WEB-BASED FEEDBACK SYSTEM: THE LIFE CYCLE MANAGEMENT AS CONTINUOUS MAINTENANCE OF APARTMENT FACILITY INFORMATION

A Thesis

by

JIN SU JEONG

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2006

Major Subject: Architecture

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Approved by:

Chair of Committee	Valerian Miranda
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August 2006

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ABSTRACT

Web-based Feedback System: The Life Cycle Management as

Continuous Maintenance of

Apartment Facility Information. (August 2006)

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This research investigates the feasibility of web technology as a means of delivering facility information for better support of facility operations and maintenance. This study proposes a web-based feedback system as a pragmatic solution to the limitations of current facility management (FM) processes, increasing the efficiency of these processes via web technology.

In practice, work orders and records are often misplaced, resulting in reduced efficiencies, redundancies, and time-consuming, costly tasks. This problem may be overcome by use of a system that stores information digitally and provides a web-based interface. The interface could allow operations personnel to create documentation, share and monitor work orders, provide feedback for service online, and facilitate communication between facility teams. The benefit for a FM department is that it can receive feedback on performance, which would improve the quality of service and build a record of practical experiences.

In this research, the software was tested using two types of prototype testing: first, system testing to evaluate functionality, usability and capability; and second, a post-task

questionnaire survey was conducted to test and review the concept, interface, and usability of the system. Facility Management Industry Advisor Council (FMIAC) members answered the questionnaires after using the system posted on the web. By using web-based feedback system, a facility web site can be created and maintained easily through a standard web browser. The questionnaires from the FMIAC members were analyzed to test research questions. The tests show that the software aids facilities managers in maintaining living documents of their facilities.

DEDICATION

Dedicated to

My father and mother

ACKNOWLEDGMENTS

I would like to give my sincere appreciation to the chair of my committee, Dr. Valerian Miranda. He has given me guidance and support since I was inspired to start this research. He encouraged me to acquire new knowledge and gave me a lot of advice to solve all problems during my study.

Thanks also to my committee members, Dr. Guillermo Vasquez de Velasco and Dr. Mohammed E. Haque, for their time and advice. Other persons to whom I would like to show my appreciation are Kwang Jun Lee, Young No Kim and Jan Gerston. Last but not least, thanks to my family members and friends for their love and support.

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CHAPTER I

INTRODUCTION

1.1 Introduction

The majority of facility management (FM) processes are heavily based upon traditional means of information management and communication such as face-to-face meetings and the exchange of paper documents. The need to increase the efficiency of these processes via the Internet and web-based information system has been long recognized [1]. However, the use of information technology (IT) in FM practices has not progressed to levels seen in other businesses [2]. The management of facility information can be a complex and demanding task from the perspective of operations personnel who operate a building [3]; however, the effective delivery of facility information is necessary for high quality FM service.

Feedback is an important component of facility information. According to Teicholz [4], feedback on a resolution of the problem, feedback on a quality assurance for users, or feedback on the change in status of the work order is critical to the effective management of FM. With the introduction of web technology, a facility manager can access the work order to view its status. Changing the status of the work order to reflect what is happening can contribute to efficient and effective management of a facility.

This thesis follows the style and format of the journal Automation in Construction.

This study describes an investigation into how a feedback system using web-based technology is used in the life cycle of a facility. Also, the prototype of a web-based feedback system using the Internet and web-based information to document, share, monitor, and improve the facilities data would be useful for operations personnel. A web-based feedback system can give continuous maintenance and operation of facility information and minimize redundancies, inefficiencies, and time-consuming tasks that create costs. Furthermore, the system would improve FM service quality and build a record of practical experience through receiving feedback from operations personnel.

1.2 Research Problem

Architects, consultants, and facility operators from many disciplines produce information in a variety of conventional formats. As a facility evolves through its life cycle, the information necessary for efficient facility operation is often poorly structured, missing, inaccessible or incomplete [5]. Also, several researchers demonstrated that although practical experiences show that feedback of successful usage of IT as significant resources in facilities management practices, facilities practitioners grant little recognition to it [6]. The literature indicates that IT-based solutions merely allow people to search for and retrieve only explicit knowledge [7]. Therefore, the emphasis on IT along may divert attention from creating usable, practical feedback management systems; consequently, useful feedback may be lost or unexploited due to information overload due to lack of documentation and organization in the collected information.

Creation of a comprehensive collection of facility documentation will require considerable time and effort. Automation of feedback regarding electronic facility

documentation is an important part of a successful system. Because of the importance of the feedback tool, the successful design of this system within the FM industry may be responsible for the growth and success of FM industry. There definitely remains a need for better tools to assist operations personnel to operate and maintain a facility.

1.3 Research Questions

The purpose of this research is to prototype a web-based feedback system as a continuous operation and maintenance tool for the apartment facility, and to evaluate how such a system can manage the delivery and documentation of facility information. This research seeks to answer the following questions:

1. Is a web-based feedback system able to be developed to improving the delivery and documentation of the tasks of facility information by electronic means, especially work orders and feedback, in FM practices? This is a basic issue and a major driver for this study. Several kinds of documents existed in the life cycle of the facility. Operational documents especially have a purpose to record and disseminate information needed to operate, maintain and renovate the facility.
2. Is a web-based feedback system able to be developed for operations personnel to share and monitor facility information more efficiently and effectively without requiring additional training? Improved communication and collaboration may be central to improving efficiency and productivity in many work processes, but especially in improving team processes where members are dispersed in space and time. Value may be created by

improving efficiency and productivity, in addition to enhancing decision quality [8].

3. Is such as a web-based feedback system able to be developed to improve the existing work processes using and intranet or extranet? Process performance improvement is clearly one way to create value. Information and web technology can contribute to work process improvement in two ways. The first is linked to the Total Quality Management (TQM) approach, whose goal is to improve existing processes. Gains from improving small work processes can often be significant. The second contribution may be to support more radical process transformations, including major restructuring of the manner in which facilities services are delivered [8].

1.4 Prototyping Process

The concept and feasibility of web-based feedback system was demonstrated by the following procedure as shown in Fig. 1. The system development and testing process was described to be a beginning model for demonstration and evaluation purposes. The system used this prototyping process to develop and test it. Prototyping consists of building an experimental system rapidly and inexpensively to be evaluated [9]. These steps are described in detail in the following paragraphs.

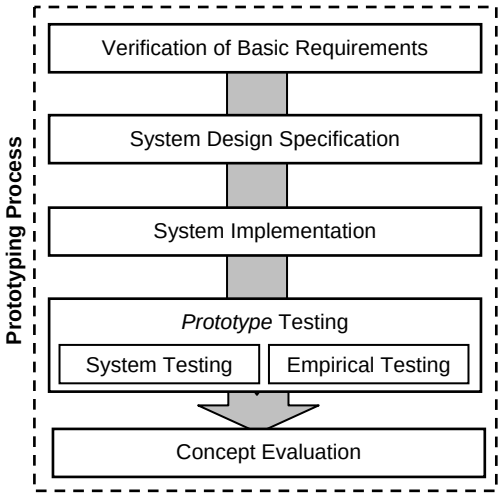


Fig. 1. The prototyping process of web-based feedback system.

Process 1. Verification of Basic Requirements

This purpose of this process was to identify the basic requirements of users and system requirements. The types and volumes of the facility data, especially work orders, were analyzed. What types of data are used? Who is involved with the data? How should the data be organized? Collecting relevant information answers the above questions as the approaches used in this process.

Process 2. System Design Specification

In this process, thought is given to system form and capabilities to achieve the needs of users. The system design's concepts are consisted of the following components:

- The conceptual model: This model prescribes the major constituents of the overall system structure and function. Moreover, it is a model that describes how the system works.

- The user model: It is a model that explains how users will use the system and matches users' practical needs. Also, this model describes system components and their relationships each other.
- The user interface design: This process prescribes the function of system interface. It will help users employ this system with accessibility and efficiency, which are the major aspects of this stage.
- The system database design: This is a process of defining database model and the concept of data entities and database management.

Process 3. System Implementation

This step is to develop a prototype according to the design concepts. The system will be implemented in the following phases:

- System security and access control
- System interface components
- Process of documenting feedback

Process 4. Prototype Testing

There are two types of prototype testing: first, system testing to evaluate usability and capability of the system, and second, empirical testing to evaluate usability and its interface in the practical fields. This process is to determine whether it works properly and meets the design fundamentals. The system is evaluated in the following steps:

- The first phase involves the creation of the facility data by the developer. The first phase of testing does not involve the actual users Facility Management Industry Advisory Council (FMIAC) members. This testing is to be carried out

by the developer to fix bugs encountered during the process of managing work orders and feedback.

- The second phase involves a survey in the form of a post-task questionnaire (see Appendix B). Participants receive the questionnaire after they used this system.

The questionnaire is divided into three sections: (1) concept and interface, (2) usability and (3) detailed feedback. The questionnaires from the FMIAC members are analyzed to test the research question. Survey results are helpful in the evaluation of the tool and its future use. Apart from gathered survey, results from the tool are available through its data monitoring. Instructors and researchers can analyze the monitored data to create better practical software tools and to study patterns of usage of tool by users.

Process 5. Concept Evaluation

This step is to evaluate the system's logical and physical concepts. The system functionality will be evaluated in order to determine whether the system can be effectively used within FM departments. The following are two areas of concern for functionality evaluation:

- usability requirements
- system capabilities

Furthermore, the system usability will be summarized by comparing between customer-side feedback and operations personnel-side feedback and the usage of the developed system and conventional methods.

1.5 Significance of the Study

Currently, very few companies build databases for their archives and allow employees to access this database. However, the overriding problem is the ongoing task of creating and updating the database or web site. Learning to develop and maintain a web site for a facility typically requires time and specialized training. Many FM companies are also still hesitant to apply these technologies and integrate then into their work process because they are reluctant to change their existing working systems. The system developed in this study could be a new alternative to hasten facility data delivery and archiving by allowing operations personnel to create and update work order records easily and, therefore, conveniently provide feedback of each work order. This system can allow sharing of information to communicate and collaborate between operations teams and maintenance teams. An important benefit of this tool includes a monitoring work process. Another benefit is to determine and demonstrate the feasibility of web-based feedback system by studying the needs of FM industry.

As regards prototyping, the system will be a web-based information management system which documents, shares, and monitors work orders for operations personnel and facilitates communication and collaboration with facility teams by using Internet technology.

CHAPTER II

THE REVIEW OF THE RELATED LITERATURE

The literature review is separated into seven fields; (1) current facility documents and delivery media, (2) information technology in facility management practices, (3) information sharing as communication and collaboration tool, (4) industry practice of current software, (5) feedback for facility management development, (6) information system design, (7) functionality testing and survey and questionnaire as testing methodology. Each of these fields provides information that is vital for this research.

2.1 Current Facility Documents and Delivery Media

Although the documentation of facilities is often literally called “as-built” drawings, that term is misleading in regard to purpose and participants. Several kinds of documentation of a facility can be distinguished in the facility life cycle. Design drawings describe the facility during the design process, and thus represent what the facility might become. They assist in building consensus and making architectural and engineering decisions. Bid documents describe the building to the extent that an accurate price can be determined. Construction documents describe the result of decisions by the architects and engineers and their instructions to the contractor in the form of drawings and specifications. They have an important role as part of legal documents governing the work to be executed. At the completion of construction, design professionals may produce “record drawings” that describes the final documentation of the design which incorporates all revisions made during construction. These also may have a primarily legal purpose proscribing the extent of responsibility of the designers. Contractors or

project managers may also produce “as-built drawings” that describe the facility as it has been constructed and as it purportedly exists at the time of commissioning. Demolition drawings are used to describe the scope of work in removing a facility or parts of a facility. Collectively, one may group all of these kinds of documentation as “facility documentation.” Table 1 summarizes the kinds of facility documentation, when they are used and what their purposes are [10].

Table 1
Facility documentation at different usage [10]

Type of documentation	Stage in life-cycle	Purpose
Design drawings	Design	Record and communicate design to assist in decision-making
Bid documents	Bidding and construction	Communicate scope of construction
Construction documents, Shop drawings	Construction	Communicate materials, methods of construction and finishes
Record drawings	End of construction	Record final design that incorporates changes made during construction
As-built drawings	End of construction	Record the state of the facility at delivery
Operational documents	Occupancy	Record and disseminate information needed to operate, maintain and renovate the facility
Demolition drawings	Demolition and renovation	Describe scope of demolition

None of these documents are actually intended to support operation of the facility. Although design documents or as-built drawings may serve as a starting point toward operational documents, they do not effectively express the information that is needed to operate a facility. A survey of U.S. Army facility managers reached a conclusion that “Most information established during construction is usually not structured in a way to support the tasks needed by facility operators/maintainers” [11].

The documents that are commonly produced by designers and constructors are poorly structured for supporting the wealth of non-graphic data, ready accessibility and ease of change that are necessary to maintenance and operations [10].

The information needed for operation of the facility is different from that found in any one of the other kinds of facility documentation. It also must be organized in different ways. In particular, five characteristics of “operational documents” stand out [10]:

1. They should describe the processes of operating the building, including the intent of the designers.
2. They require less detail than construction documents but greater integration and more structured organization to allow a wider variety of queries and retrievals. A digital format is crucial.
3. They must incorporate various kinds of information, including graphics, text, tables and operations manuals.
4. They should be accessible by personnel who are not in the design and construction industries.
5. They must be easy to change to allow incorporation of modifications to the facility, both routine and exceptional.

Operational documents must support many processes that involve facilities. However, too much information can be as much of a problem as too little information. The delivery of operational facility information must be in appropriate formats to allow easy retrieval by the participants in those processes. Operational information may best be

stored using a variety of information technologies, including scanned images, electronic drawings, databases, and text files. New information technologies are potentially very good solutions to the problems of storing and publishing facility information. In particular, intranets allow integration of various types of information in highly structured forms, such as database records, and in loosely structured hypertext forms while integrating graphics and text [10].

2.2 Information Technology in Facility Management Practices

As people become more family with the use of information technology, and applications become more sophisticated and easier to use, it seems reasonable to expect that IT will become an integral and vital part of many facility management (FM) organizations. One of the most exciting changes in technology that occurred in the last decade has been the explosion of the Internet [4]. The Internet proper is divided into three separate application domain types or categories: internets, intranets, and extranets. Millions of people from around the world use the Internet. In architecture, engineering and construction (AEC) industries, its use has been discussed widely. According to Cohen [12], it combines interpersonal communication with collaborative work support and mass media. It is well known as a medium that facilitates worldwide communication. In a design context, Internet or World Wide Web (WWW) gives designer the ability to make powerful connections between isolated pieces of information, supporting collaborative design and group decision-making.

The literature on IT reports many underlying reasons why corporations are increasing their use of IT. Reasons why Internet has been thought of as breakthrough technology include [8]:

- Ease of use: The “point and click” web technology is easy to use, resulting in lower training cost. After users have learned to use a browser, employees are just a few mouse clicks away from information they need in order to accomplish a work task. Browsers provide one user interface to multiple sources of information.
- Access to information and applications: Because the Internet can be used in cross-platforms, it provides universal access to information and applications through web browsers. The Internet helps people and groups to share information regardless of which type of computer is being used.
- Low development costs: Internet technology is simpler and less expensive in comparison to the cost of developing and deploying traditional programs. As a result, Internet applications have substantially lower development costs.
- User-managed content: Users are empowered to access information without having to rely on others to find, compile or develop special purpose reporting programs.

These reasons can be translated into practical business and facility management issues. One key reason for the importance of Internet is simply helping to share information [8].

Internet applications promise to dramatically and even fundamentally transform the relationship between companies and their customers, suppliers and business partners [13]. Currently, FM consists of effectively managing space, teams, and projects. To understand the use of IT in FM, it is important to recognize the different roles of a facility manager. The facility manager now has so much to accomplish that automation and integration of the facilities functions is inevitable [14].

2.3 Information Sharing as Communication and Collaboration Tool

Information sharing through content publishing is one business application that the Internet is especially good at simplifying. FM organizations in large corporation also find content publishing to be a useful application. Some FM organizations have used their intranets for publishing standard furniture layouts, a list of building and general housekeeping services that are available to customers, and the list of facilities persons to contact in case they have a problem to report or a service to request. These types of publishing applications are simple but often effective. In addition to publishing documents, the Internet has also been used to publish electronic resources, such as templates, for spreadsheets and other documents [8].

Teams, communication, and collaboration are seen as organizational priorities for the 1990s. Groupware, a Lotus product, and its variant work-flow technology are the technical support that helps keep these priorities practical and efficient. Groupware is simply a tool that assists people in collaborating and working together more effectively. It typically enhances peoples' ability to communicate, coordinate, and collaborate regardless of space and time constraints [8].

Several years ago, Lotus (www.lotus.com) coined the term “groupware,” which refers simply to software that enables groups of people to work together. Lotus identified three Cs that are common to the way different people work together as follows [15]:

- communications: helping people share information such as faxing, e-mail, calendars, chat rooms, video conferencing, and project extranets;
- collaboration: helping people work together with features such as sharing folders, e-forms, approvals, and document routing;
- coordination: helping people coordinate their individual roles, such as database connectivity, workflow mapping, status, and benchmarking.

The kinds of technology typically associated with groupware fall into two categories:

- synchronous technology includes voice conferencing, videoconferencing, electronic meeting systems, and whiteboards and chat tools.
- asynchronous technology generally includes calendaring and scheduling capabilities, e-mail, conferencing and discussion, and group document sharing.

Another important characteristic of groupware is worth emphasizing: the effective implementation of groupware technology usually requires organizational change. This technology provides the capability for corporations to share information in a manner what was not possible only a few years ago. Once information becomes widely available, many companies are finding it necessary to shift management processes away from centralized and hierarchical decision-making toward more decentralized team

processes. Many are finding that team organizations improve the responsiveness of companies to the needs of their customers, which can result in not only productivity improvements but also important competitive advantages [8].

The basis of FM practices is also defined by communication, collaboration, and coordination. Document management systems, Microsoft Exchange, Lotus Notes and other web-based project management tools are all examples of collaborative groupware products. Project portals such as Buzzsaw (www.buzzsaw.com), Meridian (www.mps.com) and Project Edge (www.projectedge.com) are few examples of project extranet sites.

Web-based collaborative tools improve effectiveness by developing closer working relationships in the facilities team through the involvement of users, suppliers and customers. The effectiveness of two-way communication with existing and potential users of facilities services is recognized as a critical success factor. Improving service quality is recognized to be a process of managing user and customer perceptions in relation to expectations [8].

2.4 Industry Practices

Part of this the intent investigating various organizations are to attempt to uncover innovative and effective techniques for managing facilities information.

Contractor Responsibility for Digital Facility Information

One company has implemented detailed procedures by which contractors deliver facility information. Due to very rapid and continuing expansion of facilities and a high awareness of computer capabilities, the company has developed a sophisticated

approach. The company provides mark-ups of construction drawings to the contractor designating panel schedules and equipments tags so that the “as-built” drawings conform to internal company standards [3].

As part of their regular services at closeout of the project, the contractors must update heating, ventilating, and air conditioning (HVAC) monitoring and maintenance computer databases. Only contractors who have an understanding of these data requirements are allowed to bid on a project [3].

HVAC maintenance personnel make heavy use of automated control system and monitoring systems. All operations personnel are equipped with laptop computers by which they can access the maintenance system and control system from any network connection [3].

The efficiency of the approach is partly due to standardization of design of facilities. Cubicles are of standard design and there is little differentiation of working space in response to rank or prestige. Many of the buildings have been constructed in a short time frame so that even the cladding system, HVAC systems, and electronics infrastructure, are largely standardized. Another unusual factor in the success of this approach is that contractors in the company’s region are adept with information technology [3].

Off-The-Shelf Calendaring Software for Space Scheduling

In another company, many of the routine space and service scheduling activities are handled effectively using off-the-shelf software. After studying market alternatives, the facility managers chose to use Microsoft Exchange Server for scheduling, because

the software was already available to employees through licensing agreements. Investment in software was minimal. Exchange Server allows Outlook to work as a client and end users to share their daily schedules. Exchange Server provides peer-to-peer schedule sharing so that each user can keep and share his or her own schedule yet look at the schedules of others. The server can forward e-mail that requests a meeting to appropriate personnel. Daemons on the server can automatically check room schedules, stored as Outlook schedules, share them with users, and insert items. Using the same mechanisms, catering and audio-visual services can be scheduled and the responsible parties automatically notified at appropriate times by e-mail [3].

