Smart Cities

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"Smart cities" are a new type of city where stakeholders are jointly responsible for urban management. City Information Management (CIM) is an output tool for smart city planning and management, which assists in achieving the sustainable development of urban infrastructure, and promotes smart cities to achieve the goals of stable global economic development, sustainable environmental development, and improvement of people's quality of life. Existing research has so far established that blockchain and BIM have great potential to enhance construction project performance.

Keywords: Smart Cities ; blockchain ; building information management (BIM)

1. Introduction

The term 'smart cities' first appeared in the 1990s [1]. Since then, there have been several definitions of smart cities. In different development periods, various stakeholders will give different definitions. Among the more widely definition relates to the six dimensions—namely, smart people, smart economy, smart governance, smart mobility, smart life, and smart environment—to measure the development of smart cities [2]. Cities can make further adjustments and improvements according to their own actual development conditions, and form their own characteristic development ways. The British Standards Institution (BSI) [3] defines the smart city as 'the effective integration of physical, digital and human systems in the built environment to deliver sustainable, prosperous and inclusive future for its citizens'.

The development of smart cities takes 'citizen-focused and improving the quality of life of residents' [4] as the fundamental goal, and achieves the triad of economic, social and environmental development in the long-term development. Emerging technologies, as a tool for urban development, acquire data and knowledge all the time around the world, produce qualitative changes in substantial amounts of data, and promote innovation and change [5]. Desouza et al. [6] identify three paths to the development of smart cities: greenfield, neighborhood and platform. However, policymakers make it clear that technology is not the core of policy making and urban development, but care for citizens is. The smart city strategy brings innovative changes to the region that helps the region improve its image and status, promote industrial development, attract high-quality talents, and contributes to the formation of a smart city model that is urgently needed for resilient settlements in a climate emergency [7]. Smart sustainable cities are currently the main development mode adopted by cities around the world, because this mode can best respond to environmental changes, ensure that the government is clean and honest, innovate the global network economy, and improve the quality of life [8].

Urban development has undergone multi-stage evolution, facing the challenges of retention and elimination, rebirth and decline, and the evolution and regeneration of multiple industries such as agriculture and industry [9]. These changes have formed today's urban strategy. Every urban renewal is a process of urban iterative optimization. Western cities have undergone five transformations, from urban reconstruction in the 1950s, urban revitalization in the 1960s, urban renewal in the 1970s, urban development in the 1980s, to urban regeneration in the 1990s. The reform of the city improves the policies according to the actual development challenges and opportunities of the city, so as to carry out the systematic implementation and management of the city and improve the quality of life of the city at the same time [5].

Taking the transformation of Barcelona's Poblenou smart cities as a case, its development focuses on social inclusion [10]. From a long-term perspective, the development of the general direction is forward-looking and sustainable. Being a knowledge-intensive city can bring the following advantages to the city:

- The influx of knowledge-based talents brings strong innovation momentum to the society and the ability to face the challenges of urban development [11];
- Promote the construction of infrastructure and life security, such as business environment, cultural and recreational facilities, medical education, housing and transportation [12];

- Promote investment in real estate, such as talent centers, business districts, and school districts; and in public sectors such as transportation, universities, cultural facilities, and tourism [13];
- Promote the establishment of mutual help relationship between university education and companies, so that the university can get practical work experience and the company can get knowledge and skills [14];
- Promote citizens to participate in urban development discussions through dialogue [15];
- As a soft asset, knowledge can effectively create value for cities and provide more appropriate solutions for urban management [16].

The case of Barcelona's Poblenou smart cities shows that the construction of a smart knowledge city requires the support of all social stakeholders, analyzes the current situation, and develops strategic plans. The formulation of the plan requires the establishment of a knowledge management framework based on different city characteristics, capabilities, and limitations. Cities can learn knowledge and expertise from each other; develop innovative solutions and sustainable strategies; and develop green, open, inclusive and sustainable cities [17].

Sustainability is an important pillar for the development of smart cities [18]. Smart devices and smart services have become parts of the smart cities [19], and the application of City Information Management (CIM) can provide ideas for effectively dealing with problems in urban construction [20]. CIM is not only an innovative and comprehensive new infrastructure construction, but also a carrier for realizing the implementation of big data new infrastructure, which plays a leading role in the realization of accelerating the digital and intelligent transformation of urban industries, helping the formation of new economic and technological forms, and in the realization of urban industrialization and industrial urbanization [21]. Building Information Management (BIM) is a key direction of information management in the future construction industry [22]. Its combined platform with GIS, data analysis tools, visualization tools, and parametric design tools constitutes CIM [23], which provides strong support for the comprehensive management of cities. As a part of smart city, smart buildings must also integrate sustainable development throughout the entire life cycle. In order to make the society more sustainable, various concepts of 'green', 'environmental protection', and 'sustainable development' have emerged, but there is a gap between the concept and the actual operation [24]. The realization of the sustainable development requires technical support, however, the construction industry has always lagged behind other sectors in the use of digital information technology [25][26].

