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# Enterprise Architecture for Efficient Integration of IoT Lighting System in Smart City Framework

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**Abstract:** This research investigates the influence of enterprise architecture design in integrating Internet of Things (IoT)-based street lighting systems into an innovative city framework, emphasizing the importance of efficient lighting infrastructure as a fundamental component of a creative urban ecosystem. With a focus on building an architectural model that supports the integration of IoT street lighting with other components of a smart city, this research addresses the knowledge gap in optimizing enterprise architecture design for integration efficiency, considering technological complexity and interoperability needs between systems. The methodology applied involved an in-depth analysis of the architectural components essential to facilitate the integration of IoT-based street lighting within the more extensive intelligent city infrastructure. The findings of this study show that a well-structured enterprise architecture model can significantly improve operational efficiency, reduce energy consumption, and provide a rich source of data for strategic decision-making regarding the management and maintenance of city infrastructure. Furthermore, these results emphasize the importance of an adaptive and unified architecture design, which not only improves the functionality of the lighting system but also strengthens the synergy between IoT technologies and innovative city operations. These discoveries have a wide range of repercussions and implications, offering new insights into designing enterprise architectures that can support the transition to more efficient and sustainable smart cities, thereby improving the quality of service for citizens.

**Keywords:** Enterprise Architecture; Energy Efficiency; System Integration; Internet of Things; Smart City

## INTRODUCTION

In the era of rapid urbanization development and the increasing need for smarter and more sustainable cities, the implementation of Internet of Things (IoT)-based street lighting systems is one of the key components. The title of the article "Enterprise Architecture for Efficient Integration of IoT Lighting System in Smart City Framework" highlights the importance of enterprise architecture (Hindarto, 2023b), (Afarini & Hindarto, 2023), (Hindarto, 2023a) in integrating these IoT lighting systems into a smart city framework. Efficient integration not only contributes to reduced energy consumption and better resource management but also improves safety and comfort for citizens. In this context, the relevance of the research lies in the effort to design city infrastructure that is adaptive, responsive, and responsible to today's environmental and social challenges. This approach supports the vision of smart cities that not only focus on technological aspects, but also on improving the quality of life of its citizens. By implementing a robust enterprise architecture, cities can leverage IoT technology to create intelligent lighting systems that automatically adjust to environmental conditions and citizen needs. In addition, these well-integrated systems also support sustainability initiatives, by minimizing energy waste and optimizing resource use. Therefore, this research paves the way for the development of a comprehensive strategy in designing and implementing responsive and efficient smart city infrastructure solutions.

The specific problem addressed by this research topic revolves around the challenge of integrating IoT lighting systems into existing smart city enterprise architectures (Judijanto & Hindarto, 2023). In many cases, cities face difficulties in adopting IoT technologies into their systems due to lack of standardization, interoperability between different IoT devices, and data security challenges. These issues are becoming increasingly important as street

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lighting systems require not only efficient connectivity but also secure data integration for effective management and operations. Failure to address these challenges can result in wasted resources, security vulnerabilities, and suboptimal performance of smart city systems. Therefore, an in-depth understanding of enterprise architecture that can effectively support IoT technologies is crucial.

The impact of IoT system integration and management issues in the context of Enterprise Architecture (Hindarto, Putra, et al., 2024), (Hindarto, 2024), Internet of Things is very significant. It is known that a well-designed enterprise architecture can provide a coherent framework for the integration, management, and scalability of IoT systems within the scope of smart cities. This facilitates data-driven decision-making, more effective resource management, and more responsive and efficient service delivery to citizens. However, it is also recognized that the absence of an effective enterprise architecture can be a barrier to IoT adoption, reducing the possible benefits it can bring to smart cities. Therefore, this research does not solely focus on developing technical solutions, but also seeks a deeper understanding of how enterprise architecture can support the digital transformation of cities towards sustainability and improved efficiency. It is emphasized that efficient enterprise architecture is identified as a key factor to overcome barriers in the adoption of IoT technologies, emphasizing the importance of thoughtful architectural design in the implementation of smart city systems. Therefore, it is recognized that there is an urgent need to explore and develop enterprise architectures that can effectively facilitate the implementation of IoT systems, with the goal of achieving smarter, more sustainable, and efficient cities. The aim is to make a significant contribution to the literature in the field of enterprise architecture and IoT, with a focus on improving the integration and management capabilities of Internet of Things (Akindipe et al., 2022), (Hindarto, Hendrata, et al., 2024) systems within the smart city framework.

