Mediator and Medium:
Doors as Interruption Gateways and Aesthetic Displays

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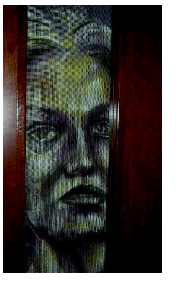

Figure 1. A window covered in a semi-transparent mesh.

ABSTRACT
Office doors are more than entrances to rooms, they are entrances to a person's time and attention. People can mediate access to themselves by choosing whether to leave their door open or closed when they are in their office. Doors also serve as a medium for communication, where people can broadcast individual messages to passersby, or accept messages from others who stopped by when the door was closed. These qualities make the door an excellent location for designing solutions that help people better manage their time and attention. In this paper, we present a study of doors, derive design insights from the study, and then realize some of these insights in two cooperating implementations deployed in our workplace.

Keywords: attention, door, interruption mediation, media spaces, ubiquitous computing

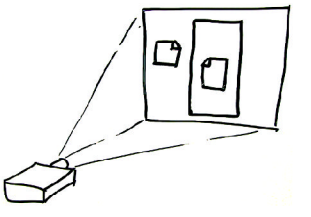

Figure 2. A sketch from our brainstorming phase.

INTRODUCTION
Many have observed that systems are becoming increasingly prolific and demanding of human time and attention [8,11]. Might these systems also serve to mediate time and attention demands between humans? Answering machines, email, and many other systems already play a role in mediating remote communication. In physical spaces however, human demands on other humans' attention are mediated by social norms, proximity and physical barriers.

One of these physical barriers is the office door. The position that a person places his or her door—wide open, half open, ajar, or closed—communicates something to passersby. In addition, doors are a medium for expressing individuality. People communicate very

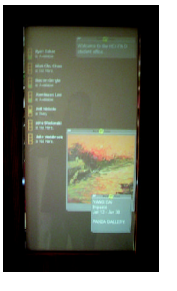

Figure 3. The public view of our LabraDoor system

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different things about themselves depending on what, if anything, is visible on the outside of their office door. From signup sheets to lecture announcements to aesthetic postcards, doors are a rich space for personalization.

In recognizing the role doors play as mediators of time and attention, and as a medium for personal expression, we sought to understand a link between the two, then design systems that exploit this link. Doors are a rich object for study because of their versatility, and peoples' interactions with doors are fertile ground for design insights. Our goal was to produce a system that could both improve door-mediated interruptions and to offer new expressive capabilities for door aesthetics. We did not envision replacing the natural uses of doors, but supplementing them in useful ways.

In this paper, we present a three-phase exploration of the door as a mediator and medium. First, we conducted a study of doors, the objects on and around them, and peoples' actions with and "through" them. Second, we leveraged these observations and insights in an ideation phase that involved affinity diagrams, brainstorming, sketching, scenarios, and follow-up observations. Third, we synthesized our two most promising ideas into functional systems that we deployed in our workplace. Now we are in the process of refining our ideas based on user feedback.

RELATED WORK

Doors have been the source of design inspirations before. Segawa et al. implemented a WWW-based message board that was deployed on a door in a graduate student residence [10]. This work differs from ours in that it was not aiming to mediate interruptions per se, though one could conceivably use it that way. Researchers at Georgia Tech conducted a short study of doors to inform a dynamic door display prototype that displayed a person's calendar and allowed visitors to leave messages [9]. Our work aimed to break free of the confines of an on-door touch screen, and to enable a more free-form medium.

Work by Buxton et al. focused on the use of the door as a physical mechanism to control accessibility for both physical and electronic visitors [3,4]. While this was similar in implementation to the door awareness system described below, it focused primarily on using the door as a physical mechanism to alter digital access to the office inhabitants via a video-mediated communication system.

Interruption mediators and context-aware computing has been a subject of investigation by interactionists for some time now. Hudson et al. have done work on situationally-appropriate interaction, where computer systems leverage some knowledge of their user's situation to decide if and when to interrupt them. For example, a cell phone might detect its wearer walking into a conference room during a scheduled appointment, infer that he or she is entering a meeting, and silence its ringer. Horvitz et al. have had similar investigations into "attention sensitive alerting" [7]. These inquiries differ from ours in that they are aimed at understanding interruptions when the interrupter is technology (e.g., an alert on the desktop), whereas we are concerned with humans interrupting each other with and through doors.

