OpenSpace:
Enhancing Social Awareness at the Workplace

by

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Submitted to the Program in Media Arts and Sciences
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Abstract

Social awareness in the workspace has been a classical architectural problem that has been tackled in various ways—ranging from architectural ways, such as the design of building atria, to technological ways, like connecting of two remote spaces using two-way audio-video tunnels. Any attempt at enhancing social awareness is fundamentally at odds with high levels of user privacy.

In this document, we shall discuss a novel sensor network based approach to enhancing the social awareness of people while maintaining low levels of privacy invasiveness.

We use a grid of motion sensors to collect anonymous information about activity in various locations of our prototypical workspace. The real time and historical components of the data are then visualized in six different ways. These visualizations are meant to be deployed as glanceable displays in public areas and personal workspaces to allow people to gain an almost subconscious awareness of the space around them. The system developed is evaluated through one on one critique interviews with users drawn randomly from the prototypical workspace. Finally the results of the evaluation are discussed and future directions for the research are outlined.

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The following people served as readers for this thesis:

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For my love, with whom I have found my deepest delights.

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Chapter 1

Introduction

1.1 Motivation

Enhancing social awareness in communities has been one of the classical problems in architectural and urban design. In many cases, communities find ways to socialize and interact around common scarce resources such as the village well, or the office coffee machine, but it is important to provide certain deliberate measures to facilitate that process. Whyte [39], in his seminal work, has found that people are attracted to places that have other people and that have something of common interest that diverse people can share and enjoy. He also mentioned food, sun, shade, circulation and sittable space as important criteria for good social spaces. Many of these themes also emerged in my discussion with Professor Bill Mitchell, celebrated architect and pedagogue in the field of urban living design. He emphasized that *transparency* in buildings and urban spaces adds to the social fabric of the place [30]. Transparency, in this case, refers to the quality of a place or a building that enables people to know enough about that activity in the common areas to be attracted to them.

The fact that people value transparency is evident from simple observations we can make in our daily lives. All of us, at one time or another, have seen people, with their notebooks and laptops, doing work in coffee shops. We might even have been one of these people a few times. Other times we might have seen someone working hard in their office, but with their office door ajar. In some way, these people are all trying to balance the tradeoff between

working hard and being socially aware at the same time. In any such situation flexibility is important—to be able to easily switch between different modes [30]. It is not easy to switch modes in a physical world. Your door can't be ajar one moment and closed next and then open again to follow your focus and concentration levels. And you surely can't be at the coffee shop one moment and in your office the next. At least not with current technologies. It is this need of being socially aware with flexibility in the workplace, of being able to flow in and out of ambient social awareness, that we are trying to address through the work in this thesis.

In terms of architectural design, an atrium is an often used way to increase transparency in a building. People can get a sense for the activity in the common areas of the building while being in their own corridor. Other ways are by making some walls transparent, using indoor windows, elevators that provide a view out and other similar measures. But the architectural means of providing transparency have physical limits that can not be overcome without using technology. Also the architectural solutions are permanent and inflexible. One can't really "turn-off" an atrium if there is a noisy party going on there. Already, email announcements about events and meetings fulfill the need for transparency in office life, but the kind of awareness that can be introduced by instrumenting space with sensors of different kinds, the approach taken in the system described in this thesis, has not been previously achieved.

1.2 Summary of thesis

In this document, we shall discuss a novel sensor network based approach to enhancing the social awareness of people while maintaining low levels of privacy invasiveness in the system development and use. The essential problem that we are trying to solve in this thesis is to bridge the gaps between the social nature of humans and the asocial nature of the work spaces by using technology in a way that has not been hitherto possible in the space of this classic problem. The ability to instrument spaces to get an information stream about the nature of activity in that space allows one to build much more potent awareness systems than possible before.

In this discourse, social awareness refers to the perception that a person in a community has about the presence, availability and interaction patterns of other people in that community. A community here refers to any group that engenders a feeling a fellowship in its participants due to some shared characteristics.

The approach that we follow in this work for enhancing social awareness in the workplace consists of instrumenting a prototypical workplace with motion sensors to collect high resolution data about the level of activity in the different spaces. Privacy invasiveness is an often-raised concern whenever activity monitoring is being considered. Motion sensing, while being a good indicator of activity in a space, is not as privacy intrusive as video or audio sensing might be. The data collected from these motion sensors is presented to users in the form of artistic visualizations, the information design of which would be aimed at getting important social indicators across to the users. The efficacy of this approach is tested by means of one-on-one demonstrations and critique interviews with prospective users. The results of the interviews allow us to evaluate the approach, learn lessons and guide future work in enhancing social awareness.

1.3 Thesis contributions

The third floor of the Media Lab was used as a prototyping environment for the project and was instrumented with 150 motion sensors to sense motion events in space. About half a dozen base stations were installed in strategic locations to collect data from the motion sensors. Though the motion sensors were wireless and battery powered, the base stations were connected via power-over-ethernet(P-o-E) cables for power and communication over the same connection.

The sensor network was supported by a software architecture designed to collect, collate and organize the data in a file server and a database server. We implemented a TCP server to provide real time data about activity observed by the motion sensors to any application within the Media Laboratory.

The social awareness application was conceived as a set of displays

visualizing activity in the lab to be placed in various spaces including public areas like the atria and the cafe and personal spaces like offices. Six such visualizations were designed and implemented to highlight different aspects of the observed data. Some visualizations were real time dynamic displays of information, some incorporated historical data along with current data, while yet others were for explorations of historical data aggregates. Some visualizations were meant to be interacted with while others were designed to be 'glanceable'. Each of the visualizations were tested for efficacy and desirability by showing them to a set of human participants and the results compared to each other. Based on the results of the evaluation, we then came up with a set of lessons for design of visualizations for social awareness. We also discuss the tradeoff between privacy invasiveness and social awareness in the context of the results of the evaluation.

1.4 Document structure

The rest of the thesis reports on the work done in the order outlined here. Chapter 2 contains a detailed discussion of other social awareness systems, along with discussion about social uses of sensor networks and privacy issues. That is followed by a description of the experimental setup and methodology used in this work in Chapter 3. Chapter 4 is a discussion on the procedure and results of the evaluation. We conclude with lessons learned and pointers for future work in Chapter 5.

Chapter 2

Background

In this section, we will discuss some of the work that relates to the various issues that we are dealing with in this thesis.

First we will discuss the various systems targeted at enhancing user awareness about the communities they live in. Some of the systems discussed did not have an explicit stated objective of social awareness, but they are cited nonetheless as they address the issue to some extent. The social awareness systems are classified based on the space they act it—online space, home and the workplace.

Since in our approach, we are trying to use a sensor network of motion sensors to gather social information about the space we work in, we will then discuss previous research that uses sensor networks for social purposes.

We will conclude this chapter with a discussion of privacy issues as discussed in the literature.

2.1 Social awareness systems

2.1.1 Online social awareness

The broad nature of social awareness means that systems that enhance it can be of many types. Let us take a simple example. An instant messaging client like AOL [2] or Yahoo messenger [4] can be thought of as a social awareness system. It allows its users to know when their 'buddies' are logged in to

instant messaging and whether they are available to chat. If the person at the other end so wishes, they can reveal further details like if they are out to lunch or which song they are currently listening to. Sitting at their own end, and without indulging in explicit interaction, a user has some perception of the state of presence, availability and, over a period of time, the interaction preferences of the people on their contact list. The system even allows them to initiate a *lightweight interaction*—brief, informal & repeated communication [38]—that further adds to their awareness of the contact. Despite providing these key cues for enhancing the user's social awareness, IM clients fail to address the problem on the following counts:

- IM use is mostly limited to people sitting at their computer.
- Users must update their status, otherwise the information becomes outdated and inaccurate.
- Due to its identity-centric nature, the awareness is limited to people whom the user knows fairly well. It is not about community or group awareness.
- The system is designed for and used in the virtual plane and is not rooted in the physical space around the user.

All of these are important issues that a comprehensive approach to social awareness needs to address.

Sometimes people who work together in group decide to collectively use an IM client to pass lightweight messages in the course of their day. Tollmar et al. [36] build a more formalized version of such a system with a possibility of an audio/video link (which, now, IM clients also provide) and setting of alerts for certain individuals for whom one wants to keep an eye out. They wanted to facilitate knowledge sharing between people in a research group with widely varying schedules and made this system for telling people where other members of their research group were, what they were doing, if they could be disturbed and what the best way was to get in touch with them. It was essentially an IM client with a little more responsibility attached to keeping ones profile updated as it tied in to their work group relations. It was observed that despite the expected level of relevance, the user information still ended up being out-of-date most of the time as users lost interest in using the system due to its strict limits about who could use it.

There have been some interesting variations of social awareness online that include both anonymous and identity-centric awareness. In one report, Cohen et al. [10] built a meta information system about a website, in which people browsing a website can know how many other people were browsing the same content. A similar system was built by Minar and Donath [29] in which they visualized crowds browsing a website.These tools helped to build an awareness of social presence in web space and develop special interest groups around subjects and documents on a website.

2.1.2 Awareness in the home

The area of providing social awareness between family members living apart from each other has been rife with interesting work. Given that family members do not necessarily have access to or experience with computers, solutions in this space have tended to be fairly rooted in the objects that we have in the physical space around us.

ASTRA [27] is a system that helps family members, who do not cohabit, stay in touch by using a combination of mobile note-taking device and a collating display at home to communicate using pictures, short messages and to-tell lists. WatchMe [28] is a wristwatch interface system that allows friends and family to be aware of one another through visual cues and text messages, while using sensors on the watch to get context about the location and activity of the users.

Some systems involve instrumenting deeply personal objects like pillows and photo frames to achieve artifact level awareness that makes emotions visible across distances. Casy [40] pillow allows sending of video snippets to family members to help connect across time zones and individual circumstances while LumiTouch [7] photo frames are digitally connected across distances such that when one photo frame is handled, the one on the other end responds by glowing. Similar systems also include Casablanca [16] or the Digital Family Portraits [31] that digitally enhance everyday objects such as lamps, message boards and photo frames, again, to provide information about the people in another space.

The method of interaction outlined in many of the above projects, and in others like the Ambient Orb [1], includes showing low resolution information

on peripheral objects or displays. The intention is to not tax a person's attention and screen space by alerts that demand immediate interaction. The technique is often referred to as peripheral, ambient or glanceable displays. Professors Ishii's lab at the Media Lab has been a seminal place for ideas on ambient display of digital information [11]. The ambientRoom project [20] introduced an ambient display for presence as a social concept that was displayed using light-patches. This mode of interaction would be used in the current project to provide an awareness of the social environment to the user. Social awareness is not a time critical need and can be put to ambient displays to be easily looked at when the user has the time and the inclination.

2.1.3 Awareness in the workspace

What would be the next best thing to meeting someone face to face? Would it be live A/V connection? Real time audio-video tunnels have been popular in social awareness applications. Just as we use physical windows in real space to look out of our offices, Dourish et al. [12] built a system to extend this capacity to remote spaces as well. The system, called Portholes, was used to enhance peoples awareness across geographically separated offices of the same company by capturing image data from various locations in these buildings and making it available across the network. The system was well received, except for some privacy concerns, and led to spontaneous connections and development of a shared culture. We would argue, though, that assistance in establishing connections and in collaborating is not only required by people in remote offices, but also between people who work together in one big building, as they might not be as socially integrated as they potentially could be.

In a similar but more recent work, researchers at MIT Media Lab and Media Lab Europe set up continuous, synchronized video installations at multiple places in the two locations to provide a ready channel for video interaction whenever people want and the same would act as a background remote awareness installation when not in direct use [5]. The screen was also used to display text messages sent via SMS to increase the usage modes of the installation.

