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Scenarios for applying RFID technology in construction project management

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ABSTRACT

Radio Frequency Identification (RFID) technology has been widely applied in various areas such as retail, electronic transaction, logistic and supply chain management, scientific research, security, etc. It has brought about great benefits in these areas through improving real-time information visibility and traceability. However, a widespread application of RFID in the construction industry has not taken place. One possible reason is that construction practitioners may have not been fully informed of its potentials. This paper aims to investigate various scenarios that can illustrate the uses of RFID technology in construction project management. The research starts from a brief summary of recent developments of RFID technology in different industrial sectors including construction. 16 researchers were split into 3 groups to investigate how RFID can be used in the management of materials, men, and machinery (M^3) for construction projects. Perspectives for future studies are proposed in order to fully realise the potentials. The research encourages a wider adoption of RFID technology in improving current PM practices. It also provides academia with a platform for further exploring the innovative uses of RFID technology in construction.

1. Introduction

Increasing demands for speed and efficiency in the face of greater complexity of modern construction projects have given rise to the need for management [1]. Today, there are higher standards for successful construction project management (CPM); traditional success criteria for CPM have been broadened from cost, quality, and time (known as PM triangle) to include safety and environment [2]. This requires project managers to make better decision to align materials, labour, and machinery based on the information available. Information is recognised as a new element for CPM success; some even proposed the paradigm that doing construction business is essentially making a web of informed decision across its process based on the information and knowledge available [3]. How to effectively manage information presents new challenges for contemporary CPM.

Among the many challenges for managing information in CPM, a particularly keen one is to improve real-time information visibility and traceability. Project managers need to acquire real-time information about materials, men, and machinery so as to make prompt and informed decisions. This echoes with Flanagan and Lu [3] who suggested that the main objective of information management is to make sure that accurate information is always available at the right time in the right format to the right person to support decision making. Here the information could include inventory of materials, positions of construction workers, conditions of machinery, and so on. The increasing complexity of modern construction projects, together with some innovative CPM models such as Just-In-Time (JIT), lean construction, prefabrication, all desires new approaches to provide real-time information with better visibility and traceability.

Notably, in industrial sectors such as logistic and supply chain management (LSCM), manufacturing, RFID technology has been widely discussed. In LSCM scenarios, for example, using RFID technology, such real-time traceability and visibility, enabled at the upstream, are important for increasing the efficiency and quality of supply chain operations, especially towards the downstream (e.g. distribution, wholesale, and retail) [4–8]. In the manufacturing sector, Huang et al. [9–11] investigated the RFID-based wireless manufacturing jobsites with better real-time information traceability and visibility. However, little attention has been paid to the investigation of RFID technology in construction which is also viewed as an information-based industry in addition to its labour, material, and capital intensive nature [31]. In comparison with the heated debates in other sectors, a widespread adoption of the technology has not been seen in real-life construction practices.

The primary aim of this research is to explore the potential applications of RFID technology in CPM. The rest of the paper comprises of five sections. In Section 2, recent developments of RFID technology in different industrial sectors including construction are reviewed. Research methods are presented in Section 3. Using a narrative form, Section 4 describes the various scenario cases that illustrate the potential applications of RFID in CPM. These scenarios have been further animated by using Google Sketch Up in our

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research. Next in Section 5, perspectives for future studies are proposed for fully realising the potentials. Finally, conclusions are drawn. The research encourages the industry to widely adopt RFID technology which has great potentials to improve current PM practice and its performance. It also provides academia with a new platform for further exploring the applications of RFID technology, overcoming its technical and economical hurdles.

2. Recent developments

2.1. Understanding RFID technology

Few people know about RFID technology although almost everyone today has at least one item with RFID in their wallet (e.g. subway card). In simple terms, RFID is a technology using radio waves of different frequencies for identifying objects. A typical RFID system comprises of a RFID tag and a RFID reader. A RFID tag is often formulated by a microchip which stores data and an integrated antenna serving as a transmitter. There are two types of RFID: the passive RFID and the active RFID where the former one has no power sources inside them but relies on the reader to supply power for wireless communication, and the latter has power sources installed inside.

RFID was firstly introduced as a sister technology to replace barcode system for identifying items. Table 1 is a summary of advantages of RFID by comparing it with barcode system and magnetic strip system. In contrast, it can store a relatively large number of data; for Passive RFID its memory can vary from 128 to 256 bytes while memory of active RFID can range from 32 to 128 kilobytes (KB) [12]. These data can be encrypted to increase data security. It is possible to read data from multiple tags in one time thus increase the efficiency of data processing. In comparison with barcode or magnetic system, no direct contact between a RFID reader and the tagged item is needed as it uses radio wave which can be classified as low, high, ultrahigh frequencies ranging from 125 KHz to 5.875 GHz. The reading distance can be as great as 15–25 m if powered in active RFID [12]. In addition to reading data, it is possible to write data back to the RFID tag, which greatly increases the interaction between items, system, and people. All these advantages enable a better real-time information visibility and traceability.

