mechanism of mediated communication? First, basic on the above situations mentioned before, the “joining process” can be departed as “with permissions” and “without permissions”, and back to the initial stage of the communication, there should have an invitation or a question before permission or an answer. However, the mediated artifact is not phone-like stuff needed an active manner to make connections. And there is a key point for consideration about the activation mechanism. Most of our focused social events are informal events. Unlike lectures or reviews or those scheduled events, people in the informal events may not be aware of its precise time of beginning and have few possibilities broadcast the invitation actively. If the inference server figures out the happening of a social event and broadcast the message to individual seats without any information for who is in the social event, it will be rude if they are unwilling to be known in social events. For this basic idea, we plan to put another mediated artifact in the social place, and when inference engine derive the initial moment of the social events, the server will inform the artifact in the social places to quest the people in the social event if they want to broadcast the messages to others. In this way, the questing method of the artifact should be in polite manner for avoiding obtrusive interruption.

Another concerned problem is the mechanism of communication channel creation. In usual remote communication cases, there will be a communication server for handling all coming data and allocate the data to its destination. We simply modify the typical framework to fit our system. The most different part is we have not only one communication server. Actually, our communication servers’ locations are based on social places. After context inference, one of the communication servers will be activated and if the social events context message is allowed to broadcast, the communication server will create several communication channels for connected individual seats. The diagram (fig 3.3.2.a) shows the clearer steps of the activating mediated awareness communications.

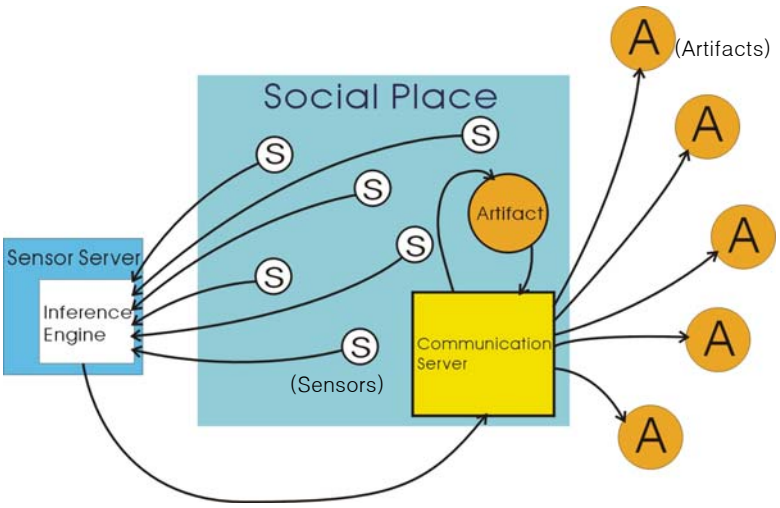


Fig 3.3.2.a Mediated Awareness Mechanism

3.4 Summary

In this section, we want to summarize the entire system framework. Before that, we have an important sensor related to human factors to aid the entire system, and that will be ID sensors. The challenge here will be how to add the ID sensor into the system and how to detect the rest human factor attributes except voices.

3.4.1 Mixed With Human Factors Sensor System

ID sensor has many types. Barcode, picture patterns (ex. Spot Code: http://www.op3.com/), IR protocol, RFID, RF tags, and Bluetooth all can be use as ID sensors, but they are quite different with their features. Table 3.4.1.a gives us the comparison of functions of these sensors.

Features	Embedded ID	Changeable ID	Proximate sensed	Remote sensed	Require power supply	Able to exchange data
ID sensors	Barcode Picture pattern RFID, RF tag Bluetooth	RFID, IR Bluetooth	Barcode Picture pattern	Bluetooth (30m) RFID (max:3m) IR (about 1m) RF tag (as RFID)	Bluetooth IR	Bluetooth IR

Table 3.4.1.a Comparison of ID sensors

The objective of the ID sensor concludes sensing “who”, “who’s” existence time in the social place, and how many “who” in the social place in unobtrusive and active manner. For achieving these goals, ID sensors have to be portable and remote sensed. Today, most of companies, hospitals, and schools all use chip cards as the ID card for identifying their members, and these are a kind of RF tags. Some hospitals hang the RFID sensor antenna at the entrance ceiling to automatically sense the arrival of hospital staffs. We can use the same approach to capture those human factors by hanging two antennas at the entrance and exit; thus, the ID sensor system has hardware components composed by two RFID antennas and a RFID reader module. Those derived ID data has to be sent to the sensor server for context inference, but they are not derived by IRX board; therefore, ID data has to be set as another identity code such as local IP + ID number. For compartmentalizing the signal of IRX board or RFID reader module, the RFID identity code has to be added a dieresis code; so the code will be local IP + “RFID” + ID number. The entire sensor data collecting process diagram has been shown in the fig 3.4.1.b.

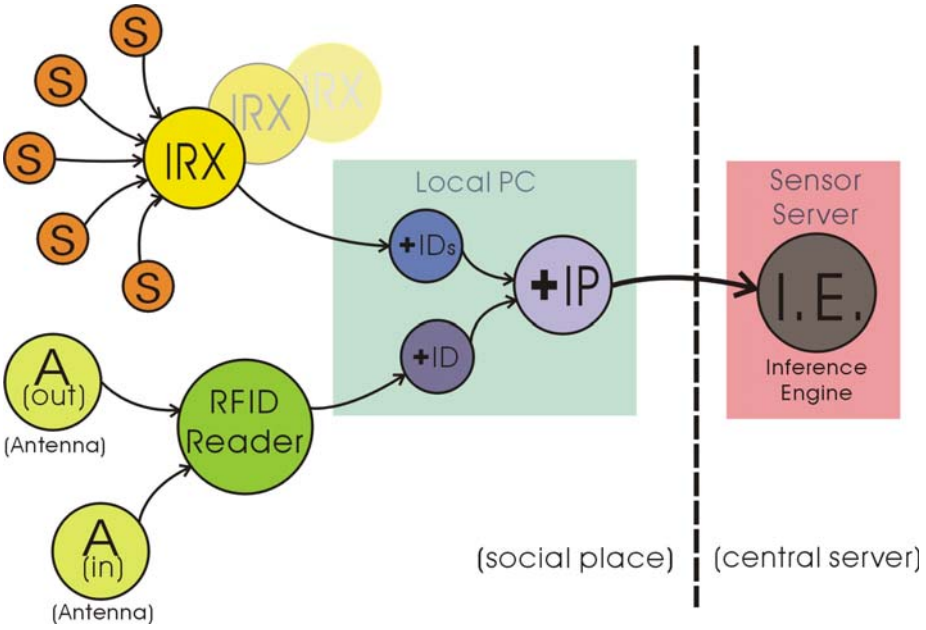


Fig 3.4.1.b Sensor data collecting process

3.4.2 Sensor Server and Inference Engine

Since we mentioned about sensor server or inference engine so many times, we haven't discussed them in detail. As we discussed before, the system has not only one communication server and depends on how many social places are involved. These communication servers locate at local PCs in social places and create networks channels to connect the other mediated artifacts at individual seats when they are activated by inference engine. However, why is inference engine not embedded with communication server in the social places? Tracing back to the purpose of social awareness, people have the potential affection to connect people; thus, we use the awareness system to break the limitations of the space arrangement and help social connections. For the purpose, the affair should be not only between social places and individual seats but also social places themselves. In the system, communication servers don't open in any time; actually, they are also can be the awareness informed part just as the other individual seats. But, how can a social place server know the states of the others to avoid confused signals? Actually, it can be known by crossing questing between communication servers. In this way, the mechanism will to complex for understanding and maintaining; hence, we specify a sensor server to do the auto-monitoring in any time. Except the inference engine, the sensor server also handles the initial apportionment of awareness invitation messages. The duty handled by only one server will save mechanism steps of the system. First, we mentioned before, sensor server can know the states of every social places, so it can handle the results of inference engine and compare the states of social places to make decisions of initial apportionment of awareness messages for social places; hence, if it can also do the apportionment for other individual seats, the mechanism will save much effort. Second, the sensor server has to decide which individual seats should be sent the awareness messages. To understand how to make these decisions, we need to discuss an issue first.

Base on the theory of social bond, people have the potential affection to connect other people but should be the related people instead of all people. For example, when review, people who already in review have certain connection to who plan to go to review but is still at the seats. In a company, people in the same department will have more connections than people in different departments. And if the awareness messages are caught by people who have less connection with who in the social events, the awareness might be seemed as a bothering affaire. Although there should be a method to define the connection level as references for sensor server to make apportionment decisions, that kind of mechanism should depend on the occasion of the office environment; hence, it is beyond this paper. No matter how complex is the mechanism, a high connection level list should be stored in a database. Now, we have the idea that sensor server has three basic components: inference engine, connection list database, relationship inference engine. The concept mechanism of sensor server is shown in fig 3.4.2.a.

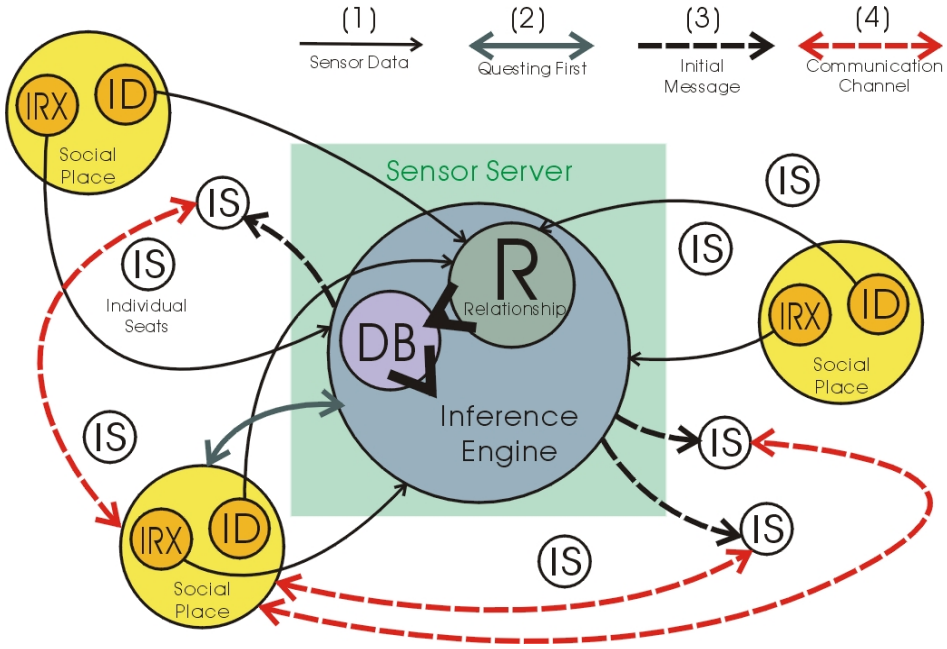


Fig 3.4.2.a Sensor server mechanism

3.4.3 Limitations and Questions

This chapter introduces the whole conceptual social awareness system, but there are many problems to be discussed and solved. Here, we take this conceptual framework as the principle for the scenario planning and implementation in the next chapter. Before the next chapter, we have to clear some questions via going through the entire process.