One very interesting use of an audio video tunnel was made by Galloway et al. in the early 80's [14] when they connected up two very public spaces on the two coasts of America using an audio-video link over satellite. They called it the Hole in Space project. This installation was very well received and heralded as revolutionary at its time. Not many complaints about privacy were reported.

This response can be contrasted to the study conducted by Jancke et al. [22], the setup of which was in a similar vein. In this study, they had connected three public spaces (kitchens) in the research building using live audio-visual feeds. Users of the system reacted very strongly to the privacy invasive implications of the systems. They wanted more control in deciding if they would be filmed and often sabotaged the video feed. Arguably, the location of the media window and the nature of that space had something to do with the different reactions. Clearly privacy is a big concern and it will be discussed in detail in a later section.

Karahalios and Donath, in their work with Telemurals [24], overcame the privacy concern while retaining the efficacy of the audio video medium by abstracting out details from the video and sound streams. They maintained the interaction without displaying the hi-fidelity camera feed directly on the either side.

2.2 Social sensor networks

Sensor networks have been used for social awareness and networking applications in the past and it would be useful to briefly discuss the relevant works here.

The active badge system [37] has been used to know where people are in space. Sensors on badges worn by users convey the current locations of the users to a central location for the purpose of routing phone calls and such. Although the data from this system could have been used to analyze and visualize some aspects of the social use of the space, this was not done in the cited work.

Networks of wearable sensors that have been used to gather information about social networks in organizations include a number of projects done by

the Human Dynamic group at MIT Media Lab [9, 26]. Sensors worn on the body or embedded in personal devices such as cell phones gather information about verbal interactions and the nature of the conversational dynamics in social networks. The objective was to understand the social network in an organization and identify the people informally entrusted with leadership roles in the various groups and subgroups.

Larger areas have been observed by instrumenting existing networks, such as GPS and WiFi, to understand the living and working patterns of users in small areas, such as universities. The techniques have also been used in an urban planning tool for larger areas, such as cities [32, 35]. The GPS system was tried out in Graz and WiFi network usage was collected for the MIT network.

Finally, in a yet unpublished work, Josh Lifton at the MIT Media Lab is working on integrating the real and virtual worlds by having sensors in the real world affect the virtual world, and actions in the virtual world have some manifestation in the real world [25]. This system has the potential of being used as a social awareness tool for people using the virtual world as a medium.

2.3 The privacy perspective

The trade off between social awareness and privacy has come up a number of times in our discussion. Privacy has been perceived to be under threat, especially when audio and video feeds have been a part of the solution, due to their hi-resolution data collection. There have been previous efforts that attempt to reconcile these two goals of maintaining individual privacy while providing cues for social awareness.

Some researchers have tried to use asymmetric connections to overcome this concern by giving up more privacy of the person initiating the interaction than the ones who are on the other side [15]. This could be an effective solution where such asymmetry would be acceptable given the social dynamics.

Another effort at dealing with privacy issues was in the form of conceptually segregating private and public spaces for a domestic video communication

system [23], that allowed higher fidelity connection in 'public' areas, and a much lower one in the 'private' areas. Considering that both the public and private areas in this case were within a person's home, it is not far fetched to imagine that the boundary between public and private in the home, might be very different for different people.

Audio monitoring has also been used to provide family members with awareness about the activities in a remote location using short audio cues while taking into account privacy concerns by iconizing and garbling the audio that is transmitted [34].

It has also been argued previously [33] that low-resolution sensors, traditionally considered worse, are better for ambient sensing than high-resolution ones. For example, simple motion sensors might be as effective as cameras and microphones for providing high level social cues, such as monitoring space occupation and level of activity, while reducing the potential for privacy invasion.

In conclusion, this chapter contained an overview of literature relevant to the work discussed in this thesis. The social awareness applications have largely involved concepts of identity-centricity, explicit user interaction and, to some extent, avoidance of privacy issues. The discussion reflects a gap in the research landscape which we are trying to explore with our approach to social awareness. We are going to discuss our methodology which allows for anonymous awareness, does not necessitate user interaction for data collection and does this without invading on user privacy by making maximum use of motion data which is a lot more benign than other forms of sensing such as audio or video recordings.

Chapter 3

The Setup

In order to test various ideas for enhancing social awareness in workplaces, we used the third floor of the Media Lab as a prototyping space to deploy infrastructure, collect data and evaluate solutions. The third floor of the Media Lab is approximately a 27,000 sq. feet space with about 60 offices, many open work spaces and some social spaces. Approximately 150 people work full time in this space. A map of the third floor is shown in Figure 3-1.

The infrastructure for the project consists of the sensor network, the data collection apparatus, the data analytics and the visualization repertoire. We will go through each of these one by one.

3.1 Sensor network

The sensor network consists of 150 motion sensors deployed around public areas of the Media Lab. Also a part of the network are 8 base stations placed around the lab to collect activity data from the motion sensors and make it available on the internet.

The motion sensors used in the study (Figure 3-2) are second generation sensors designed at MERL, the first generation of which were designed by a collaborative effort between MERL and the Media Lab. The sensors are designed to be low power; it is estimated that a sensor can be powered by battery alone for 3 years before exhausting its batteries.

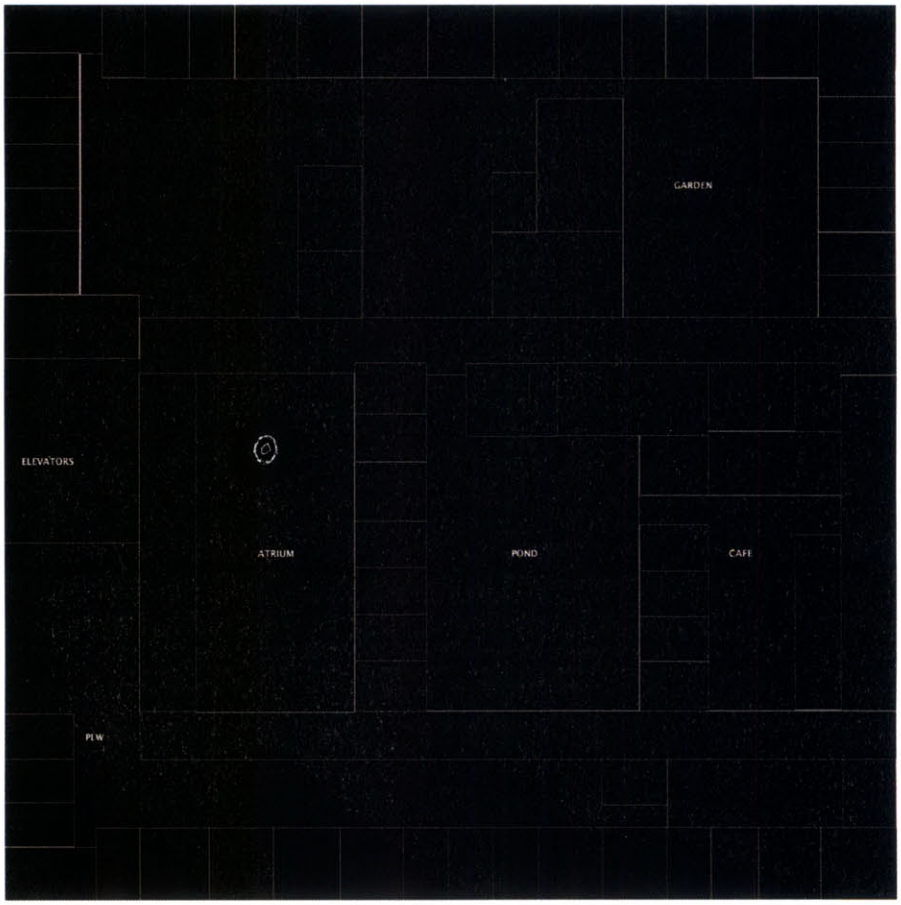


Figure 3-1: This is a map of the third floor of the Media Lab. Some of the named spaces are marked on the map.

A critical part of the sensor network comprises the base stations (Figure 3-3) that collect data from the motion sensors and make it available on the ethernet. The base stations are quite easy to install as they have a magnetic back and can be wired with a single power-over-ethernet (P-o-E) cable that is used for both power and network communication.

Communication between motion sensors and base stations takes place wirelessly on the 2.4 GHz band using the IEEE 802.15.4 protocol. The sensors are also very easy to install as a magnetic back combined with wireless functionality and battery operation ensures that we can just stick the sensors pretty much where we want.

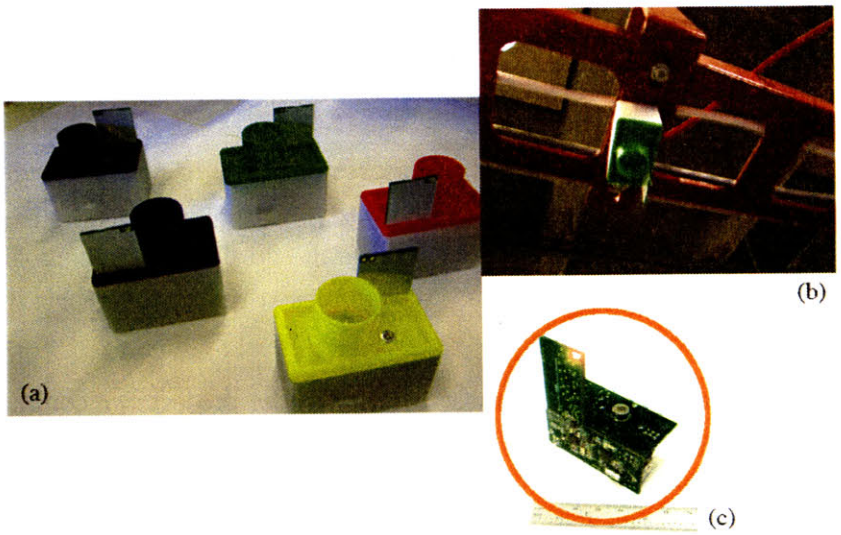


Figure 3-2: (a) These are the motion sensors used in this project. (b) This is a motion sensor magnetically attached to one of the cable trays in the Media Lab. (c) Here is the inside of one of the sensors. The scale is visible in this image.

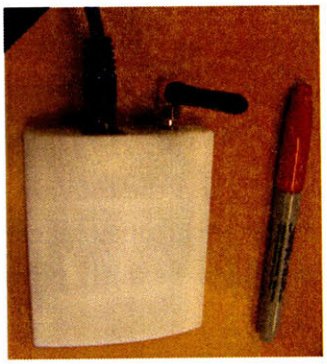


Figure 3-3: This image shows one of the base stations next to a Sharpie for scale. The base stations derive power from and communicate using the same wire connection (P-o-E cable).

3.1.1 Deciding locations for sensors and base stations

Locations of the various motion sensors were finalized after some consideration. In making this decision, we were dealing with a trade-off between getting a high resolution picture of the activity around the space and minimizing privacy invasion. For a major part, what keeps this data from being privacy invasive is its anonymous nature. Simple one bit motion

sensors report their data about when they see motion without associating the data with any sort of person identity. We are not collecting privacy infringing information such as video and audio data.

Though the benign nature of motion sensors compared to audio or video sensors was more conducive to addressing users' privacy concerns, the location of where sensors were placed could still end up jeopardizing the privacy of certain individuals if sensors were placed right above their work place, for example.

