ENHANCING WORKER ONSITE SAFETY MANAGEMENT USING RFID TECHNOLOGY IN CONSTRUCTION

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ABSTRACT

Effective access control and attendance records regarding staff and site security may be necessary and helpful in managing construction safety consideration. Safety-related on-site information monitoring can be enhanced through Radio Frequency Identification (RFID) and web technology to share information between the jobsite and office. This study demonstrates the effectiveness of an application called the RFID-based Jobsite Safety Information Management (RJSIM) system in construction projects, demonstrating that the system will alarm and notify safety staff if a worker enters jobsite without wearing Personal Protective Equipment (PPE). The RJSIM system is then applied to a case study on a commercial building in Taiwan to verify the proposed methodology and demonstrate the effectiveness of access control and worker attendance records for a jobsite. The advantage of the RJSIM system lies not only in improving worker safety control in construction jobsite, but also in providing dynamic control and management to track access control and attendance records on a jobsite.

Keywords: Construction Jobsite Management; Safety Management; RFID; Web-based; Information Management

1. INTRODUCTION

Managing construction jobsite access control effectively is extremely difficult owing to the complexity of a construction site's layout. Effective access control and attendance records regarding staff and worker security in construction jobsite is necessary and helpful in managing construction safety considerations. One of the main characteristics for RFID technology is increased speed and accuracy of data entry. Integrating promising information technologies such as RFID technology and data entry mechanisms can help improve the effective communication of worker access and attendance information flow between construction jobsite and site office. Therefore, RFID-based access control management solutions enable efficient and accurate access control of worker attendance records for a jobsite.

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This study develops a web-based RJSIM System for improving the acquisition of entrance information on construction site. The study include (1) developing a RFID-based safety management system to increase the efficiency of access control and worker attendance (2) enhancing construction job safety monitor and control and providing real-time information to detect whether the workers are properly wearing Protective Equipment (3) providing the site office with up-to-date information from the entrance of construction areas, and (4) enhancing jobsite access control regarding field staff, engineers and workers with attendance records automatically.

2. THE APPLICATION OF RFID TECHNOLOGY IN CONSTRUCTION SAFETY

RFID is an automatic identification solution that streamlines identification and data acquisition, operating similarly to bar codes. RFID is the projection of radio waves and signals to transmit data and conduct wireless data retrieval and storage to identify the status of workers and object contents (Yin et al. 2009). An RFID system is composed of an RFID tag and an RFID reader. The RFID tag consists of a small microchip and an antenna. Data are stored in the tag, generally as a unique serial number. RFID tags can be either passive (no battery) or active (battery present). Active tags are more expensive than passive tags and have a read range of 10–100 meters. Passive tags have a read range of 10mm to approximately 5m (Manish and Shahram, 2005).

IT solutions are considered to assist safety management in many researches and projects. Lee et al. (2009) designed and built a mobile safety monitoring system to detect the workers' safety through RF technology for fall accidents in construction jobsites; Teizer et al. (2010) developed an autonomous pro-active system to improve safety management by using RF remote sensing and actuating technology to alert workers and equipment operators, Chae and Yoshida (2010) developed an accident prevention system with working area information using RFID technology to prevent collisions with heavy equipment, Carbonari et al. (2011) proposed a system to assist the real-time management of health and safety in construction jobsite. Lo (2011) developed an RFID-based jobsite safety information management system in construction projects. Lee et al. (2012) developed a real time locating system to provide accurate and robust localization for jobsites safety management; Li et al. (2012) used game technology to visualize the safety assessment process; Jia et al. (2012) built a safety monitoring system with GIS technology for improving and maintaining the safety standard in construction.

This research focuses on the development of a construction-specific practical application method, Enhancing worker onsite safety management using RFID technology in construction.

3. DEVELOPMENT OF THE RJSIM SYSTEM

The RJSIM system is based on an information-sharing platform that integrates web and RFID technologies. The system purpose to detect whether workers are wearing protective equipment and another is to provide dynamic control and management to track access control and attendance records on a jobsite, have two RFID systems used in the study. One is an HF system that tracks

jobsite access for all project participants, another system is used to track construction area access for related managers, field engineers, and workers. All authorized participants can make effective safety-related decisions based on real-time data collection and sharing. Emails and messages are automatically sent from the server to the project managers and relevant safety-related participants in a specific event when data are updated on the server side.

3.1. Framework of the RJSIM System

The RJSIM system is based on the MS-Windows XP system with Internet Information Server (IIS) as the web server. The prototype was developed using Active Server Pages (ASP), which are easily combined with HTML and JavaScript technologies to transform an Internet browser into a user-friendly interface. The RJSIM system provides a solution involving a single, unified database linked to all functional systems with different levels of access to information, based on user role, both within an organization and across organizations and other participants.

