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INTEGRATION IOT AND BIM FOR TECHNOLOGY AND IOT ENVIRONMENT

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Abstract: This research focuses on technology and integration tools for IoT environments, with an emphasis on three main aspects: the integration of Building Information Modeling (BIM) and IoT, the utilization of real-time data, and the urban IoT framework. The integration of BIM and IoT enables a smarter and more efficient building management system by utilizing IoT data to monitor real-time building conditions and improve maintenance and operational processes. This research seeks to identify challenges and solutions for technology integration in increasingly complex IoT environments, while also offering guidance for practical implementation in the urban and building sectors. In this research, we use a literature analysis approach, the main process is to identify relevant sources, including articles, journals, conferences, books, and industry reports published in the last five years. The results of this study are an implication that the application of IoT device integration with BIM can help improve operational and maintenance efficiency, optimize construction management, improve safety and mitigate risks in a company.

Keywords: building informations modelling(BIM); environment; internet of things(IoT)

Abstrak: Penelitian ini berfokus pada teknologi dan alat integrasi untuk lingkungan IoT, dengan penekanan pada tiga aspek utama: integrasi Building Information Modeling (BIM) dan IoT, pemanfaatan data real-time, dan kerangka kerja IoT perkotaan. Integrasi antara BIM dan IoT memungkinkan sistem manajemen bangunan yang lebih cerdas dan efisien dengan memanfaatkan data IoT untuk memantau kondisi real-time bangunan serta memperbaiki proses pemeliharaan dan operasional. Penelitian ini berupaya mengidentifikasi tantangan dan solusi integrasi teknologi dalam lingkungan IoT yang semakin kompleks, sekaligus menawarkan panduan untuk penerapan praktis di sektor perkotaan dan bangunan. Pada penelitian ini kami menggunakan metode pendekatan analisis literatur, proses utamanya adalah dengan mengidentifikasi sumber sumber relevan, meliputi artikel, jurnal, konferensi, buku, dan laporan industri yang dipublikasikan dalam lima tahun terakhir. Hasil dari penelitian ini yaitu didapatkan sebuah implikasi bahwa penerapan pengintegrasian perangkat IoT denan BIM dapat membantu meningkatkan efisiensi operasional dan pemeliharaan, optimasi manajemen kontruksi, peningkatan keselamatan dan mitigasi resiko pada sebuah perusahaan.

Kata kunci: building informations modelling(BIM); environment; internet of things(IoT)

INTRODUCTION

The Internet of Things (IoT) has rapidly evolved into a transformative technology, connecting billions of devices and sensors across sectors such as healthcare, agriculture, manufacturing and smart cities[1]. This network of interconnected devices generates huge amounts of data, enabling automation, real-time monitoring, and predictive analytics[2]. However, the true potential of IoT can only be realized through effective integration technologies and tools that enable disparate devices and platforms to communicate seamlessly, ensuring interoperability, scalability, and security in increasingly complex environments.

In the research conducted by (Mohammed, Baydaa Hashim Safie, Nurhizam Sallehuddin, Hasimi Hussain, Afifuddin Husairi Bin) shows a mapping study result shows that research on BIM integration in IoT has been getting more attention in the last 6 years with stable and consistent publication output. Prominent application domains, validation methods, contribution aspects, types of research, and simulation tools in the field of study are identified and presented. Five types of research are also identified, namely solution proposals, experience papers, evaluation research, validation research, and opinion papers, with solution proposals receiving greater attention.[3]

At the heart of IoT integration is the challenge of connecting multiple devices, each with different communication protocols, data formats, and operational standards[4]. This diversity requires the use of integration technologies that can bridge the gap between devices, cloud platforms, and data analytics systems. Middleware, API, and edge computing solutions are critical to this process, ensuring that data flows efficiently across the IoT ecosystem without any friction[5]. These tools not only improve connectivity but also support distributed computing, which improves the overall efficiency of the system.

One of the applications of BIM and IoT integration carried out in previous studies is the importance of building information that relies heavily on conventional storage capabilities to provide professional analysis. The IoT and smart devices offer a large amount of live data stored in heterogeneous repositories, and therefore the need for smart methodologies to facilitate IoT-BIM integration is essential[6].

Cloud computing platforms play a critical role in enabling IoT integration by providing the infrastructure needed to store and process large amounts of data[7]. By leveraging cloud services, organizations can scale their IoT deployments and integrate multiple data sources into a unified system. Additionally, the rise of microservices and containerization technologies, such as Docker and Kubernetes, have facilitated more flexible and modular IoT architectures, allowing for easier deployment and management of IoT applications.

Security is another important factor in IoT integration, as the proliferation of connected devices increases the attack surface for potential cyber threats[8]. Integration tools must ensure data encryption, authentication, and secure communication between devices and platforms[9]. Blockchain technologies and secure protocols, such as Transport Layer Se-curity (TLS) and Message Queuing Te-lemetry Transport (MQTT), are often used to provide a strong security layer in IoT environments, addressing issues related to privacy and data integrity[10].

