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โครงการระบบเฟอร์นิเจอร์สำนักงานอัจฉริยะ

โดย สุรพงษ์ เลิศสิทธิชัย

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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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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).

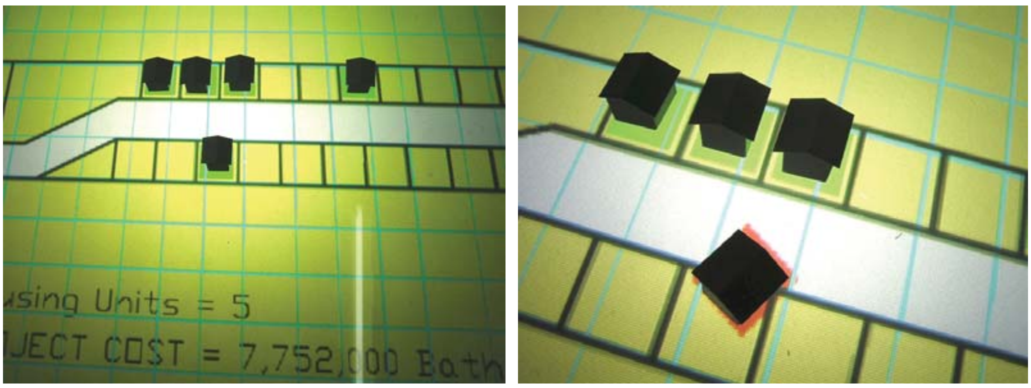

Figure 3.2 TangiDESK surface with building objects and projected land plots (left). Building code system underlines illegal placement of object with red outline (right).

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).

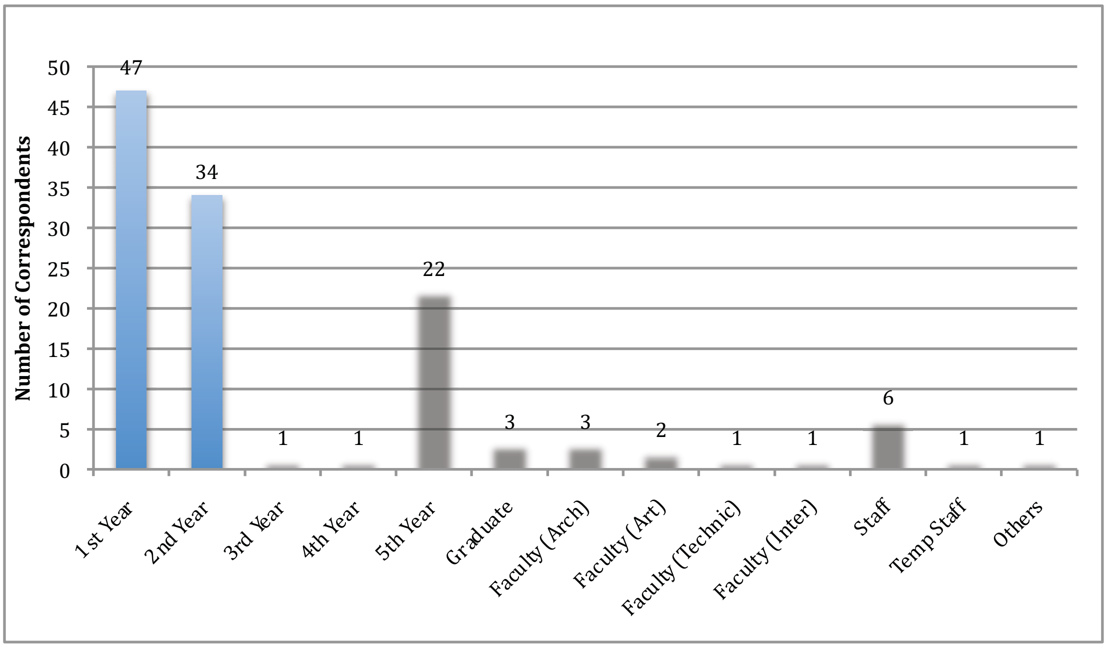

Figure 4.1 Sampled information from target users of the prototype system. Out of 124 correspondents, 87% are students, 7% are staff, and 6% are instructors.

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.

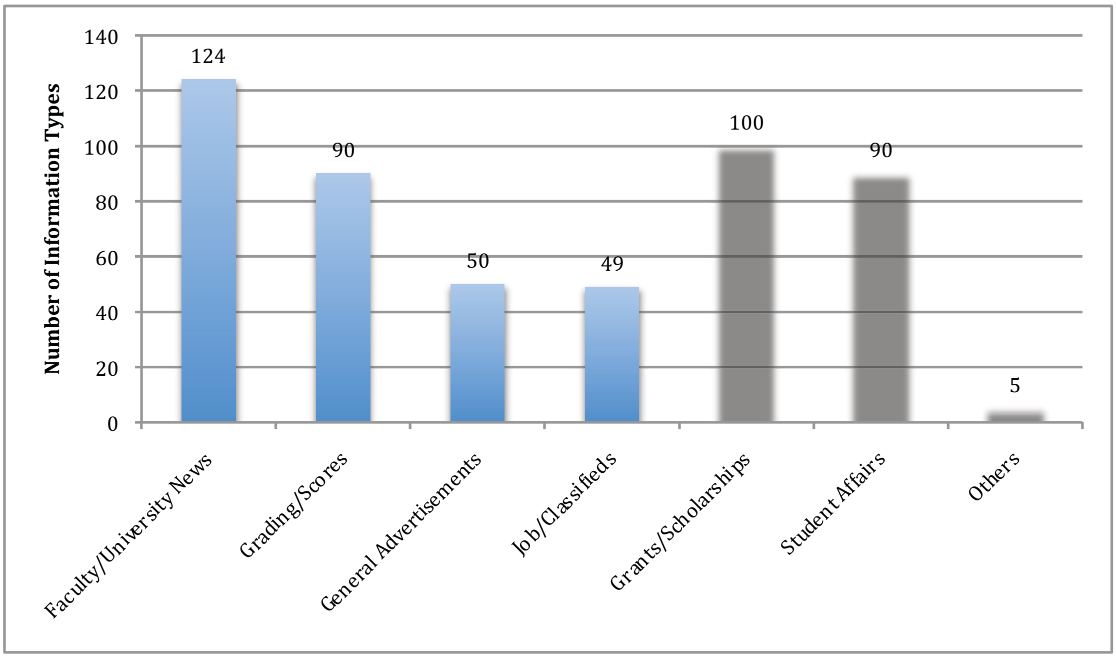

Figure 4.2 The common types of information seen on bulletin boards within the faculty of architecture.

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.

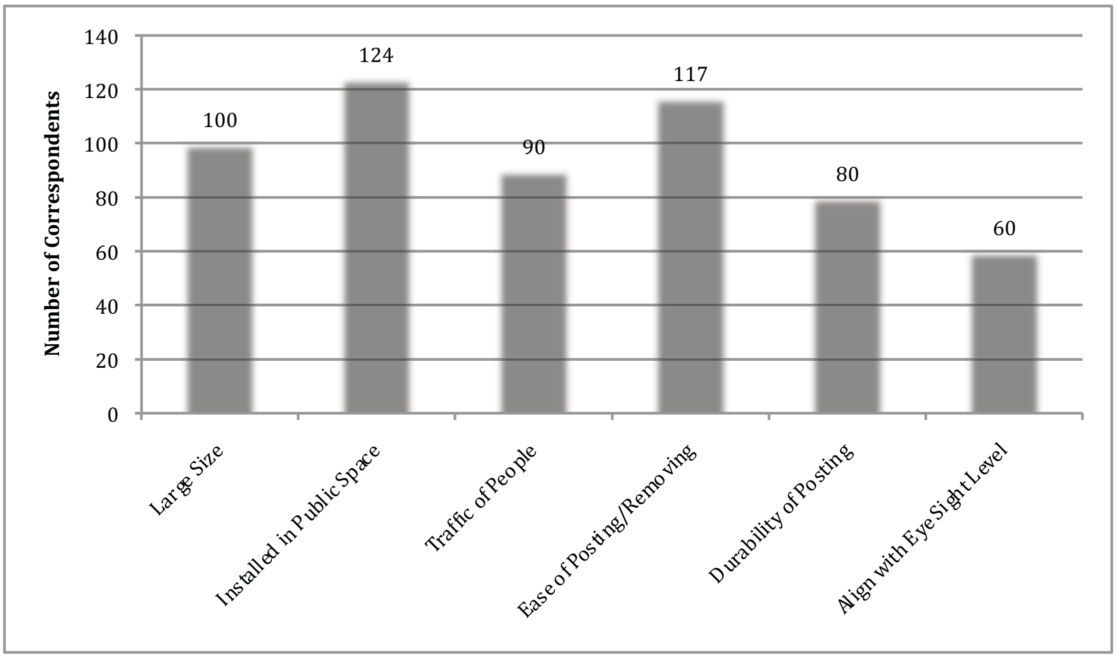

Figure 4.3 Physical attributes of a bulletin board that is preferred by target users.

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.

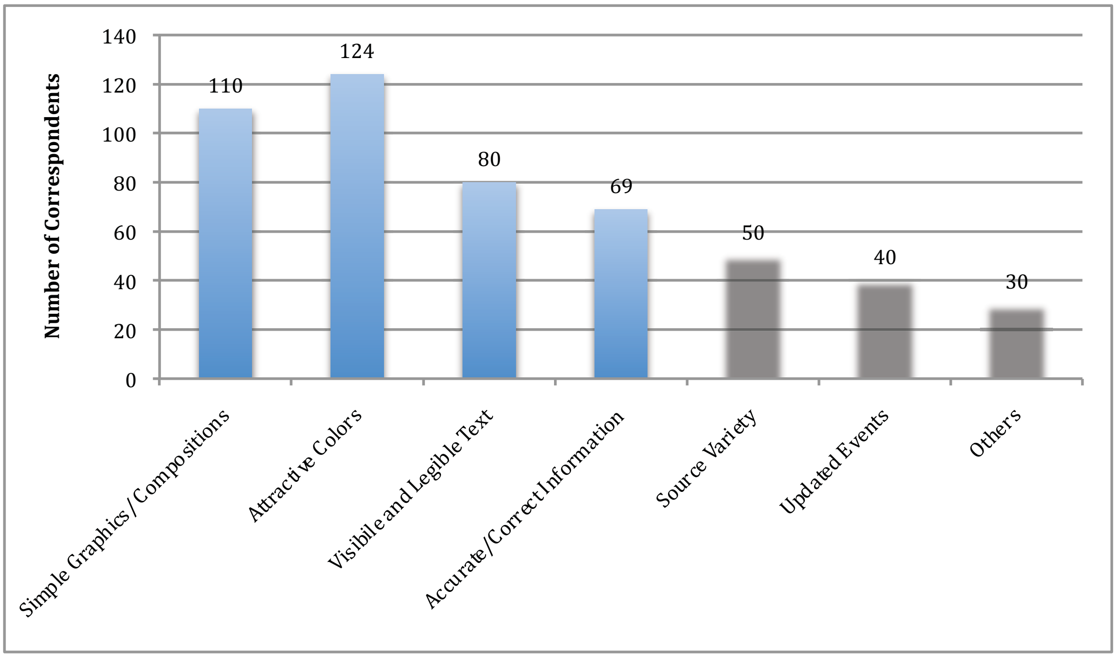

Figure 4.4 Factors that impact the visibility and attractiveness of content on a bulletin board.

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.

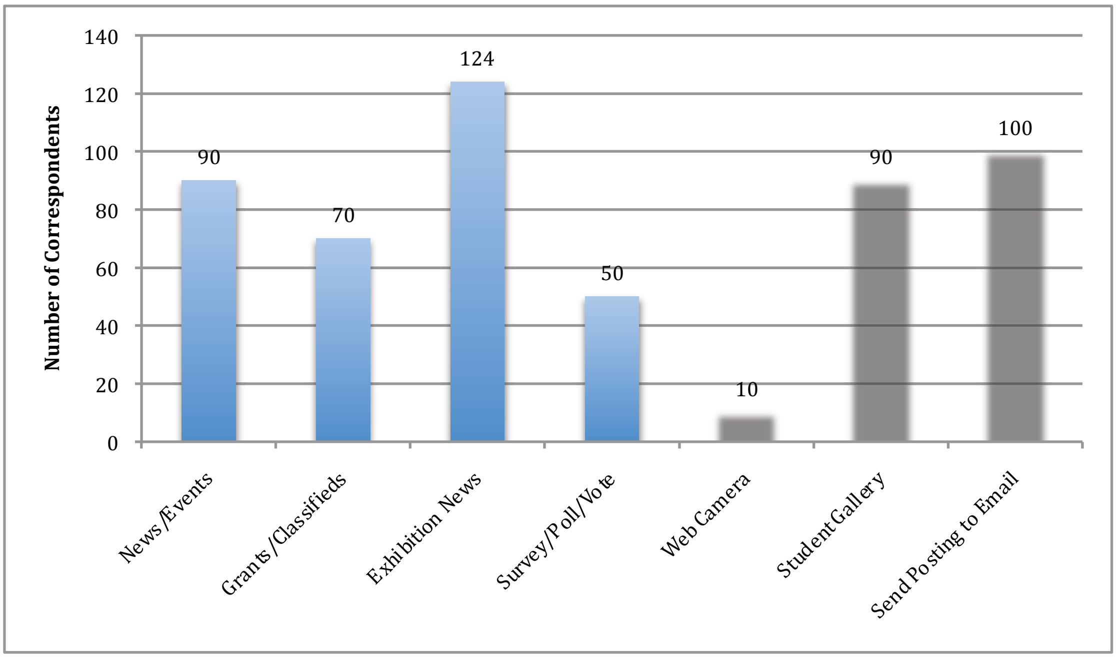

Figure 4.5 Interactive features and multimedia content that is preferred on the new bulletin board.

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).

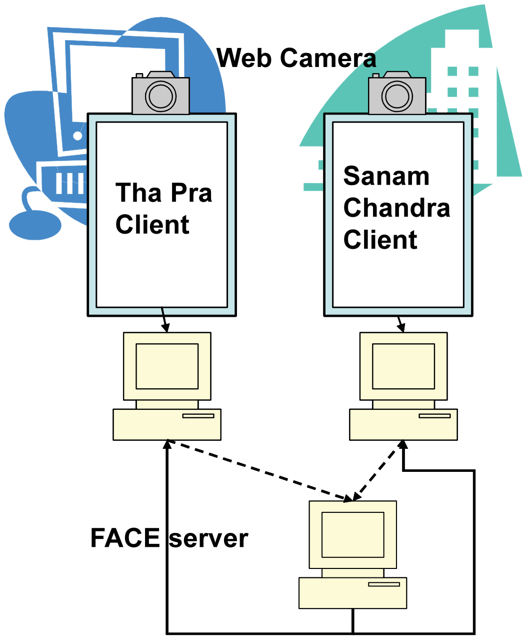

Figure 4.6 FACE Network System Architecture consisting of one server and two clients at different campuses.