In this proposed research, a qualitative approach was chosen as the method to collect and analyze data. Initially, a survey will be conducted to identify the specific needs and challenges faced in the integration of IoT-based street lighting systems. Then, case studies on several cities that have implemented similar systems will be analyzed to understand the best practices and lessons learned. This comprehensive analysis will then be followed by the development of a proposed enterprise architecture model. The needs and challenges identified through the survey will form the basis of the model development. The best practices and lessons learned from the case studies will be used to refine the proposed enterprise architecture model. The proposed model will be designed based on the analysis of the collected data. The entire process from data collection to model development will be carried out using a qualitative approach, ensuring that the data obtained is in-depth and comprehensive.

The contribution of this proposed research lies in the development and validation of an enterprise architecture model that not only facilitates the integration of IoT technology with smart city infrastructure but also considers security, privacy, and sustainability aspects. Compared to previous studies, this research offers a more integrated and holistic approach in addressing the challenges of IoT-based street lighting system integration. This contribution is important for the development of smart cities that are not only technologically advanced but also safe, sustainable, and responsive to the needs of its citizens. The expected research results include the development of an innovative and scalable enterprise architecture model for the integration of IoT-based street lighting (Chiradeja & Yoomak, 2023) systems within the smart city framework. This model is expected to increase operational efficiency, reduce energy consumption, and improve service quality to citizens. Furthermore, the research results are expected to provide new insights into data management and security in the context of IoT street lighting systems, assisting in policy making and strategic decision making. An essential goal in the pursuit of a smart city—one that is safer, more efficient, and environmentally friendly—is the integration of IoT technology into street lighting systems. With an eye toward lowering energy consumption, raising security, and improving citizen comfort, this study seeks to investigate the function of enterprise architecture in incorporating this technology into smart city infrastructure. It is stated as follows: How can enterprise architecture be optimized to support IoT-based street lighting systems in an innovative city framework? Maximize its role in reducing energy consumption, improving security, and making citizens more comfortable. (RQ 1). How can an efficient enterprise architecture help cities overcome the obstacles to adopting IoT technologies for street lighting systems? This will ensure optimal data security and seamless integration. (RQ 2).

## LITERATURE REVIEW

Exploring the significance of enterprise architecture in telecommunications transformation, a study titled Enterprise architecture breakthrough for telecommunications transformation: A reconciliation model to solve bankruptcy delved into this topic (Dachyar et al., 2020). The research, published at an unspecified time, emphasizes the effectiveness of reconciliation models in assisting telecommunications companies in navigating bankruptcy. According to the study findings, the successful adoption of enterprise architecture can support the necessary strategic and operational adjustments to prevent financial collapse. Internet of Things in their study titled A Survey of Internet of Things: Architectures, protocols, applications, Recent Advances, Future Directions, and Recommendations (Darabkh, 2020). The review encompasses architectures, protocols, applications, recent advances, future directions, and recommendations. The publication, released in an unspecified year, highlights the

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impact of IoT on various industrial sectors and daily routines. It also outlines the existing challenges and provides suggestions for the future. Industrial Internet of Things and its Applications in Industry 4.0: State of The Art (Chandra et al., 2021). The research, conducted by Rohit Sharma, Rajesh Singh, Anita Gehlot, and other experts, emphasizes the role of IIoT in enabling intelligent automation and enhancing manufacturing efficiency. This publication, released in a confidential year, provides valuable information on the latest uses of IIoT in Industry 4.0 and sets the stage for future exploration in this area. Mian Ahmad Jan and colleagues delved into the topic of Security and blockchain convergence with Internet of Multimedia Things: Current trends, research challenges and future directions (Ahmad et al., 2021) to tackle security concerns in the Internet of Multimedia Things (IoMT) by utilizing blockchain technology. The research emphasized the latest trends, research obstacles, and upcoming paths. Published in an unspecified year, the study highlights the significance of tackling security issues in IoMT and the promise of blockchain as a remedy. Research Smart-building management system: An Internet-of-Things (IoT) application business model in Vietnam (Nha et al., 2019) highlights the promising aspects of IoT applications in intelligent building management in Vietnam. This study provides insights into leveraging IoT to enhance building operational efficiency within a business framework. According to the findings, implementing IoT in building management enhances energy efficiency and improves the user experience.