AN OBSERVATIONAL STUDY OF DOORS

The first phase of our inquiry was to observe the roles doors play along two dimensions: (1) as mediators of interruptions between office visitors and office inhabitants, and (2) as a medium for aesthetic and informational personalization. We sought to develop an ontology [12] of door-mediated interaction by noting *objects* (e.g., signup sheets), *properties* (e.g., sizes and colors of posters taped to door), *actions* (e.g., a person hovering outside an open door, wishing to be seen), and *relationships* (e.g., differences in interruptions based on social status). Our first observations were therefore targeted at understanding door objects and their properties.

Objects and Properties

We spent roughly fifteen hours examining hundreds of doors around Carnegie Mellon University in hopes of discerning patterns in the types of objects that people, mostly university professors and staff, placed on and around their doors. We targeted buildings representative of diverse educational subjects: business, fine art, computer science, humanities, and engineering. Our goal in this observation was to "look afresh" at the variety of doors, door objects, and their properties.

We documented our findings photographically. After the study, we put our pictures and notes on web pages so that we could share the results among our group and encourage discussion.

We saw many objects on and around doors, including postcards, magazine clippings, newspaper articles, humor cartoons, political cartoons, signup sheets, lecture announcements, job listings, hand-in boxes, personal notes, "I'll be back in *x* minutes"-style notes, plastic clocks depicting return time (often past due), instruction sheets (usually outside administrators' offices), clipboards, and course handouts.

One noteworthy object was more of a "system" than a singular artifact (see Figure 4). A civil engineering professor had a note in the center of her door that read, "If you are going to leave something for me, please leave it at the chair—do not put it under the door." At the bottom of her door she had taped a letter-sized sheet of white paper. On it was written, "Please do not slide anything under my door. Please leave it on the chair." A large arrow pointing up-and-left accompanied the text. To the left was the chair with a note reading, "Please leave this chair next to PH123B!"

Figure 4. A door "hand-in" system. There are two notes on this door and one on the chair, instructing students to place papers on the chair instead of sliding them under the door.

This "hand-in system" confused us until we observed the professor when she returned from lunch. She was on crutches and was unable to bend over to pick papers off her floor. She told us that people still slide things under her door despite the "obvious" signage. Her system was not adequate because, according to her, students did not read her signs.

Another office owner had placed a mesh screen (see Figure 1) with unusual visual properties behind the window in his door. When viewed straight on, the mesh screen looked opaque and a beautiful woman's face appeared. When viewed from an angle however, the mesh "disappeared" and the viewer was able to see into the office. This provided an interesting aesthetic that also served to modify the interaction of the typical window. The mesh required the visitor to take an active part in determining whether or not the office owner was available. In addition, for the office owner, the amount of visual distraction outside the window was limited. Instead of seeing visitors and non-visitors walking past or looking into the office, the visual activity and vibrancy was muted for the office inhabitant. He could still make an assessment as to the urgency of the visitor based on the duration of time the visitor spent adjusting the angle to look through the mesh, and the level of activity of their "shadow" on the other side of the mesh. This "material and glass" combination proved a source of inspiration during the brainstorming and synthesis phases of our project.

We observed a huge diversity of objects and myriad properties associated with them. But a pattern began to emerge and we began to be able to classify roles these objects filled. These roles were:

- Information distribution (e.g., lecture announcements)
- Information depository (e.g., sign-up sheets, hand-in boxes)
- Personal expression (e.g., aesthetic images, cartoons, sentiments about September 11th)
- Instructional (e.g., "Joe, meet me at the concert")
- Temporal (e.g., "I'll be back in x minutes")

Our understanding of properties, both of doors and of the objects on and around them, developed as well. While most doors seemed to be the same size, their materials differed widely. Some doors were made of metal and painted gray, others of wood with large glass windows. Still others were wooden with small vertical glass panes or no glass at all.

Properties that applied to many of the objects were: duration of relevance (e.g., a few weeks vs. a few minutes), intended audience (e.g., one person vs. general public), and perceived importance (e.g., final exam instructions vs. casual cartoon). A host of other properties governed perceived importance itself: informational content, size of object, size and weight of text within the object, color, position, and so on.

We realized, during our discussions of this data, that we would need another set of observations. Having better understood the objects and properties on and around doors, we still lacked an understanding of how people interact with doors and the relationships that are mediated by them.

Actions and Relationships

To resolve this problem, we conducted a second round of observations that were aimed at witnessing the actions that take place around and "through" doors, and the relationships that those actions serve. These observations were harder to come by than the object-observations of the previous study. For these, we had to wait long enough outside doors to witness the arrival and departure of people. We spent ten hours sitting in a hallway and observing people as they interacted with and "through" doors.