First we start at the monitoring part, and this part includes sensor server and different sensors in social places. The purpose of monitoring part is to monitor the states of social places and capture the context of the initial moment of the social events. The key element to do the most jobs is inference engine. Simply to say, inference engine use the sensor data to figure out if there is a social event in the social places, and if there is, inference engine will send the initial awareness message to related parts. However, we didn't know exactly the mechanism of inference process. To understand the process, we have to analyze what kind of social events to recognize. At the first of this chapter, we list some social events to find some physical contexts can be detected by correspond physical sensors; however, we haven't discuss the precise sensor data range of a social event should have. Actually, we believe the situation will be different depends on what kind of office environment that we want to set the system. Informal social events may be more helpless then formal social events in some offices, and in other offices informal social events are helpful for coordinating collaborative work. If we cannot decide which social event is more important, the inference engine will get confused when two social events happened almost at same time. Therefore, if we don't specify the office type, the process of inference engine and what social events should be observed are hard to define.

Second is the context mediated awareness part which includes context mediated artifacts and mechanism of communication server. This part is the main purpose of the social awareness system. The social awareness can be extended out of social places through connected context mediated awareness artifacts. As far as we talked about the mediated artifacts, the contents are not inclusive of the image and operative mechanism of the artifacts except the design principles. We can't specify the operative mechanism for one reason: from the perspective of designing, the mechanism can be designed in many ways just if it can match the mechanism of communication server and ambient interface design principle. We will use a example of our implementation in next chapter to explain the operative mechanism of the context mediated awareness artifacts.

Chapter Four Implementation

We plan the basic framework of the social awareness system in general office environment at last chapter. In this chapter, we would like to implement a scenario of social awareness to discuss much deeper questions and possibilities. First we are going to introduce our fundamental hardware module.

4.1 Fundamental Module

In chapter three we mentioned that social context attributes need to be read by sensors, but we didn't explain how to read the sensor value and how to do these sensors. Actually, there are so many I/O modules for computers to transform analog signals to digital signals. However, the module we need not only for reading sensor values but need for prototyping the context mediated artifacts. Another constraint is our budget. For both reasons, we choose "IRX2" (Fig. 4.1.a) as our basic module.

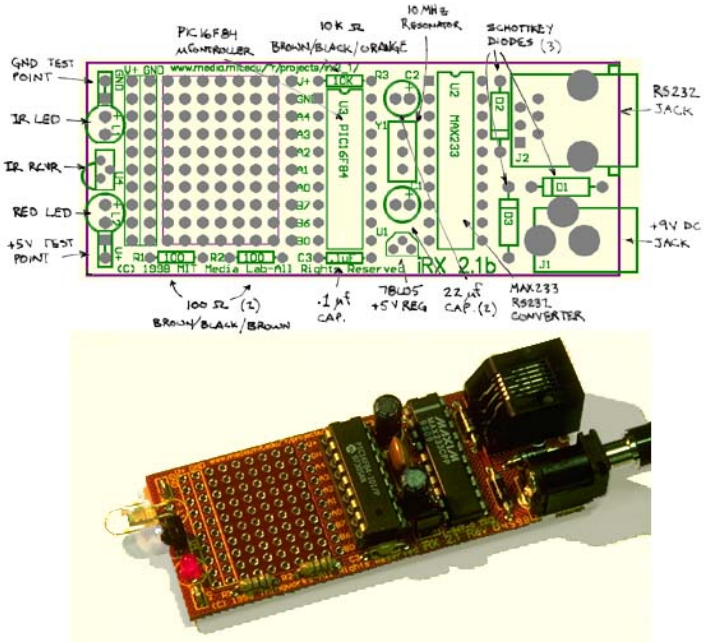


Fig. 4.1.a IRX2 [W12]

IRX2 is designed for fast prototyping for HCI domain, and it is developed by personal computing group in Media Lab. It contains an 18 pin IC and a RS232 communication IC as its main part. With the RS232 communication IC, it can communicate with a PC using RS232 I/O interface. Its heart, an 18 pin IC is a microcontroller which can be re-write its firmware to control the I/O of its pins. The first edition of the IRX2 uses PIC 16F84 as its microcontroller, and the second edition uses PIC 16F84A. However, both of PICs are not qualified for our purpose: transforming analog signals to digital signals. For improvement, we choose PIC 16F88 as the core of our implementation. This microcontroller has seven ports for processing analog-to-digital signals. Through the communication

IC (MAX 233 CPP) we can read the data in any form we set. Fig 4.1.b shows the diagram of the basic idea of our simple sensor module.

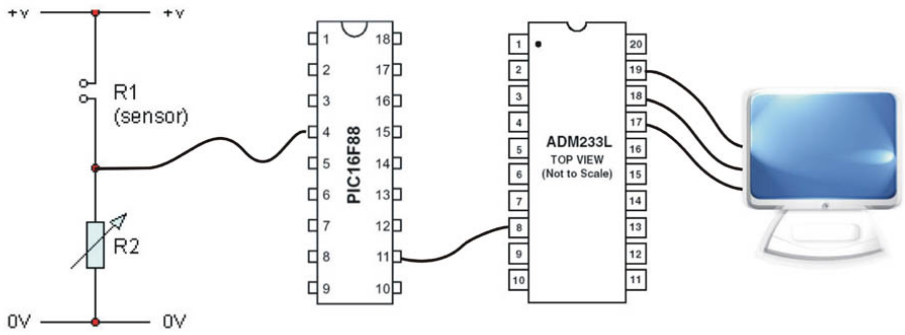


Fig 4.1.b sensor reader module

As we said in the chapter two, most of sensors perform as potentiometers, but some don't. Table 4.1.c lists the sensors corresponding to the attributes.

Attributes	Human (lasting time, quantities, who)	Human(Voice,)	lights	sounds	temperatures	objects
Sensors With (#) is potentiometer	1.ID sensors: (RFID, Bluetooth, RF tag)	1.microphone (plugged in PC)	1.CDS (#) 2.photo resistor (#)	1.microphone (for IRX2)	1.temperatures sensor (#)	1.pressure (#) 2.proximate (capacitor or IR) 3.ID tags

Table 4.1.c sensors

Form the list we found that not every sensor can be applied to the IRX board, especially human factors. Due to the ID sensor is complex, we introduce in 3.3 section. Here we introduce the sensors which can be applied to the IRX board.

4.1.1 Light Sensors for IRX board

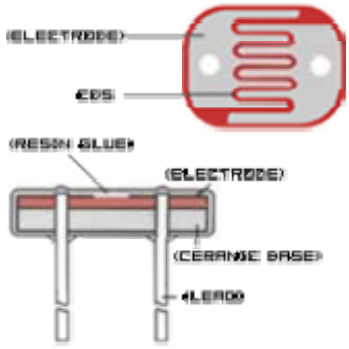


Fig 4.1.1.a CDS

CDS is a varistor. When the environment becomes lighter the resistance value of CDS will be lower, and if the environment becomes darker, the value will be higher. Despite the light part, some CDS have the specific resistance value for the totally dark part. We choose the CDS with range:
light part: 140K~300KΩ
dark part: 20MΩ

Due to the supply power of IRX board is 5V, thus, we can read any analog signal from 0V to 5V and transmit the signal to the computer. In order to make the CDS fit the range, we had to use resistors to adjust the output value. Fig 4.1.1.b is the circuit for CDS.

The CDS we choose only has the size as big as a finger nail. This is much convenient for us to sense any appliance equipped lights by setting one or more CDS modules. For example, if we have to know whether a projector is working, we can put a CDS module in front of the louver of the projector, and put another one over the projector. After comparing the two module data, we can figure that whether a projector is working. Another light sensor, photo resistor, is used for specific range in spectrum, and the price is much higher than CDS. Hence, we don't have to use the photo resistor.

4.1.2 Temperature Sensor

Temperature sensors are also form as resistors. When temperature gets higher, the resistance value is getting lower, and when temperature gets lower, the resistance value is getting higher; however most thermo resistors are not used for thermometers. Blessedly, we have better choice for IRX board. Chip DS1821 (Fig 4.1.2.a) is a programmable digital thermostat and thermometer. Through a wire connecting to the microcontroller and the reader program, we can read the precise temperature value in degrees formed as text on the PC. Via this convenient sensor, we can find out whether a room has air-conditioning or too much crowd.