It examines the successful integration of Internet of Things (IoT) street lighting systems into an intelligent city to fill knowledge gaps in the literature. Although previous research has emphasized the significance of enterprise architecture, IoT applications, and security challenges in relation to smart cities, there is still potential for enhancing system integration more comprehensively and efficiently. This study focuses on addressing the specific issue of the need for a comprehensive enterprise architecture model that can efficiently integrate Internet of Things (IoT)-based street lighting systems with other components of smart city infrastructure. The research aims to make a substantial contribution to the advancement of a more innovative city that is both sustainable and efficient by tackling this issue.

## METHOD

This research was designed using a qualitative research type, whose approach focuses on exploring the meaning and in-depth understanding of the phenomenon of the integration of Internet of Things (IoT)-based street lighting systems in the smart city framework (Shankar & Maple, 2023). As a method, analytical descriptive was chosen to enable a systematic, factual, and accurate description of the facts and nature of the phenomenon under study. An empirical normative approach was applied to assess current practice in the context of relevant theory, blending empirical observations with existing theoretical norms. The main data sources include journal reviews, documentation, and relevant literature, where data is collected through in-depth literature studies to gain a comprehensive understanding of the research topic. The location of this research was chosen in Indonesia, as the country has unique challenges and opportunities in smart city development, especially in the context of implementing IoT street lighting systems. The choice of Indonesia as the research location was based on the consideration that the country is in the process of rapid urban transformation and has geographic and demographic diversity that provides a rich context for the case study. Indonesia is considered an ideal natural laboratory to explore and analyses the implementation of smart city technologies.

Inductive reasoning was used to draw conclusions from the data collected in this study rather than relying on preexisting theories or hypotheses. The procedure started with gathering exploratory data, and then it moved on to classifying the data for analysis. After that, we look for trends and correlations to fill in the gaps in our knowledge about how to connect enterprise architecture in an intelligent city framework with street lighting systems that are based on the Internet of Things. Because they provide access to up-to-date scholarly research, industry standards, and theoretical frameworks in the domains of enterprise architecture and Internet of Things technology, literature, documentation, and journal reviews were selected as the principal data-gathering methods. A comprehensive analysis was conducted using these sources to gather pertinent information. This data was then combined to evaluate the current state of Internet of Things Street lighting system implementation within an innovative city framework, with a focus on Indonesia. Improving efficiency, safety, and convenience in an urban context in Indonesia is the overarching goal of this research, which aims to give a thorough understanding of how intelligent city frameworks integrate Internet of Things (IoT) street lighting systems. This strategy should allow the research to have a significant impact on the field's literature and practice.

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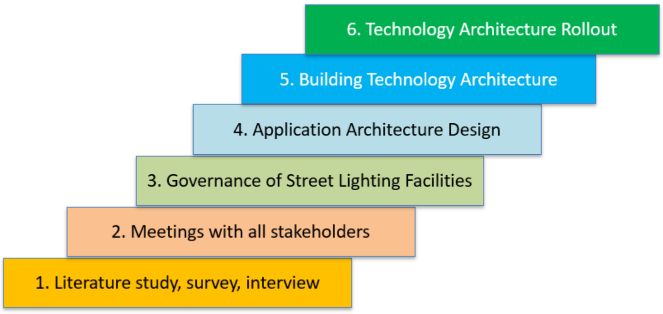


Figure 1. Steps of research method
Source: Researcher property

Figure 1 depicts the sequential process of the research methodology aimed at creating and executing a technology architecture, specifically in the realm of Internet of Things (IoT) connected street lighting. The following text provides a comprehensive breakdown of each step:

1. Research involves conducting a literature study, survey, and interviews. Conducting comprehensive literature reviews is an integral part of the literature study, designed to lay the groundwork for understanding context and theories. The survey is used to collect empirical data, while the interviews are conducted with individuals who possess relevant knowledge or experience in order to obtain detailed insights.
2. Engaging with All Stakeholders: Following the collection of initial data, researchers arrange meetings with stakeholders, such as facility proprietors, users, service providers, and local authorities. The objective is to acquire a range of different viewpoints, ascertain needs and prerequisites, and deliberate on potential limitations that may arise.
3. Governance of street lighting facilities involves developing policies and procedures for their management. The focus is on creating a structure that guarantees efficient and long-lasting street lighting and responsible resource utilization.
4. Application Architecture Design: This phase entails creating the architectural blueprint for the application that will be implemented. This design takes into account the interaction between the application and the street lighting hardware and network components, as well as the collection, analysis, and utilization of data.
5. Technology Architecture Development involves building the overall technology architecture after completing the application architecture design. This process includes integrating the required hardware, software, and network infrastructure.
6. The technology architecture rollout is the last phase where the designed technology architecture is implemented. This entails the implementation, evaluation, and deployment of the developed Internet of Things (IoT) street lighting system, along with monitoring its performance and making necessary adjustments.

These steps encompass an iterative and collaborative process that includes data collection and analysis, stakeholder engagement, technical design, and practical implementation. This process guarantees that the resulting technology solutions are not only theoretically valid but also practical and tailored to users' and stakeholders' requirements.

## RESULT

The research presented here suggests creating and incorporating an Internet of Things (IoT) street lighting (Thungtong et al., 2021) system into a smart city framework to enhance energy efficiency and public safety. The system utilizes technologies such as the Internet of Things and advanced data analytics in data centers located in monitoring systems to optimize the real-time usage of streetlights. This research offers a novel solution for effectively sustainably managing city resources and being more responsive to the needs of the community.

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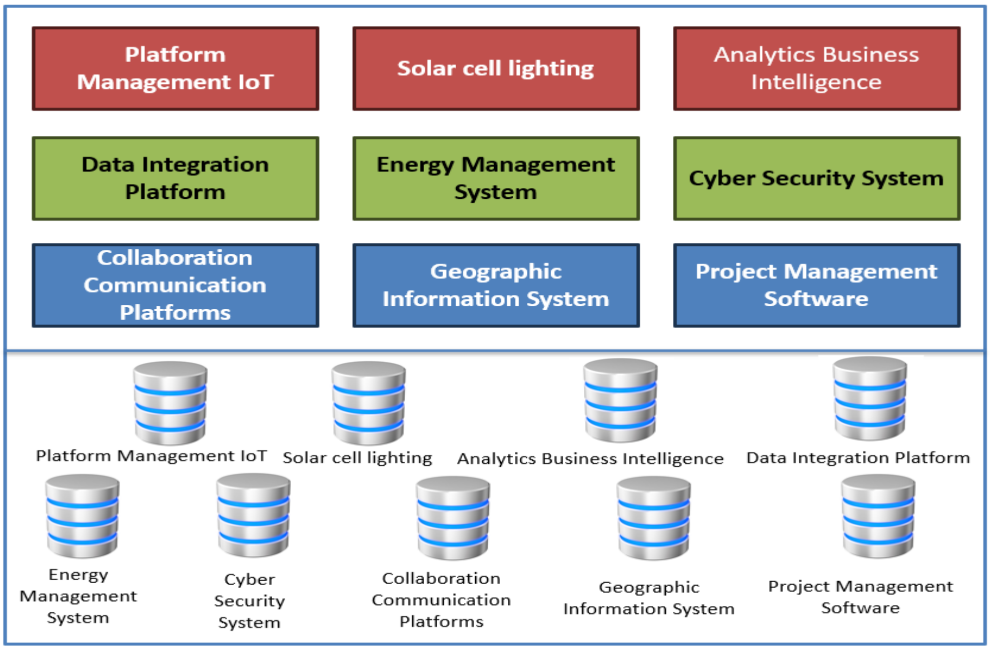


Figure 2. Application Architecture and Information Architecture
Source: Researcher property

Figure 2, the modern Internet of Things (IoT) ecosystem for smart city infrastructure is a complex network that combines different technological components to form a unified and effective system. The core of this ecosystem is the Platform Management IoT, a strong foundation that coordinates the communication and operational capabilities of internet-connected devices. Envision a sophisticated network of streetlights that not only provides illumination to the city but also collects and transmits vital environmental information. This innovative platform enables the development of intelligent applications such as Solar Cell Lighting, which is an environmentally friendly solution that utilizes renewable energy to decrease the city's carbon emissions and operational expenses. The advanced solar cell technology seamlessly combines with the IoT management platform to create a sustainable lighting system that efficiently adjusts to real-time lighting requirements, thereby promoting environmentally friendly technology in urban areas.