Some actions that we witnessed include:

- glancing in doorways while walking down a hallway
- knocking on a door gently, leaning in to listen for activity from within the office, then leaving
- sliding an assignment under the door, then scurrying away
- lifting a handout from a bin outside a door
- reading a poster on a door
- knocking heavily, saying a first name through the door
- furtively testing the doorknob to see if the door is unlocked or not
- hovering outside a closed door waiting for someone
- hovering outside a half-open door, traversing the visual field of a busy office inhabitant, apparently hoping to be seen but trying not to interrupt

Most of these actions dealt with one of two goals: gaining the attention or audience of the person in the office, or depositing or retrieving information apart from the office inhabitant. Both of these priorities played roles in our design.

Though many of the relationships we observed dealt with the objects themselves, the most interesting were the relationships between the visitors and the office inhabitants. Specifically, we noticed that the relationship between the visitor and the inhabitant governed the way in which the interruptions took place. Interactions are affected by the different status levels the inhabitant and visitor have within the office or organization (i.e., the power distance) [6]. For example, we observed undergraduates arriving at professors' doors. These students were timid in their approach: they knocked quietly and left quickly when a door was unopened. In contrast, older members of the academic community—other professors, graduate students, and staff—were much bolder in their approaches. We realized from this that any good design would have to accommodate the different relationships between visitors and office inhabitants. For example, a "doorbell" design that played a tone at the same volume no matter who was pressing it would defy this principle.

After we completed this second round of observations, we started to make further sense of what we had observed with an eye towards design.

FROM OBSERVATION TO DESIGN

The second phase of our effort was in taking our observations and the organizational ontology developed from it, and leveraging them for design insights. To determine what questions we might answer, we decided to do a clustering of observations with sticky notes and poster board.

Affinity Diagramming

To elicit potential breakdowns and areas for improvement in the way office doors mediated the interruptions we observed, we wrote short descriptions of our observations on sticky notes and placed

Figure 5. The affinity diagram after all observations were added from the objects study and action study. They are shown on purple and yellow notes respectively.

Figure 6. The affinity board after meta categories had been added. The new categories are shown with violet, green, and orange-colored notes.

them on tag board (see Figure 5). We started out by creating special categories for object and property observations (purple notes) and action and relationship observations (yellow notes).

This process took some time: each sticky was placed, and then moved as other notes changed the conceptual topography of the board. In the end, we had clusters of common concepts but needed an additional level of abstraction before we could identify the problems that should be solved.

To aid in this process, we added meta categories to the board, based upon our previous analysis and viewing the arrangement of the notes on the board. We then adjusted the notes as needed to fit the notes around them (see Figure 6). The meta categories appear on the board as violet, green, and orange-colored notes.

For example, we noticed when doing our object observations that many objects were primarily aesthetic entities. The lower-right corner of the board contained a cluster of aesthetic object observations.

As we organized and reorganized the board, we began to see where design effort might be applied:

- Exploring the effort to interrupt (reducing, changing)
- Exploring the communication of *time* between office inhabitants and office visitors (when returning, daily schedule, how long gone, when stopped by, etc.)
- Augmenting aesthetic expression through digital means
- Making available an office inhabitant's state of business to targeted desirable parties (e.g., a professor's state shown only to his or her Ph.D. students but not to all students)
- Tracking exchanges between office inhabitants and office visitors, whether informational or tangible
- Developing new affordances for interruption
- Aiding in the flow of information between inhabitants and visitors; that is, augmenting the "information conduit" between them

From the affinity diagramming, we were able focus on specific solutions that addressed one or more of these general areas.

DESIGN IDEAS

The next step within the second phase of our endeavor was to generate design ideas. This required multiple brainstorming sessions and a continual reference to the observations and insights from the first phase of our research. In this way, our ideas were generated fluidly yet grounded in our previous work. Even the most far-fetched ideas had their roots in the knowledge that we acquired during the studies and clustering exercises. The following is a description of several ideas we generated during the brainstorming process.

The Visitor

The door is commonly used as an access point to an individual or group of individuals working within an office space. The door mediates these visits and there are common social practices involved in the initiation of an interaction. The following design ideas augment situations found in real life.

Knock Knock…

Perhaps the simplest of these interactions comes in the form of a visitor attempting to make contact by knocking. Sensors could be placed in or around the door to detect vibrations, and an "access log" could be retained regarding the time and frequency with which visitors knock on the door.

