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The Application of BIM and RFID Technology in Building Engineering Informatization Based on IPD Mode

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Abstract: This paper expounds the IPD mode, namely the integrated project delivery mode, BIM model and RFID technology, studies, analyses and discusses the integration and application of BIM and RFID technology from the perspective of the value of IPD mode, and studies the effect and actual benefit of the integration of BIM and RFID technology in construction project management through the application of engineering practice cases, the application of the combination of BIM and RFID technology in construction site personnel management and intelligent building construction is analysed and discussed in detail. The integration of BIM and RFID technology is an important guarantee for the implementation of intelligent building project management and an inevitable trend for the development of intelligent buildings and smart cities. Through the theoretical research and engineering practice of this paper, it is expected to provide reference and reference for the engineering management of the construction industry in china, and promote the level and status of the construction industry as the pillar industry of national economic development.

1. Introduction

With the continuous improvement of china's economic size and technological level, engineering construction projects are developing towards large-scale, complex, and specialized refinement. The functions provided by buildings and structures are more diverse, and the number of special designs involved in the construction process of construction projects is also increasing. The goals set by project construction units in the construction process are not only limited to cost, progress, and quality, but also to the informatization, green environmental protection, and environmental protection of construction projects new requirements have been put forward for the assembly rate and carbon emissions compliance of prefabricated buildings. In the context of the new era, with the continuous development and changes of the construction environment and the entire process, it is urgent to innovate the construction mode and information technology in the construction industry. Under the commonly used project delivery mode in the industry, conflicts of interest and conflicts

with the overall interests of the construction project may arise between the participating units of the construction project. In order to further improve the production efficiency and ensure quality and quantity of construction projects, there is an urgent need for a new project delivery model to develop and apply which can continuously optimize and improve the interest relationships between the participating units of the project.

The integrated project delivery model, also known as the IPD model [1], takes the collaborative work of all participating units in construction projects as the core concept, providing reliable guarantees for the effective implementation of digital and information integrated management in construction projects. In the IPD mode, during the entire process of a construction project, all key stakeholders, including government authorities, construction units, entire process consulting units, design units, construction units, material and equipment supply units, sign multi-party cooperation agreements to collaborate and complete the early planning, scheme and construction drawing design, construction and other project production process management work of the construction project, fully leverage the professional skills and management advantages of each participating unit, and minimize the occurrence of errors and changes in the project production management process as much as possible [2].

The IPD model requires the support of building information model technology in the implementation process of construction project management. BIM is a relatively complete information model, in which the information, implementation process, and various resources of each stage of the entire lifecycle of a construction project can appear in one model, and each participant can view and use them. Radio frequency identification (RFID) [3] is the core technology of the internet of things engineering. With the improvement of the level of internet of things engineering technology and the continuous progress of intelligence, one of the main future development directions of intelligent buildings is inevitably RFID technology.

2. Research Status and Application Value of IPD Mode

2.1 IPD Mode Concept

The American institute of architects (AIA) recognizes the IPD model by integrating the personnel, systems, organizational structure, and production practices of the entire project into a framework during the initiation, design, and construction process of construction projects, and synergistically utilizing the various abilities and experiences of all project participants to achieve optimal project benefits and maximize project value for the construction unit, a delivery method that maximizes efficiency [4].

2.2 Characteristics and Research Status of IPD Mode

The American institute of architects (AIA) has analyzed the engineering practices of construction projects that have already applied the IPD management model, and summarized the five core characteristics of the IPD model: early involvement of project core participating units in production management, shared risks and benefits among project stakeholders, joint consultation and decision-making among project participating units, and a certain degree of exemption from responsibility and authority among project key participating units the participating units of the project jointly determine the ultimate goal of the project. Sive [5] believes that the five characteristics of the IPD model must exist in a construction project to achieve the management form of IPD. However, from project practice, it can be concluded that the characteristics of the IPD model are not fully covered in a project. On this basis, ghassemi [6] et al. Proposed targeted applications based on the characteristics of IPD construction projects to improve efficiency and

value.

2.3 The Application Value of IPD Mode in Construction Engineering

The IPD mode is a brand new engineering handover method, which takes the IPD protocol framework as the core and adheres to the principles of mutual trust, cooperation, sharing, and openness. It integrates technology, management, processes, and systems to meet the requirements of the project construction unit. In this model, personnel, systems, engineering practices, and business architecture are effectively integrated, and based on an information collaboration platform, greater value is ultimately created through collaborative cooperation in project initiation, planning and design, construction, and operation and maintenance stages.

