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A Development Framework to Support the Life Cycle Facility Management Information Services for Residential Complex

Jin Su Jeong

School of Engineering and Industrial Design, Technical University of Madrid, Madrid, Spain

Email address:
jsbliss@gmail.com

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Abstract: This research investigates the feasibility of web technology as a means of delivering facility information services for better support facility operation and maintenance. Our research proposes a web-based service request and feedback system as a pragmatic solution to the limitations of current facility management (FM) processes with a case study of university residential complex. In practice, work orders and records are often misplaced resulting in lower efficiency and customer satisfaction. Information technology (IT) could be an important tool for reaching efficiency and effectiveness within operation and maintenance, provided that correct and relevant IT is applied. In this study, a model for stating information digitally with a web-based interface and identifying facility services management IT requirements is developed. For customer satisfaction, the end-user point-and-click graphical interface could allow residents to report facility problems using a problem fixture on a floor plan image, trace their work order in progress, view schedules for maintenance, and provide feedback for service online. 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. Moreover, this paper enhances the use of a structural practice for the identification of IT requirements which is essential in the pursuit of quality FM services for realization of sustainable buildings in the long run.

Keywords: Facility Information Services, Construction, Information Technology, Service Quality, Customer Satisfaction, Feedback

1. Introduction

The management of facility information can be a complex and demanding task from the perspective of operation personnel who operate a building [1, 2]. The effective delivery of facility information is an essential element for high quality facility management (FM) services. The majority of FM processes, however, are still 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 has been long recognized [3]. The use of information technology (IT) in FM has not progressed to the level that can be seen in other businesses [4, 5, 6]. One of strategies dealing with operation and maintenance information is a computerized maintenance management system (CMMS) which has become mandatory for facility departments. Integrating CMMS with IT helps facility mangers operate and maintain a facility better with facility information efficiently [3, 7, 8]. However, it has been developed for commercial complexes which are expensive to install, need to have an operator, and are hard to adjust to another types' complex.

In recent times, all the major players in the CMMS marketplace are developing web solutions [9]. The internet in its various guises has provided exciting opportunities for customer and service operation to interact [10, 11, 12]. This new way is to find customers' base communication as being digital and making information active. Better communication between customers and FM departments would deliver high quality of service and improve performance of service operation [13, 14]. In the current competitive age where information is readily available, service quality has become the focus of many organizations [15]. In addition, feedback is the important component of communication between

customer and FM department which can facilitate successfully facility information in FM business. According to Teicholz [10], 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. This is because many companies have realized that satisfying customer is the key to long term success [16]. Therefore, the facility information delivery needs to be effective not only for customer as to deliver high quality facility management service, but also for FM department as to operate and maintain efficiently.

In order to address this gap, this paper was initiated with an aim to developing an application into how the implemented web-based framework can be used to support the demands of computerized maintenance management that IT is supporting maintenance needs in the life cycle of apartment facility information in a holistic manner. Also, the purpose of this paper is to further discuss how this application using the internet and web-based technology to document, share, monitor, and improve the facilities data would be useful for end-users such as operation personnel and customers.

2. Background Information

2.1. Facility Documentation Assessment in Current Practice

As-built models and drawings are essential documents used during the operations and maintenance (O&M) of buildings for managing facility spaces, equipment, and energy systems [17]. As-built drawings are often literally called as the facilities' documentation. That term, however, is misleading in regard to purpose and participants. The kinds of facility documentation summarize when they are used and what their purposes are [18]. Several kinds of documentation of a facility can be distinguished in the facility life cycle. As-built documents are therefore of greatest value to building owners and managers and are used continuously for assessing building performance, managing building repairs and renovations, and assisting building decommissioning [19, 20].

Design drawings depict the facility during the design process. Thus, they represent what the facility would be in the future and assist to make architectural and engineering decision in building consensus [21]. In bid documents, the results of an accurate price extent can be determined and described. Construction documents including shop drawings are the outcome of the architects' and engineers' decisions in which their instructions give to the contractor in the form of drawings and specifications [22]. Also, this step of documents has a key role as part of legal documents governing the work to be executed. In the construction completion, record drawings describing the final documentation of the design may be produced by design professionals. These incorporate all revisions which made during the construction period and also may have the extent of designers' responsibility as a primarily legal purpose. At the same moment, contractors or project managers depending on the contract may create as-built drawings which describe the constructed facility at the time of commissioning [23]. Finally, demolition drawings are necessary to explain the scope of work in the case of removing the entire facility or some parts of a facility.