The RJSIM system server has three distinct layers, presentation, application and database, each with its own responsibilities. The presentation layer defines administration privileges and end-user interfaces suited to the end-user's work. Users can access required information via web browsers such as Internet Explorer and Google Chrome. Additionally, administrators control and manage information via a web browser and a separate server interface. The application layer defines various applications for collecting and managing information. These applications enable system security, information sharing, and system monitoring and administration. The database layer includes MS-Access 2003. Furthermore, RJSIM is written using HTML and ASP. Safety-related records maintained by general contractors can be extracted and summarized into safety reports.

3.2. Components of the RJSIM System

RFID Elements of the RJSIM System include RFID tags, readers, and a central portal system. Significantly, both the RFID tags and RFID readers are located on the client side, while the portal system is on the server side. All safety-related information acquired by RFID readers is recorded in a centralized RJSIM system database. All safety-related authorities can access required information via the portal based on their access privileges. The system consists of RFID HF and UHF technology. HF system due to short distance read range requirement is selected to monitor field staff at the jobsite entrance, passive HF tags are attached to the ID card of each staff member, engineer, and manager. Furthermore, the UHF passive RFID technology is used because it has the long distance read range capability; UHF system is utilized for the worker access control at the entrance of the construction area in the jobsite, UHF tags are attached to the safety helmet, fluorescent vest, and safety belt for jobsite engineers and managers.

The central portal provides engineers and managers with safety-related information about worker access and attendance. Managers can access different information and services via a single online front-end. Site office staff can calculate daily wages automatically and refer to various other access

and attendance data, the data are stored on the central portal via the web environment after being collected from the RFID readers, and thus become accessible to relevant participants. Data verification is performed to ensure that the data obtained are valid. The web-based system needs sufficient security measures to prevent hackers from accessing sensitive information.

4. CASE STUDY

4.1. Description of Case Study

The UHF tags are attached to the Personal Protective Equipment for jobsite engineers and managers. The RJSIM system must verify that has all four of these elements on whenever he enters the construction area. These include: (1) personal ID card; (2) safety helmet; (3) fluorescent vest; and (4) safety belt. To implement the prototype system, eight HF RFID devices with antennas were setup at read points in the four jobsite entrances. Each HF RFID device was designated at the jobsite entrances to read the tag signals indicating: (1) identification of staff and workers, (2) worker arrival, and (3) worker exit. Ten UHF RFID devices with antennas were set up at read points in three construction areas of the jobsite (See Fig.1&2). The tags provided only their identification number and a time reading. Worker attendance records at the jobsite were made by real-time collection from all RFID devices at different jobsite entrances, illustrates the implementation flow diagram of the safety monitoring process in the jobsite (See Fig.4), the RJSIM system can check attendance records and calculate wages. Tracking the number of workers on a jobsite is important because the construction manager must ensure that workers have exited the jobsite safely. The RJSIM system based on RFID technology provides useful information over the web environment. The engineers and managers could access information on worker jobsite access and attendance records for jobsite safety control, illustrates screenshot from the RJSIM system in the case study (See Fig.3).

4.2. Test Result

The validation test involved requesting that the engineers and managers selected to use the system complete a questionnaire to provide feedback. The RJSIM system was demonstrated to the respondents, who were then requested to express their opinions of the system via the questionnaire.

Both UHF and HF passive tags were used to implement the RJSIM system in this study. At each stage of the operation, the tag data were read successfully to generate the required data. Actually, the read rate at each read point was observed to be in the range 98–100% within a 2.5m distance. The high read rate demonstrates that UHF passive tags could be a feasible solution for tracking worker access when well designed and implemented.

One major advantage in the system is to collect attendance data effectively for better analysis and management, thus assisting managers and engineers in managing and monitoring the safety management process. The RJSIM system enhanced the safety management performance at the jobsite in three different categories based on the questionnaire, namely effective enhancement of

safety controls and management in the construction area, improved efficiency of worker attendance management, and effective calculation of wages.

Effective enhancement of safety controls and management in the construction area, the RJSIM system could assist in checking for workers wearing Protective Equipment, and average working times. In particular, the RJSIM system will alarm and notify safety staff if a worker enters the jobsite without wearing all safety equipment. The test results showed that the worker access and safety control on the construction site was controlled more consistently when the RJSIM was used compared with the results with conventional control methods.