3. Building Information Modelling

BIM, also known as building information model, is a three-dimensional digital model that integrates information from all building implementation processes and is a very practical analysis tool. Simply put, it means using simulation software in a computer to first simulate an actual building model, and then conducting simulation experiments, analysis, and testing to identify potential problems that may arise during project implementation in advance and find solutions. Its advantage is to build corresponding BIM models based on the basic construction data of the project engineering. Under this model, engineering quantity data is extracted and standardized [7]. BIM models have similarities and differences with virtual prototypes in the manufacturing industry, both of which use virtual models to replace physical objects. They can analyze and test the various stages of the lifecycle from concept design to manufacturing/construction to delivery and maintenance, just like real physical prototypes.

As shown in figure 1, both the virtual prototype model and BIM model are based on cad models, which are then imported into their respective simulation software. Through a series of processes, simulation models are created, analyzed, and tested. The BIM model involves various stages of the entire lifecycle of a construction project, including early planning, design, construction, and operation and maintenance stages. Each stage has its own functions that can be implemented to meet the needs of personnel from all parties involved in the project.

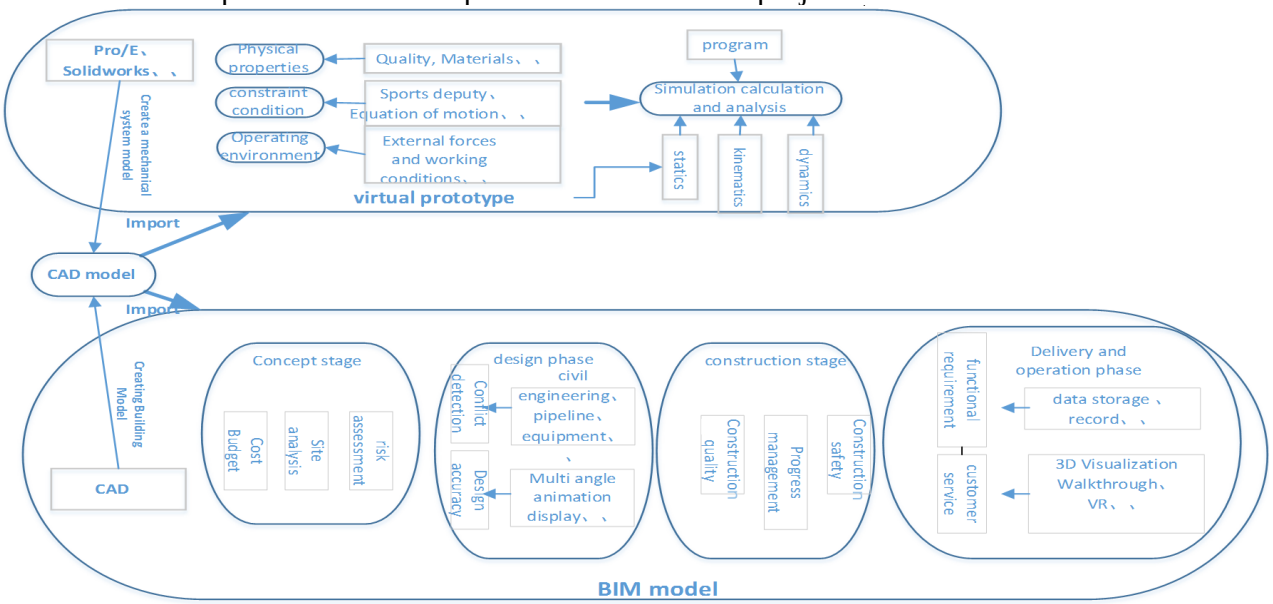

Figure 1: Comparison between Virtual Prototype Model and BIM Model

4. Radio Frequency Identification

The internet of things technology has made tremendous progress and development in recent years, and automatic recognition is a very important technical measure in the internet of things technology. Radio frequency identification technology is an automatic identification technology that transmits data through radio waves. It automatically identifies and obtains real-time data through radio frequency signals, and does not require manual intervention during the automatic identification process, enabling normal operation in various extremely harsh natural environments. Compared with other automatic identification methods, radio frequency identification technology has many advantages, such as non-contact and the ability to identify high-speed moving objects. It can be said that it is currently the most important automatic identification technology [8]. The RFID system consists of a reader/writer, an electronic tag, and a system layer. During operation, the reader/writer sends a certain frequency of radio waves to the tag. At the same time, the electronic tag sends out the stored information, and the reader/writer receives and interprets the data. The real-time data received is transmitted to the computer system for corresponding data analysis and processing. RFID technology can achieve information collection in the perception layer of the IOT architecture, as shown in figure 2.