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).

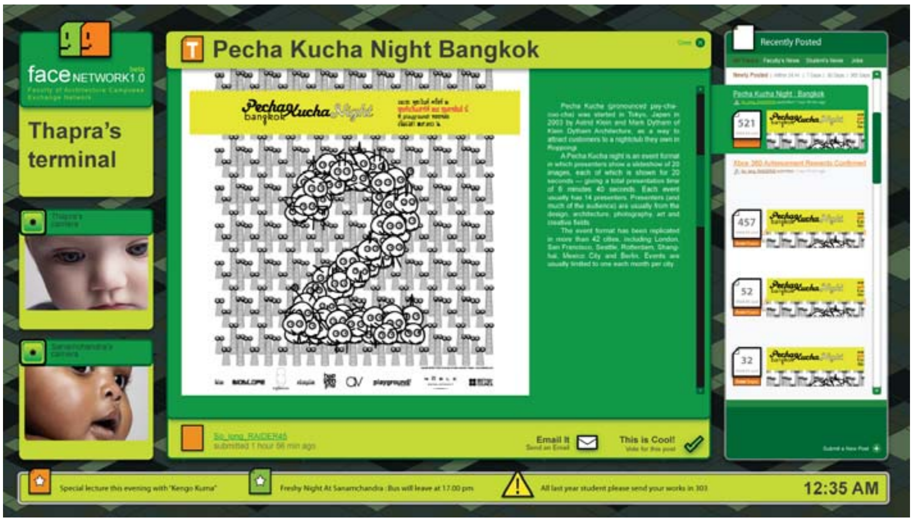

Figure 4.11 The appropriate user interface screen percentage in the landscape orientation.

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).

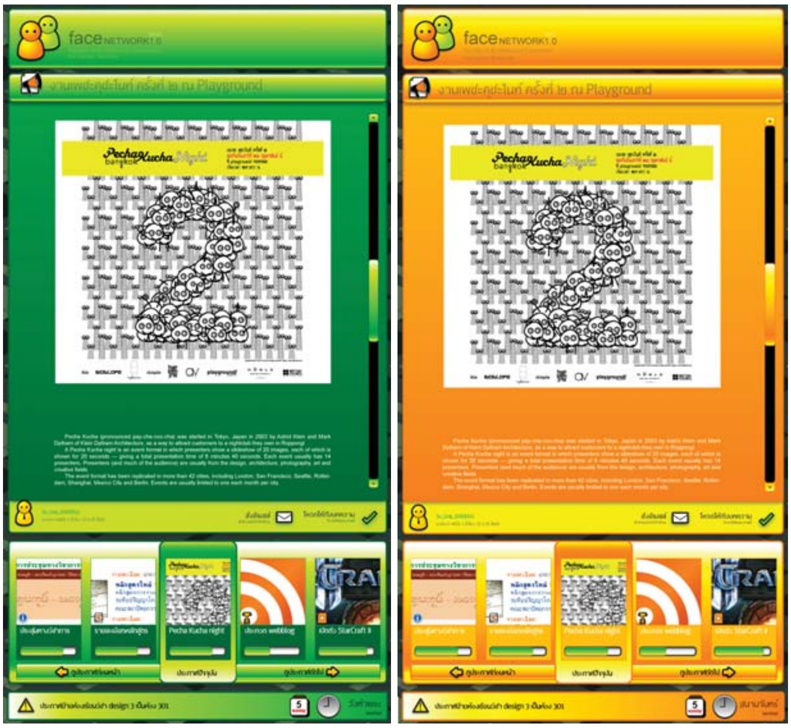

Figure 4.12 The proposed FACE user interfaces in a vertical orientation. The Tha Pra Campus interface is color-coded in green (left) while Sanam Chandra Campus is color-coded in orange (right).

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.

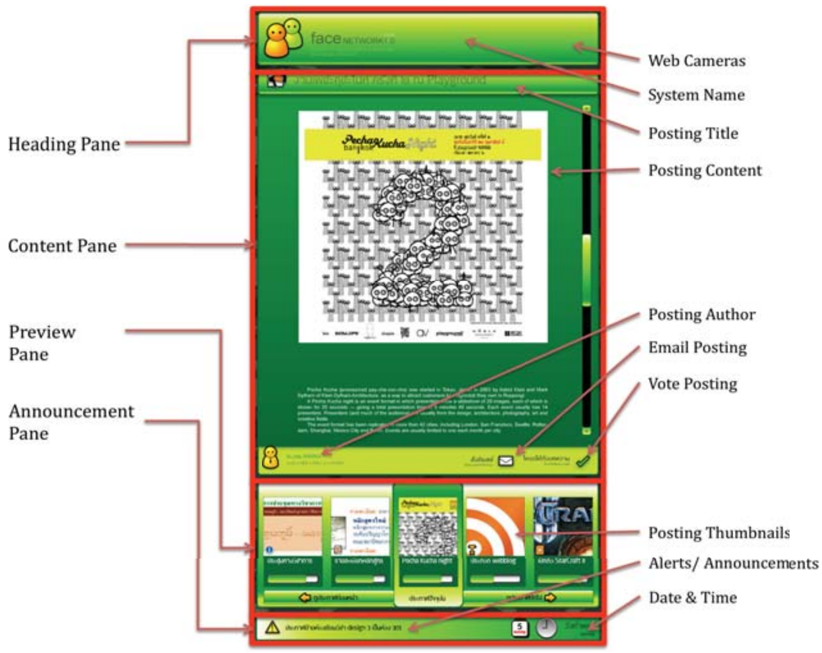

Figure 4.13 The main user interface consists of four window panes (left pointers) and embedded feature components (right pointers).

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).

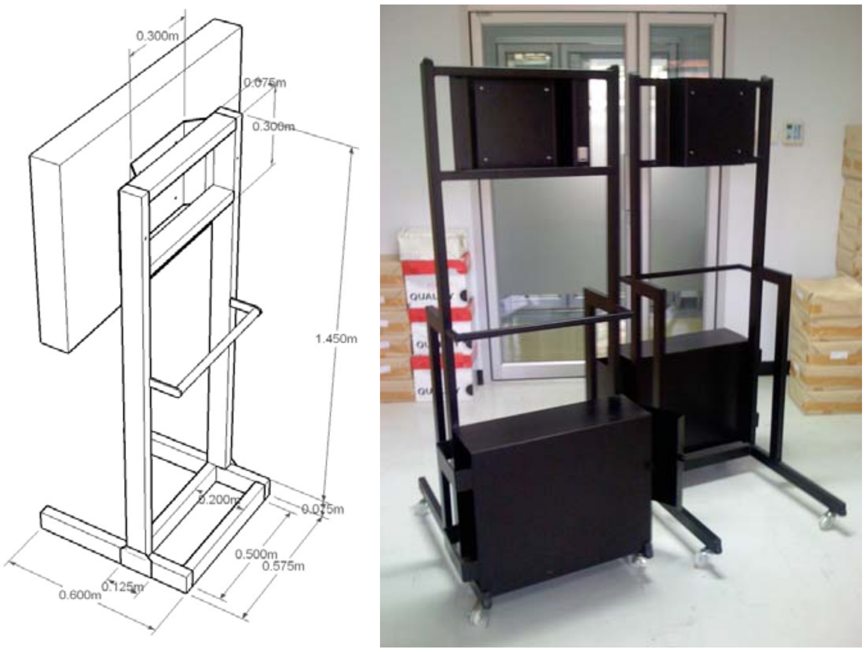

Figure 4.15 The customized LCD display stand is a black-coated steel casing on wheels with a lockable storage compartment.

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.

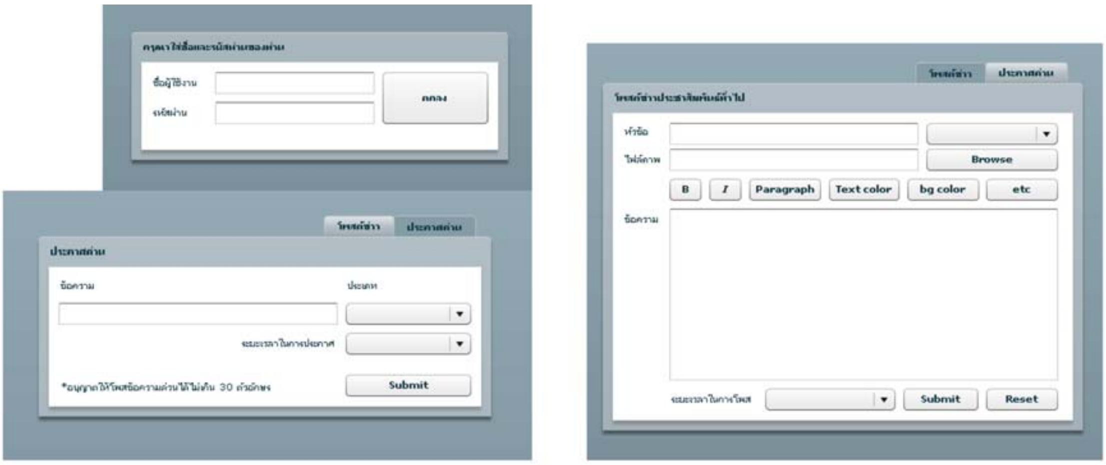

Figure 4.16 Administration dialogue boxes to log in (top), post announcements or alerts (left), and post content (right).

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).

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[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).

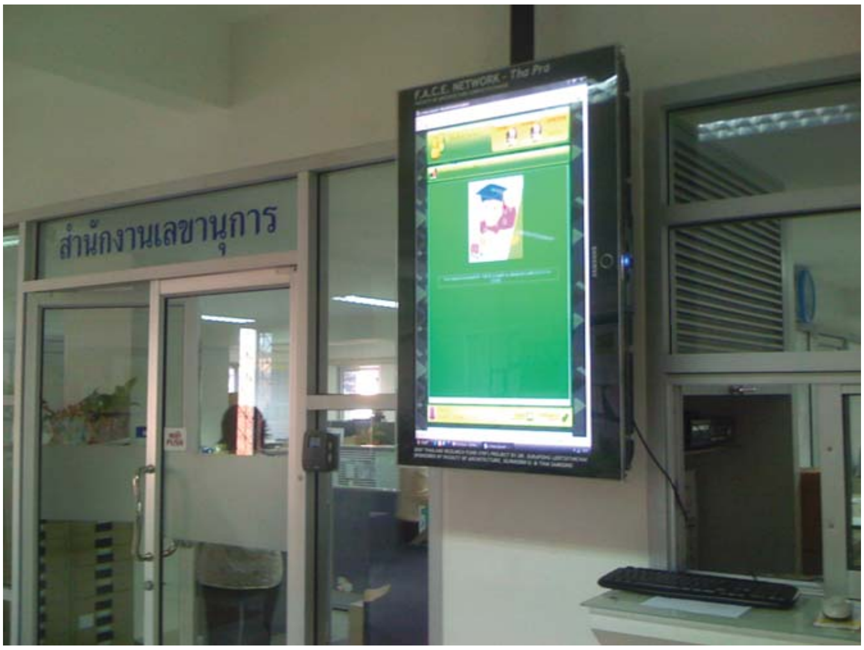


Figure 4.18 The redesigned FACE Network prototype. An integrated LCD display installed permanently to the ceiling in front of the administration office of the faculty of architecture in Tha Pra campus.

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.

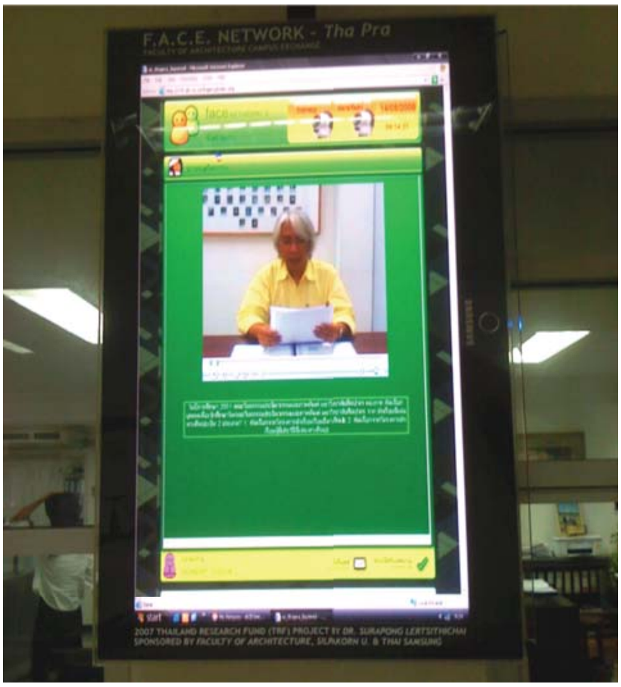


Figure 4.19 The FACE Network display during a test run with video content embedded within the post.

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).

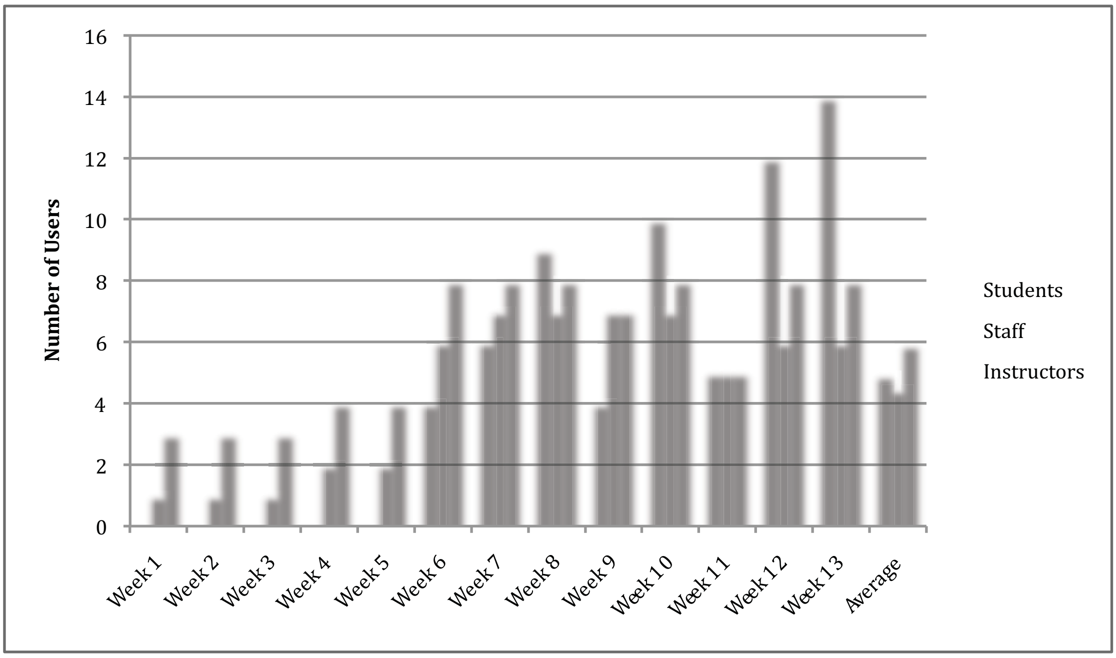


Figure 5.1 Number of users of the system divided into students, staff, and instructors.