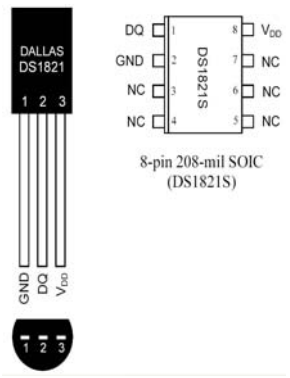
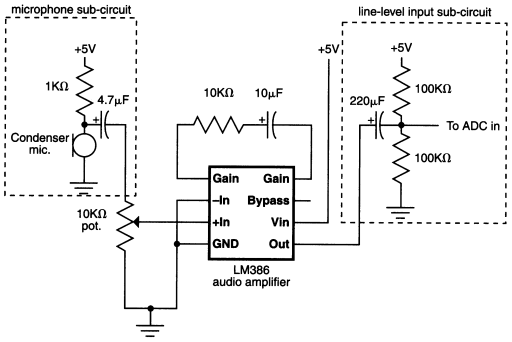


Fig 4.1.2.a DS1812

4.1.3 Sound Sensor for IRX board

Fig 4.1.3.a sound sensor circuit (O'Sullivan and Igoe, 2004, p357)



Sound sensor is used microphone as its main part. Most often used microphone type is condenser microphone. However, it needs complex circuits to support its function. The biggest problem to use the microphone is the signal which is too weak to detect. The support circuits have the main purpose to amplifier the sound signal that sensed by microphone. But if we want to detect the sound sensitively in environment we have to amplify the signal hundred times. In usual case, people will use a pre-amplifier to make signal clearer. In our case, if we need to keep the sensor module in small size, we cannot use a big and expensive pre-amplifier. In the book physical computing, a sound circuit is recommended. (Fig 4.1.3.a)

4.1.4 Object Sensors

Object sensor in this paper means the sensor is used to interact with objects and detect the attributes of objects. For instance, a floor embedded with pressure sensor can be used to detect whether there is a man standing over it, and if we have several pressure sensor as an array, we can know a man's positions. Therefore, if we need to know if a static object (ex. walls, closets, shelves…etc.) has been approached by users, we need to put proximate sensors on it. To choose a suitable proximate sensor depends on putting on what kind of objects. Sharp GP2d12 chip (Fig 4.1.4.a) is the IR receiver module for measuring distance. The distance range is between ten to eighty centimeters.

Fig 4.1.4.a GP2d12

But if we plan to use a proximate sensor with a wall, column, or floor, we have to better choice for flat object. Capacitor sensor is another often used proximate sensor. (Checking the simple introduction here: [W13]) It is better than distance sensor for our case for two reasons: 1. capacitor sensor only responds to objects with electric magnets. In our case, we want sense a human not objects, and GP2d12 responds to any object; thus, capacitor sensor is better. 2. Most capacitor sensor uses a thin and flat cooper board as its sensor part; hence, it is suitable for flat object. However capacitor sensor is very proximate sensor. The distance range is about between zero centimeters to ten centimeters. Except walls, columns, and floors, we also can use proximate sensor with sofa or chairs to detect if a man is sitting on. So, object sensor is also set for the purpose to detect human actions. The data of these object sensors is the reference for the other sensors, especially ID sensors.

4.1.5 The Mechanism for Collecting Sensor data

The data of sensors have to be collected for inference engine; therefore, there should be a mechanism for collecting these sensor data to a server. The key will be on how to identify what sensor it is and where it comes from. For the solutions we propose few steps for processing data from IRX board to the sensor server. The step flow shows in the fig 4.1.5.a. Before understanding the steps, we have to design a set of identity code for sensors. As we know that PIC 16F88 has seven ports for analog-to-digital signal processing, but it doesn't mean that an IRX board only can read seven sensors. Actually if we use five ports of the microcontroller to control a multiplexer (we use CD4067B), we can connect at most seventeen sensors to the IRX board. Thereby, the identity code may be composed of place ID, IRX ID, sensor ID, and sensor data. The step flow shows the different part of code should be added in which step.

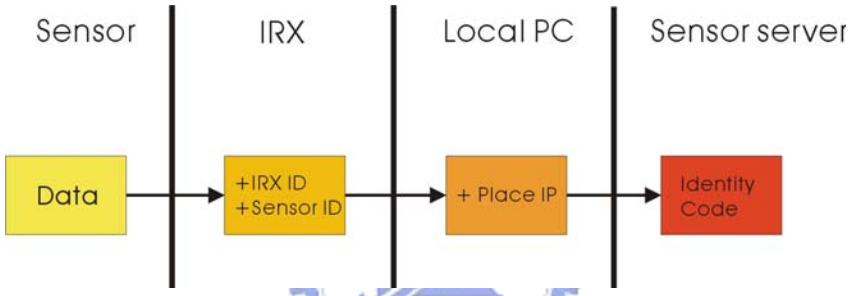


Fig 4.1.6.a Step flow

4.2 Implementation of the Scenario

4.2.1 The Framework of the Scenario

According to the framework based on the last chapter, we set a simple one to match the scenario. Here, we only have a communication server in the coffee corner, four people, a simple social event and a work group. We simplified the whole system for building a prototype for inference engine, communication server, and the mechanism of context-mediated artifact. For the idea, we can separate the whole framework based on location types in the scenario, so the framework can be saw as three parts: Fig. 4.2.1.a

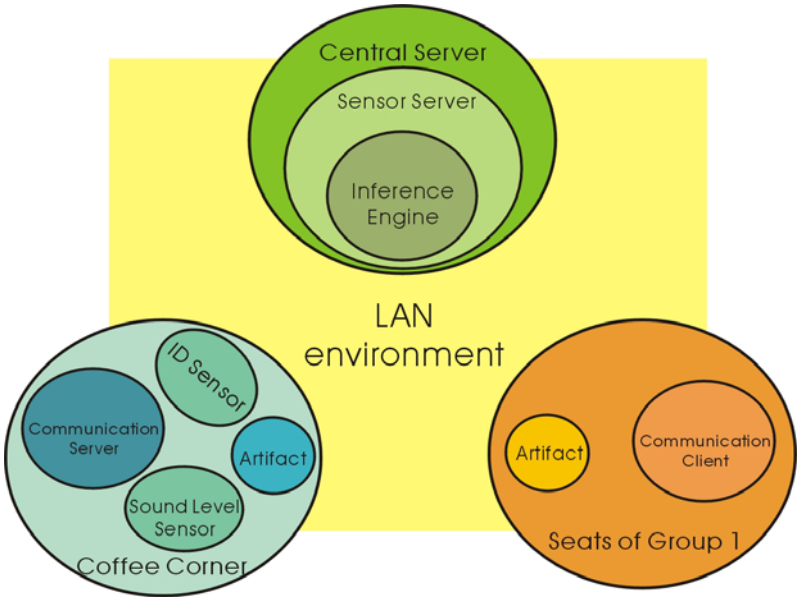


Fig. 4.2.1.a Scenario framework

From the diagram we can see that the sensor types in the coffee corner only for detecting chatting or discussion; thus, the mechanism of inference engine has to figure out whether there is a chatting in the coffee corner. Individual seats are inclusive of all seats in group1 not just Mary's.

4.2.2 Central Sensor Server

To understand this part we also have to know the sensor part in the coffee corner. The mechanism of the sensor server had been mentioned in last chapter; however, the wide range RFID antennas are too expensive for me to afford the implementation. For the reason, we choose the second choice: Bluetooth as the ID sensor. We choose Bluetooth with two reasons: (1) most of Bluetooth chips have the sensing range about ten meters, and the range will be decayed if there are too many obstacles around the sensing environment; thus, the actual sensing range is about five meters to eight meters. The range is suitable for a little room. (2) Every Bluetooth chip has a global unique code as the Bluetooth address, the code contains 12 characters or numbers (ex. 000A94002D09). Except the Bluetooth address, the Bluetooth spec also offers a identity name for user defined through devices such as PDA, mobile phone, notebook, or PCs. This identity name can be very friendly such as "Hugo's NB" or "Hugo's PDA". The friendly name is better than Bluetooth address for identification process in the scenario. However using Bluetooth as ID sensor is unreasonable. A person may have more than one Bluetooth devices, and that id is represented as a machine not a person; thus, in the real test, we can't use Bluetooth as ID sensors, so this example can't be set as real test.

4.2.2.1 Chatting & Sensors

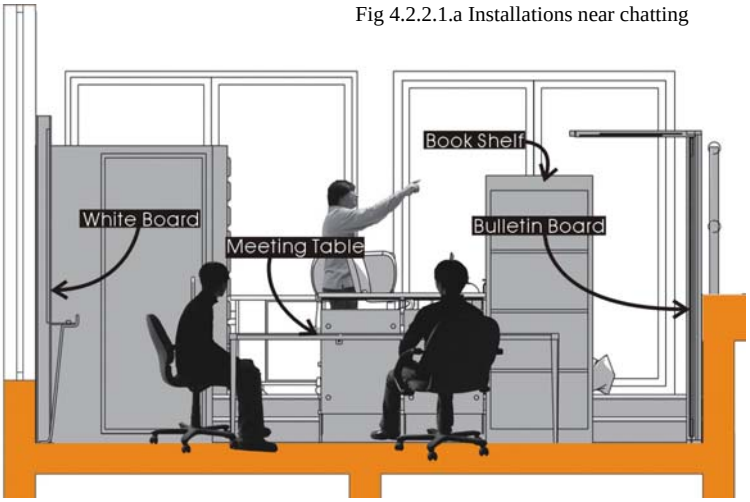


Fig 4.2.2.1.a Installations near chatting

In the scenario, there are three people chatting in the coffee corner, so if we want to know if there is a chatting happening we have to use ID sensor to know the quantity of people has in the range of coffee corner, and use sound sensor to compare the volume between the ordinary time and the chatting time. Here we have a problem: to recognize if the voice is human voice need a speech recognizing engine. Microsoft speech recognizing engine is freeware API for visual studio environment, but it needs clear voice input. Thus, we use the sound volume level to implement the prototype of inference engine. Sound volume sensor (circuits in CH. 3) has been read into the IRX board, and the signal starts at 2.5 volts. (The total range is between 0 to 5 volts.) The sound signal goes up or down when sensed the air vibrations; therefore, when we received the signal near 0 or near 5 we know that there are some voices around sensor. Since the sensing range of the sound sensor is about 20 to 30 cm, we have to put not only one in the room but set lots of them in the room near the sofa and table. Fig 4.2.2.1.a shows the installations which might be near a chatting.

4.2.2.2 ID Sensor Software Framework

As mentioned before, we use Bluetooth instead of RFID as the ID sensor, and for the reason we don't have to use two antennas for counting the existence time and the existence of a user. Bluetooth chip has basic sensing range; therefore, we just need one Bluetooth chip set in the middle of a social place. However, the protocol of Bluetooth is more complicate than RFID, so we need to know basically how the sensing process works.