FIATECH

FIATECH, a non-profit consortium in the USA, has developed the Capital Projects Technology Roadmap, which is a cooperative effort of associations, consortia, government agencies, and industry working together to accelerate the deployment of emerging and new technologies that will revolutionize the capabilities of the capital projects industry. The particular interests are the Intelligent and Automated Construction Job Site and the Integrated Automated Procurement and Supply Network, which incorporate the following visions of the future [16]:

- location and status of all materials, equipment, personnel, and other resources will be continuously tracked on-site, thus enabling a ‘‘pull’’ environment where needed resources are delivered on demand;
- automation of construction processes will augment manual labor for hazardous and labor-intensive tasks such as welding and high-steel work;

- construction job sites will be wirelessly networked with sensors and communications technologies that enable technology and knowledge-enabled construction workers to perform their jobs quickly and correctly;
- asset lifecycle information systems will continuously monitor the job site for compliance with cost, schedule, and safety to provide downstream facility operations with much better documentation about the history and current state of the facility;
- the site monitoring and tracking system will compare daily construction progress against the plan and coordinate the continuous flow of materials and assemblies to the point of need; reducing the need for on-site storage;
- the site asset tracking and control system will enable workers to instantly locate the resources they need and get them delivered for immediate use.

2.5 Feedback for Facility Management Development

Porter [17] noted that a tension exists for most individuals regarding feedback, as the desire to gain valuable information conflicts with a desire to avoid anything that might harm one's self-concept. This desire to avoid negative feedback can be problematic because for feedback to be used as a developmental tools it must be accepted [18] and [19]. Although there exists voluminous literature on acceptance of feedback, most studies examine feedback that is:

- focused on performance on a specific task (for a review of task-based feedback effectiveness [20]) or on performance in a specific job; and
- presented within the context of a supervisor/subordinate dyad.

Considerably less research has focused on reactions to management development feedback [21], which is not based on a specific task or even necessarily tied to an individual's job, and which is often given by individuals other than the immediate supervisor in the context of specific training and development programs. Recent research suggests that the changing nature of work requires individuals to continually develop and change [22], so we might assume a rise in developmental feedback and developmental programs. For example, the use of multi-source instruments for developmental feedback has increased [23] and assessment centers conducted for developmental purposes are common. The effectiveness of such programs rests on the assumption that individuals gain insight into their developmental needs. Farr [24] noted that organizations should be concerned about perceptions of the accuracy of all feedback mechanisms, not just performance appraisal, yet research on feedback from management development programs has been limited.

Table 2 highlights the primary differences between feedback in a management development program and job performance feedback, which has been the typical focus of feedback research [25]. The purposes of job performance feedback and management development feedback differ in key respects. Rather than focusing on specific aspects of job performance that might require improvement, feedback in management development programs is provided to guide self-improvement at a broader level. Typically the feedback is not tailored toward a specific job or job duties, although it may certainly be applicable to one's current job situation, but rather it is focused more broadly on skills and abilities [25].

Table 2
Comparison of management development program and job performance feedback [25]

	Management development program feedback	Job performance feedback
Goal	Self-improvement	Performance improvement
Focus	Self	Task
Context	Career/life	Current job
Giver	Outside one's work environment	Supervisor (typically)
Nature	Scores on assessment instruments and exercises	Evaluation of performance of job duties

Automation of feedback regarding the electronic facility documentation is an important part of successful system. One strategy for managing maintenance of the facility documentation is to monitor requests for information through automatic records and notification. When a user requests a document, software will first determine if the documents is available. If it is not yet available, then the system informs the user of the location of paper documents and then informs the staff responsible for maintaining the system that the document has been requested. The staff then can digitize the document and link it into the system to assure that the next time that it is needed it is linked. By analyzing patterns of requests and cross relating projects that are beginning, the staff can prioritize documents for inclusion in the system [3].

Errors in documentation can lead to other semi-automated feedback. For example, if a user of facility drawings detects error, the software can supply a plug-in component. The user can then mark-up the drawing and forward the corrections to the staff that are maintaining the system [3].

The information system that envisioned in this research does not have to be created in totality in one step. It is possible to "boot-strap" the system so that an initial

partial implementation gathers data to inform additional implementation. By monitoring the patterns of use of a partial system or trial system, it should be possible to develop rigorous data for cost/benefit analysis, reduce risk and further sharpen the image of the complete system [3].

2.6 Information System Design

Information systems can be designed to have the means and mechanisms for data receipt, processing, storage, retrieval, and analysis. To be effective, the design and operation of information must be carried out in close association with the primary procedures of the data sets, as well as other groups producing integrated analyses or intermediate products. There are software application tools for the purpose of real estate management, operations and maintenance, space management and also financial management. With an automated system, processing takes place at a level at exceeding manual methods [14].

An important component of an information system is a database to make it efficient. A database requires a database management system (DBMS), a set of computer programs for organizing the information in a database, to manage its structure and control access to the data stored in the database [9]. A DBMS supports the structuring of the database in a standard format and provides tools for data input, verification, storage, retrieval, query, and manipulation. According to Ramakishman [26], DBMS is software, designed to assist in maintaining and utilizing large collection of data, and the need for such systems, as well as their use, is growing rapidly. The DBMS that are well known and widely used these days are Access, Oracle, Informix, FoxPro and others.

The most recent database model is the relational database model. The relational model, first developed by E.F. Codd (of IBM) in 1970, represents a major breakthrough for both users and designers [27]. A relational database stores data in such a way that it can be added to, and used independently of, all other data stored in the database. A database that stores data in a structure can be visualized as one or more tables of rows and columns, which may be interconnected. A row corresponds to a record (tuple); columns correspond to attributes (fields) in the record. User can query a relational database without knowing how the information has been organized. Although relational database have the advantages of ease-of-use and analytical flexibility, their weakness can be slower retrieval speed. Structured query language (SQL) is one example of a relational database. SQL is a standard interactive and programming language for getting information and updating a database. Many database products such as Microsoft's Access and Oracle support SQL with proprietary extensions to the standard language. Queries take the form of a command language that lets you select, insert, update, locate data, and so forth. There is also a programming interface.

Active Server Pages (ASP), a web programming system made by Microsoft, is a new technology for building dynamic and interactive web pages. Instead of using browsers to locate the pages, ASP uses web server before returning the results to users as HTML (hypertext markup language) [28]. ASP allows the dynamic updating of website content rather than a display of static information. With ASP technology, a web page, upon being loaded into a user's browser, connects with the website's database of latest facts and loads those details from the database. In addition, with the connection to databases

on the server, ASP can achieve many more functions than HTML such as retrieving, inserting, updating or deleting the data stored in the database.

Another important role in the information system is the user interface. The user interface is the software component that functions as the communicator between users and a system. To design user interface, user skills, user tasks, and cognitive styles must be considered [29]. The user interface plays a crucial role in the correct and productive use of the information system. It is not sufficient for the interface to be accessible—it must also be user-friendly; that is, easy to use and navigate by all, regardless of devices used.

Accessibility guarantees use to anyone; accessible design ensures graceful transformation, as well as understandable and navigable content. Usability renders Internet navigation more effective, efficient and satisfactory [30] and [31]. Design of user interface demands attention to the following attributes:

- Arrangement of components: This point is quite relevant since value-enhancing features are more "visible" when located in an area that is rapidly encountered by eye movement and does not require page scrolling. The most relevant features/functions should be placed in a “relevant” position which means at the top of the page or in an easily-reached point.
- Expressive power: A visual representation can communicate certain kinds of information much more rapidly and effectively than other methods [32]. For this reason the interface design should try to maintain the same degree of expression in both the visual and aural versions.

- Number of elements: Simplicity helps unskilled users navigate the interface easily while an interface full of elements can create confusion and waste time.
- Function: A user typically performs a simple search and specifies one or more words, obtaining a large set of results. Further criteria selection can be specified in order to restrict search results. Preferences and commands, although very powerful, are rarely used, even by skilled individuals.

2.7 Testing Methodology

Testing methodology is divided into the following two areas of concern; first, system testing to evaluate functionality, usability and capability; and second, empirical testing using survey and questionnaire to evaluate usability and interface in the practical fields. This process is to determine whether system works properly and meets the design fundamentals.

Functionality Testing

The goal of functionality testing is to provide the practicing engineer with tools that improve the likelihood of obtaining high quality computer software and lower the risk of selecting inappropriate computer software. This guide outlines procedures user can use to help to assess the suitability, capabilities, and limitations of software by suggesting what features to look for, what questions to ask, and what steps to take [33]. The functionality of computer software can be defined in simple terms as its ability to solve specific classes of problems using specified methods and approaches on prescribed

hardware and operating systems. Further, functionality in software implies that it can handle input and produce output in forms satisfactory and convenient to the user [33].

Evaluation starts by determining if the computer software performs its intended function. A program must be able to solve specific problems using accepted methods on prescribed hardware. This implies that it uses specific input and produces specific output that satisfies users' needs, and that both the input and output are in a convenient format. Functionality must be defined by the user, not the vendor. Therefore, software evaluator must be qualified to make these judgments. If your in-house staff does not have the technical know-how to perform such as audit, then a third party should be used to perform the assessment [33].

All computer software has limitations; these limitations are important measures of functionality. The software evaluator must analyze the limitations in light of the constraints of the operating environment and the typical problems solved in the course of the organization's business–another indication that the evaluator needs to be highly skilled [33].

The evaluation process must include a complete review of how well the program functions on your computer hardware. The functionality must be tested on all equipment. Every new hardware acquisition must be examined with the consideration that the application must work on that equipment. Evaluation of functionality must be afforded the time necessary to adequately test all the options available. This process should be expected to take days, not hours [33].

Survey Questionnaire

In architectural practice, survey questionnaire can provide important information for ongoing projects. In his facility planning and pre-design consulting service, architect Lawrence Stern frequently develops questionnaires to assess how physical design can support both individual and work group practices [34].

Among the variety of data collection tactics used in correlational research, the survey questionnaire is perhaps the most frequently employed. Indeed, its ubiquity is so well established that the terms “survey research” and “correlational research” are sometimes considered interchangeable. The survey questionnaire, however, is just one of many possible data collection devices available for the correlational research design. The great advantage of survey questionnaire is that they enable the research to cover an extensive amount of information—from demographic characteristics, to behavioral habits, to opinions or attitudes on a variety of topics—across a large number of people in a limited amount of time. However, achieving this breadth of information usually comes at the cost of in-depth understanding of the issues surveyed. Depth of understanding is more likely to be achieved through a qualitative research strategy for instance. Nevertheless, the longstanding popularity of the survey tactic stands as a testimony to its usefulness in many circumstances [34].

Questionnaire Design

Questionnaires are a versatile, inexpensive way to gather data from a potentially large number of respondents. Often they are the only feasible way to reach a number of reviewers large enough to allow statistically analysis of the results. A well-designed

questionnaire that is used effectively can gather information on both the overall performance of the test system as well as information on specific components of the system. If the questionnaire includes demographic questions on the participants, these can be used to correlate performance and satisfaction with the test system among different groups of users.

A questionnaire should be viewed as a multi-stage process beginning with definition of the aspects to be examined and ending with interpretation of the results. The final results are only as good as the weakest link in the questionnaire process, so careful attention should paid to the planning of objectives. Although questionnaires may be cheap to administer compared to other data collection methods, they are every bit as expensive in terms of design time and interpretation [35].

Design begins with an understanding of the capabilities of a questionnaire and how they can benefit one's research. The steps required to design and administer a questionnaire include [35]:

1. defining the objectives of the survey,
2. determining the sampling group,
3. writing the questionnaire,
4. administering the questionnaire, and
5. interpretation of the results.

Questionnaires are like any scientific experiment. One does not collect data and then see if they found something interesting. One form a hypothesis and an experiment that will help prove or disprove the hypothesis [35].

Modern computers have only made the task of collecting and extracting valuable material more efficient. Among the guidelines to be followed to make the questionnaire a sound research tool are those to ensure the questionnaire is understandable and free from bias. Mindful review and testing is necessary to weed out minor mistakes that can cause great changes in meaning and interpretation. When these guidelines are followed, the questionnaire becomes a powerful and economic evaluation tool [35].

A Format Comparison between Web-based and Pencil and Paper Questionnaires

College students at the on-line Open University of Catalonia (UOC, see www.uoc.edu) were assigned at random to either an Internet or to a pencil and paper survey (format condition) to complete two measures of psychological distress (depression and stress). An e-mail message explaining the procedure for participating in the study, as well as a compromise of confidentiality and anonymity was sent out to students in the on-line behavioral science courses. For the pencil-and-paper condition, a cover letter and a stamped return envelop was enclosed with the instruction sheet. The envelopes were placed at random in several boxes at the entrance of the rooms where students had off-line presentations at the beginning of the semester. The envelopes looked alike but were actually of two kinds (whether they belonged to the Internet or to the pencil-and-paper condition). For each student, an eight-digit code was created according to his/her original e-mail address at the UOC. A username and password is provided by the UOC at the time of students' course registration, and several security measures are regularly implemented to keep the system secure. Thus, it was possible to

assign a unique and non-meaningful eight-digit code to each of the participants in the study [36].

For the Internet condition, the enclosed instruction sheet listed a universal resource location (URL) to access the on-line questionnaire. Also, in the upper right side of this page, the eight-digit code was provided. To complete the survey, participants had to first log-on with their original username and password to get access to the UOC server. Once the participants tried to access the URL containing the on-line survey, access was granted for eight-digit codes that matched with original e-mail address in the database. This procedure did not decrease response rates while it increased data quality [37]. Once the participants submitted their responses by clicking the corresponding button, their entry in our database was blocked, not permitting further trials to complete the questionnaire. This procedure allowed controlling for additional possible questionnaire abuse [36].

For the paper-and-pencil condition, participants found enclosed with a stamped return envelope a cover letter which contained a different URL where they could download a printer-friendly version of the survey, instructions to return the questionnaires in the enclosed envelope, as well as the eight-digit code to enter the URL. This eight-digit code was used to assure that only one survey per respondent was finally coded into the database [36].

CHAPTER III

RESEARCH METHOD

Several approaches and sources of data were used to perform this research. The literature review revealed very little information on the use of information technology and feedback mechanism in facility management. A seven-step process, therefore, was developed to perform the research. First, the general literature on the facility documents and delivery media was reviewed to obtain a better understanding about the facility delivery and documentation usage. Second, information technology was reviewed as a breakthrough technology as an alternative to existing FM practices. Third, information sharing as a communication and collaboration tool is necessary was reviewed to learn know such practices improves current work processes. Fourth, industrial practices were reviewed to learn how information technology current practical practices improve the work processes by using information technology. Fifth, feedback for management development was reviewed to learn the nature of feedback and to learn how it contributed to the success of a system. Sixth, information system design was reviewed to assess the system components, such as database management system (DBMS), structured query language (SQL), Active Server Pages (ASP), and user interface. Seventh, testing methodology was reviewed to obtain a better understanding about the functionality testing and survey questionnaire.

Next, a prototype of a web-based feedback system—a small form at the bottom of each work order page asking the user for feedback on the work order content—was constructed as a feedback delivery and documentation instrument.

3.1 Literature Review

The literature review process involved reviewing journal articles, books, and Internet publications related to the following areas: architecture, FM, feedback mechanism system, IT, web technology, software development, user interface design and software testing. Each of these fields of knowledge provided information that is vital for this research.

3.2 Software Development

A prototype of a web-based feedback system was constructed as a feedback delivery and documentation medium. The system documents, shares, and monitors work orders for operations personnel; archives feedback, such as practical experiences of operations personnel; and facilitates communication and collaboration with facility teams by using Internet technology.

The general structure of web-based feedback system is a server/client system. A web-based feedback system is programmed using Active Server Pages which is a server-side script to create dynamic web pages that are able to retrieve and display data and modify data records. Active Server Pages are implemented through an embedded text script rather than a compiled program. This web-based feedback system runs on a Windows 2000 server and several types of PC workstations. Web-based feedback systems are independent of any web browsers, since they are a server-side application. A database management system, Microsoft Access, was used to save feedback data of each work order in the model apartment facility.

The web-based feedback system has three major functions as follows;

1. Login section, which allows authorized user logs into the system.
2. Work order description section, where users can view, add, update and delete work orders and add feedback. The data can be shared through the system improving communication and collaboration.
3. Feedback description and history section, where a user can select and create feedback as practical experiences for each work order, and view the description of the feedback.

The above functions are illustrated in Fig. 2 as the activity sequence of the system.

3.3 Scope and Limitations

Definition of the scope of this research required a clarification of the meaning of "delivery of facility information." The phrase has different meanings depending upon different vantage point in the facility life cycle. Delivery of facility information means: (1) delivery from consultants to the operator's information system, (2) delivery from the information system to the operations personnel, and (3) delivery from the operations personnel to the information system as feedback [3]. The research in this study focused on the third vantage point, delivery from the operations personnel to the information system of feedback related to the apartment's facility management and operations. Also, this prototype deals with communication and collaboration for operations personnel.

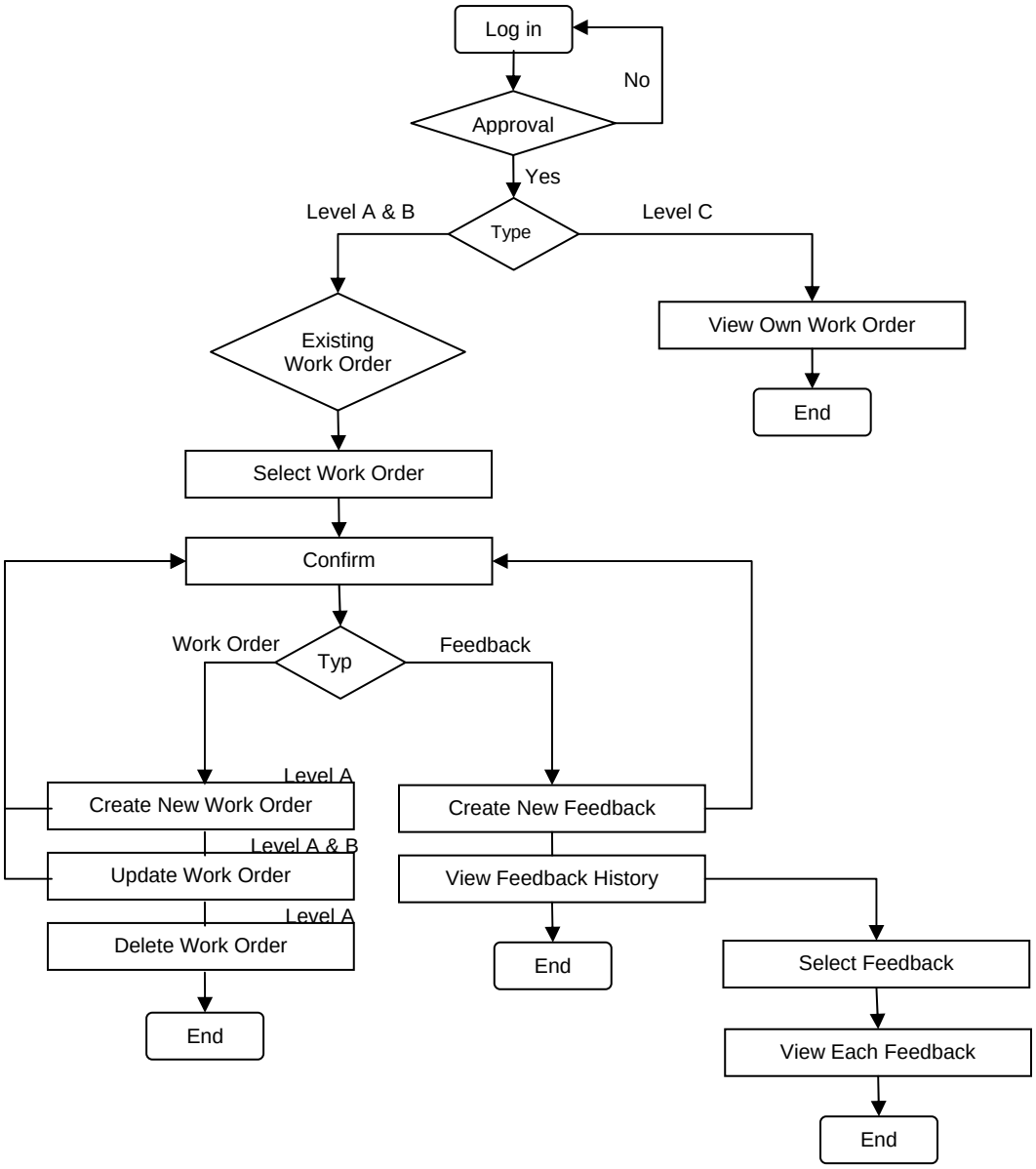


Fig. 2. Flow chart of web-based feedback system mechanism.

The system development and testing process was described as being a rudimentary model for demonstration and evaluation purposes. The system used the prototyping process to develop and test it (see Fig. 1). This research is limited in that the

software is a proof of concept implementation only. Additional functions and optimizations would be required to produce an effective tool for everyday use. The user trial were trivial in scope and do not indicate practicality for a comprehensive facility project.

CHAPTER IV

SYSTEM DESIGN

4.1 Conceptual Model

The web-based feedback system was developed to collect, categorize, and deliver the apartment facility information into an electronic format. This tool enables operations personnel, to enter data or upload files into the system for storage in the centralized database. Users can retrieve these data conveniently later. Operations personnel can build work order and feedback data easily using this system to be a tool. Because the system provides blank pages that the users can enter and collect the feedback of the facility data starting from the beginning to the end of the apartment facility, the system can be used any facility.