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 users of the system logging in and submitting content to the system regularly. It was only during the sixth week that a few students began sharing their content to the community.

From statistics, it is quite obvious that had the prototype usage been further recorded, more students would have contributed to the network and by time will surpass the amount of content contributed by the staff and faculty members. Ramifications for what may result in too much information or inappropriate content was not discussed or thoroughly planned at this stage.

Another set of data that was of interest is the number of interactions during the thirteen weeks categorized by weekdays. The average number of interactions per day is 9.29 postings and the popular days to post content are Thursday, Friday, Wednesday, Tuesday, and Monday consecutively (Figure 5.2). This is due to the fact that most Thursdays are set for faculty meetings and thesis reviews so not many classes are scheduled during this day. Most students are present during this day to work on studio projects that are usually submitted on Fridays so they tend to browse the board and or make contributions throughout the day. Similarly, instructors and staff submit most of their content during this day simply because they have the spare time only on this particular day.

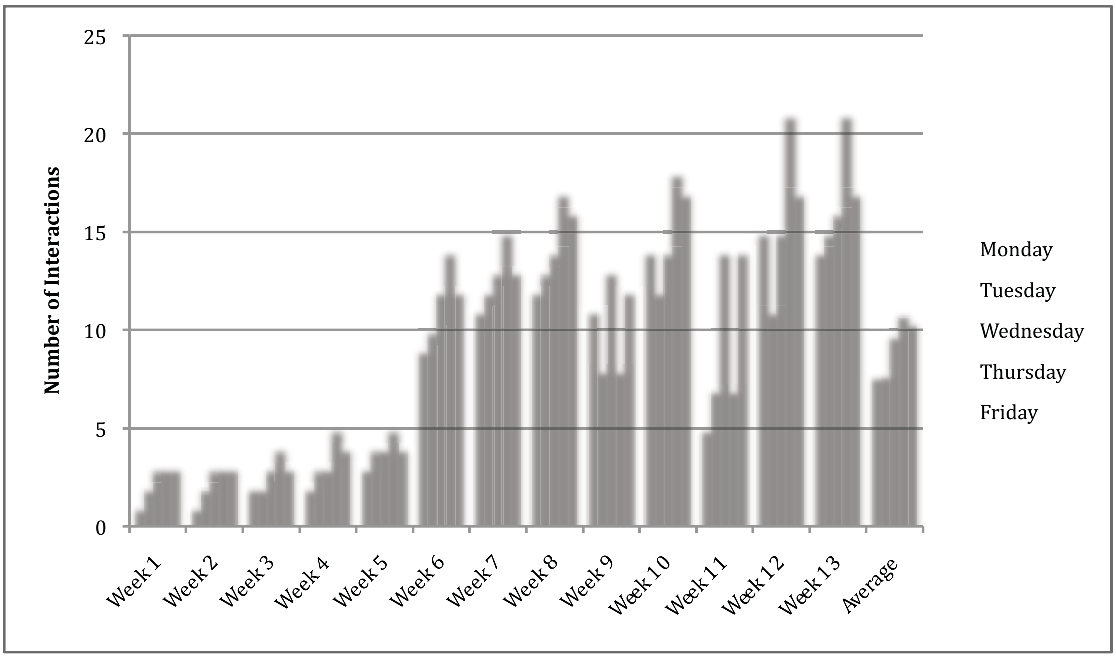


Figure 5.2 Number of interactions performed in each week with Thursday having a maximum total of 141 while Monday having only 100 interactions in total.

Looking at the number and types of interactions with the board itself (Figure 5.3), statistics reveals that browsing is the most common interaction that users conduct with an average of 39.54 interactions per week and 514 interactions in total. Browsing activities consists of clicking on the main content window, clicking on the preview thumbnails, or scrolling through any of the content within the interface. The second most common interaction is posting content in which accounts for 4.69 interactions per week and 61 postings in total. In spite of this, when compared to the number of browsing, the number of postings is still relatively low even when combined with other interactions. The least common type of interaction is the email feature where users send an average of 1.08 emails per week and 14 emails in 13 weeks. The voting interaction is also low accounting for only 15 votes in 13 weeks or an average of 1.15 votes per week. However, it is also encouraging to see the rise of email interactions in the last four weeks which suggests that it may be a valuable feature when users become more accustomed to the system.

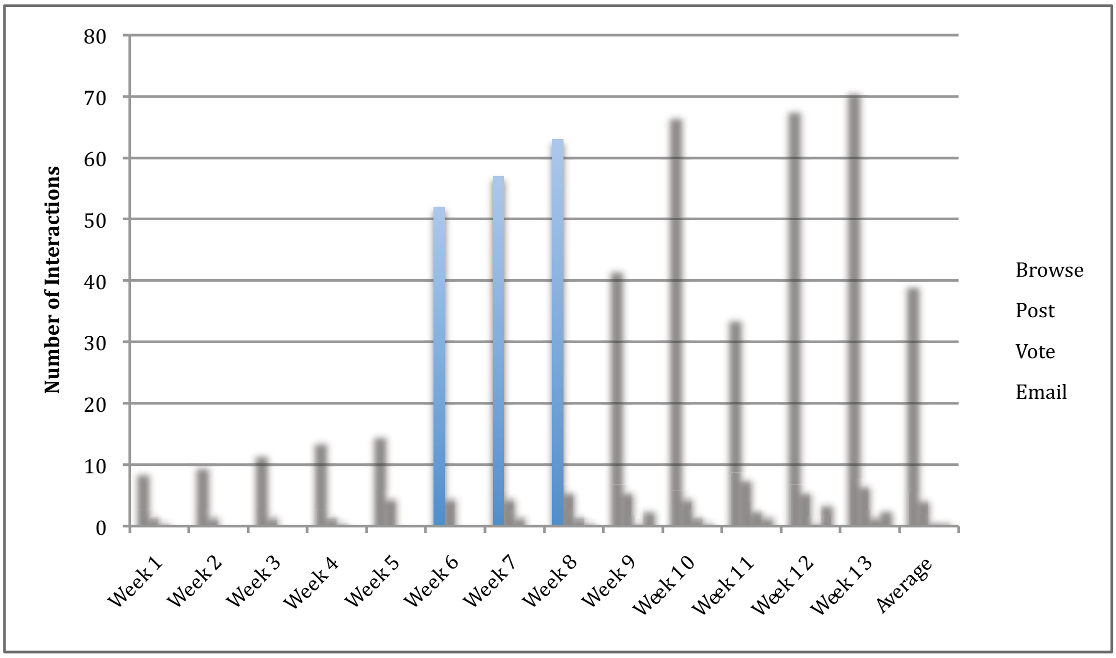


Figure 5.3 The amount of interaction types conducted in each week. Out of 604 interactions in 13 weeks, browsing accounts for 85%, posting accounts for 10%, voting at 2.6%, and email at 2.4% of all interactions.

When distinguishing the types of information that was being posted by users, 23 postings were images, 22 were plain text, 10 were text announcements, 4 were video, and 2 were text alerts (Figure 5.4).

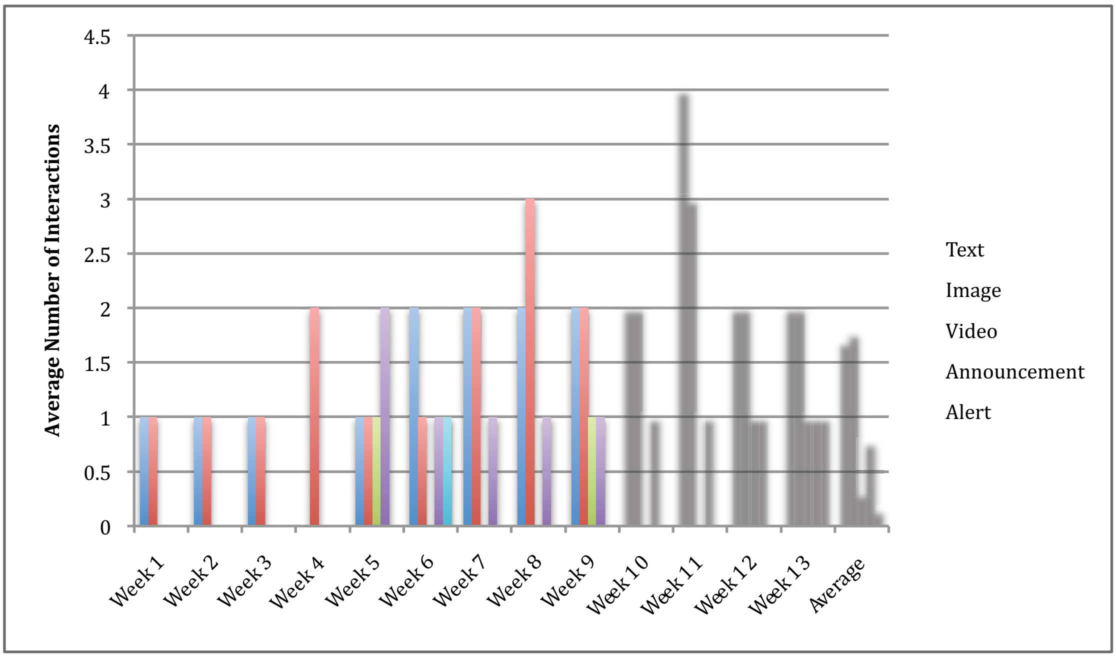


Figure 5.4 The types of content posted on the interactive bulletin board. Out of a total of 61 postings, images account for 37%, text 36%, announcement 16%, video 7%, and alerts 4%.

Due to limited time for testing, no significant patterns could be defined from these statistics but it is fair to conclude that if users become more familiar with the system features and its user interface, the variety of the content types should increase in time.

For the last set of statistics, the timeframe from which users prefer to use the system is observed. A standard timetable from Silpakorn University divides a normal academic day into eight slots from 8:30 am to 7:30 pm (Figure 5.5). Each university faculty should have a different pattern which should also be unique to the learning process of that particular faculty. For the faculty of architecture, on average users prefer to interact with the system between late morning and early afternoon and especially on Thursday. This suggests that if an instructor or staff would like to make public announcements, it should be done before this time slot and before Thursday if possible.

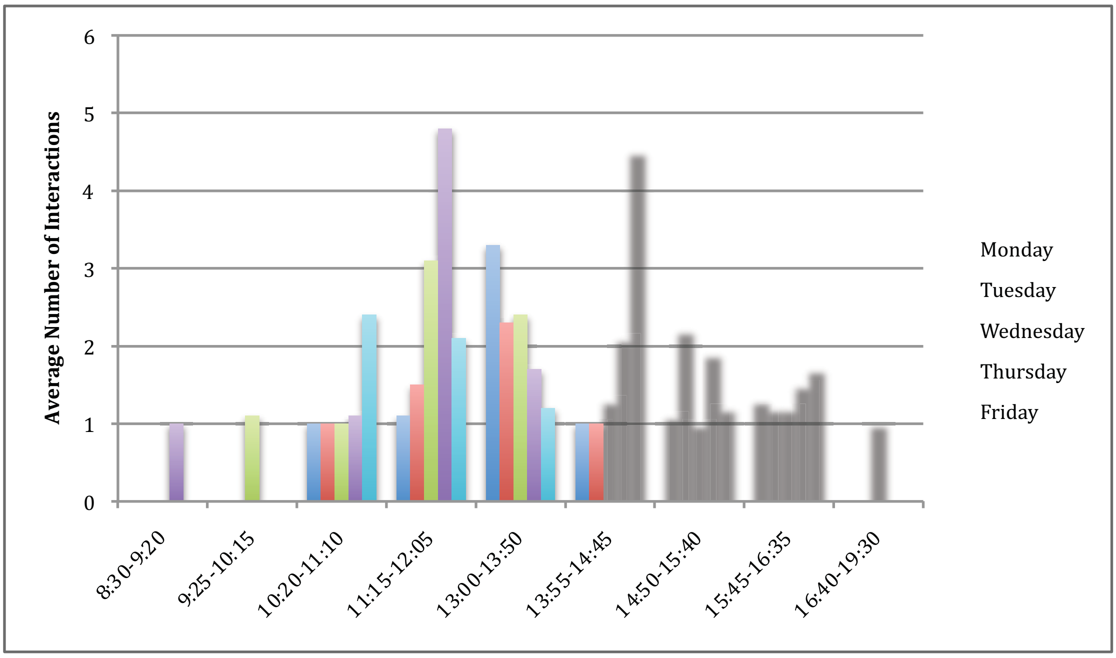


Figure 5.5 Average number of interactions grouped by the faculty timetable.

5.2 USER FEEDBACK

In addition to remote monitoring of the system usage, an informal interview was conducted to gather direct user feedback and suggestions for future revisions of the system. When asked about the user interface of the system and its usability, most users had no problem navigating or finding information when browsing through its content. However, for features specific for administration users, some users required guidance and reminding of some functions and settings which is a normal occurrence for any software application user.

The remaining questions besides the usability of the system was to validate whether such system could promote or encourage interactions among people within the faculty of architecture. The result of user feedback was quite encouraging. Out of 124 correspondents, 10 strongly agreed that the system helped strengthened the interaction between staff, students, and instructors from both campuses. Another 110 agreed with the same claim, while 1 was neutral, and the remaining 3 disagreed (Figure 5.6).

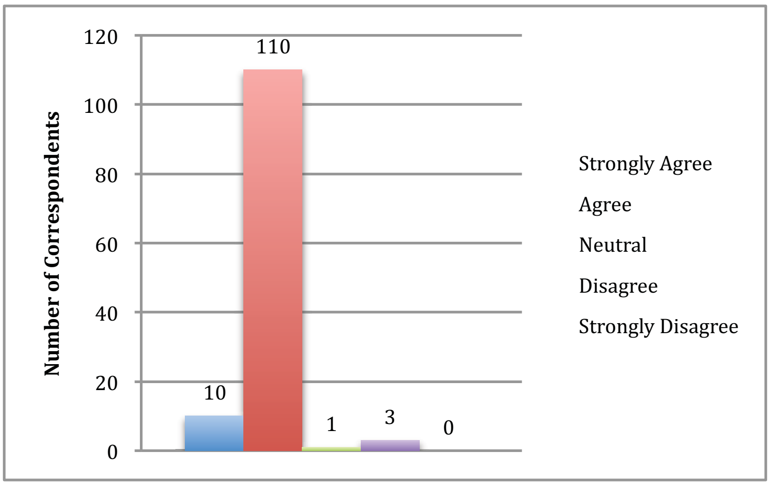


Figure 5.6. User feedback of the Interactive Bulletin Board prototype (FACE Network) after 3 months of deployment and real use, users agreed that the system encouraged more interaction among staff, students, and instructors between the two campuses.