All of these kinds of documentation may group and be called as facility documentation. None of these documents, however, are actually intended to support operation of facility and are poorly structured for supporting the wealth of non-graphic data, ready accessibility and ease of change that are necessary to maintenance and operations [18]. Inefficiencies and ineffectiveness in processing, communicating, and revising as-built documents outcome in high costs imposed on building owners. A 2004 NIST report found that an estimated $1.5 billion is wasted every year as a result of unavailable and inaccurate as-built documents causing information delays to FM personnel. Also, a survey of U.S. Army facility mangers supports the current situation which concludes most information established during construction is usually not structured in a way to support the tasks needed by facility operators and/or maintainers. Changes that occur during occupancy must also be updated in drawings and equipment databases to ensure accurate records. An additional $4.8 billion is therefore spent annually on FM labor alone to verify and validate existing as-built documentation [19].

2.2. Information Technology in Facility Management Practices

As people become more familiar with the use of IT, 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 FM organizations [24]. Surveys have indicated a few basic types of software currently used in FM [25]. CAD applications such as AutoCAD, RUCAPS, or Computer vision are primarily developed for architecture or engineering design and drafting. Thus they usually do not intrinsically provide FM-specific functionality such as area measurement, though they are sometimes used for simple FM-related functions such as space allocation. A problem with these stand-alone CAD applications for FM is that they are typically used primarily as drawing tools, and are not used to store FM data within the drawing [2].

One of the most exciting changes in technology that occurred in the last decade has been the explosion of the internet. Millions of people from around the world use the internet. In architecture, engineering and construction/facility management (AEC/FM) industries, its use has been discussed widely [26]. According to Cohen [27], 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 strong connections between isolated pieces of information, supporting collaborative design and group decision-making. The literature on IT reports many essential reasons why corporations are increasing their use of IT. Reasons why

internet has been thought of as breakthrough technology include [28].

These reasons can be translated into practical business and FM issues. One key reason for the importance of internet is simply helping to share information. Internet applications promise to dramatically and even fundamentally transform the relationship between companies and their customers, suppliers and business partners. 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 [29].

2.3. Communicative and Collaborative Facility Information Services

Web technology promises the fundamental transform of the relationship among companies, their customers, and business partners. Web-based communicative and 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 [30]. Improving service quality needs to be conceded to be a process of managing user and customer perceptions as well in relation to expectations.

A lot of research efforts had been devoted to studying user satisfaction with construction services and products. For instance, Ahmed and Kangari [31] attempted to identify the factors important to construction client satisfaction. Maloney [32] examined the relationship between construction product/service and customer satisfaction. On the satisfaction of home buyers, Torbica and Stroh [33] proposed a model for assessing the design, quality and service dimensions of houses. More recently, Yang and Peng [13] reported on the development of a customer satisfaction evaluation model for construction project management. Customer satisfaction is the key factor influence the delivery of quality-driven facility and support services. The way in which the facilities organization presents itself have a strong influence on customer expectations, and the ongoing management of customer relationships demands frequent and clear communication. Business organizations accommodate a variety of building users such as directors, managers, office staffs, production workers and support staffs [34]. Each of these group generate its own facilities requirements, while each individual within each of these groups views his or her request as the most important issue.

The next step for customer service knows what customers' exact requirement, needs, and wants are. Then facility managers can define quality FM services and structuring service delivery accordingly with involving customers in the service delivery process. After service delivering, assessing customers' satisfaction level with service delivery increases the performance of FM personnel. Customer feedback should be linked to continuous service delivery for the improvement process. Porter [35] 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 tool it must be accepted. A well-designed user interface should also improve the satisfaction of the occupants with the services provided to them by maintenance personnel [36].

The primary differences between feedback in a management development program and job performance feedback has been the typical focus of feedback research. 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 [37].