The structure of web-based feedback system consists of three parts, as shown in Fig. 3: the user interface layer, the application layer, and the database layer. Through the layer of user interface, which is a web browser, users can communicate with the system. The layer of application is composed of hypertext markup language forms and Active Server Pages scripts. ASP scripts are performed on the server to manipulate data in the database to provide relevant user information. The database layer is composed of Microsoft’s Access and file repository using the Dext FileUpload Component, located on a server.

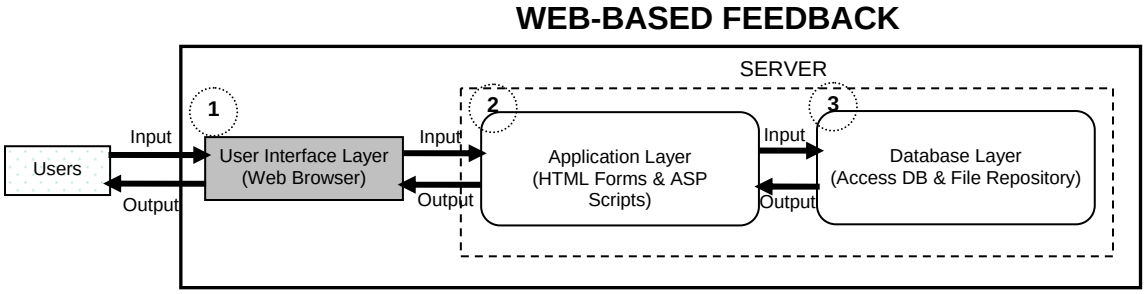


Fig. 3. The conceptual model of web-based feedback system.

In this system, users both request the data from the database through the system interface and input any data into the system. This process can be possible to use user interface and application layer, as shown in Fig. 3.

4.2 User Model

The user model is shown in Fig. 4. A web-based feedback system user model is divided conceptually into four major parts:(1) authentication, (2) management of work orders, (3) creation of feedback, (4) comprehensive database.

The web administrator will give system permission to all users. Before accessing facility data, however, users have to identify themselves by using a login identification and password in the authentication part. At that point, users will be able to access the

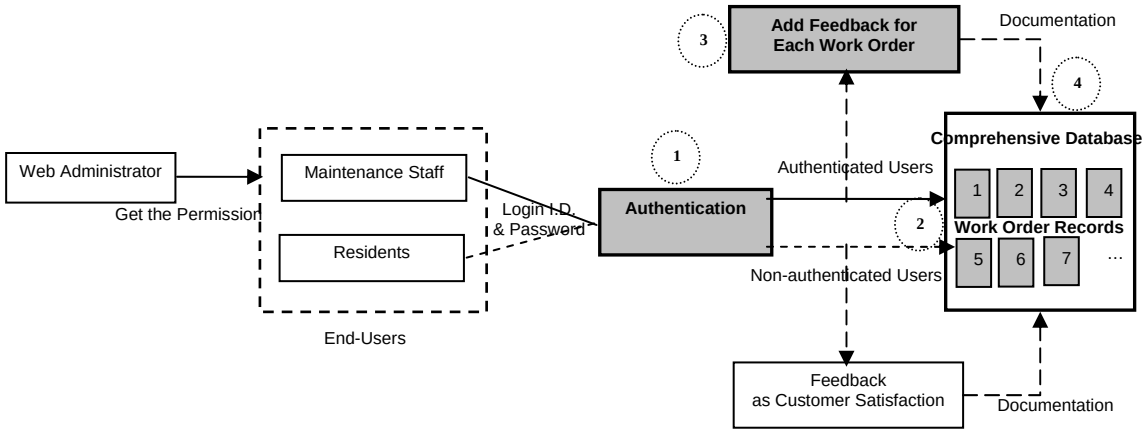


Fig. 4. The concept of web-based feedback system user model.

facility data part or update part, depending on their authorization levels. As shown in Fig. 5, shows the process creating and delivering feedback documents. The system analyzes requirements of document contents from the comprehensive facility database, and then creates the documents template from the existing templates. Users can create new feedback through the system and can confirm feedback documents which are made by them. Authenticated users include operations personnel such as facilities directors, managers, supervisors, and maintenance staff. Access levels to each section of the system vary by user, as summarized in Table 3. In this system, the target users are supervisors, with group level A, and maintenance workers, with group level B.

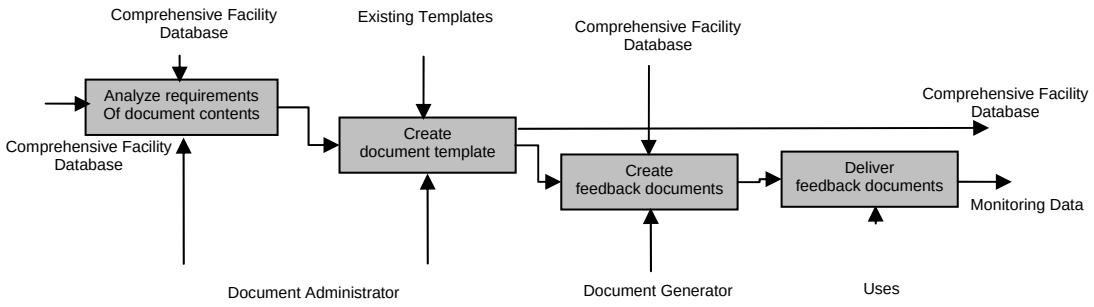


Fig. 5. Process of creating and delivering feedback documents.

To secure important data, the data section is divided into two parts: the comprehensive database part and individual work order part. Some personnel can access partial work orders, either those for which they are responsible or they may have access to the comprehensive databases. Non-authenticated users may only be able to access their own work order records.

Table 3
Different access levels for each user group

Users	Group Level	Level of Authorization
Associate Director	A	6
Assistant Director	A	5
Manager	A	4
Supervisor	A	3
Maintenance Worker	B	2
Resident	C	1

4.3 User Interface Design

Commonly, the user interface is works as the communicator between users and a system [19]. In the web-based feedback system, the user interface provides some

interactive forms which facilitate user access to data. HTML forms and Active Server Pages scripts are used to create the interface. Table 4 lists system tools interface for accomplishing tasks such as input, edit, view or search for data.

Table 4
User interface tools

User interface tool	Function of each interface	Component of interface
Forms	Input and Edit Data	Text Boxes Radio Buttons Check boxes Dropdown Menus
Navigations Bars	View and Search Data	Buttons Check Boxes
File Browsers	Upload Files	File Browsing Box

According to Nielsen [38], five usability measures exist for the user interface. It should be (1) easy to learn, (2) efficient for the user, (3) easy to remember, (4) be equipped with built-in error protection, and (5) subjectively pleasing. The user interface plays a crucial role in the correct and productive use of the information system. The interface must be accessible, user-friendly, easy to use, and easy to navigate. Accessibility guarantees use to anyone. Accessible design uses color, image, and graphics to guide users, as well as understandable and navigable content. Usability renders Internet navigation more effective, efficient, and satisfactory. Navigation of a web-based feedback system should be clear and consistent. The title of each section should be shown in a consistent format and links should be located on every page in the same page and sequence. Navigation images should be seamlessly integrated into the web site, and important and often used links should be visible without scrolling.

4.4 System Database Design

The dual objectives database design is absence of redundancy and optimized access. The web-based feedback system uses one centralized database to efficiently document all data, reducing redundancy, inconsistency, and time-consuming tasks that create cost.

The system database concept is divided into three major sections: the user interface layer, consisting of administrator and user web browser; the application layer written in HTML forms and ASP scripts, and the database layer, containing the file repository stored in an Access database.

When a file is submitted, it will be sent to the appropriate directories on the server. Pieces of data captured from users input into provided forms will be sent to the central project database, which is driven by a database management system such as Access, FoxPro, etc. Only the system administrator or users who have been assigned authorization can access the database directly on the servers. Once the database is connected, the system can manipulate the data using structured query language (SQL).

In web-based feedback system, data is stored in a relational database. The data consists of textual information, drawings and images. As a step in the creation of the database, all entities are mapped onto appropriate relational tables. Main tables include information as:

- Apartment facility unit and detail,
- User information,
- Work order, and

- Feedback history for each work order.

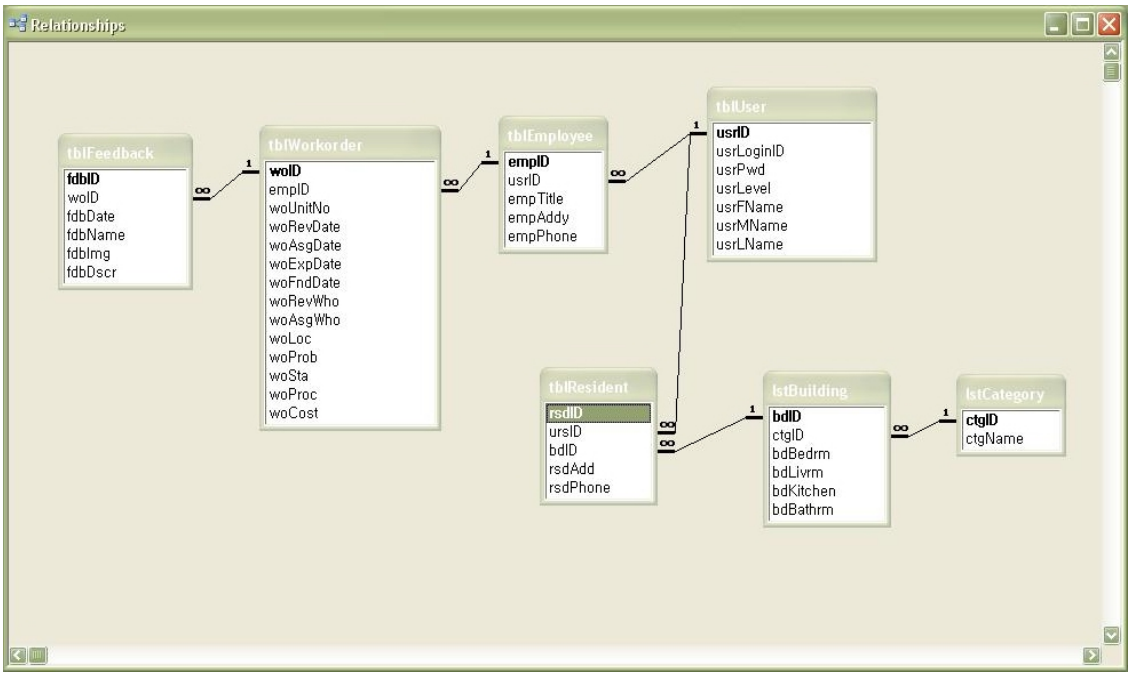


Fig. 6. Data model showing relationship between all tables.

For the purpose of this research, Microsoft Access is used for database system. Work order and feedback constitute a major portion of the database. The rest of the database stores user information and information related to the apartment facility. Each table consists of rows and columns. Each horizontal column forms a record and each vertical column represents a field. Data entered by users is stored in the form of records.

The database comprises a total of seven tables. The tables and their functionalities are described in Fig. 6. Two tables, tblWorkorder and tblFeedback, form the core of the database. The fields associated with each of these tables are described in Tables 5 and 6.The fixed records for each field, such as woLoc, woProb, and woSta, are

described as well. When users request particular information in the database, the SQL query embedded in the ASP scripts identifies the particular record or records and selects the field valued that were requested. As the database is designed on the concepts of relational database, some of the tables have a relation with one another. A relationship exists between two tables when a key field from one table matches to a key field in another table. Relationships are necessary for data normalization, a process of eliminating duplicate information from the database. A relation is in first normal form (1NF) if every field value is non-decomposable (atomic) and every tuple (row) is unique [27]. There are no repeating groups in each table (relation) in the database design, as shown in Fig. 6. A relation is in second normal form (2NF) if all of its attributes are dependent on the whole key; that is, none of the non-key attributes are related only to a part of the key [27].

Table 5
The fields of tblWorkorder (table of work order)

Field Name	Data Type	Description	Records
woID	Auto Number	Primary key of woID field	-
empID	Number	The key connects with empID in tblEmployee	-
woUnitNo	Number	The unit number in the apartment	-
woRevDate	Date/Time	The date receiving work order	-
woAsgDate	Date/Time	The date assigning work order	-
woExpDate	Date/Time	The date expecting when work order will be finished	-
woFndDate	Date/Time	The date finishing work order	-
woRevWho	Text	The person who receives the work order	-
woAsgWho	Text	The person who assigns the work order	-
woLoc	Text	The location is the place the problem occurs in the apartment	Living_Room Kitchen Bedroom_1 Bedroom_2 Bathroom Whole_Unit
woProb	Text	The problem type occurred in the apartment	Switch_Plate Switch_Out Fluorescent_Out Incandescent_Lamp_Out Ballast Faucet_Leaking Water_Pressure Pest_Control Lock_In Lock_Out Lock_Set Door_Hinge Smoke_Detector Gas_Detector Air Conditioning_Low Heater_Low Disconnect_Rubber_Cover Disposal Fluorescent_Starter Termite_Damage Spring_Cooler
woSta	Text	The status is for monitoring work order processes.	Not_Yet Await Work_In Done
woProc	Text	The descriptions about work order	-
woCost	Currency	The spending cost for work order	-

Table 6
The fields of tblFeedback (table of feedback)

Field Name	Data Type	Description
fdbID	Auto Number	Primary key of fdbID field
woID	Number	This key connects with woID in tblWorkorder
fdbDate	Date/Time	The date leaving feedback for work order
fdbName	Text	The feedback name for each work order
fdbImg	Text	The image of feedback shows what type of problem occurs
fdbDscr	Text	The description about feedback for each work order

It is third normal form (3NF) if there are no transitive dependencies. In other words, none of the non-key attributes are dependent upon another attribute, which in turn is dependent on the relation key [27]. Records in the above data model have all non-key attributes, which are fully dependent on primary key; hence, there are no transitive dependencies. For instance, table tblEmployee has a one-to-many relationship with table tblWorkorder through a key field named empID. This means that a single user, maintenance staff, can have many work orders in the database but every work order can only have a single user.

CHAPTER V

SYSTEM IMPLEMENTATION

5.1 System Access Control and Security

Login identification (ID) and password taken together becomes the key to allowing or restricting access to the system based upon level of authorization. Before using the system, users will be assigned a login ID and password from the system administrator. The extent of systems access is determined by, and can be changed by, the system administrator. To access the system, users are required to input the login ID and password only one time at the beginning as shown in Fig. 7. This restricted access to data will increase the efficiency of the system usage because the users do not waste their time accessing other data which they do not have the permission. For example, maintenance workers will not be able to see the comprehensive database, but will be able to see some information related with his or her job duties. In another example, users who have read-only permission will not see a new or delete button on any page.

On the main entry page of the system as shown in Fig. 7, the user is asked for the login ID and password. Fig. 8 graphically shows the concept of the system access control. When the user is authenticated, the user session will be assigned for each user.

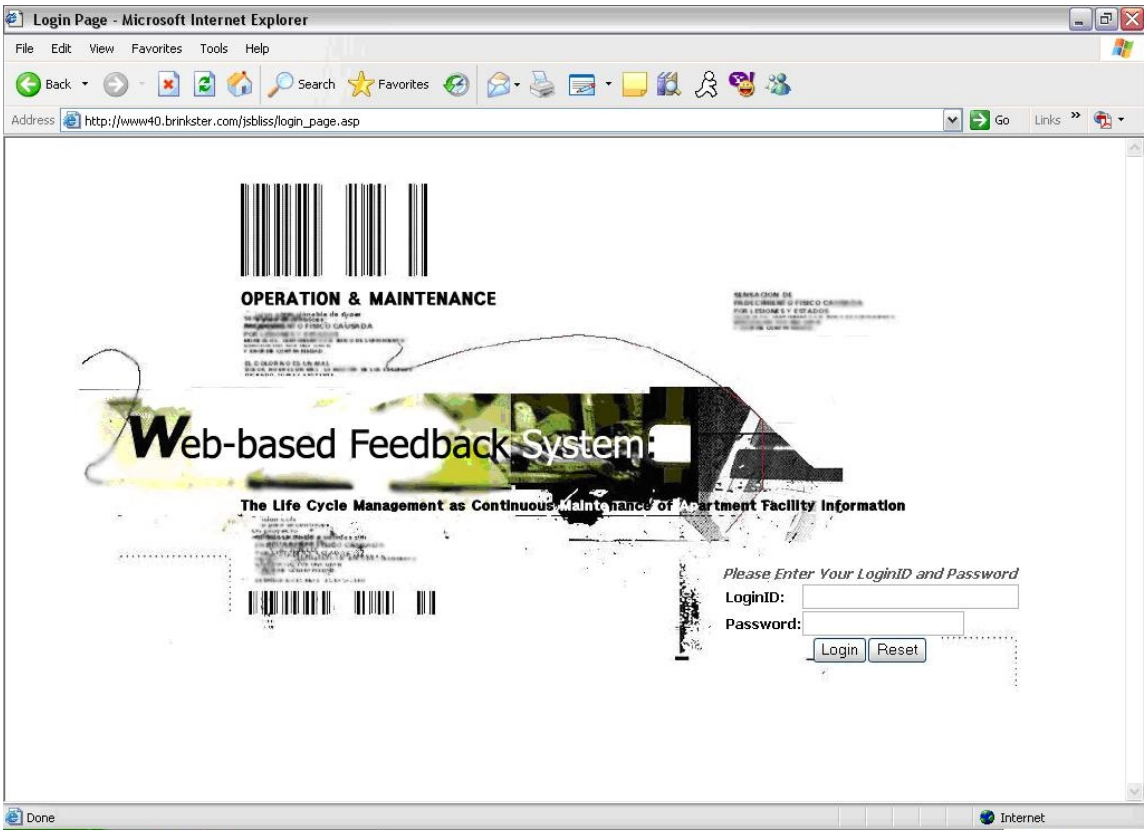


Fig. 7. Screen image of login page.

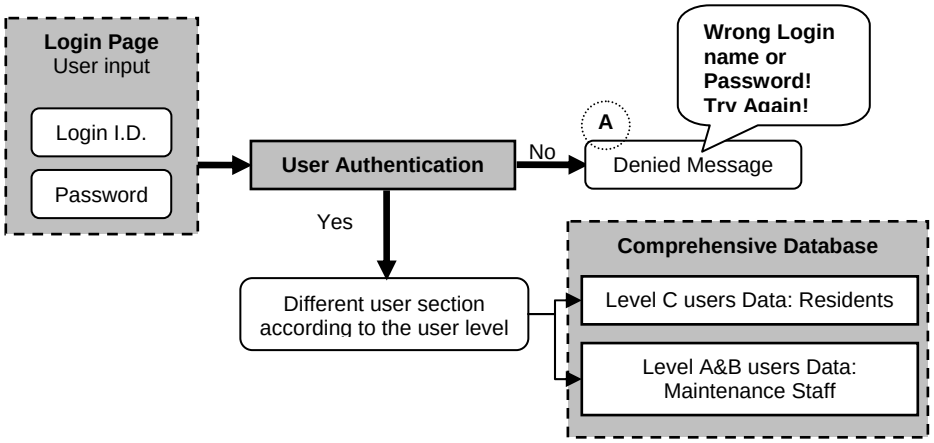


Fig. 8. Conceptual diagram of system access control.

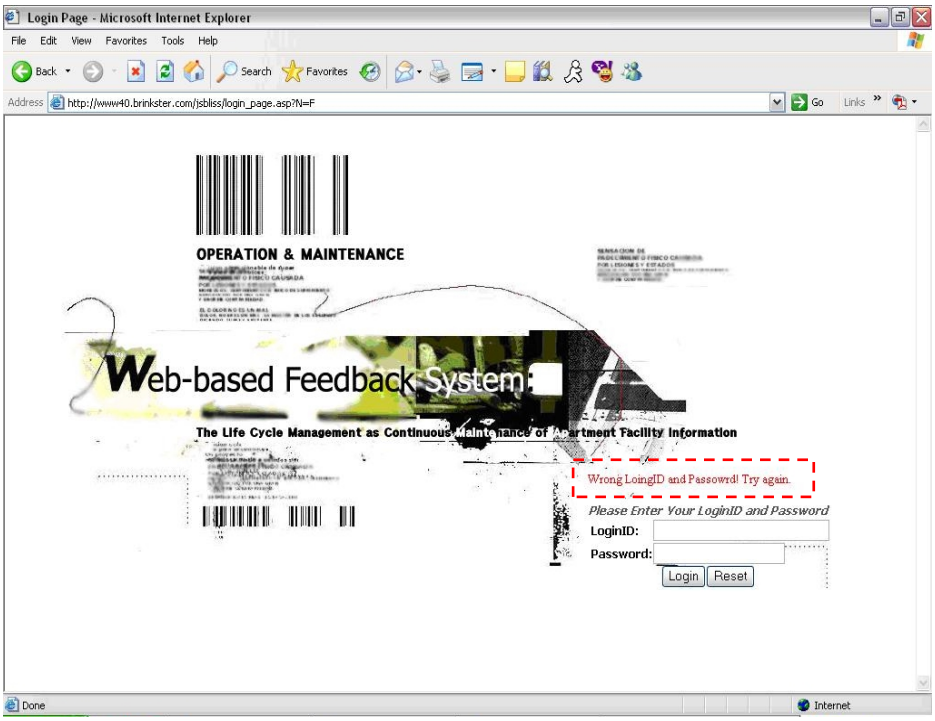


Fig. 9. Screen image of the denied message in login page.

