รายงานวิจัยฉบับสมบูรณ์

โครงการระบบเฟอร์นิเจอร์สำนักงานอัจฉริยะ

โดย สุรพงษ์ เลิศสิทธิชัย

กรกฎาคม 2552

สัญญาเลขที่ MRG4880218

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สนับสนุนโดยสำนักงานกองทุนสนับสนุนการวิจัย

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ระบบเฟอร์นิเจอร์สำนักงานอัจฉริยะ สามารถจำกัดความได้เป็นระบบที่ผสมผสาน ระบบเฟอร์นิเจอร์สำนักงานทั่วไป และอุปกรณ์ไฟฟ้าแบบตอบโต้ได้เข้าด้วยกัน เพื่อเป็นการสาธิต ให้เห็นว่า เทคโนโลยีสารสนเทศสามารถนำมาประยุกต์ใช้กับอุปกรณ์ต่างๆ ที่มีอยู่ทั่วไปใน สำนักงานได้นั้น ได้มีการพัฒนาระบบเฟอร์นิเจอร์สำนักงานอัจฉริยะต้นแบบหลายชิ้นงาน เพื่อพิสูจน์แนวความคิดว่าระบบ ดังกล่าวสามารถรองรับ และสนับสนุนรูปแบบกิจกรรม การทำงานที่เปลี่ยนแปลงไปมาในสำนักงานได้

หนึ่งในระบบต้นแบบที่จัดทำขึ้นมาคือ ระบบบอร์ดประชาสัมพันธ์อิเล็คทรอนิกส์ ที่ใช้เป็นแหล่งเก็บ และแสดงข้อมูลของกลุ่มคนทำงานในสถานที่ทำงานหนึ่ง บอร์ดประชาสัมพันธ์ทั่วไป มักใช้เป็นพื้นที่แปะประกาศ โฆษณา และข้อมูลต่างๆ ให้กลุ่มคนในระแวกเดียวกันได้รับรู้อย่างถูกต้องและรวดเร็ว ในทางกลับกัน ระบบบอร์ดประชาสัมพันธ์อิเล็คทรอนิกส์นั้น นอกจากจะยังคงไว้ซึ่งการใช้งาน แบบบอร์ดประชาสัมพันธ์เดิมตามปกติแล้ว ยังสามารถทำให้เกิดการ ปฏิสัมพันธ์แบบสองทิศทางไปและกลับระหว่างผู้ใช้กับตัวระบบได้ ซึ่งบอร์ดประชาสัมพันธ์แบบออนไลน์เองก็ไม่สามารถทำได้

ฉะนั้นการพัฒนาระบบบอร์ดประชาสัมพันธอิเล็คทรอนิกส์ที่ใช้กับกลุ่มคนทำงานเฉพาะกลุ่มนั้นจะจัดทำขึ้นเพื่อศึกษาพฤติกรรม และการปฏิสัมพันธ์ทางสังคมของกลุ่มผู้ใช้เป็นวัตถุประสงค์หลักของงานวิจัยนี้ การวิเคราะห์ความต้องการเบื้องต้นของกลุ่มผู้ใช้ จากแบบสอบถาม และจากการสัมภาษณ์ กลุ่มตัวอย่าง คือกลุ่มนักศึกษา เจ้าหน้าที่ และอาจารย์ ภายในคณะ สถาปัตยกรรมศาสตร์ มหาวิทยาลัยศิลปากรนั้น จัดทำขึ้นเพื่อกำหนดรูปแบบ ลักษณะการใช้สอย ให้มีความเหมาะสมกับการทำงานจริง ระบบต้นแบบที่พัฒนาขึ้นมานี้มีชื่อว่า Faculty of Architecture Campus Exchange Network หรือ FACE Network ซึ่งข้อมูลการใช้งานจริงในระยะเวลาสามเดือน กับข้อมูลจากการสัมภาษณ์ผู้ใช้งาน จะมาสรุปเป็นเงื่อนไข และแนวทางการออกแบบระบบ เฟอร์นิเจอร์สำนักงานอัจฉริยะ ในรูปแบบอื่นๆ ต่อไปในอนาคตได้ รูปแบบและพฤติกรรมการใช้งานของกลุ่มคนทำงานที่มีการเปลี่ยนแปลงไปตามกาลเวลานี้ จะส่งผลกระทบต่อการทำงานในสภาพแวดล้อม หรือสถานที่ทำงานอื่นๆ ให้มีประสิทธิภาพและยืดหยุ่นมากขึ้นได้

คำหลัก: ยูบิคิวตัสคอมพิวติ้ง, รูมแวร์, ระบบเฟอร์นิเจอร์, บอร์ดประชาสัมพันธ์.

ABSTRACT

Project Code: MRG4880218

Project Title: Intelligent Roomware System

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Intelligent roomware system can be depicted as a hybrid system; part furniture and part interactive electronic device. In an attempt to demonstrate how information technology can be implemented into everyday objects used in work environments, a series of intelligent roomware system projects are proposed as proof of concept prototypes designed to support work activities conducted in work environments. One of such series is an "Interactive Bulletin Board" that is generally used as a storage or holding place for displaying related information to a local community. Typical bulletin boards are used to post notices and advertisements targeted at audiences in the area or in close proximity. An interactive bulletin board on the other hand, can provide a two-way interaction that is not possible in traditional bulletin boards while retaining interactivity common in most online bulletin boards. Therefore, the proposal of implementing an interactive bulletin board that is specific to an audience and a location to observe user behaviors and social interactions is the main objective of this first research project. The second objective is to set a design framework by collecting user requirements from questionnaires and interviews with students, faculty, and staff of the faculty of architecture at Silpakorn University. Data obtained is then analyzed to determine features suitable to the working environment and a working prototype proposed as a "Faculty of Architecture Campus Exchange Network" or "FACE" can be developed. Data mining collections from the use of this prototype system as well as user feedback from the system uncovers behavior patterns of users that impacts social interaction within their working environment.

Keywords: Ubiquitous Computing, Roomware, Furniture System, Bulletin Board.

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LIST OF FIGURES

1. INTRODUCTION

Emerging information and telecommunication technologies have altered our ways of life and are continuing to change the way we work and interact with one another. These behavioral changes have a direct impact on the design of furniture systems and workspaces in modern office settings. With rapid advancements in work-related computer technology, workplaces are forced to reform in order to keep up with the changing work processes. Office furniture systems must also be repurposed and reconfigured in order to remain functional and support possible changes in work behavior. In the dawn of technology-driven work, furniture systems that are overly specialized for specific tasks and activities can simply become obsolete. Workspaces that cannot adopt and adapt to new infrastructures and various types of new work activities cannot be used to its fullest and in some cases can be completely unusable.

1.1 MOTIVATION

Although new work processes are widely adopted in workspaces, the design of office furniture and workspaces remains almost unchanged (Streitz, 1998). This is due to the fact that furniture must conform to the fixed human scale and workspaces must follow the required space used to perform work activities. However, with new forms of virtual work processes that are increasingly shifting our way of work from physical interactions towards virtual collaborative interactions, the need for physical work areas and large meeting rooms will inevitably change. Our requirement for furniture and workspace to perform work activities will decrease and the level of dependence on flexible infrastructures, mainly technology-driven software applications, will eventually increase.

This rapid rate of technological and organizational change calls for furniture that will be able to adjust and adapt to unforeseen technology and worker requirements. It is clear that the way people work and interact with each other will constantly be changed by new technologies. Combining something that has a constant design with technology that changes rapidly is a paradox. In other words, embedding information technology directly into furniture systems and providing users with interchangeable and upgradeable applications that encourage user interaction and group collaboration can increase the level of flexibility to overcome future changes in work patterns.

1.2 OBJECTIVES

The main goal of this research is to have a greater understanding of how new information and communication technologies impact the way people work and process information in order to design and develop novel furniture systems. The study process will help define a design

framework of such furniture systems that may assist designers and manufacturers in the design and development of a new breed of interactive furniture for future work environments.

The second goal is to extend the framework and prototype a novel furniture system as a working proof-of-concept product that is both intelligent (interactive) yet functional and flexible like any office furniture system. The prototype will be evaluated for further development and patented or possibly deployed and used in a real world setting. Findings and results from the prototype will contribute to the knowledge of design as well as human-computer interaction.

1.3 HYPOTHESIS

This research hypothesizes that new furniture systems can be redefined by incorporating information technology and enhance the way people work and conduct work activities. It also suggests that not only do they impact the way people work, it should also promote social relationships among people in the work environment.

1.4 METHODOLOGY

The methodology of this research can be divided into two phases beginning with a qualitative research to study and analyze previous work in order to define a design framework for new types of roomware systems. The second phase of this research is an empirical quantitative research. During this phase, a roomware object will be selected, designed, and prototyped to prove the validity of the design framework. Data gathered from a preliminary evaluation of the prototype will be analyzed to validate the design framework and for further development in future systems. Details of both phases are described in the following procedures.

