

Mobile Application for Building Defect Management System

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Abstract

Construction inspectors usually use sheets of paper and/or field notes. As a result, they have a lot of typical and routine jobs in construction sites, such as observing the work and determining whether it conforms to the provisions of the design. Consequently, there is no access to conventional computers to be used as real-time decision aids through the project quality inspection at outdoor construction sites. One of the problems is due to the gap between the outdoor construction site and the office in terms of time and space. This paper aims to determine the process of inspection and prepare a standard checklist, which is practically used at construction sites. Furthermore, a suitable prototype developed for a mobile inspection system, based on the potential requirements, needed in the construction site. Data was collected from studying literature and also through interviews and the administration of questionnaires to local construction organizations, mainly in Johor and Pahang areas in Malaysia. Using the rapid prototyping, method developed a prototype. Ultimately, a hybrid standard defect checklist and reference system was integrated to fulfil the needs in construction sites.

Keywords: Mobile Inspection, PED, Prototype Development

1. Introduction

Traditionally, paper-based data capturing is employed for communication, which typically is time consuming, exhausting task for project managers and may include human-errors¹. On the other hand, some of the project tasks are highly interdependent, and this may cause interactions in practical and effects on all involved partners and project results²⁻⁴.

The inspection process is one of the routine activities in the construction industry to confirm design provisions. Each inspection is carried out by one or more inspectors. The typical inspection activities are following: preparation for reviewing, conducting the review, collecting and evaluating data, writing report, processing and distributing the report and finally, following-up action, controls, and information sharing⁵.

Currently, inspection activities are done using paper-based blueprints. Therefore, the process is slow and

expensive. In addition, the delivery of information to the proposed contractors is done using hard-copied reports. Depending on the project the time period between the information gathering and delivery is time consuming⁶.

Therefore, it seems that the construction industry would be a wide area for the application of handheld computers because of their special features, such as light weight, being pocket-size, having processing features and software applications same as the desktop personal computers⁴. Handheld computing applications have the capability to include textual information and graphical information about construction as well as form-based software to collect data⁴. Furthermore, handheld computers are nowadays becoming more powerful and less costly, and even some of them has been embedded into cell phones. This combination has played the potential role in preparing the atmosphere to employ Portable Electronic Devices (PED) in the construction industry.

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Handheld computing devices like PED can be implemented in this area to automate inspection of the traditional construction process.

This study is done mainly in the Johor and Pahang areas in Malaysia to:

1. Survey the current practical inspection systems and review the applied standard inspection checklist at construction site.
2. Identify the needs and requirements of the mobile inspection system at construction sites.
3. Develop a suitable prototype for a mobile inspection system based on the potential requirements needed in the construction site.

2. Study Background

Using mobile computing and handheld computers for information management is being inclusive in the construction industry to collect and transfer data through an electronic document^{4,7}.

Advances in information technology have made it possible to use mobile computing systems in construction sites. Therefore, construction industry adopted the interaction between mobile computing systems and construction job⁸. Kenji Kimoto developed a particular structural prototype, which is collecting information from the site, and data could be retrieved and analysed once the device is sent back to the office⁹. Moreover, this prototype was programmed with set of static codes, which make the prototype specified for structural engineering analysis. Therefore, this prototype is not being able to record dynamic interactions owing to the dynamic nature of construction projects.

3. Construction Defects

Defects that occur during the construction process account as a key concern of the project managers. Construction defects may always affect project schedule and performance¹⁰. There are various types of facilities, materials and activities inside the construction site that may generate several forms of defects in different level of Intensity¹¹. Commonly, the procedure of defect detection begins by surveying different construction defects, and then investigating the suitable method of defection under the given site conditions. Besides, most of the defect detection systems have been designed for construction stage, and they

do not consider those defects that occur after building operation. Therefore, there are still complaints and drawbacks reported with existing inspection system¹¹.

As a result, the inspection process at the construction site is an important process and is necessary to be conducted by the construction project supervisor, such as an engineer and technical assistant to ensure that the construction project is complying with the specified work standard, specification and guideline.

In order to do so, a standard defect checklist and the development of the interview pilot questionnaire was done and updated in accordance with previous researches¹²⁻¹⁶. It was carried out to identify the process involved, and the problems encountered during the inspection process at the construction site. Finally, a standard electronic defect checklist, which is commonly used by the Public Works Department (PWD) has been created and implemented in a pocket PC. However, the nature of the construction projects requires that these documents be set up in an electronic format specifically for each individual project.