A Bluetooth device must be able to determine what services are on the devices found; thereby, the original purpose of device discovery of Bluetooth radio is to find Bluetooth services. The Bluetooth specification separates discovery of devices and discovery of services into separate process. In the Bluetooth terms, device discovery is known as an inquiry. When a Bluetooth device issues an inquiry, the other devices in the area respond to the inquiry requests depending on their discoverable modes. The Bluetooth SIG had defined two types of inquiries: "general" and "limited". A general inquiry is used to find all devices in an area. A limited inquiry is used to find all devices in an area that are

discoverable for only a limited length of time. A Bluetooth device can be general, limited, or not discoverable. For implementation, we have to set all Bluetooth device inquiry modes as general and set a Bluetooth in the middle of the social place to keep perform general inquiries, and we can get the other devices' Bluetooth address to the inference engine.

Today, most of APIs for programming Bluetooth are based on the mobile platform such as Windows CE and J2ME, and these platforms are implemented in mobile devices. Last year, Microsoft XP service pack 2 offers the Bluetooth API for windows PC user. Though the API is freeware, however the class structure is more complicate than JAWBT and isn't designed according to Bluetooth SIG's specification. JAWBT is the Java Bluetooth API for J2ME devices, and it is also named jsr-82. The API has much simpler structure than Microsoft XP sp2, and is designed according the Bluetooth function much directly. However, JAWBT can't be directly used for programming in a PC. Actually, most of classes in jsr-82 are interfaces definitions, so users can design the API by themselves as long as they can drive the hardware of Bluetooth. We found a JAVA API for J2SE platform called "JavaBluetooth Stack" (http://sourceforge.net/projects/javabluetooth). The author, Christian Lorenz declares: The JavaBluetooth Stack is a 100% Java implementation of the Bluetooth Specifications Version 1.1. It uses the javax.comm package to address the Bluetooth chip, and implements the jsr-82 (javax.bluetooth) API. Due to this API is purposed on research and is still in process, there are some limitations on hardware of Bluetooth devices *(The debug module for most BT device is based on BCSP interface, but this API needs UART interface to work with javax.comm API)*.

The executed environment of JavaBluetooth Stack is designed for TCP/IP network. The term "stack" means network stacks. The structure goes like this: first, starts the Bluetooth server and the server is a PC plugged with H4 mode Bluetooth device. From the aspect of the scenario, the Bluetooth server locates at the coffee corner. Second, some remote computers create Bluetooth clients to connect the Bluetooth server and drive it to use its function and get the information. In the scenario, the remote client is the sensor server. In this structure, different computers can offer different Bluetooth service at the same computer. The following figure shows the idea of the structure to use in social awareness system.

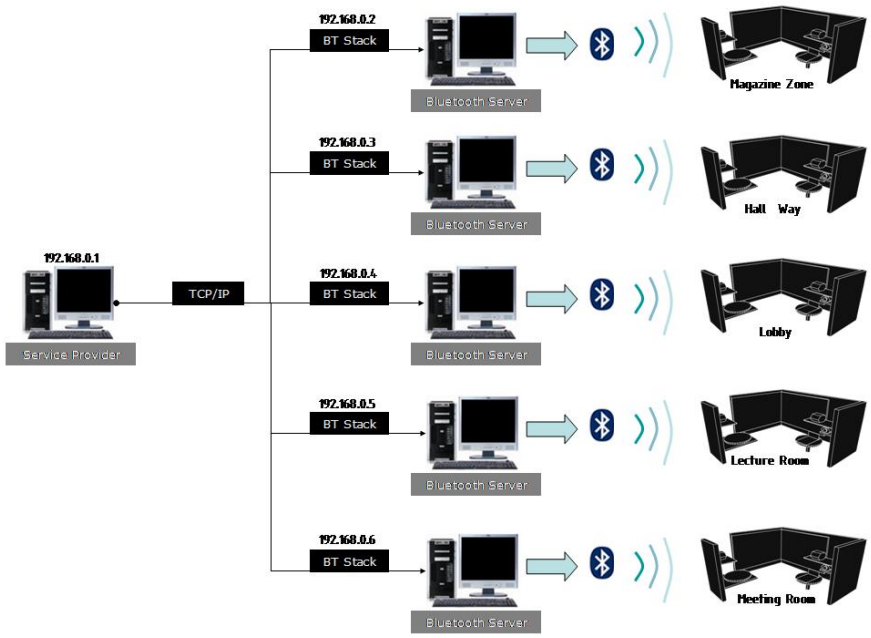


Fig 4.2.2.2.a JavaBluetooth Stack used in social awareness system

In this structure, the inference engine needs to create a Bluetooth client to execute the remote devices inquiry, and doesn't have to create a decoding program to decode the ID codes mentioned in the chapter three, because the inquiry will be directly sent via network from the Bluetooth server to the Bluetooth client; therefore, the part of ID sensor doesn't need to go through communication server in the social places. Fig. 4.2.2.2.b is the mechanism of the JavaBluetooth Stack works between inference engine and communication server.

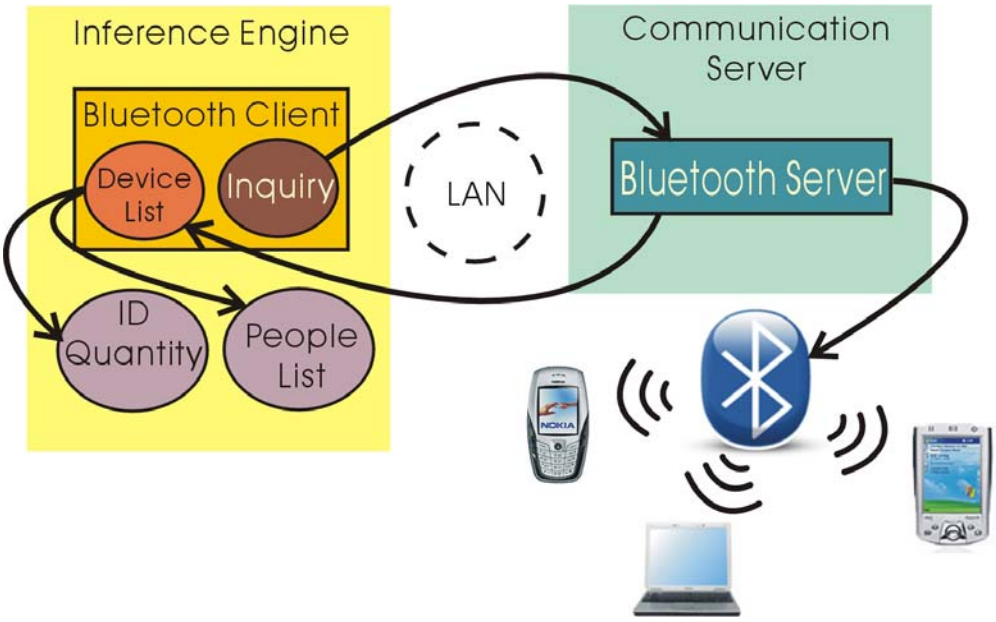


Fig. 4.2.2.2.b Mechanism of JavaBluetooth Stack as ID sensor

4.2.2.3 Mechanism of Inference Engine

Due to the structure of JavaBluetooth Stack, the ID sensor is a specific case in the inference engine. Actually, every sensor has different signal orders; thereby, we have to create specific class for every sensor in the inference engine. Every sensor value will be sent with identity code and location code to sensor server, and before inference, these codes need to decode by those specific sensor classes. After inference, if the result shows happening of social event, the command for the mediated artifact in the social place will be added the location code to send back and drive the mediated artifact to show the awareness message. Next figure is the basic mechanism for the inference engine.

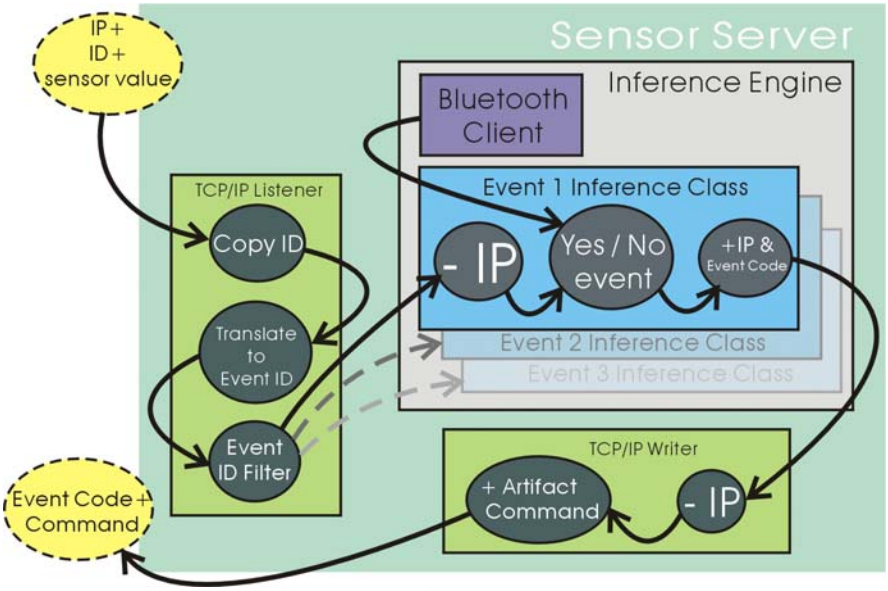


Fig. 4.2.2.3.a Mechanism for the inference engine

There is a basic question about the mechanism. An inference needs more than one sensor value to do the social event inference and most of inference class needs ID data for inference, so we use the ID sensor update frequency as the base time to do the event inference. Bluetooth does an inquiry for per 10 seconds, and other sensor data updates per every second; therefore, some sensor value has to use these 10 records to do a pre-inference and then compares other pre-inference results of sensors to do the final inference. Fig. 4.2.2.3.b shows the idea of the core of social event inference.

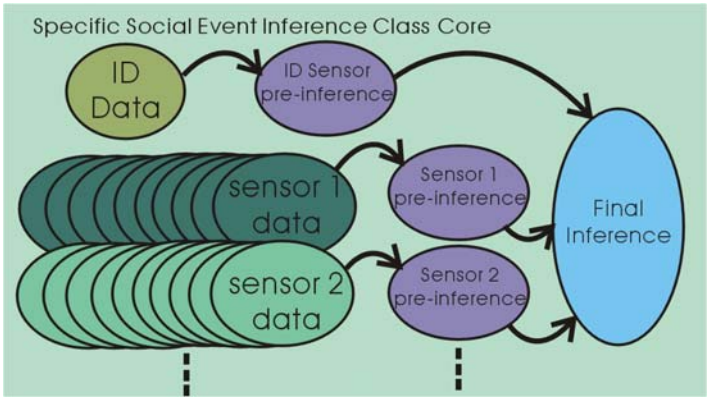


Fig. 4.2.2.3.b Inference Core

4.2.3 Communication Server

According to the framework, the communication server is an installed computer in the social place; therefore, the computer has the duties about communication server and driving the mediated artifact in the social place. In this section, we are going to introduce the mechanism of the communication server in detail.