Phase I

1. Appoint research assistants.
2. Analyze state of the art and related work in the area of intelligent roomware.
3. Survey of target user requirements and current conditions.
4. Define design framework for a novel roomware system.
5. Identify office furniture system elements to redefine:
    5.1. Flat surfaces: desktop, white boards, walls, carpet, etc.
    5.2. Furniture: podium, chair, lamp, cabinets, etc.
    5.3. Architectural elements: door, window, column, roof, etc.
6. Obtain necessary equipment, materials, hardware and software.

Phase II

1. Acquire furniture product and hardware.

2. Design and develop physical prototype (physical enhancements and technology fitting, etc.) as a full scale mock up system.
3. Design and develop software to control and manage information on prototype and its environment.
4. Integrate and test software and hardware on prototype framework.
5. Conduct preliminary user studies on working prototype.
6. Deployment of revised prototype at an actual workplace.
7. Analyze data from user feedback and evaluations.
8. Conclusion.

2. LITERATURE REVIEW

2.1 MODULAR FURNITURE SYSTEM

The concept of modern office furniture or modular furniture systems was considered a radical idea when it was first introduced several decades ago. Common factory workspaces filled with linear desks and white-collar workers were the norm at the time and did not allow for future changes in work behavior. Herman Miller, who developed the first modular furniture system, wanted to design a different furniture system that will be able to support the changing way of work from being a single task work environment to a multipurpose complex workspace. It suggested that the new office furniture should accommodate physical changes to the office organization and respond to changes in work behavior effectively and efficiently. The brainchild of that idea eventually became the ActionOffice system which is comprised of modular components that can be combined and recombined to become whatever an office needs over time (Figure 2.1). Although times have since changed but the idea of the ActionOffice has been revisited over and over again and has proven to be an effective system even in the present day.

Figure 2.1 Herman Miller's ActionOffice as the first open-plan office system developed and produced during 1965-1968.

2.2 UBIQUITOUS COMPUTING

As we progress to the information age, the vision of work productivity and collaboration has been drastically reduced to knowledge-based work. Organizations thrive on new ideas and depend more on work creativity and innovation than merely work productivity. Modular furniture systems alone cannot address every aspect of this change in a physical form so we need to take a closer look at the changing work process itself and how new workspaces can be formed. Designers of workspaces have created several office models (Becker & Sims, 2000; Brill, 1984; Duffy, 1997) that encourage workers to interact and collaborate in different environmental settings. For example, in a hotel-style workspace, workers can work in a dynamic setting and not

own a personal workstation but rather utilize a shared space in different times and locations. By simply settling into a workstation, personal information will be ready at their fingertips with little or no effort to re-customize their workspace as they go on to work on another workstation regardless of location. This is a glimpse towards new trends in office models that are designed around the implementation of information technology.

This new work scenario originally derived from a concept in the early 1990s at Xerox PARC called “Ubiquitous Computing” or “Calm Technology” (Weiser, 1991). Ubiquitous computing is a movement to distribute and embed computers into normal everyday artifacts and architecture where the look and feel of a computer becomes invisible to the user (Weiser, 1993; Weiser & Brown, 1995). User interaction with ubiquitous computer is intended to be a non-intrusive and a user-friendly experience allowing users to focus more on work tasks rather than operational tasks. Working in an enhanced environment is an ambitious and somewhat expensive undertaking for organizations.

As an alternative to the broad ubiquitous computing idea, a recent trend in the computer-supported collaborative work (CSCW) focuses on a smaller scale of ubiquitous computing and concentrates on individual computer-embedded artifacts in the workspace. The main interaction is driven by physical or tangible actions done towards an object or furniture item. Objects can be used as an interface to physically manipulate digital information with interactions that are as simple as turning a dial or flipping a switch. These user interfaces are called “Tangible User Interfaces” (Ishii & Ullmer, 1997).

2.3 ROOMWARE

Combining tangible interfaces with workspace furniture is the natural progression for workspaces of the future to inherit the best qualities of both worlds. One of the prominent research projects related to intelligent workspace furniture is called “roomware.” According to the originator, Norbert A. Streitz, roomware is the result of integrating information and communication technology in room elements such as doors, walls, and furniture to support dynamic work activities in a workspace (Streitz et al, 1998). A suite of roomware called i-Land (Streitz et al, 1999) was developed to support the roomware idea which consisted of a communication chair or “CommChair”, an interactive table or “Interactable”, and an interactive wall called “DynaWall.” The prototypes were well received in international conferences and have proven to be a promising direction for new office furniture designs (Figure 2.2).

Figure 2.2 The CommChair (left), the DynaWall (middle), and Interactable (right) prototypes developed by Streitz et al. as a suite of roomware called “i-Land.”

2.4 PLASMA POSTER

In a separate research area, public large displays that are used to share and distribute information among different communities have been researched extensively in the past few years. One of such project called “Plasma Posters” are a new form of social technology that allows people to share digital content using large screen, interactive, digital poster boards (Churchill, 2003). They are designed for public places, allowing people to share content, advertise events and offer commentaries for others to read as they go about their daily business.

People can post pictures, text, Web pages and digital movies as email attachments to the Plasma Posters. Unlike digital advertising boards, Plasma Poster interfaces are custom designed to allow people to scroll, read, follow hyperlinks, and print posted content. It is also possible to send comments to content authors and forward content to others by pressing a few buttons on the interface. The software running underlying the Plasma Posters, the Plasma Poster Network, hosts, distributes and publishes multi-media content to a network of displays. Fuji-Xerox Palo Alto Laboratory or FXPAL, as the originator of this project, has conducted a long-term trial of Plasma Poster within the workplace (in FXPAL and FX Japan) and in a local community hang out place (Canvas Gallery in downtown San Francisco). The Plasma Posters at FXPAL can be seen in Figure 2.3.

Figure 2.3 Plasma Poster installed and used daily at FXPAL as a long-term trial of the prototype system.

We are now seeing second generation roomware designs that implement more software features and mechanics than ever expanding its capability to interact with not only the user but with other roomware devices intelligently (Streitz et al, 2001; Streitz et al, 2002). For example robotics technology (Parnichkun, 1998) and bi-directional interfaces (Lertsithichai, 2002) can be utilized to create an entirely new breed of intelligent furniture (Lertsithichai et al, 2003). However, current roomware designs are strictly confined to standalone objects or furniture and are yet to be designated as a system or set of modular elements that physically combine or recombine to become reconfigurable workspaces.

2.5 INTELLIGENT ROOMWARE SYSTEM

This research intends to study new ways of working and how spaces can be derived dynamically by user demand or on an ad hoc basis with the help of new information technology. Equipped with new working styles, the research will extend the notion of roomware towards a novel furniture system called the “intelligent roomware system” that is both physically and virtually interchangeable. Users will have several sets of “physical” configurations and “virtual” supporting functionalities to create their personal workspace and conduct any number of work tasks and types. Once a design framework for the intelligent roomware system is defined, a prototype will be designed, developed, and evaluated in order to validate the second generation of roomware concepts.

Intelligent roomware system can be depicted as a hybrid system, part furniture system and part interactive electronic device. The second generation of such system should integrate more flexible software and hardware and become more ubiquitous and intuitive to use for a wider range of users. They will become not just smart furniture but intelligent furniture that can be any familiar object surrounding us with flexible integrated functions. From prior research in the area of roomware design, specific use of roomware in an architectural setting can be categorized into three main types which are furniture, flat surfaces, and architectural elements.

Furniture, the smallest roomware system, is any type of standalone hardware that we use to conduct activities with. It can be used directly by users or with other objects for the purpose of function or decoration within a room such as chairs, tables, white boards, easels, partitions, etc. Flat surfaces are usually the floor, wall, or ceiling planes within a space or room. These planes are used to define a territorial space, provide privacy to occupants, enclose particular functions, and distinguish interior and exterior spaces. Architectural elements are certain parts of a building that has specific functions and is incorporated in the building structure but distinct enough to be visually noticed or physically touched by a person, i.e., columns, windows, doors, walls, roofs, building façade, etc. Most architectural elements are integrated parts of a room or space and quite large in scale but have very little to do with work activities of a user (Figure 2.4).

Figure 2.4 Flat wall surfaces used as interfaces to digital information[1] and intelligent furniture[2].

The difference between these three categories is the scale and function from which will determine how one interacts with these objects. Standalone furniture are usually used by individuals to execute very fine tuned interactions and the scale of such device is relatively small compared to the scale of a building structure where it is located. Flat surfaces and architectural elements are much larger and interactions with them can be crude and less articulated. Depending on the scale, users can apply functions that are more appropriate when used individually or as a group onto different scaled rooomware.

[1] The "Target Breezeway" project at Rockefeller Center in New York City, designed by Electroland, LLC.
[2] The "White Box" by Austrian high-end furniture maker Skloib, is an innovative home automation control for music, lights, TV and moving presentation in a room.