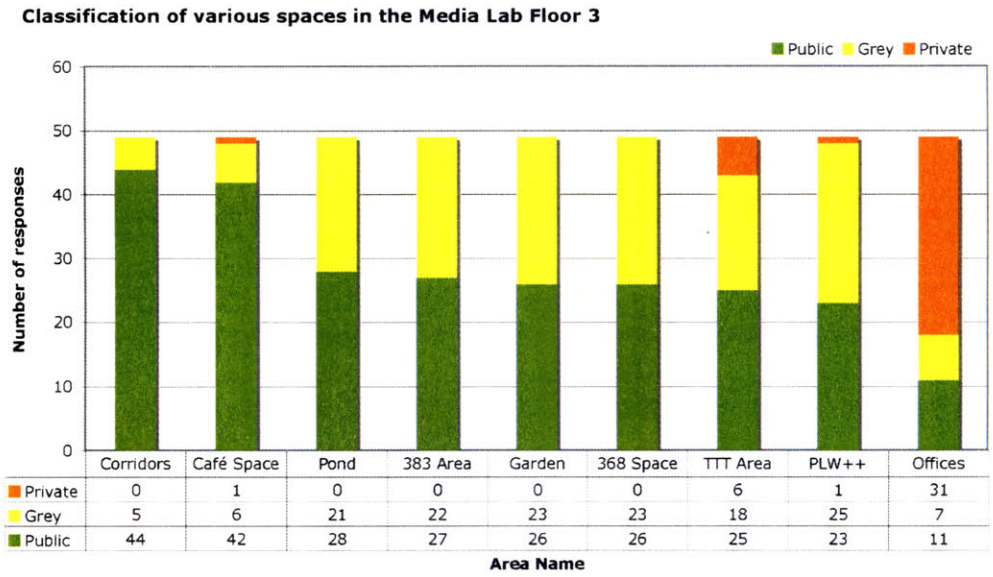
In order to understand the privacy sensitivity of the project, we conducted a short electronic survey of people working in the Media Lab. We first asked them how they would classify various spaces in the Media Lab as public, private and grey (that is between public and private). The graph in Figure 3-4 plots their responses against various physical areas/spaces. The various spaces shown in the graph include offices that are primarily used by one or two individuals, open workspaces of research groups that are used by the group members, social spaces like the cafe and the student lounge and corridors around the lab. Some of the open workspaces have names that they are identified by, like garden, pond, bt, plw and 368 space, and the same identifiers are used to refer to these spaces in this thesis also.

It can be observed that corridors and the cafe are considered fairly public places, while the offices and one of the open office spaces used by administrative staff are perceived to be fairly private and the rest of the spaces fall in between the two.

We also asked them how comfortable they were with having motion sensors in workspaces that they had classified as private, public or grey in the previous question. The graph in Figure 3-5 plots their responses against the three classifications.

The plot shows that respondents, on an average, are very comfortable with sensors in public areas (mean 4.14), fairly comfortable with them in grey areas (mean 3.66) and are neutral with a bias towards discomfort in the spaces marked by them as private (mean 2.97).

After considering the survey results, we decided not to place sensors in offices or areas which were primarily used by a single individual. The locations of the motion sensors are shown in Figure 3-6. They are installed about 6 feet



	Corridors	Café Space	Pond	383 Area	Garden	368 Space	TTT Area	PLW++	Offices
Private	0	1	0	0	0	0	6	1	31
Grey	5	6	21	22	23	23	18	25	7
Public	44	42	28	27	26	26	25	23	11

Figure 3-4: Survey respondents were asked how they would classify various spaces of the Media Lab between public, private and grey (in between private and public). This graph plots the responses of the people against the various named spaces in the Media Lab.

apart from each other to get a good resolution of the activity and motion data in the covered space.

The base station antennas have an unobstructed range of approximately 40 feet. Since the insides of buildings are not unobstructed and usually contain radio blocking material such as concrete and metal, a total of 8 base stations were used to collect data from different parts of the third floor where the sensors are installed. The locations of the base stations were selected for maximum coverage and are shown in Figure 3-6.

3.2 Data collection

Each motion sensor contains an IR sensor and can sense activity in a cone of approximately 6 feet ground diameter. This can be changed by adjusting the physical length of the shroud surrounding the sensor lens. Whenever any motion sensor observed motion beneath it, it informed base stations in its vicinity using radio communication. Each radio packet primarily consisted of

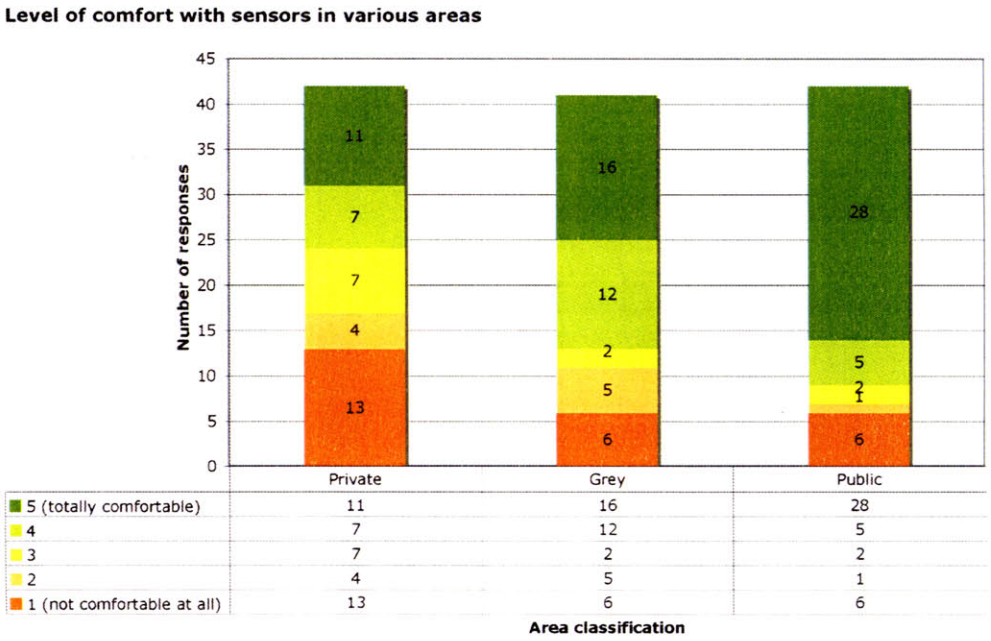


Figure 3-5: The survey respondents were informed about the motion sensors and asked about their comfort level in having the sensors in the public, private and grey areas as marked in the previous question. The graph in this figure plots their responses.

two pieces of information, the sensor ID and the time in milliseconds at which the activity was observed. Activity reporting is binary, either present or absent. The *amount* of activity is not recorded by a sensor.

Each base station, in turn, made that information available to others on the ethernet. Base stations can be accessed via TCP to receive information about activity around that base station. Some motion events were available from multiple base stations but the sensor id and millisecond timestamp made those values unique and duplicates were easily filtered out. In the system architecture, we had a computer constantly seeking information from various base stations about recent happenings and storing that information in a filesystem, and also a central database. The data could then be used for real time applications as well as for historical data analysis.

The various applications that need to use the data from the sensors can do so in two ways. They can either access the database to get the events from the time period of interest, or they can access the 'fresh' data that is available

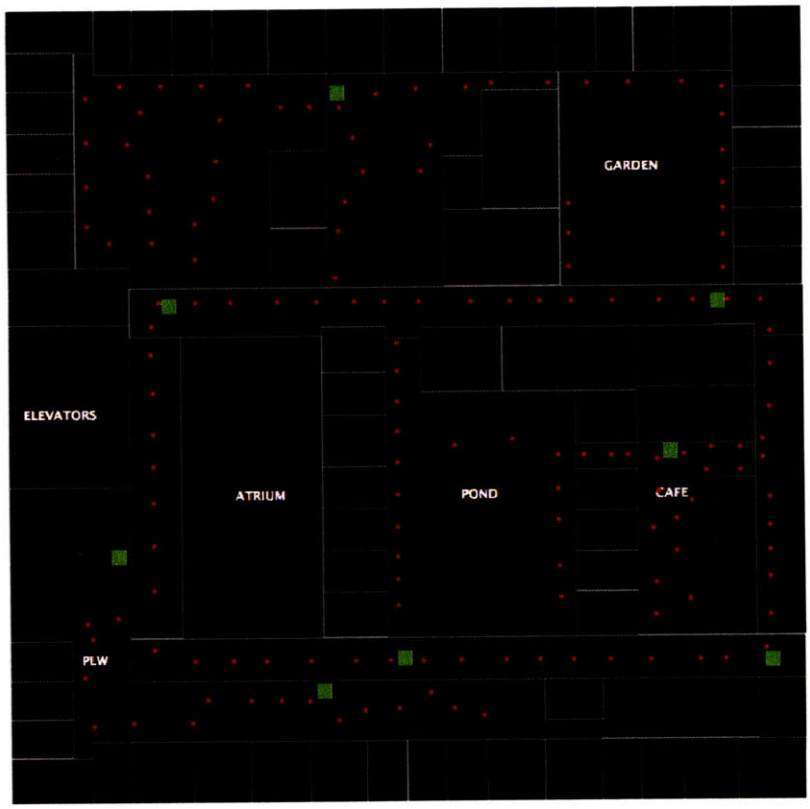


Figure 3-6: Locations of motion sensors and base stations. The red dots are the motion sensors and the green squares are the locations of the base stations.

from a server which is in turn collecting it from all of the base stations. The architecture of the system is shown in Figure 3-7.

3.3 Display apparatus

The user facing part of the system consists of data visualizations for two kinds of uses:

1. As installations in public space
2. As glanceable displays for personal use

In the first case, the intention is to bring more transparency into the building by visualizing the social activity in the public spaces of the building. People glancing at the display, while casually walking by, or stopping and looking at

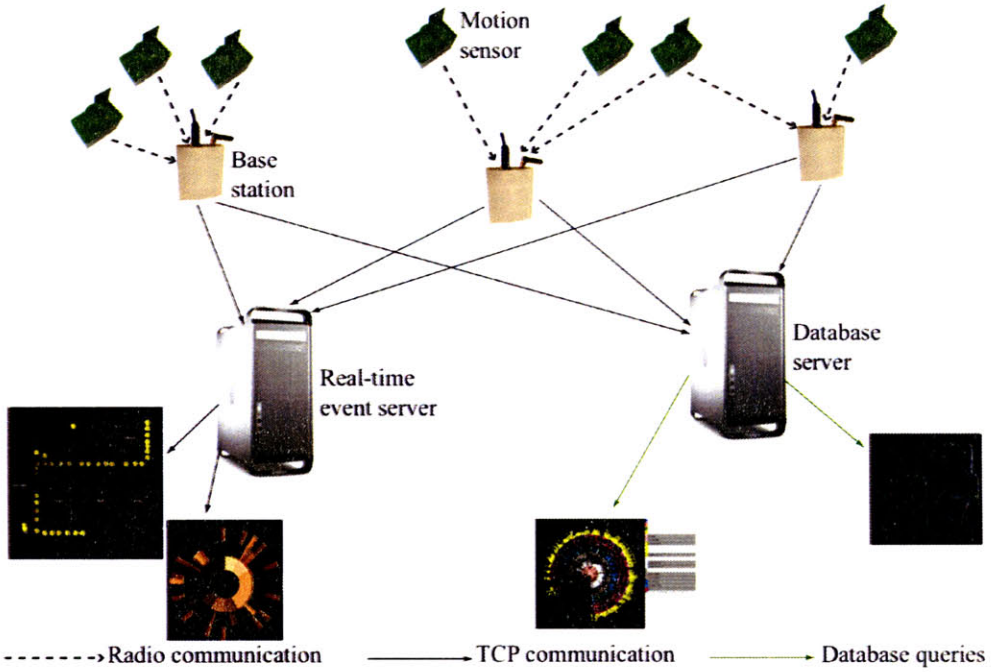


Figure 3-7: High level system architecture. The arrows show the flow of information between the modules.

it for short durations of time, would be able to know the public spaces where other people are currently, have been recently, or are usually present. The visualizations are also expected to play the role of social catalysts by providing people in the same area a common topic to comment about.