4. Methodology

This study is done mainly by using two methodologies, firstly, interview and questionnaire and secondly, the rapid prototype model. In the first phases, to identify the most common used standard checklist, a face-to-face interview was conducted with construction players like contractors and developers. A pilot questionnaire, drafted from the findings of literature, was used prior to developing the interview questionnaire. The collection of data was limited to the Johor and Perak states of Malaysia. Analysis of data from the interview questionnaire was conducted to select and rank the most commonly used defect checklist.

In the second phases, the study was concerned with the rapid prototyping method. In rapid prototyping, interactive prototypes were developed that could be quickly replaced or changed in line with design feedback. This feedback has been derived from users, as they work with the prototype to accomplish a set of tasks in the process of rapid prototype development and evaluation as a primary platform for the defect checklist.

5. Mobile Inspection System Design

Through the rapid prototyping technique, a Mobile Defect Inspection System (MDIS) prototype was developed and

tested to more effectively manage and inspect the defect. It can save time, cost and workload. It is also so simple and easy to use, since there is no installation required or a high level of computer skills needed. Combining the mobile device technology, PED and portal support, real time data entry into the mobile defect management system portal server can be done easily and, then the current defect scenario at the construction site will be reported. The defect inspection process can easily be done by using the mobile device to defect data and for picture recording anywhere, anytime, without carrying a heavy plan or defect recording sheet. Figure 1 shows basic mobile inspection concept at construction site.

With the automation feature of the portal, a defect report will instantly be created for a correspondent party. In the meantime, the administrators can also make their decisions or judgments, based on the real time defect report update from the system.

Finally, since this system is automated; data can be entered and a respond received instantly. Data missing, data re-entry or fragmentation in defect communication problems will be solved. Besides this, each participant involved in this system will be brought closer on each other.

6. Defect Management Process

The traditional defect management process is shown in Figure 2, which is the result of interviews with the construction companies.

After reengineering the traditional defect management process with the aid of MDIS (Mobile Defect Inspection System), it has changed and its framework is shown in Figure 3 as a MDIS framework.

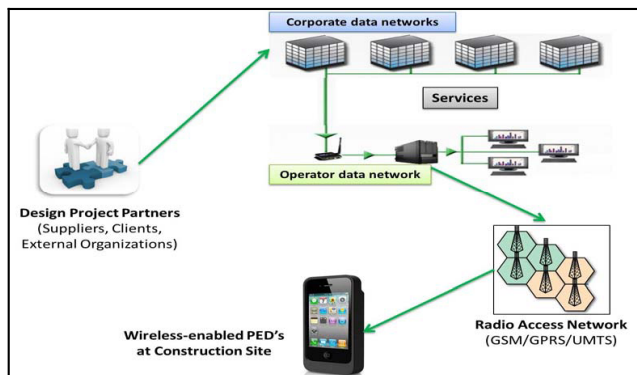


Figure 1. Basic mobile inspection concept at construction site¹⁷.

7. MDIS Data Flow for Input and Output

To identify the data entry requirement, the input and output data in MDIS is shown in Figure 4. As it is illustrated in Figure 4, the data that needed to be downloaded by the portal to the inspector’s PED includes:

- A selected standard defect inspection list form
- Listed Predicted Total Defects (PTD) needed to be inspected
- List of inspection type
- Type of building

And the feedback from the inspector’s PED to the portal system is a filled selected standard defect inspection form, which contained:

- PTD number (it is a unique lot number)
- Location
- Contractor Information
- Level
- Employee Information
- Inspection Information
- Comment
- Picture (if any)

After all the information is completely sent to the database portal, the output from the portal of the MDIS