An increasing body of work was published on BIM. Moreover, BIM has different functions for different stakeholders. However, due to the limited understanding of technology among practitioners and the current obstacles, the key functions of BIM cannot be brought into play, and the full potential of BIM has not yet been realized [27][28]. Interoperability is also challenged by decentralized collaboration in the construction industry. This opacity and lack of communication cannot give positive feedback to all stakeholders [19][29]. This will lead to disjointed teams with divergent priorities, which is not conducive to the overall progress of the project [25].

Blockchain is an encrypted distributed accounting technology and also is a decentralized database, which has the potential to address interoperability problems of barriers/challenges facing smart city [26][30]. Blockchain can store data securely and easily for query on the chain, providing support for the long construction cycle and reducing unnecessary work. Limited yet increasing studies explored the integration of blockchain and BIM in construction projects [31][32][33]. These studies, however, focus on applications in the financial aspects of construction (payment security, comprehensive project delivery) and security. Penzes [27] further emphasizes the importance of blockchain in the construction industry and describes its potential applications in Payment and Project Management, Procurement and Supply Chain Management, and BIM and Smart Asset Management. There are few related explorations on how blockchain and BIM affect the development of the entire cycle of sustainable building for smart cities and there is insufficient research on investigating the relationship between BIM, blockchain, and sustainable building. In addition, the potential benefits of integrating blockchain and BIM have not been fully realized in the construction industry.

2. Sustainable Building, Blockchain, and BIM

The integration of digital technologies, such as BIM and blockchain, has contributed to the digital transformation of sustainable buildings [19]. It can be seen from the table in the results that there are few studies that discuss the three together.

In the design phase, information, construction knowledge, environmental, social and economic impacts need to be taken into overall consideration [34]. It is necessary to unify decision-makers, supervisors, investors, designers, construction parties, owners, and other stakeholders to participate in the design of BIM [8]. BIM integrates with sustainable building

design process model [35] to collect a lot of unstable data information. Meanwhile, blockchain can balance privacy and accessibility to ensure the safe transmission of data to organizations or devices [36]. Liu et al. [37] established the relationship and role of BIM and blockchain in sustainable building design information management from the perspective of architects, which emphasizes how users (stakeholders of sustainable building design projects/BIM customers) manage.

With the assistance of BIM, the project was designed to comply with architectural and engineering specifications during the preliminary design [38]. In the process of simulation, the model is continuously optimized, and problems are solved in time. This can foreseeably avoid many problems encountered by traditional architectural design and construction [39]. Such as the order of construction, size, safety, placement, selection of materials, shapes, and environmental issues caused by spaces. Early planning for these issues will make the initial design more standardized, and each stakeholder can understand the design process, clarify the work content of all parties, and make the work more organized. At the same time, blockchain can provide interoperable protocols for all partners to ensure effective authorization interactions among decision makers, designers, and construction parties; and handle data interoperability issues well [40].

During the construction phase, renovation is more energy-efficient, environmentally friendly and cheaper than new ones [41]. However, BIM is not mature enough to maintain and update existing BIM in renovation projects, and data collection is a challenge [42]. Therefore, it is very important to provide a rich semantic database and integrate different information sources [43]. Using architectural design knowledge can improve the effectiveness of BIM reconstruction [44]. For worn-out buildings that do not meet legal requirements, using BIM for repairs has huge energy-saving potential [45].

In the operation phase, effective operation activities can improve the built environment and enable it to have more integrated functions [46]. Blockchain can realize transactions from sales and operations to finance and management, of which the smart contract can balance the profits of each partner and the interests of the company and users in an open and transparent manner [47]. The circular economy runs through the construction industry, retaining used building materials as a material library [48]. City managers and architects are familiar with the reuse of these building materials. These experiences can increase the market for reused materials, reduce the use of raw materials, focus on environmental benefits, and promote the sustainable construction of smart cities. BIM and blockchain can help analyze the most valuable materials for recycling [49].

The integration of FM, BIM, and blockchain can greatly improve the execution of construction projects and provide assistance for maintenance management and construction performance evaluation activities [50]. The implementation of BIM needs to adopt the bottom-up approach and ensure that all parties participate in planning and the participants have sufficient understanding and technical capacity [51]. Blockchain can assist BIM to efficiently use data to objectively evaluate projects, simulate building performance and full-cycle usage to improve the overall construction project quality, and achieve the goal of environmental protection and efficient resource conservation [52][53].

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