I**mproved efficiency of worker attendance management,** the RJSIM system generated data on worker attendance. The data generated from the RFID readers were available for advanced analysis. The managers and safety-related engineers could access the worker attendance information through the RJSIM system. The consistent record of worker attendance and wearing safety equipment confirmation indicates the improved efficiency of worker access and safety control.

Effective wage calculation, the RJSIM system could assist in the calculation of daily wages. Wages can be calculated and analyzed based on the working time collected from the RFID system. The test results showed that the worker access and safety control on the jobsite was controlled more consistently when the RJSIM was used compared with the results with conventional control.

5. CONCLUSIONS AND SUGGESTIONS

5.1. Conclusion

The RJSIM system generated information on entrance/exit time of the jobsite, checked for Protective Equipment, and analyzed average working times. This study presents a web-based portal system that incorporates wireless technology and wireless RFID readers to improve jobsite safety information acquisition and to better monitor the safety management process on construction jobsite, the application of the RJSIM system helps to improve the monitoring of safety management in a commercial building project in Taiwan. The integration of RFID technology and web-based technologies helps engineers and managers to monitor and control the whole jobsite from the entrance. Furthermore, the UHF RFID system offered real time monitoring of whether workers wore safety equipment. Integrated with HF RFID system, real-time feedback was provided to the safety authorities. Compared with current methods, Test results showed that worker access and safety control on the jobsite was more consistent when the RJSIM was used compared with conventional control methods.

5.2. Suggestions

Based on the findings of the present case study, UHF RFID devices appear to be useful tools for monitoring safety processes on construction jobsite. The following suggestions are presented:

The human body shield and perspiration will reduce RFID readability, suggested to equip the RFID reader equips on top of the gate entrance and attach the tag on top inside of the worker’s helmet.

This study suggests providing camera functionality in the system, the camera in the RJSIM system would automatically take photographs of the entering worker to determine whether a worker is wearing his assigned ID card. The pictures can be integrated as additional information for safety management. Such as worker walking and carrying with equipment at entrance should be tracked in the construction area of the jobsite, UHF passive tags could be a better solution for high readability and long reading distance. The system can be extended functions of worker location tracking by increasing of RFID quantity. The RJSIM system can be further extended to become a part of enterprise resource management system in future.