Other questions that were asked confirmed all the design and implementation criteria of the system prototype according to the first user requirement study. With this data collection and user feedback, findings of the research can be analyzed and concluded.

5.3 DATA ANALYSIS

From the system database, certain patterns have emerged allowing assumptions about user behavior of the system to be made. Weekly usage of the system shows that every Thursdays have the highest system usage out of the week while Mondays have the least amount of daily usage. This pattern is synonymous with student and instructor schedules in the week and specific to users of the tested faculty. In the Faculty of Architecture, most Thursdays are scheduled with architectural thesis reviews for fifth year students which are conducted once every month. People in the faculty will be present on this day and therefore activities and usage of the system is apparent when more people are present to interact with one another.

The types of information that is commonly posted are text, images, and text announcements due to the fact that it is more convenient and less time-consuming for users to execute. However, video and multimedia content were also a favorite type when asked about what the strengths of this interactive bulletin board was.

The most common function used by most users is the browse content function. The numbers are constantly high and continue to grow higher as time goes by. The other functions are posting content but the numbers show a slow start but gradual growth in number of postings during late stages of the experiment.

Finally, when users were asked to give feedback about their perception of the system and what they thought about replacing existing board with the interactive bulletin board. There was a mix of agrees and disagrees but all in all, users confirmed that it was not a solution to replace existing boards but to enhance existing boards with features and content that is not possible with existing boards. They do, however, feel that the implementation of such interactive bulletin board has drawn more users to interact with each other not only in front of the interactive bulletin board but asynchronously when sending information of the posting to their friends and colleagues email addresses.

The activity of hanging out in front of the administration office not only provides people with a updated information, the board can also help initiate conversations about certain interest or events that people may share or have in common. This has certainly impacted the way people utilize the space and forever change the way we perceive the bulletin board furniture of the future.

5.4 ENCOUNTERED PROBLEMS

During the prototype development and implementation stages, several problems were encountered that became more than just challenges but setbacks to the entire development process. The following are major setbacks that had to be resolved along the way with explanations and solutions that were implemented.

Deployment Site

The faculty of architecture was undergoing a major renovation which was part of the University's planned policy for the Tha Pra and Sanam Chandra campuses. Construction began in late 2007, but unfortunately the installation site for the prototype system was closed for an entire academic year so installation and testing of the prototype system was not possible until the completion of the renovation in early 2009. This setback caused delays not only to the testing of the system but to the hardware development as well.

System Features

Due to recent changes in university policies for Internet activities to comply with the new IT regulations set by the Ministry of Information and Communication Technology, the web camera feature was not implemented during the testing of the system. Any web camera activities were disabled and banned throughout the university therefore having live video feed was absolutely impossible even from within the same campus. The web camera feature was disabled and not used during the prototype experiments.

User Interface Design

The size and resolution of the user interface was not thoroughly tested with client PCs and the actual LCD display during the development phase of the interface design. The mismatch between the user interface size in pixels, the graphics card resolution, and the LCD display resolution and aspect ratio, caused the fixed height of the interface to be longer than what the graphics card and LCD display could display. It was intended that the screen size be fixed so all components of the system can be viewed at once. This was not possible when the user is forced to scroll down to view the preview window and announcement messages near the bottom of the screen. In plain sight, no users actually know that there was content beyond the visible borders of the frame.

Hardware Development

The most problematic hardware during development was the customized stand. The footprint of the stand was slightly longer than expected due to miscommunications between the designer and metal worker. It took up more space in the front of the display and caused users to stand further to the back to interact with the system. The LCD display locking mechanism that was supposed to be easily lockable and detachable was also not implemented due to miscommunications as well. But since the stand was not used for experimentation, the problems were still good design lessons.

6. CONCLUSION

6.1 SUMMARY

Intelligent roomware system is a research project that proposes the utilization of existing hardware, furniture, flat surfaces, or architectural elements with enhanced information technology to suit certain needs of users throughout time. From this concept, a series of prototypes were developed and a design framework was defined as a set of guidelines to build and implement such systems more effectively. One particular prototype, the FACE Network, was built on the basic requirements set by the target users and designed according to the design framework. After three months of real use the system was evaluated and its data was analyzed. User feedback was also collected to analyze how well the prototype performed and whether the underlying concept actually worked for the targeted users. The results verified the hypothesis that was set by this research and future planning of new roomware systems can be deployed according to these findings.

6.2 RESEARCH FINDINGS

The first and foremost research finding of this research project is the design framework that has been defined by analyzing prior research and testing of roomware prototypes. The framework consists of five distinct qualities or attributes that intelligent roomware systems should embody. The first is “Physical Presence” which allows users to interact and receive feedback through various body senses intuitively. “Multiple and Flexible Functions” is the second attribute which provides users with adaptability of interactions and functions within the system. Third is “User Engagement” which encourages users to interact with the system with little or no prior training. “Digital Information Output” is the fourth attribute in the framework. Information provided by the intelligent roomware must be digital information so as to obtain and update information quickly and accurately. The last attribute is “Scalable Tangible Interactions” which 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 different sized roomware appropriately.

The second research finding relies on data gathered from user interactions recorded during the test run of the prototype. Statistics revealed some interesting patterns of how the prototype was used. For most users, browsing was the main type of interaction accounting for 85% of all interactions. The second interaction type was posting information which was performed only by administration users accounting for 10% of interactions. The remaining interaction types were voting and emailing when combined accounted for only 5% of all interactions. The only pattern that became obvious was the email feature that showed gradual increase during the last month of system deployment. This suggests that with time, more interactions that involve sharing information or contributing information will occur more often in the community.

The third set of findings is information received from user feedback after the experiment has concluded. When asked whether the interactive bulletin board was useful in obtaining information (browsing, viewing votes, emailing content), the answer was yes without doubt. Users were asked if they thought that the interactive bulletin board could someday replace the existing physical bulletin board. The answers were split but most users see the potential of interactive bulletin boards becoming a new type of furniture in its own right and do not think they will be used to replace all existing boards. Another interesting question is what users think the greatest benefit for using this interactive bulletin board would be. Multimedia content display, interactivity of the board, convenient storage and browsing, large attractive content, creates lively space, are among answers users replied. When asked whether the interactive bulletin board can be used as a tool to promote a sharing learning atmosphere in the University, the answer was yes and most likely.

From all the research findings, it is fair to say that the design framework for Intelligent Roomware System is validated through user trial and the hypothesis is also confirmed that such system can impact the way people work and promote social relationships among people in the work environment.

6.3 FUTURE WORK

With promising results, the future work of this research project can continue to explore more roomware products that can be further enhanced, implemented, and tested similar to the prototype developed for this research. A larger much more complex scale of roomware is also a suitable direction for this research to pursue in the future. However, more elaborate user studies along with long-term experiments must also be taken to account for future work in this area. If roomware designs were more diverse, problems in many roomware designs can provide a better understanding of future user requirements and along the way, validate or add-on to existing design frameworks as contribution to the knowledge of design technology.

REFERENCES

Back, M., Lertsithichai, S., Chiu, P., Boreczky, J., Foote, J., Kimber, D., Liu, Q. and Matsumoto, T. (2008). Rethinking the Podium, in Dillenbourg, P., Huang, J., and Cherubini, M. (Eds.) *Interactive Artifacts and Furniture Supporting Collaborative Work and Learning*. Springer 2008, pp. 97-110.

Becker, F., and Sims, W. (2000) *Offices That Work: Balancing Cost, Flexibility, and Communication*. New York: Cornell University International Workplace Studies Program (IWSP).

Brand, S. (1994). *How Buildings Learn. What Happens After They Are Built*. New York: Penguin Books.

Brill, M. (1984). *Using Office Design to Increase Productivity*. Environmental Design Research (2 volumes) Wolfgang F.E. Preiser, editor.

Brill, M., Weidemann, S., and Bosti Associates. (2001). *Disproving Widespread Myths about Workplace Design*. Jasper, IN: Kimball International.

Churchill, E.F., Nelson, L., Denoue, L. and Girgensohn, A. (2003). The Plasma Poster Network: Posting Multimedia Content in Public Places. *Proceedings of Interact 2003*, Switzerland.

Duffy, F. (1997). *The New Office: With 20 International Case Studies*. London: Conran Octopus.

Huang, J., Waldvogel, M., & Lertsithichai, S. (1999). Design of the Swisshouse: A Physical/Virtual Cooperative Workspace. *Proceedings of CoBuild'99*, 215-220.

Ishii, H. & Ullmer, B. (1997). Tangible Bits: Towards Seamless Interfaces between People, Bits, and Atoms. *Proceedings of Conference on Human Factors in Computing Systems* (CHI'97), 234-241.

Khampanya, R. and Lertsithichai, L. (2009). *Tangidesk: A Tangible Interface Prototype for Urban Design and Planning*. CAADRIA 2009 Full Paper.

Kidd, C., Orr, R., Abowd, G., Atkeson, C., Essa, I., MacIntyre, B., Mynatt, E., Starner, T. Newstetter, W. (1999). The Aware Home: A living laboratory for ubiquitous computing research. *Proceedings of CoBuild '99*, Springer-Verlag LNCS 1670, pp. 191-198.

Lertsithichai, S., Seegmiller, M. (2002). "CUBIK: A Bi-Directional Tangible Modeling Interface". *ACM Conference on Human Factors in Computing Systems 2002*. pp. 756-757.

Lertsithichai, S., Chiu, P., Foote, J., Liu, Q., Kimber, D. (2003). A Convertible Podium System. U.S. Patent Application.

Parnichkun, M. & Ozono, S. (1998). CDCSMA-CD Communication Method for Cooperative Robot Systems. *Journal of Advanced Robotics. Robots Society of Japan*, Vol.11, No.7. 669-694.

Streitz, N. A., Konomi, S., Burkhardt, H. J. (Eds.) (1998). Cooperative Buildings – Integrating Information, Organization and Architecture. *Proceedings of the First International Workshop on Cooperative Buildings (CoBuild'98)*. Springer: Heidelberg. 4-21.

Streitz, N. A., Geißler, J., Holmer, T., Konomi, S., Müller-Tomfelde, C., Reischl, W., Rexroth, P., Seitz, P., Steinmetz, R. (1999). i-LAND: An interactive Landscape for Creativity and Innovation. *Proceedings of the ACM Conference on Human Factors in Computing Systems (CHI'99)*. ACM Press, New York.

Streitz, N., Tandler, P., Mller-Tomfelde, C., Konomi, S. (2001). Roomware: Towards the Next Generation of Human-Computer Interaction based on an Integrated Design of Real and Virtual Worlds. In J. A. Carroll (Ed.): *Human-Computer Interaction in the New Millennium*, Addison Wesley, pp. 551--576.

Streitz, N., Prante, T., Mller-Tomfelde, C., Tandler, P., Magerkurth, C. (2002). Roomware: The Second Generation. *Video Proceedings and Extended Abstracts of ACM CHI'02*. ACM Press, New York, NY, 506-507.

Weiser, M. (1991). The Computer for the 21st Century. *Scientific American*, 265 (3), 94-104.

Weiser, M. (1993). Some Computer Science Problems in Ubiquitous Computing. *Communications of the ACM*, 137-143.

Weiser, M. & Brown, J. S. (1995). Designing Calm Technology. http://www.ubiq.com/hypertext/weiser/calmtech/calmtech.htm (19 Dec. 1998).

Wellner, P. (1993). Interacting with Paper on the DigitalDesk. *Communications of the ACM*, 36 (7), 87-96.

RESEARCH OUTPUT

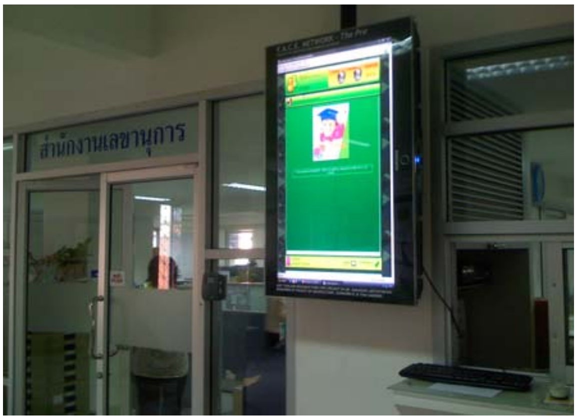
1. PUBLICATIONS

Back, M., Lertsithichai, S., Chiu, P., Boreczky, J., Foote, J., Kimber, D., Liu, Q. and Matsumoto, T. (2008). *Rethinking the Podium*, in Dillenbourg, P., Huang, J., and Cherubini, M. (Eds.) *Interactive Artifacts and Furniture Supporting Collaborative Work and Learning*. Springer 2008, pp. 97-110.

Khampanya, R. and Lertsithichai, L. (2009). *TangiDESK: A Tangible Interface Prototype for Urban Design and Planning*. CAADRIA 2009 Full Paper.

2. APPLICATION

Final research prototype, "FACE Network," developed and deployed as the first Interactive Bulletin Board for internal use at the Faculty of Architecture at Silpakorn University Tha Pra campus. The system has been in service since May 4th 2009 and is currently installed in front of the administration office on the second floor of the Faculty of Architecture building.



3. INTELLECTUAL PROPERTY

The research prototype system titled "Interactive Bulletin Board" was submitted to the Department of Intellectual Property, Ministry of Commerce as a Thai Patent application filed on August 31, 2009 with the Thai title as "ระบบบอร์ดประชาสัมพันธ์อิเล็คทรอนิกส์."

APPENDIX

1. USER STUDY QUESTIONNAIRE

แบบสอบถามเกี่ยวกับบอร์ดประชาสัมพันธ์ในคณะฯ

แบบสอบถามชุดนี้ได้จัดทำขึ้นเพื่อรวบรวมข้อมูลความคิดเห็นไปประกอบการวิจัยในโครงการวิจัย สกว. เรื่อง "Intelligent Roomware System" ของ อ.ดร.สุรพงษ์ เลิศสิทธิชัย จากคณะสถาปัตยกรรมศาสตร์ มหาวิทยาลัยศิลปากร ซึ่งจะทำการพัฒนาบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ต้นแบบ (Interactive Bulletin Board Prototype) เพื่อนำไปทดลองใช้งานภายในคณะฯ

1. ข้อมูลของท่าน และคณะฯ ของท่าน

ข้อมูลในส่วนนี้จะนำไปใช้ในการวิเคราะห์ผู้ใช้บอร์ดประชาสัมพันธ์ในคณะฯ รวมทั้งข้อมูลเบื้องต้นของคณะฯ ท่าน

ชื่อ ____________________ นามสกุล ____________________

* ชื่อคณะฯ ____________________ * ชื่อวิทยาเขต ____________________

* อีเมลล์ ____________________ (*กรุณากรอกข้อมูลที่มี * ให้ครบ*)

1.1 ท่านมีตำแหน่งหน้าที่และบทบาทอะไร ในคณะฯ ของท่าน?

