Real-Time Management in a BIM Model with RFID and Wireless Tags

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Abstract

Radio Frequency Identification (RFID) tags and wireless tags can be used to track objects or people within a defined a physical space. A BIM model on the other hand is the digital definition of a physical space. The possibility of these two technologies emerging together for real-time management during construction is exciting. The hybrid model can be used to monitor the procurement of construction materials to the jobsite. The same model can also be used to manage the movement of materials and equipment once they arrive on the construction jobsite. This method of tracking can be used for monitoring the progress of construction as it happens and can ultimately have an impact on the schedule of the overall project. This technology can also be used to track construction personnel on a job-site. Such tracking can significantly change the way security on construction job-site is monitored. The technology required for merging RFID and wireless tags with a BIM model are explored. Existing technology for the creation of the hybrid model and past case studies are examined. Future uses of this technology and its impact on construction management are speculated.

Keywords: building information modelling, radio frequency identification technology, job-site monitoring
1. Introduction

The use of information technology applications in the architecture, engineering and construction (AEC) sector has been on the upswing for the past decade. The latest technology that is rapidly changing the landscape within the AEC sector is Building Information Modeling (BIM). This paper explores the possibility of combining radio frequency identification (RFID) technology with BIM and a few associated applications that might result due this combination. It is argued that the use of this combination of technologies can provide a safer work environment for the construction worker and also enable project managers to monitor the productivity of construction workers.

2. RFID technology

This section of the paper addresses the technologies available for implementing RFID in a business environment including a brief introduction to RFID technology is presented. An overview of BIM is also provided as this paper deals with combining BIM and RFID technologies.

2.1 Radio frequency identification Technology

RFID technology is employed to track objects, animals and people. The technology consists of an RFID tag that is attached to the object being tracked and a RFID reader that identifies the tag when it is within the range of the reader. An RFID tag transmits a signal through radio waves that in turn are received by an RFID reader. It is widely accepted that this technology will replace the use of Bar Codes for tracking purposes. Two types of RFID tags are available commercially. An active RFID tag shown in Figure 1 contains a battery and transmits a signal autonomously and may be tracked when it is within range of the reader. A passive tag does not have a battery but is activated when it is within range of the reader. The information collected by the reader in both cases may be kept in a database. This technology provides real-time information about the presence of an RFID tag within range of a reader and therefore any object or person it is attached to.


Academicians have explored the role of RFID tags in construction for some time now (E.J Jaselskis, T. El-Misalami, 2003). Studies done by D. Grau et. al (2009) have demonstrated the effectiveness of using RFID tags in tracking materials to improve productivity in construction. J. Song et. al (2006) have shown that the delivery of construction materials to the jobsite can be automated by the use of RFID tags. RFID tags have also been used to track tools on a construction site (A. Sattineni, G. Garrett, 2006). The case for real-time monitoring and its benefits to construction productivity have been made (R. Navon, 2005). RFID tags were used in Brisbane Tunnel construction project to monitor the safety of workers underground (D. Friedlos, 2008). RFID tags are also being proposed by C.H Ko (2009) to develop a building maintenance system.

2.2 Wi-Fi RFID tags

Another new technology that will play an important role in the use of RFID tags in the future is the Wi-Fi RFID tag. Active RFID tag requires the use of RFID specific infrastructure to read the signal transmitted called the RFID reader. The Wi-Fi RFID tag can be read by any 802.11b or 802.11g wireless access point device instead of a RFID reader. The Wi-Fi RFID tag connects to the wireless access point similar to a laptop computer. There exist two advantages of Wi-Fi RFID tags over active RFID tags. The first one is the range of distance a tag may be located to be picked-up by the reader is much higher with a wireless access point device. One disadvantage however is that technology will require additional methods such as checkpoint triggers for locating the tag within a confined space since wireless access devices have a much wider range than RFID tag. Checkpoint triggers are essentially the devices that can read a tag with a much smaller range. Another advantage is that expensive RFID tag readers are not required. This Wi-Fi tag shown in Figure 2 has been used in the healthcare industry for tracking patient movement within a hospital.
2.3 Building information modeling

The National Building Information Model Standard (NBIMS) defines (Facility Information Council, 2007) a building information model as “A digital representation of physical and functional characteristics of a facility… As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward.” BIM technology improves the overall quality of design, provides better performing buildings requires fewer change orders during construction, allows the contractor to optimize the schedule and cost of the project and provides for efficient handover of the buildings to the operations and maintenance. In the United States BIMs are becoming more prevalent on the jobsite and being used to improve the overall process of construction (McGraw Hill Construction, 2008).

All indications from the AEC industries are that the use of BIM in construction will continue to increase and significantly modify the practice of designing, constructing and maintaining future buildings. An industry survey report published by McGraw Hill Construction (2008) indicates that the use of BIM among contractors alone in the US would increase by 18% in just one year. The report also indicates that over 50% of all responders were using BIM, evidence that the likelihood of future projects using BIM is very high.