3. DESIGN FRAMEWORK

In the past, the author has worked extensively on several projects related to roomware design and has continued to pursue new research in this area specifically related to intelligent roomware systems. There are three projects that were prototyped separately with different affiliations. The first was a "convertible podium" prototype, researched and developed in Fuji-Xerox Palo Alto Laboratory in California, US in 2005. The second is an interactive desktop for urban design collaborations called the "TangiDESK" project conducted by a Masters degree student at the faculty of architecture and planning at Thammasat University during 2007. Lastly, the third prototype called the "Intelligent Bulletin Board" is implemented in the faculty of architecture at Silpakorn University as a prototype interactive bulletin board since 2006. The third prototype is the main prototype conducted for this research project since its location is where the author is currently employed and therefore, has access to resources to conduct extensive testing of the system and analysis of its data.

3.1 THE CONVERTIBLE PODIUM

As the use of rich media in mobile devices and smart environments becomes more sophisticated, so must the design of the everyday objects used as containers or controllers. Rather than simply inserting electronics into existing frames, an original design for a smart artifact can enhance existing use patterns in unexpected ways. The "Convertible Podium" is an experiment in the design of a smart artifact with complex integrated systems (Lertsithichai et al, 2003; Back, et al, 2008). It combines the highly designed look and feel of a modern lectern with systems that allow it to serve as a central control station for rich media manipulation in next-generation conference rooms. It enables easy control of multiple screens, multiple media sources (including mobile devices) and multiple distribution channels. The Podium is designed to support in a flexible manner the various interaction tasks that are dependent on the social context of the meeting, from authoring and presenting in a rich media meeting room to supporting remote telepresence and integration with mobile devices.

The Convertible Podium is a central control station for rich media manipulation, including multi-screen multimedia presentation, shared annotation, and digital multi-media support for teleconferencing (Figure 3.1). Designed for intelligent meeting support and capture, it is an intuitive, easily operated way station for directing digital information. It is a valuable tool that can allow presenters to easily create and integrate rich media experiences into their work. It is also an experiment in integrating physical design and form with rich media functionality.

Figure 3.1 The “Convertible Podium” project shown here as it is encased in a sleek aluminum frame, equipped with a large LCD touch screen, a mounted video camera, a scanner, and a set of room environmental controls.

3.2 TANGIDESK

TangiDESK is a tangible interface prototype to assist in the design and planning of urban design projects (Khampanya & Lertsithichai, 2009). The prototype derives from the need for an intuitive user interface similar to a designer’s or architect’s computer-aided design (CAD) system but also simple enough for non-designers like city planners and developers who are not accustomed to CAD interfaces to use and understand easily. TangiDESK displays a plan view of an urban project on its top surface while physical objects placed on the surface by users represent urban elements such as buildings, roads, parks, or landmarks to form a three-dimensional representation of the site. Objects placed here by any user will be detected by the system and additional information about the object is projected in real-time for users to view its general properties and construction costs. Users can manipulate the objects or modify its relationship with other elements in the site while making preliminary design decisions together in a single environment. With TangiDESK, designers and planners can collaborate and make informative decisions more effectively and accurately in early stages of an urban design project (Figure 3.2).

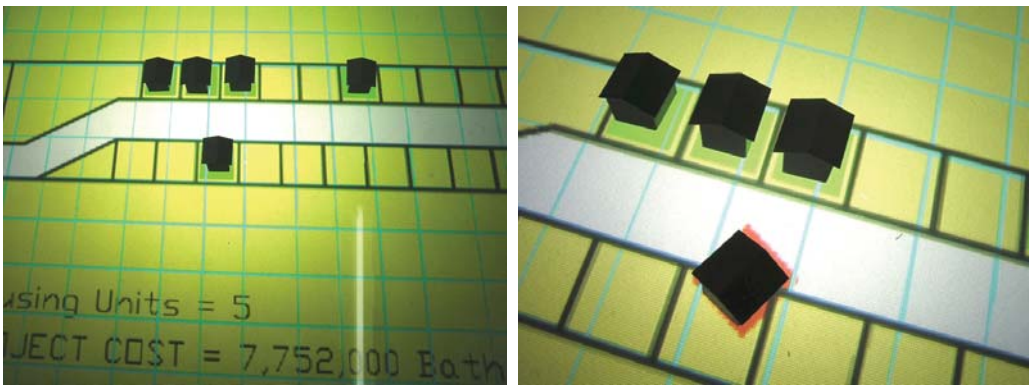

Figure 3.2 TangiDESK surface with building objects and projected land plots (left). Building code system underlines illegal placement of object with red outline (right).

As an intelligent roomware furniture, TangiDESK is designed as a table top device similar to work tables and is used to produce architectural design work. A working demonstration of the prototype shows that users who were both architects and planners utilized the system with great ease and achieved decisions that needed both parties to agree upon much quicklier than with traditional media and equipment.

3.3 INTERACTIVE BULLETIN BOARD

The chosen work environment for the third roomware prototype to be deployed is the faculty of architecture at Silpakorn University due to its convenient location and access to target users. After careful review of current furniture and objects within the faculty of architecture building where the prototype will be deployed, it became apparent that a particular wall on the second floor in front of the administration office where a crowd of students usually gather became the focus of the entire space. On this wall several bulletin boards were attached in a linear fashion filled with general announcements from the faculty, outside organizations, and student postings (Figure 3.3). Everyday faculty members and staff will post new information to the board and a crowd of students will gather around the boards to read the posted information with great interest and sometimes jot down certain information into their notebooks.

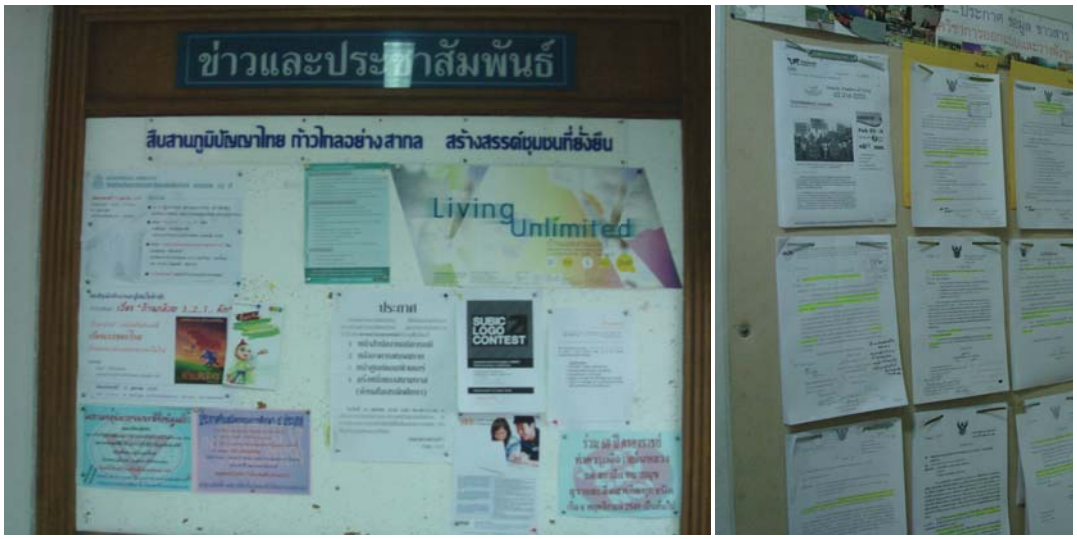

Figure 3.3 Existing bulletin boards that are scattered throughout the premises of the faculty of architecture in Silpakorn University (Tha Pra Campus) are physical pushpin boards.

Having observed this interaction between faculty members, instructors, staff, and students for the several weeks, it can be concluded that the bulletin board is actually an important piece of furniture for everyone in the faculty to use as an asynchronous communication device among one another. Therefore deciding to enhance the bulletin board to become an experimental roomware prototype seemed very appropriate for this setting.

This proposed prototype is dubbed an “Interactive Bulletin Board” that is generally used as a type of storage or holding place for displaying related information to a local community. Typical bulletin boards such as the ones seen in the faculty of architecture are used to post notices and advertisements targeted at people in the area or in close proximity. However, the interaction for these physical bulletin boards is solely one way since users cannot respond to any postings directly or cannot carry away the information with them to be used later on. On the contrary, an online bulletin board (on the world wide web), which is the opposite of the traditional bulletin board, are usually interactive and can respond to user interactions such as copying and distributing digital information at will. The only setback with the online bulletin board is that it is not tangible and does not correspond to geographical locations or local communities like physical bulletin boards.

An interactive bulletin board on the other hand, should be able to provide the two-way interaction that is not possible in traditional bulletin boards while retaining interactivity common in most online bulletin boards. Therefore, the proposal of implementing an interactive bulletin board that is specific to a user and a location to observe their behaviors and social interactions is the main objective of this research prototype. Data gathering as well as user feedback should be able to define a behavior pattern found in the use of this system that impacts social interaction among people in the faculty.