4.2.3.1 The Mechanism to Activate Communication Channels

Keys to activate the communication server are inclusive of both sensor server commands and human factors. If the inference engine finds that there is a social event in the social places, the sensor server will send the awareness command to the communication server and drive the mediated artifact to show the awareness message for people in the social events. Just like the scenario, if someone had noticed the flash of red light and touched the decorative light, the communication server starts to be activated to do two actions: first, the communication server will send the command of mediated artifact to the sensor server for sending the awareness message for related individual seat and getting the IPs of individual seats. In the scenario, all seats of group one had been sent the social awareness messages. Second, the communication server starts the timer for waiting the responding of individual seats. Fig. 4.2.3.1.a is the steps of processing the starting of mediated awareness between the sensor server and the communication server.

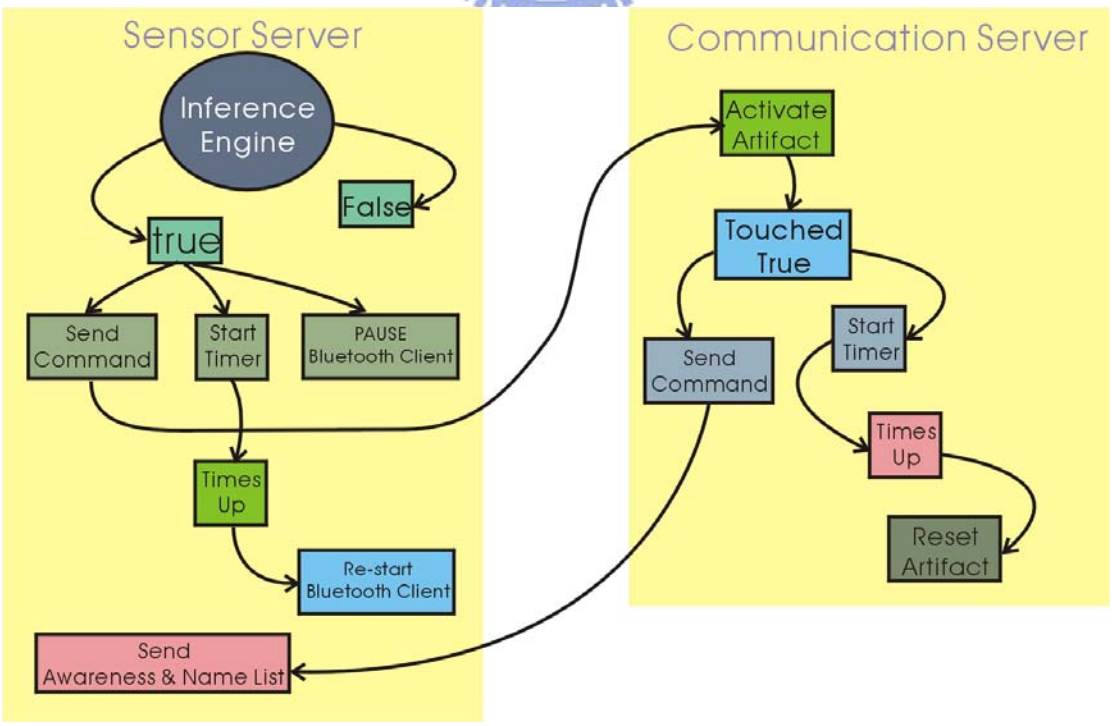


Fig. 4.2.3.1.a Starting of mediated awareness

4.2.3.2 What in Communication Server

Basically, communication server is also a bridge of related individual seats to social places. The basic communication rules are required for implementation of communication server. A class to deal with the command of mediated artifact is required, and this class also has to drive the mediated artifact in the social place. We use RS232 I/O interface for connecting to our mediated artifact, so this class could be the comm. writer and listener. And the class has to link to TCP/IP listener and writer for connecting mediated artifact and LAN environment.

4.2.4 Context-Mediated Awareness Artifact

In the scenario, the context-mediated awareness artifact is a decorative light and its color and flashes represent the social awareness message and the communication mechanism with the social place. Before designing the software and hardware of the decorative light, we need to set the mechanism of communication process and the meanings of light signals.

4.2.4.1 Meanings of Light Signals

Basically, the light colors in the scenario have three colors: red, green, and blue, and we add the flash mode of these colors; therefore we have six meanings for the mediated artifact. The flash mode means that the message comes from the remote device, and light colors without flash are the local operation results. Red light only has the flash mode, so it means the awareness from the remote devices or sensor server. Green color at local is represented that people at local have willing to contact others, and in flash mode means someone from remote is willing to contact the local person. Blue color at local means that the person at local is willing to accept the invitation of contact and in flash mode performs the idea that someone from remote has willing to accept the contact invitation. Table 4.2.4.1 shows the basic meanings of the decorative light.

	Red	Green	Blue	Yellow	White
constant	N/A	awareness feedback: giving contact	accept contact invitation	awareness information retrieval (individual seats) always accept contact invitation (social place)	decorative light reset
flash mode	social awareness	got contact	got acceptance message	N/A	N/A

Table 4.2.4.1.a Light meanings

From the table, there are more three colors for the decorative light. Basically, those colors are for augmented function of the decorative light. We mentioned the operative method for driving the decorative light is just a touch. How does this simple action change those colors? We can set buttons as much as how many colors we have. In that way, time of operation will be longer for recognizing those buttons. Hence, we set the constraints in the firmware to simplify the operation as short and long touch. Table 4.2.4.1.b is the list of operation methods.

	Red	Green	Blue	Yellow	White
Operation	N/A	short touch	short touch	long touch	long long touch: After a long touch and do again
Constraints	Not for local operation	at beginning; after blue light	after green light	any time	Any time

Table 4.2.3.1.b Operation Method

4.2.4.2 Mechanism of Communication Process between Social Places and Individual Seats

The scenario mentioned the simplest mechanism of the communication between an individual seat and a social place. The steps are like the below figures.

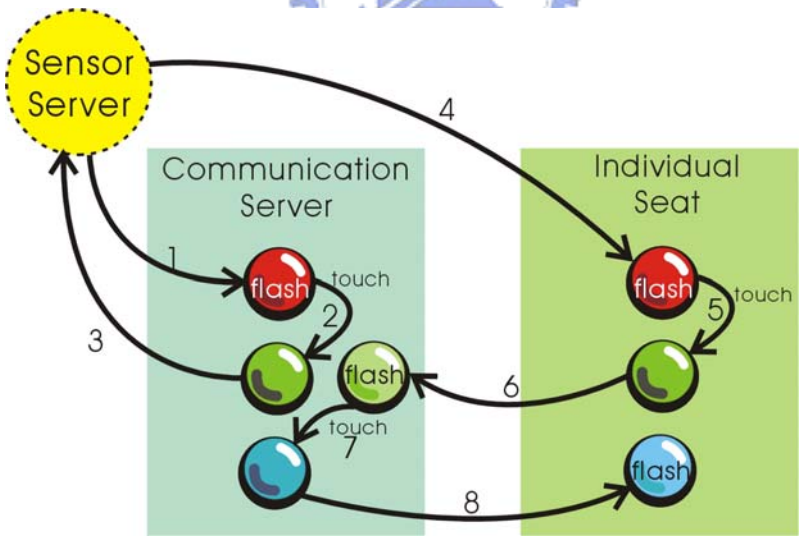


Fig. 4.2.4.2.a Basic mechanism of artifact communication

The above mechanism skips possibilities of the communication with multiple individual seats in limited time. To match the possibility, the basic operation method needs to be augmented. We can't make sure the quantity of individual seats that will make the contact; hence, the augmented operation doesn't have to evolve that element. We set light yellow has different meaning in social places. It activates the mechanism of accepting any contact request from any questing individual seats, and the

mechanism stops when the decorative light has been reset. The light can be reset by two ways: It can be automatically reset by the timer of communication server or actively by people in social events. The modified mechanism is showed below.

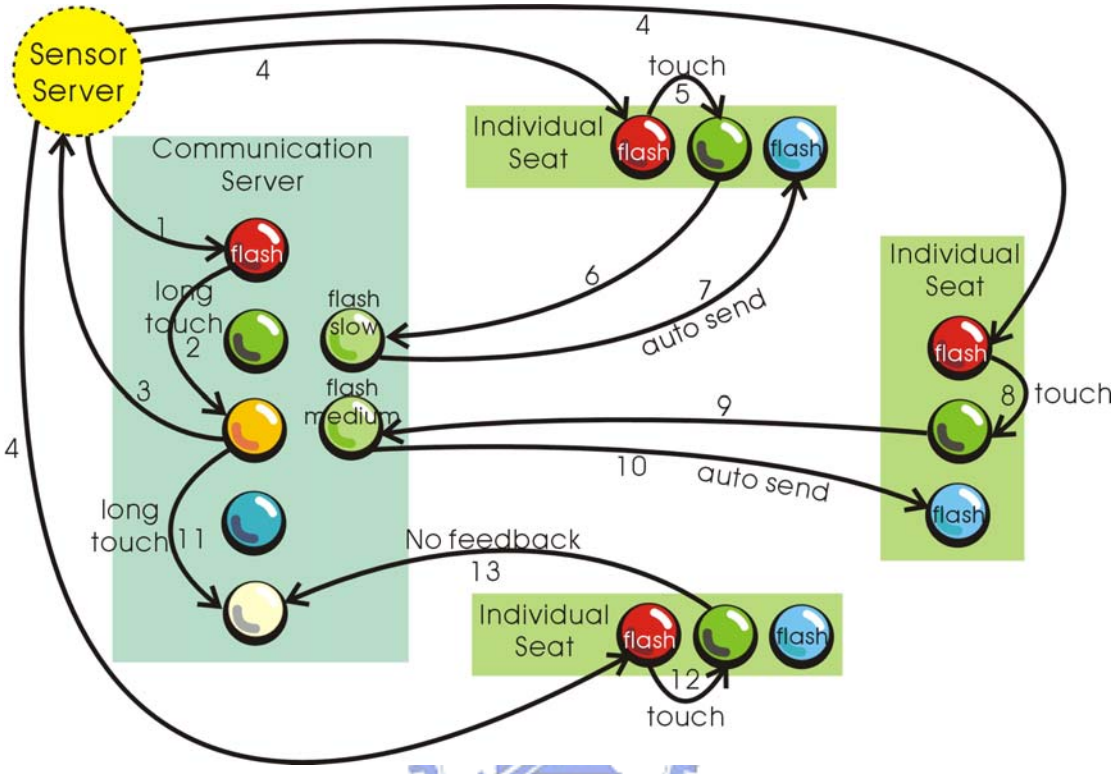


Fig. 4.2.4.2.b Mechanism for multiple users

The above figure describes a scenario of communications between a social place and three individual seats. After the first social awareness in the social place, users in the social event allowed other related people try to make contact with them. One of them touched the light for a while to tell the system to send auto-feedback for someone want to make contact. Before they prepare to leave the social place, one of them touch the light for a while again, and the light turned to white to reset the system. At this time, the third individual seat had no chance to make the contact with the social place.