In the second case, the displays are still intended to be glanceable, that is, simple enough to be taken in at a glance. The difference is that these visualizations are more customizable and allow people to keep tabs on only the information that they are interested in. The personal visualizations are also meant to provide long term, slowly changing trends in the sensor data. The aggregate and slow change nature of these visualizations might not make for an interesting display running all the time, but might provide an interesting cut of the data for individual browsing. The personal display system would also do well to have a system of alarms to alert the user whenever something pre-defined happens. For example, when the conference room is free or when the visiting delegation is headed towards your office as a part of their organizational tour. This capability has not been implemented in the current attempt.

3.4 Analytics and visualizations

The various visualizations that were developed for the above purposes and the data analytics that went behind those visualizations are discussed below.

3.4.1 OpenMap

The most basic visualization that we built was a dynamic visualization that worked in real time and showed the map of the third floor of the Media Lab, as that is where the motion sensors were located. The map was overlaid with markers for the various sensor locations. We called this visualization OpenMap (Figure 3-8).

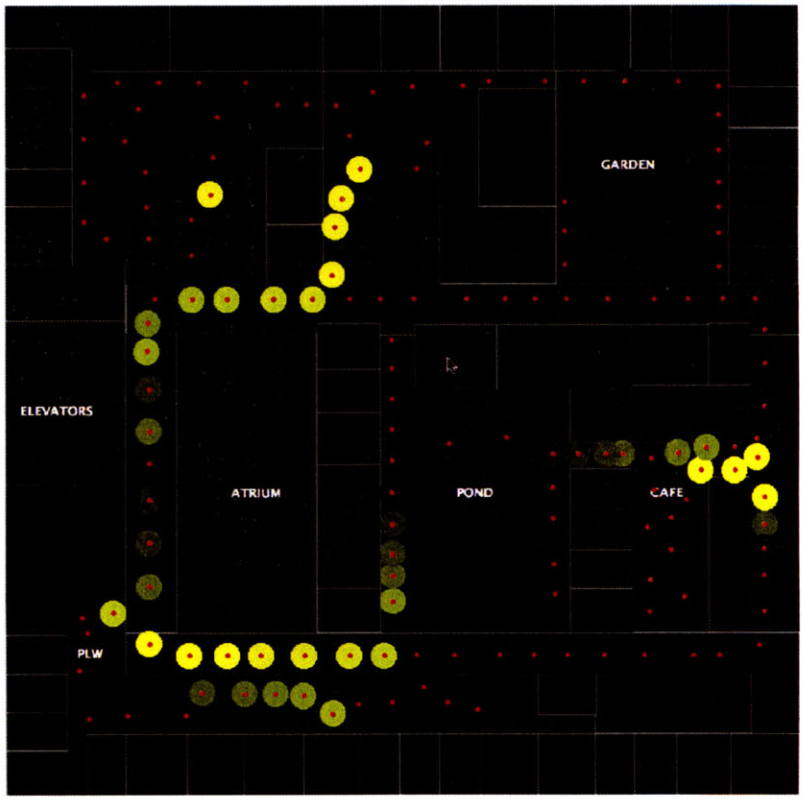


Figure 3-8: The figure shows a screen shot of the OpenMap visualization, which runs in real time. The activated sensors show up as bright yellow circles that fade with time. The visualization shows the hot spots of activity on the third floor at the time of the screen shot.

Whenever activity was observed by a sensor, the sensor marker at that point glowed with a big yellow disc that slowly faded away. Given the slight incorporation of history in the system, the person observing the visualization could trace the path of people moving through the space.

The visualization is anticipated to help people be more socially aware by increasing the transparency of the building around them. It was anticipated that getting a sense of the current activity in the space around them, and a subconscious perception of the socialization in space and time over a period of usage of the visualization, would help them feel more in tune with the social scene around them.

3.4.2 OpenWindow

This visualization (Figure 3-9) is essentially a 3D version of the OpenMap visualization introduced above. What it brings to the table is the option of letting the user set his or her own perspective.

OpenWindow was visualized as a means for users to set for themselves an *open window* on a location of their choosing which would then afford them a vantage point, a feeling of looking into a space that might be visually inaccessible to them from their workspace.

3.4.3 LastClock

This visualization is an adaptation of the visualization by the same name done by Angesleva and Cooper [6] in 2005. The visualization, shown in Figure 3-10, shows the recent history of a specific area, in this case, the cafe/kitchen space of the Media Lab, by showing the aggregate intensity of activation data from various motion sensors placed in the Cafe. Brighter colors denote higher aggregate intensity, as compared to average, and darker colors show lower intensity of aggregate activity in that time span. The time markers are shown in red.

The visualization runs in real time. Every second, it updates the segment of the outer ring corresponding to the last second with the color corresponding to the activity level in the past second. As the seconds marker in the outer

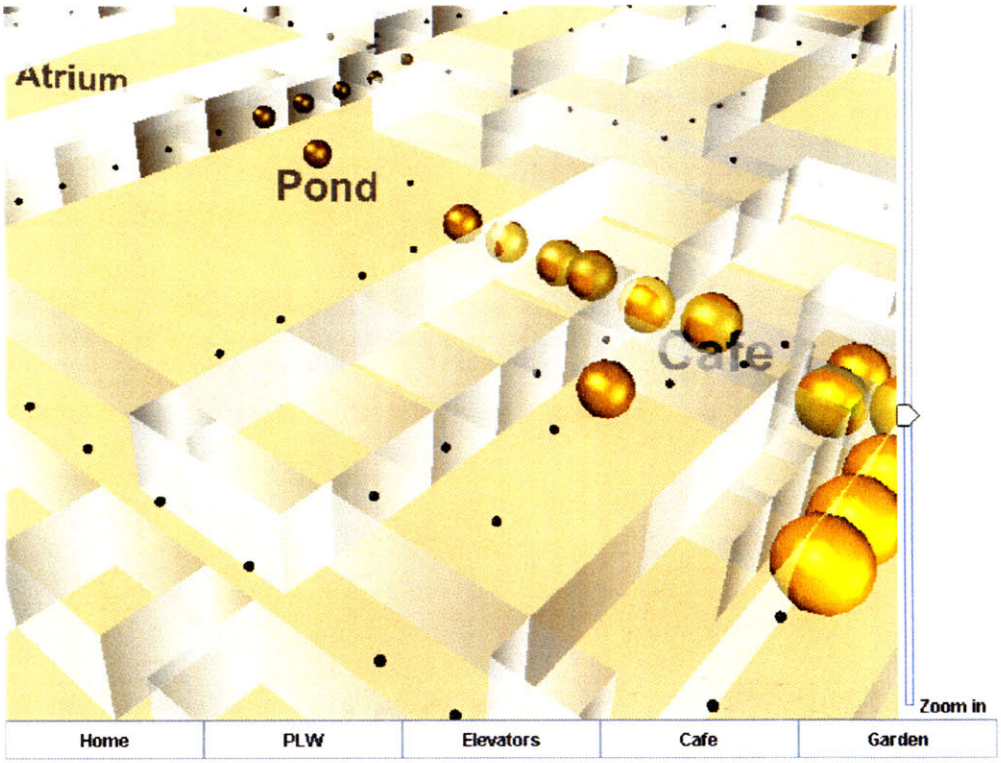


Figure 3-9: This is a screen shot of the OpenWindow interactive visualization. The users could move through the 3 dimensional space to focus their attention on a specific part of the building giving it their own perspective. This perspective is the user's *open window* in space

ring completes each minute, the minutes hand in the middle ring moves forward and updates the last minute's segment with the color signifying the activity in the past minute. In a similar fashion, when the minute hand finishes its hourly cycle around the clock, the hour hand updates and colors the most recent hour with the appropriate color marker. Thus the outer ring ends up showing the last minute of time, the middle ring shows the last hour and the inner ring shows the last 12 hours of activity. As we look back in time, a brighter color for a segment means that there was more than usual activity at that time.

We deliberated on a number of design issues associated with the visualizations. For example, one if the things that we thought about was whether the LastClock should show 12 or 24 hour of history. We decided to go with a 12 hour version since people are more familiar with that type of

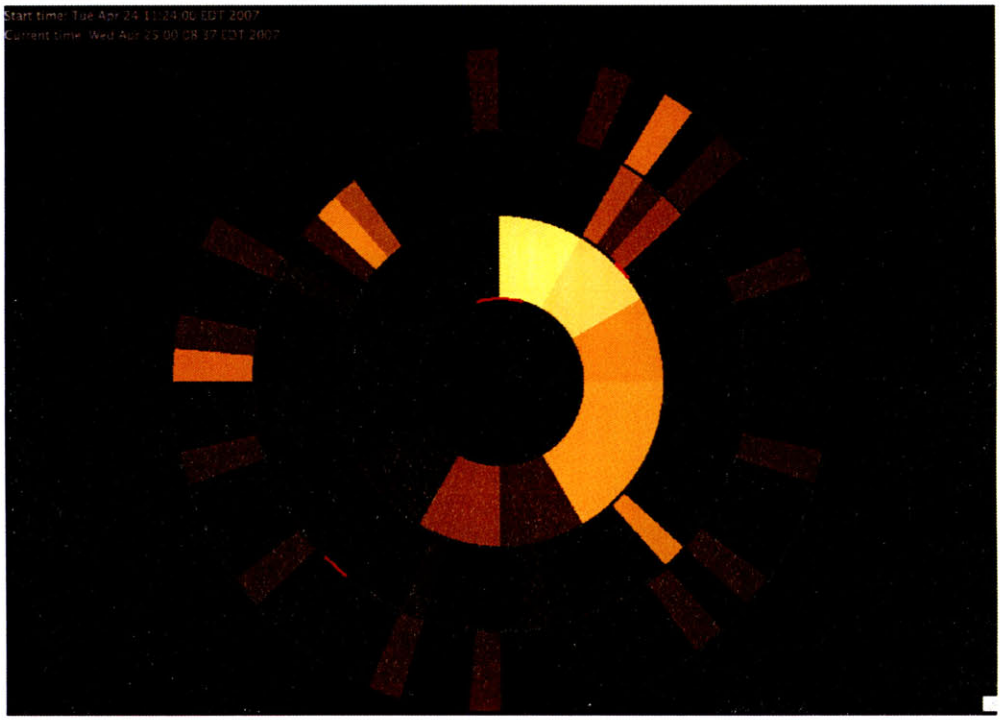


Figure 3-10: This is the LastClock visualization. From the current time, it shows the *last* 12 hours of activity in a chosen area. The inner ring shows the amount of activity in the *last* 12 hours, the middle ring shows the *last* hour and the outer ring shows the *last* minute. The brightness of the colorfill is proportional to the amount of activity in that time period. The red arcs show the current time and at each update of the hour, minute and second, the color in the last changed segment is updated.

the analog clock and hence would arguably be better able to glean temporal information from the visualization. What might be helpful is to have a panel of, say, seven, or maybe fourteen, of these clocks for the last 7 days of the week to show more of a history than just 12 hours at a time.

Even without activity, the visualization is somewhat useful as the red markers show the current time. This is helpful because then the visualization can "piggy back" on existing visualizations that people are used to seeing in their workspaces and the move would not require larger change and adjustment on their part.

The screenshot in Figure 3-10 shows the activity in the cafe space from noon through midnight on a randomly selected Tuesday in August. As you can see,

the cafe was very active during lunch time and became progressively quieter as the day went by until about 5 p.m. Then, we see medium amount of activity between 5 and 8 p.m., and after that the place is pretty quiet.

3.4.4 OpenClock

The visualizations that we have introduced so far allow us to view only the current or immediately recent data from the motion sensors. But an important way of understanding social happenings in a workspace is by looking at the trends of space usage and interactions in space in the past data. The next few visualizations that we will consider allow users to browse the historical aggregates of activation data for such purposes.

OpenClock, as seen in Figure 3-11 is an interactive visualization where a user can input the area and time of interest (up to a period of 12 hours) to plot the activation data on a *clock* to compare activity across areas and times.