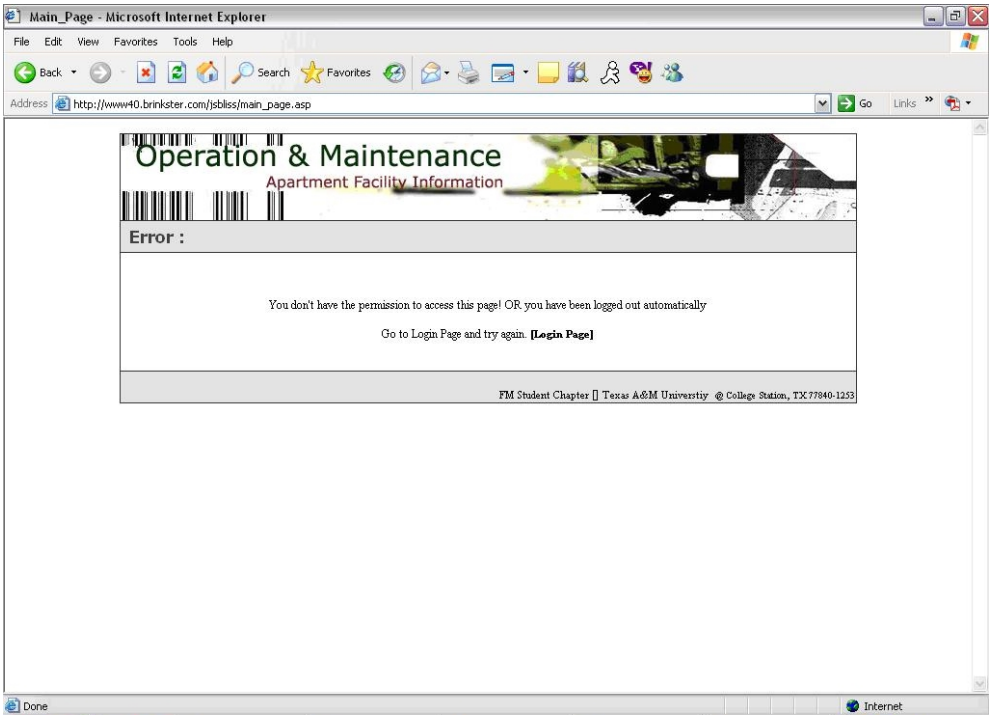


Fig. 10. Screen image of security for the system.

The user session will be valid as long as the user is still working on the system and will be abandoned when the user logs out from the system or stops working for more than 20 minutes. This time limit is to protect the data in case that user leaves without logging out from the system as shown in Fig. 10. In addition, the security detector is included in every page of the facility data. Therefore, if a user requests a page before logging into a user session, a denied access message will be given to the user as shown in Fig. 9.

5.2 System Interface Components

The interfaces of a web-based feedback system are composed of three major components: (1) top banner, (2) navigation bars, and (3) main work area as shown in Fig. 11. The design of the interface is consistent among all pages of the system. The top banner houses web-based feedback system's logo. The navigation bars component contains navigational hyperlinks links in conspicuous text and color. The main navigation bar is located just below the banner and a high visibility. The third component is the work area, containing forms that collect user inputs and display results.

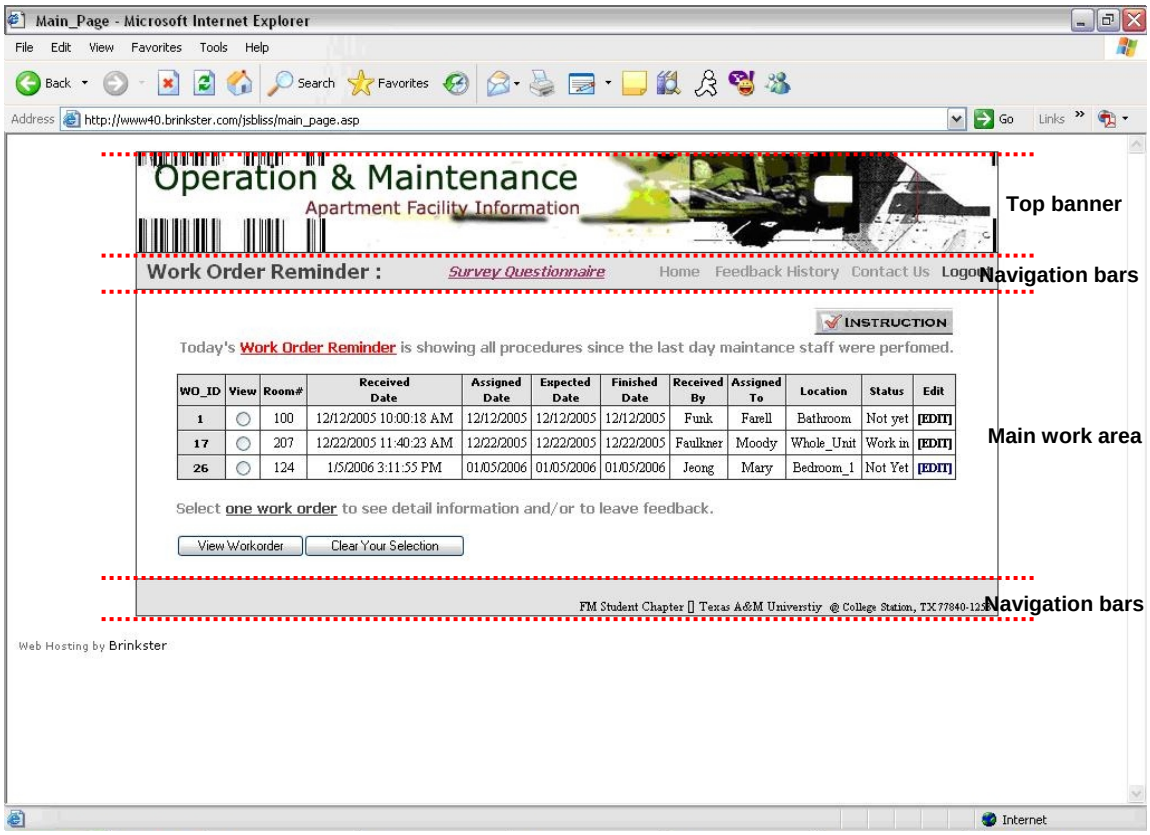


Fig. 11. Screen image of the interface component of web-based feedback system.

5.3 Process of Documenting Feedback for Each Work Order

Once the user is logged in and authenticated (Fig. 2, Chapter III), a feedback process is created, as shown in Fig. 12 through Fig. 15. After gaining access, the user can see information according to his/her authentication levels. As shown in Fig. 12b, the user must check the radio button to see detail work order information and feedback format. A user can add new feedback about a work order. The title of required input fields are shown in red type. Users should input the required fields if they want to process next step as shown in Fig. 13. The user can see feedback history as delivery and documentation method. Feedback history has same format as shown in Fig. 12b. Each

work order can have more than one feedback. So in this system, users have two different ways to arrange feedback as shown in Figs. 14a and 14b. Last, users can see feedbacks for each work order after choosing feedback as two different ways as shown in Fig. 14a and 14b. Maintenance workers can see the detailed information of each feedback and can leave more feedback for each work order as shown in Fig. 15.

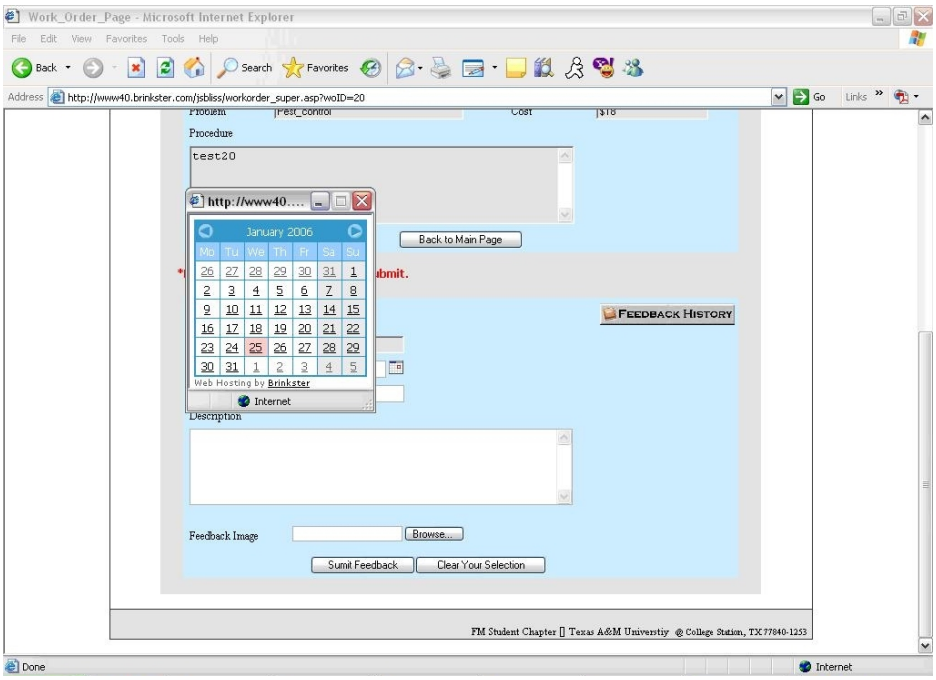


Fig. 12. Screen image of first step in documenting feedback for each work order.

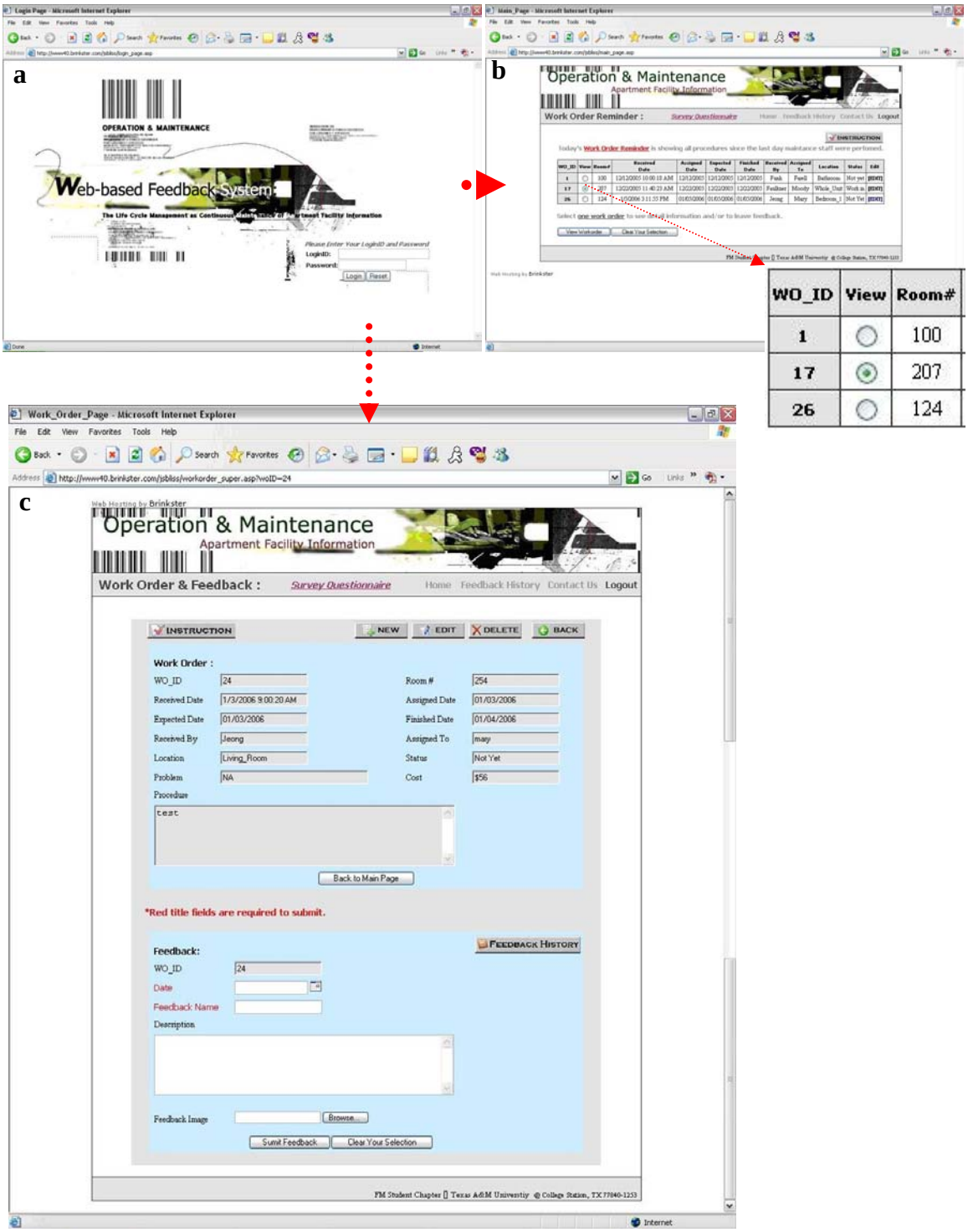


Fig.13. Screen image of second step in documenting feedback for each work order.

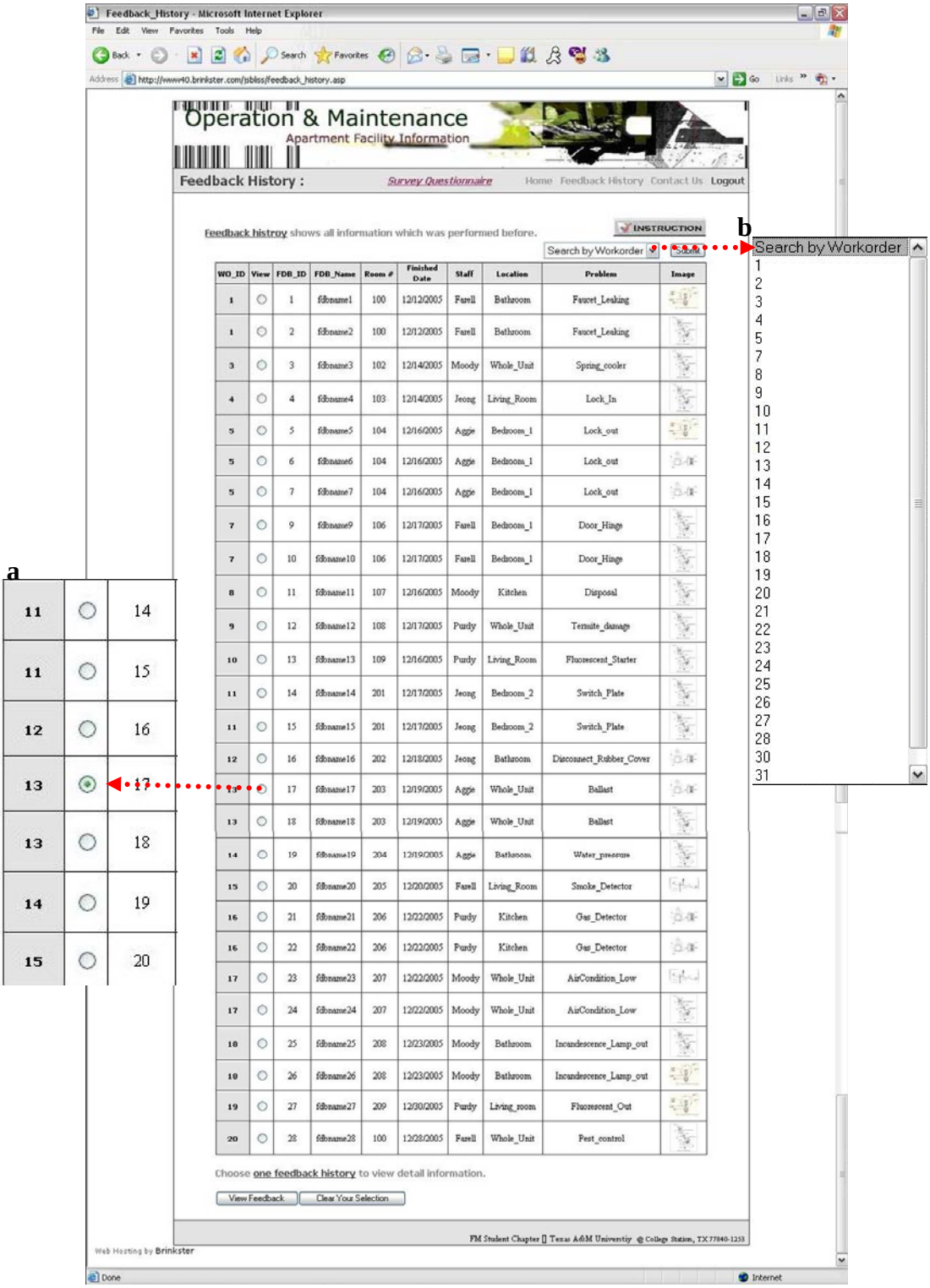


Fig. 14. Screen image of third step in documenting feedback for each work order.

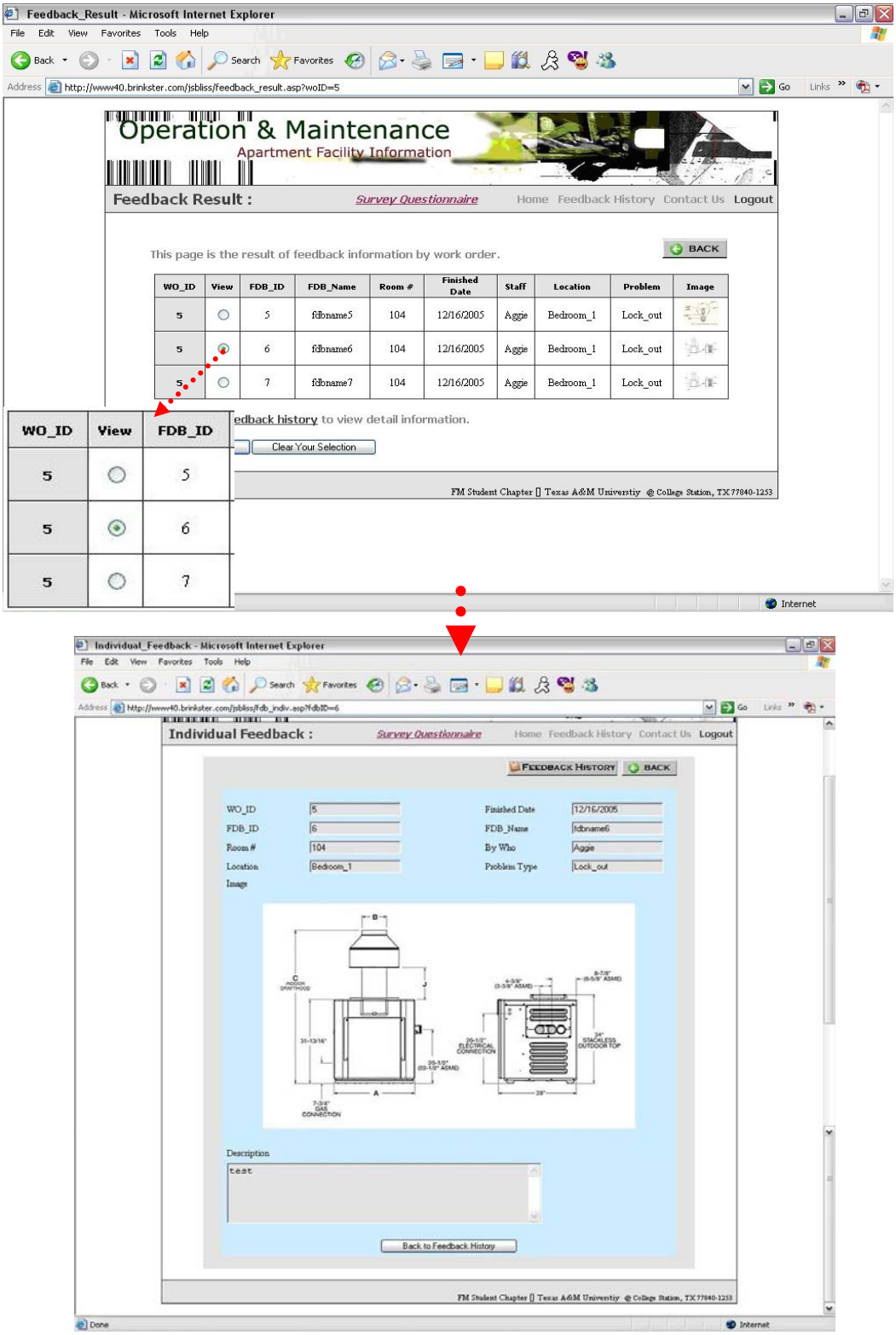


Fig. 15. Screen image of fourth step in documenting feedback for each work order.