This information could then be used in several ways. The owner of the door could set the log to notify them of visitors when they are away. For example, imagine sitting in a meeting just down the hall. As usual, the meeting has run late and you are reluctant to leave due to the importance of the topic. You are also expecting a visitor that you have been trying to meet for weeks. They knock on your office door and you are notified via your handheld or wireless device, giving you enough time to quickly pop out of the meeting and notify the visitor that you will be just a few minutes longer.

Who's There?

Suppose that instead of being just down the hall when your visitor knocks, you are pulling into the parking structure a few minutes away.

We imagined a device mounted on the door capable of receiving and transmitting messages from a distance (e.g., via cell phone, by email or a web interface). Messages could now be posted on the door in the office owner's absence. For example, "Joe, if you're waiting outside my door right now, hang tight, I'm five minutes away." Similarly, "Jill, I'm not going to be in the office today. I'm sick, can we reschedule?"

Cindy…Cindy Who?

A third idea we had was to investigate the notion of privacy and develop an application that allows select visitors to access private information on the door.

Pre-specified visitors could gain access to the monitor in order to receive information that is not public but is meant primarily for them. For example, "Cindy, I'm not really sick today, I'm on the chairlift—grab your skis and come join me!"

Physical Tokens for Interruption

Although knocking is a simple means of interruption, it can be jarring to an office inhabitant who may be trying to concentrate. We observed in our study that people would sometimes hesitate to knock if they thought their interruption might have social repercussions. In response, we conceived of replacing the knock with a physical token that represented the desired amount of interruption.

Tokens would be obtained from a bin located beside the door (see Figure 7). They would vary in size and material, from billiard balls to marbles to sheets of paper. A visitor to the door could pick a token from the bin appropriate to the amount of interruption they desired. They would insert the token into a one of several slots in the door, each placed at a different height. The token would fall through the door and onto the floor of the office. The sound and motion from the falling token might *ambiently* interrupt the office inhabitant, if they were present.

This use of physical tokens for interruption is valuable even when the inhabitant is not in their office. The number of items on the floor informs the inhabitant of the number of visitors they missed upon their return.

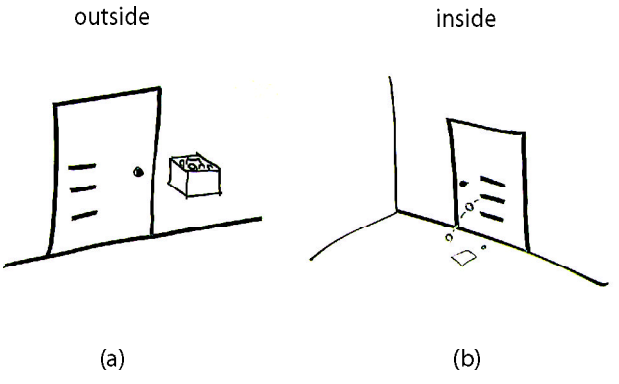


Figure 7. Sketches showing our conception of physical tokens for interruption. **a)** The outside of a door with the bin of tokens. **b)** Tokens falling inside a door.

Ephemeral Displays

This abstract idea of interruption as tokens led us to think about other representations of door interactions that were more ambient in nature. Our ideas focused on communicating interruptions or activity levels using the four Grecian elements (air, fire, water, and earth) as a medium.

Air

The movement of air can be a subtle yet noticeable sensation. Instead of using a token to interrupt, we thought about using puffs of air of various intensities. When a visitor comes to an office with an important issue for the inhabitant, the puff could be strong. Others might choose a soft puff, in case the inhabitant was deep in thought and did not want to be distracted.

Fire

Extra information about the activity level of an office inhabitant could affect the behavior of a visitor to the office. If the inhabitant puts a message on their door asking not to be interrupted, potential visitors must be sure their business is sufficiently important if they choose to interrupt. Instead of requiring inhabitants to manually leave notes, an automatic indicator could be created of activity level within the office. In particular, heat can be an intuitive indicator of activity. If the door is hot, visitors might choose not to interrupt because lots of activity is going on within the office. A cold door would indicate that the inhabitant is not in her office, and a warm door would invite visitors in.

Water

A perturbed pool of water could also represent activity level. A few ripples in the pool could indicate that the inhabitant is not busy, whereas sizeable waves would say, "do not disturb."

The pool of water could also be used inside the office door, to represent activity level in the hallway. As people walk outside the office, waves could be created in the pool moving in the same direction as the person. A knock on the door could be represented by a splash in the pool.