Regarding the electronic facility documentation, feedback automation is an important part to be a successful system. One strategy for managing maintenance of the facility documentation is to monitor requests for information through automatic records and notification [18]. By analyzing patterns of requests and cross relating projects that are beginning, the staff can prioritize documents for inclusion in the system. Also, errors in the process of the documentation can lead to other semi-automated feedback. Therefore, the information system that envisioned in this research can be a boot-strap system; an initial partial implementation gathers data to inform additional implementation, rather than a total system in one step. 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. Research Methods

Several approaches and sources of data are used to achieve the goal of this study. As the first step, research method of this study is to review the general literature on facility documentation assessment, information technology use and communicative and collaborative services in the facility information management to obtain a better understanding about the processes used in FM industry. This review includes an assessment of the CMMS strategies of major software provider. Next, we developed an application which has two access levels from point of customers' view and point of facility management staffs' view. The web application is constructed to support the demands of CMMS that IT is supporting O&M needs in the life cycle of residential complex information in a holistic manner. In residential buildings, the facilities quality is influential to the living quality for residents who live there. Therefore, the functional facilities quality is dependent on their O&M

quality. The prototype interface could allow the customers to report their facility problems, trace their work order in progress, view their schedules for maintenance and provide feedback for service online by using graphic user interface (GUI). Also, it is a web-based facility information management system which documents, shares and monitors work orders for operation personnel and facilitates communication with customers by using internet technology.

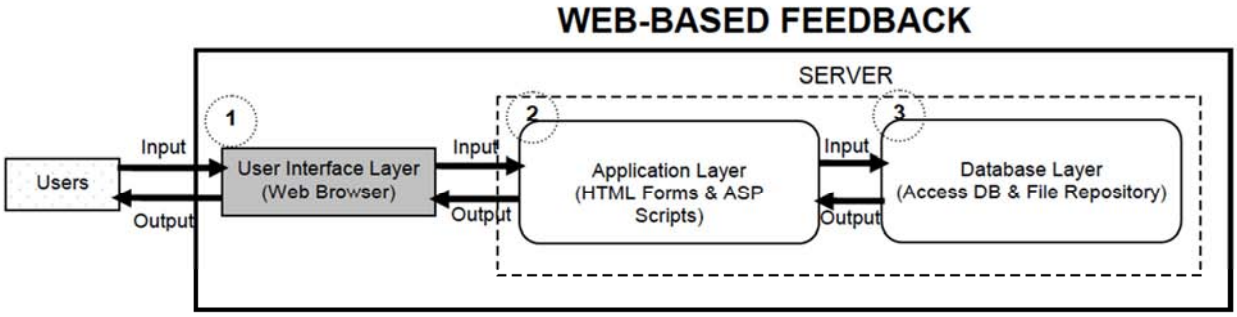

Figure 1. *An overview for system diagram framework.*

The general architecture of web-based application is a server/client system. The relationships of the system architecture, which are depicted in Fig. 1, have three major system components: the user's web browser, the application server, and database server. Arrows and numbers explain the starting and ending points of an information processing procedure. The system starts with users' inputs in the web browser. The web server provides for the efficient processing for responding to users' hypertext transfer protocol (HTTP) requests. For dynamic programs, JavaScript is necessary to bridge client and server side communication. Then, the application server programmed by active server pages (ASP), a server side script, gets these parameters and parses them as a structured query language (SQL) query to the database server, MS Access. The database management system (DBMS) returns its results to the ASP program, which processes the result and output. The implemented web-based application is independent of any web browsers, since it is server-side application. MS Access is used for system database. All service request work orders and feedbacks will be saved through MS Access database. By now, the whole information processing procedure, which explained arrows and numbers in Fig. 1 finishes and users can repeat the same procedure according to their preferences.

The system uses centralized database concept to document all data proficiently. The entire facility data are stored in one database. The diagram in the Fig. 1 illustrates the three layers in this prototype system: Each layer has distinct responsibilities. The prototype system design is divided into three major sections: first, user interface layer consisting of administrator and user web browser; second, application layer written by hypertext markup language (HTML) and ASP scripts; and third, database layer having MS Access database and file repository.

4. Results and Discussion

With the selected case study area, the web-based application is developed to support the quality facilities services for end-users, operation personnel and residents. The application allows facility staffs to manage operation and management needs of residential buildings in the life cycle information as a holistic manner. It will be also a tool to build an operation and maintenance history with the proper and easy manner. For residents' side, the interface allows them to report facility problems, trace work orders in progress, view schedules for maintenance, and provide feedback for service online by using a GUI. 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 a facility, the system can be used any facility. The electronic information end-users handle is storing in a database and can be retrieved easily later. The application which documents, shares and monitors work orders for operation personnel can be also facilitate communication with customers by using internet technology.