CHAPTER VI

SYSTEM TESTING AND EVALUATION

6.1 Prototype Testing Process

The software was tested using two types of prototype testing: first, system testing to evaluate functionality, usability and capability; and second, empirical testing to evaluate usability and interface in the practical fields of facility management. The characteristics assessed by each testing process to verify design fundamentals are shown in Fig. 16. The system was evaluated using the following steps:

- The first step involved the functionality testing of the system by the developer the guide for evaluating engineering software. The first phase of testing does not involve the actual users. This testing is to be carried out by the developer in order to fix bugs that are encountered during the process of system application.
- The second step involved a survey in the form of a post-task questionnaire (see Appendix B). Participants received the questionnaire on the web after they used the system. The questionnaire was divided into three sections: (1) concept and interface, (2) usability, and (3) detailed feedback. The questionnaires from the respondents were analyzed to test the research questions. Survey results are helpful in the evaluation of the tool and its future use. Apart from gathered survey, results from the tool available through its data monitoring will be helpful in that instructors and researchers

can analyze this generated audit trail to create better practical software tools and to study patterns of usage of tool by users.

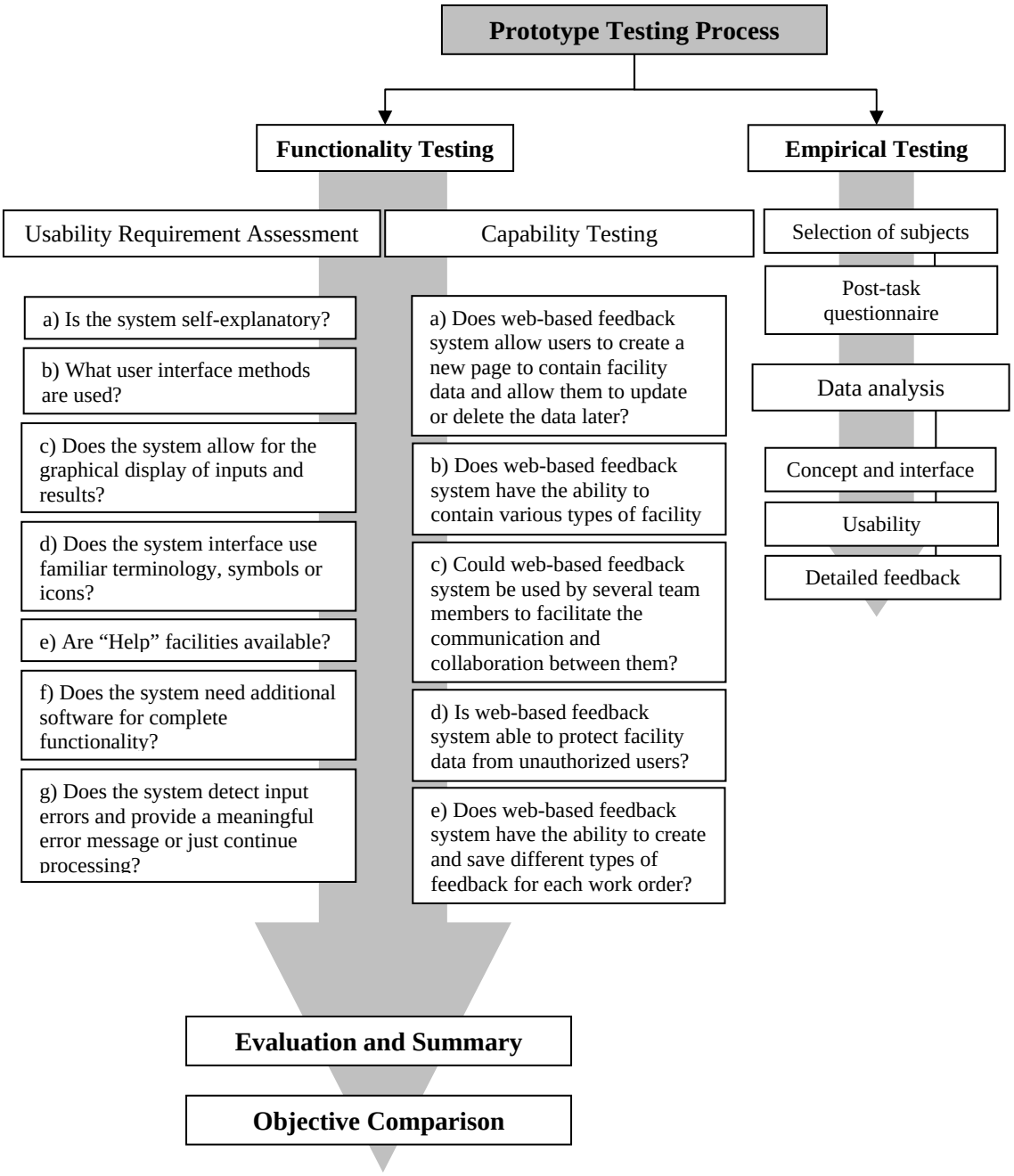


Fig. 16. Prototype testing process diagram.

6.2 Testing Phase 1: Functionality Testing

A prototype of a web-based feedback system was set up and tested based on the guide for evaluating engineering software [33]. A number of considerations and system features could have direct impact on the usability and the capability of the system. The functionality testing and evaluation of the system was carried out to determine whether the system can effectively perform its functions. In this study, the test was separated into two sections:

- Usability requirement assessment.
- Capability testing.

Usability Requirement Assessment

The usability requirement evaluation involves assessing software components to see if they must comply with the guide for evaluation engineering software. Moreover, the system interface which is included in these features is a significant element which could influence the functionality of software and the efficiency of users. The evaluation from the review of the prototype features, which are considered as part of the essential functionality of the software, consists of the following:

a) Is the system self-descriptive?

This system is written with hypertext markup language and Active Server Pages scripts, which use a web browser to show data. Because its interface is easy to understand and familiar to users, as it resembles typical web sites, the system is self-explanatory. Users require no additional training to view and search for the information. When needed, a link to instructions is clearly indicated on the main work area, where

users can find it easily and hyperlinked to another web page. Hypertext links are distinguished by their color and forms.

b) What user interface methods are used?

This system uses screen pick devices, such as mouse and keyboard, menus in navigation bars, and screen forms, and tables. These methods are widely used in most web sites on the Internet and most computer applications.

c) Does the system allow for the graphical display of inputs and results?

In this system, data input or output type is showed in both graphic and text format as shown in Fig. 17. The results of data are displayed as image or photo formats and in a tabular form formatted for content and logically grouped. Also, to make users understand the message easily, error messages are translated from programming language to graphical display as shown in the figures on p. 63.

d) Does the system interface use familiar terminology, symbols or icons?

Terminology used in this system is targeted to various user groups, such as operations personnel. Some jargon, therefore, may be unfamiliar to personnel outside the targeted user group. However, most icons and graphics on web-based feedback system interface use familiar symbols and comprehensive terminology.

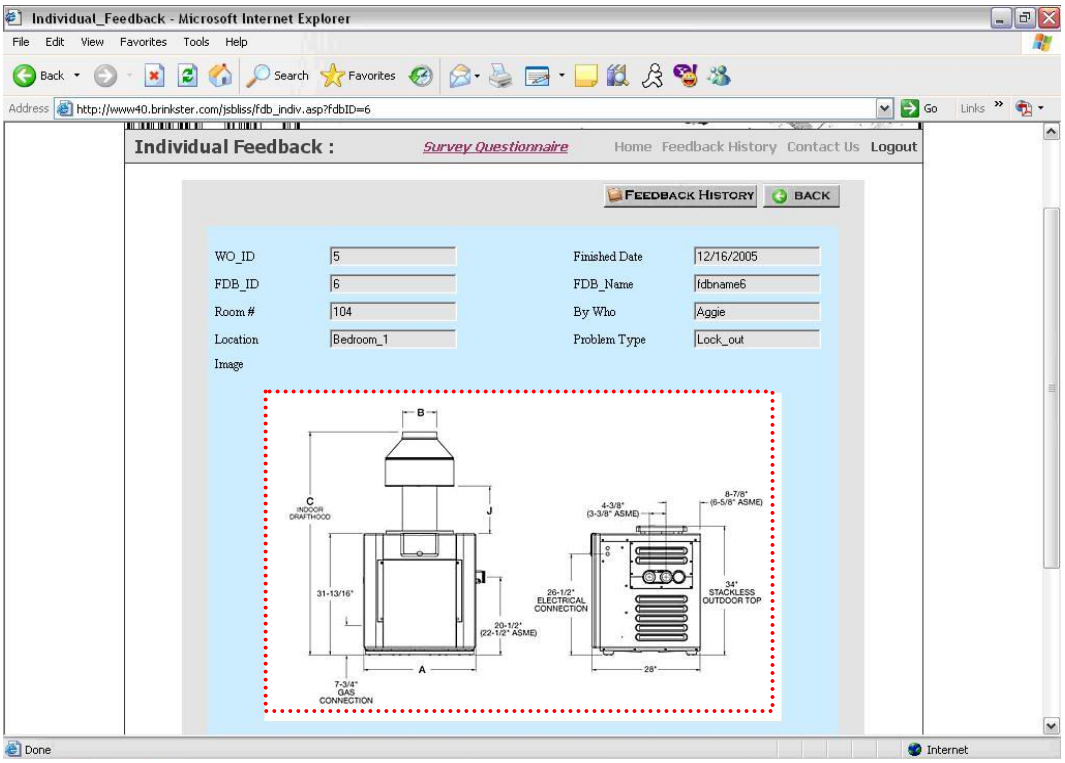


Fig. 17. Screen image of the graphical display of results.

e) Are on-line Help facilities available?

This system provides Help facilities for some applications, but not the entire system. The instructions for each section are located on right or left side where they are easily found. An icon hyperlinks to context-sensitive instructions and descriptions. For instance, the screen display providing instructions telling users functions available with a particular tool is shown in Fig. 18.

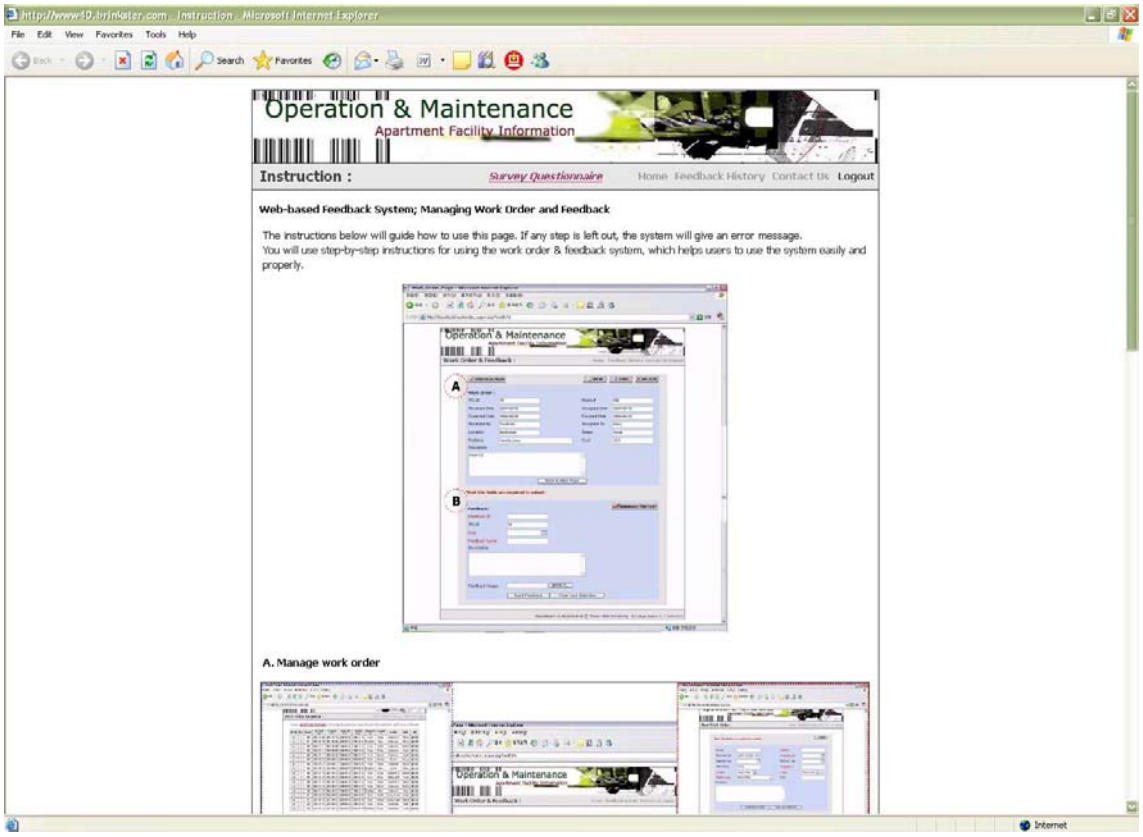


Fig. 18. Screen image of \Help\ facilities.

f) Does the system need additional software for complete functionality?

Web-based feedback systems need a connection to a server to perform most functions and use a web browser to display data. The system needs some plug-ins to extend functionality, such as uploading image files and sending e-mails. To upload image to server, this system uses Dext.FileUpload Component, as shown in Fig. 19. The e-mail component is shown in Fig. 20.

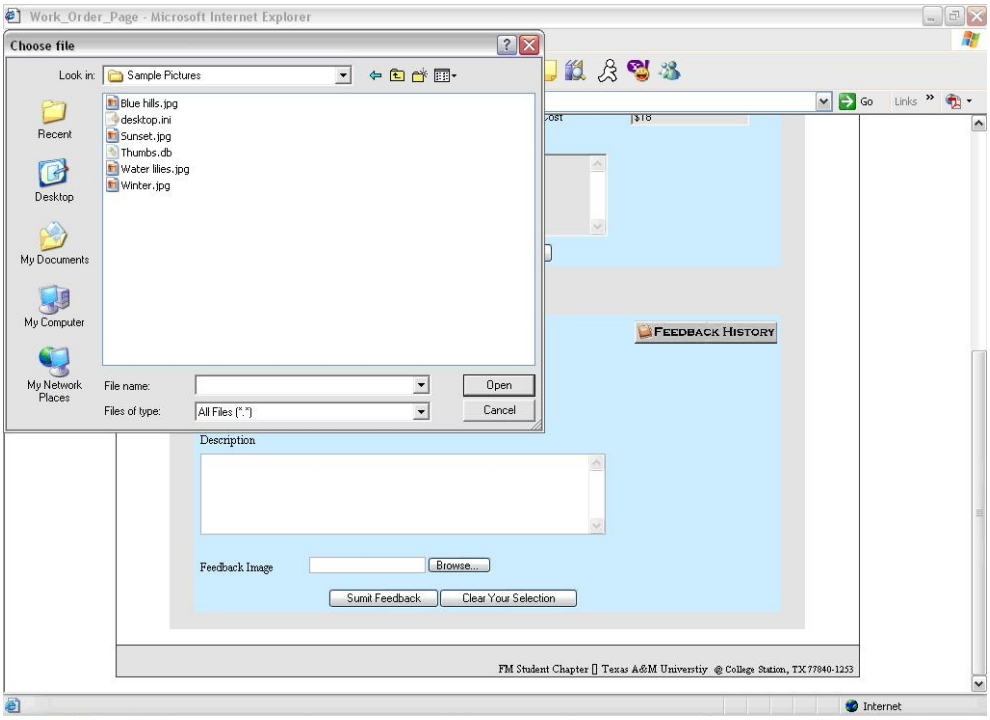


Fig. 19. Screen image of file upload component.

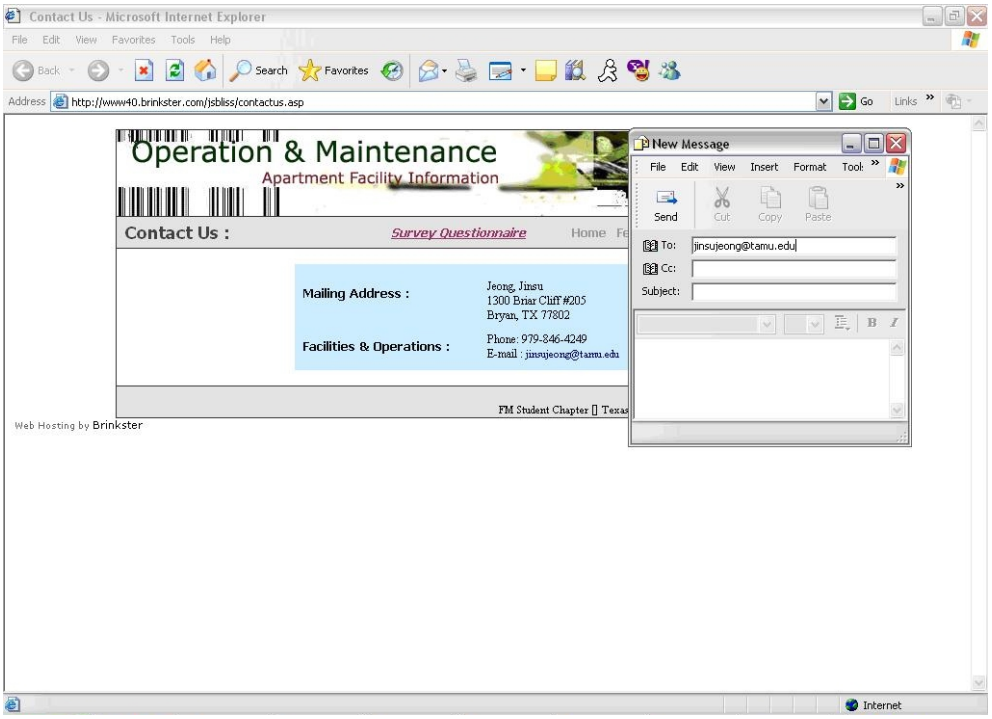


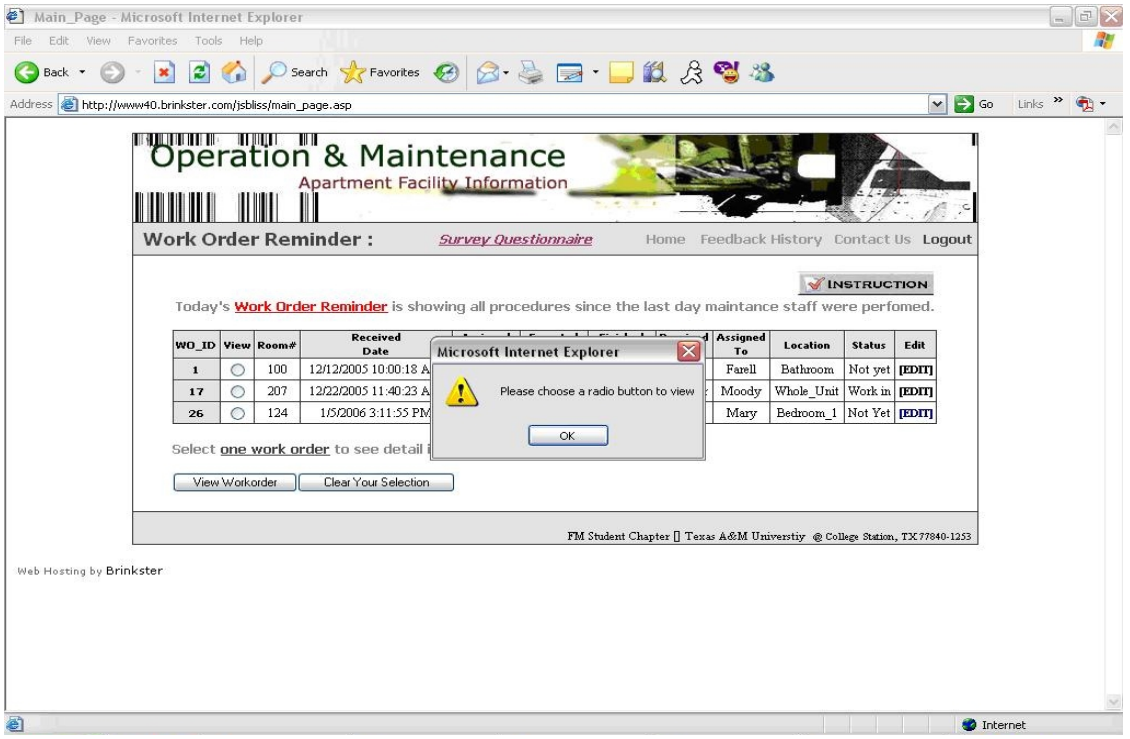
Fig. 20. Screen image of e-mail component.

g) Does the system detect input errors and provide a meaningful error message or just continue processing?

