Mobile application tool for individual maintenance users on high-rise residential buildings in South Korea

Hee-Sung Cha, Ph.D.[1,a], Jun Kim[1], Do-Hee Kim[1], Jia Shin and Kun-Hee Lee[1]

[1]*Department of Architectural Engineering, Ajou University, Suwon, South Korea*

Abstract. Since 1980's, the rapid economic growth resulted in so many aged apartment buildings in South Korea. Nevertheless, there is insufficient maintenance practice of buildings. In this study, to facilitate the building maintenance the authors classified the building defects into three levels according to their level of performance and developed a mobile application tool based on each level's appropriate feedback. The feedback structure consisted of 'Maintenance manual phase', 'Online feedback phase', 'Repair work phase of the specialty contractors'. In order to implement each phase the authors devised the necessary database for each phase and created a prototype system that can develop on its own. The authors expect that the building users can easily maintain their buildings by using this application.

1 Introduction

The construction industry in Korea has grown rapidly for decades. At this time, countless new towns have been constructed enormously in order to solve the housing shortage problems. In this stage, construction companies have just focused on new construction orders, whilst maintenance of existing buildings has been relatively disregarded from the business area. As a result, many apartment houses requiring maintenance are not maintained properly. Also, it is difficult to conclude a contract with a maintenance company because most of the apartment complexes have different owners in each housing unit. As a result, the home owners themselves become responsible for maintenance work. However, there are too many paper-based building maintenance manuals for the house owners. Also, although the house owner would like to use the maintenance manuals, there is a need for some expert advice. There are also maintenance work that experts have to deal with directly. From the standpoint of the home owners, it is necessary to distinguish what can be directly repaired, what needs advice, and what the expert should do because of the cost issues. Therefore, in this study, after accumulating information about maintenance data, the authors develop a system which is selectively connected to maintenance manuals and maintenance experts according to information input by homeowners.

2 Literature Review

In the mid-2000s, a number of building maintenance system proposals for maintenance work using PDAs were developed. [1],[2],[3] As the smartphone became widespread to the general public since

[a] Corresponding author : hscha@ajou.ac.kr

2010, some studies have been conducted to use the smartphone to perform maintenance work on the buildings. However, this study focuses on the maintenance work of the building managers, not the owners of the building.[4],[5] Therefore, there is a need for a new system that allows the home owners to directly perform maintenance work throughout the advice of professionals, if necessary. Given a smartphone application, the ordinary phone users can easily be accessible to the proposed system.

3 Concept Design of Maintenance Application

In order to analyze the maintenance work, the authors classify the defects that can occur in the buildings. The defect type is classified as whether the residents themselves can be maintained, whether expert advice is needed, and whether they should be done by a professional. In addition, repair methods when defects occurred are classified in the same way as defect classification as seen in Table 1.

Table 1. Maintenance defect significance and solutions

Sig. Level	Type of Defect	Solution
1	Residents can repair	Action of Residents
2	Residents can repair, but need professional advice	Advice of Expert
3	Residents can't repair, need direct professional repair	Action of Expert

In order for residents to carry out "level 1 Residents Action", the system needs to provide maintenance manual with the residents. The maintenance manual must also be continuously updated. In order for residents to carry out "level 2 Expert advice ", The system should have the function for the residents to carry out the maintenance work and then provide the feedback by the expert. The system also needs a function that can compensate the experts who provide the feedback. In order for the experts to carry out "level 2 Expert advice ", the ordering, bidding, and awarding process for selecting experts in the system should be included. In this process, residents should be provided with information to assist them in selecting the experts. In Level 3, the selected contractors are evaluated, and the rating score of the construction result is assigned so that it could be confirmed by home owners. Based on this concept, the system algorithm is developed as depicted in Figure 1.