The sample for the application is the general public including those with little experience of the internet as well as professionals with greater levels of experience. For that reason, the user interface is designed to follow five usability levels of experience: 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. Accessible design uses color, image, and graphics to guide users, as well as understandable and navigable content. The user model describes how users will use the application is showed in Fig. 2, the concept of web-based application user model which is divided into three major parts: first, the authentication part; second, facility information service interface which has the service request and feedback part; and third, the comprehensive database part. The end-users are separated into two levels of authorized users, FM staffs who divided different level groups by authorization level, and residents. The web administrator will give the permission to all users to be able to use the system. Before accessing facility data, all users have to pass the authentication part to identify them by using a login name

and password. Then, they will be able to access the facility data part or service request and update part depending on their authorization level. As shown in Fig. 3, it 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.

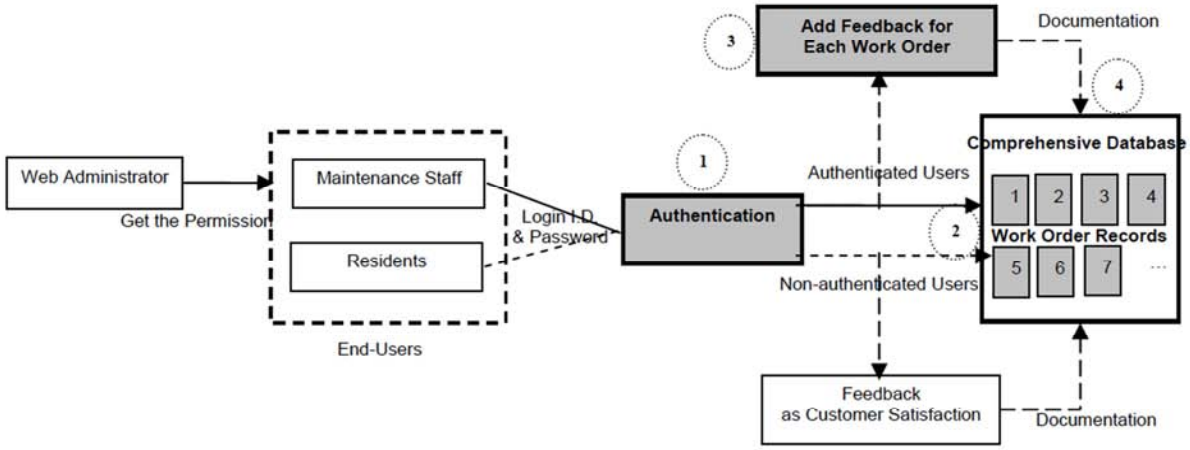

Figure 2. *The conceptual user model of web-based facility information system.*

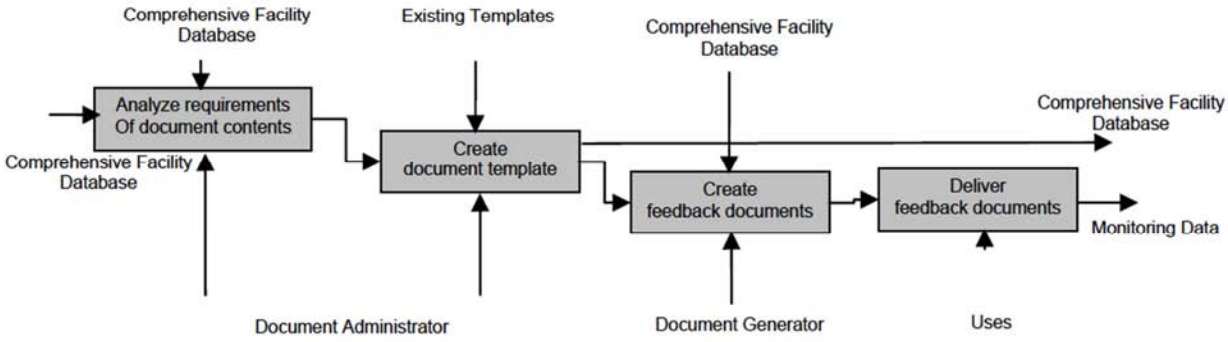

Figure 3. *The process of creating and delivering feedback documents.*

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. 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. 4a, the user is asked for the login ID and password. Some can access partial work orders which are related with themselves or can access all comprehensive databases as shown in Fig. 4b and 4c but non-authenticated users, residents, only can access their own work order records. 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. 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. Once the user is logged in and authenticated, a feedback process is created, as shown in Fig. 4d. After gaining access, the user can see information according to his/her authentication levels and 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. The user can see feedback history as delivery and documentation method.