This system provides a meaningful error message when users enter invalid data in the forms of the new feedback and work order section. Required fields are indicated in red. When invalid data are submitted, the web-based feedback system detects the invalid data and displays an error message notifying the users to correct input data and check the buttons. The error message is translated from programming language to a comprehensible and meaningful message. Fig. 21 to Fig. 23 shows examples of the resulting error message when users did not provide appropriate information. Users cannot continue processing until they provide the proper information and filled the required fields.

Capability Testing

To verify that this system can execute all tasks properly, system capabilities must be tested. To test capability, first accounts were set up for target users, such as supervisors and maintenance staff. These user accounts have different levels of authorization as shown in Table 3, Chapter IV. To investigate the tasks and output performed by the system, the system was tested by accessing each different user level. The test and results are described as follows:



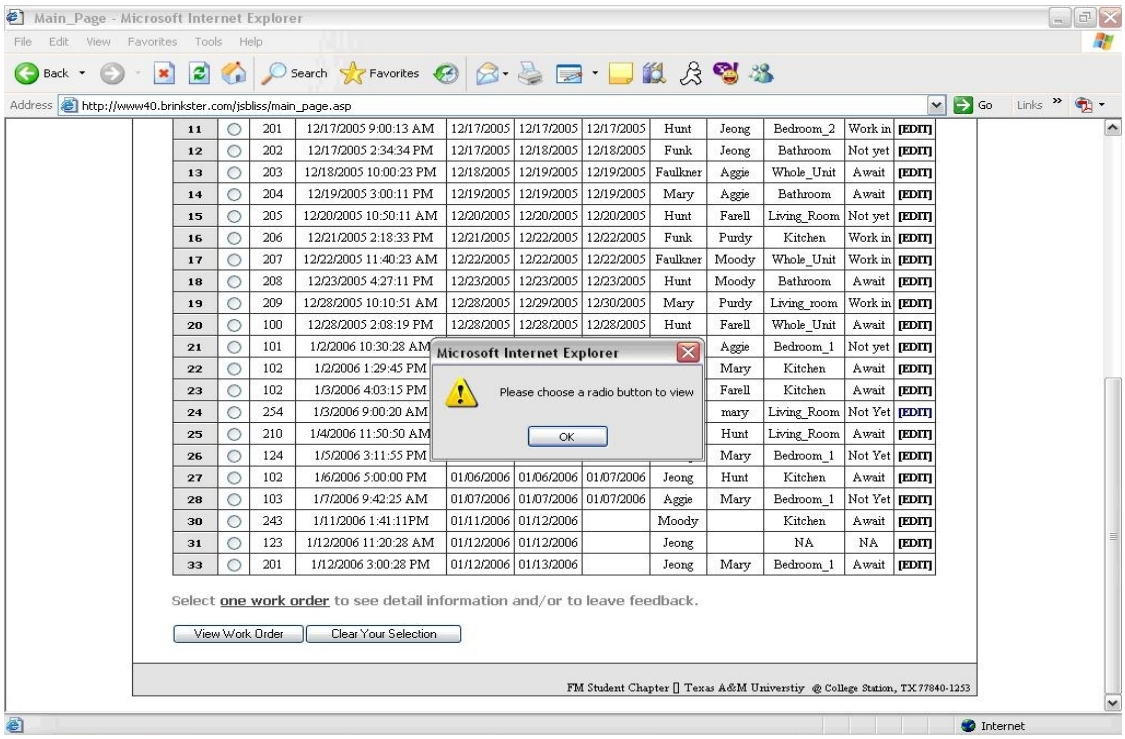


Fig. 21. Screen image of processing error messages in the work order reminder field.

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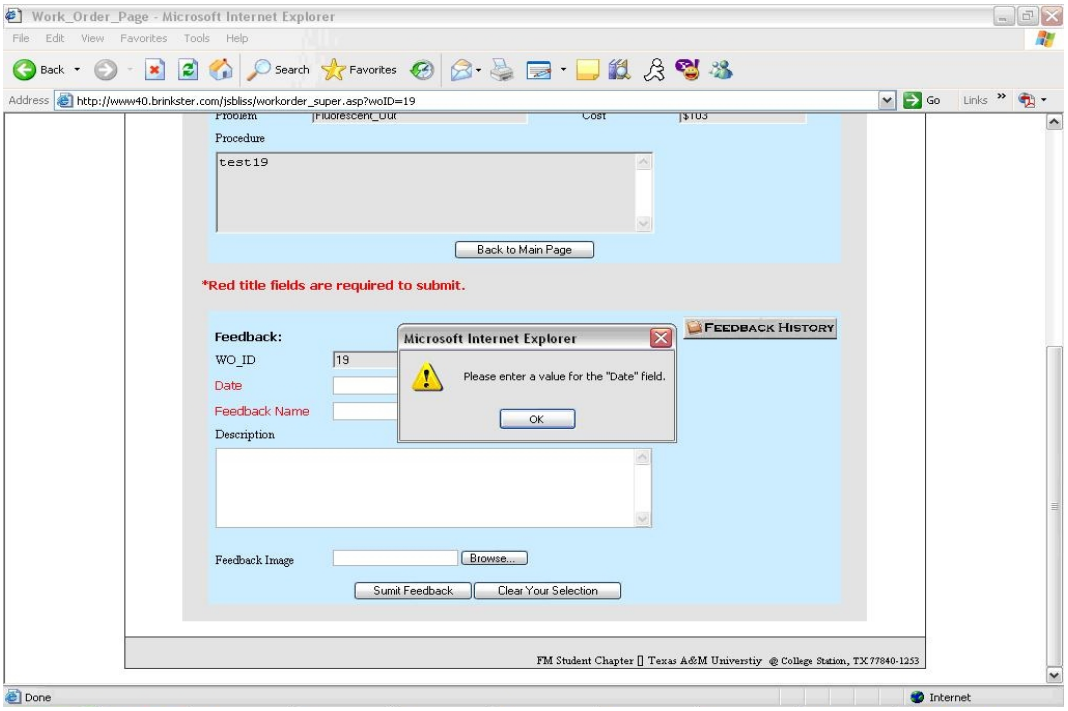


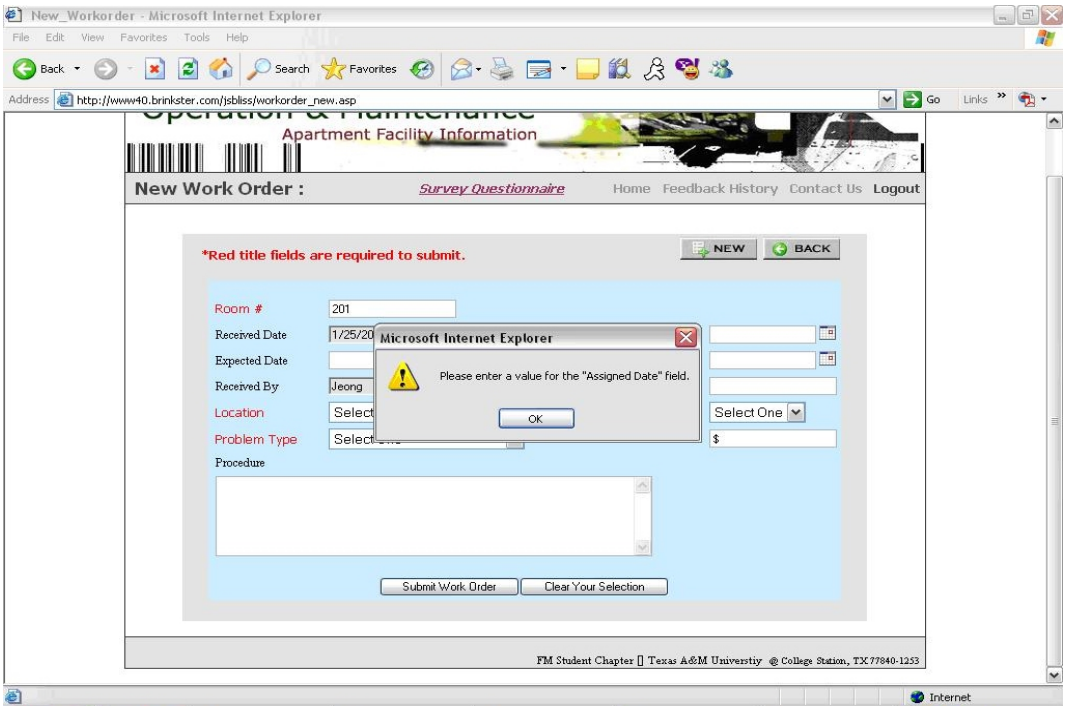
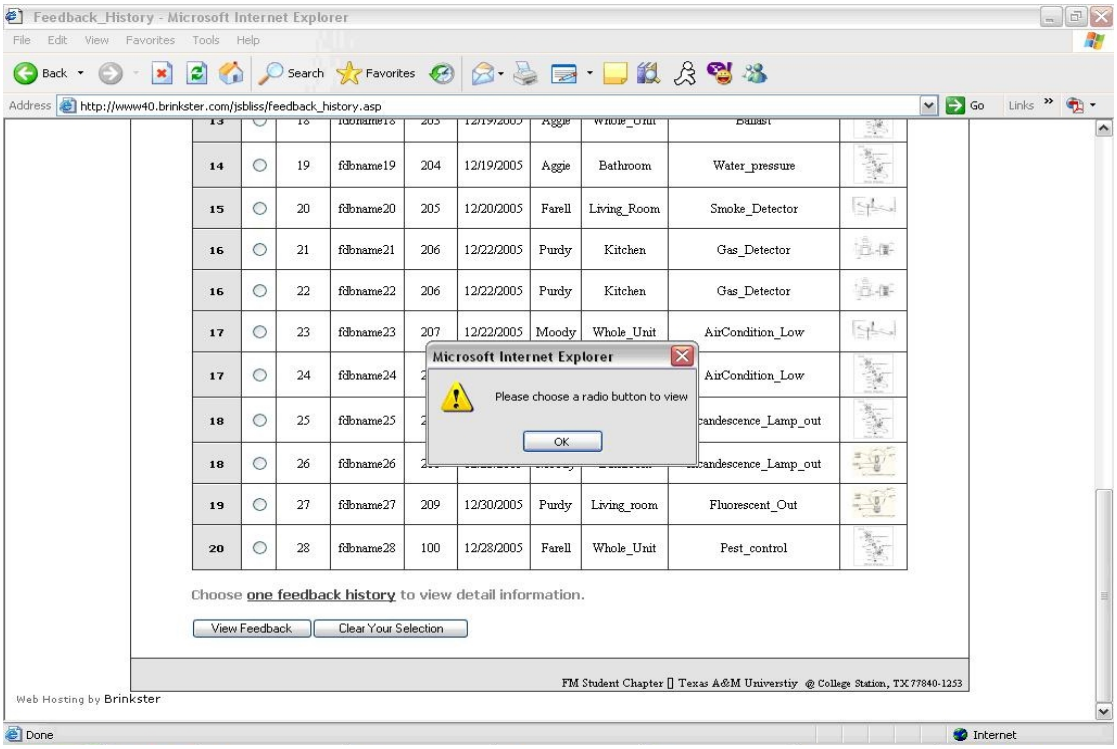


Fig. 22. Screen image of input error messages in the work order fields.



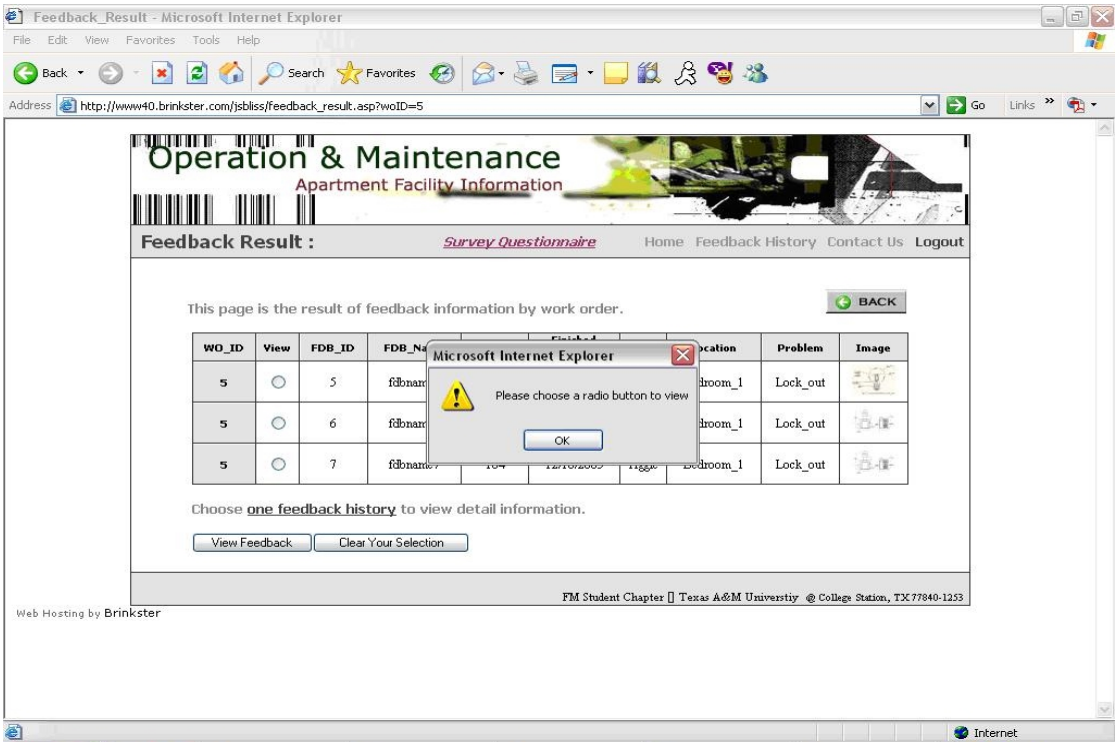
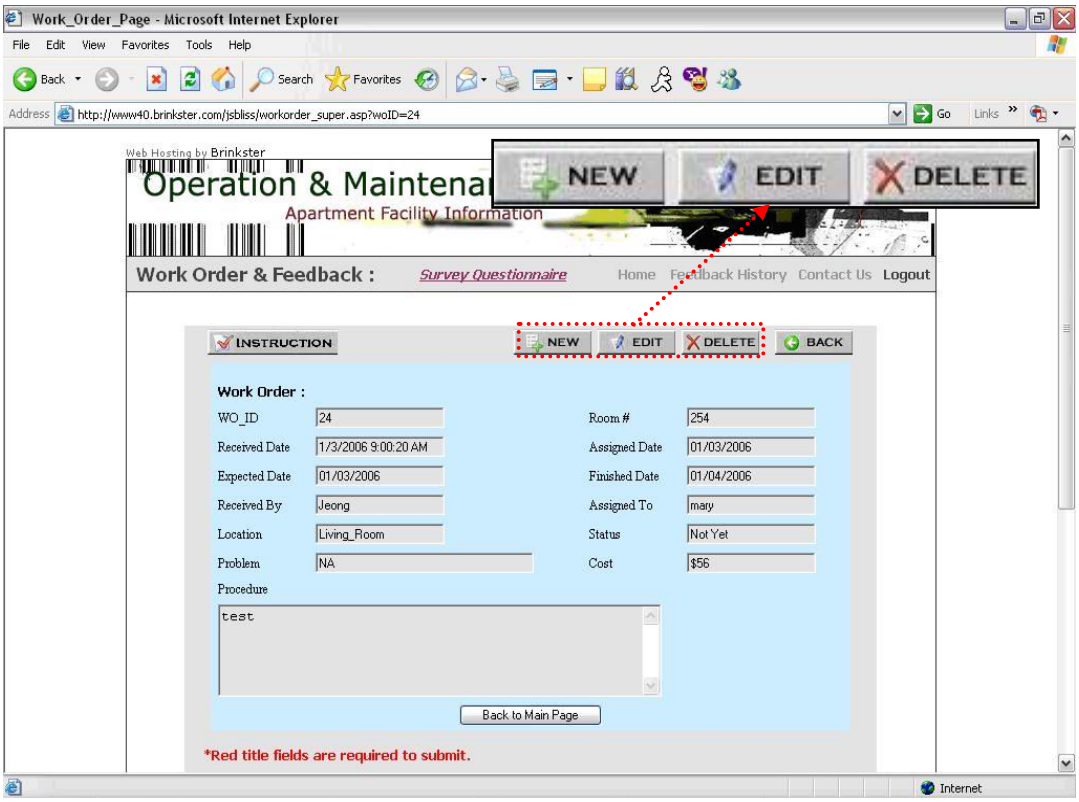


Fig. 23. Screen image of processing error messages in the feedback field.

a) Does the web-based feedback system allow users to create a new page to contain facility data and allow them to update or delete the data later?

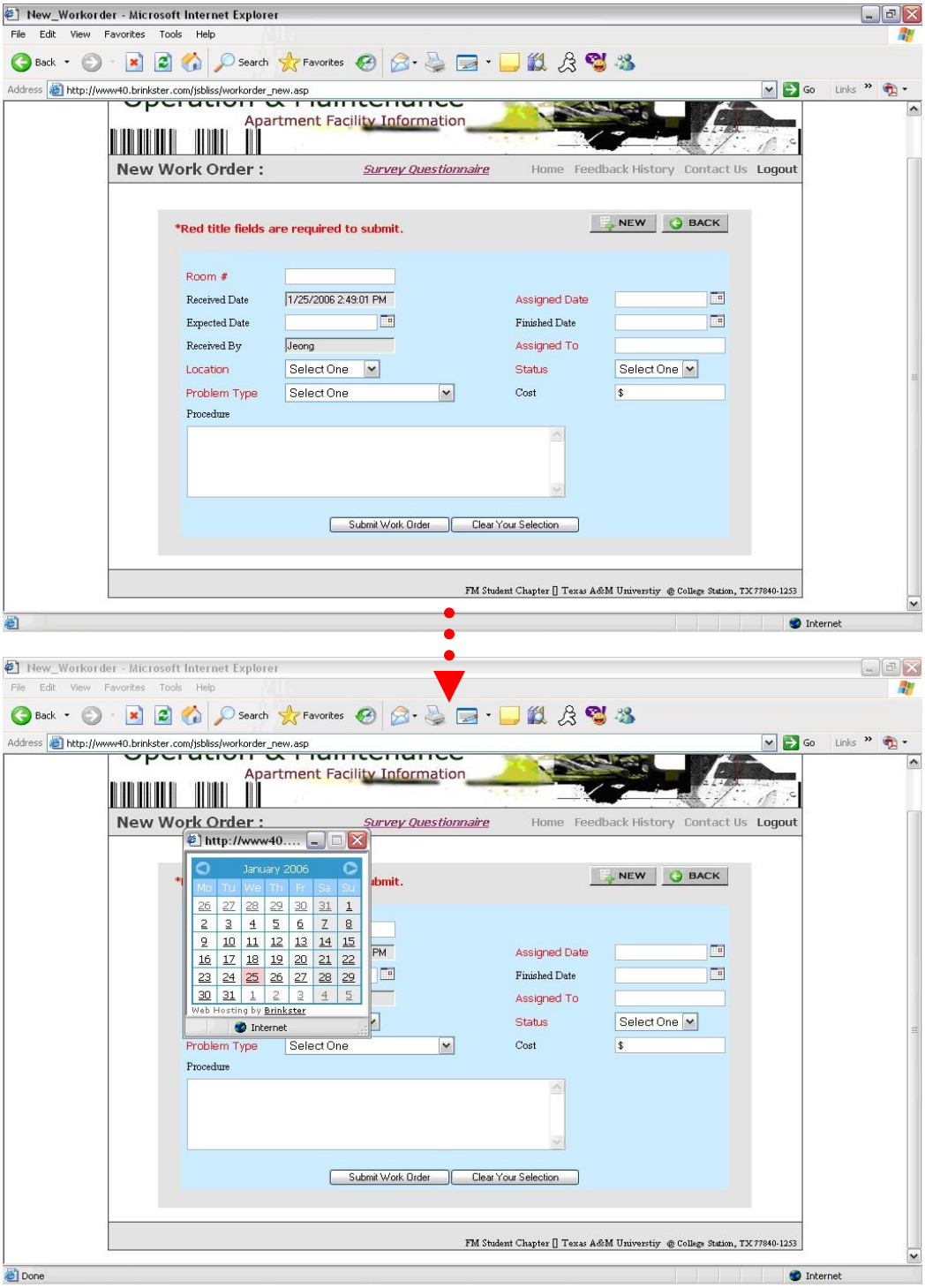
The system was tested using the administrator account, which has full authorization to access any section containing creating, updating, and deleting pages. New work order and/or feedback were created, updated, and deleted by using the provided forms in each part of the system during the test. Afterward, users can see the new pages which were added or changed. The system performed the tasks of creating, editing and deleting properly. The data output were displayed as they were input from the user.