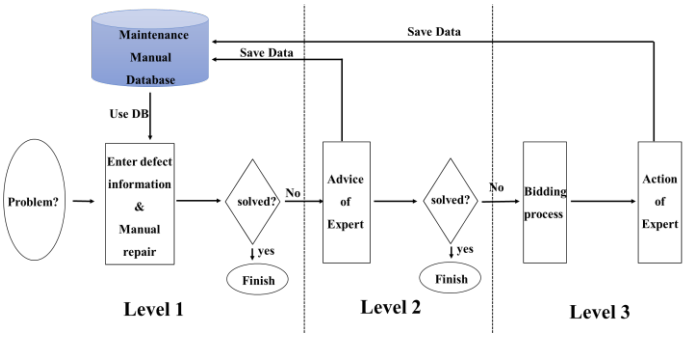

Figure 1. Conceptual algorithm for building maintenance based on smartphone application tool

The application uses three-step approach that progresses in sequence according to the defect classification. This concept consists of level 1 (Residents can repair), level 2 (Residents can repair, but need professional advice) and level 3 (Residents cannot repair, need direct professional repair). When a resident discovers a building defect, he/she carries out self-repair through the manual as the first step. If this method fails, the resident tries again with expert advice. If this method also fails, the resident selects the vendor and constructs the maintenance. In this process, the advice and maintenance contents are stored in the maintenance manual database. When this process is repeated, the maintenance database is updated.

4 Developing Application Tool for Building Maintenance

The proposed system begins with the user's running the application. The user enters the building information and creates a checklist based on whether or not the defect has been checked in advance. If it is proved that this is a problem according to the inspection, the first method, "repair according to the manual," is tried. If the 'repair by manual' fails, the user will enter the second level, 'level 2 expert advice'. At this stage, the user has to send the photographs and information about the defect to the experts. When the expert receives the information, the advice is sent back to the user in text format. If the user does maintenance work using the information received from the expert and fails to remove the defect, the next step will be taken. The third stage is the stage where the experts construct themselves. To do this, the user bids the construction work. After the experts are selected through the awarding, they will perform maintenance work. After the construction is completed, the user will rate an expert and end the entire procedure. The user follows the detailed procedures in each step to repair or exchange information.

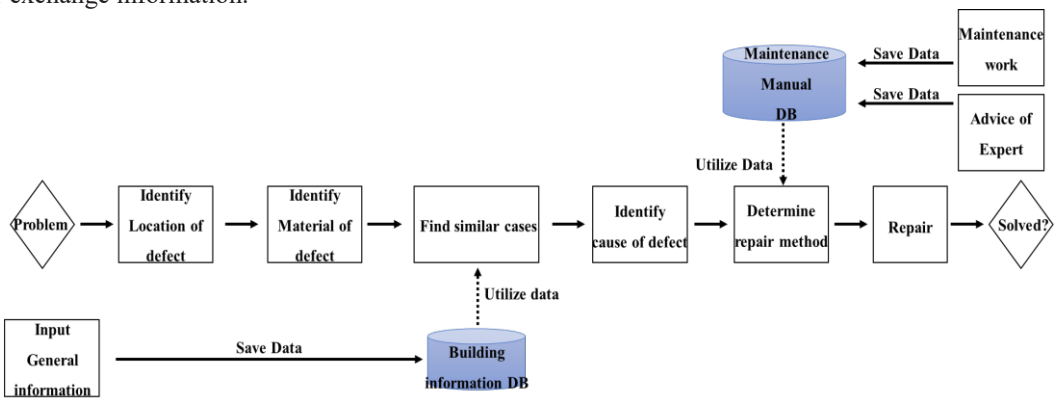

Figure 2. Detailed system design of level 1

Figure 2 shows a detail procedure for level 1. If a defect occurs, the system gets the information about the location and the building materials. The next step is to find a similar case to the defect and make a comparison. The user carries out repair work according to the maintenance manual. The general information entered in this process is stored in the building information DB, and the repair method is retrieved from the maintenance manual DB. Through this process, the user can perform the repair work in Level 1. The detailed procedure for Level 2&3 is shown in Figure 3.