[ ] อาจารย์ (*ภาควิชา:* ____________________)

[ ] นักศึกษา (*ชั้นปีที่:* ____________)

[ ] เจ้าหน้าที่ (*ประเภท:* ____________)

[ ] อื่นๆ (*โปรดระบุ:* ____________________)

1.2 คณะฯ ของท่านมีวิทยาเขตกี่วิทยาเขต?

[ ] วิทยาเขตเดียว (*โปรดข้ามไปตอบชุดคำถาม 3*)

[ ] มี 2 วิทยาเขต

[ ] มีมากกว่า 2 วิทยาเขต (*จำนวน:* ________ *วิทยาเขต*)

1.3 หากคณะฯ ของท่านมีหลายวิทยาเขต ท่านใช้เวลาอยู่ที่วิทยาเขตใดมากที่สุด?

[ ] วิทยาเขต ________________ มากที่สุด

[ ] ใช้เวลาเท่าๆ กันทุกๆ วิทยาเขต

[ ] ไม่สามารถประเมินได้

1.4 คณะฯ ของท่านมีผู้ที่รับผิดชอบในการจัดการข้อมูลประชาสัมพันธ์ หรือไม่?

[ ] มี ผู้ที่รับผิดชอบคือ อาจารย์ / นักศึกษา / เจ้าหน้าที่

[ ] ไม่มี

[ ] ไม่ทราบ

2. *ข้อมูลเกี่ยวกับบอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน*

ข้อมูลส่วนนี้จะนำไปใช้วิเคราะห์การใช้งานและข้อดีข้อเสียของบอร์ดประชาสัมพันธ์ในคณะฯของท่าน

2.1 ที่คณะฯ ของท่านมีบอร์ดประชาสัมพันธ์หรือไม่?

[ ] มี ประมาณ _____ บอร์ด [ ] ไม่มี (*ข้ามไปตอบชุดคำถาม 3*)

2.2 ท่านเคยอ่านข้อมูลที่ประกาศบนบอร์ดประชาสัมพันธ์ของคณะฯ หรือไม่?

[ ] เคย ประมาณ _____ ครั้งต่อ วัน / สัปดาห์ / เดือน [ ] ไม่เคย

2.3 ท่านเคยนำข่าวสารประชาสัมพันธ์มาติดประกาศที่บอร์ดประชาสัมพันธ์ของคณะฯ หรือไม่?

[ ] เคย ประมาณ _____ ครั้งต่อ วัน / สัปดาห์ / เดือน [ ] ไม่เคย

2.4 บอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน มีติดตั้งอยู่ที่บริเวณใดบ้าง?

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________
6. ____________________
7. ____________________
8. ____________________

2.5 ท่านอ่านข่าวสารประชาสัมพันธ์จากบอร์ดประชาสัมพันธ์แห่งใดในข้อ 4 บ่อยที่สุด?

(โปรดระบุ 5 อันดับแรก)

1. ____________________
2. ____________________
3. ____________________
4. ____________________
5. ____________________

2.6 ข้อมูลประเภทใดที่ท่านพบบ่อยบนบอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน?

(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1--พบบ่อยที่สุด ถึง 5--พบไม่บ่อยนัก)

[ ] ประกาศทั่วไปของอาจารย์ หรือ ส่วนบริหารของคณะฯ หรือมหาวิทยาลัย

[ ] ผลคะแนนการเรียน และการสอบ

[ ] โฆษณา และประกาศทั่วไป (*ขายของ, ของหาย*)

[ ] ประกาศสมัครงาน และว่าจ้าง

[ ] ประกาศทุน และงานประกวดผลงานต่างๆ

[ ] ประกาศทั่วไปของนักศึกษา (*กิจกรรมนักศึกษา, ศึกษานอกสถานที่*)

[ ] อื่นๆ (*โปรดแนะนำ:* ____________________)

2.7 ข้อมูลประเภทใดที่ท่านอ่านบ่อยบนบอร์ดประชาสัมพันธ์ในคณะฯ ของท่าน?
(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ประกาศทั่วไปของอาจารย์ หรือ ส่วนบริหารของคณะฯ หรือมหาวิทยาลัย

[ ] ผลคะแนนการเรียน และการสอบ

[ ] โฆษณา และประกาศทั่วไป (*ขายของ, ของหาย*)

[ ] ประกาศสมัครงาน และว่าจ้าง

[ ] ประกาศทุน และงานประกวดผลงานต่างๆ

[ ] ประกาศทั่วไปของนักศึกษา (*กิจกรรมนักศึกษา, ศึกษานอกสถานที่*)

[ ] อื่นๆ (*โปรดแนะนำ:* ___________________________)

2.8 ท่านคิดว่าองค์ประกอบใดมีความสำคัญต่อลักษณะภายนอกของบอร์ดประชาสัมพันธ์ที่ดี?
(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ขนาดบอร์ดที่มีความใหญ่โต

[ ] สถานที่ติดตั้งที่เป็นสาธารณะ

[ ] สถานที่ติดตั้งที่มีคนพลุกพล่าน

[ ] ความง่ายในการติดประกาศข่าวประชาสัมพันธ์

[ ] ความคงทนถาวรในการติดประกาศข่าวประชาสัมพันธ์

[ ] ระดับความสูงที่พอดีกับระดับสายตา

[ ] อื่นๆ (*โปรดแนะนำ:* ___________________________)

2.9 ท่านคิดว่าองค์ประกอบใด ที่ทำให้ข้อมูลบนบอร์ดมีความน่าสนใจ?
(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ใช้กราฟฟิค และองค์ประกอบที่เรียบง่าย

[ ] ใช้สีสันที่สวยงาม และสะดุดตา

[ ] ใช้ตัวหนังสือที่มีขนาดใหญ่ สามารถมองเห็นได้แต่ไกล

[ ] ข้อมูลที่มีความถูกต้องแม่นยำ มาจากแหล่งข้อมูลที่มีความน่าเชื่อถือสูง

[ ] ข้อมูลที่มาจากหลายๆ หน่วยงานหรือหลายๆ วิทยาเขต

[ ] ข้อมูลที่ใหม่และทันเหตุการณ์

[ ] อื่นๆ (*โปรดแนะนำ:* ___________________________)

2.10 ท่านได้รับทราบข้อมูลข่าวสารจากคณะฯ หรือหน่วยงานอื่น ๆ จากการอ่านบอร์ดประชาสัมพันธ์ในคณะฯ ของท่านเป็นประจำ?

[ ] เห็นด้วยมากที่สุด
[ ] เห็นด้วยน้อย

[ ] เห็นด้วยมาก
[ ] ไม่เห็นด้วย

2.11ท่านได้มีการติดต่อแลกเปลี่ยนข่าวสารและข้อมูลประชาสัมพันธ์กับนักศึกษาหรืออาจารย์ ที่อยู่ต่างวิทยาเขตกับท่านหรือไม่?

[ ] มี โดยประมาณ _____ ครั้งต่อ วัน / สัปดาห์ / เดือน
[ ] ไม่มี

3. *ความคิดเห็นเกี่ยวกับโครงการวิจัยบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ต้นแบบ*

ข้อมูลในส่วนนี้จะนำไปใช้เป็นแนวทางในการออกแบบบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ต้นแบบ (Interactive Bulletin Board Prototype) ให้กับคณะฯ ซึ่งบอร์ดดังกล่าวจะประกอบไปด้วยจอ LCD ขนาด 42 นิ้วและเนื้อหาข้อมูลแบบอิเล็กทรอนิกส์ที่มีการฉายหมุนเวียนบนจอ โดยผู้ใช้สามารถโต้ตอบกับข้อมูลบนจอ และผู้ใช้คนอื่นๆ ได้

3.1 ท่านคิดว่าบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ที่จะนำเสนอในงานวิจัยดังกล่าวควรจะมีลักษณะเหมือนหรือแตกต่างจากบอร์ดประชาสัมพันธ์ในคณะฯ ของท่านอย่างไร?

[ ] เหมือน ________________________________ [ ] ต่าง ________________________________

________________________________ ________________________________

________________________________ ________________________________

________________________________ ________________________________

3.2 คุณสมบัติ (Features) ใดที่ท่านอยากให้มีในบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์?

(โปรดให้ลำดับความสำคัญ ตั้งแต่อันดับ 1- มากที่สุด ถึง 5 - น้อยที่สุด)

[ ] ประกาศข่าวต่างๆ

[ ] ประกาศทุน / สมัครงาน

[ ] แจ้งข่าวเกี่ยวกับนิทรรศการต่างๆ

[ ] แบบสอบถาม / โพลล์ / และการลงคะแนนเสียง

[ ] Web camera ถ่ายทอดสด

[ ] ส่วนสำหรับแสดงผลงานนักศึกษา หรือ ผลงานวิจัย

[ ] บอร์ดสามารถโต้ตอบกับผู้ใช้งานได้

[ ] สามารถส่ง Forward email เพื่อกระจายข่าวได้

[ ] อื่นๆ *(โปรดแนะนำ:* ________________________________)

3.3 หากคุณสมบัติที่ต้องการจากข้อ 2 อยู่ในการพิจารณาขณะทำการออกแบบ และได้มีขึ้นอยู่ในบอร์ดประชาสัมพันธ์อิเล็กทรอนิคส์ ท่านจะใช้งานและอ่านข้อมูลในบอร์ดต้นแบบนี้หรือไม่?

[ ] ใช้งานบ่อย

[ ] อาจใช้ บางครั้ง

[ ] ไม่ใช้งานเลย

3.4 ท่านคิดว่า บอร์ดประชาสัมพันธ์ที่มีคุณสมบัติในการโต้ตอบกับผู้ใช้ได้ จะทำให้มีการแลกเปลี่ยนข้อมูล และช่วยเสริมสร้างความสัมพันธ์ที่ดีระหว่างนักศึกษา อาจารย์ และเจ้าหน้าที่ให้มากขึ้นได้?

[ ] เห็นด้วยมากที่สุด

[ ] เห็นด้วยมาก

[ ] เห็นด้วยน้อย

[ ] ไม่เห็นด้วย

ขอขอบคุณทุกท่านที่ให้ความร่วมมือในการตอบแบบสอบถามชุดนี้
หากตอบแบบสอบถามเสร็จแล้วขอความกรุณาช่วยส่งคืนมาที่ ____________________ ก่อนวันที่
______________ขอบคุณครับ/ค่ะ - คณะผู้วิจัย

2. INTERNATIONAL PUBLICATIONS

2.1 Back, M., Lertsithichai, S., Chiu, P., Boreczky, J., Foote, J., Kimber, D., Liu, Q. and Matsumoto, T. (2008). *Rethinking the Podium*, in Dillenbourg, P., Huang, J., and Cherubini, M. (Eds.) *Interactive Artifacts and Furniture Supporting Collaborative Work and Learning*. Springer 2008, pp. 97-110.

2.2 Khampanya, R. and Lertsithichai, L. (2009). *TangiDESK: A Tangible Interface Prototype for Urban Design and Planning*. CAADRIA 2009 Full Paper.

Rethinking the Podium: A Rich Media Control Station for Next Generation Conference Rooms

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Abstract. 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 tucking electronics into existing forms, an original design for a smart artefact can enhance existing use patterns in unexpected ways. The Convertible Podium is an experiment in the design of a smart artefact with complex integrated systems. 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.

1 Introduction

Next generation meeting rooms are designed to anticipate the onslaught of rich media presentation and ideation systems. Even today, high-end room systems feature a multiplicity of display screens, smart whiteboards, robotic cameras, and smart remote conferencing systems, all intended to support heterogeneous data and document types. Exploiting the capabilities of such a room, however, is a daunting task. Faced with three or more screens, all but a few presenters opt for simply replicating the same image on all of them.

At the same time, creating engaging meeting experiences can improve communication, facilitate information exchange, and increase knowledge retention. The incorporation of media-rich engagement strategies in meetings creates a need to provide the presenter with appropriate tools for managing these media.

The Convertible Podium is a central control station for rich media manipulation, including multi-screen multimedia presentation, shared annotation, and digital multimedia support for teleconferencing. 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.

(A) **(B)** **(C)**

Fig. 1. Design sketch: a convertible podium converting from a media-screen podium (A), to a capturing device (B), to an upright mode that can be used for an avatar representation of a remote presenter, an interactive whiteboard, or an information board (C)

Unlike conventional podiums, the Convertible Podium is a compact, lightweight, mobile design that can provide multiple functionalities by converting its form. It converts from an interactive rich media presentation podium to other functions useful in a conference room environment, including capturing devices, an avatar representation for a remote presenter, an interactive whiteboard, and an information board. An important design imperative is that all devices are integrated into the frame structure of the podium. Some devices are assigned multiple functionalities, depending on what interaction mode is active. However, only one mode of interaction is possible at each conversion. Similar to multi-purpose furniture or “Roomware" [24], the Convertible Podium combines its affordances as a regular podium with the capabilities of other presentation devices while maintaining its primary form and usefulness as a podium.

The Podium provides a focal point for the attention of the meeting and directs information in as many directions as required—both locally and remotely. It allows one person to manage multiple documents and streams of information directed to or from the conference room, or to multiple displays within the room. The Podium also controls the room environment: lights, sound, and projector controls. More than just a presentation device, the Convertible Podium facilitates rich media authoring, data and image capture, and interactive communications. One person can easily and rapidly convert the system between its active modes.

Interacting with the Convertible Podium can be done in three physical modes (Figure 1). In the interactive podium mode, a local presenter can use this podium to make presentations using multiple screens in a random-access fashion, simply using the familiar drag-and-drop technique to project anything, in any order, from a pool of slides or other media. Of course it is also possible to present media in the more familiar linear fashion, just as one presents PowerPoint slides on a single screen. Or, a presenter can switch between these modes, choosing random access to slides at times, and using pre-scripted linear segments at other times [14].

When the Podium's hood is lifted halfway, it goes into "Capture" mode, allowing the capture of documents and images via scanner and camera. A scanner which lies under the LCD monitor is exposed and is used via the "second screen": a small-form networked computer [20]. The presenter can also use the exposed document cameras for live demos or for showing off objects during a presentation.

In the third mode, "Avatar/Telepresence," the Podium's hood is fully upright. In this mode, it can be connected to a remote avatar for teleconferencing, or converted to an interactive whiteboard or an information board for supporting different presentation activities in the room. As an avatar appearing on the upright LCD screen, a remote presenter can access the Podium from a remote desktop, a laptop, or another Convertible Podium. The multiple room displays and the room speakers can output live video and audio from the remote presenter.

For example, during a discussion, the display can be used as an interactive whiteboard to capture annotations and notes contributed by participants in the room. If the Podium is not actively in use, it can also be placed in front of a room and used as an information board to display a room calendar, or other kinds of asynchronous messages, similar to a bulletin board. Details of the functions within each mode are listed more fully below.

2 Context: rethinking the conference room

The Convertible Podium project is informed by contextual inquiry into the implications of rich media for the kinds of work conducted in meeting rooms and lecture halls. It is designed to integrate with continuing research in multimedia, education, collaborative work and knowledge sharing systems. As new technologies like e-paper (electronic paper) make displays even more ubiquitous, the challenge becomes the management of rich media content across a number of screens. Added into the mix are meeting participants and the devices they carry with them: laptops, cell phones, and PDAs.