3.4 DESIGN FRAMEWORK

From literature review and the development of intelligent roomware prototypes, a set of ground rules or framework can be laid out to determine how to design these systems logically and systematically in the future. The following summarizes the most important criteria and features of an intelligent roomware system.

Physical Presence

All intelligent roomware must have a physical presence with a set of physical input that users can interact with the system. The look and feel of the components must be intuitive enough for users to learn how to use it just from looking or simple trial and error. The scale must also be manageable for users, meaning that they are not too big to handle and not too small to touch but just right for users hands or body limbs can contact sufficiently.

Multiple and Flexible Functions

Functions of an intelligent roomware must be multipurpose and flexible. It should provide such adaptability so when work behavior or activities change, it may adapt effortlessly to support new actions set by the user. In many ways, functions can be interchangeable by simply upgrading or

installing new software to the system. However, it is also possible to upgrade or revise the system by integrating new hardware or input devices to support other unintended interactions from users.

User Engagement

Intelligent roomware must encourage users to interact with the system with little or no prior training. Designing interactions and feedback that are intuitive and users respond well to is important to gain user engagement with the system.

Digital Information Output

Information provided in the intelligent roomware must be digital information so as to obtain and update information quickly and accurately. By the term digital information, not only does it mean text and graphical images, other formats of information such as music, sounds, visual colors, etc. are also valid sources of data users may comprehend and respond to as well. Therefore, feedback to users must also be digital information that is transformed into physical information that can be sensed visually, audibly, or haptically.

Scalable Tangible Interactions

The physicality of intelligent roomware requires that tangible interactions be the main means of communicating with the system. But because the extended scale of such roomware, the tangible interactions must also be scalable to fit the size appropriately. For furniture, the level of detail of tangible interactions must be accurate enough to handle minute gestures. For flat surfaces and architectural elements, the scale of each interaction must be more approximate than accurate to accommodate large-scale input and output.

These are the primary design framework for intelligent roomware systems that is hypothesized and must be validated by implementing and evaluating a prototype system.

4. PROTOTYPE DESIGN

With the intelligent roomware design framework, a series of prototype systems to test the framework must be implemented. These prototypes should demonstrate how information technology can be implemented into everyday objects used in work environments such as furniture, boards, desks, etc. A series of prototypes are proposed as proof of concept projects designed to support activities conducted in work environments. These working prototypes must demonstrate that the criteria set forth in the framework is valid and can be applied to new types of roomware in the workplace.

4.1 FACE NETWORK

In the faculty of architecture at Silpakorn University, there are two main campuses that students must attend. The first and second year students are required to study at the Sanam Chandra campus (located in Nakorn Pathom) while the third, fourth, fifth, Master, and Doctorate degree students are to attend the Tha Pra campus (located in central Bangkok). Activities and events conducted in the two campuses rarely align together and students in the different campuses do not have the opportunity to interact with one another on a regular basis. This problem has caused a lack of social engagement and participation among students as well as instructors in both campuses. Consequently, such problem can jeopardize the close student-instructor relationship that has been one of the most constructive ways of teaching at Silpakorn University.

Similar to the Plasma Poster, a community can benefit from such an interactive public display that can act as a mediator between students and instructors in the two campuses. From initial interviews with students and instructors in both campuses, activities such as sharing updated events and news information, pulling student and instructor polls and opinions, displaying sample student work, or promoting instructor research work and professional work are among the preferred information that both parties share common interests in.

Therefore, a system is proposed as the “Faculty of Architecture Campus Exchange Network” or “FACE Network” in short to become a common platform by which students, staff, and instructors can submit, view, and respond to certain shared information. The next step is to define what features and designs would be required and preferred for the users of this system.

4.2 USER REQUIREMENT STUDY

Before the actual design of the system, a series of questions were given to students, staff, and faculty of the Tha Pra and Sanam Chandra campuses. The questionnaire was an attempt to determine what features should an interactive bulletin board incorporate if it were to be deployed and used regularly in the faculty premises. The first series of questions were designed to obtain

general user information and define the demographics of the target users. In the faculty of architecture, there are a total of approximately 828 people consisting of 729 undergraduate (Bachelors degree) and graduate (Masters and Doctorate degrees) students, 69 instructors (full-time), and 30 staff (full-time and contractors) according to official statistics of 2008[3].

A total of 200 questionnaires were distributed to all staff, instructors, and students in both Tha Pra and Sanam Chandra campuses while 124 questionnaires were completed and returned. From the statistics, the majority of users or 87% can be defined as students, while 7% and 6% are staff and instructors respectively (Figure 4.1).

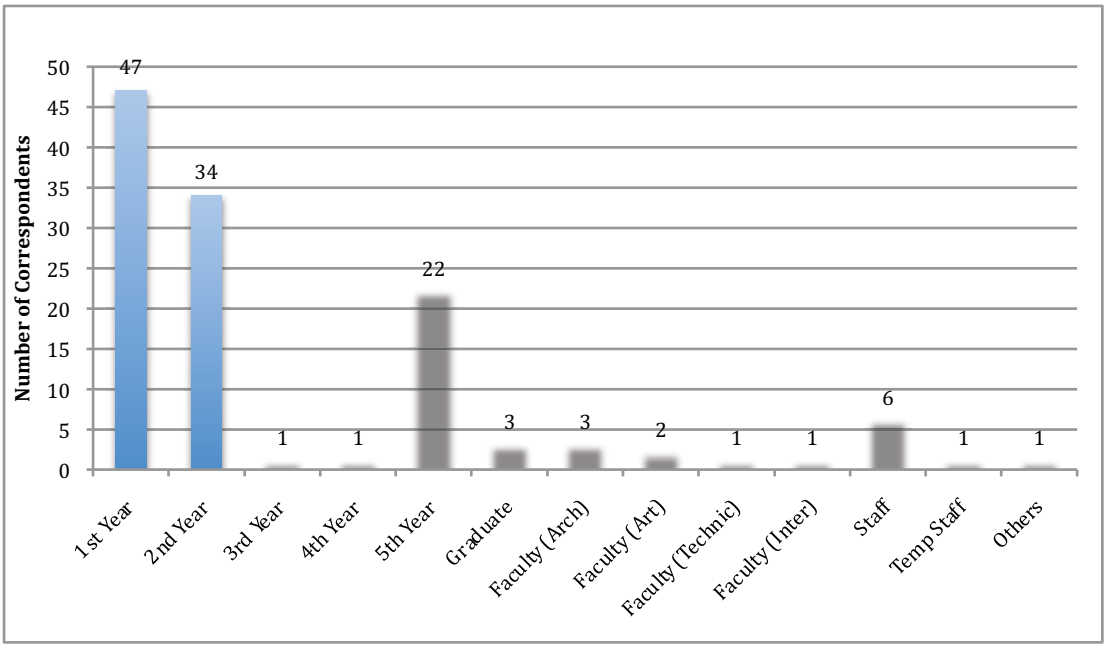

Figure 4.1 Sampled information from target users of the prototype system. Out of 124 correspondents, 87% are students, 7% are staff, and 6% are instructors.

The next series of questions targeted at what types of information users recognized being displayed most often on traditional bulletin boards in the faculty (Figure 4.2). Almost all users identified that faculty news and announcements were information that they see most often and are prioritized when viewing the boards. Announcements of grants and scholarships, course related announcements, and student affairs and events come in second, third, and forth respectively. The types of information that have the lowest popularity are classified advertisements, career opportunities, and job hunting.

[3] The number of people in the faculty of architecture Silpakorn University at the end of the academic year 2008 is inclusive of faculty members who are in leave of absence and currently pursuing a degree abroad.

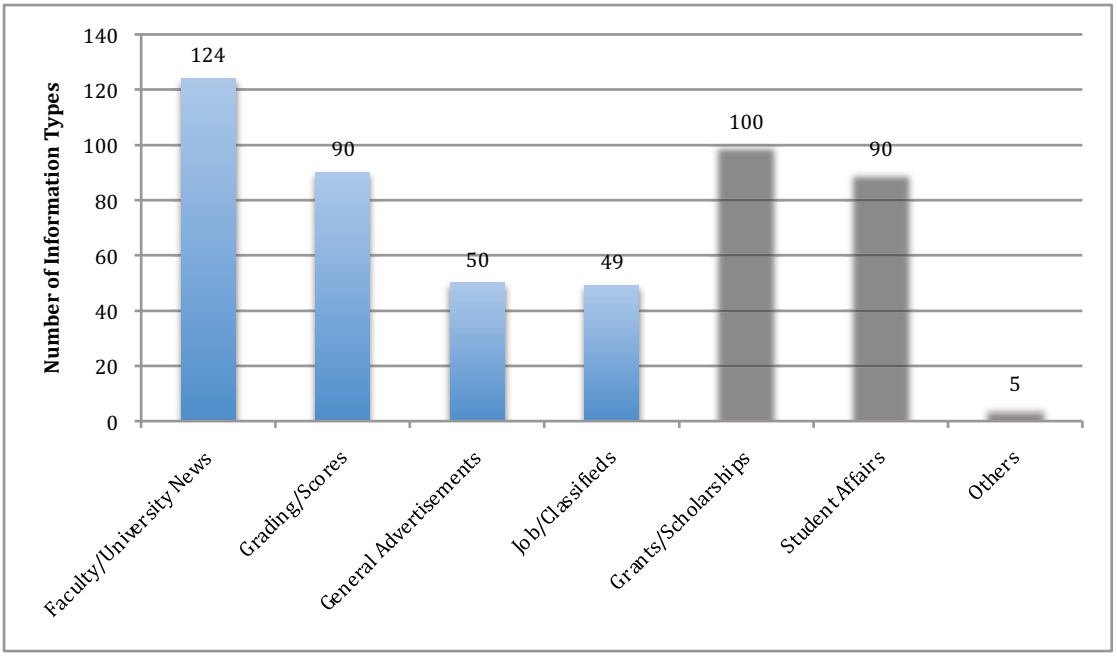

Figure 4.2 The common types of information seen on bulletin boards within the faculty of architecture.