Simultaneously, the Analytics Business Intelligence application enables city administrators to extract valuable insights from vast amounts of data. By utilizing advanced analytics, it is possible to identify patterns in energy consumption, lighting requirements, and operational efficiencies. This lets decisions be made based on data, which can help the city better meet the needs of its residents. The Data Integration Platform complements the data-driven approach by serving as the city's digital nervous system. It connects different data sources and ensures a smooth flow of data. The integration is crucial because it allows the Energy Management System to efficiently utilize the data to optimize energy usage throughout the network, adjusting to different demand levels and minimizing unnecessary energy consumption.

Meanwhile, the foundation of this advanced system, the Cyber Security System, serves as an unwavering guardian protecting against the ever-present dangers in the digital realm. This system incorporates stringent protocols to safeguard sensitive data and infrastructure from cyber threats, thereby ensuring the integrity and dependability of the intelligent city's operations, given the paramount importance of cybersecurity. The Geographic Information System, in conjunction with security measures, adds a spatial component to data, providing a geospatial viewpoint that is essential for the planning, monitoring, and implementation of city-wide initiatives. City planners can enhance their decision-making process regarding the deployment of IoT street lighting by utilizing data visualization on a map. This enables them to make more informed choices regarding the optimal locations and methods to serve the community. The suite of applications is complemented by Collaboration Communication Platforms and Project Management Software, which optimize project execution and promote efficient collaboration among teams. These platforms guarantee the precise execution of projects, such as the implementation of the IoT lighting network, while adhering to the budget and timeline. They facilitate effective communication among all levels of city management. The Project Management Software enables meticulous monitoring of progress, resources, and timelines, ensuring the realization of the ambitious objective of transforming the urban landscape with intelligent lighting. This unified combination of applications serves as the central control system, intelligence, and security of a smart city's lighting system. Collectively, they create a robust and interrelated structure that can introduce a new period of urban effectiveness, sustainability, and safety. The

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lighting of city streets is merely the initial step in a wide range of intelligent city capabilities that are ready to transform the urban experience.

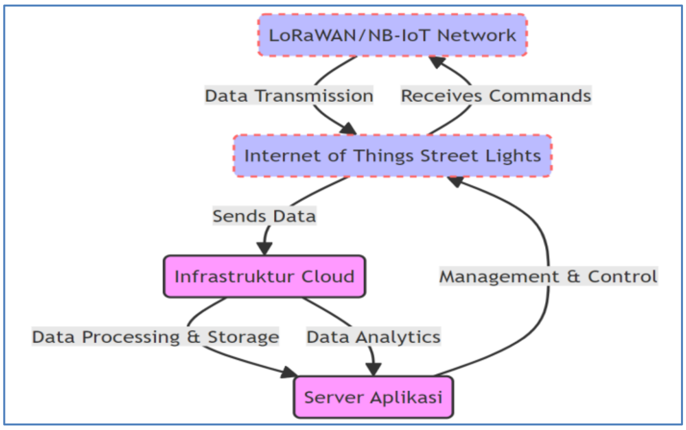


Figure 3. IoT send to datacentre.
Source: Researcher property

The data processing and communication flow in an IoT-integrated street lighting system is shown in Figure 3, which is a flow diagram. The following is an explanation of the process flow shown:

1. LoRaWAN/NB-IoT Network: For wireless communication, the system makes use of the Long-Range Wide Area Network (LoRaWAN) or the Narrowband Internet of Things (NB-IoT) network. This network is responsible for two-way communication: transmitting data from IoT streetlights and receiving commands from the cloud infrastructure.
2. Internet of Things Street Lights: Street lights equipped with IoT technology send collected data back to the cloud infrastructure. The transmitted data may include information such as energy usage, operational status of the lights, environmental conditions, and more.
3. Cloud Infrastructure: After receiving the data from the streetlights, the cloud infrastructure will perform several functions:
4. Data Processing & Storage: The received data is processed and stored. This process may include data normalization, data collection from multiple sources, and data storage in a secure database for long-term access or further processing.
5. Data Analytics: The processed data is analyzed to generate valuable insights. This analysis could include identifying energy usage trends, predicting device failures, and optimizing streetlight operations.
6. Management & Control: Based on the analyzed data, management and control systems make decisions regarding streetlight operations. This can include lighting settings based on time of day or environmental conditions, triggering maintenance, and updating device firmware or configuration.
7. Application Server: Finally, the processed information is sent to an application server. This server can be part of the cloud infrastructure or can be a separate server that serves to run specific applications that use data from the IoT streetlights, such as asset management applications, surveillance systems, or user-specific applications that provide an interface for interaction with the lighting system.