The result could confirm that an authorized user be able to add a new facility data, and to update or delete the data later. Fig. 24 illustrates one example from the test. The test assigned a user with an administrator account to create a page containing the required data. After accessing the work order and feedback section (a), the user was able to create a new page, and to update or delete an existing page. The user began by creating a new page by using the new page form (b). After form was submitted, a new page was created as shown in (d). Afterward, the user accessed the editing form (c). It could be seen that the form also provided the data that the user submitted before and allowed the user to edit those data. After editing, the user submitted and viewed the page again and found that the data have been changed correctly and were displayed on the same page the user created at the beginning (a).



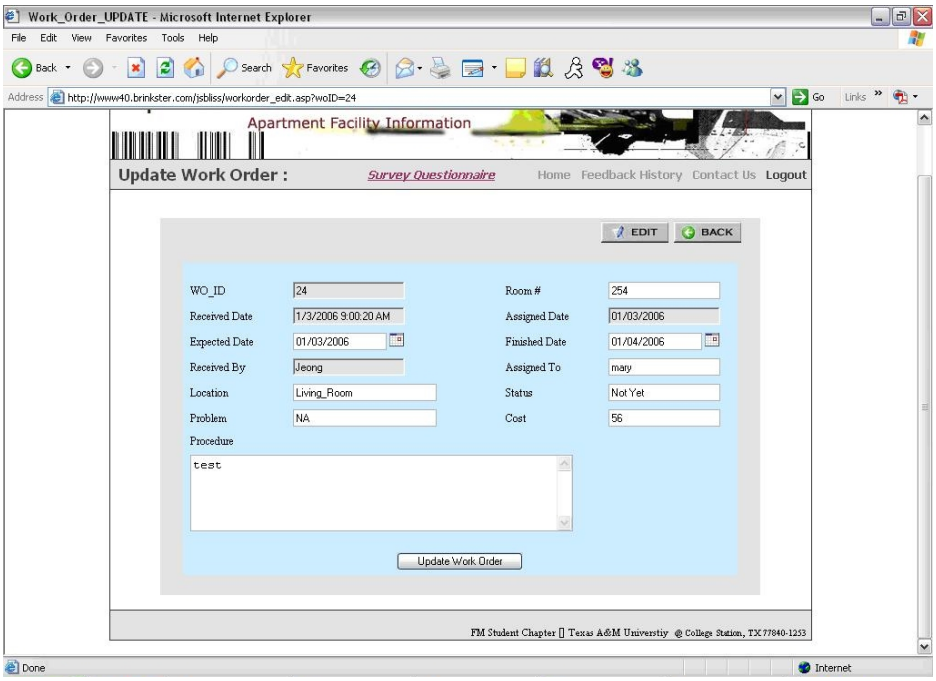
(a) Selecting new, edit or delete work order options

Fig. 24. Screen images of new, update and delete work order.

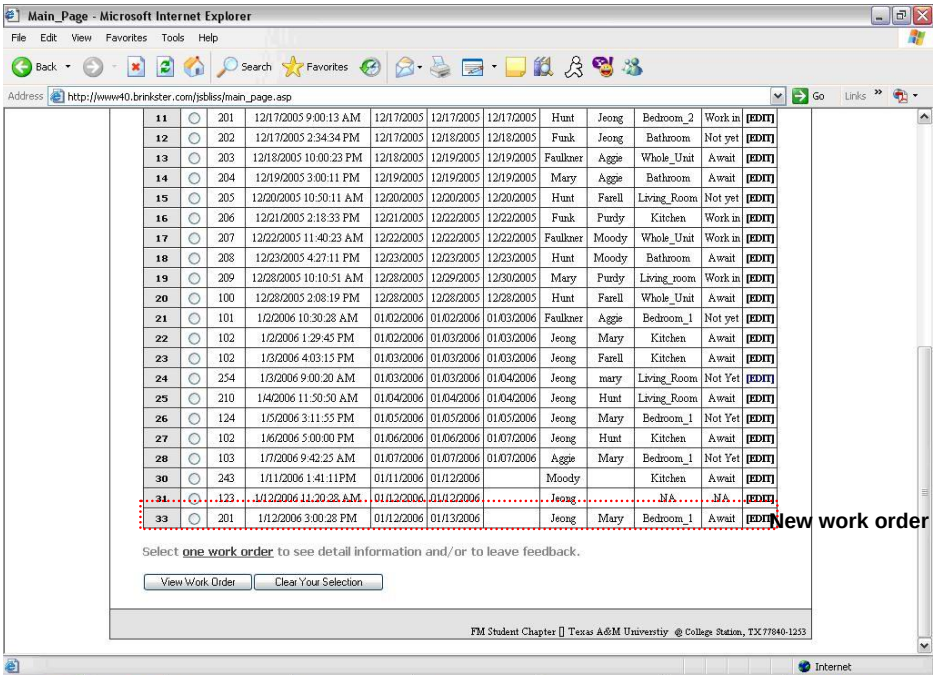


(b) Creating new work order

Fig. 24. continued.



(c) Editing the existing work order



(d) Confirm the new or changed work order

Fig. 24. continued.

b) Does web-based feedback system have the ability to contain various types of facility data?

Testing determined that the system has the ability to include various types of facility data, such as text data, photos, and graphic. An example of the test is illustrated in Fig. 25. During the test, text data were submitted to each section and a few feedback images were uploaded to creating a new feedback for each work order. The system was able to contain data such as text inputs and image files. The image files were selected and uploaded, with a text description entered into the form. The web-based feedback system received and stored the text data and the files into the database and displayed them on the new page correctly.

A web-based feedback system uses a web browser to display data, so is limited to displaying only files in web-based format. For instance, images must be in formats such as .jpg and .gif. Some formats might need plug-ins to display the file content. Also, image files such as .jpg or .gif are web-based format need additional component to upload to the system.

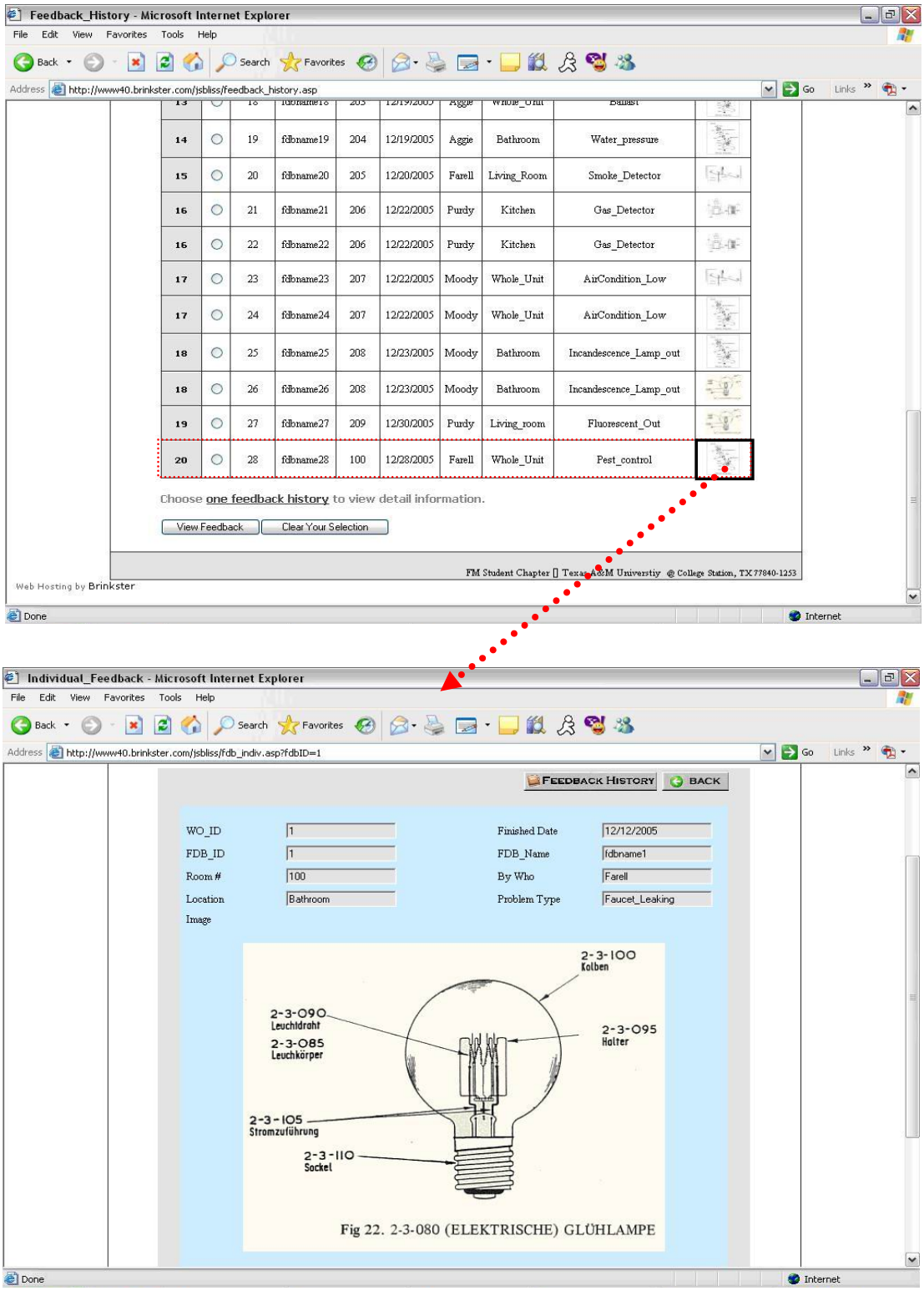


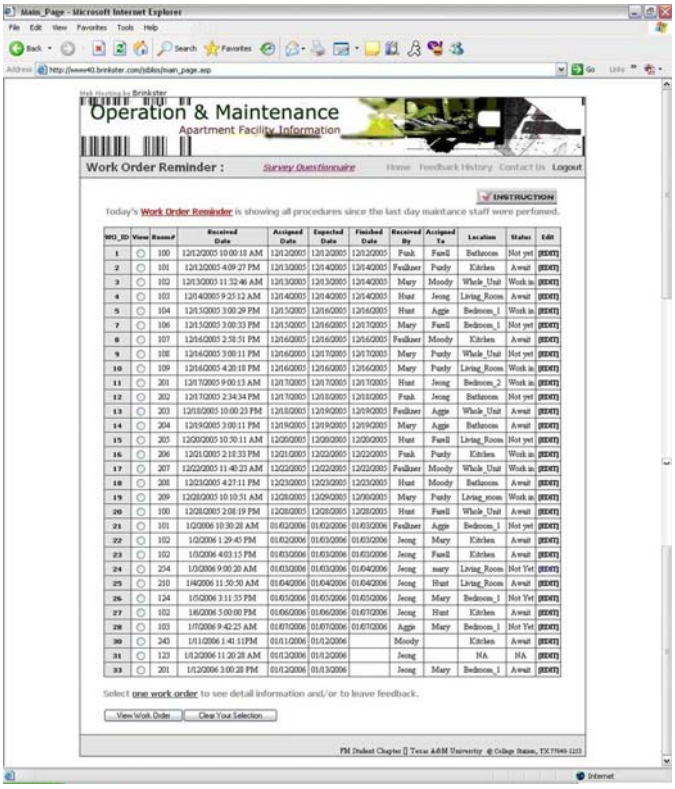
Fig. 25. Screen images of facility data showing text and images.

c) Is the web-based feedback system able to be used by several team members to facilitate the communication and collaboration between them?

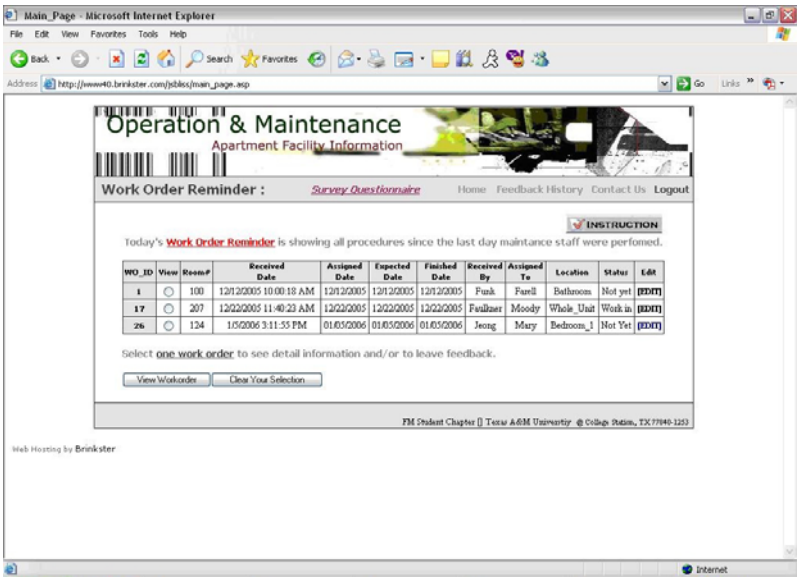
The system can facilitate the communication and collaboration between several team members. To test this system feature, the system was set up on the web (http://www40.brinkster.com/jsbliss/information_sheet.asp). All facility data were provided and stored in the database on the network server. During the test, the system was tested by allowing several user accounts to access the system simultaneously. Users logging on the system viewed several pages of data randomly on each machine. The requested data was displayed properly in response to user requests. In addition, the data could be viewed on other machines immediately when new data were submitted on the system.

d) Is the web-based feedback system able to protect facility data from unauthorized users?

The system was tested by accessing the system. The results are shown in Fig. 26 that the system displayed different navigation pages for each user according to their authorization level. The account of director, manager, and supervisor were able to access all work orders (a). The accounts of maintenance workers were able to access only information which is related to their job functions (b). Maintenance workers' access was limited to adding new work order, deleting the existing work order, and viewing all facility information. A denied message was given to the invalid user accounts in the login section (c).

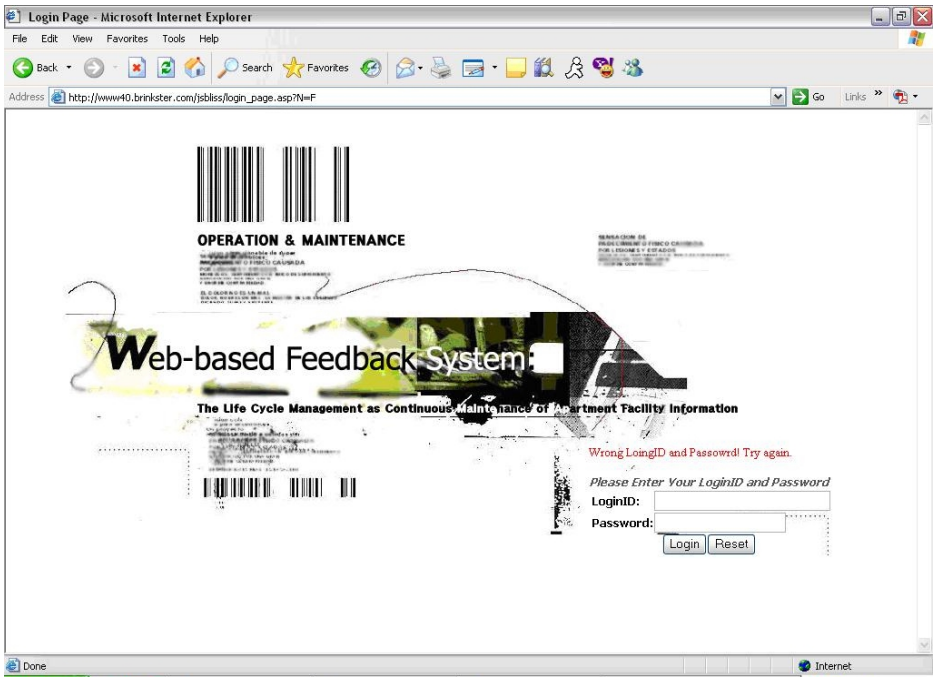


(a) Screen image of the page to be viewed by above supervisor access level



(b) Screen image of the page to be viewed by maintenance workers

Fig. 26. Screen images of different pages for different users.

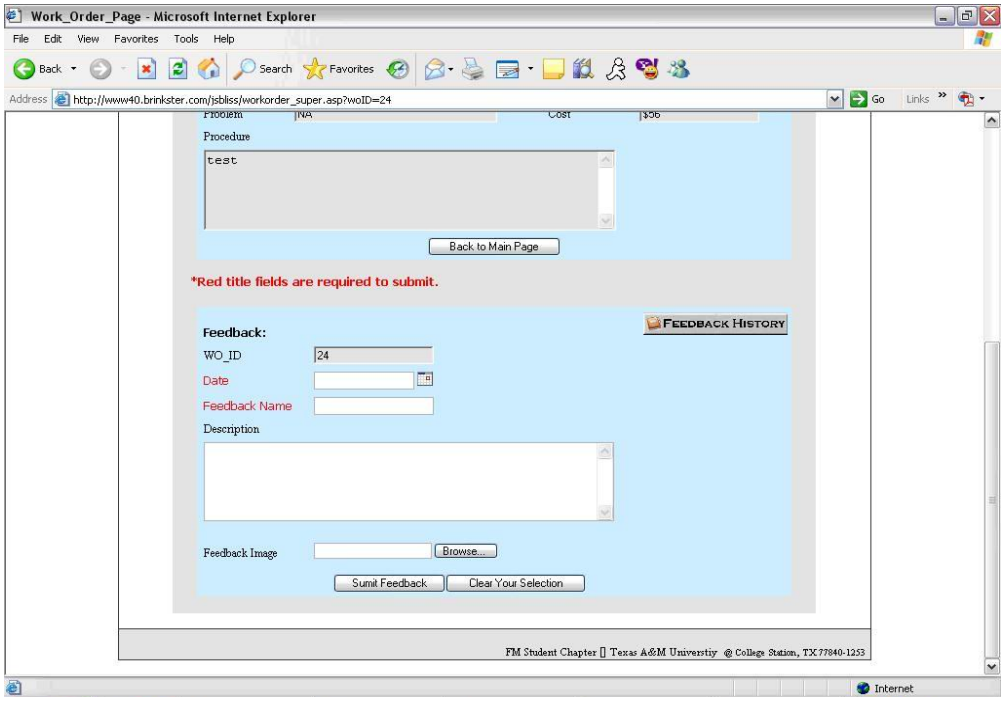


(c) Screen image of the page to give the denied message for individual users

Fig. 26. continued.

e) Does web-based feedback system have the ability to create and save different types of feedback for each work order?

The system gives the ability to create more than one feedback instance for each work order. Moreover, the feedback is data saved into database automatically. Users can later view this information electronically in convenient format. The process and result of creating and viewing the different types of feedback for each work order are shown in Fig. 27.



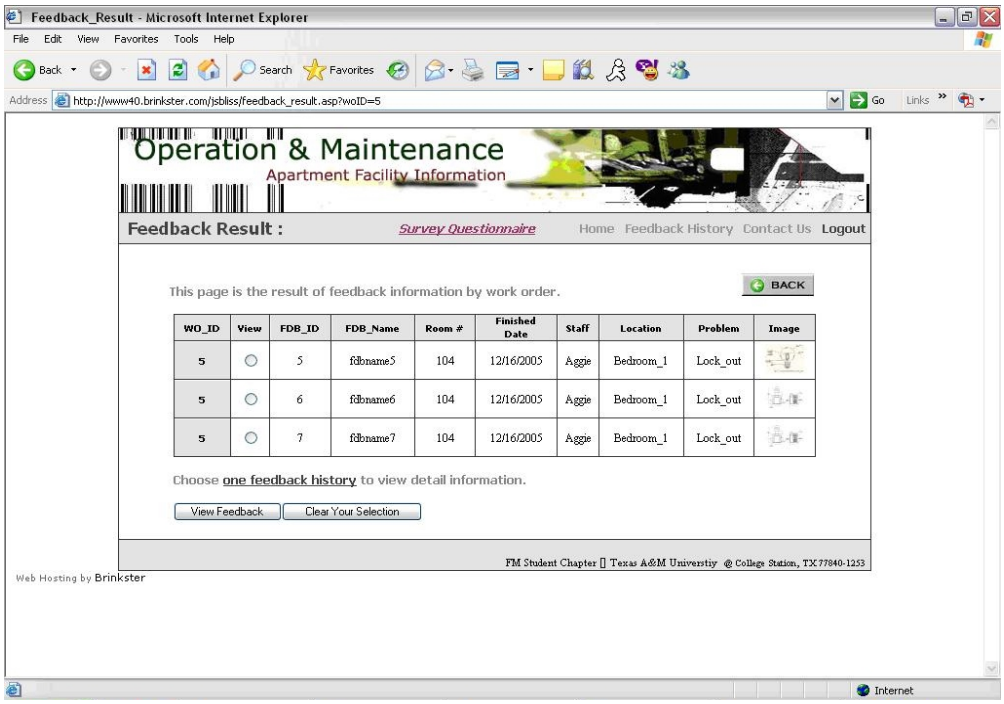


Fig. 27. Screen images of creating different types of feedback for each work order.