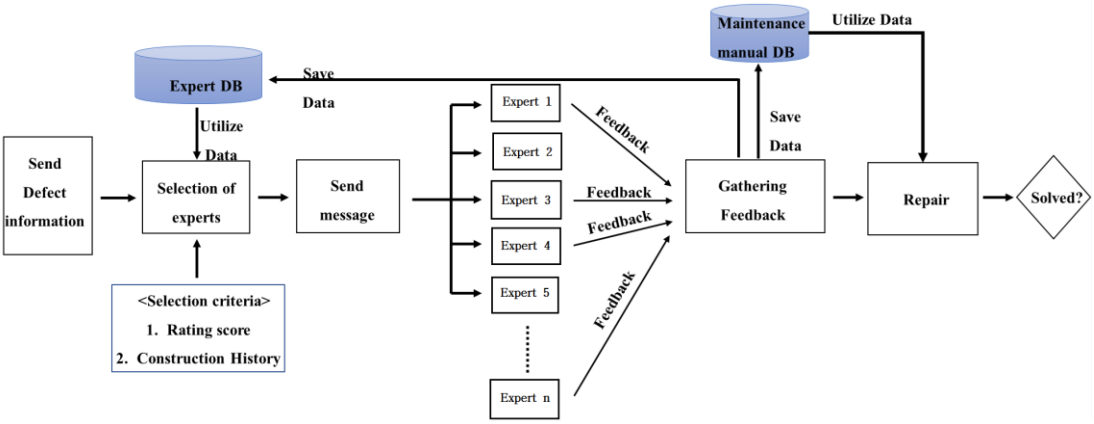

Figure 3. Detail design of level 2 &3

When the user sends the information from the level 1 to the specialist, the expert is selected according to the information sent. Expert DB is used in this process. Using the information provided by the specialist, the user will perform maintenance work. This information was also stored in the maintenance manual so that it could be used again in case of the next problem.

5 Detailed Design of Information Structure

Information generated in the whole process accumulates in four DBs (building information, defect cycle, maintenance manual, and expert information). The structure of each DB is organized as shown in Fig.4.

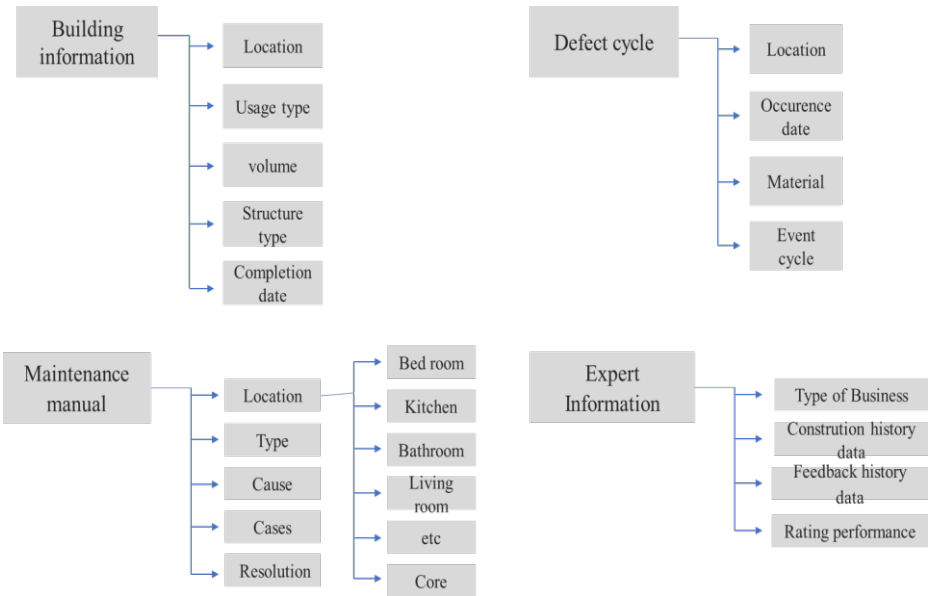

Figure 4. System Information Database Structure

Each DB includes detailed information as depicted in Figure 5. The examples of DBs developed in this study are provided in detail from Table 2 to Table 5.