In this diagram we can noticed that the frequency of green light flash will be increased depending on how many contacts of individual seats. We use this slight change to tell people in social places that more than one person wanted to contact with them. However, the above scenario is not enough to be the mechanism of operation method to both social places and individual seats, especially individual seats. As we mentioned in chapter two, this system is based on context cues and serves as mediated social awareness. The message sent to individual seat is the context of the social place, and the contents include “who”, “when” and “what social event”. These messages form as a cue to send to individual seats, but we haven’t mentioned how to store the cue, or how to know the event after it passed. Next part we describe the mechanism of individual seats operations.

4.2.4.3 Operative Mechanism in Individual Seats

Fig. 4.2.4.3.a Xport

(http://www.gridconnect.com/)

As we know that most of individual seats have a PC or a notebook for works, we can use the advantage to set the decorative light plugged to that PC or notebook. Actually we can use a connection component for Ethernet/IP to serial (Fig. 4.2.4.3.a) to build in the decorative light and in this way we don't have to connect the LAN via a computer; however, we need a computer to show the detail information of context cues. An operation method is needed for context cues retrieval. In the next figure, we describe the complete data flow of the operation in individual seat.

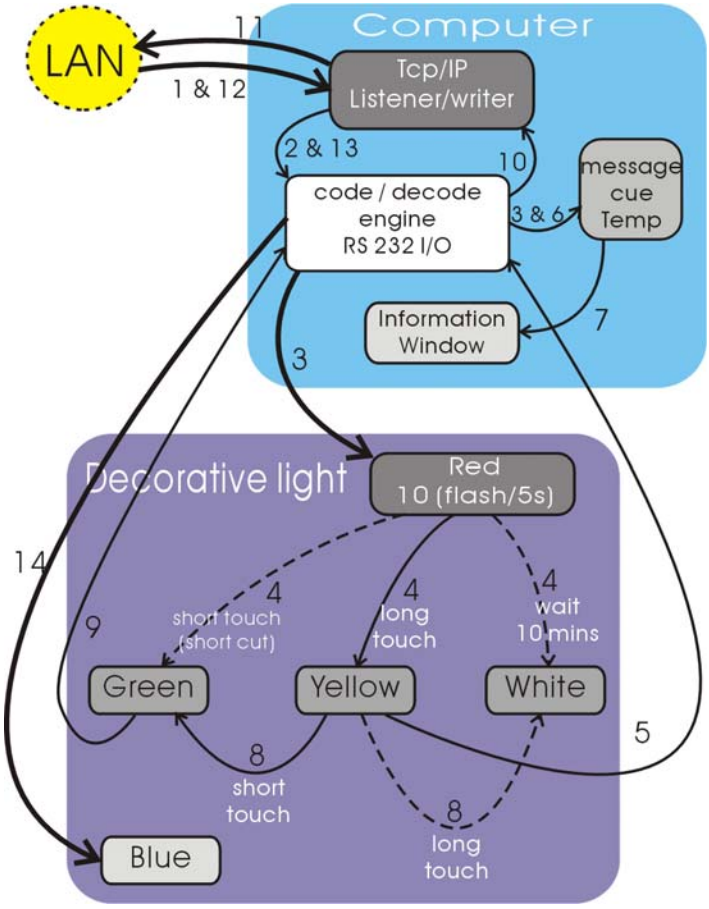


Fig. 4.2.4.3.b Data flow in individual seats

4.2.4.4 Operative Mechanism in Social Places

We gave the simple image about the operation method in social places at section 4.2.4.2. In this section we define the mechanism more specific in social places. Before the data flow diagram, we have to know that the decorative lights are different between social places and individual seats due to the

Fig. 4.2.4.4.a Stock Orb
(http://www.ambientdevices.com/cat/orb/)

mechanism of operation method. The most different feature is the flash frequency of the light; in the individual seats set, we don't need to change the frequency of flashes. Beyond the light in individual seats, we have better choice to use the consumer product as our decorative light in social places. "Stock Orb" (Fig. 4.2.4.4.a) can match our requirement. Its specification offers the simple protocol to control the color and flash frequency of the light and simply drove via RS232 I/O interface (Fig. 4.2.4.4.b). So, we just need to add the "touch" circuits on it to do the touch part in the mechanism. Of course, Stock Orb also offers the circuit diagram, so we also can make it by our self. Stock Orb also offers the programming interface to let developers easily control the orb via JAVA. Fig. 4.2.4.4.c shows the entire data flow in social places.

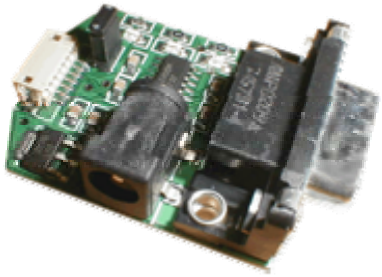


Fig. 4.2.4.4.b Stock Orb developer kit
(http://www.ambientdevices.com/cat/orb/)

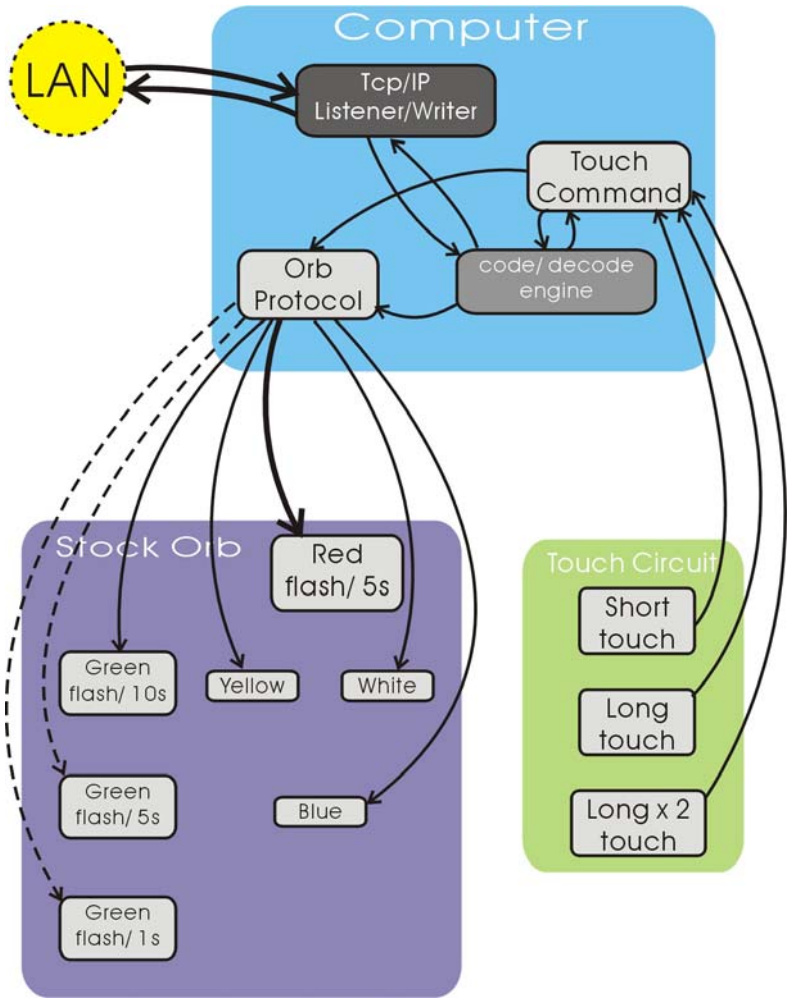


Fig. 4.2.4.4.c Data flow in social places

4.2.5 Hardware

In the hardware part, we use IRX board to integrate our prototype. The basic component diagram looks like fig. 4.2.5.a.

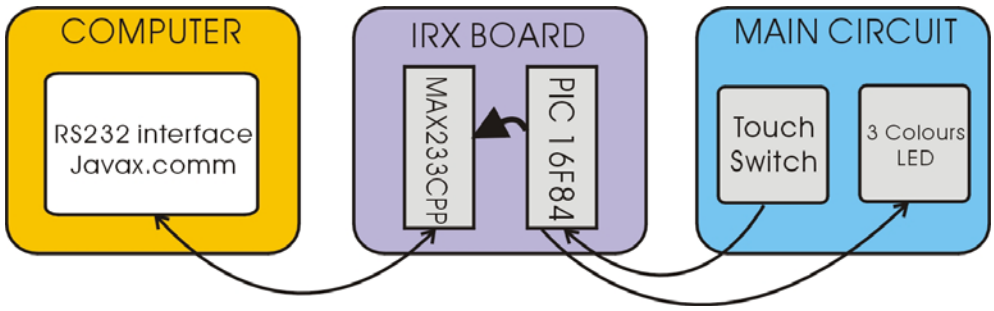


Fig. 4.2.5.a Hardware components

4.2.5.1 Touch Switch

The touch switch is base on the theory of capacitor sensor; the difference is signal type: capacitor sensor is a kind of proximate sensor and its signal is analog. Touch switch is a switch with digital output signal. The book, “Physical Computing” recommends a touch sensor chip (QT 113; http://www.qprox.com/products/index.php) for implementing touch switches. The basic circuit of using the chip is shown in the fig. 4.2.5.1.