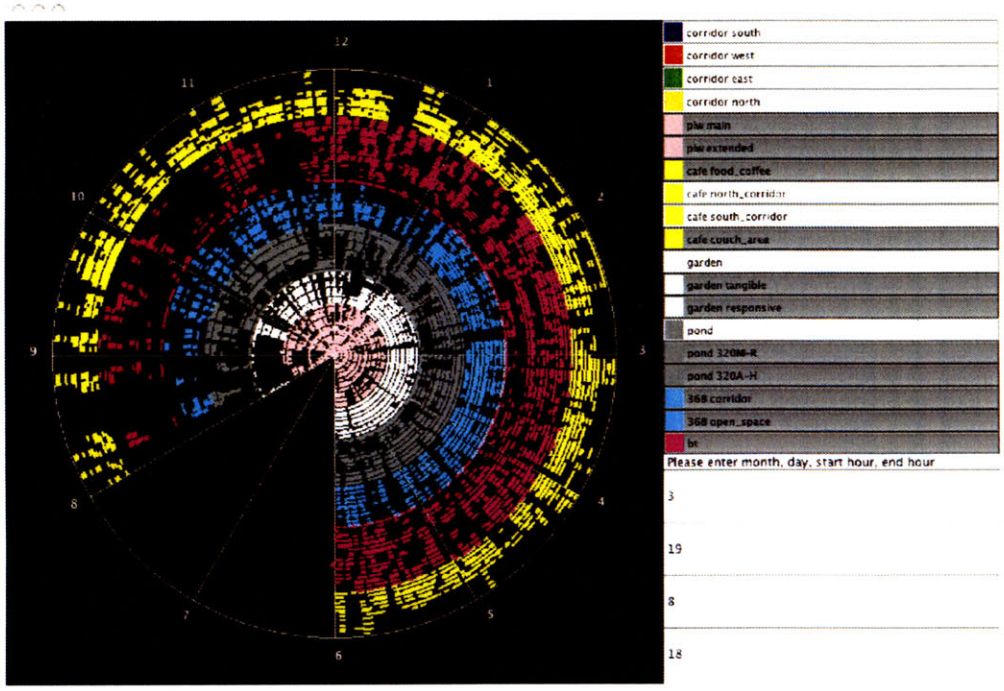


Figure 3-11: This is the OpenClock visualization that allows the user to interactively choose the time and areas in space that they are interested in and view the activity in that period for those areas. The different areas are shown with different colors.

The sensors each form a concentric circle with a unique radius on the clock and the times that those sensors are active in the given period determine which part of the circle is shown and which part is left dark. A clock was used as plotting device to allow the users to parse the temporal content of the data with practiced ease.

In the screenshot shown in Figure 3-11, we can see the space usage of different color coded spaces in the Lab in a particular workday between 8:00 a.m. and 6:00 p.m. The column on the right allows the user to choose the areas—the grey buttons are the selected areas—that they are interested in, and also pick the date and time interval that they would like to see. The activity for the chosen time is then plotted on the clock.

It can be seen that, on that particular day, the workspace called 'bt' (in magenta) did not become vary active until almost noon while the 'garden' (in white) became active starting 9.30 a.m. Looking at multiple days worth of this data might suggest something about the work schedules of people working in different areas.

3.4.5 OpenTrack

It is straightforward for a human observer to virtually *connect the dots* on the OpenMap visualization when he or she sees someone moving from one area to another. The trace of a person's movement from one space to another is also a basic analytic unit of the data as it allows us to build models of space connectivity, and perform traffic pattern analysis for the entire space.

Tracks for this purpose were built using the model of the *tracklet* introduced in [21]. The idea behind the computation is to link together activations that are unambiguously related to each other in space and time. Wherever ambiguities exist, the tracklets are broken and joints or links are established between as many tracklets as might exist in the given space time window. We have computed that information to find the tracks that people usually traverse in the Media Lab.

OpenTrack visualization in Figure 3-12 plots the tracks in a specified time period on the map of the third floor to give a sense for how *worn out* some of the paths are in the Lab.

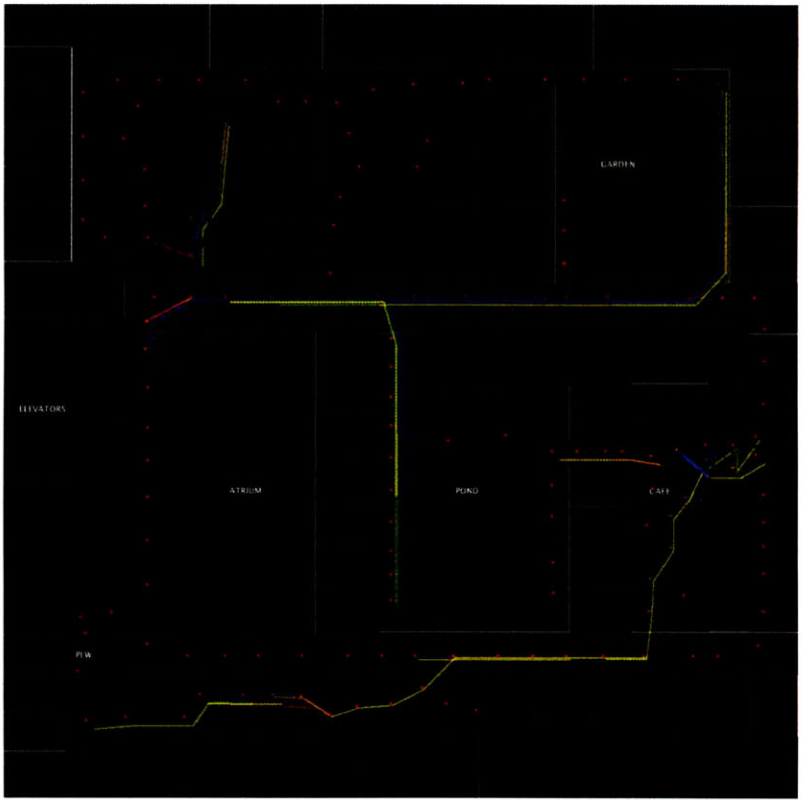


Figure 3-12: The OpenTrack visualization above shows the *tracks* for given time period plotted on the floor plan of the third floor. The tracks are constructed from the activation data by linking together observations that are related to each other in time and space.

This particular screenshot is showing the tracks in the Media Lab for a period between noon and 1 p.m. on a randomly selected Saturday. It can be noticed that the east corridor was used way more than the west corridor in the given time.

The idea behind the OpenTrack visualization is similar to the one that is increasingly being used by landscape designers to figure out the best routes for paved paths in public gardens. They let people use the space for a period of time until actual human tracks start appearing by wearing down of the grass and then build their paved paths on the same tracks. This gives the gardens an organic look while at the same time preventing disuse of the space in the future by moulding itself to human patterns. The paths are also more usable in the end. Though the purpose for us here is not to figure out

the best way to lay corridors, a similar visualization idea can allow us to figure out the paths that are most frequented by the populace to help in decisions involving locations of common resources and attempts to increase collaboration in the space.

3.4.6 Connections

One important statistic that is inherent in the tracks analysis above is the strength of connection between two areas on a work space. A high degree of collaboration between individuals and groups would manifest itself in the form of increased numbers of instances of people going between their respective areas. This would lead to a higher than usual number of tracks between the two end points and that is fairly easy to measure given that we can find the tracks by the above method.

The visualization to show this information comprises of a social network structure where each area forms a node in the graph that can potentially have links with any of the other areas. The Connections visualization is shown in Figure 3-13.

The strength of the connection between any two areas, as measured by the number of tracks going between them, is shown by the width of the line between the two nodes. The thicker lines mean a stronger connection whereas thinner lines denote a correspondingly weaker connection.

The values for connectivity between each area are normalized by the total number of tracks in that period.

The screenshot in Figure 3-13 shows the connections between various areas in the Media Lab for a randomly selected week in the data. We can see that for many of the work spaces, leaving aside the corridors and the cafe, there is only a nominal level of connectivity.

In conclusion, this chapter introduced the infrastructure, methodology and artifacts developed and used in this thesis. The approach, as introduced, is evaluated in the next chapter.

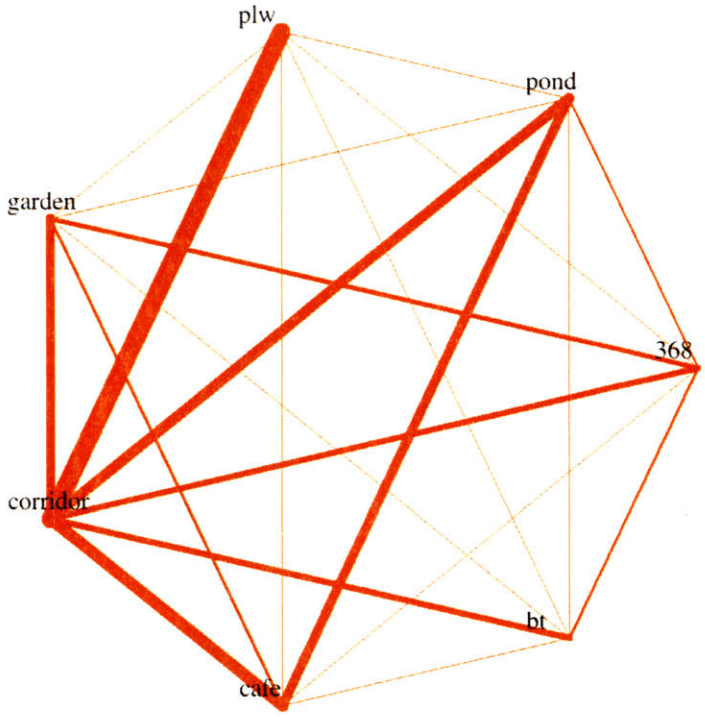


Figure 3-13: This visualization is called the Connections. It shows the strength of the connectivity between pairs of areas in the lab based on the number of tracks that start in one location of the pair and end in the other. This is a new version of the visualization, the old version of which is shown in Figure C-1 in the Appendix C. It was the old version that was shown to the users at the time of the evaluation.

Chapter 4

Evaluation & Discussion

Social awareness is, at best, a vague concept for most people. Different individuals have their own, slightly different, definitions of how they construe *social awareness*. This makes it hard to normalize the impact assessment across different individuals. This difficulty is compounded by the fact that the impact of visualizations of data on the human psyche is hard to measure. The results for any long term study to evaluate the impact of visualizations for enhancing social awareness in people would necessarily be compounded by a number of other factors that may affect a workspace in the duration of the study. Since such factors might affect the entire community at the same time, the effects of these would be hard to randomize out.

Given these difficulties, and the fact that this is a fairly novel approach to social awareness, we decided that it would be worthwhile to conduct informal critique interviews with potential users to try and understand their initial receptivity to the method. Positive responses in the critique interviews would warrant longer term studies with a few individuals to guide detailed design decisions. In this section, we will discuss the procedure followed to evaluate the system and the results for the same.

4.1 Evaluation procedure

In order to evaluate the efficacy of the various visualizations in the two usage modes for enhancing the social awareness of the people in a workspace, we

conducted *user critiques* with 15 people (12 males, 3 females) from the Media Lab community. The participants were recruited somewhat randomly as we went around the lab and signed up the first 15 people who were willing to do it. The participants, aged 20 to 54 years, had been at the Media Lab for varying amounts of time, ranging from 3 months to 15 years. They were drawn from various different work roles in the lab—they included 4 Ph.D. students, 5 M.S. students, 3 administrative staff and 2 technical staff members.

In one-on-one interviews, the participants were asked a variety of qualitative and quantitative questions. The qualitative questions included soliciting their opinions about the meaning of social awareness, and about the impact and value of the various visualizations. The other questions were aimed at quantifying the effectiveness and desirability of the various visualizations so we could compare the different visualizations and design options.