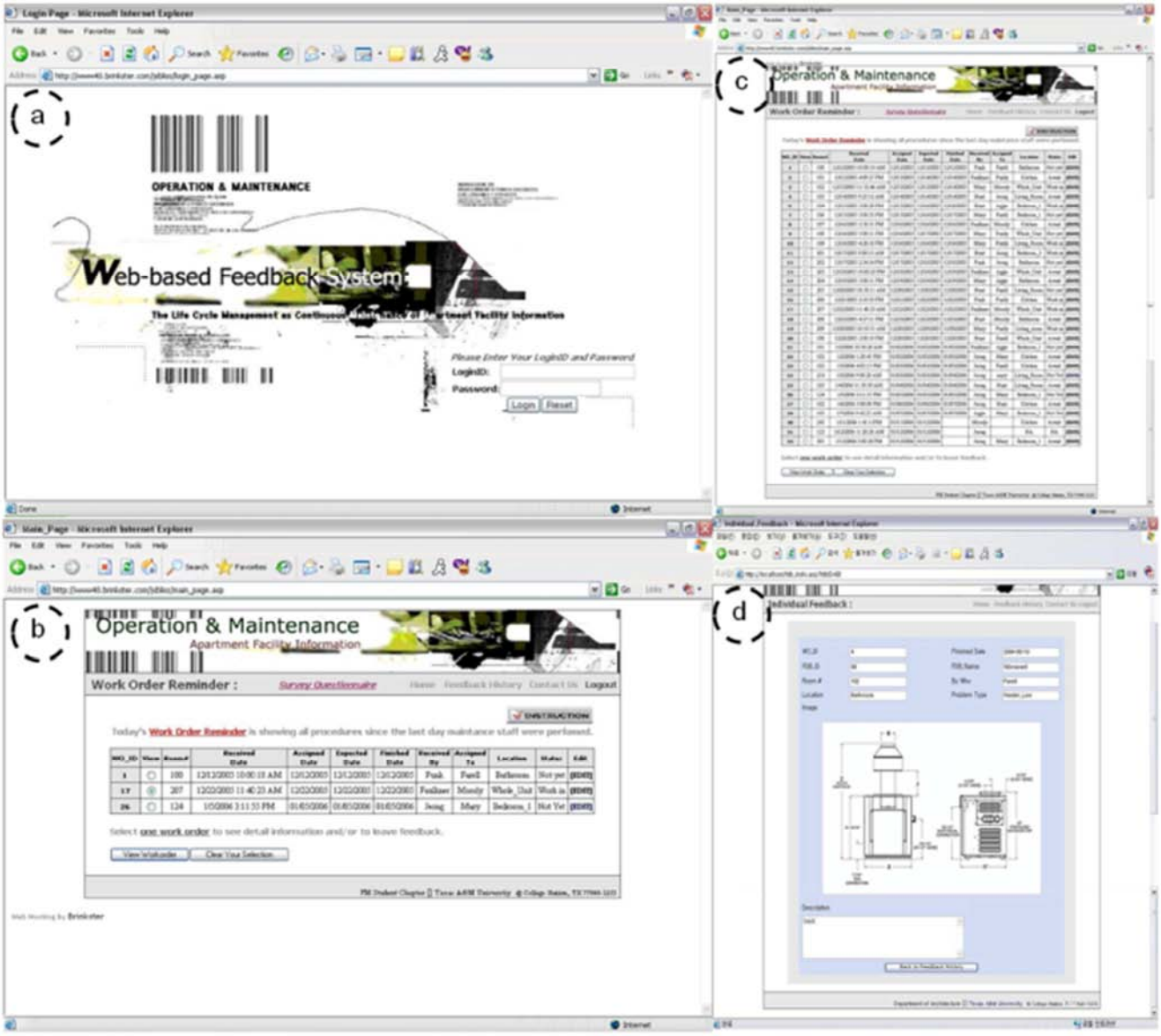

Figure 4. *Screen images of processing feedback documents from the view of operation personnel.*