Fig. 2. Two top-down views of designs for a rich media conference room, showing a variety of options for multiple wall-mounted displays, varied seating to encourage informal as well as formal meetings, and embedded interfaces as well as connectivity for mobile devices.

Opening up a meeting room's media systems to support distributed collaboration raises yet another set of presentation and display issues. We are interested in analyzing and supporting not only the room systems, but also the process of work that happens there. For example:

- How should the room support presenters and participants during a variety of situations, including formal and casual meetings, discussions, and presentations?
- What capture technologies and media database functions are appropriate, and how do they support ongoing collaborations?
- How can both presenters and meeting participants interact with multiple-screen, multimedia, remote presentations?
- What are the implications of new technologies like e-paper as well as current technologies like RFID, cell phones, PDAs, and other multi-function devices?

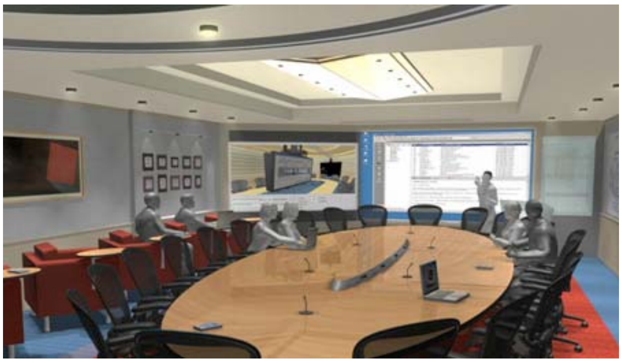

Fig. 3: Two design views of a rich media meeting room: integrating multiple modalities (audio and visual), wall-sized screens, encouraging formal and informal interchange, and creating channels for shared input from meeting participants via portable devices

2.1 Function follows form: interactive furniture for meeting rooms

Lightweight, mobile, and transparent, the Podium's deliberately sleek aluminum form references tools or equipment as well as furniture. As such, it encourages hands-on participation and control. Our approach to the design of the Convertible Podium has its roots in Mark Weiser's ubiquitous computing [26] and Hiroshi Ishii's tangible media [9]. Weiser's vision of widely distributed, networked devices permeating our living and working spaces has begun to be realized with the advent of cell phones, PDAs, and smart furniture. At the same time, Ishii's research into the affordances of tangible controls for complex software systems has driven the work of many research designers. Tangible devices and ubiquitous computing are a natural match; Fishkin [6] has created a taxonomy detailing research in this area. A number of researchers have combined these two ideas in the context of devices for reading, writing, and document management e.g. [3, 18, 21], which map well to frequent meeting tasks.

Fig. 4. The Convertible Podium's first operational prototype is CNC-machined from aluminum and acrylic panels and incorporates an onboard computer, WiFi, RFID, and custom sensing electronics.

Researchers at labs such as the MIT Media Lab and the Aware Home project at Georgia Tech (and there are many others) have built smart networked objects, including interactive furniture, for home, personal and business environments [11, 19]. A major criterion in this podium design is a form factor that is both elegant and functional. We also wanted to create an article of smart furniture with physical dynamics – that changed its physical shape as well as digital content. This is a "transformer" metaphor, where current functionality is mapped to the physical state of the object: function follows form.

2.2 Related work

Early versions of the electronic conference room focused on television and telecommunications technologies to support remote collaboration or to capture an electronic record of meetings. Today's media technologies for the meeting room are generally digitally integrated and often serve a variety of ends: multimedia presentation, meeting capture, note taking, informal design sessions, discussion group support, and Web use, as well as traditional live lectures. A huge amount of research has been undertaken in this area, e.g. [1, 10, 15, 17, 24], along with work done at our lab [4, 5, 7, 13, 27]. In the Podium project, we make an effort to fold much of this technology into the Podium itself, streamlining both the communication methods and the control systems for them. Many current podiums are ad hoc repositories for such centralization, with bits of technology added on; we are designing it in deliberately.

Commercial podiums on the market are mostly podium enclosures designed to accommodate a variety of equipment that is used to facilitate different presentation needs in a classroom or lecture hall. A typical podium designed for a multimedia room is equipped with devices ranging from large devices such as a PC, a display, or a document camera to small add-on devices such as light visors, microphones, or an A/V switching device. Each stand-alone device has a specific function and requires a dedicated space for installation. Packaging all these devices into a single podium requires a bulky and heavy enclosure with several tethered (or many untethered) cables, making it difficult to move the podium from one room to another, or even to a different spot in the same room.

Since this combination of the convertible design and functionalities is unique, there is no other podium available that incorporates these features or is similar in implementation. However, there are a few systems that are similar in part.

Teleportec has a product called the Teleportec lectern [25] which is a podium with a reflective screen similar to a teleprompter's set up. It uses a monitor that lies flat at the podium base to display video of a remote presenter and a large 30"x 40" transparent projection surface angled at 45˚ facing the front of the podium to reflect the display on the base. Using reverse chroma key, the background is removed and the presenter appears visible behind the podium. However the Teleportec lectern has no user interactivity and cannot be used by a remote presenter. It is a fixed set up that requires a backdrop wall to hide a videoconferencing camera behind the podium and in some cases a canopy to avoid direct light on the glass surface. The image of the remote presenter on the reflective screen may not be fully visible at extreme corner viewing angles. Because of its fixed setup, it is not portable and cannot be easily moved from one room to another.

Smart Technologies Inc. has a product called Sympodium [22] which comes in four variations; an interactive lectern, a tabletop lectern, and two integration modules. The Sympodium interactive lectern is equipped with a touch sensitive LCD display that allows users to annotate over documents and control applications from a connected internal PC, laptop, or document camera. The desktop image is displayed through an external projector or large presentation screen allowing audiences to view annotations from the presenter's display. Sympodium has only three video source inputs which can be manually switched by the user. It cannot integrate more input and output devices and cannot control presentation devices or environmental settings.

ETH – Zürich has produced a prototype interactive podium called the "SpeakersCorner"[12] designed to facilitate local and remote teaching. This system is a customized podium enclosure equipped with a touch screen LCD display, a document camera, a dual-processor PC, a fold away keyboard, and an integrated connecter with USB, video, and network connections. It provides a multimedia platform for a presenter to show his/her slide presentation while making real time annotations on the slides. However, each input device implemented here is a stand alone device, designed for a specific application. They are placed in separated parts of the podium and cannot be used for multiple applications.

3 Rich media and active meeting participation

Rich media is usually understood to mean a combination of static and dynamic images and text, including video and multimedia documents available locally or via the internet. As displays become larger and more ubiquitous, the uses and designs of rich media will also change. How can we comfortably control, for example, three parallel video streams, along with presentation slides and a live remote presenter? What kind of content maps well into such a rich environment? How do local participants interact with the information they see projected around them, and how do remote participants interact with the same information?

Active meeting components such as presentation, discussion, small group work sessions, debate, and problem solving can all be enriched by thoughtful use of multimedia components. Whether on-site, remote, or asynchronous meeting situations, the cluster of information applications in the Podium can enable or improve these common tasks and interactions:

- Participant interactions with leader and with each other via online text, in-room backchat, and sending text or images from mobile devices like cells and PDAs
- In-sequence presentations, especially a quick series of them (six or seven people each presenting a five-to-seven minute talk, for example)
- Drawing onscreen (live whiteboard, capture to web instantly)
- Multiple side-by-side comparison views -- not just two-way as with most slide projector setups
- Guest lecturers via remote viewing – avatar mode plus rich media presentations
- Printing and paperwork including JIT printing
- Document camera for demos or quick capture for images from workgroup sessions

Fig. 5. The Convertible Podium's operational prototype upright in preparation for avatar mode. A motorized counterbalance system is installed within the aluminum strut along the left side of the Podium's faceplate, to handle the weight of the LCD monitor and its aluminum framing. In later designs, the monitor will be replaced with thinner lightweight displays such as e-paper or OLEDs

4 Operation: functionality follows the form of the device

One person easily accesses and controls complex functionality through simple physical manipulation. As the counter-weighted hood swings open, the Podium switches modes and applications, from presentation, to capture, to remote conferencing or networked whiteboard. The tangible interface offers centralized control over both room and computer systems.

4.1 Mode 1: Rich media presentation

The Podium uses ePic, a rich media presentation application especially developed to handle multiple screens, as one of its primary presentation mode for showing slides, Web, video or other media [14] Live annotation is available via touch screen (using finger or pen). Any image can be transferred to any screen with a flick of the finger across the touch screen; alternatively a sequence of slides and media can be pre-programmed to execute across any number of screens, in any order. Speakers are also individually addressable for audio output.

Because the monitor screen shows not only control systems but also the content of the screens themselves, a presenter does not need to turn away from the audience, toward the screen, to read what's on his or her own slide. This, though simple, is one of the single biggest affordances of the Podium: allowing a presenter to keep facing the audience, rather than turning from them.

Fig. 6. An early example of a user interface: ePic multi-screen remote presentation

4.2 Mode 2: Image and data capture

As the hood of the Podium hinges into the half-way open position, the Capture Mode becomes available. Digital images and real-time video demos are captured via onboard scanner and a document camera (Figure 7). A visor light provides needed light levels. Image capture is controlled via a small secondary computer (originally we planned to use a PDA, but we have decided instead to use a small-form-factor Windows XP computer, made by OQO [20]). Images can be directed to room screens, to nearby or remote printers, or filed in a meeting media database.

As the LCD screen flips upwards, a document or object placing area is revealed beneath the screen, along with a thin scanner. Beneath the screen is a light visor to highlight the area. A hi-resolution digital camera is centered at the top edge of the screen. In this mode, the camera is used as a document camera to take snapshots of a document or to stream video of an object demo.

- Scanner for on-the-spot document capture
- Document camera with visor lighting
- Small screen computer for capture systems
- JIT (just in time) printing

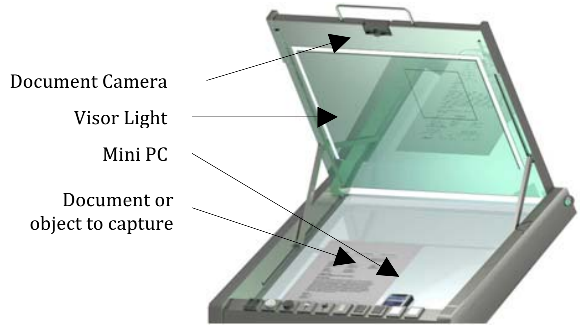

Fig. 7. Design sketch: during capture mode, the high-resolution digital camera becomes a document camera for capturing documents or physical objects

4.3 Modes 3, 4: Avatar / interactive whiteboard

Avatar/telepresence mode supports human-scale video avatars for teleconferencing. In an effort to enliven the static talking-head video image most people associate with videoconferencing, the Podium's Avatar/telepresence mode features a life-sized, center-screen image of a remote presenter's face. The image appears on the Podium's LCD screen when it is fully upright, appearing there at approximately human head height. The facial image can also appear on one of the room screens if desired. Remote presenters can control rich media multi-screen presentations from their remote locations, and interact with meeting participants via high-quality video and audio streaming.

Networked interactive whiteboard and interactive annotation systems enable local or long-distance group work such as planning, brainstorming and discussion.

- Teleconferencing and remote presentation via existing systems
- Or via experimental high bandwidth video streaming
- Networked drawing/slide annotation system
- Automatic meeting capture and retrieval

4.4 Post-laptop design (backwards compatible)

Though the Podium is deliberately designed as a post-laptop device, it of course allows the connection of many kinds of external devices including laptops, PDAs, cell phones, and portable USB/FireWire drives. Or, through the use of a network application using RFID cards [8] one's personal files can be securely uploaded from any networked computer on the LAN.

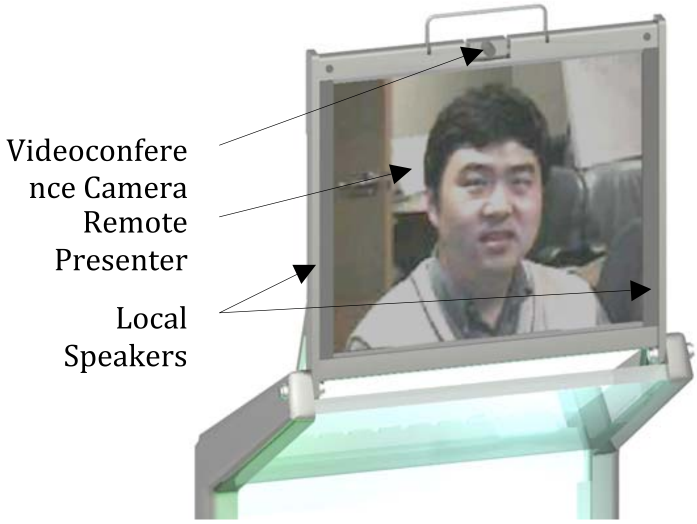

Fig. 8. Design sketch: Avatar mode.

5 Physical design and technology

The Convertible Podium is human-scale, lightweight, mobile, a clean, simple, powerful control center. Intended to avoid tangles of cabling, its mobile design allows the front of the room to be a flexible space. It is easily wheeled aside to allow different configurations according to group needs.

- **Aluminum and acrylic** are the basic building materials, plus built-in custom electronics: tangible control strip, LCD monitor/touchscreen, LEDS for mode indication and a visor light for the document cameras.

- **An acrylic panel** (a 24'x 38.6" vertical support bent to a 24"x 20" lectern surface that is 31.6° from horizontal) is outlined and supported by **one-piece aluminum/alodine-finish side supports**. The body of the podium consists of an acrylic panel shaped like a slightly angled upside down letter "L." The panel can be sidelit with LEDs (colored according to mode) and the control panel can be etched with the company logo. Along both sides of the panel are two aluminum frames that are the main structure of the podium and hold the entire body together. These side supports are also used as conduits for internal wiring and cables as well as a holder for wireless network antenna.

- The desktop surface area is a **touchscreen LCD display** measuring 24" diagonally. At the bottom edge of the display between the two side frames is a tray that holds the control electronics. The control unit is a strip holding physical controls such as dials, switches, and sliders that are used as physical controls mapped to certain functions or commands in the application currently in use. Beneath the controller tray is space for external connection jacks: USB, audio, and FireWire.

- The **wheeled base** (also aluminum/alodine) is a modified x-shape with an **underslung tray** that holds the **electronics** (laptop computer, AC power, A/D control card, USB hub and various USB remotes, network connections.)

- **Modal functionality** is cued from position of the **swing-open hood**: Presentation, Capture, Telepresence/Avatar or WhiteBoard.