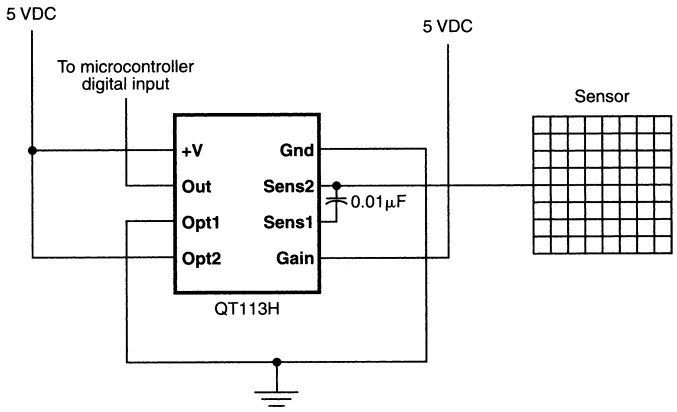


Fig. 4.2.5.1.a Usage of QT113

Fig. 4.2.5.1.b Touch Switches

Actually, there is a kind of touch switch as consumer product. (Fig. 4.2.5.1.b) Those products are not suitable for implementing with a microcontroller, and the sensor shape is fixed. We use QT113 for easily integrated with microcontroller and easily modified sensor shape.

The touch switch in the social place can be easily compatible with IRX board. Fig. 4.2.5.1.c shows the integrated circuits.

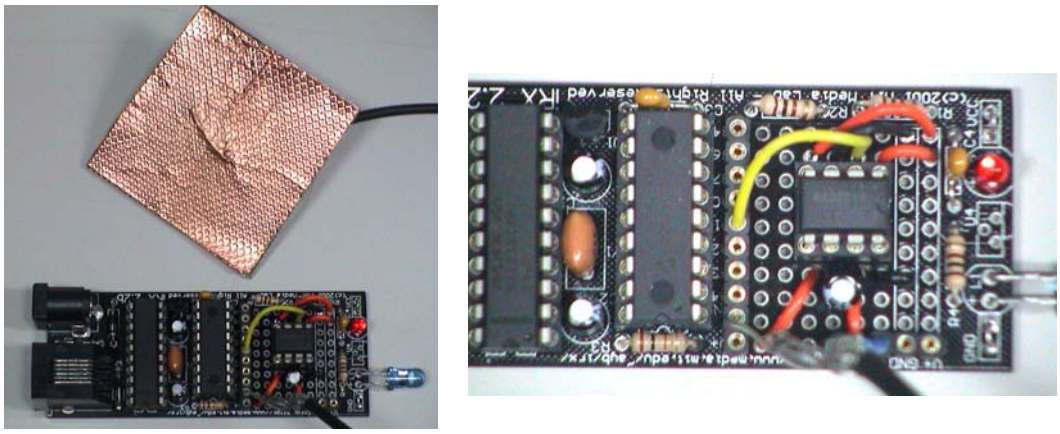


Fig. 4.2.5.1.c IRX with QT113

4.2.5.2 Integrated Part

In the social places, we don't have to care about the light because of using the Stock Orb, but we have to integrate the light circuits with the touch switch part. In fact, these two circuits have no direct connection; they connect instrumentally via the microcontroller (PIC 16F84). We use three ports of PIC 16F84 to control the colors (red, green, blue) of two LED and use one port to read the digital signal of QT113. The signal from QT113 sends high voltage (about 5V) while sensing no touching movement and sends low voltage while touched. We use a port to read the signal and use a counter in the microcontroller to identify the long touch and the short touch. (Fig. 4.2.5.2.a) Finally, we packed the circuits and IRX board into the decoration. (Fig. 4.2.5.2.b)

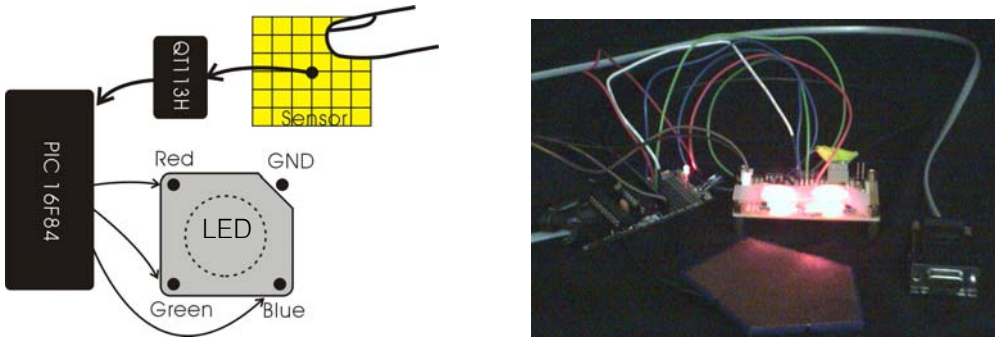


Fig. 4.2.5.2.a Integrated parts

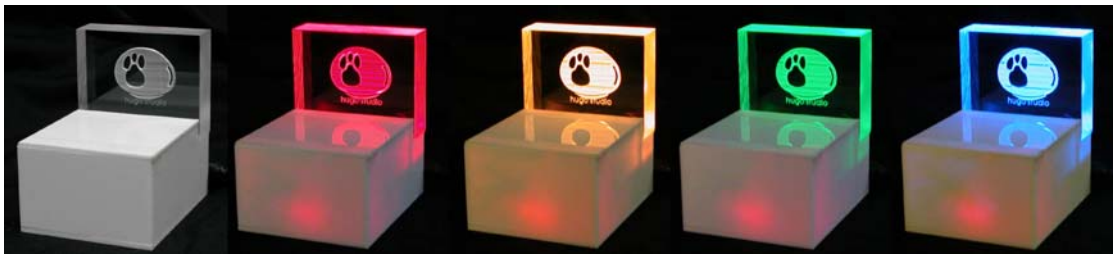


Fig. 4.2.5.2.a five colors of decorative light

4.2.5.3 Firmware

The firmware in the PIC 16F84 has been set for three missions: sending commands and states of the light, identifying long touch or short touch, executing commands from computer. Old days, most of firmware is written in assembly language. In recent years, we can use BASIC or C language to program the firmware that we need, and it's easier and more convenient. To design the firmware of PIC chip series we need "MPLab IDE" for writing the program and connecting the burner to burn the firmware into chips. Most of developers use "PIC Start" as the PIC chip burner and we do too. However, "MPLab" doesn't offer the C language compiler for PIC program. We use the CCS compiler for "MPLab" [W14], and in this way we can use C language to design the firmware. Fig. 4.2.5.3.a shows the components in the firmware of individual seats.

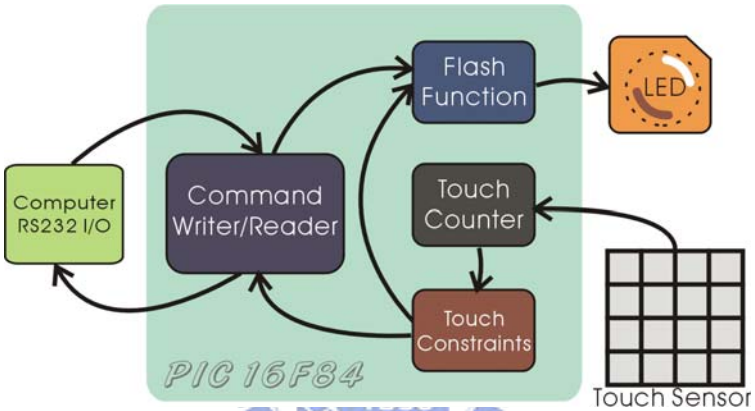


Fig. 4.2.5.3.a Components in firmware

4.3 Limitations and Discussions

4.3.1 Limitation on Display Patterns

Some of ambient display systems use some easy picture patterns to perform its information. How a man can recognize the meaning of a pattern? The project "Hello.Wall" (Prante, et al., 2004) used the pattern that represents the mark of a group or that mark is predefined by the user to remind him/her something while he/she walks through the "Hello.Wall". The project uses the predefined or recognized patterns as their display patterns; however, in this way, people need to learn to remember meanings of these patterns and turn them as intuitional knowledge. And in this way, it is possible for users to bring the meaningful peripheral efficiently to the central. If the pattern is a little concrete and appears in situated places, people often can bring it to the central and realize the situation or state and bring it back quickly without pre-learning the meaning of the pattern. For example, when we run out of lube while driving, we have the immediate idea from seeing the red light of the pattern, "out of oil". That

pattern is a funnel of oil, and the red light gives us the feeling of urgency. Except the above reason, the situation, “driving” also makes the composed meaning to be simply associated. Another example is the color on the lock of the doorplate in the toilet. If there is someone in the toilet the lock color is red, and if there is empty, the lock color is green. No one tell us the represent meaning before, but we still can associate the meaning. The context of the situation or the place helps us to associate the true meanings of the ambient display patterns. In the scenario of this chapter, we use the Stock Orb is not really proper for the situation. If we don’t pre-learn the meanings of those colors and of flashes of colors, we might be hard to associate that someone has the willing to join the conversation. The decorative light should be added picture patterns to help people recognize the meanings of the display patterns.

4.3.2 Limitation on Operative Interface

Although the operative interface of the decorative light is simple as a touch, the constraints of operation might be complicated enough to need little learning. If we use many buttons to control functions of the light, the way can’t bring the operation of buttons back into the peripheral quickly. We use the example of toilets in the last section to explain a batter solution. When a man goes into the toilet and lock the door, and at the same time the action, “lock the door” will turn the lock color into red. The operation is simple and ambient. We don’t have to worry that someone outside will break into the toilet because we do nothing to tell them that someone is in the toilet. It means that good operation interface is associated with both the peripheral and central instead of interruption of the central. In fact, most of ambient interface hardly achieve this goal. They just can lower the level of interruptions.

