Proceedings of CONF-CIAP 2026 Symposium: International Conference on Atomic Magnetometer and Applications
DOI: 10.54254/2753-8818/2026.HZ29358

BIM-Driven Multi-Technology Integration Across the Building Lifecycle

Xinyi Wang

Department of Earth Sciences and Engineering, Southwest Jiaotong University, Chengdu, China
Xinyi.wang@okstate.edu

Abstract. With the rapid development of digitalization, BIM has become an important information management hub throughout the whole life cycle of the building. Starting out as just a 3D modeling tool, BIM is now so much more. Today, it is a main platform that can connect with the Internet of Things (IoT), big data analytics, and cloud computing. This paper takes a look at how it is changing what traditional construction runs on by having all the real-time data collected and predicted and working at a distance. Specifically, BIM is given the ability of real-time sensing and monitoring by the IoT technology, and turns static models into dynamic representations of the physical environment. Big data analysis makes use of past and present operations data to give out predictions that improve decisions about upkeep and making energy use better. Cloud platforms take the BIM role beyond what it can do, by providing scalable online collaboration environments for problems in version control and resource sharing and cross-discipline working. All these added up to making building life cycle governance transition from those old, inactive procedures to new, lively data-oriented operation procedures. It also brings up persistent problems such as interoperability issues, cost and security risk. as for the future, it looks like there will be a way of creating BIM-based digital twin ecosystems, this could make the industry much more predictable, controllable and innovative in a sustainable fashion. In that case, BIM is not a common technology, it is the foundation of building a smarter future.

Keywords: Building Information Modeling (BIM), Internet of Things (IoT), Big Data, Cloud Platform, Full Lifecycle

1. Introduction

The digital transformation of the construction industry is always being carried out, but it has changed, from using only one type of technology to combining several technologies as a whole in depth. It's exactly because of these constant technological convergences of BIM, IoT, big data, and the cloud that have completely changed the way how manage the building lifecycle, making it more efficient. On integrating BIM into particular technologies, a lot of related studies exist, yet a lot still needs to be explored with respect to how BIM can systematically function as an integrative hub throughout the entire building lifecycle, starting from planning, construction, operation until maintenance, renovation and decommissioning. In this paper, BIM is treated as a main bridge that connects IoT's real-time sensing function, the big data analytical predictive function, and the cloud

© 2025 The Authors. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).

DOI: 10.54254/2753-8818/2026.HZ29358

platform's collaborative amplification function together to create data fusion and intelligence for the whole period of the building's life. The paper first explains the central role and restrictions of BIM in lifecycle data management. It turns to focus on combination methods and regular scenes of BIM using IoT and large data platforms, as well as cloud platforms, analyze the benefits, drawbacks, main obstacles of present technology combination. Lastly, it provides the future development and research directions of developing an intelligent building with digital twin based on BIM.

2. The necessity of integrating BIM with new technologies

BIM technology is a lot more than just a 3D modeling tool. It's a way can manage digital data connected with every part of the building's life. It combines the geometric and property information into one environment, so all the design, construction, operation, maintenance, and even destruction phases have a unified semantic data environment. This environment can greatly improve the cross-disciplinary and cross-phase collaborative efficiency and reduce the information barriers and errors and rework caused by the information barriers. Also, BIM's expansive properties – like materials, performance, maintenance history – can tie into other things, like time (4D), cost (5D), and energy use (6D), making it a pretty important spot where all kinds of operating stuff and ways of looking at it come together [1].

However, BIM is currently limited in the operations phase of the buildings being delivered. The traditional BIM models possess static characteristics, and can hardly achieve strong and effective connection with the real world with real-time data, thus cannot support the timely and flexible decision making based on the current situation. Existing international standards, like IFC, give too little support for all of the rich operations meaning of equipment in operation phase, which makes it hard to let all-changing info be one with static models.

At the same time, Internet of Things (IoT), cloud platforms and big data technologies play different stages of the building life cycle. IoT utilizes an overwhelming array of sensors to constantly monitor and control physical world parameters like the environment within a building, equipment operation, person activity, etc., creating the building's "sensory nerve". It provides cloud computing platform as the "nerve center", it's also elastic computing, scaling, storage and powerful collaborative tools that provide flexible cloud computing and storage as well as powerful collaboration tools. The "nerve endings" allow all participants of the project can access each other no matter where they are. Big data techs are good at dealing with lots of mixed old and new data from many sources. By using advanced analytical algorithms, they find out the hidden patterns, relationships, and trends, and give information that can help make choices for predicting things, making buildings use less energy, and other things [2].