Fig. 9. The control strip features large, tangibly pleasing buttons and knobs that map clearly to software and environment controls. The control modules are modular and can be custom-designed for use with specific installations. In this case, software controls appear on the right; room controls are on the left

5.1 Programmable tangible control strip

The Podium consolidates environmental and multimedia controls at one easy-access point. A custom analog/digital hardware module, combined with the touch screen, offers control of many common meeting room tasks: screen/projector settings, room lighting, audio volume, presentation and annotation software, and remote teleconferencing.

- Control strip hinges open for easy access to electronics
- Modular plug-n-play design: controls are configurable in software.
- Custom modules can be CNC-machined to meeting changing specifications or to suit a new client.

5.2 Custom electronics and software

Custom software (one version written in MAX/MSP, and another in C++) and A/D hardware control systems drive the Convertible Podium's services. The Podium's onboard laptop "brain" networks with a number of exterior systems. For sound, projection, and light control in the room, it communicates via an http/python middleware protocol [6] with a standard AMX environmental control system. [1]

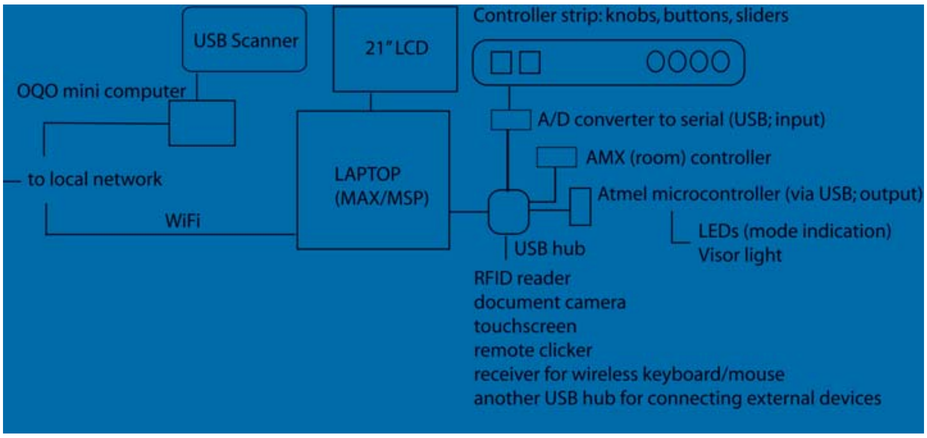

Fig. 10. Inside the Podium: system sketch

For teleconferencing and remote presentation, meeting capture, media control, and document sharing, we use the same protocol to communicate with a suite of applications developed in our lab. One application was developed for authoring and presenting on multiple screens and speakers, both locally and remotely. [27] Another, PIP (Personal Interaction Points), allows a person to simply swipe an RFID card across a reader to automatically open a directory listing all her Powerpoint files on her own machine (as long as it's on the same local area network). [8] When RFID chips become more common in cell phones (as the FeliCa RFID chip already is in Japan), that means that a presenter could use a simple swipe of her cell phone as an identifier to open the Podium's systems and upload a presentation automatically.

Fig. 11. Above right, the right arm strut on the mill bed.

5.3 CNC-machined parts, custom modules

We deliberately chose computer-controlled machining as a primary element in the build process, to provide modular adaptability to a particular client's needs (for example, an etched logo on the front of the control strip, or an extended set of controls for a more complex lighting setup). Most major Podium parts were computer milled (CNC, or computer numerical control, is a standard machining procedure) from aluminum, allowing a slim-line curved design with enough hollow space for the electronics and cabling. The relatively large number of onboard devices meant lots of room was needed for cabling – not only for the signal cables, but for power as well.

Fig. 12. The control strip and LCD screen installed, on the left; the control strip without buttons, the base and the side struts partially assembled, right.

6 Next steps

Though much of the rich media authoring and control software that supports it has been under development for years, we have just completed the first operational physical prototype of the Convertible Podium. Before moving on to the next stage of design, we will do several usage studies, on each mode's software and on the physical aspects of the device. Results from these studies will certainly impact the next stages of the design and may result in modifications to this first prototype as well.

We also intend to create a suite of lightweight podium variants, including specialized applications for mobile devices, for meeting rooms, classrooms, seminar rooms, and tabletops. Each can be fine-tuned for a particular context or environment. As displays and electronics become increasingly thinner and lighter, we expect to see improved mobility and flexibility in the design.

We intend more work on the integration of *n*- mobile devices into an electronic conversation or discussion, particularly cell phones. In addition we intend to make the physical frame of the Podium even more flexible, adding motorized height and angle adjustability. Companion objects such as e-paper media screens or tabletops, smart whiteboards, and other smart-room components may be integrated into the next iteration of the Convertible Podium system.

Finally, we found that for smart furniture, interesting things happen when *function follows form,* especially in conjunction with tangible controls and rich media. This heuristic has led us to a rich design space that we intend to continue to explore.

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References

1. Abowd, G., Atkeson, C., Brotherton, J., Enqvist, T., Gulley, P., LeMon, J. Investigating the capture, integration and access problem of ubiquitous computing in an educational setting. *Proceedings of CHI '98*, pp. 440-447.
2. AMX control systems, AMX Corporation. http://www.amx.com/solutions-commercial.asp
3. Back, M., Chow, M., Gold, R., Gorbet, M., Harrison, S., Macdonald, D., Minneman, S. Designing interactive reading experiences for a museum exhibition. *IEEE Computer Magazine*, 34 (1): 1-8 (2001).
4. Chiu, P., Kapuskar, A., Reitmeier, S., Wilcox, L. Meeting capture in a media enriched conference room. *Proceedings of CoBuild '99*, Springer-Verlag LNCS 1670, pp. 79-88.
5. Chiu, P., Liu, Q., Boreczky, J., Foote, J., Fuse, T., Kimber, D., Lertsithichai, S., Liao, C. Manipulating and annotating slides in a multi-display environment. *Proceedings of INTERACT '03*, pp. 583-590.
6. Fishkin, K. P. A taxonomy for and analysis of tangible interfaces. *Journal of Personal and Ubiquitous Computing*, **8**(5): 347-358 (2004).
7. Foote, J., Liu, Q., Kimber, D., Chiu, P., Zhao, F. Reach-Through-the-Screen: A new metaphor for remote collaboration. *Proceedings of PCM '04 (Pacific Rim Conference on Multimedia)*, Springer-Verlag LNCS 3333, pp 73-80.
8. Hilbert, D., Trevor, J. Personalizing shared ubiquitous devices. *Interactions Magazine*, 11(2): 34-43 (2004).
9. Ishii, H., Ullmer, B. Tangible Bits: Towards seamless interfaces between people, bits and atoms. *Proceedings of CHI '97*, pp. 234-241.

10. Johanson, B., Fox, A., Winograd, T. The Interactive Workspaces Project: Experiences with ubiquitous computing rooms. *IEEE Pervasive Computing* 1(2): 67-75 (2002).
11. Kidd, C., Orr, R., Abowd, G., Atkeson, C., Essa, I., MacIntyre, B., Mynatt, E., Starner, T. Newstetter, W. The Aware Home: A living laboratory for ubiquitous computing research. *Proceedings of CoBuild '99*, Springer-Verlag LNCS 1670, pp. 191-198.
12. Kunz, A., Kennel, T. Speakerscorner. ETH – Zürich. http://www.zpeportal.ethz.ch/research/projects/speakerscorner/speakerscorner.pdf
13. Liao, C., Liu, Q., Kimber, D., Chiu, P., Foote, J., Wilcox, L. Shared interactive video for teleconferencing. *Proceedings of ACM Multimedia '03*, pp. 546-554.
14. Liu, Q., Zhao, F., Doherty, J, Kimber, D. An EPIC enhanced meeting environment. *Proceedings of ACM Multimedia '04 (Video Demo)*, pp. 940-941.
15. MacIntyre, B., Mynatt, E. D., Voida, S., Hansen, K. M., Tullio, J., Corso, G. M., Support for multitasking and background awareness using interactive peripheral displays. *Proceedings of UIST '01*, pp. 41-50.
16. Mayer, R. E. *Multimedia Learning*. Cambridge University Press (2001).
17. Moran, T., Palen, L., Harrison, S., Chiu, P., Kimber, D., Minneman, S., van Melle, W., Zellweger, P. "I'll get that off the audio": a case study of salvaging multimedia meeting records. *Proceedings of CHI '97*, pp. 202-209.
18. Nelson, L., Ichimura, S., Pedersen, E., Adams, L. Palette: A paper interface for giving presentations. *Proceedings of CHI '99*, pp. 354-361.
19. Omojola, O., Post, E.R, Hancher, M.D., Maguire, Y., Pappu, R., Schoner, B., Russo, P.R., Fletcher, R., Gershenfeld, N. An installation of interactive furniture. *IBM Systems Journal*, 39(3-4) 861 ff. (2000).
20. OQO, 2005. Handheld windows XP computer. http://www.oqo.com
21. Schilit, W., Price, M.N., Golovchinsky, G., Tanaka, K., Marshall, C.C. As We May Read: The reading appliance revolution. *IEEE Computer*, 32(1): 65-73 (1999).
22. Smart Technologies Inc., Sympodium, 2003. http://www.smarttech.com/products/sympodium/index.asp
23. Sony FeliCa RFID technology. http://www.sony.net/Products/felica
24. Streitz, N., Geisler, J., Holmer, T. Roomware for Cooperative Buildings: Integrated design of architectural spaces and information spaces. *Proceedings of CoBuild '98*, Springer-Verlag LNCS 1370, pp. 4-21.
25. Teleportec Lectern System. http:www.teleportec.com
26. Weiser, M. The Computer for the 21st Century. *Scientific American,* 265(3): 94-104.
27. Zhang, H., Liu, Q., Lertsithichai, S., Liao, C., Kimber, D. A presentation authoring tool for media devices distributed environments. *Proceedings of ICME '04*, pp. 1755-1758.
28. Zhao, F., Liu, Q. A web based multi-display presentation system. *Proceedings of ACM Multimedia 2004 (Demo)*, pp. 176-177.

TANGIDESK: A TANGIBLE INTERFACE PROTOTYPE FOR URBAN DESIGN AND PLANNING

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Abstract. This paper describes the design and implementation of TangiDESK, a tangible interface prototype to assist in the design and planning of urban design projects. The prototype derives from the need for an intuitive user interface similar to a designer's or architect's 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.

Keywords. Tangible User Interface; Urban Design and Planning; Computer-Aided Design; Collaborative Design; Project Feasibility.

1. Introduction

During the early design phases of any urban construction project, specifically in schematic planning, the main task of the design team (architect, engineer, interior designer, etc.) is to gather as much project requirements as possible from the development team (owner, planner, advisor, etc.) and devise working schematic designs that can be studied further for project feasibilities in later phases of the design process (Wuthikosithi, 2003). These schematic designs can be presented in various formats or produced in many types of medium in which are determined by what is considered the most effective communication method between both the design and development teams.

For the design team, the most common communication method is to use two-dimensional drawings produced by Computer-Aided Design systems (CAD) to convey design information by means of representing three-dimensional buildings and surrounding elements (road, pool, landscape, infrastructure, etc.) and depict their relationship in the project site. On the other hand, the development team communicate their planning information regarding costs, schedule, management hierarchy, and feasibility studies in forms of tables and diagrams generated by spreadsheet software that may or may not be easily transferred into designs and drawings.

In both cases, it may be difficult for each team to easily comprehend each other's information due to the fact that their information may be incoherent or are typically viewed in separate working environments. Also, the level of expertise and experience in the use of tools and of their analytical thinking are very different and are not effectively integrated in one seamless medium or environment.

2. Related Work

The problem of information transfer between the design and development teams may result it certain delays of decision-making efforts agreed by both teams and eventually the lack in feasibility of the schematic design. In past years, there have been several attempts to eliminate this problem by integrating familiar analog techniques with efficient digital environments that allow designers to interact with digital information seamlessly and intuitively during early design processes. Some of these include Tangible User Interfaces (TUI) for urban design (Ullmer and Ishii, 1997; Underkoffler and Ishii, 1999), Augmented Reality systems (AR) for urban planners (Billinghurst and Kato, 1999; Buchmann et al., 2004) and 3D simulations for feasibility studies (Freeman and Steed, 2006; Keawlai, 2007; Fisher and Flohr, 2008).

MetaDESK and Urp are TUIs that have urban design and planning applications developed for designers who need to collaborate with many parties simultaneously in a single environment. However, the main purpose is to view existing designs and not to assist designers in making informative design decisions along with city planners and urban designers.

FingARtips is an AR project that requires users to wear heads-up displays or virtual glasses to be able to view digital information that is overlaid onto physical objects in the real world. However, this feature is limited by the amount of concurrent users the system can handle at a given time and the cost of equipment per user may not be feasible for many participants.

This paper intends to explore new applications with TUI technologies by assisting design decision-making tasks that designers and developers face together during the early stages of schematic design in an urban design project. The proposed system consists of a tangible user interface as its primary means of user input and a semi-intelligent system to interpret user interactions that provides useful information to users in real-time in order for them to make better-informed design decisions.

3. Early Design Phase in Urban Design and Planning

During the schematic design phase of an urban design and planning project, the main participants of this phase are architects, owners, city planners, real estate developers, and financial analysts who contribute their specific expertise to make collective decisions for the project (Wuthikosithi, 2003). Some of these tasks include planning building zones, infrastructure, public common spaces, green area, and number of buildings. Also, they need to consider the design in conjunction with local building codes and estimate construction costs in order to conclude the project feasibility study.

It is during these tasks that both designers and developers need to exchange information back and forth in a linear fashion until a final compromise is met leading towards an agreeable and effective design. However, due to the problem of incompatible work environments of both teams, information cannot be easily transferred or modified simultaneously by both teams to compact the time spent in this phase. The ideal solution for this problem is to have an integrated environment for both designers and developers to use concurrently and be able to manipulate, modify, or make changes to either the design or the building information with great ease. As such, many decisions that need input by each party can be resolved at the spot and changes in the design can then be updated instantly.

In summary, we have concluded that the four main issues that have the most impact in the decision-making conducted during the project feasibility study are building types, building area, building codes, and cost estimation. As for the ideal interface for the system, it must be flexible and intuitive for both designers and developers to use together with applications for both parties to utilize in a single environment.

4. Design Tool for Urban Design and Planning

In order to prove our conclusion about the ideal tool for urban design and planning, we plan to build a system that takes into account the four project feasibility issues identified earlier and the interface design that incorporates an integrated work environment for both designers and developers.

4.1. APPLICATION FRAMEWORK

The main application of this system lies in the interpretation of user feedback and providing the user with both an intuitive interface and instant feedback of relevant results. The process starts from the user interacting with the physical objects as if he would do so with an actual physical model of an urban project. Information is then calculated on the fly and results are projected immediately in the corresponding location where the physical object is located on the tabletop (Figure 1).