The participants were initially asked to answer some simple questions for which they had to study the visualization screenshots provided. This was done in order to help the participants understand the visualizations. The exact interview template that was followed for the evaluation is included as an appendix at the end of this report (Appendix A). The second part of the appendix (Appendix B) contains the abridged and anonymized results of the evaluation for the 15 participants.

4.2 Results

4.2.1 Social awareness

Each of the participants were asked about their concept of social awareness. This generated a wide variety of responses. About half of the people agreed that social awareness includes some form of perception of presence of people around the lab. About a quarter of the people concurred that knowledge of interactions between people was an important component of social awareness. The rest of the fragmented responses included perception of moods, personalities, personal events and work engagements of other people along with an understanding of social etiquette and personal boundaries.

After this question, the participants were were asked to use the following definition of social awareness for the rest of the evaluation:

> Social awareness refers to the perception that a person in a community has about the presence, availability and interaction patterns of the other people in that community. A community here refers to any group that engenders a feeling a fellowship in its participants due to some shared characteristics.

This was the definition that we had used in the conception of this project and in the design of its visualizations, and it is not very different from the consensus definition that emerged in the evaluation.

The participants were asked to rate how socially aware they thought the Media Lab community was. They were then asked to rate their own social awareness about their workplace. The response in both cases was higher than the mid value on the Likert scale of 7. The average response for the social awareness of the ML community was 4.87 with a standard deviation of 0.83. The average rating for the participants' own social awareness was the same, that is 4.87, but with a slightly higher standard deviation (0.99). The fact that participants consider their work space fairly socially aware has no direct bearing on the work done in this thesis but makes for an interesting comparative data point for when the study might be replicated in another workplace that might have a different architectural and population characterization than the Media Lab.

4.2.2 Effectiveness

Participants were asked to grade the effectiveness of each visualization for enhancing their social awareness and helping them to better understand the social scene of the Media Lab community on a scale of 1 through 7, where 7 was the most effective. The participants rated the OpenClock (Figure 3-11) visualization as the most effective one, whereas the Connections (Figure C-1) was the least effective visualization. In multiple pair-wise t-tests, the difference between OpenClock and Connections was significant (p=0.0395) whereas the difference between the other visualizations was not statistically significant. The comparative responses for each visualization are plotted in Figure 4-1.

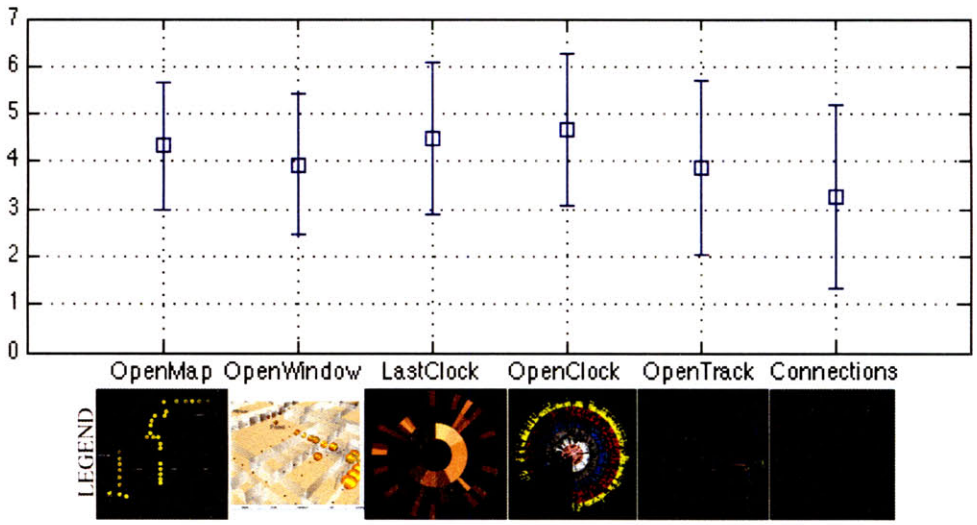


Figure 4-1: Effectiveness of the various visualizations for enhancing social awareness on a scale of 1 through 7 based on the responses of participants in the critique interviews.

4.2.3 Desirability and impact of public and personal displays

The participants were also asked to rate the desirability and suitability of each visualization for display in public spaces such as the atrium or the cafe on a scale of 1 through 7. The two visualizations they most wanted to see were the OpenMap (Figure 3-8) and LastClock (Figure 3-10) visualizations and the one they found least desirable for public areas was the Connections (Figure C-1) visualization. The difference between OpenMap and Connections was statistically significant (p=0.0042), as was the difference between LastClock and Connections (p=0.0042). None of the other pairs showed a statistically significant difference in the responses. The comparative responses for each visualization are plotted in Figure 4-2.

They were next asked the same question, but for personal spaces such as their office or workspace. Again, they preferred OpenMap and did not fancy having the Connections visualization in their personal areas. In multiple pair t-tests, a number of difference between visualizations were statistically significant. The OpenMap and LastClock were statistically different (p=0.0411), so were OpenMap and Connections (p=0.0002), OpenWindow and Connections (p=0.0011) and OpenClock and Connections (p=0.0153). The comparative responses for each visualization are plotted in Figure

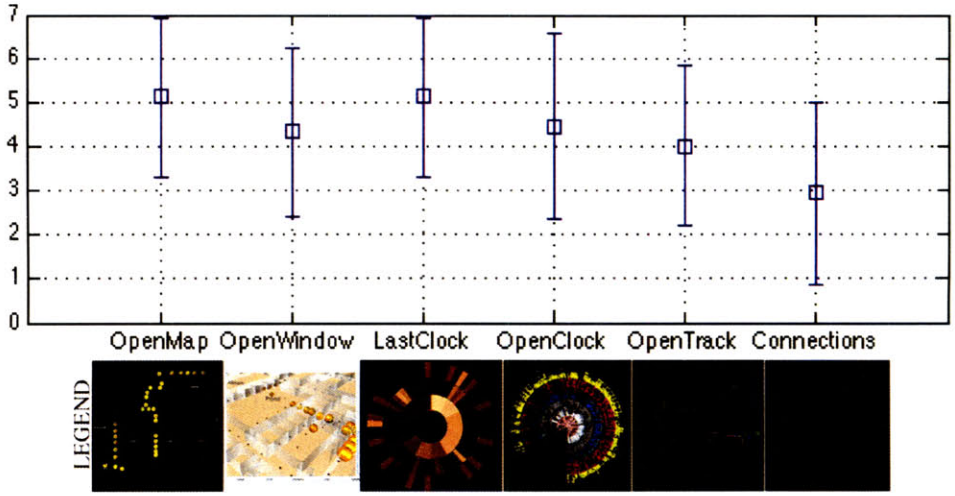


Figure 4-2: The desirability of various visualizations for display in public areas like the atria or the cafe as per the participants' responses.

4-3.

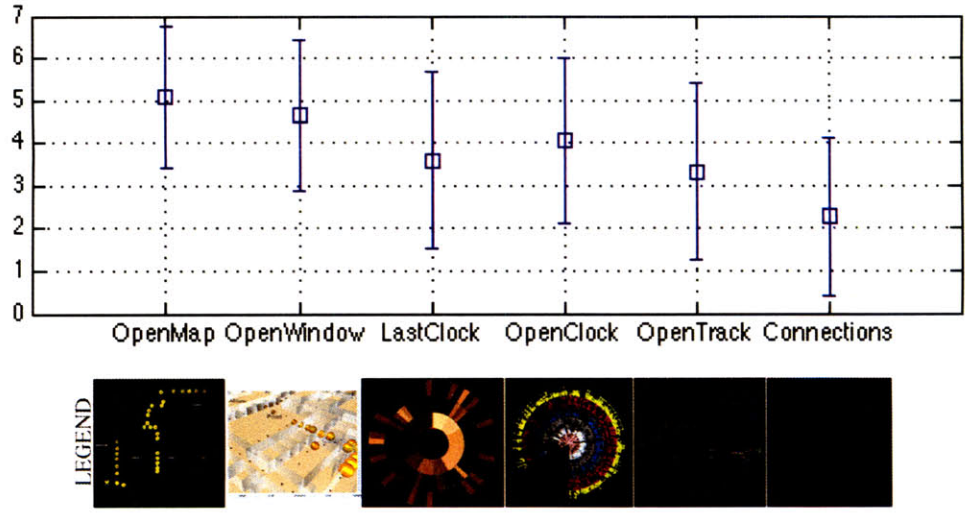


Figure 4-3: Participants were asked about the desirability of various visualizations for display in personal areas like their offices or workspaces. This graph plots their responses.

4.2.4 Privacy invasiveness

Another issue that interested us was the perception of privacy invasiveness of each visualization. The participants were asked to rate the privacy invasiveness of each visualization on a scale of 1 through 7; 7 being the most invasive. Though the privacy invasiveness for each visualization was rated fairly low, the OpenMap was deemed to be the most invasive while the LastClock was considered the least invasive of their privacy. OpenMap and LastClock (p=0.0149), OpenMap and connections (p=0.0242), and OpenWindow and LastClock (p=0.0383) were significantly different from each other. The comparative responses for each visualization are plotted in Figure 4-4.

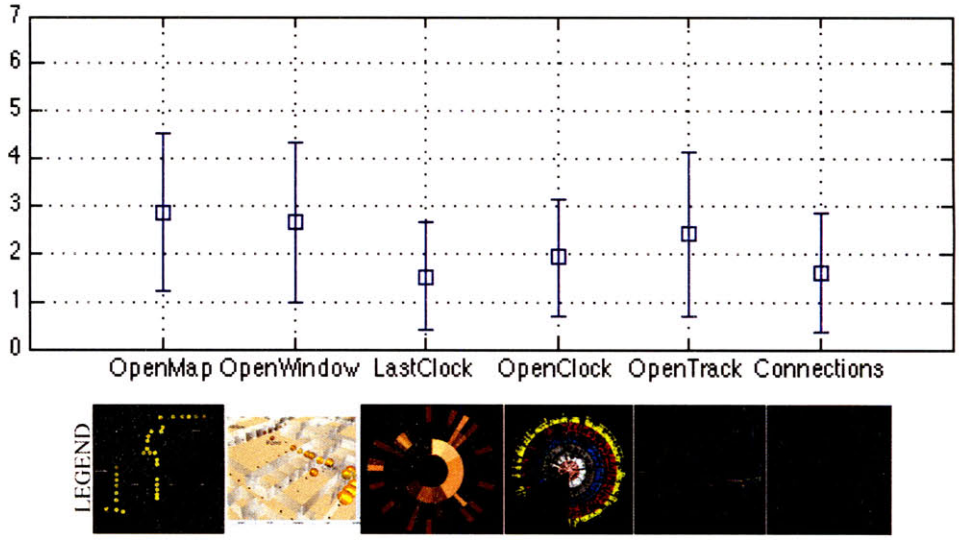


Figure 4-4: The participants perception of the privacy invasiveness of various applications.

4.3 Discussion

As we assimilate the information from the plots in Figures 4-1, 4-2, 4-3, and 4-4, and also from responses to qualitative questions posed during the critique interviews, a few trends seem to emerge, though none of the trends are so pronounced as to be universal. If there is one big observation that can be made from the evaluation, it would be that there is no such thing as an

average user, as everyone has their own constructs of what they mean by a certain concept, what they like in certain visualizations, what they don't like in certain others and their reasons for these likes and dislikes. In this section, we will attempt to describe the diversity of opinion observed during the evaluation.

From the different visualizations that they saw during the course of the critique interview, the participants said they would be able to understand a number of features of the space around them. They said that the OpenMap and OpenWindow interfaces, shown in Figures 3-8 and 3-9 respectively, would help them get a better understanding of where people were, and when they were around. It would also give them an inkling about where people meet and hang out. The participants mentioned being able to keep abreast of events happening in the lab and not missing out on them. A number of people used the metaphors of breath, and rhythm, and heart beat of the lab to explain the ways in which they perceived the visualizations would help them be more socially aware.