The next set of questions was to determine the criteria for designing physical bulletin boards (Figure 4.3). All users agreed that the public location and positioning of the board was the highest priority and easy access and ease of use was the second priority. The third criteria is that the size of the board must be large enough for users to notice it and read its content from a distance. Next is that the location of the board must have constant traffic of users. The two least preferred criteria are the durability of the posting material and the alignment of the line of sight and the height of the posting respectively.

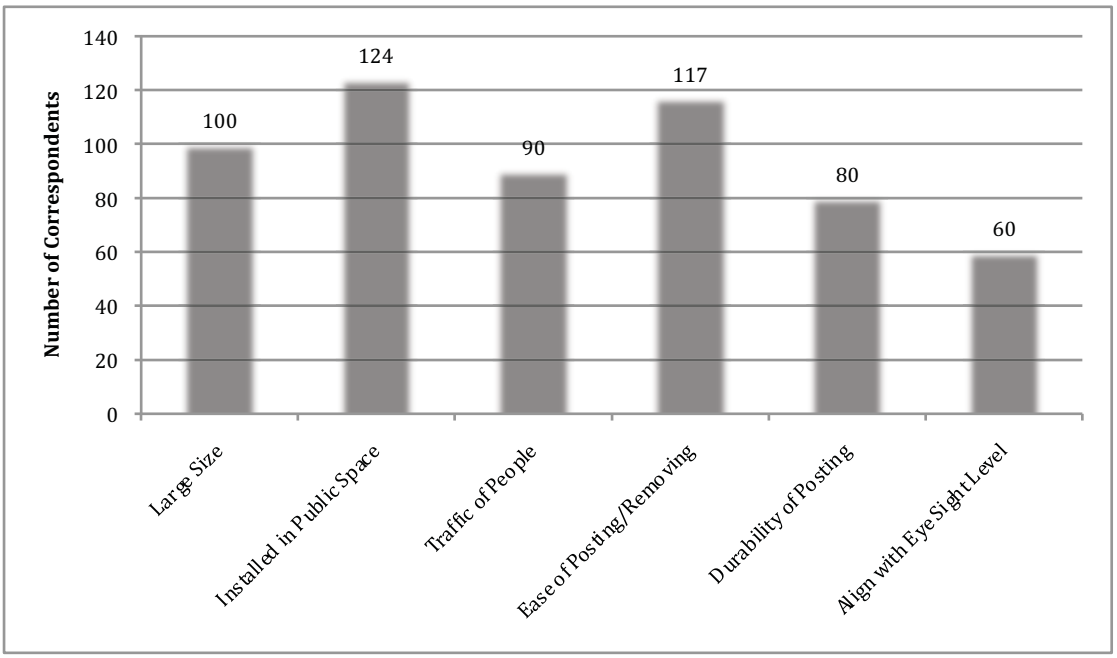

Figure 4.3 Physical attributes of a bulletin board that is preferred by target users.

Some of the criteria that make the bulletin board more interesting and attractive were also asked in the questionnaire (Figure 4.4). The board must have attractive colors and should be aesthetically pleasing was scored highest among answers from users. Good and simple graphic composition followed closely as the second factor. Large and legible text and correct and accurate information were third and fourth in the list. Having information that comes from various sources and origins was also important to diversify the board's content. And lastly, updated and current information was the least factor to determine the board's attractiveness in the opinions of users.

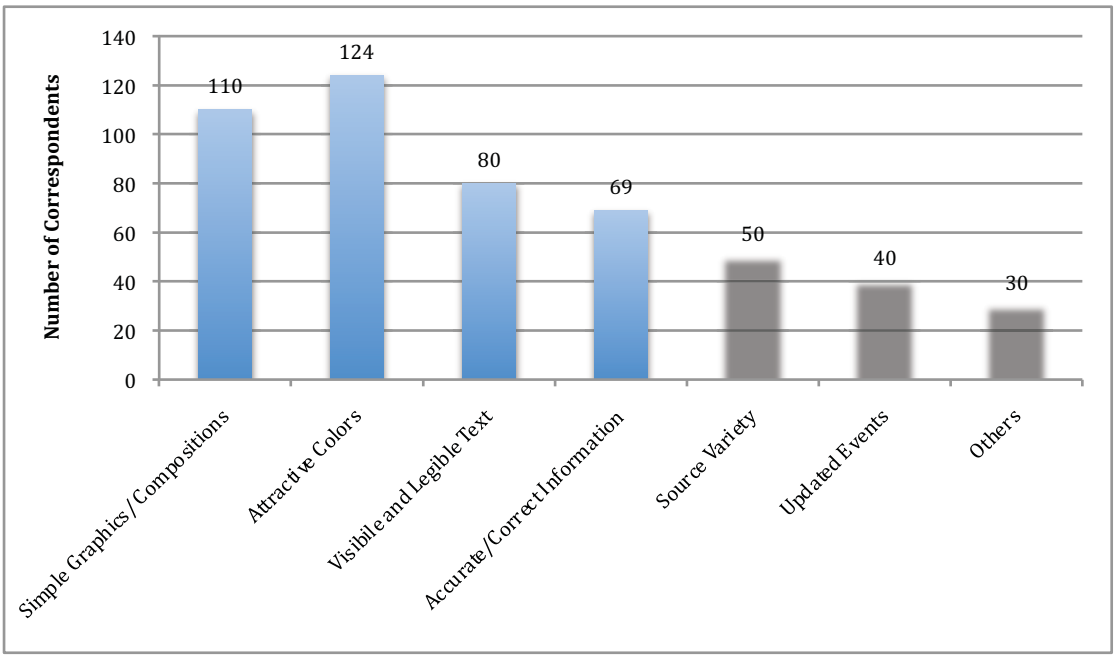

Figure 4.4 Factors that impact the visibility and attractiveness of content on a bulletin board.

From the feedback, certain components were identified as preferred features that are most likely to be incorporated in the new interactive bulletin board (Figure 4.5). The feature that is mostly requested is an email feature that allows users to send certain announcements and information to their email addresses directly. Other features include a student work gallery, a poll/ survey feature, and a web camera respectively. However, the low number of users who prefer the web camera feature suggests that virtual co-presence of people on opposite campuses is information that does not impact their social activities. The type of content that is preferred consists of exhibition and events announcements, general faculty announcements, scholarships, and career opportunities respectively.

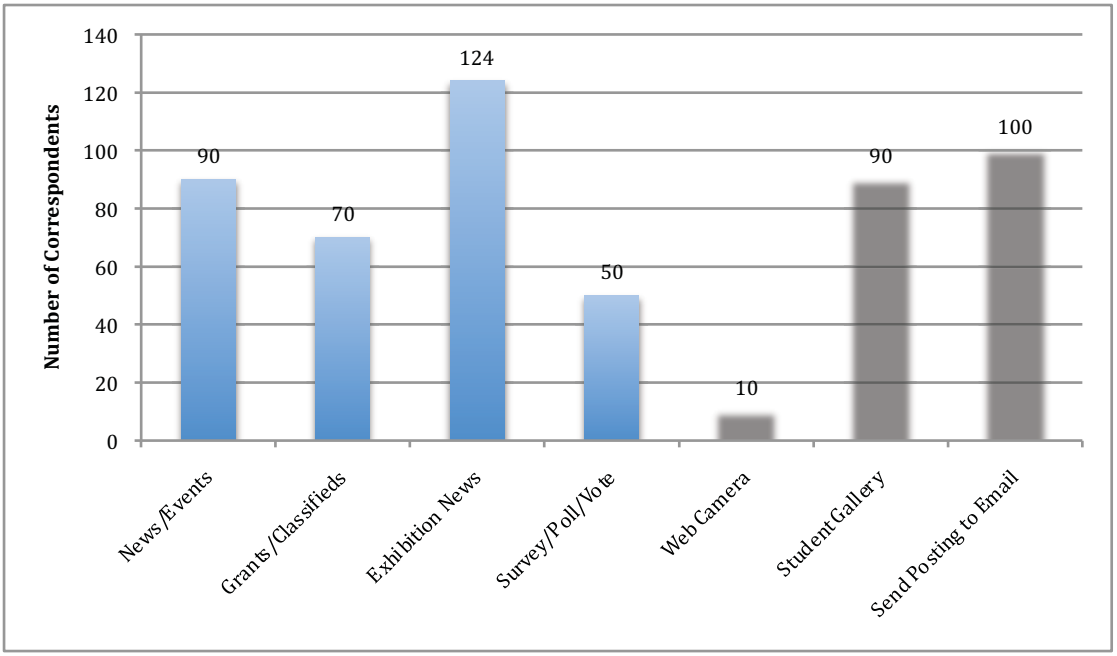

Figure 4.5 Interactive features and multimedia content that is preferred on the new bulletin board.