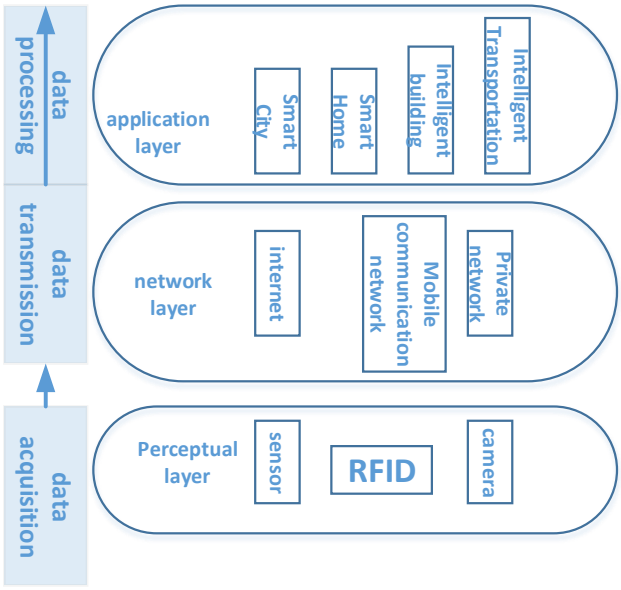

Figure 2: The Position of RFID in the Architecture of the Internet of Things System

Under the IPD mode, the BIM model runs through the entire life cycle of the building. The model information at each stage should be shared with each other to maintain the flow of information, and there is no need to repeatedly model. Throughout the entire building life cycle, all parties involved should fully utilize the BIM platform, timely obtain information, make joint decisions, and better manage building informatization while ensuring the interests of all parties. The collection, transmission, and processing of information rely on internet of things technology, big data, cloud computing, and more. The integration of BIM and FRID technology helps to establish cross building digital infrastructure [9]. The advantages of its application in construction engineering provide technical support for the fast and efficient processing of information throughout the entire project construction process. The fusion of the two cutting-edge technologies combines the on-site tracking of RFID technology with the information management of BIM technology, ultimately achieving a significant improvement in the utilization of information data obtained during project construction, the data information truly brings into play the value that

construction projects should have.

5. The Applicability of IPD Mode in Construction Project Management

In past engineering practices, the construction unit has conducted bidding and procurement for the design and construction of the proposed project separately. The application of the IPD model is beneficial for the construction unit to propose construction goals such as building informatization, green buildings, sponge cities, energy conservation and environmental protection, carbon emissions, and prefabricated buildings in the early stage of project approval and design. The specific role of the IPD model in building informatization application in large-scale construction projects is shown below.

5.1 Key and Difficult Core Issues in Solving Large-Scale and Complex Buildings

Large and complex construction projects are mostly public or industrial buildings with special usage functions, which pose great challenges in project design and construction processes. In the design phase, large and complex buildings have strong professional collaboration requirements, especially industrial buildings that need to meet their own production needs, with complex content and a high degree of specialization. During the construction phase, the large and complex number of power bridges, production and domestic water pipelines, ventilation pipelines, and professional pipelines in large and complex buildings are intertwined, and the design and construction requirements for different functional rooms are completely different, posing challenges to on-site construction management. The IPD model integrates information technology into the organizational structure and workflow of construction projects, and a reasonable risk sharing plan will constrain the owner to use their own advantages to excessively transfer risks and force other participants to bear them. It can also avoid other participants from harming the overall interests of the project in pursuit of immediate personal interests, effectively increasing the probability of project success [10], and can effectively solve the key problems of large and complex buildings difficult core issues. The IPD mode solves the organizational boundaries between different participating units in construction projects, prioritizing the resolution of identified issues. Each participating construction unit of the project intervenes in advance during the design phase, continuously optimizing the design work by integrating the implementation needs and professional knowledge of each participating unit, reducing the uncertainty and repeatability of the project implementation after the design, and making the design meet the functional use requirements of the construction unit for the building. In terms of information integration and utilization in construction projects, the application of emerging technologies such as BIM and RFID provides technical support for the IPD model [11].