4.3.3 Limitation on Sensing Social Events

Sensors used in the scenario can’t sense the precise social events. At most, the system is doing some hypotheses about what happened in the social place. If the system can’t do the precise hypothesis, the system might be inefficient, but to capture the precise environment and human factors without interruption or operation are still very hard via today’s technology. In the scenario, there is no mechanism to ask people in social events for confirming if the social event is chatting, but the social awareness information will be sent to individual seats as context cues showed on the screen. If the system sensed the wrong social events (ex, chatting —> meeting), the message may lead the wrong results against to the expect results. In the scenario, we have only one social event to sense, but in the real conditions, we still can’t provide the better solution.

There are more problems about variety human interactive situations worthy to discuss, and these situations will help us to modify the system framework. We will discuss them in next chapter.

Chapter Five Conclusion and Discussion

5.1 Discussions of the Context Mediated Artifact

In the system, we mentioned three components in the first chapter. The mediated artifact is the only part that is the closest one and the only one which can be manipulated by users. The sensor server and the communication server play well to support the mediated artifact works; therefore, we chose to test the mediated artifact in the scenario for further discussion.

The implementation of the mediated artifact in the last chapter is designed for the specific situation in the scenario. In this section, we want to discuss the possibility of using the same artifact to fit the framework in the chapter three and the user experience about the social awareness context mediator. And we'll discuss some basic principles beyond the recommend principles mentioned in the chapter two from user experience of the context mediated artifact.

5.1.1 The User Experience of the Mediated Artifact

In this part, we interviewed some users about the using experience of the mediated artifact. The operative environment focuses on individual seats. We evaluate it from five aspects: efficient awareness, bothering level, sufficient information, efficient focus changing, and convenient interface. Most of the subjects are well educated designers, and we set the simulation program to simulate the situation in the scenario. The communication server in a coffee corner and the sensor server in a controller center have been played in the simulation program in a remote computer. The experimental environment is like the figure 5.1.1.a. The user will receive the awareness message anytime during a half hour when they were seeing movies and could choose either to respond the message or not after seeing the detail information. Users were asked to evaluate the system based on the five aspects, and answers were collected as a questionnaire (appendix 1).

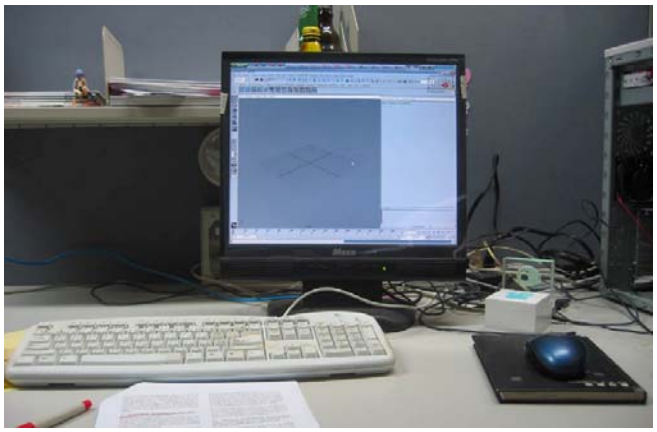


Fig. 5.1.1.a Testing environment of individual seats

Ten subjects involved in the experiment, and they contributed some unexpected results and interesting commands in the questionnaire. We describe these interesting findings in five aspects.

Efficient awareness: the commands of subjects implied that five of them could not remember the meanings of signals in a short time. One of them thought that colors shown by mediated-artifact confused him to make next operations. Another subject thought that she had no similar experience before; therefore she had to take time to think about the meanings of signals. And one of them also thought that the mapping meanings and signals should be easily associated.

Efficient focus changing: most of the subjects thought that they could switch his/her focus among awareness signals, messages back and their original works. However, few of them thought that the meanings of signals and the operation methods kept them thinking about the meaning of the signals which results that they could not change their focus efficiently.

Bothering Level: in this part, almost all subjects thought that the awareness signal is not bothering at all. Even some users had not much impression of awareness signals. But most of them thought that the flash type should be faster and shorter. Many subjects agreed that the visual awareness signals can reduce the bothering level.

Sufficient Information: we list the four elements: when, who, where, and what event in the detail information, and in the condition set in the scenario, the subjects should know at least one of the people in a social event; thereby, most subjects thought that the detail information is clear enough and they might choose to join the social event. To the aspects of context cues, almost half of them thought that they probably would ignore or forget the previous detail information, and this would be the reason why they wouldn't ask colleagues about contents of the previous social activity.

Convenient Operation Interface: our operation methods are short touch and long touch. Most subjects could accept the operation methods and learned them easily but not so fast, they needed some time to practice to be familiar with it. Therefore, some people didn't think that operation methods were easy to learn especially when facing the time to choose the operation method. The other aspect was worthy mentioned: the sensitivity of the touch sensor is difficult to adjust to satisfy every subject, and many subjects had no experience of operating touch switches. They thought that would take time to operate precisely.

Others: Half of them didn't think that physical awareness signals are better than virtual awareness signal. The most important reason is that they thought that depends on different situations and what kind of works a user is doing. Despite this, all subjects are willing to accept this kind of context-mediated artifacts.

5.1.2 Possibility of Using the Mediated Artifact to the Entire System

Monitoring social events of the entire system framework include not only informal social events but also formal social events. The artifact is more suitable for informal event awareness. Most of subjects didn't think that the artifact bothering and some of them even had shallow impressions of the

flash light. The bothering level is not enough for formal social events. If the formal social event is a scheduled meeting or any other social activity, the bothering level of awareness message must be high enough to draw the user's heed as soon as the coming of signals. Some of the subjects recommend that the flash light should flash faster and lighter and few of them think that sound can draw more heed than visual awareness message. Here, we found that the mediated artifact can match all social events. If it has to do it, functions have to be embedded with both low and high level bothering awareness methods. But in our scenario, we can't test and evaluate the actual requirement of formal social events to mediated artifacts. Therefore, the previous mediated artifact can't apply to the whole system framework. The situation also pointed that the design of the system should be modified depending on the context of types of office environment. Some working environments have tougher rules or schedules for employees which keep them away from many informal events in social places. The rate between informal and formal social events is varied in different kind of work office. And the brought benefit rate between informal and formal social events is different, too. The reason supports us to believe that the system needs to modify to match both informal and formal social events. Due to the observed environment and scenario implementation, we believe the system framework is more suitable for informal social events; hence, the mediated artifact can be used in the environment that contains more informal social events.

5.1.3 Conclusions of User Experience

Basically speaking, all subjects accept the kind of artifacts while they are working, and most of them thought that they will consider going to join the social events after seeing detail information, that means that it is possible to extend the physical contact by spreading out the awareness message and using context-mediated artifacts. Although half of them didn't thought that they would ask the other colleagues about the social event taking place; however, there are still more than half of them thought that they would. We believe the key point probably is inefficient chatting contents provided by our system or subjects' personal habits. We can say that it is possible to keep developing the system.

According to the summary of the questionnaire data, we found some recommended design principles for designing ambient-device- like context-mediated artifacts. These principles are beyond ambient design principles which mentioned in the chapter two. We list these principles below.

- *Awareness signals should be easily associated with the meanings of awareness messages and operation functions.*
- *The bothering level of signals should be considered to match different kinds of social events.*
- *The mechanism of heed changing between physical and virtual should be easy.*
- *The operation methods should be intuitive.*
- *The size of the artifact should be easily fit the size to be close to computer screen.*

These principles are summarized from our experience and subjects' commands; we believe these can make up the incompleteness of the framework about the context-mediated artifact mentioned in the

chapter three.

5.2 Conclusions

In big working environment, the arrangement of the plan often blocks the physical contact of staff. In this paper, we presented the concept, design, and implementation of a combination of ambient displays, ambient interfaces, sensor networks and context mediated awareness in order to support and expending informal communications and physical contact in wide range working environment. The system acts the monitoring of the environment context in social places with unobtrusive manner and sends the awareness messages only if received users' agreement. In this way, people can invite or spread the invitation messages at the same time when the social event moves. The social awareness message connects the related people who have a work seat in offices. If one of staff is at his/her seat, he/she can get the message directly, and if he/she is not at her seat, he/she still can see the message cues via operating the mediated artifact. The entire system sends physical contact messages and acts in physical environment and is manipulated physically. The way of designing emphasizes the reality of physical operative methods and the agenda to differentiate the other short message software system, such as MSN, ICQ or Skybe …etc. The agenda also implies a metaphor that a physical signal leads to a physical social event. We also find the deep challenge on sensing the existence of social events, and the entire system needs evaluation in real office environment and further implementation of more specific agenda of work offices. For finding out the possibility of further development, we had tested for eleven users to simulate the situation in scenario, and we can sure that it's possible for further development and we also recommend design principles for context-mediated artifacts.

5.3 Contributions

We revealed the possibility of a combination of ambient displays, ambient interfaces, sensor networks and context mediated awareness. And we present the principles and frameworks of how these four elements expend the range of informal communications. Beyond this, we also think that the framework is the fundamental way to help informal physical contact in big office environment, and the purposes and the focused social events can be changed depending on the types of work offices. We offer experience of a scenario implementation about a design studio. The implementation describes details of how we process the data and the operation method. And these frameworks and experience shall release more hidden issues about sensing social events, ambient interfaces and benefits of informal communication.

5.4 Limitations

In this thesis, the implementation level of the sensor server and the communication server is difficult to test their executive efficiency and the precision of the social events detection, and even the base infrastructure of sensor server is needed to be modified in more detail process, for instance, the efficiency of sensor networks, the accuracy of inference engine, syntax of other social events, and sensor signal processing. In the other aspects, we have not use wide range RFID as ID sensor because of insufficient supports, and we believe that it will increase the efficiency of sensor works; thereby, we represented the conceptual framework for making the prototype to support the context-mediated artifact works close to the real situation to help us find the possibility of social awareness system.

5.5 Future Work

In the chapter three, we mention that many physical sensors need to be programmed in detail and be evaluated about the precision and ability of sensing the physical elements in environments. Actually, the mechanism of inference engine also has many other computational methods to consider. It also needs a method to evaluate its efficiency for choosing a best approach to do a social event inference. In other way, we can seek more benefits of informal communication in different types of working offices. In the aspect of context mediated artifacts, there are still many possibilities about ambient patterns, interaction modes and contents for us to develop different context mediated artifacts for different situations. The nearest goal we have to do is to test the scenario in the real design studio to see the benefits and influence among the designers, design works and design activities.