After the questionnaires were collected and analyzed, certain user requirements and design criteria that the prototype system should follow can now be identified and implemented to the first prototype system. In summary, user requirements that can be identified as core features and be implemented in the prototype FACE Network system are as the following.

1. Emailing Posting Content
2. Browsing and Viewing Posting Content
3. Voting and Surveying User Opinions
4. Live Announcements and Emergency Alerts
5. Live Web Cameras from Both Campuses

4.3 SYSTEM ARCHITECTURE

The prototype proposal includes two large LCD screens, one server PC, two client PCs, two web cameras, two sets of input devices, and a service application (server and client). The hardware is a simple set up of a stand to attach the LCD screen and input devices (mouse, keyboard, or track ball) while providing lockable storage for the PC and network devices. The web camera will be mounted on top of the structure at a location that can capture images of the user. The software application should by implemented as a web interface (PHP with JavaScript or similar technology) with data mining capabilities, dynamic web page generating capabilities, and a content display window to display posted information as well as live video feed from a web camera (Figure 4.6).

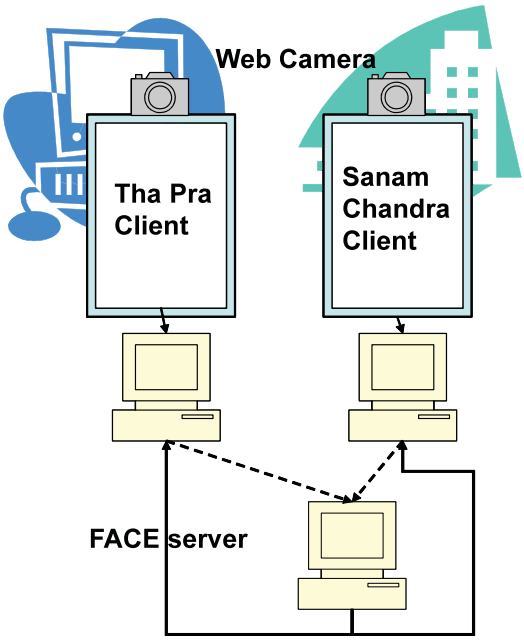

Figure 4.6 FACE Network System Architecture consisting of one server and two clients at different campuses.

The process of using the system should be as simple as sending information (via the bulletin board input) to the server such as text, images, or web links. The client should display posted information in a looped sequence similar to a slideshow, giving each posting a certain amount of display time (10 to 20 seconds) before circulating to the next postings in the list. Instructors can post course-related announcements, sample student work, grades, etc. as a way to promote content created by students. Students can view postings, add comments, and provide acknowledgements or even give polls on certain issues about the faculty. The web camera will show live video feed from the other campus and user at the other end of the display (Figure 4.7).

Figure 4.7 A simulated FACE Network prototype set up at the Tha Pra Campus.

4.4 DEPLOYMENT SITE

From user feedback, it is determined that the most suitable location for both client systems to be deployed is in a public area with heavy traffic of students, staff, and instructors. The prime location was set as the area in front of both administration offices in the two campuses. The administration office in Tha Pra campus is located on the second floor near the main stairwell. Particular areas to place the system are near the office entrance door and next to the document-handling window (Figure 4.8).

Figure 4.8 Administration office on the second floor of the faculty of architecture building in the Tha Pra campus (photographed in December 2006). The empty window between the document handling window and the public telephone is the preferred location of the system.

As for the administration office at the Sanam Chandra campus building or Silp Pirasri 1 building as it is officially called, is located on the fifth floor (as of December 2006). This location is where first and second year students gather to obtain current news and announcements from the faculty and mostly where students submit their assignments. The main staff of this building which include two staff members, a technician, and a librarian are also present in this floor. Therefore, placing an interactive bulletin board near the office window would be most appropriate and safe (Figure 4.9).

Figure 4.9 Administration office on the fifth floor of Silp Pirasri 1 building. The empty window in the middle is where the Sanam Chandra client is to be installed.

4.5 USER INTERFACE DESIGN

Interactions with the FACE Network system is conducted by means of using the system's user interface. Users must be able to utilize the system intuitively with little or no prior instructions which will be a major challenge to overcome. The first few designs of the user interface were designed to accommodate the landscape orientation of a LCD display (Figure 4.10).

Figure 4.10 The first user interface designs balancing the screen percentage between content and features in a landscape orientation.

Most computer monitors are set in this landscape orientation and users are most accustomed to browsing content in a horizontal format. The challenge of landscape orientation lies in balancing the appropriate amount of screen percentage for content and features (i.e., content, email, vote, browse, and announcements) and still makes the content readable (Figure 4.11).

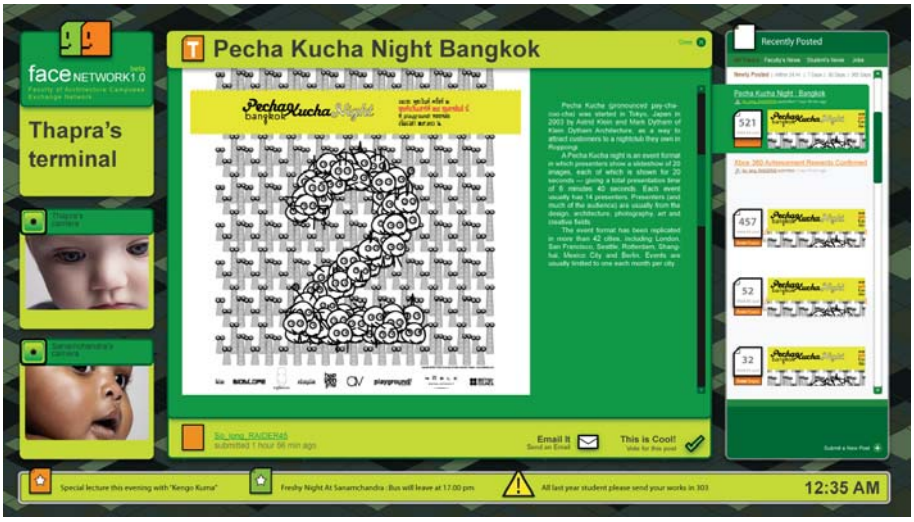

Figure 4.11 The appropriate user interface screen percentage in the landscape orientation.

However, current postings placed on existing bulletin boards are usually printed on an A4 format paper and in a vertical orientation. Similarly, posters and advertisements are mostly found to be in the same landscape orientation suggesting that for general purposes, a vertical or portrait screen format seemed more appropriate for the prototype. The second interface design was fixed in portrait format and positioned all components to fit a vertical arrangement. In this version, a color scheme was also introduced to distinguish the two client interfaces from one another and create identities for Tha Pra and Sanam Chandra campus clients (Figure 4.12).

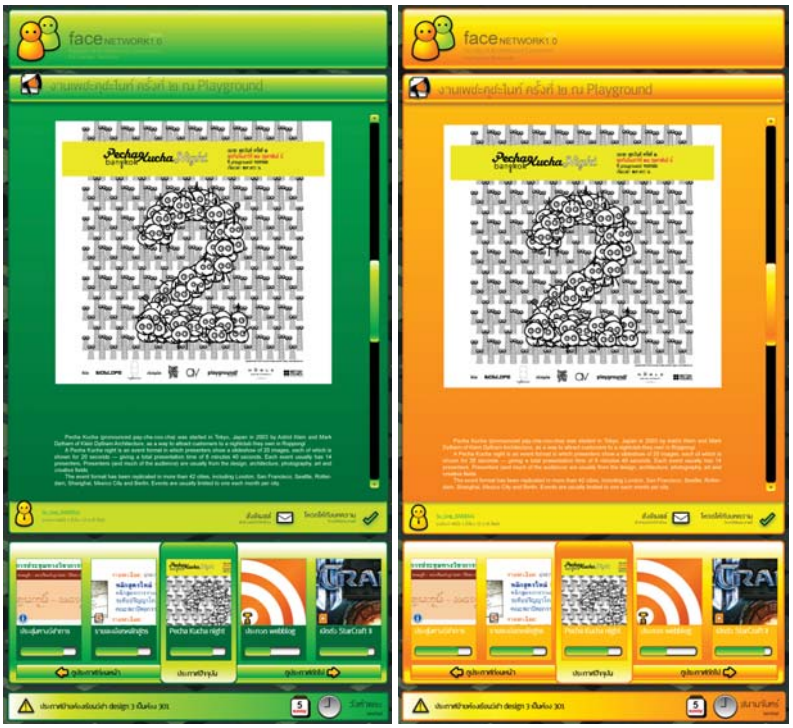

Figure 4.12 The proposed FACE user interfaces in a vertical orientation. The Tha Pra Campus interface is color-coded in green (left) while Sanam Chandra Campus is color-coded in orange (right).