They mentioned the curiosity that these visualizations would feed; that they would welcome the awareness that these visualizations would bring about the building and the people in it. Especially for the OpenWindow interface, where participants liked the ability to define their own perspective, they said that it would be like a *sixth sense* for them. Many of the users mentioned that they would like to use the visualizations in times when the lab was not totally full, like in the night. They mentioned that seeing other people around would help them feel less alone on a late night at work. They said that if they see activity in their friends areas, they might visit there when they take a break. There was also a mention how this system would be useful to the people who are new at the lab to understand and plan their day around the pulse of the lab. Another useful impact that participants perceived taking place was that people would increase their interaction with other research groups after realizing the difference in connectivity between the different groups. Following demo groups around as they move during the day was suggested as a useful application of the system. On a lighter note, one participant mentioned how he now knew the most commonly used paths in the Media Lab and that he would put up his posters there for most effectiveness. Thus, participants mentioned that they would find the

information contained in many of the visualizations useful.

Despite the fact that participants were able to glean the expected information from the visualizations designed in this process, none of the visualizations received an extremely high effectiveness rating (LastClock and OpenClock both got an effectiveness rating of 4.47, which is only a little more than the mid point of the Likert scale from 1 through 7). One of the biggest criticisms that the work received was that it was not about social awareness. Despite helping in perception of presence and space connectivity, the participants felt that some key information for enhancing social awareness was missing in the work. This included information such as the number and identity of people, the kind of activity they were engaged in, the disposition that they had and the content of the conversations. The participants realized that addressing their criticism would mean increased privacy invasion, and mentioned that they would not like that without the control of opting in and out.

One thing that there was a fair amount of consensus about was the privacy invasiveness of the visualizations. The knowledge of location in the visualizations such as OpenMap and OpenTrack made them more privacy invasive for the population interviewed. Most people thought that the privacy invasiveness was low and that they would not be worried about it. Even in this case, one participant ended up saying that the visualizations were really invasive of people's privacy, and it would "freak her out" if she were to use them. Though that was a lone voice, it was surely present.

One interesting observation from the quantitative results is that though the participants said that the OpenMap was more invasive in terms of privacy as compared to the other visualizations, it was also considered to be fairly effective and was very much desired for display in both public and personal areas. This is not surprising since more information, when relevant and used effectively, usually means that a visualizing would be better at making an impact, but at the same time, it would also be more invasive on privacy. Though the converse is not necessarily true in either case.

Another important thing that we were trying to get at was the receptivity of the participants to these visualizations in public and personal spaces. Most of the people said they would like to see the visualizations displayed, though there was quite a variation between different visualizations in this case. The

dynamic real time visualizations found more takers in public areas than the visualizations that showed historical trends. The participants seemed to indicate that they don't imagine themselves making the effort to browse the social history of the lab, or as one participant put it—"historical stuff doesn't give immediate gratification."

One interesting thing to note was that people were more interested in seeing the visualizations in public areas than in their own personal work spaces. The only exception for this case was the OpenWindow visualization where people liked being able to customize it to their own physical point of view and hence preferred to use it in their workspaces, rather than in public space, where they felt it would trivialize the experience of social awareness enhancement.

Some participants mentioned that visualizations in public areas would play the part of social magnets, attracting people to reflect on the social happenings in the lab around them. They thought that the increase in discussion about social activities caused by the installation of these visuals would end up making the people more social. One participant even said that the visualizations would serve as a reminder to be social.

In personal spaces, they mentioned that the visualizations would serve as curiosity feeders, but might end up becoming distractions if they were always on. The participants appreciated the aesthetic value of the visualizations and said they were interesting to watch and that they wouldn't mind having something in their offices that looks pretty, while giving some useful information. They also said that the wow factor would wear out in time and then they might stop noticing the visualizations. Some of the participants suggested that in their personal space, they would prefer to have the information on a browser where they could check it when they felt like it, like they check Facebook [3] these days. One interesting, and very valid, viewpoint that came up about deployment of these visualizations went as follows:

> In general, to make people more sociable, you need to help them get out of their office, and not give them more information on their desks itself. These are great to display in public areas but might not have the same effect in personal work spaces.

Some of the problems that the participants mentioned had to do with the design of the visualizations. The LastClock visualization turned out to be very confusing for many of the participants. They didn't like the fact that the most recent data was right next to the oldest data. For the OpenClock, they mentioned that the radial placement of the various areas did not give the different spaces the same representation in the visualization, and thus made the comparison across spaces more difficult. For the Connections design, they mentioned that though the lack of connections between spaces was the most important piece of information, it wasn't well presented in the visual.

In conclusion, we see that people did find the visualizations useful in the ways anticipated though they had some doubts about their continued effectiveness over time in enhancing social awareness. They did not feel that the visualizations were highly privacy intrusive and were positive to the prospect of having these visualizations around them.

Chapter 5

Conclusions & Future Work

In this thesis, we have been trying to address the disconnect between people and the social happenings around them in their work place, while minimizing privacy invasion. We have tried to enhance the social awareness of people by using visualizations of data about motion and activity in the public areas of the workspace. The results from the evaluation have been very illuminating in understanding how people perceive social awareness and in gauging the effectiveness of the current approach in making them more socially aware.

5.1 Lessons learned

There are many things that we can learn from the evaluation. For example, it is clear that a public space deployment of such visualizations would be better for social awareness purposes than a deployment in their workspaces. The information would be useful to have even in personal workspaces but only with visualizations that are very easy to understand, pretty to look at, update dynamically, and don't require explicit user interaction. If we could piggy back our visualizations onto some existing objects that people already have, like clocks and maps, then they would be even better integrated into everyday life.

Another thing that is fairly apparent from the discussions with the participants is that there is information and treatment which is clearly

lacking in this approach to social awareness. The sensors deployed do not tell important things about the social activity around the lab, information that is decidedly important to the intended users of the system.

- The sensors can not differentiate between one, two or more people.
- Their binary classification does not allow them to distinguish between high, medium or low levels of activity.
- The lack of awareness of the type of sound associated with the activity hurts too since many a times the difference between a very approachable and social group is the amount and type of conversations they are having, even though their motion patterns may be quite similar. A similar thing can be said for facial expressions of people.
- Another big constraint in our sensing apparatus is that we have no idea about the content of the conversations
- The identity of the individuals engaging in that conversation is also unknown.

Many of these pieces mentioned by users would be helpful to motivate someone to get out of their office and seek an interaction. Without some of these pieces, it is possible that the system could end up simply being a curiosity-feeder without causing real behavioral change in the people around the workspace.

5.2 The privacy tradeoff

The above additions to the sensing apparatus are good for completeness of the collected data but most of them come with a big impact on privacy invasiveness. A sensor network that is collecting id or other personal data like content of speech would be a complicated proposition to have if the user is not the one who owns and manages the data. While designing system that are meant to be stand alone and not interacted with much, most of the privacy management needs to be handled in software and can not be offloaded to the user. Given the variation in needs and perceptions of the users about their own privacy, managing privacy for them is a hard problem.

This is a trade-off that we have to consider while making our decisions and choices about social awareness systems.

If there are ways to make the data more rich without compromising on privacy, they should surely be incorporated into the system. Such enhancements could include an analog motion sensor rather than a binary one to allow the sensor to tell us more about the activity happening in space. It would also help to connect the visualizations to real events, thus making them more relevant to people. If the OpenMap is showing a lot of people going to an area and there is an event post in one corner about the details of the event, the visualizations could turn from becoming an interesting display to an event reminder for social activities. This could be accomplished by allowing users to post events tied to locations and times and classified by keywords. The event could then be posted at the appropriate time to the right location and be available to people based on the match between their interests and the event key words. The system could be made even less dependent on user interaction by scraping the events off the lab mailing lists and classifying them based on the information contained in the email.

There are a few other potential ways to analyze the data to bring out useful information without resorting to privacy invasive methods. One of these ways is to analyze successive motion activity between nearby sensors to understand walking speed. This would help classify hectic versus relaxed spaces/times based on how fast people move around. Another way would be to analyze tracks in real time to provide dynamic information about path choices while that information is still relevant.

5.3 Critique of the evaluation process

The rank performance of the various visualizations in the user evaluation could have been because of the limitations in the evaluation process itself. Simple measures like randomizing the order in which the participants saw the visualization might have removed the biases that fatigue and desensitization might have brought into the results.

It is also hard to predict the exact impact that a system would have on a person after a period of regular use by just letting the user look at the

visualization for a few moments and comment about it. True evaluation of the system would be in real deployment with users and then checking for an enhanced social awareness by another method.

Even though the displays are meant to be glanceable, one way of preliminarily evaluating the system would be to offer it to the users on their desktops and check to see how many keep using it. Another caveat is that using the system does not mean that it is leading to enhancement of social awareness. Since we were not sure if an entirely unbiased evaluation of the system could be conducted in this manner, we didn't follow that approach in this thesis.

Also, the prototypical space for the evaluation was chosen as the Media Lab which is already a fairly small and well knit workspace. The architectural measures such as an atrium and incorporation of transparency in workspaces might mean that the Media Lab is more socially aware than average already.

5.4 In conclusion

The network of motion sensors and assisting software infrastructure is a useful tool for enhancing social awareness if used in the appropriate manner. The information provided is subtle and not directly actionable though that is an asset if looked at from the perspective of privacy invasion. The fact that the system is manifested in the form of visualizations means that the potential benefits of the system can be disbursed without a direct interaction by the user. The sensor network itself can potentially be used for a number of other uses such as traffic pattern analysis and space usage analysis for redistribution of space and resources, activity monitoring for more efficient indoor climate control and building security, all of which need to be explored in other research projects.

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Appendix A

User Evaluation Template

A.1 Demographic information

1. Gender _____
2. Age _____
3. How many months have you been at the Media Lab? _____
4. How would you categorize your role at the Lab (student, admin staff, facilities, necsys)? _____

A.2 Perception of social awareness

1. How would you briefly describe *social awareness in the workspace*?

_____

_____

In this discourse, social awareness, refers to the perception that a person in a community has about the the presence, availability and interaction patterns of the other people in that community. A community here refers to any group that engenders a feeling a fellowship in its participants due to some shared characteristics.

2. On a scale of 1 to 7 (7=very much, 1=none at all), how socially aware do you feel the Media Lab community is?

   1 2 3 4 5 6 7

3. One the same scale, where would you place your own social awareness?

   1 2 3 4 5 6 7

4. In your opinion, which are the most social areas of the Media Lab?

---

5. Which time of the day and time of the week is the most social time at the Media Lab?

---

6. As you might know, we have put up motion sensors in the public areas of the third floor of the Media Lab. In the questions to follow, I shall show you some visualizations that we have built for the data being collected from these sensors . But before we discuss further, I would like to ask how you think motion sensors around the lab could help to increase the social awareness of the members of the Media Lab community?

A.3 Visualization critiques

I shall now show you a series of visualizations and briefly explain their usage. For each of the visualizations I will ask you a similar set of questions aimed at understanding the efficacy of the visualizations. The questions are not meant to test you. Any problems that you might have, reflect on the design of the visualizations, and are in no way a reflection on you.

A.3.1 OpenMap

The visualization that you see is showing the third floor of the Media Lab. Each of the red dots is the location of a motion sensor and when the sensor detects motion, it glows up with a yellow circle. The activation thus shown fades after a short while.

1. For this screenshot of the OpenMap, please tell me how many people or groups of people are moving around in the third floor?

---

2. Where do you think most of the activity is at that instant?

---

3. Can you tell the starting points and the destinations of the various people/groups from the visualization?

4. Please describe the way, if any, in which this visualization helped you to understand the social scene in the situation depicted.

---

5. On a scale of 1 through 7, where 7 is the best, please rate the efficacy of this visualization at helping you understand the social scene at the lab.