5.2 Meet the Full Lifecycle Requirements of the Construction Unit for the Building

In recent years, the management requirements of construction units for project construction are not limited to basic goal control during the construction process. Under the guidance of government business regulatory departments, construction units have proposed new requirements for sustainable full life cycle applications such as building informatization, green buildings, carbon emissions, sponge cities, and prefabricated buildings. The IPD model utilizes integrated thinking and methods to establish an integrated and collaborative information project management team, enabling each participating unit to accurately understand the project lifecycle requirements proposed by the construction unit.

6. Practice of Integrating BIM and RFID Technology in IPD Mode

The first phase project of Huixian high end equipment manufacturing industrial park has a total construction area of 97106.54 square meters, including steel structure factories, warehouses, office buildings, dormitories, canteens, and switching stations. It was invested and developed by Huixian Yuhui industrial development co., ltd. The construction unit learned about the successful cases and advantages of IPD model in large-scale and complex industrial building informatization and decided to apply the IPD model to this project.

6.1 Application of RFID Technology in Personnel Management of High End Equipment Manufacturing Industrial Park Project in Huixian City

Due to the special working environment of construction sites, there are usually problems such as large personnel changes, diverse types of work, and frequent personnel entry and exit. Therefore, a relatively intelligent system is needed for the management and information collection of workers. Therefore, the intelligent management system for construction site personnel must support functions such as identity recognition, backend operation, and data update. In the system, the division of safety areas is achieved based on the three-dimensional digital model established in the early stage of BIM. With the continuous progress of the construction project, the safety areas in the model are also updated synchronously, completing the safety management of on-site workers in the project. Worker information can be entered into RFID tags for identification, improving work quality and efficiency, and providing technical support for later information traceability. The personnel management system for industrial parks based on BIM and RFID is shown in figure 3. The RFID electronic tag module and reader module carrying worker information complete the automatic recognition of object information and transmit it to the management system center [12]. The BIM model provides the created model and security area division function. Through network communication modules, information transmission and sharing are achieved, ultimately achieving image display monitoring, real-time data update and tracking, intelligent information retrieval, data storage in the cloud at the construction site workers use functions such as voice prompts and intelligent alarms through the gate system.

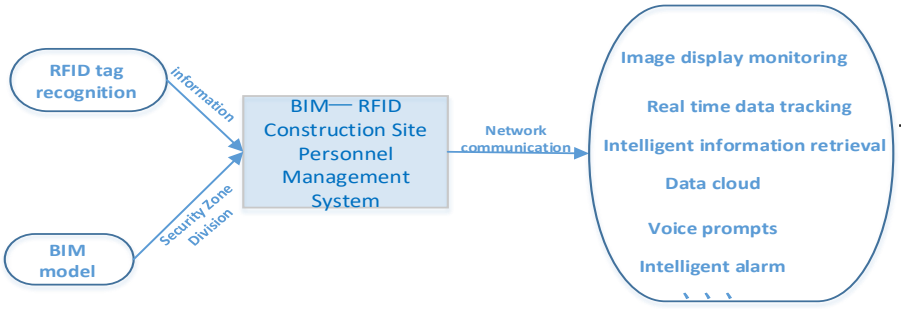

Figure 3: Industrial Park Personnel Management System Based on BIM and RFID

6.1.1 Safety Functions

Non-professional personnel entering the construction site are likely to cause safety accidents. These workers do not have a certain level of safety protection awareness and are not familiar with

the division of safety areas on the construction site, which makes them very prone to personal injury and even life-threatening. In response to such situations, construction workers can wear safety helmets equipped with RFID chips. The RFID chip in the safety helmet is detected by the detection channel, and the gate linkage control system receives the information and drops it to allow workers to pass through, in order to avoid accidents. Construction workers can also wear smart bracelets, which record detailed information about the workers, including their job type, physical condition, and other information. Once a worker enters a hazardous area, the bracelet will give an alarm, or when an unexpected situation occurs, the relevant information can be directly transmitted to the information center, so that managers can take corresponding measures in a timely manner.