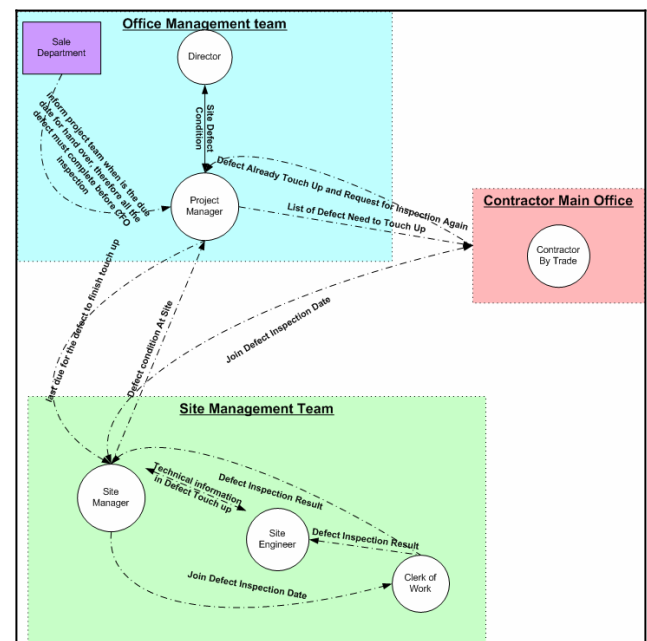


Figure 2. Traditional defect management business process.

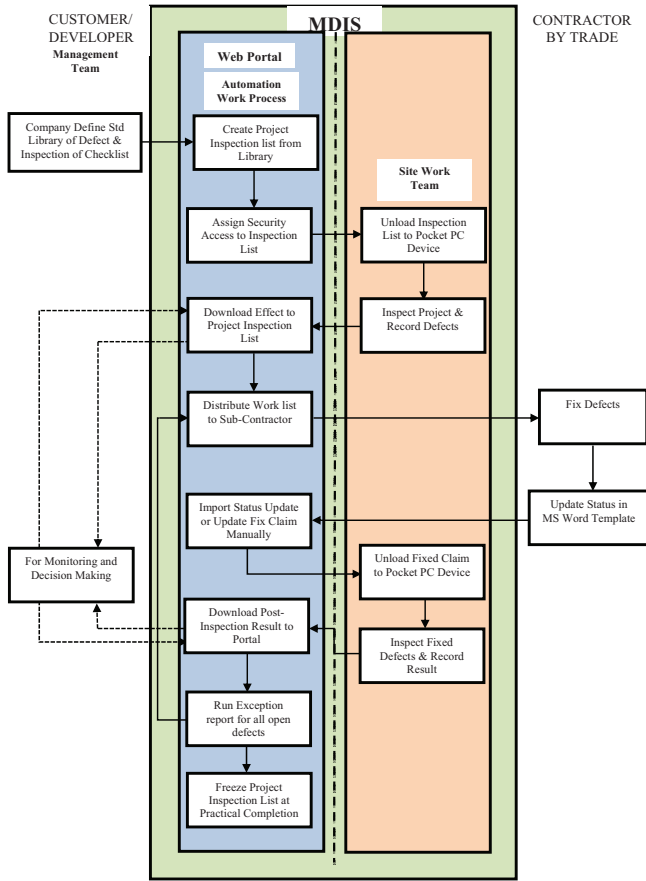


Figure 3. MDIS framework.

system will automatically generate a list of defect reports to a responsible contractor and also a report to the system administrator about the current number of logged defect, and the number of completely fixed defect.

The seven key elements of MDIS database structure includes:

i. List of Standard Defect Check List

Previously, a standard defect checklist is used by local Malaysian construction industry, which follows the most common types of defect checklist.

ii. Inspection Information

Consists of the information from construction site, which contains general project information and site inspection reports.

iii. Employee Information

All data related to the project employees and includes the inspector’s background information.

iv. Level

That information related to projects with multi-storey building.

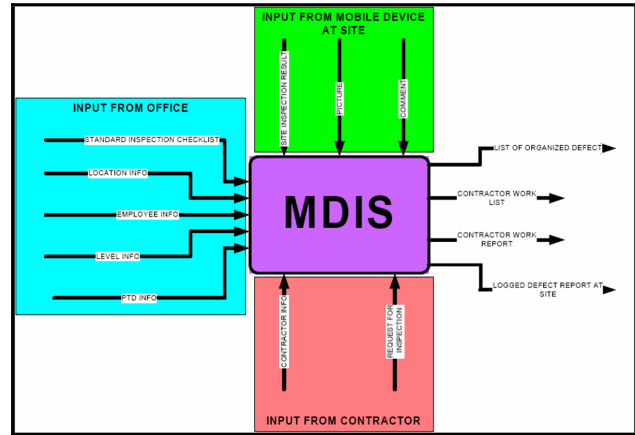


Figure 4. Data flow for input and output of MDIS.

v. Location

Information of different sections of the building, such as Car park, Master Bedroom and Kitchen.

vi. Contractor Information

All the necessary contractual information, such as content of contract, contractor’s trade, project schedule and budget.

vii. PTD Number

This is a particular lot number, which is provided by the land office of Malaysia to a specific land or property and will be used as an essential key to collect defect information.