2.2. RFID technology in various industries

Owing to its advantages, the RFID technology has been used in a wide range of areas. Walmart is a big figure in promoting RFID technology; using its dominant position in industries, Walmart requires its top suppliers at the upstream to adopt RFID technology which will facilitate operations towards the downstream (e.g. distribution, wholesale, and retail) (RFID Journal, 2003; [10,11]). RFID is also widely used in facilitating electronic transaction (e.g. Toll collection in U.S., Octopus card in Hong Kong, or Oyster card in London), logistic and supply chain management (e.g. the internet of things), manufacturing and assembly (e.g. the assembly of cars), express service (e.g. American express), scientific research (e.g. tracing snakes and migratory birds), medicine (e.g. identifying a specific patient), and security (e.g. access control). It is envisaged that the technology, with its superior capability to provide real-time information, will significantly improve the effectiveness and efficiency of the above processes. More up-to-date applications of RFID can be found in the RFID Journal which devotes solely to the technology and its many business applications. Many governments and institutions take RFID as a strategic direction.

Table 1
A comparison of RFID with its sister technologies.

	RFID technology	Barcode system	Magnetic strip
Read rate	Fastest	Slow	Medium
Storage capacity	Largest	Smallest	Modest
Ease of reproducing a "fake" one	Difficult	Easy	Difficult
Ease of positioning for sensing	Easy	Difficult	Easy
Cost of a tag	Cheap	Cheapest	Expensive
Ease of obtaining information	Difficult (if encryption is done)	Easy	Easy (use a reader)
Knowledge of items' exact position	Easy	Difficult	Difficult
Write	Possible	Impossible	Impossible

The research on RFID is developing popularity. In the manufacturing industry, for example, RFID was recognised as an automatic objective identification (auto-ID) technology. Notably, research is conducted to investigate how RFID technology can deal with real-time field information, and consequently how it can reengineer traditional manufacturing systems such as the development of wireless manufacturing, assembly shop-floor configuration, and adaptive assembly planning and control (e.g. [9–11]). According to Tajima [8], the largest area of applications of RFID was logistic and supply chain management (LSCM). Li and Visich [32] attempted to summarise RFID benefits in LSCM by listing 39 benefits across the supply chain. Tajima [8] reported that research of RFID in LSCM, either adopting an empirical or an analytical approach, was mainly motivated by the same research question: what is the realistic value of RFID? In comparison with the studies focused on a given industry, a future vision is to integrate the above process of manufacturing, distributions, and sale, and to achieve an ambition of the 'Internet of Things'. According to Teresko [13], the 'Internet of Things' refers to a global network of computers and objects in which computers are able to identify and store information on any object, anywhere in the world, instantly.

2.3. RFID in construction

The construction industry has characteristics that separately are shared by other industries but in combination appear in construction alone [14]. The areas seeing the applications of RFID in other industries can also be seen in construction while with heterogeneity. To the construction industry, RFID technology is not completely new. Early in 1995, Jaselskis et al. [15] envisaged its potential applications in construction, including concrete processing and handling, cost coding for labour and equipment, and materials control. Since that, a few more studies have been conducted to explore potential applications of RFID in this industry.

Jang and Skibniewski [16] developed an embedded system for tracking construction assets (e.g. materials and equipment) by combining radio and ultrasound signals. Likewise, Goodrum et al. [12] implemented the technology for tool tracking on construction job sites. Dziadak et al. [17] developed a model for the 3D location of buried assets based on RFID technology. Domdouzis et al. [18] explored the applications of RFID in the construction industry including automated tracking of pipe spools and other valued items, and an on-site inspection support system. Tzeng et al. [19] explored the influence of combination manners of RFID and interior decorating materials on RFID system recognition. Yin et al. [20] developed a precast production management system using RFID technology in the face that prefabrication is increasingly adopted in construction. Wang [21] explores how the RFID technology can be used to enhance construction quality inspection and management. Chin et al. [22] developed an information system to support the logistics and progress management based on this strategy by combining the RFID and 4D CAD.

However, not many applications of RFID have been seen in real-life construction practices in spite of the desire for this technology. In Hong Kong, for example, institutions are starting to explore the use of