   1 2 3 4 5 6 7

6. How much would you like to see this visualization in the public spaces like the atrium or the cafe?

   1 2 3 4 5 6 7

7. What do you think would be the effects of having it in these areas?

---

8. How much would you like to have this visualization in your workspace where you can glance at it anytime?

   1 2 3 4 5 6 7

9. What would be the effects of having it always available to you?

---

10. How privacy invasive is this visualization?

    1 2 3 4 5 6 7

A.3.2 OpenWindow

OpenWindow is a 3D version of the visualization that you just saw. It allows you to browse the space and fix your attention on your area of interest. It is your own personal window in space and you can rotate, translate and zoom it as you choose. Please take a couple of moments to browse the system.

1. Please describe the way, if any, in which this visualization helped you to understand the current social scene of the Media Lab.

---

2. On a scale of 1 through 7, where 7 is the best, please rate the efficacy of this visualization at helping you understand the social scene at the lab.

   1 2 3 4 5 6 7

3. How much would you like to see this visualization in the public spaces like the atrium or the cafe?

   1 2 3 4 5 6 7

4. What do you think would be the effects of having it in these areas?

---

5. How much would you like to have this visualization in your workspace where you can use and interact with it anytime?

   1 2 3 4 5 6 7

6. What would be the effects of having it always available to you?

---

7. How privacy invasive is this visualization?

   1 2 3 4 5 6 7

A.3.3 LastClock

This visualization shows the *recent history* of the activation data from the various motion sensors placed in *the Cafe* area of the Media Lab. It runs in real time. The outer ring is showing the last minute of time, the middle ring is showing the last hour and the inner ring is showing the last 12 hours of activity. A brighter color for a segment means that there was more than usual activity at that time. The red markers show the current time.

1. For this screenshot of the LatClock, please tell me whether the current time is AM or PM?

---

2. What do you infer about the activity in the cafe in the past 12 hours from the screen shot?

---

3. Please describe the way, if any, in which this visualization helped you to understand the social scene of the time duration in the screen shot.

---

4. On a scale of 1 through 7, where 7 is the best, please rate the efficacy of this visualization at helping you understand the social scene at the lab.

   1 2 3 4 5 6 7

5. How much would you like to see this visualization in the public spaces like the atrium or the cafe?

   1 2 3 4 5 6 7

6. What do you think would be the effects of having it in these areas?

---

7. How much would you like to have this visualization in your workspace where you can glance at it anytime?

   1 2 3 4 5 6 7

8. What would be the effects of having it always available to you?

---

9. How privacy invasive is this visualization?

   1 2 3 4 5 6 7

A.3.4 OpenClock

Till now we have seen visualizations that allow us to see the current or the immediately recent data from the motion sensors. The next few techniques are going explore trend visualization in the data. OpenClock allows us to visualize activations in a particular period of time, up to 12 hours at a time. Another mode allows us to focus in on a specific hour also. We can also pick and choose the areas of the workspace to focus on.

1. For this screenshot of the OpenClock, please tell me which area was most active between 8 and 9 a.m.?

---

2. What time is the cafe most active on that day?

---

3. Please describe the way, if any, in which this visualization helped you to understand the social scene in the situation depicted.

---

4. On a scale of 1 through 7, where 7 is the best, please rate the efficacy of this visualization at helping you understand the social scene at the lab.

   1 2 3 4 5 6 7

5. How much would you like to see this visualization in the public spaces like the atrium or the cafe?

   1 2 3 4 5 6 7

6. What do you think would be the effects of having it in these areas?

---

7. How much would you like to have this visualization in your workspace where you can use and interact with it anytime?

   1 2 3 4 5 6 7

8. What would be the effects of having it always available to you?

---

9. How privacy invasive is this visualization?

   1 2 3 4 5 6 7

A.3.5 OpenTrack

It is straightforward for a person to virtually *connect the dots* on the OpenMap visualization when he or she sees someone moving from one area to another. We have computed that information to find the tracks that people usually traverse in the Media Lab. OpenTrack visualization plots the tracks in a specified time period on the map of the third floor to give a sense for how *worn out* some of the paths are in the Lab.

1. For this screenshot of the OpenTrack, please tell me which paths appear to be the most used ones?

---

2. Given these two screen shots from a Wednesday and a Sunday, how do the movement patterns compare across weekdays and weekends?

---

3. Please describe the way, if any, in which this visualization helped you to understand the social scene in the situations depicted.

---

4. On a scale of 1 through 7, where 7 is the best, please rate the efficacy of this visualization at helping you understand the social scene at the lab.

   1 2 3 4 5 6 7

5. How much would you like to see this visualization in the public spaces like the atrium or the cafe?

   1 2 3 4 5 6 7

6. What do you think would be the effects of having it in these areas?

---

7. How much would you like to have this visualization in your workspace where you can use and interact with it anytime?

   1 2 3 4 5 6 7

8. What would be the effects of having it always available to you?

---

9. How privacy invasive is this visualization?

   1 2 3 4 5 6 7

A.3.6 Connections

This visualization plots the strength of the connections between any two areas of the Media Lab based on the tracks going between them in a given period of time. The brighter colors mean a stronger connection whereas darker colors denote a correspondingly weaker connection.

1. For this screenshot, what areas seem to be most connected to each other?

---

2. Given these two screen shots from the week before Spring break and the Spring break, how do the movement patterns compare across the two periods?

---

3. Please describe the way, if any, in which this visualization helped you to understand the social scene in the situations depicted.

---

4. On a scale of 1 through 7, where 7 is the best, please rate the efficacy of this visualization at helping you understand the social scene at the lab.

   1 2 3 4 5 6 7

5. How much would you like to see this visualization in the public spaces like the atrium or the cafe?

   1 2 3 4 5 6 7

6. What do you think would be the effects of having it in these areas?

---

7. How much would you like to have this visualization in your workspace where you can use and interact with it anytime?

   1 2 3 4 5 6 7

8. What would be the effects of having it always available to you?

---

9. How privacy invasive is this visualization?

   1 2 3 4 5 6 7

A.3.7 Plots

Finally, I will show you a basic plot of the data collected from these visualizations over this entire period of time.

1. From this screenshot, what times are the most active in the lab?

---

2. From this other screen shot, what areas are the most active in the lab?

---

3. Please describe the way, if any, in which this visualization helped you to understand the social scene in the Media Lab.

---

4. On a scale of 1 through 7, where 7 is the best, please rate the efficacy of this visualization at helping you understand the social scene at the lab.

   1 2 3 4 5 6 7

5. How privacy invasive is this visualization?

   1 2 3 4 5 6 7

A.4 Final analysis

1. What other views of the data would you be interested in looking at?

---

2. What do you think are the merits and the drawbacks of the approach to social awareness outlined in the previous discussion?

Appendix B

Evaluation Results

B.1 Demographics

User	Gender	Age	ML Age	Role	ML soc. aw.	personal soc. aw.
1	M	20	2.5	urop	5	4
2	F	33	2.5	admin	6	6
3	F	26	7	admin	5	5
4	M	38	7	admin	6	6
5	M	25	9	ms	4	3
6	M	31	12	ms	5	5
7	M	29	19	ms	6	6
8	M	28	19	ms	5	6
9	M	26	19	ms	4	5
10	M	26	32	phd	4	5
11	M	33	45	phd	5	5
12	M	27	55	phd	3	3
13	M	29	57	phd	5	5
14	M	36	120	tech staff	5	4
15	F	54	180	tech staff	5	5

B.2 OpenMap

User	efficacy	public space	private space	privacy invasion
1	6	3	7	4
2	2	1	1	6
3	5	6	5	2
4	5	7	7	5
5	5	5	3	1
6	4	7	6	1
7	6	5	6	4
8	5	6	6	3
9	5	7	7	2
10	2	2	6	5
11	4	6	4	1
12	5	5	5	2
13	4	6	4	3
14	5	5	4	3
15	2	6	5	1

B.3 OpenWindow

User	efficacy	public space	private space	privacy invasion
1	3	4	2	3
2	1	1	1	6
3	5	5	4	1
4	5	7	7	5
5	6	3	6	1
6	3	4	6	1
7	4	5	5	4
8	6	6	6	3
9	3	4	4	2
10	3	2	6	5
11	5	5	5	1
12	5	5	5	2
13	5	7	6	2
14	3	1	2	3
15	2	6	5	1

B.4 LastClock

User	efficacy	public space	private space	privacy invasion
1	2	5	1	1
2	2	1	1	5
3	6	6	5	1
4	3	5	1	1
5	2	1	1	1
6	5	7	6	1
7	6	6	6	1
8	6	5	5	2
9	5	5	6	1
10	6	7	1	1
11	4	6	5	1
12	6	6	4	1
13	4	6	5	2
14	6	5	4	3
15	4	6	3	1

B.5 OpenClock

User	efficacy	public space	private space	privacy invasion
1	2	1	1	3
2	6	1	1	5
3	6	6	6	1
4	7	7	7	1
5	2	1	5	1
6	3	4	2	4
7	6	7	5	2
8	5	5	5	2
9	4	3	2	1
10	3	6	5	1
11	6	6	4	1
12	6	4	6	2
13	4	5	5	2
14	5	6	2	2
15	5	5	5	1

B.6 OpenTrack

User	efficacy	public space	private space	privacy invasion
1	1	4	1	2
2	1	1	1	4
3	2	2	1	1
4	2	1	1	1
5	6	5	4	1
6	4	5	4	2
7	4	4	5	2
8	6	6	5	4
9	5	6	7	1
10	5	4	3	7
11	6	6	5	1
12	6	5	6	3
13	4	6	4	2
14	2	2	2	4
15	4	3	1	1

B.7 Connections

User	efficacy	public space	private space	privacy invasion
1	1	1	1	2
2	1	1	1	5
3	5	6	6	1
4	1	1	1	1
5	2	1	1	1
6	4	2	1	4
7	3	2	1	1
8	6	5	4	1
9	3	2	1	1
10	7	7	6	1
11	3	4	3	1
12	6	5	4	2
13	3	4	1	1
14	2	2	2	1
15	2	1	1	1

Appendix C

Previous Versions of Visualizations

C.1 Connections

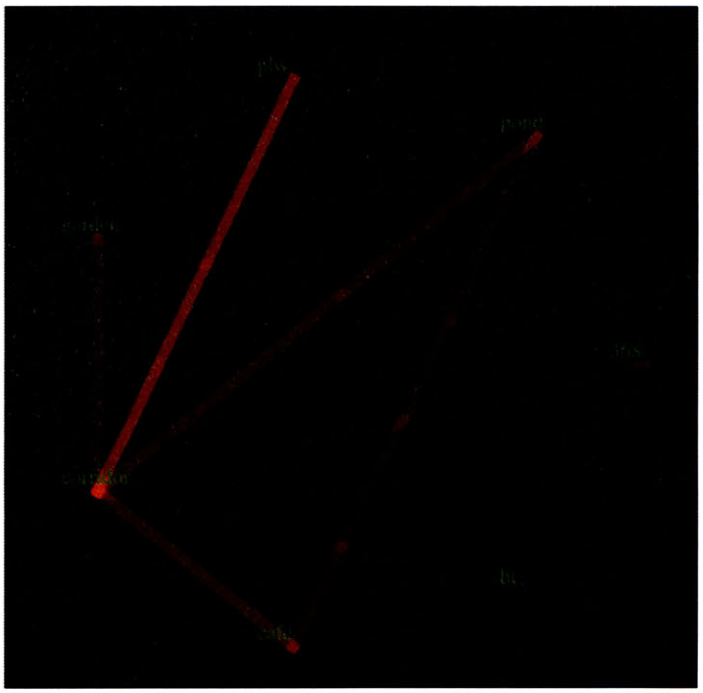

Figure C-1: This is the old version of the Connections visualization that was shown to the users during the evaluation.