3. Using RFID tags in a BIM model

RFID tags are tracked electronically and the information can be stored in a database to be used later. A typical RFID tag may be setup to be tracked at regular pre-set intervals such as 10 seconds or 1 second. Each RFID tag may be located by assessing the position of the last reader to track it. Regardless of the type of RFID reader and tag combination used some computing will be required to accurately assess the location of the tag within a pre-defined physical space. Once this information is obtained it may be translated into a CAD file or similar format so that it may imported into the BIM model.
In order to monitor the movement of people on a construction site, it would be more important to find the general location of a person rather than the precise co-ordinates. Hence the location of the tag readers can be pre-decided at the specific control points such as site entrance, elevators, stairwell entrances or any location deemed hazardous within the construction site. In the case of Wi-Fi RFID tags, additional location beacons shown in Figure 3 may be used to locate tags within a room or a pre-determined zone of the construction site.

A BIM model that is compliant with the Industry Foundation Classes (IFCs) inherently adheres to a common data model. Most BIM software allows an external file to be imported and overlaid on the BIM model as shown by the red symbols in Figure 4. The RFID data described above can be imported into the BIM model and displayed. The resulting model can be monitored by the construction project manager or superintendent to ascertain that construction workers are at the proper location. Some additional modules within the BIM model may be needed to set up automatic triggers to highlight workers that are in a restricted area.
3.1 Materials tracking in BIM model using RFID tags

RFID tags may be attached to building materials either by the manufacturer or upon arrival on the jobsite. RFID readers may be located on the job site near the material storage areas. By using this technology a project manager or site supervisor may keep track of the security of building materials stored. A simple spreadsheet may be setup to locate all the materials and send alert if any materials that are missing. This information could also be used to track the progress of work on the construction site. As an example if an RFID tagged steel beam is read by a reader in a location other than the material storage area then it might be deduced that the steel beam is being placed in its proper or perhaps even improper place. This method may be used from a remote location enabling a senior manager at the home-office to keep track of construction progress on the jobsite.

3.2 Construction worker safety supervision

It is globally accepted that safety risk to construction workers is very high. Over 2800 deaths have occurred in the U.K, over the past 25 years, as a result of construction activities (Health and Safety in Construction Industry, N.D). Accidents on construction sites are commonplace and tend to cause major havoc for the schedules and budgets of projects. Minimizing safety risk is an important concern for a construction company, regardless of its size. Studies done by S. Chae and T. Yoshida (2010) have shown that RFID tags may be used in preventing collisions between workers and heavy equipment in a construction environment. Another study done by W. Wu et al (2010) has demonstrated that near miss accidents can be studied in a construction environment using RFID technology.
Productivity of construction workers is directly related to the profitability of a construction project (Motwani et al, 1995). Supervision is an important aspect of measuring construction productivity. Incorporating RFID technology in a BIM model on construction site could alert the supervisor when a construction worker ventures outside the area where the work is being performed. The site supervisor may also use this information to direct construction workers to appropriate locations within a jobsite further improving productivity. As an example, the supervisor might ask the nearest construction workers at a specific location to tend to a material delivery truck that has just arrived on the construction site to minimize wait time. Studies done by Z. Riaz et. al (2006) demonstrate the lack of decline in safety accidents in construction and discuss how information and communication technology (ICT) may be used to reduce the accident rates. The technology proposed in this paper will use ICT to potentially minimize accidents in the construction industry. A proposed workflow for tracking construction workers through RFID technology in a BIM model is presented in Figure 5 below.

Figure 5: Proposed workflow to track construction workers in a BIM model using RFID Tags

Under extreme circumstances a construction site may have to be evacuated. This may occur during a fire drill, actual fire, controlled explosion and time of the day when the construction site is shut down after all workers are supposed to have left for the day. The approximate location of workers on the site in such circumstances may be detected by these RFID tags and appropriate action may be taken.
3.3 Privacy concerns for tracking construction workers

Anytime the movement of people is tracked, privacy concerns for the use of that information exist. These concerns must be addressed before the technology can be implemented. The tracking information must be used solely to monitor construction safety and productivity. The storage of the information must be limited to a few days only so that the data is not misused at a later time. It must be communicated to the construction workers that the proposed technology will enhance their safety provide for a better work environment.

4. Conclusions

Construction worker safety is an important issue on any jobsite. Accidents in the construction industry are both costly and dangerous to the workers. Also productivity of the construction workforce has a direct relationship to the profitability of the construction company. This paper has presented scenarios in which RFID technology can be used in a BIM to improve safety and productivity on a construction site. The use of RFID technology and BIM technology is gaining popularity. The application of each technology has been separately verified by its use in the industry and academicians. Indications are that these two technologies will continue to gain popularity in the industry. The accurate and real time combination of these two technologies would result in a 3-D model of a construction site that shows location of workers. Construction project managers and site superintendents may use this model to identify workers that are not at the proper location, which might result in either a loss of productivity or a potential safety hazard if not handled in a timely fashion. Construction materials may also be tracked on a jobsite in real-time using this combination of technologies. Several other applications of this combination of technologies may well exist but have not been addressed in this paper.

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