In previous research[11] produced a 3D model generated in the context of involvement in the BIM process integrated with IoT devices, and also in this study obtained an application of new technologies in the construction industry such as BIM, IoT, and Blockchain where in the architecture used there is an examination of interconnection and interoperability such as security, management, and efficient monitoring are factors that are considered important for organizational operations.

Integration of technologies and tools within an IoT environment is critical to unlocking the full potential of connected systems. As IoT continues to expand into various industries, the development and implementation of efficient integration solutions will be key to overcoming technical challenges and ensuring smooth operation of IoT networks[12].

The purpose of this research is the integration of several technological devices to be implemented in a company system. By utilizing advanced middleware, cloud platforms, edge computing, and security protocols, organizations can harness the power of IoT to drive innovation and improve operational efficiency in a company that will implement a new technology device.

METHOD

In this study, we use a literature review approach to explore the various technologies and tools used in the integration of the Internet of Things (IoT) environment. The first process carried out is the identification of relevant sources, including journal articles, conferences, books, and industry reports published in the last ten years, namely from 2015 to 2021. We utilize academic databases such as IEEE Xplore, Scopus, and Google Scholar to ensure a comprehensive and up-to-date coverage of existing research.

After collecting relevant literature, we filtered it based on inclusion and exclusion criteria. Inclusion criteria included articles that discussed integration tools and technologies in the context of IoT, while exclusion criteria included publications that were not directly related to integration or that did not contribute significantly to our understanding of the topic. This process resulted in a number of articles that were then analyzed in depth to draw relevant conclusions.

The analysis was conducted using thematic analysis techniques, where we identified key themes emerging from the collected literature. We grouped the identified technologies and tools into categories based on their functionality, such as communication protocols, integration platforms, and data management tools. In addition, we also evaluated the advantages and disadvantages of each of the existing tools and technologies, to provide a clear picture of the current state of IoT integration.

As a final step, we synthesize the obtained findings and compare the analysis results with previous studies. We also consider the practical implications of the findings for further development in the field of technology integration for IoT. With this approach, we hope to make a significant contribution to research and practice in the field of IoT, as well as open the way for further research related to innovation in system integration.

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RESULTS AND DISCUSSION

Integration IoT and BIM

A literature review from 2015 to 2021 highlights successful practices where IoT is integrated with BIM to improve sustainability in the built environment. Findings suggest that this integration can lead to improved resource management, real-time monitoring, and better decision-making across the building lifecycle[13].

In addition, the integration of IoT with BIM also supports better collaboration between various stakeholders in a construction project. By providing centralized and transparent access to data, all parties involved from architects, engineers, contractors, to building owners can communicate more effectively. This helps reduce errors and confusion that often occur due to asynchronous information. Research shows that the application of this technology not only improves project efficiency but also leads to higher quality and sustainable outcomes in infrastructure development[14].

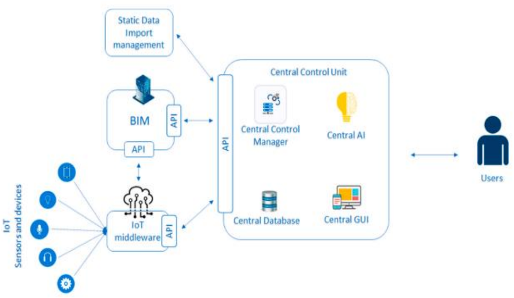

Figure 1. General modular architecture for the integration of BIM and IoT systems.

IoT Middleware: This middleware acts as a bridge between IoT devices and other systems. The middleware receives data from IoT sensors, performs initial processing, and then sends the data to other components via API. BIM: BIM is a digital model that contains static data related to a building or infrastructure, such as design, architecture, and other physical data. This data is used as a reference for managing the building. Static Data Import Management: This component manages the import of static data into the system, most likely related to building information taken from BIM. API: API is used to connect BIM and IoT Middleware to other components, such as the Central Control Unit. API ensures that data can move smoothly between different systems.

Real-time data utilization

The use of IoT in BIM platforms has been proven to improve operational efficiency in construction and facility management. The concept of having permanent access to an updated set of performance data, including environmental and localization data, has shown potential benefits in project management and worker safety[15].

In addition, real-time data also enables more effective predictive maintenance. By analyzing data from IoT sensors, facility managers can identify potential issues before they become critical, such as mechanical system failures or pipe leaks. Integrating this information into BIM provides a clear visualization of the location and status of equipment, speeding up the repair process and reducing downtime. Thus, leveraging real-time data not only improves operational efficiency but also extends the life of the building and improves occupant safety[16].