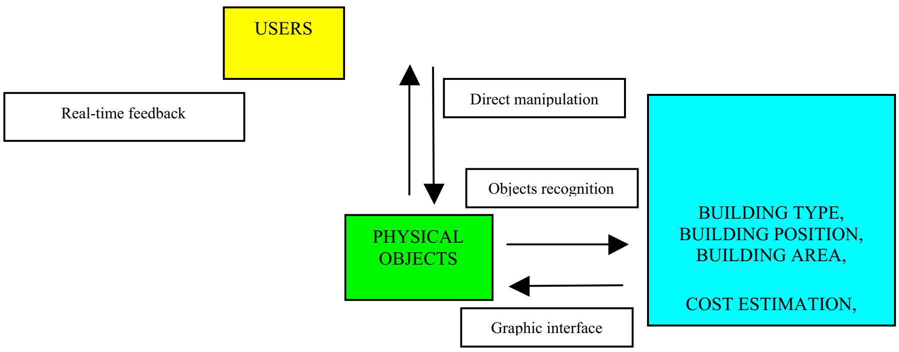


Figure 1. The System Application Framework.

Users can reiterate the process of manipulating objects, adding or removing objects until both designers and developers have agreed upon a satisfactory design. The system can then output the building types, positions, basic properties, and costs into a working drawing for further detail developments.

4.2. SYSTEM COMPONENTS

The system is comprised of four main components: the Tangible interface, the Object recognition component, the Graphic presentation component, and the Database component (Figure 2). Users will interact with the system from a tabletop surface while all computations and feedback will be provided from beneath the table surface.

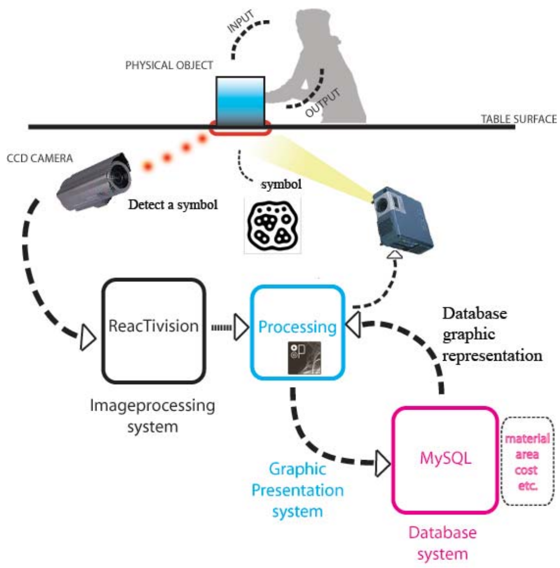


Figure 2. Overall Components and Process Diagram.

4.2.1. Tangible Interface

Tangible user interfaces (Ishii and Ullmer, 1997; Kim and Maher, 2006) are intuitive interfaces used to couple physical objects with digital information by means of physical input from its users. For this system, the tangible interface is the most crucial component for the user since it represents both information and manipulations to physical objects. The tabletop is also important for completing design tasks such as moving and removing objects that is most familiar in design tasks of designers and developers.

With the tangible interface, the input and output sources are integrated in the system. The CCD digital camera as means of input is attached to the bottom of the table. The projector as means for output is used to project information by overlaying it beneath the physical object. Whenever a marker is moved, rotated, or removed altogether, the camera will detect all changes, make calculations, then project the results onto the current marker wherever it is in its present location.

4.2.2. Object Recognition Component

There are many object recognition systems that are widely available for public use such as ARToolKit (Kato and Billinghurst, 1999) which is a software library for building Augmented Reality applications and reacTIVision (Kaltenbrunner and Bencina, 2007) which is an application framework designed for developing table-based tangible user interfaces. Both systems allow users to download and develop specific applications around the framework that utilize optical cameras to track physical markers in the real world.

We have explored both systems and designated reacTIVision as the main object recognition system due to its robust processing capabilities and flexibility in integrating popular programming environments i.e., Processing and Pure Data. reacTIVision works by acquiring images from a CCD camera and searches the video stream frame by frame for specific fiducial symbols or markers that are attached underneath a physical object (building object). Once a fiducial symbol is identified, it is matched to a library of unique fiducial ID numbers and its corresponding data in which can then be displayed or projected as user feedback (Figure 3).

Figure 3. reacTIVision fiducial ID recognition diagram.

reacTIVision includes several unique fiducial symbols with its system for users to attach to a single object or multiple objects according to the users' main application. The fiducial tracking algorithm is also highly efficient due to its well-designed marker geometry. This allows the system to minimize the size of its fiducial symbols, speed up its recognition process, and enable the system to handle the tracking of many fiducial symbols concurrently.

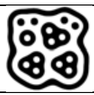
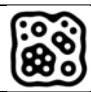
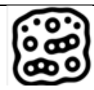
4.2.3. Graphic Presentation Component

Once a fiducial ID has been retrieved, the system will need to generate the graphic representation to be displayed on screen or on the tabletop. This representation is generated by Processing (www.processing.org: Aug 2008) which is an open source programming language and environment working in conjunction with reacTIVision. When a fiducial ID has been detected, Processing will retrieve the ID number and find a match in an existing database in order to execute further commands such as calculating cost estimations or generating graphic images to be displayed back to the reacTIVision enabled tabletop.

4.2.4. Database Component

Currently, the database is developed with MySQL for ease of use and its scalable database. Most importantly, Processing can interface directly with MySQL to obtain data such as building types, building area, construction cost, etc. that is embedded within each fiducial ID or physical object on the tabletop (Table 1). The database component can also be updated when more fiducial IDs or new building objects are introduced into the system. A wider range or general properties can also be added if further analytical tasks are needed for complex calculations as well.

TABLE 1. Database of the fiducial symbols used in the system.

Fiducial Symbol				
Fiducial ID	Fiducial_ID_1	Fiducial_ID_2	Fiducial_ID_3	Fiducial_ID_4
Building Type	House 1	House II	Garden	Pool
Cost per Sqm.	฿8,973	฿10,356	฿100	฿10,000
Total Area	200 sqm.	300 sqm.	2500 sqm.	400 sqm.
Coordinates (x, y)	70m, 20m	100m, 20m 130m, 20m 160m, 20m	100m, 25m	150m, 25m
Amount	1	3	1	1
Construction Cost	฿1,794,600	฿9,320,400	฿250,000	฿4,000,000

5. TangiDESK Prototype Design and Implementation

From our many observations in urban design projects, we think that the best and widely accepted means of design and planning a project should be a collaborative effort between designers and developers. All main decision makers must be present to gather around a large tabletop surface covered with models and large master plans. Changes and modifications to the models or drawings should be recorded, documented, and distributed among the participants for later reference.

From this observation, we decided to tackle the problem of information transfer between project team participants that occur at these tabletops and utilize a tangible user interface system to integrate design elements with spreadsheet data. The prototype system was named “TangiDESK” to describe the properties of where the collaboration effort occurs and how it is handled. Then a real-life project is carefully chosen to obtain real data and scenarios. The TangiDESK system is then designed and implemented around the required collaborative design tasks.

5.1. PROTOTYPE CASE STUDY

To better explain how TangiDESK can be implemented and used in actual urban design and planning projects, a scenario of an existing local housing project based in Rangsit, Thailand is used as a case study for design schematic development. The housing project is called “Rangsit Thanee” located about 40 kilometers from central Bangkok to the East, and has simple housing project elements such as a single main road, equally divided land parcels, modular homes, a central facility (swimming pool), and public open spaces (landscape).

The entire project is a very long strip piece of land with the main entrance located at one end of the strip. Because of this unique land feature and the size of the tabletop being limited by screen resolution, the strip is deliberately divided into three parts: front; middle; and back, to better match our equipment capacity and for development purposes of the system. This is also similar to project development phases that favor development of the inner most land plots or parcels first in order to increase the value of land plots closer to the front near the main entrance (Figure 4).

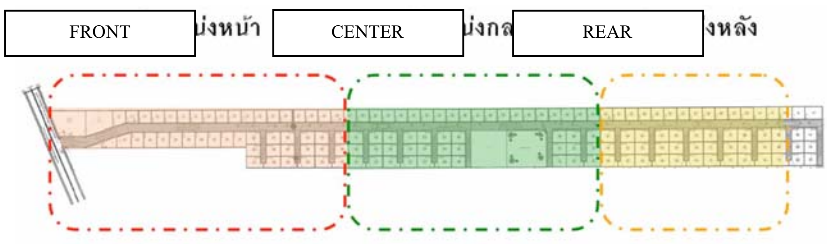


Figure 4. Rangist Thanee Project Master Plan.

5.2. PROTOTYPE IMPLEMENTATION

TangiDESK consists of the four main components as explained earlier with additional building objects and swimming pool object as its physical objects. We use a hard top table and replaced its surface with a matte surface sheet of plexi-glass. The hardware we used consists of an infrared CCD camera, an infrared light source to illuminate the surface from below, a LCD projector, and a PC with 1.5 GHz Core2 Duo processors, 2 Gigabits of RAM, and an NVidia Geforce 5700 graphics card. All equipment, except for the building models with fiducial symbols attached beneath, are located under the tabletop surface as shown in Figure 2. The software applications used are Processing, reacTIVision, and MySQL.

In addition to the tracking of building objects, TangiDESK also employs a semi-intelligent checking system that assists the user in examining building code regulations and construction costs that impact decision-makings of the designer and developer alike. When a building object is added, removed or replaced, the system will automatically check for conflicts in local building code regulations that may occur due to changes in proximity of a building object to the property line, set back line, or other building objects and display in real-time on the table surface (Figure 5).

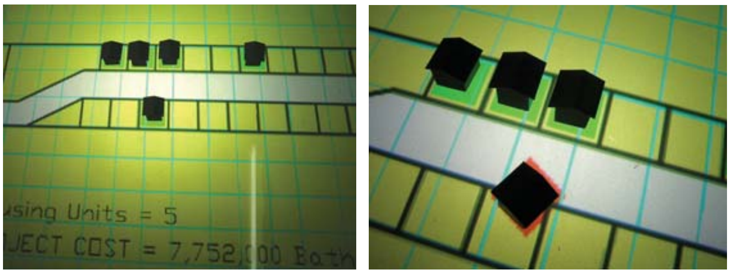


Figure 5. TangiDESK surface with building objects and projected land plots (left). Building code system underlines illegal placement of object with red outline (right).

For example, if the user were to move a certain building beyond the building set back limitation set by the code at a particular project site, then the system will highlight the building in red indicating that the relocation of this building is illegal to execute as a warning to the user. The implementation of the TangiDESK prototype has provided designers and developers a simple way to collaborate with one another and assist both parties in the process of simple design and decision-making tasks such as placing building objects in appropriate locations, summarizing individual and total construction costs, detecting any building code errors, and allowing multiple users to interact with the system simultaneously.

5.3. PRELIMINARY PROTOTYPE EVALUATION

A preliminary study of TangiDESK was conducted with twelve participants consisting of seven architects and five urban planners who were given a brief introduction about the features of the system and the required tasks. These tasks included placing and rearranging building objects on the table, identifying any changes to the construction costs, and detecting any illegal placements of objects according the building code regulations. The participants were then allowed to interact with the system freely and in no particular order to explore its features with no prior training and guidance.

Initial feedback of the system was very positive and encouraging since all participants commented that the system was very easy to use and required no or little explanation to utilize the interface. Also, some urban planners were very eager to manipulate the physical building representations just to observe changes in the costs and feasibility of the project when moving the buildings little by little. Some architects find the system useful for uncovering effective schematic design alternatives without having to wait for feedback from developers and planners.

4.4. PROTOTYPE LIMITATIONS

As in any prototype, TangiDESK was not designed to be a full-featured system that incorporates all decision-oriented constraints needed for both the designer and developer teams. For instance, the current system cannot modify the orientation and direction of the existing road in the project site since the main road inside a project site is one of the first fixed costs of the project that must be predetermined before dividing individual land plots. Both designers and developers must agree with the designated road before utilizing TangiDESK for other design decisions. The prototype also lacks the output mechanism that will transfer the final design into a working drawing since this feature must be thoroughly explored in a limited timeframe.

5. Conclusion and Future Works

This paper presents a tangible user interface prototype called TangiDESK designed to assist designers and developers in decision-making tasks during the early schematic design phase of an urban design project. The prototype consists of four main components, which are the tangible interface, the object recognition component, the graphic representation component, and the database component. We have utilized reacTIVision for object recognition, Processing for graphics and calculations, and MySQL for database. Initial evaluation of the system was encouraging but we need further system adjustments and more user studies to improve user feedback.

However, there is much room for improvement in TangiDESK. For example, adding more useful features and design tasks, recording all activities that occur, employing an output mechanism, providing continuous scrolling or panning to the interface, and adding 3D walk-through simulation features. In addition, the hardware could also be upgraded, industrial grade USB2 or FireWire cameras will provide higher resolution images and frame rates, and more variety of building objects specifically road objects would improve the quality of user interaction for all participants.

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References

Billinghurst, M. and Kato, H.: 1999, Collaborative Mixed Reality, *ISMR99, Mixed Reality – Merging Real and Virtual World.* Pp. 261-284.

Buchmann, V., Violich, S., Billinghurst, M. and Cockburn, A.: 2004, FingARtips: gesture -based direct manipulation in Augmented Reality, *Proceedings of the 2nd international conference on Computer graphics and interactive techniques*, 15-18th June, ACM Press, New York, Pp. 212-221.

Fischer, J.and Flohr, D.: 2008, Selective Stylization for Visually Uniform Tangible AR, *in* B. Mohler and R. van Liere (ed), *EGVE Symposium08*, The Eurographics Association.

Freeman, R. and Steed A.: 2006, Interactive Modeling and Tracking for Mixed and Augmented Reality, *VRST'06*.

Ishii, H. and Ullmer, B.: 2006, Tangible Bits: Towards Seamless Interfaces between People, Bits and Atoms, *CHI97*, March 22-27, ACM Press.

Kaltenbrunner, M. and Bencina, R.: 2007, reacTIVision: A Computer-Vision Framework for

Table-Based Tangible Interaction, *TEI07,* February 15-17, Baton Rouge, Louisiana

Kato, H., and Billinghurst, M.:1999, Marker Tracking and HMD Calibration for a video-based Augmented Reality Conferencing System. In *Proceedings of the 2nd International Workshop on Augmented Reality* (IWAR 99). October, San Francisco, USA.

Keawlai, P.: 2007, Interactive Feasibility-Based CAAD System for Infrastructure and Open Space Planning in Housing Project Design, *CAADRIA08*, Thailand, PP143-148.

Kim, M. J. and Maher, M.L.: 2006, The Impact of Tangible User Interfaces on Collaborative Design, *Joint International Conference on Computing and Decision Making in Civil and Building Engineering*, Montreal, June 14-16.

Ullmer, B. and Ishii H.: 1997, The metaDESK: Models and Prototypes for Tangible User Interfaces, *UIST 97*, October 14-17, ACM Press.

Underkoffler, J. and Ishii H.: 1999, Urp: A Luminous-Tangible Workbench for Urban Planning and Design, *CHI99,*May 15-19*,* ACM Press.

Wuthikosithi, A.: 2003, Architechtural Professional Practice, Chulalongkorn University Press, Pp 159-160.