After that, the system retrieves the type of problem in certain place. Most repair work has the similar pattern and routine to fix where the problem happens so that we are able to categorize the problem so that we are able to categorize the problem type based on the place. The customer clicks the detail place or chooses from drop-down menu for reporting. There are more convenient tools for web-browsing of drawing file like Autodesk DWF viewer and composer. Although it can zoom-in, out and redlining on file through web, the customer may feel uncomfortable to learn new tool. Therefore, we develop this one-click service request on drawing file by using image-map tag of HTML. When residents log in the system, the perspective drawing of the floor plan is retrieved from the database. Based on the login information, the database retrieves the different floor plan for where the residents live. Most of the residents' apartments consist of a living room, bedroom, kitchen, and bathroom. In the first step, the resident clicks the part of the image where the problem happened. To help the user click the right area, when a mouse hovers over a specific room, the color of the room turns blue by using swap image scripts in Java. In the second step, the resident clicks the component which has problems. Each room has common items (such as doors, windows, lighting, outlets, etc.) and unique components (such as kitchen range, sink, cupboard, toilet, bathtub, etc.). After that, the image of the selected area magnifies in size to be the same as the previous image of the whole floor plan. In this step, the ASP generates a sentence for the place which resident selected as shown in blue box. In the second step, the resident clicks on the detailed part of the fixture. When the mouse hovers over each fixture on the image, the name of component appears on the image so that the user can select the correct part. In the next step, the final

form of the service request appears right after the image. The location and fixture of the problem has already been chosen in the previous stage. Additionally, a red dash-dot layer will be created around the fixture of the problem to help the user recognize the area they selected. The system can do this because it recognizes the identification number of each fixture and it creates a layer for the specific fixture. For the type of problem, the ASP scripts retrieve problem types only related with the specific area and fixture selected in first and second steps. This is possible because the associated table has information on which fixture has what kinds of problems. If the type of problem does not appear in the drop-down menu, the resident can select "other" and write down a detailed explanation about the problem in the description box. The administrator can add this problem to the database if the same kinds of problems happen frequently. Before submitting the service request, a confirmation step appears to make sure the user reports the exact problem correctly. The user can submit multiple problems one by one after every submission.

5. Conclusions

The implemented web-based application is the result of the attempt to optimize the advantages of the internet and web technology to improve the facilities information services quality for end-users with a practical case, residential complex, in the field of FM. This implies the FM field can take the advantages of the internet and web technology as other fields do. The application provides a typical format of an apartment management web site which allows facility staffs to deal with operation and management needs of residential buildings in the life cycle information and also builds an operation and maintenance history with the proper and easy manner for operation personnel. For residents' side, the interface allows them to report facility problems, trace work orders in progress, view schedules for maintenance, and provide feedback for service online by using a GUI. The prototype could simplify the process of some facility intranet or extranet setup. The facility database could be centralized and effectively used over a network. The distinguished advantages of the centralized database are the accuracy and security of the data.

The greatest benefit of this research will be the resulting effective facility information transaction by prototyping web-based application. The obvious benefactors of this information will be end-users, residents and facilities managers. In practice, work orders and records are often misplaced resulting in lower efficiency and customer satisfaction. This may be overcome by a system that states information digitally. Through GUI report system, the residents will feel comfortable more to use than calling in or walking in. It will reduce the volume of calls or visits to a customer desk and save time to put request manually into system. 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 experience. Also, it will aid facilities managers in terms of how they make a living document.

Facilities managers are always forced to know about when equipment should be replaced or how much money they can save by replacing new equipment. 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. What was the problem? This question enhances the knowledge base for facilities departments. A holistic evaluation of FM services requires assessing not only their performance levels but also the levels of their input resources. Elaboration has been given on how a snapshot of the current performance state may be recorded. It serves as a footprint against which changes in cost-effectiveness of expenses on different aspects of FM services can be measured. This kind of information, in addition to constructed quality and environmental quality of buildings, is essential in the pursuit of quality FM services for realization of sustainable buildings in the long run.

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