Earth

Activity level in the hallway can also be represented in other ways. We conceived of a *virtual mud mat*, which would simulate a muddy

patch of ground on the floor outside of a door. As visitors walk up to the door, their footsteps would be recorded in the virtual mud. When the inhabitant returned from a meeting, they could look at the mud mat to see if anyone came by while they were gone.

Door Awareness

The accessibility of an office inhabitant is displayed by the physical state of their door. Whether the door is wide open or slightly ajar gives an indication of the inhabitant's availability and willingness to host visitors.

A desktop application capable of receiving data (e.g., open or closed) from distant doors across a computer network could be created. This information then could be displayed to a wider audience through a web page or alternative display medium.

Students in our lab were particularly interested in this idea because they could avoid traveling upstairs to their advisors' offices when their doors were closed (meaning the advisors were either absent or not receiving visitors).

The Video Door

This design idea was intended to explore the use of video to alter the visibility of people on both sides of a door. In contrast to a window, which provides an unalterable two-way channel for observation, the use of video could create two one-way channels. This allows the inhabitant to modify or constrain each channel.

We thought of ways to implement this system on a door with a glass window. The state of the hallway outside a door could be captured as a video stream and projected onto the back of the office door. A video image from inside the office could be projected to the outside via the window. This dual-projection could be achieved by placing a semi-transparent vellum over the window and using a back-projection technique to make the projected image viewable to those on the other side (see Figure 8). Inhabitants could choose to turn on or off this projection at will, or vary the granularity of the display (e.g., by adjusting the transparency of the visual space in a similar fashion to the mesh screen described above). This would allow the office inhabitant to alter their availability to the outside world. In addition, it would allow them to alter how much of the outside world they would like to see (e.g., down the hall or nothing at all).

We were particularly interested in the flexibility of the video door display technique and the idea of door awareness. Our initial implementation effort focused on these two ideas.

DESIGN IMPLEMENTATION

In the third phase, we put our design ideas to work in the implementation of two systems: the door awareness system and LabraDoor. These systems work together to enhance the awareness of interruptibility while providing new means for aesthetic expression on doors. Each system is explained in turn.

Door Awareness System

This system allows people to observe the state of a door from a distance. In its current implementation, three possible door states are observable: *wide open*, *ajar*, and *closed*.

During our observations, we noted that most professors follow a similar system: if their door is open or ajar, they are amenable to receiving visitors; if not, then they are either out or not willing to meet at that time. It was this insight that drove the underlying assumptions: knowing the state of the door yields something reliable about the state of the person behind it.

The development of this system considered one of the reasons cited for the failure of groupware designs: an unequal distribution of the cost in relation to the benefit an individual receives [5]. The common illustration of this problem is group-calendaring systems. These systems often require a large amount of effort on the part of the individual to make their schedule available to others. While this is often of great value to others, it has an unequal value in proportion to the effort required by the individual to maintain and keep the data up to date. This asymmetry of cost and benefit undermines the value of the system and often leads to its demise. We attempt to avoid this imbalance in our system by using the physical door itself to provide status information. In this way, there is no additional work overhead on the part of the office inhabitant. The benefits are provided to a wider audience (e.g., the visitors), with little or no additional effort on the part of the door owner. While this may lead to increased interruptions due to a wider audience seeing the status of the individual, the door owner can simply change the frequency with which his or her door is open or closed (as is typically done in the physical world to moderate interruptions).

The architecture of the door awareness system involves placing cheap magnetic contact sensors on the door and door jam. To differentiate between "wide open" and "ajar", we put two such sensors on each door that we outfitted: one near the door's hinges and the other on the far end (see Figure 9).

These sensors send their signals over wires to a PIC microcontroller that forwards the data to a Hewlett-Packard Jornada 720 device through a serial port. The Jornada sends the data across a wireless network to a web form written in PHP. The microcontroller is needed to translate the sensor data into a computer-readable digital form, and the Jornada is needed for its wireless networking capabilities.