Components of the main user interface comprises of four main window panes (Figure 4.13). The first window is the “Heading Pane” which displays the FACE Network project title, the current date and time, and access buttons to webcams in both Tha Pra and Sanam Chandra campuses. The second pane is the “Content Pane” where all posted content is displayed. The content type can be regular text, images, video, or flash animations. On the top of this pane there is a title label, in the middle is the content, and at the bottom is a modify label which shows the post author’s username, time of post, and allows users to send the post to his or her email addresses, and finally a vote button to pull a poll related to the post. This pane takes up approximately 70% of the screen real estate. The third pane is the “Preview Pane” which displays thumbnails of the five most recent postings with the current posting in the middle, the previous two on the left and the next two on the right. The last window pane is the “Announcement Pane” which consists of dynamic text that can be categorized as announcements or alerts. Content in the announcement pane is set to loop continuously and does not necessarily loop in sync with the content pane.

Figure 4.13 The main user interface consists of four window panes (left pointers) and embedded feature components (right pointers).

In the actual prototype interface that was implemented, the current date and time is displayed on the top right corner near the heading pane. This was changed due to the small space that could accommodate only a fraction of the clock and calendar icons and this was barely legible from a distance. In addition, the content windows also employ icons and symbols to represent certain information and lessen the amount of information overload the users may experience from the various information in the interface (Figure 4.14).

Figure 4.14 User interface icons to represent posting categories, announcement types, and user types.

4.6 HARDWARE DEVELOPMENT

In addition to the user interface design, the hardware and other supporting devices are also crucial components to the system. The equipment required for the prototype set up are as the following.

LCD Display

The main LCD displays are two 40” full high-definition Samsung LCD TVs with a resolution of 1920x1080 pixels, one for each campus client system. An additional 17” Samsung LCD display model 740NX is utilized for the server computer.

Custom Stand

A custom built stand is made of steel tubes assembled into a shape of a stand with a lockable storage compartment (Figure 4.15).

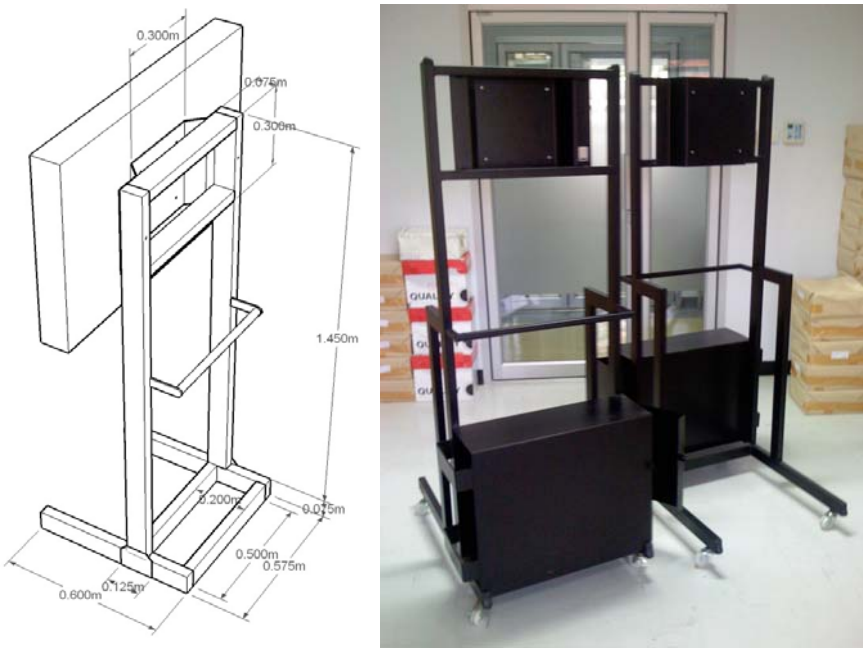

Figure 4.15 The customized LCD display stand is a black-coated steel casing on wheels with a lockable storage compartment.

Personal Computers

There are three computers used in this prototype system, one server PC and two client PCs. The specs for the clients are a Windows XP based computer with a Core 2 Duo chip at 1.86 GHz, 1 GB of RAM, 160 GB hard drive, DVD-RW drive, nVidia nForce 4 graphics card, with standard keyboard, mouse, and speakers. The server machine has the same basic specs but installed with a Linux operating system. Also, there are three UPS units for the three computers.

Digital Internet Cameras

The Internet cameras for two client systems are 10/100 fast Ethernet IP cameras from D-Link model DSC-2100. They are used for the web camera feature to display live video from both Tha Pra and Sanam Chandra faculties.

Input Devices

To limit user interaction to only simple tasks as selecting and clicking, a trackball mouse that does not have to be placed on a flat surface is utilized. The actual mouse may seem cumbersome to use at first but it is more convenient to handle and requires less space.

4.7 PROTOTYPE FEATURES

The prototype consists of several features that users may interact with and utilize for certain purposes. The main features can be categorized into two groups according to who the user

is. For administration purposes, functions to organize, manage, author, and edit content and users are features designed for administration users. In addition, administration users can also access and analyze information regarding users and interactions within the system to determine behavior patterns and user preferences. The following describes these features in detail.

Administration Users

1. Logging In (access administration features)
2. Manage Users
    2.1. Adding Users (adding staff, student, and instructors and setting user privileges)
    2.2. Disabling Users (disable user from logging in but data is not deleted)
3. Posting Content
    3.1. Multimedia Content (choice of image, video, text, or Shockwave Flash)
    3.2. Announcement Content (select type of post as announcement or alert)
    3.3. Vote Content (add vote choices to the list, minimum of three and maximum of four)
4. Data Management
    4.1. User Statistics (collect data of user in text form)
    4.2. Interaction Statistics (collect data of types and time of interactions with the system)

General Users

1. Browsing Content
    1.1. Viewing all posts (main content window)
    1.2. Scrolling through content previews (browsing through content thumbnails)
    1.3. Selecting a content preview (selecting a content thumbnail and opening the content in main window)
    1.4. Viewing announcements and alerts (faculty emergency announcements and alerts)
    1.5. Viewing titles, authors, time and date (additional features to show more detail of the posting information)
2. Emailing Content
    2.1. Selecting send email button
    2.2. Inputting email address (dialog pop up window with virtual keyboard to input email address)
    2.3. Sending email (sending email with content attachment through mail server)
3. Submitting Votes
    3.1. Selecting choice (agreeing to make vote by selecting single choice from a given three or four choices)
    3.2. Submitting vote
    3.3. Viewing vote score (selecting view vote score to see current vote percentages)

4. Viewing Webcam

4.1. Selecting webcam location (selecting Tha Pra or Sanam Chandra icons to pop up new window with live video feed from camera attached to each client)

Users who are administrators can access the administration features as described above (Figure 4.16). Administrators who are content authors (or posting authors) must log into the system from a specific URL[4] or IP address[5] then posting content and announcements is possible. Administrators who manage the system can also log in and create a list of users who can have certain rights or access to a limited amount of features. For example, authors should not be able to add or disable other authors in the system.

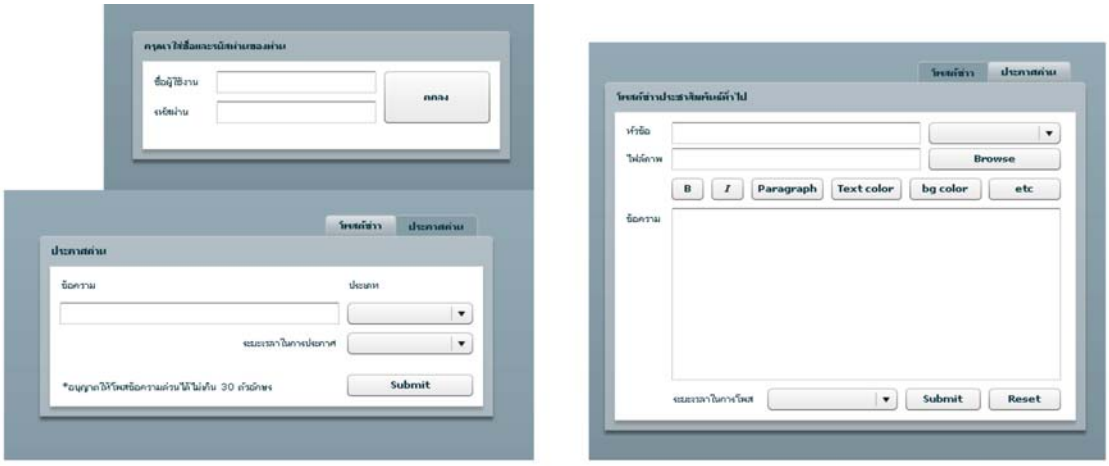

Figure 4.16 Administration dialogue boxes to log in (top), post announcements or alerts (left), and post content (right).