6.3 Testing Phase 1: Evaluation and Summary

The functionality testing results are summarized in Table 7. It can be seen that web-based feedback system could perform data delivery and documentation tasks properly according to system design concepts. To evaluate the testing phase 1, objective comparison was used to verify performance of this system between customer-side feedback and operations personnel-side feedback and between a conventional method and the web-based method. The evaluation and summary for testing phase 1 was separated into two sections:

- Evaluation and summary of prototype testing
- Objective comparison

Evaluation and Summary of Prototype Testing

Table 7
Summary of web-based feedback system test and evaluation

Functionality Testing and Evaluation			
Usability requirement assessment	Yes	No	Comments
a) Is the system self-explanatory?	X	-	HTML, ASP, and web browser gives understandable user interface.
b) What user interface methods are used?	X	-	Menus, sub-menus, screen format and tables, and screen pick devices.
c) Does the system allow for the graphical display of inputs and results?	X	-	Image formats, tabular form, and error messages.
d) Does the system interface use familiar terminology, symbols or icons?	X	-	Some terminologies are jargon.
e) Are on-line Help facilities available?	X	-	The instruction is available on the right or left side of some sections.
f) Does the system need additional software for complete functionality?	X	-	Some plug-ins is required to upload image files and send emails.
g) Does the system detect input errors and provide a meaningful error message or just continue processing?	X	-	If invalid data are submitted, the system will ask the user to correct them before continuing the process.

Table 7 (continued)

Functionality Testing and Evaluation			
Capability testing	Yes	No	Comments
a) Does web-based feedback system allow users to create a new page to contain facility data and allow them to update or delete the data later?	X	-	Users can create, update, and/or delete date according to their authorization level.
b) Does web-based feedback system have the ability to contain various types of facility data?	X	-	Some plug-ins is required to upload image files.
c) Is web-based feedback system be used by several team members to facilitate the communication and collaboration between them?	X	-	Set up on the web (http://www40.brinkster.com/jsbliss/information_sheet.asp).
d) Is web-based feedback system able to protect facility data from unauthorized users?	X	-	According to authorization level, user can access the date which is authenticated.
e) Does web-based feedback system have the ability to create and save different types of feedback for each work order?	X	-	Each work order is able to have more than one feedback.

Objective Comparison

To evaluate the functionality testing, objective comparison was used verify performance of this system between customer-side feedback and operations personnel-side feedback and between conventional method and web-based method. The objective comparison to verify this system was divided into two sections as mentioned above:

- Customer-side feedback and operations personnel-side feedback
- Conventional method and web-based method

Comparison of Customer-side Feedback and Operations Personnel-side Feedback

The literature indicates that information technology-based solutions merely allow people to search for and retrieve only explicit knowledge [7]. Therefore, the emphasis on IT may reduce the attention to making feedback practical and useful; consequently,

feedback may be lost or unexploited due to information overload or processes that do not document and organize information that is collected.

The purpose of obtaining customer feedback is to describe how successfully the project was managed and to judge customer satisfaction with the project. Table 8 summarizes work process analysis of the evaluation work [39]. Electronic surveys can be used to automate and simplify the evaluation process.

Table 8
Work process analysis example: evaluation work [39]

Task	Possible problems	Possible intranet solution
Obtain feedback from customer	Time to survey customers; low response rate to paper questionnaires	Use electronic surveys (electronic forms); automate the work flow.
Analyze customer response	Time to enter and analyze data	Automate data analysis and report generation.
Report companywide experience	Time to collate, analyze and report customer response over time by job categories	Create a historical database of all customer evaluations; automate reports.

The purpose of operations personnel-side feedback is to improve facility management service quality and build a record of practical experience through receiving feedback from maintenance teams. Also, practical experiences provide feedback of successful usage of IT as significant resources in facilities management practices.

Comparison of Conventional Method and Web-based Method

An objective comparison between conventional methods (using face-to-face, paper documents, and electronic formats) and web-based method was conducted to validate and compare the performances of web-based feedback system as shown in Table 9.

Table 9
Comparison of conventional method and web-based method [40]

Task	Conventional method	Web-based method
Retrieving the information from the past	Users are required to search through paper files or electronic files. If the user is not the person who saved or organized the files, User could waste a lot of time to search for a file from large data storage.	Users are able to search the needed information by using navigation bars to search and view the stored data. A user will be able to search the stored data conveniently, although the user is not the person who submitted the data.
Distributed the information within a team or between teams	Users may send faxes, mails, e-mails, make a phone call, or hand in person to send the information to team members. However, the users will have to spend some time to organize these records later.	Users can post the information on the web and send automatic emails to inform team members. The information will be saved and organized at the same time.
Organizing electronic files	Users are required to create folders and sub-directories on data storage and manually copy and organize file into each folder.	Users are able to use file-upload feature in each section and submit files to the database. The copies of files will be organized in provided folders and the hypertext links to the files will be automatically created.
Creating a facility web site	Users are required to write HTML documents and scan photos or images to create each page of a facility web site. The knowledge of HTML is also required for maintaining the content of the site.	Users are required to fill out the creating forms and submitted the data to create each page of a facility web site. The users may be needed to scan and upload some photos or images. However, the users are able to create or edit a page without requiring the knowledge of HTML.

The web-based method using the Internet and web-based information to document, share, monitor, and improve the facilities data would be useful for operations personnel by comparing two methods. Also, the summary of the reasons why Internet has been thought of as breakthrough technology was described (see 2.2, Chapter II).

6.4 Testing Phase 2: Empirical Testing

After being granted approval from The Institutional Review Board (IRB) (see Appendix A), a post-task questionnaire survey was conducted to test and review the concept, interface, and usability of the system (Fig. 28). Facility Management Industry Advisor Council members answered the questionnaires after using the system posted on the web as an aid in work order management, feedback delivery, and documentation of their practical experiences. The questionnaires from the FMIAC members were analyzed to test the research questions. The survey will be helpful in the evaluation of the tool and its future use.

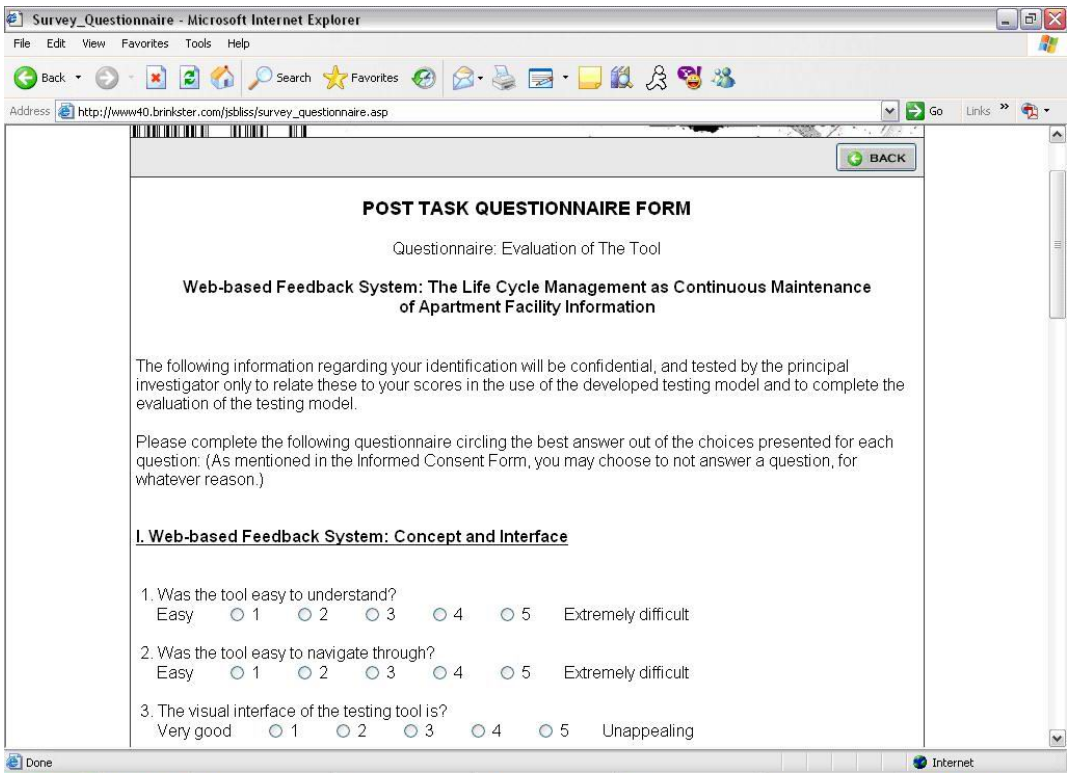


Fig. 28. Screen image of post-task questionnaire on the web.

Selection of Subjects

The target population to study the above research questions consists of experts in the fields of facility management (FM), five or less FMIAC members who are the expert of facility management field. The web-based feedback system software contains information about selected university apartment data from various sources and organized in an electronic format. The information was collected from the journal articles, books, and the Internet. The method of recruitment and selection is as below:

Method of recruitment and selection

1. Obtain FMIAC members' e-mail address.
2. Send e-mail describing this system in detail to determine his/her willingness intention to participate in this questionnaire survey.
3. Notify tester of his or her login name and password via e-mail.
4. The electronic survey sheets were given to the participants after they tested the web-based system.
5. Surveys were saved automatically to the database after completion by the respondents.

The Post-Task Questionnaire

The aim of the post-task questionnaire was to collect the FMIAC members' evaluation of the tool. The questions asked in the form were divided into the following categories:

1. Concept and interface
2. Usability

3. Detailed feedback: A subjective space provided for the participants in the survey form to express their evaluation descriptively about the design of the tool, usability and its application in the practical field.

6.5 Testing Phase 2: Data Analysis

Table 10 shows the data collected from the post-task questionnaire form. The analysis of the survey results reflects that the users accept web-based feedback system. The research method was limited to a very small group and therefore has limited reliability. Further research could improve its validity and reliability.

Detailed Feedback

It was observed that respondents were expressive in answering the detailed feedback. They offered some good suggestions about the application and about the design as a whole. Detailed feedbacks from the participants on the application are transcribed as below.

1. Is there anything you would like to have in this tool that was not there?
    - Text-based search facility would also be good in feedback case falling under more than one category.
    - It would be more helpful if users can mark-up the drawing and forward the corrections using a plug-in component.
    - I can’t think anything not there.
2. Which part about the tool you like least?
    - No, I don’t have. Tool’s functionalities as add new case, browse case, add feedback and browse feedback is a satisfactory way to access information.

- More visuals in the work order's section.

3. Additional comments

- Overall concept of this tool is good. Would like to see it implemented for the real field.
- Design is impressive and easy to work with.

Table 10
Data analysis: concept and user interface of the system
Total number of subjects: 3

fStatements from Post-task Questionnaire	Number of Participants				
	5	4	3	2	1
	Positive ---------- Negative				
I. Web-based feedback system: Concept and Interface					
1. Was the tool easy to understand?		2	1		
2. Was the tool easy to navigate through?	1	1	1		
3. The visual interface of the testing tool is?	1	2			
4. Was the tool easy to learn?		2	1		
5. Are the buttons labeled meaningful?	1	2			
6. Effort to browse for facility in the tool was	A lot Reasonable Minimal			1 2	
7. The effort to add new facility information into the system was	A lot Reasonable Minimal			2 1	
8. Previous experience with such a similar tool	Yes No			1 2	
	5	4	3	2	1
	Positive ---------- Negative				
II. Web-based feedback system: Usability					
1. The task that tool supports as Add new work order and/or feedback and Browse work order and/or feedback is satisfactory way to collect and access the information?		2	1		
Suggestions:	- Diverse types of graphics and images needed - Detailed search function in feedback section needed				
2. The information provided in the tool about work order and/or feedback is readable?	3				

Table 10 (continued)

Statements from Post-task Questionnaire	Number of Participants				
	5	4	3	2	1
	Positive ---------- Negative				
II. Web-based feedback system: Usability					
3. The tool's facility to add and view feedback about work order was?		2	1		
4. Do you think tool will be helpful in saving your time, while providing you information at one place?		2	1		
5. Did you like working with this tool?		2	1		
6. Performance of the tool was satisfactory?		2	1		
7. Would you recommend such a tool to other people?	1	1	1		

CHAPTER VII

CONCLUSION

7.1 Conclusion

The demonstration of the web-based feedback system prototype validated the first research question:

Question 1: ***Is a web-based feedback system able to be developed to improve delivery and documentation of the tasks of facility information by electronic means, especially work orders and feedback, in FM practices?***

The web-based feedback system can be developed to facilitate the tasks of creating and updating facility information in FM practices. It can be seen from the capability testing that web-based feedback system improves delivery and documentation of work orders and feedback history. It provides tools to assist operations personnel in collecting and organizing facility data, especially feedback history for each work order, conveniently.

The results of web-based feedback prototype development validate the second research question;

Question 2: ***Is a web-based feedback system able to be developed for operations personnel to share and monitor facility information more efficiently and effectively without requiring additional training?***

The feedback delivery and collection medium, such as a web-based feedback system, could be developed for operations personnel to share and monitor facility data efficiently and effectively without requiring additional training. From the capability

testing, it is shown that this system can perform the tasks of monitoring and sharing data conveniently. By integrating a database management system with web technology, a prototype web-based feedback system was developed allowing operations personnel to data via a web browser user interface. The web-based feedback system provides the tools and forms to enable the operations personnel to maintain a web-based facility archive or web site without knowledge of HTML.

Web-based feedback systems are the result of the attempt to exploit the advantages of the Internet and web technology to improve the feedback delivery and collection medium in the field of FM. This implies the third research question regarding how the field of facility management can take the advantages of the Internet and web technology as other fields do:

Question 3: ***Is such as a web-based feedback system able to be developed to improve the existing work processes using intranet or extranet in the field of FM?***

Web-based feedback systems provide a typical format for an apartment management web site. This could simplify the process of some facility intranet or extranet setup. The facility database could be centralized and effectively used over a network. The distinct advantages of the centralized database are the accuracy and security of the data.

In summary, from the prototype development, the advantages realized by implementation of a web-based feedback system are two-fold. First is the resulting improvement in effective information transaction by the prototype web-based feedback tool. The obvious benefactors of this information would be facilities managers. Second,

the management of facilities would be enhanced if facilities managers could have an efficient means to know when equipment should be replaced and cost saving effected by replacing equipment. Also, such a program will aid facilities managers in maintaining a living document of their facilities.

The facility department has to realize that the work order is a living document. Once the work is complete, there is still the need for feedback. This system enhances the building of knowledge base for facilities departments.

7.2 Further Research

The study has consequently addressed current industry practices and has also sharpened the image of future systems. The feedback received from the test participants and the study of related research can lead to a wide scope of future work. To improve the system for use in a particular case, the specific formats and styles of working aspects should be further investigated and tailored to more closely fit the exigencies of the particular facility. Also, the system and its potential to make information available to users from virtually anywhere can be used to make the widely available.

Enhancements to the system implementation include:

- Additional search facility: Currently the application allows viewing of work orders and feedback on the table format. In order to view the particular work order and/or feedback, a user has to select the work order and/or feedback. For making various and easy search of them, a text-based search facility could also be applied for retrieving cases. A user could type in key words of the desired case.

- Use of other interface and media: Other interface can be incorporated to provide more information. A future implementation could include various interfaces to fit other devices like personal digital assistants (PDA), tabular personal computer (PC), or cell phone. Also, audio and/or video format and 3D graphical models and animations of the particular projects could implement for future media. Several basic technologies can contribute visual explorations of the system as follow:

  Drawing web format (DWF): DWF files can have multiple named views, and layers that can be toggled on and off, as well as embedded links. The settings can be controlled via Java Script and parameters in the HTML code [3].

  Redlining: A number of tools are becoming available that allow simplified editing of a computer-aided design (CAD) file to support mark-ups, note errors, and indicate changes. One such tool of particular interest is CADViewer by Arnona Inc. programmed in Java to allow mark-up of DWF files displayed using a web browser. Another tool is the Volvo View by Autodesk. The Express version is available as a free download. The software can view many file formats and can apply redlines to DWF files [3].
- Adding new information: Currently the application allows users to add a new work order and/or feedback in a specific format. This can be more flexible by allowing users to enter additional information not currently expressed by the software.

- Lager sample size: Testing can be made more rigorous by having each participant take paper-based as well as web-based test in a within subjects experimental design. Also, larger sample sizes would have to be used to effectively test research question in future research activities, as the sample size is very small in this research.

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APPENDIX A

COPY OF APPROVAL FROM IRB

VPR
Office of the Vice President for Research
Texas A&M University

Office of Research Compliance

Academy for Advanced Telecommunication and Learning Technologies

Center for Information Assurance and Security

Comparative Medicine Program

Institute for Scientific Computation

Institute for Telecommunications and Information Technology

Integrative Center for Homeland Security

Microscopy Imaging Center

Office of Business Administration

Office of Distance Education

Office of Graduate Studies

Office of Organizational Development and Diversity

Office of Proposal Development

Office of Sponsored Projects

Professional Development Group

Technology Commercialization Center

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October 3, 2005

RECEIVED
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COLLEGE OF ARCHITECTURE
DEAN'S OFFICE

MEMORANDUM

TO: Jin Su Jeong
Architecture
MS 3137

FROM: Dr. J. Steven Moore, Chair
Institutional Review Board
MS 1186

SUBJECT: IRB Protocol Review

Title: Web-Based Feedback System: The Life Cycle Management as Continuous Maintenance of Apartment Facility Information

Protocol Number: 2005-0489
Review Category: Expedited Review
Approval Date: October 3, 2005 to October 2, 2006

The approval determination was based on the following Code of Federal Regulations:
45 CFR 46.110(b)(1) - Some or all of the research appearing on the list and found by the reviewer(s) to involve no more than minimal risk.

Remarks: Expedited Review Category 7

The Institutional Review Board - Human Subjects in Research, Texas A&M University has reviewed and approved the above referenced protocol. Your study has been approved for one year. As the principal investigator of this study, you assume the following responsibilities:

Renewal: Your protocol must be re-approved each year in order to continue the research. You must also complete the proper renewal forms in order to continue the study after the initial approval period.

Adverse Events: Any adverse events or reactions must be reported to the IRB immediately.

Amendments: Any changes to the protocol, such as procedures, consent/assent forms, addition of subjects, or study design must be reported to and approved by the IRB.

Informed Consent/Assent: All subjects should be given a copy of the consent document approved by the IRB for use in your study.

Completion: When the study is complete, you must notify the IRB office and complete the required forms.

APPENDIX B

POST TASK QUESTIONNAIRE FORM

Questionnaire: Evaluation of The Tool
Web-based feedback system: The Life Cycle Management as Continuous Maintenance of Apartment Facility Information

The following information regarding your identification will be confidential, and tested by the principal investigator only to relate these to your scores in the use of the developed testing model and to complete the evaluation of the testing model.

Please complete the following questionnaire circling the best answer out of the choices presented for each question: (As mentioned in the Informed Consent Form, you may choose to not answer a question, for whatever reason.)

I. <u>Web-based feedback system: Concept and Interface</u>

1. Was the tool easy to understand?
Easy 1 2 3 4 5 Extremely difficult

2. Was the tool easy to navigate through?
Easy 1 2 3 4 5 Extremely difficult

3. The visual interface of the testing tool is?
Very good 1 2 3 4 5 Unappealing

4. Was the tool easy to learn?
Easy 1 2 3 4 5 Extremely difficult

Web-based feedback system Form: Usability Testing

5. Are the buttons labeled meaningful?
Very meaningful 1 2 3 4 5 Distracting

6. Effort to browse for facility information (work order and/or feedback) in the tool was
a) A lot
b) Reasonable
c) Minimal

7. The effort to add new facility information (work order and/or feedback) into the system was
a) Minimal
b) Reasonable
c) A lot

8. Previous experience with such a similar tool?
a) Yes
b) No

II. <u>Web-based feedback system: Usability</u>

1. The tasks that tool supports as Add new work order and/or feedback and Browse work order and/or feedback is satisfactory way to collect and access the information? (Rate your satisfaction)

Not at all 1 2 3 4 5 Very Satisfactory

Suggestions:

2. The information provided in the tool about work order and/or feedback is readable?
Very Helpful 1 2 3 4 5 Not at all

3. The tool's facility to Add and view feedback about work order was?
Very Helpful 1 2 3 4 5 Not at all

4. Do you think tool will be helpful in saving your time, while providing you information at one place?
Not at all 1 2 3 4 5 Very much

5. Did you like working with this tool?
Not at all 1 2 3 4 5 Very much

6. Performance of the tool was satisfactory.
Strongly Agree 1 2 3 4 5 Strongly Disagree

7. Would you recommend such a tool to your friend?
Strongly recommend 1 2 3 4 5 Not at all

III. <u>Detailed feedback</u>

1. Is there anything you would like to have in the tool that was not there?

2. Which part about the tool you liked least?

3.. Please provide additional comments

(Thank you very much for your participation)

VITA

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