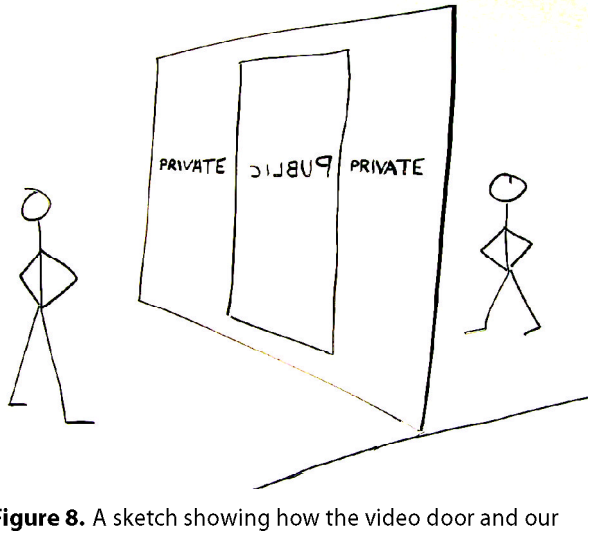


Figure 8. A sketch showing how the video door and our LabraDoor system project readable views to people on both sides of a closed door.

The data is entered into a mySQL database after it is processed by the web form. Another PHP form is used to access the data for displaying the status of the door on a web page (see Figure 10). The result is an anytime, anywhere ability to view the states of the doors via a web browser.

We outfitted three doors in our department with these sensors. The first two doors belonged to professors and the third was our own lab door. Our lab holds 15 hardworking graduate students in two connected rooms. The main advantage that we found using the system is the ability to discern whether or not to trudge upstairs when we needed to see professors.

The door awareness system provides an effortless way to extend the range of the interruptibility often indicated by door state to more people than those in local physical proximity to the door. It also does more than persist on one's desktop as a web page in a browser. This system was used as content for LabraDoor, as explained below.

LabraDoor

The LabraDoor system initially began as an exploration of the video door idea, but rapidly changed into a more flexible medium.

The rationale behind LabraDoor was that we wanted a free-form aesthetic display on the door but not one that was confined to the boundaries of a wall-mounted LCD or other flat-screen device. We also wanted the display to reveal different things to those inside the office than those visiting the office, as we had conceptualized for the video door.

LabraDoor involves no door-mounted hardware but does require a door with a window. The display is projected onto the door from inside a room (see Figure 8). The window is covered with vellum, a translucent material that maintains the high-resolution integrity of the projection without dispersing the light (as paper does). The projection is wider than the window, yielding a two-part display. The space outside the vellum-covered window is a private area visible only to those inside the office (see Figure 11a). We covered this surface around the window in white tag board to enhance its readability (the door underneath was wooden). The portion of the projection that appears on the vellum shows through the window to those in the hallway. To visitors, it appears as though a huge LCD screen has been embedded in the door itself! This is the public area of the display (see Figure 11b).

Notice that the private image and public image must be oriented differently with respect to the projector so that the display is readable to viewers in both areas. Those viewing the public part of the display from the hallway are looking beam-on, but the inhabitants are seeing the beam reflected off the surface of the door, much like a mirror. In order for people on both sides of the screen to have readable areas, the portion of the screen overlapping the window must be flipped horizontally. We wrote "Inverter" software that flips an arbitrarily sized rectangle on the screen. The result is that objects moved from the private margins to the public center are horizontally flipped as they cross into this rectangle, which allows viewers in the public and private areas.

Since the image source for LabraDoor is a computer, anything can be shown on the door. But not everything we *could* show would support our understanding of doors as media and mediators. So far we have experimented with four items for display on our lab door:

Door Awareness System

We turned the desktop being displayed into a web page with Microsoft's Active Desktop, and then embedded the web page showing our awareness information in it. The display was kept mainly in the private area of the door (outside the vellum-covered window) and allowed all of our lab mates to know the availability of the professors upstairs. One Ph.D. student entered the lab, then suddenly remembered, "Oh, woops! I had a meeting with Professor X that started ten minutes ago!" He then saw the awareness display update Professor X's door from "closed" to "wide open" and said, "Oh, it looks like he just arrived also." A wave of relief passed across the student's face, then he calmly walked upstairs to meet the professor. But for our system, he may have been running!

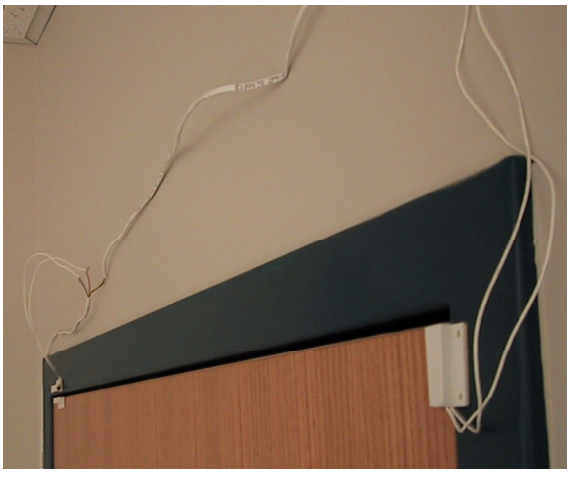


Figure 9. A photograph showing two magnetic contact-switches affixed to a door. The placement was chosen to discriminate between the open and ajar door states.