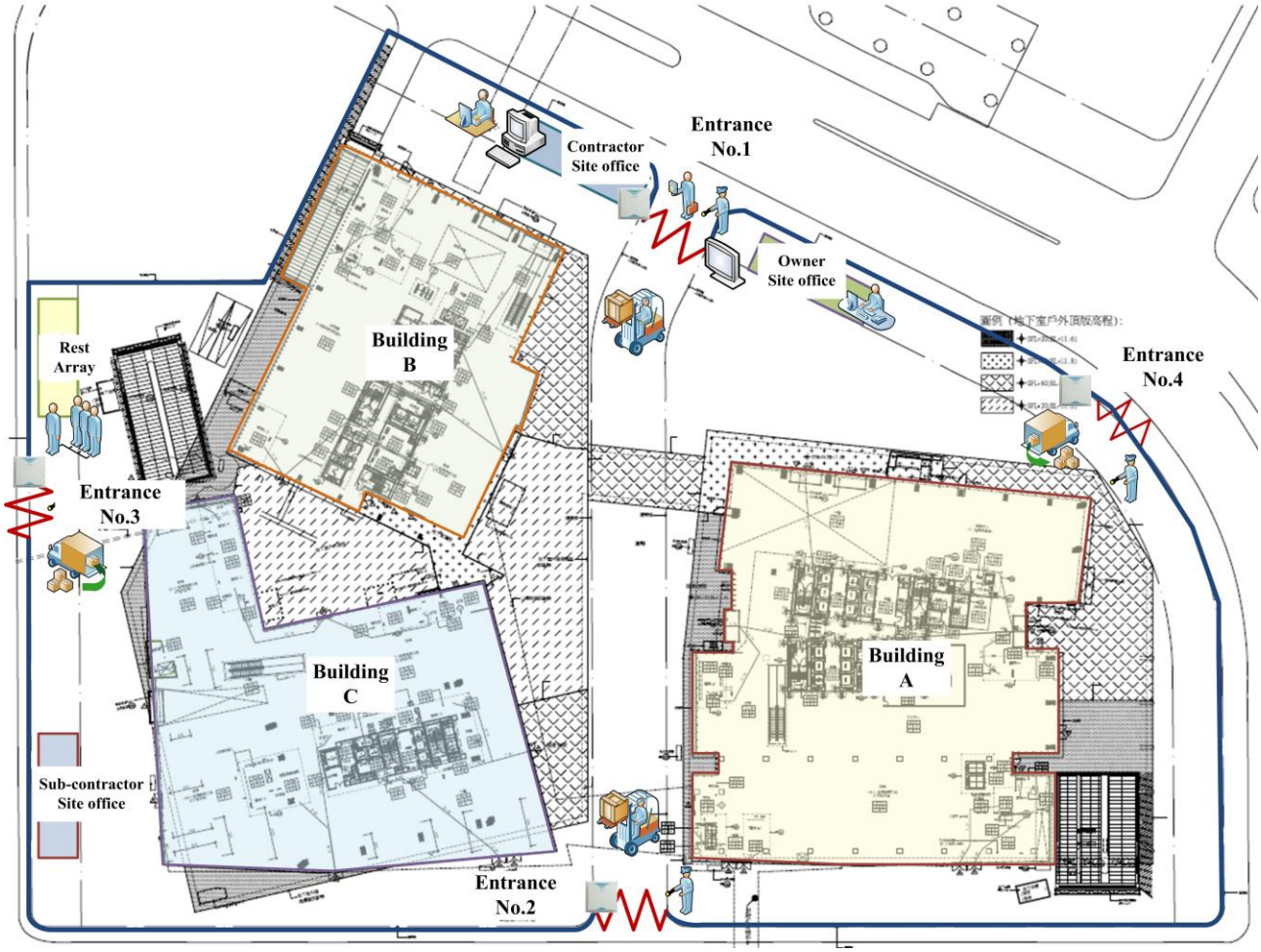

Figure 1: The Location of RFID devices installed in the case study.

Figure 2: Installed RFID devices in the construction site.

A.系統管理 | B.資料維護 | C.報表及查詢

統計區

日期	2011/06/26 16:19 (星期日)								
施工人員統計彙總：							工區人數資訊		
今日進場人數	231	目前場內人數	159	累計進場人數	69752		目前A工區人數	目前B工區人數	目前工區總人數
進場包商統計彙總							37	57	94
今日進場總包商數量	14	目前場內包商數量	13	累計進場包商數量	30		今日A工區人數	今日B工區人數	今日工區總人數
							48	101	149

重讀數據

人數統計表(包商) ◉ 今日 ○ 全部 轉出

包商	廠內人數	今日人數資訊			今日偏差值資訊			累計人數資訊		
		事前計劃	工前共識	實際出工	偏差一	偏差二	偏差三	事前計劃	工前共識	實際出工
[CTCB] - 中國信託商業銀行	2	0	0	2	0.00	0.00	0.00	0	0	1663
[FCA] - 宗邁建築師事務所	1	0	0	1	0.00	0.00	0.00	0	0	2248
[LK] - 亞翔工程股份有限公司	19	0	0	19	0.00	0.00	0.00	0	0	11307
[LK001] - 季橋工程有限公司	11	29	0	12	100.00	58.62	0.00	5960	1584	1707
[RSEA] - 榮工工程股份有限公司	22	87	164	26	-88.51	70.11	-84.15	17238	41375	18030
[RSEA001] - 春源鋼鐵	15	0	0	34	0.00	0.00	0.00	0	0	5776
[RSEA005] - 美敦工程有限公司	1	6	0	1	100.00	83.33	0.00	2202	0	978
[RSEA006] - 裕銘工程有限公司	8	0	0	8	0.00	0.00	0.00	0	7	2341
[RSEA009] - 中信保全股份有限公司	3	0	0	5	0.00	0.00	0.00	0	0	1823
[RSEA010] - 宏績興業有限公司	23	32	0	27	100.00	15.63	0.00	5171	0	2949
[RSEA011] - 耀祖企業社	18	0	0	18	0.00	0.00	0.00	3471	0	1687

人數統計表(包商-工項) ○ 包商 ◉ 包商-工項 ○ 全部 轉出

包商	工項	廠內人數	今日人數資訊			今日偏差值資訊		
			事前計劃	工前共識	實際出工	偏差一	偏差二	偏差三
[CTCB] - 中國信託商業銀行	[XXX00] - 專案-整廠	2	0	0	2	0.00	0.00	0.00
中國信託商業銀行 小計		2	0	0	2			
[FCA] - 宗邁建築師事務所	[XXX00] - 專案-整廠	1	0	0	1	0.00	0.00	0.00
宗邁建築師事務所 小計		1	0	0	1			
[LK] - 亞翔工程股份有限公司	[XXX00] - 專案-整廠	19	0	0	19	0.00	0.00	0.00
亞翔工程股份有限公司 小計		19	0	0	19			
[LK001] - 季橋工程有限公司	[161425] - 電機工程-電機-暗管預埋工程	11	16	0	12	100.00	25.00	0.00
季橋工程有限公司 小計		11	16	0	12			
[RSEA] - 榮工工程股份有限公司	[XXX00] - 專案-整廠	22	0	0	26	0.00	0.00	0.00
榮工工程股份有限公司 小計		22	0	0	26			
[RSEA001] - 春源鋼鐵	[DBB01-A] - 獨立結構工程-結構-地上鋼結構-鋼結構-A區	0	0	0	34	0.00	0.00	0.00

Figure 3: Screenshot from the RJSIM system in the case study.