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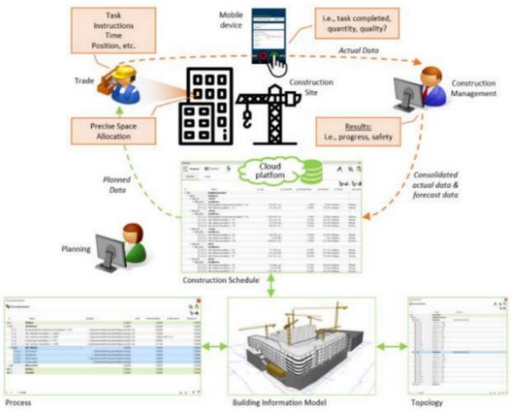

Figure 2. IoT system architecture.

Mobile Devices: At the top, there are mobile devices used by workers on the construction site. These devices serve to receive task instructions, including time, position, and other specific details. The data collected from these devices is sent back to the construction management system. Construction Management: The image shows the interaction between the actual data collected from mobile devices and the construction management system. This allows project managers to monitor progress, quality, and safety in real time. Cloud Platform: In the middle, there is a cloud platform that integrates data from multiple sources. This data includes project plans, construction schedules, and building model information. Consolidating data on a cloud platform facilitates analysis and forecasting of project progress. Construction Schedule and BIM: At the bottom, data from the cloud platform is used to update the construction schedule and building information model. This creates connectivity between the process, topology, and schedule, ensuring that all elements of the project are well-coordinated.

BIM and off-site construction are increasingly being applied in the architecture, engineering, and construction industries due to the many benefits to project stakeholders, such as improved design visualization, better data exchange, reduced construction waste, increased productivity, and higher product quality[17].

Urban IoT framework

A comprehensive survey of urban IoT systems reveals that these systems are critical to advancing the Smart City vision. In addition, the urban IoT framework also emphasizes the importance of collaboration between various stakeholders, including government, the private sector, and citizens. By developing an open ecosystem, developers can create applications that leverage analyzed data to improve public services, such as traffic management, air quality monitoring, and waste management.

This collaboration drives innovation and strengthens citizen participation in decision-making, creating smarter, more sustainable cities that are responsive to the needs of their citizens. The framework focuses not only on technology, but also on social and environmental aspects, creating holistic solutions to urban challenges.

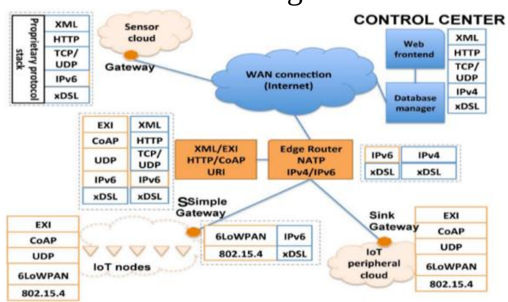

Figure 3. Conceptual representation of an urban IoT network based on the web service approach.

Sensor Cloud: Uses various protocols (XML, HTTP, CoAP) to connect sensors and IoT devices to the system. Gateway: Acts as a bridge between the

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local network (IoT nodes) and the internet (WAN). Manages communication and data between sensors and the control center. Control Center: Where data received from the gateway is processed and analyzed. There is a web interface for users and a database to store information. Edge Router: Manages the connection between IPv4 and IPv6, and NAT to ensure efficient communication. IoT Nodes: Individual devices that collect data and communicate via protocols such as 6LoWPAN.

The integration of IoT with BIM not only drives smarter construction practices but also drives sustainability. This alignment reflects the growing societal demand for environmentally responsible building practices, in line with global efforts to mitigate climate change.

Although the results are promising, this study identified limitations such as the complexity of implementing standard architectures for IoT systems. Heterogeneity of devices and data can create barriers to seamless integration and access[18]. Addressing these challenges is critical to realizing the full potential of IoT in construction and urban management.

The proposed modular architecture for integrating IoT with BIM provides a framework for future research and development. It suggests pathways to improve data interoperability, enhance user experience, and facilitate real-time decision-making in construction and urban planning. Further exploration of this framework may yield innovative solutions that are responsive to the evolving technological landscape and societal needs.

Prototypes developed to integrate real-time data into existing systems need to be validated in various working environments. This will help in assessing the practicality and effectiveness of the proposed solution, ensuring that it meets industry standards and user expectations.

CONCLUSION

Efficient technology integration is essential for ensuring seamless communication between IoT devices across various sectors, including manufacturing, transportation, healthcare, and smart homes. Integration technologies enable interoperability between hardware, software, and platforms, allowing devices and systems operating on different protocols to function cohesively.

Integration tools such as middleware, IoT gateways, and communication protocols play a crucial role in addressing key challenges like data security, device management, and efficient data transfer. Implementing IoT integration with BIM can enhance operational efficiency, optimize construction management, improve safety, and mitigate risks in organizations.

Future research should focus on developing advanced middleware platforms to address interoperability challenges and improve communication between IoT devices. Additionally, exploring the implementation of international standards can facilitate cross-sector integration, creating a more seamless IoT environment. Another key area is strengthening data security by developing robust tools and protocols to protect transmitted data, evaluating current security policies, and designing innovative security-integrated IoT devices to ensure user trust and ecosystem sustainability.

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