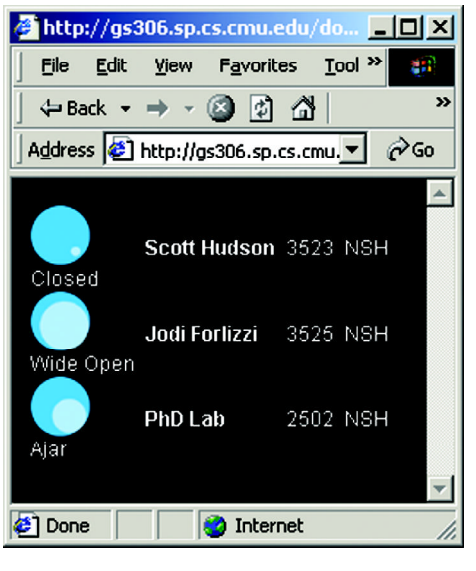
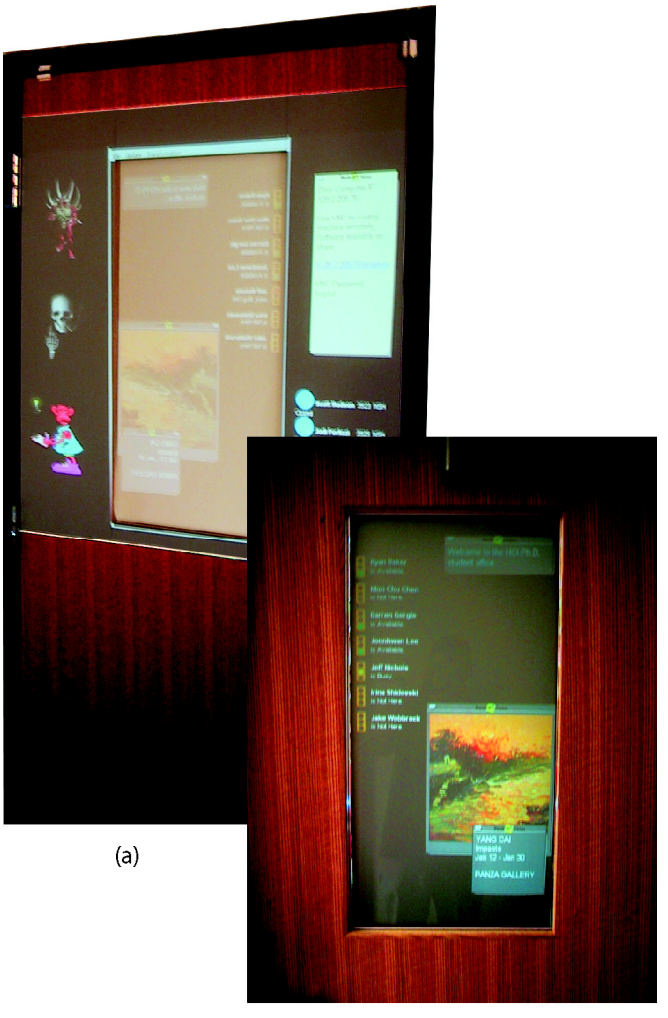
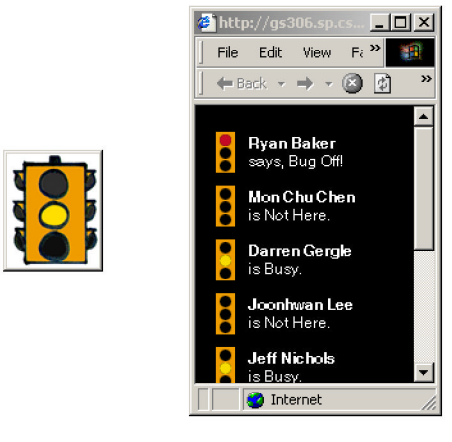


Figure 10. A screenshot of the web page displayed by our door awareness system. We chose to use an abstract indicator of door state instead of pictures of a door.



(a) (b)

Figure 11. Pictures of the LabraDoor system as it is being used on our lab door. **a)** The private view. **b)** The public view showing a gallery notice and StatusLight information.