Overall, this diagram depicts a centralized IoT system where streetlights as IoT devices are connected to a cloud network capable of big data processing, analysis, and remote management, enabling automated operation and intelligent management of the street lighting infrastructure.

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Figure 4. Technology Architecture.
Source: Researcher property

In figure 4, the technology architecture shows a three-layer model for Internet of Things (IoT) systems that are used for solar cell street lighting. Here's what each layer is made of:

1. The Perception Layer: This is the IoT architecture's lowest level and is in charge of gathering data from the real world. In this layer, sensors measure things like light intensity, movement, temperature, and more. Solar cells use solar energy as a power source, microcontrollers process the data from the sensors, GPS finds the location of the device, and MAP can be used as a module for mapping data or showing geography.
2. Network or Internet of Things Layer: This layer links the application layer to the perception layer. Within this layer are network devices, like wireless routers, that send the data gathered by sensors to platforms that can process it. It also has other tools for communication that are linked to the network, like cameras and lights with solar panels.
3. Application Layer: The data sent and collected by the first two layers is processed and shown in this layer so that it can be used. This layer has interfaces like dashboards for managing and monitoring data, maintenance apps for monitoring the lighting infrastructure's condition and maintenance needs, and modules for retail consumers, which could be related to marketing or providing services and information to end users.

This model is used for automation and intelligent management in specific situations, like street lighting systems that use solar cells. These kinds of systems can change the amount of light automatically based on sensors that pick up the light levels around them. They can also keep an eye on the status of lighting devices for maintenance purposes and may even be able to offer extra services to customers or retail parties. By using this method, solar-powered street lighting will use less energy, be more reliable, and provide better service while also cutting costs.

## DISCUSSIONS

How can enterprise architecture be optimized to support IoT-based street lighting systems in an innovative city framework? Maximize its role in reducing energy consumption, improving security, and making citizens more comfortable. (RQ 1).

To enhance the efficiency of enterprise architecture in supporting street lighting systems based on the Internet of Things (IoT) within a cutting-edge urban framework, it is necessary to achieve seamless integration of technology and implement effective scalability strategies. Effective technology integration necessitates a versatile framework that can readily adjust to evolving technologies and the requirements of cities. This not only enhances the utilization of resources but also allows for better energy management, resulting in a decrease in overall energy consumption. An architecture should be designed to guarantee robust data security, considering the heightened cybersecurity risks in IoT systems. Through the implementation of rigorous data security protocols and state-of-

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the-art encryption, the sensitive information of citizens and the operational data of the city can be safeguarded against external threats. Furthermore, adopting a data-centric architectural approach will facilitate the immediate gathering and analysis of data, thereby enhancing the efficiency of city services and enabling swift security responses.

Moreover, the enterprise architecture must facilitate robust interoperability among diverse IoT devices and platforms. Interoperability is crucial for optimizing the operation of street lighting systems and integrating them with other components of smart city infrastructure, including transportation systems and public safety. Therefore, a combination of different elements can be formed to enhance the effectiveness of operations and reinforce the security of the city. Facilitating interoperability between various IoT devices requires the development of industry standards and consistent communication protocols, which will enable effective communication and cooperation. This approach not only optimizes energy utilization but also enhances safety and convenience for urban dwellers. Engaging stakeholders in the enterprise architecture design and implementation process is an essential and pivotal step. This engagement guarantees that the IoT-based street lighting system is tailored to the specific requirements of citizens, thereby improving their safety and convenience. Input from citizens and other stakeholders can offer valuable perspectives that aid in tailoring the safety and convenience features of the system. Furthermore, this cooperative method encourages the community to integrate and approve novel technologies, guaranteeing that investments in intelligent urban infrastructure produce optimal advantages. By optimizing enterprise architecture to consider these factors, cities can effectively implement IoT-based street lighting systems that are both energy efficient and conducive to the creation of safer, more convenient, and sustainable urban environments.