4.8 PROTOTYPE IMPLEMENTATION

The actual prototype system deployed at the Faculty of Architecture in Silpakorn University Tha Pra campus differs slightly from the original design. There were two versions deployed; first with its customized mobile stand and second with everything fixed in place permanently. The first prototype was designed to be a mobile unit on a stand with all equipment secured inside the customized steel stand (Figure 4.17).

[4] URL is short for Uniform Resource Locator which is a string of characters to represent an Internet address.

[5] IP Address is an Internet Protocol Address which is similar to URLs but are instead a set of numbers to identify a specific networked computer.

Figure 4.17 The first prototype stand with a locking compartment to enclose a PC. Unfortunately, the stand was not used for the user test of the system so no equipment were attached or installed on to the stand.

The Internet web cameras were not installed due to recent restrictions in Internet web camera activities and limited bandwith connections between Tha Pra and Sanam Chandra campuses, therefore the webcam feature unfortunately was not implemented into the final prototype. However, the flexible design of the system does allow for this feature to be implemented in the future when the Internet infrastructure is readily available to support such use.

The current hardware set up has been modified as well to suit the physical changes to the space, particularly, in the second floor lobby where the administration office is located and certain hardware devices were replaced with traditional and more familiar devices. The stand from which the LCD display is attached to, was removed entirely so that the display can be attached directly to the ceiling in front of the administration office. All periphery equipment inside the stand including the client PC, UPC, and tethered cables were tucked away in a hidden cabinet behind the office wall.

The input device, originally designed as a single handheld trackball mouse, was now replaced with a more traditional mouse and keyboard placed adjacent the display. The reason for this change was strictly based on poor user feedback of the trackball mouse since it was rather counter-intuitive to use and even difficult to operate with a single hand. But the setbacks were space required to place the mouse and keyboard is limited and does not align well with the LCD display itself causing users to perform poorly when trying to interact with the system from a distance.

The Tha Pra faculty building itself has had a major renovation overhaul in 2007 which in part delayed the plan to install the interactive bulletin board in front of the administration office for an extended duration of one academic year. After the completion of the renovation, the current

system was since revised and reinstalled in March 2009 and has remained there as of present (Figure 4.18).

Figure 4.18 The redesigned FACE Network prototype. An integrated LCD display installed permanently to the ceiling in front of the administration office of the faculty of architecture in Tha Pra campus.

The biggest set back was the Sanam Chandra client system which was never implemented and installed at the proposed location. This is due to the same renovation process that went on during 2007 at the Silp Pirasri 1 building where the administration was relocated to the second floor. The new administration office is surrounded by clear-glass ceiling-height windows which became a target for major equipment theft in the area. Therefore, the client was not installed to avoid any risks of theft of the equipment.

The user interface of the prototype has also been modified slightly to accommodate set backs in the changed hardware and some poor usability of the system. The clock display which was originally designed as a dial clock, was changed into a numeric display and along with the date, were relocated from the bottom right corner to the top right corner of the screen for better visibility when viewed from a distance. Also, content such as video that was not initially defined as content that is viewable on the interactive bulletin board was implemented (Figure 4.19). This change was for the better but caused delays to revise some of the program codes to allow video to play for an extended amount of time than the standard 10 seconds before moving to the next slide.

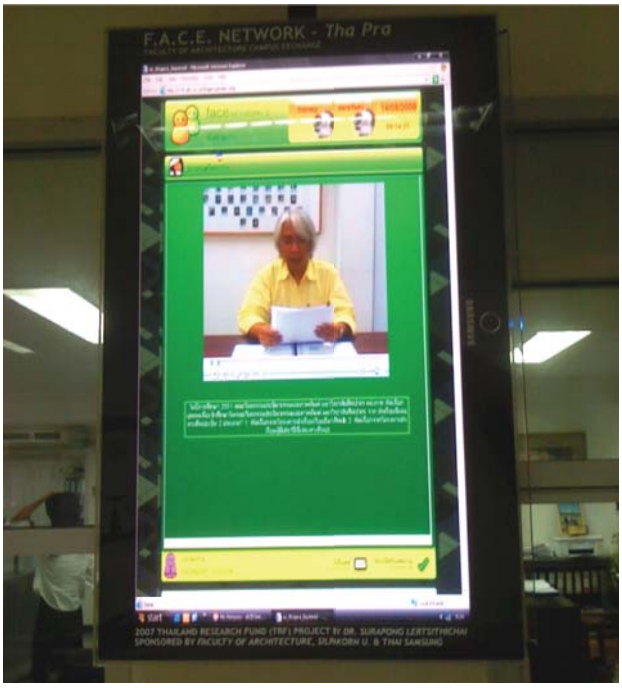

Figure 4.19 The FACE Network display during a test run with video content embedded within the post.

5. PROTOTYPE EVALUATION

The test of the Tha Pra prototype system started during the first semester of 2009 from May until July with a total of three months in service. Data collection started on Monday May 4th, 2009 and concluded on Friday July 31st, 2009 with a total of thirteen weeks of real usage data. The information gathered from the system is mainly usage statistics that can be divided into three categories. The first is the number of users (average type of users per day, week, and month), the second is the statistics of the interactions (average amount and type of interactions per day, week, and month), and the third is the statistics of the content (average amount and type of content per day, week, and month).

5.1 USAGE STATISTICS

The number of users who utilized the system is divided into three groups who are students, staff, and instructors. During the first month before the beginning of the first semester of 2009, the main contributors or authors of content are staff and instructors and no students were present during these months (Figure 5.1).

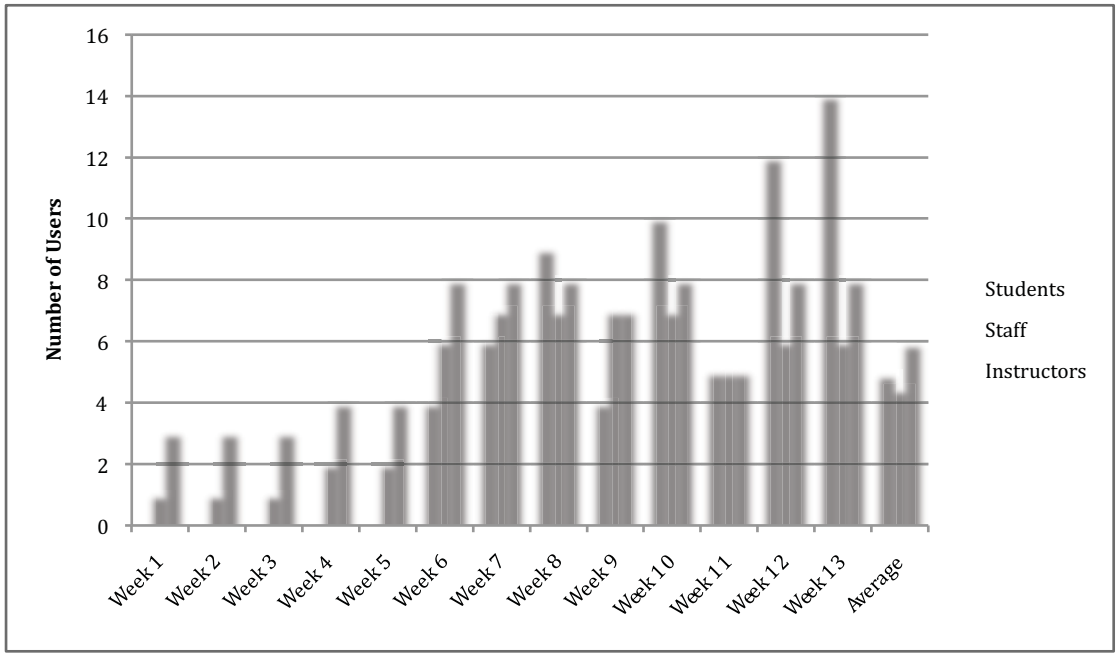

Figure 5.1 Number of users of the system divided into students, staff, and instructors.

During the first three weeks of deployment, no students were involved in the usage of the FACE Network prototype because it was the last month of the summer break. After the semester began early June or the fourth week, students became aware of the new addition and a few student representatives were given user accounts to contribute content to the bulletin board. The numbers shown in Figure 5.1 are amount of usage by user type. Most staff and instructors who were original contributors (most are in the faculty promotion committee already) remained as main