(a) (b)

Figure 12. Screenshots of the two elements of the StatusLight system. **a)** The "chip" that is used for changing status. **b)** The web page that shows status of every user.

Virtual Notes

We encouraged our 15 lab colleagues to place their own notes and artwork on the door. To do this, we used VNC [2], which permitted remote access to the projector and allowed users to change the displayed information. We placed 3M's Post-It Notes program [1] on the desktop of the projector machine and encouraged anyone to leave notes, either in the private area for fellow lab inhabitants, or in the public area. Further, some people told their friends about the door, and some of these friends logged on to the projector machine from afar and posted notes as well.

Static and Kinetic Digital Art

To enhance the "aesthetic media" aspect of our door, we encouraged the posting of digital artwork, both still and kinetic. One of the first images shown on the door was of a painting that was on exhibit at a local gallery. The person who posted this artwork also placed a Post-It note below it, giving the location, time of day, and duration of the exhibit. Other art that was posted included abstract animations and animated characters.

The StatusLight Program

The LabraDoor system was originally envisioned for use on office doors where one person owned the office. For practical reasons, we installed it on the door to our lab, in which 15 students work in a shared space. But we still believed the door could better mediate interruptions of the people in the lab, despite the large numbers.

In an attempt to do this, we developed a client-server program called StatusLight (see Figure 12). StatusLight is a small "chip" portraying a stoplight that resides on the desktop of each person in the lab and communicates with a mySQL database. By clicking on the green ("I'm Available"), yellow ("I'm Busy"), or red lights ("Bug Off!"), a student directly updates his or her status. When all the lights are off, the status is, "I'm Not Here." The status is then portrayed via a PHP-driven web page, and is projected on the door with LabraDoor or can be viewed from a distance (like our awareness sytem) with a web browser.

One of our lab colleagues called her friends outside the university to tell them about the web page that showed her availability status. She assured them that she would use it, and that they could view the page to determine if and when she was in the lab, and how interruptible she was at any given time.

Knowing from a distance a person's presence or absence in the lab yields more benefits than one might think. The person's status is portrayed on the door, and we hope to see a decline of visitors who enter the lab and ask for a person who is not there. We also hope to see a decline in the number of phone calls to the lab for people who are not present. This is currently a problem because the entire lab of 15 people shares one telephone! Literally hours of work are lost due to the accumulation of telephone interruptions in the lab.

At the time of this writing, StatusLight has been deployed only a short while, and its long-term ramifications—adoption by lab students, the reliability of information, usage patterns—remain unknown. We are excited to investigate this in the future. We also recognize that a system that requires users to update their own status suffers from a misalignment of costs and benefits. More sophisticated sensing, perhaps in the chair of users to detect if they are seated, could go a long way toward making the status projections more useful and reliable. For now, StatusLight shows a

person is "Not Here" if they have not touched their keyboard or mouse for a half hour or more.

FUTURE WORK

Though our initial deployment of LabraDoor and the door awareness system show potential, it is clear that more design work is needed. Several issues must be addressed.

The door awareness system needs to be tested on groups larger than just two. With additional members, it will be possible to investigate the larger social impact of such a system. We are also planning to collect social networking data to see how awareness and use of both systems impact groups. Is social awareness increased? Are the traditional constraints of proximity reduced?

Privacy issues are also an area of major interest. Several students have refused to use the StatusLight software, because they do not want others to know when they are in the office. The professors who are currently using the awareness system have also expressed worry about issues that will arise if history information is made available from that system. Would people come by the office more readily if they could check a log and see that the professor's door opened and closed recently?

We are also interested in exploring some of the technical issues with our projects. The LabraDoor does not currently support interaction with the surface of the door. Instead users must run the VNC software from their personal machines to interact with the LabraDoor. We are exploring the use of computer vision techniques to recognize when a user touches the door. We believe free-form interaction will improve the usability of the door system immensely.

Finally, we would also like to explore the issues that are arising because of LabraDoor's use in a shared office space. When we originally conceived of the system, we anticipated it being used by one person on their personal office door. This person would have full control of their door, in terms of aesthetics, information content, and so forth. In our group environment, everyone has full control of the door but different priorities for how it should be used. We are worried that conflicts may arise in the future between different people who have conflicting priorities for use of the door.

ACKNOWLEDGEMENTS

The authors would like to thank Scott Hudson, Brad A. Myers, Robert Kraut, Desney Tan, James Fogarty, Daniel Avrahami and the entire group of HCII Ph.D. students who graciously allowed their lab door to become an aesthetic mediator.

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