6.1.2 Personnel Attendance

At present, some construction sites still use manual attendance methods, but the difficulty of implementing manual attendance is relatively high. Due to the large number of workers on the construction site, managers may make mistakes in attendance, or there may be situations where workers work on behalf of each other. When construction personnel wear safety helmets with built-in RFID responders, they can accurately record their entry and exit time when entering the construction site. Moreover, wearing safety helmets when entering and exiting the site can be verified through facial recognition and RFID information before entering and exiting [13].

7. Development Prospects and Problem Analysis

7.1 Development Prospects

RFID technology is the core of the internet of things and its application in various industries is constantly being promoted. With the continuous development of technologies such as intelligence and sensors, the cost of RFID chips is gradually decreasing. RFID tags have a variety of shapes and can be suitable for different scenarios. Compared to barcodes, RFID tags have stronger plasticity, better resistance to pollution, durability, and corrosion resistance, and are not limited by size and shape [14]. The integration of sensors and RFID tags allows for the collection of information from tags while also sensing various dynamic information, such as temperature and humidity. Implement information transmission between components and networks, thereby achieving automatic positioning, identification, monitoring, and control of components. The integration of RFID and BIM in the IPD mode plays an important technical support in building informatization and future smart city development.

7.2 Existing Problems

(1) RFID technology has not yet formed a globally unified standard system.

(2) The cost issue of RFID tags. The biggest issue in promoting RFID technology in building informatization is cost control. With the reduction of costs, RFID technology will be more widely applied.

(3) Safety issues. With the development of RFID tags, when the tag enters the reading and writing range, it will unconditionally send a signal to the reader, making it impossible to determine the security and legality of the reader. Holders of items with RFID tags may also leak important personal information, which can pose a threat to personal information security and privacy. Its security is also a key issue worth considering.

(4) There is not yet a mature solution and environment for the integration of BIM and RFID in the application of building informatization. There is no mature system in china that combines the

two and integrates them for application. However, the integration and application of BIM and RFID technology informatization in the IPD mode will be a development trend.

The development trend of combining BIM and RFID in building informatization is shown in figure 4. The BIM model achieves smarter models and more comprehensive software, while RFID technology achieves lower costs, more mature technology, more complete standard systems, and better security. Based on this, a BIM-RFID information integration solution is formed, forming a relatively good application system, which is an important guarantee for the future development of intelligent buildings and smart city informatization.

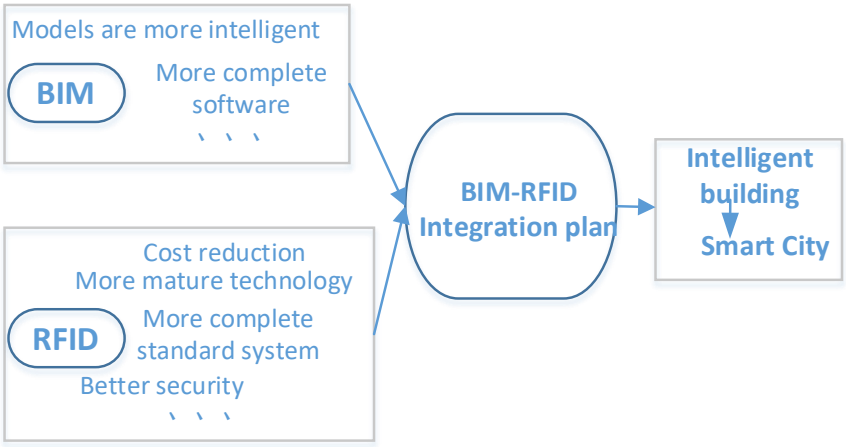

Figure 4: Development Trend of Combining BIM and RFID

8. Conclusion

In the context of the widespread application of big data information in the new era, the circulation and transmission of data are particularly important. Projects in construction informatization that use the IPD mode as the delivery method are based on BIM technology. BIM technology is applied in construction projects to change the traditional rough construction method, greatly reducing the investment in human and material costs. At the same time, it can effectively control costs, standardize project management, and utilize its intuitive and comprehensive management characteristics, effectively promoting the progress and development of construction engineering informatization [15]. The project delivery method of the IPD new model is more suitable for large and complex construction projects. In practical engineering applications, there is still a situation where the level of informatization is not high. Therefore, improving the information management system will be the focus of further research. In summary, theoretical research combined with engineering practice has proven that the application of BIM and RFID technology in building informatization under the IPD mode has improved the multi-dimensional benefits and value of project construction.

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