Table 2. Building information DB

Location	Usage type	Volume (m^2)	Structure type	Completion date
316, Yeongtong-ro, Yeongtong-gu, Suwon	Apartment	3572.3	Wall structure	2010.11
96, Gyeongin-ro 3-gil, Guro-gu, Seoul	Villa	120.6	RC	2005.3
564, Nakdong-daero, Sasang-gu, Busan	House	82.64	RC	1999.01
102, Jungbu-daero, Paldal-gu, Suwon	Apartment	2500.23	Wall structure	2010.03
129, Jungbu-daero, Paldal-gu, Suwon	Office	12000	SRC	2012.4

Table 3. Defect cycle DB

Location	Event cycle(year)	Material
Kitchen-window	10	PVC window frame
Livingroom-finish material	5	Wall paper
Bathroom-Plumbing	3	Stainless pipe
Kitchen-HVAC	4	Exhaust hood
Livingroom-Electronic	1	Lamp

Table 4. Maintenance manual DB

Location	Type	Cause	Solution
Window frame	Can't open	PVC window frame	Need re-construction
Tile	Efflorescence	Poor construction	Grinding with sand paper
MEP	Water leaking at the toilet	Stainless pipe	Need Experts work
MEP	Puddle on the floor	Poor construction	Need re-construction
MEP	Don't work	End of life	Replacement

Table 5. Expert information DB

Expert	Type of business	Construction History(times)	Q & A History(times)	Rating
AAA	Tile	5	10	4.5
BBB	Window frame	10	12	4
CCC	Finish work	4	8	5
DDD	Masonry	5	15	3.5
EEE	MEP	8	10	5

6 Prototype smartphone application tool for building Maintenance

The smartphone application has been made by referring to the algorithms in Figures 2 to 4 by incorporating the information in Tables 2 to 5. The screenshots of the smartphone application are shown in Fig.5. There are four screens in the application. The initial screen shows a general information regarding building maintenance practice, such as ①Input general information, ② Use Checklist, ③ Q&A with Experts, ④Bidding, ⑤Counsel with specific Expert,⑥ Service center. The second screen shows an example of maintenance checklist (⑦ in Fig. 5) and in-situ solution items (⑧ in Fig. 5). The third one, maintenance manual screen, provides a cause-effect-solution relationship (⑨ in Fig. 5) in order to pinpoint the specified defect problems. Through menus ⑦, ⑧, and ⑨, the user is provided with a way to use the necessary checklists and to refer to the manuals. With functions Q&A screen (⑩ and ⑪ in Fig. 5), users can send photos and texts to experts and receive comments from them.

Figure 5. Exemplary Screenshots of Mobile Application Tool

7 Conclusion

Four positive effects are expected through this study. First, by using the easy-to-access application, it is expected that an active exchange of information among maintenance subjects can be achieved in a timely manner. Second, by providing users with a maintenance manual that is constantly updated, it can provide meaningful information for the general home owners who have little knowledge about the building maintenance. Thirdly, in case of defects, the repair work can be executed through acquaintance, personal contact, or using the Internet service. Using this application, the repair contractors can be selected based on the company's work performance and reliability. Fourth, since the information is structured in real time by using the application, the data about the defect cycle, time, and the location of the defect are continuously accumulated, so that preventive maintenance will be possible in the future. In this study, the authors classify the information into contents that the user can understand for the user's convenience. It is an advantage to be able to use easily by ordinary people who do not have enough knowledge of building maintenance through this method. However, it would be better to use a standard format, i.e, IFC (Industrial Foundation Class), which is used in BIM, to accumulate the relevant information. In this study, the authors have studied how to store and utilize information centered on the apartment, but future study need to be extended to the areas where information can be classified in various building types. Finally, in this study, the home owners have proposed a procedure to connect with experts individually, but a new method is needed for a new business format through collective bargaining agreement.

8 Acknowledgment

This research was supported by the Basic Science Research Program, through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (No. 2015R1A2A2A01005242).

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