8. System Design and Prototype Development

In order to meet the mobile inspection purposes, the MDIS system was intended to apply for combination of two separate system parts. As shown in Figure 5, the portable part of MDIS system is a tool, such as PED that runs at window RT system and the other part is a system administrator, such as Microsoft Windows 98 OS to record the workstation data.

Two different OS platforms (Win RT and Standard Microsoft Windows 98) are supported by the MDIS prototype and it is needed to use a language, which can communicate between these two different OS platforms. Besides, all the information is recorded inside the database server and that’s why the MDIS needs to be operated in an Internet Information Service (IIS).

To communicate between the different platforms, the Active Server Page language (ASP), Visual Basic (VB) and

JAVA were employed eventually in the MDIS prototype. The MDIS process interactions are controlled by using ASP language and the MDIS system, secured by VB language in design form. The Graphical User Interface was adopted by applying JAVA language and also, it is involved in controlling of the table form GUI.

Additionally, The Hyper Text Markup Language (HTML) was used to control the orientation and presentation of information to the user on different platforms. For the retrieving the data, the ActiveX Data Object (ADO) method was used for portal server, and the Structured Query Language (SQL) was used after connecting user to the database based on the end-user requirement. Figure 6 shows schematic MDIS system platforms interactions.

9. Testing and Validation

To test and validate the prototype an 85 unit double storey house was selected as a test field for MDIS prototype to:

- Evaluate the prototype performance and the accuracy of the results;
- Identify the potential applications of the prototype in construction industry;
- Assess the effect of the interaction with the prototypes system on the user;
- Obtain comments and recommendations for improving the prototype system.

One day before testing the prototype at the construction site, there was a short briefing on the operation of

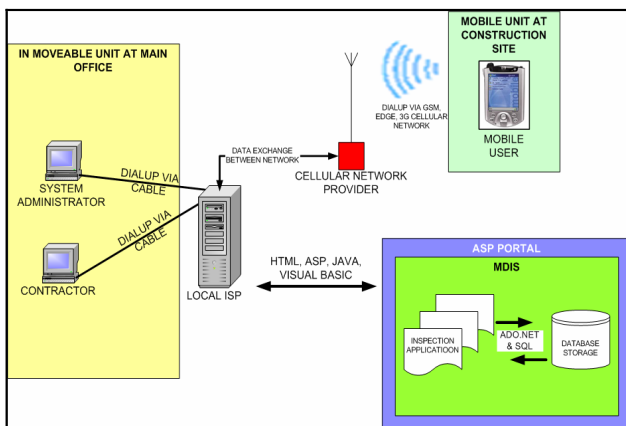


Figure 5. Mobile Defect Inspection System (MDIS) main system topology.

MDIS prototype, involving the site manager and the prototype user. The prototype went through several trial runs with appropriate refinements before testing and validation at the construction site to improve it. The process continued until the prototype was ready for a demonstration. When the prototype was ready, the interviewers from the targeted company were invited for the demonstration. Once the prototype was demonstrated, the summative evaluation was undertaken, and the findings were used to improve the final prototype. The Login and Menu screen can be seen on Figure 7 as a result.

10. Conclusion

This article developed a MDIS prototype to let users enter data and information at any place and anytime in their PED. Since the MDIS prototype provided the cellular network signal, which can connects to the internet, the MDIS users can access and record the information in every construction site and also outside of the construction site. On the other hand, the MDIS system also includes the non-moveable units, such as the work station in the office. It provides an environment to integrate all the involved participants (inspector, management team and contractor) in the inspection process.