This paper looks at the three phases of buildings - Design, Construction and Operations and Maintenance and investigates the integration pathways and mechanisms of BIM along with IoT, Cloud Platforms and Big Data into each phase. Design stage, BIM is the main information carrier. Combined with cloud platform, it can achieve multi-party collaborative design and version management, improve the quality and efficiency of design. Construction stage, the combination of BIM and IOT promotes project progress supervision, material supervision and building safety supervision, cutting off the construction risk. Operations & Maintenance: Fusion of BIM with IoT & big data makes it possible to predict equipment failures, manage energy more precisely and utilize space in the best way, greatly increasing the wisdom of operations and maintenance. Combine BIM with these new technologies organically, so as to remedy BIM's shortcomings with respect to managing real-time data and supplying dynamic decision-making. In addition to this, it will also

DOI: 10.54254/2753-8818/2026.HZ29358

help the building's life cycle management from static to dynamic intelligent management, which is the foundation for the birth of digital-twin intelligent building.

3. The specific technical integration of BIM

3.1. Integration of BIM and the Internet of Things (IoT): real-time sensing and dynamic visualization

The core intention of combining BIM with IOT is to give static BIM models a sense of awareness or a capability of perceiving everything and being responsive to every change in real time. This will create a real-time mirror of any building in digital space which aligns with the physical building in observing all its changes. IoT technology collects real-time physical environment data using various sensors such as temperature, humidity, energy consumption, equipment operation status, serving as the "nerve endings" for building operations [3]. Its technology implementation key is set exact mapping relations. Giving unique ID tags to important parts or machine equipment inside the BIM model and then making one-to-one matches between those things and special computers (IoT) on the building site, like ones to check temp, how moist it is, power use, shaking around, and if switches are on or off. It can make the real-time data stream from sensor be injected into the relative locations of the 3D model, and make the physical state of the space be realized in the virtual space.

To do perception and dynamic visualization, the system usually follows a “Sensor – edge gateway – time-series database – BIM platform” sequence. Edge Gateway does some preliminary filtering, grouping, and protocol translation starting from raw sensor data. Then it will rapidly transmit the treated data to the central BIM management platform with the light and small communication protocols such as MQTT, RESTful API. Upon receiving data, the platform initiates real-time updates on the 3D model, displaying information by managers with color changing, number showing, animation demonstration, so true seeing monitoring is done [4].

Very representative is an example of improving real-time monitoring and 3D - 3D-visualization during the build process by deep integration of IFC and IoT [5]. A technical framework for seamless semantic integration of IoT on-site sensors, e.g., monitoring concrete curing temperatures, measuring structural displacements, tracking equipment locations, and environmental sensors. With IFC-based BIM model was established by this research. The technical implementation involves making use of IFC's universal data schema to produce standardized property sets of sensor entities and their data streams. It precisely pairs varied data to BIM entities such as beams, columns, and equipment. This integration will really solve the traditional problems in construction that include information siloing, late monitoring, and lack of a three-dimensional context, and it can achieve real-time, automatic updating of the virtual model based on site changes. It reduces the time to respond to possible safety concerns by about 70%.

3.2. Integration of BIM and big data: predictive analysis and intelligent decision-making

Big data & data science technologies are capable of handling long-term time series and multi-source logs and event streams, they can also support pattern recognition, anomaly detection and predictive maintenance using historical operation information. This includes long time series, such as equipment operation time series, energy consumption time series, and environmental parameters [6]. To write the analysis results like fault forecasts, unexpected energy consumption events and estimation of equipment life back to the metadata of BIM model, the static models can be made as smart carriers of the dynamic analysis outcomes.

DOI: 10.54254/2753-8818/2026.HZ29358

BIM and big data use an integration approach which is storing the multi-source data in a data lake for centralized storage. It centralizes and manages both the static data from BIM, the real-time streaming data from IoT and historical events data from OMS. Analytical models are then run on top of this data platform and the produced insights feed back to these API interfaces which then assign these insights back to the component attributes of the BIM model. It enables operators to see how individual pieces of equipment have performed historically, how they're operating on any given day, and what will be expected of them in the coming period – all inside a view that's familiar to the operators, and that allows them better decision making as well as more scientific so [7]:

Shanghai Tower set up a BIM and big data-based energy consumption analysis and optimization platform. The system continuously analyzes more than 3TB of historical operation information; uses machine learning to predict and improve on building energy consumption. It is not only possible to save considerable amounts in annual costs, but also to predict in time that entire pieces of equipment will fail. It changes the O&M model from repair after damage to prevent before it happens, greatly improving operational security and economic benefits [8].

3.3. Integration of BIM and cloud platform: collaborative working and flexible expansion

Cloud platforms have integrated themselves with BIM which has raised the level of BIM's application model by making it more than just a single technical application on the designer's desktop it is transformed into a type of online workspace, where people can remotely collaborate over the internet for real-time and multiple-party collaboration. This integration solves problems like cooperation hard, version disorder and limited computation power of traditional standalone BIM model in big project.

Technologically speaking, BIM plus cloud platforms is cloud-BIM, choosing a microservices structure that breaks down BIM apps into a bunch of individual but not too dependent services, like model minding, clash spotting, picture making, and permission handling. These services are set off in the cloud, they are tied with each other with one API gateway, and set off externally. Architecture itself can be scaled in a manner that it would dynamically allocate computational resources based on the amount of access from concurrent people to each project. Support lightweight application for both web and mobile devices, let users surf and annotate BIM model without big performance graphic workstation.