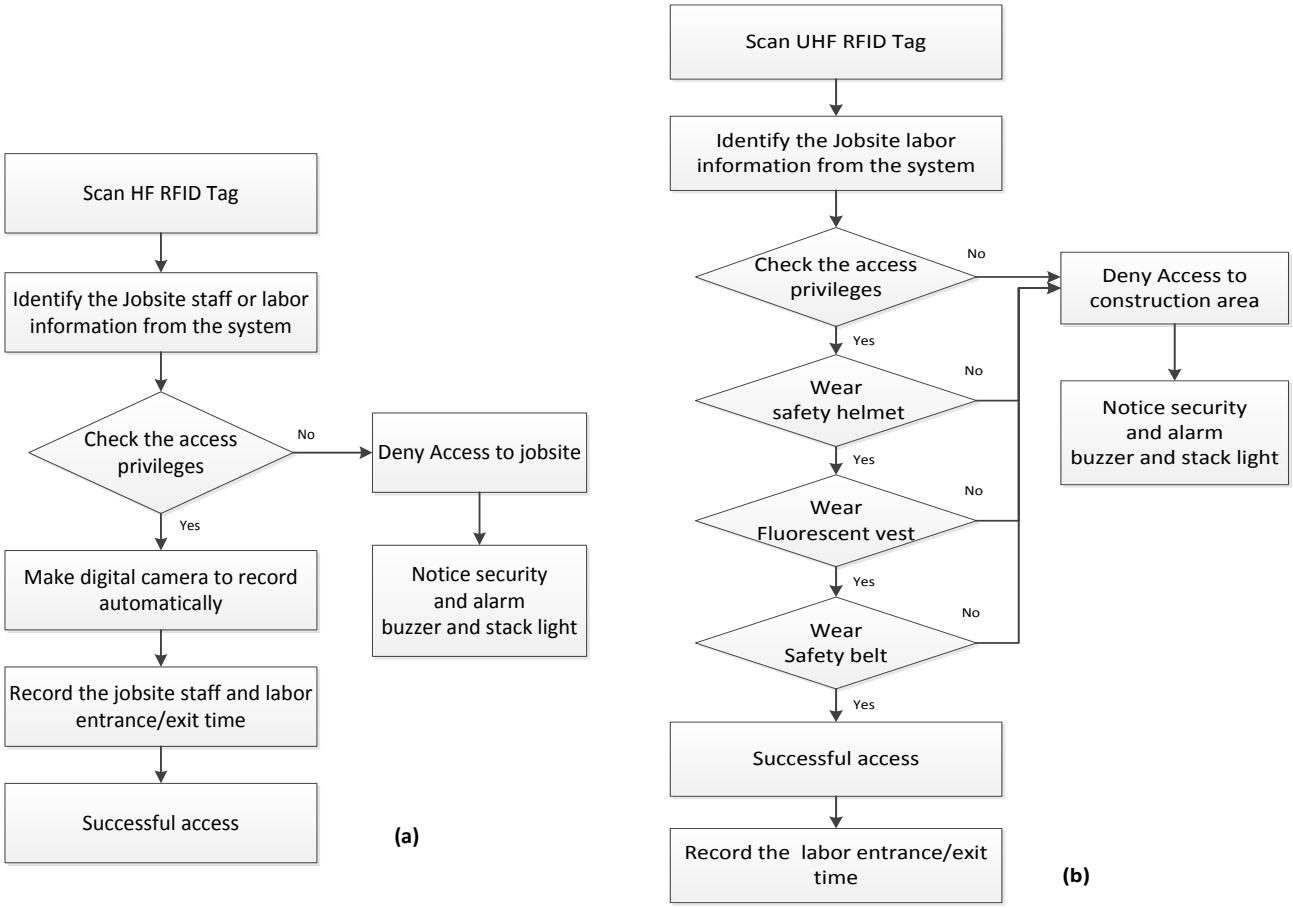

Figure 4: The implementation flow diagram of the safety management in the case study.

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