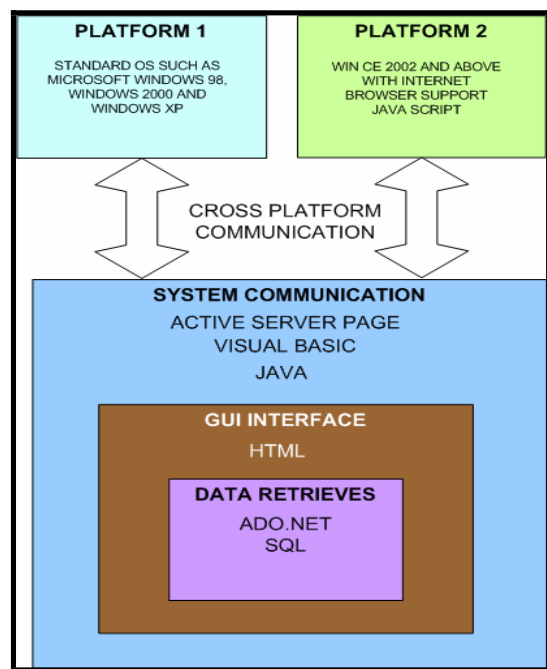


Figure 6. Interaction between MDIS system platforms.



Figure 7. Login and menu screen for PED.

11. Acknowledgement

This research was financially supported by Universiti Teknologi Malaysia (GUP reference number PY/2012/00304), Graduate University of Advanced Technology of Kerman and the scholarship offered by Islamic Azad University, Fouman and Shaft Branch. The authors would like to express their gratitude to the above mentioned universities for the assistance and support provided to the authors during the time of research.

12. References

- Arslan G, Tuncana M, Birgonulb MT, Dikmenb I. E-bidding proposal preparation system for construction projects. *Build Environ*. 2006; 41(10):140–13.
- Ruqaishi M, Bashir HA. Causes of delay in construction projects in the oil and gas industry in the gulf cooperation council countries: a case study. *J Manage Eng*. 2013 Aug 1; doi:10.1061/(ASCE)ME.1943-5479.0000248
- Matias J, Cachadinha N. Evaluating the potential benefits and challenges of lean construction adoption in the portuguese construction industry: a survey study. *Proceedings IGLC-18*, July 2010; Haifa, Israel: Technion; 2010.
- Chen Y, Kamara JM. A framework for using mobile computing for information management on construction sites. *Automat Constr*. 2011; 20(7):776–88.
- FHWA HS, Kerley MM, Richmond V. *Federal highway administration*. Washington, DC; 2004.
- Ochoa SF, Bravo G, Pino JA, Rodríguez-Covili J. Coordinating loosely-coupled work in construction inspection activities. *Group Decision and Negotiation*. 2011; 20(1):39–56.
- Williams TP. Applying handheld computers in the construction industry. *Practice Periodical on Structural Design and Construction*. 2003; 8(4):226–31.
- Anumba CJ, Wang X. *Mobile and pervasive computing in construction*. John Wiley & Sons; 2012.
- Kimoto K, et al., The application of PDA as mobile computing system on construction management. *Automat Constr*. 2005; 14(4):500–11.
- Gordon C, Boukamp F, Huber D, Latimer E, Park K. Combining reality capture technologies for construction defect detection: a case study. *EIA9: E-Activities and Intelligent Support in Design and the Built Environment*, 9th Europa International Conference; 2003 Oct. p. 99–108.
- Chong W-K, Low S-P. Assessment of defects at construction and occupancy stages. *Journal of Performance of Constructed Facilities*. 2005; 19(4):283–89.
- Kim GH, Shin Y, Kim T-Y, Lee Y-D. Case study of the application of a digital pen to a defect checklist of an apartment housing project. *Appl Mech Mater*. 2013; 303: 2303–6.
- Aljassmi H, Han S. Analysis of causes of construction defects using fault trees and risk importance measures. *J Constr Eng Manage*. 2013; 139(7):870–80.
- Das S, Chew MY. Generic method of grading building defects using FMECA to improve maintainability decisions. *Journal of Performance of Constructed Facilities*. 2011; 25(6):522–33.
- Volkovas V, Petkevicius K. Modeling and identification of buildings' construction defects. *Proceedings of the World Congress on Engineering; WCE 2011 Jul 6–8; London, U.K.* 2011.
- Chong W, Low S. Latent building defects: causes and design strategies to prevent them. *Journal of Performance of Constructed Facilities*. 2006; 20(3):213–21.
- Anumba C, Aziz Z, Obonyo E. Mobile communications in construction—trends and prospects. *Proceedings of the 2nd International Conference on Innovation in Architecture, Engineering and Construction*. Loughborough, UK, 2003 Jun 25–27; p. 159–68.