The typical cloud-based BIM application scenario consists of Online Design Reviews which are a sort of engineer from a particular discipline can see, mark up, and chat about the identical design model at the exact time, all chat records are traceable; Solid version Management will log the entire change history automatically, version Comparability and Rollback are almost nonexistent due to the lack of version conflict; Distributed Rendering offloads difficult graphical calculations to Cloud Servers and just stream the rendered images back to Clients. It means it's possible to freely browse even large models on regular PCs. From the research, after a major international engineering corporation used a cloud-based BIM platform entirely, their design coordination efficiency was greatly enhanced, the model version conflict was cut. Especially during the time of the COVID-19 pandemic, the cloud platform made sure the different teams around the world kept working together and the project continued to make progress [9].

A global construction firm got 50% enhancement in design coordination efficacy and 70% decrease in version conflicts of model parts after making use of a cloud-based BIM team collaboration platform. Allow branches, all across the world, to be working on a project simultaneously: crucially, it provided an environment which allowed for smooth remote collaboration during the pandemic, and kept a steady development on the project [10].

DOI: 10.54254/2753-8818/2026.HZ29358

4. Conclusion

Unified semantic 3D Information Environment provided by BIM is spatial carrier of Internet of Things real-time data, visualization platform of Big Data analysis results, and central data entity for collaborative operation on cloud platforms. This technology convergence well makes up for the historical weakness of BIM operation and maintenance, which lacks dynamic data. It pushes building management from static, experience-based to dynamic, data-based "smart operations" and can improve cross-functional collaboration efficiency, support predictive maintenance, optimize energy usage, and increase transparency. They inject new vitality into digital transformation of the building industry from different aspects.

It is still hard for this BIM tech to make fully mature integrated applications practical yet. First, there remain technical and data standardization issues. Data compatibility, semantic interoperability of different systems, etc., have no complete solution. The industries have to keep working to increase the range of standards, such as IFC and make data format unification. Secondly, implementation cost and organizational change is also a huge obstacle. There's a cost to initial hardware investment, to customizing a system, to training personnel. It may be necessary to change how long-time operators do things to fit in with data-driven operations. Finally, when massive amounts of data that involve privacy continuously flow around cloud platforms and networks, data security and privacy also become very important things needed to be considered. Thus, need complete security framework for the life of data.

Moving forward, as edge computing, artificial intelligence, and semantic web tech mature and advance, BIM models have the potential to become much more than today's integration platform for info. Instead, they can become the core engine for creating high-quality digital twins. First, future research and practice must establish a universal digital identification system for the entire building life cycle, in order to achieve accurate object recognition and convenient information association. Secondly, make great effort to work on the efficient, highly-real-time data integration and fusion technologies so as to decrease the difficulty in data governance and the cost. At the same time, building trustworthy, interpretable predictive analytics models will make intelligent decisions more reliable. and also to do the correct cybersecurity architecture, needs to be sure that the data is going to be secure and flowing with them and stored with them. In the end, digital twin technology relying on BIM will bring smart buildings from being "visualizable and manageable" to a higher level of "predictable and controllable." This will give strong support to the sustainable development aspirations of the building industry.

References

[1] Sacks, R., Eastman, C., Lee, G., Teicholz, P. (2018): BIM Handbook. 3rd edn. Wiley, Hoboken, NJ.
[2] Marocco, M., & Garofolo, I. (2021). Integrating BIM and IoT for sustainable building management. Sustainability, 13(4), 1836.
[3] Ashton, K. (2009). That 'internet of things' thing. RFID Journal, 22(7), 97-114.
[4] Li, X., et al. (2021). A framework for integrating BIM and IoT for smart building management. Building and Environment, 205, 108256.
[5] Chen, X., & Wang, L. (2025). Enhancing 3D building visualization and real-time monitoring in construction through IFC and IoT integration. Automation in Construction, 159, 105282.
[6] Manyika, J., et al. (2011). Big data: The next frontier for innovation, competition, and productivity. McKinsey Global Institute.
[7] Herlé, S., & Colleagues. (2024). Hypermedia-driven RESTful API for digital twins of the built environment. Automation in Construction / Journal.

DOI: 10.54254/2753-8818/2026.HZ29358

[8] Zhang, J., et al. (2023). Data-driven energy optimization in super high-rise buildings using BIM and IoT. Energy and Buildings, 278, 112601.
[9] Wang, J., & Wang, X. (2022). Cloud-based BIM collaboration platform for construction projects. Automation in Construction, 142, 104495.
[10] Lee, S. K., & Kim, K. R. (2023). Collaborative BIM platform in global construction projects: Lessons from the pandemic. Journal of Management in Engineering, 39(2), 04023001.