How can an efficient enterprise architecture help cities overcome the obstacles to adopting IoT technologies for street lighting systems? This will ensure optimal data security and seamless integration. (RQ 2).

A streamlined enterprise architecture can help cities overcome obstacles to implementing Internet of Things (IoT) technologies for street lighting systems by offering a cohesive framework for integrating the systems. Flexibility, scalability, and interoperability are crucial factors to consider in architectural design within this context. Applying these principles ensures that IoT street lighting systems can be seamlessly incorporated into current city infrastructure without necessitating significant revisions or expensive system replacements. Furthermore, an architecturally designed system that prioritizes compatibility across various platforms enables cities to seamlessly integrate the most up to date IoT solutions without concerns about technical incompatibilities. Consequently, cities can consistently enhance and modernize lighting systems using the most advanced technology, thereby optimizing energy efficiency, and decreasing operational expenses. Efficiently utilizing energy and minimizing expenses are critical objectives in the administration of urban infrastructure, such as street lighting systems. Solar Power Plants offer a sustainable solution by harnessing solar energy, which is both eco-friendly and inexhaustible, to provide power for the lighting system. Furthermore, the incorporation of street lighting software facilitates enhanced precision and automation in the management of lights, thereby minimizing energy inefficiency and guaranteeing optimal utilization of power. The integration of solar power generation and software technology not only decreases reliance on fossil fuel energy sources but also produces substantial cost savings for the municipality's operations and enhances environmental sustainability.

When using IoT technologies, like street lighting systems, it is essential to make sure that data is safe. A proficient enterprise architecture integrates sophisticated data security protocols to safeguard against unauthorized access and cyberattacks. Sensitive information and city operational data are protected through the implementation of end-to-end data encryption, multi-factor authentication, and various other security techniques. These measures guarantee that the data gathered and transmitted by the IoT-based street lighting system is securely safeguarded, thereby reducing the likelihood of data breaches and enhancing public confidence in the innovative city system. Therefore, cities can fully leverage the potential of IoT data collection to strengthen decision-making and optimize service efficiency while maintaining security and privacy. Efficient enterprise architecture encompasses the crucial aspect of seamlessly integrating IoT technologies with the existing infrastructure of a city. Through the establishment of explicit communication standards and protocols, as well as the implementation of a centralized platform for data management, IoT street lighting systems can seamlessly integrate with other urban systems, including security surveillance and traffic management. This all-around approach not only makes a smart city more efficient but also gives its residents a better, more unified, and easier-to-use experience. Consequently, cities are increasingly interested in implementing IoT technology for street lighting systems to enhance operational efficiency and guarantee the safety and convenience of citizens.

## CONCLUSION

The research revealed that incorporating the Internet of Things architecture into a solar cell-powered street lighting system enhances its efficiency and allows for automated management and control. The primary results indicate that the utilization of LoRaWAN and NB-IoT technologies in the communication network enables dependable data transmission and reception of commands from the data center to the intelligent streetlights. The cloud infrastructure serves as a central hub for processing, storing, and analyzing data received from streetlights.

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It also manages and controls the operation of the lights based on the analyzed data. From an Enterprise Architecture perspective, these findings validate the significance of integrating and orchestrating technology components to facilitate streamlined business operations. This study offers significant findings on the application of IoT in smart city infrastructure, facilitating data-driven decision-making and reducing dependence on human intervention. These findings provide a basis for organizations and policymakers to create and execute IoT solutions that can enhance the quality of public services and energy efficiency. Additionally, it provides instructions on how technology can be incorporated into enterprise architecture to enhance the management and upkeep of urban assets. Nevertheless, it is essential to acknowledge the limitations of this research. One aspect to consider is the emphasis on LoRaWAN and NB-IoT technologies, which may partially represent the capabilities of other existing IoT network technologies. Furthermore, the exploration of data security and privacy aspects in IoT deployments still needs to be completed despite their critical importance. To enhance future research, it is advisable to perform a comparative assessment of different IoT network technologies and delve into the realms of security and privacy with greater depth. Additional investigation could also examine the economic and social consequences of Internet of Things (IoT) implementations on a more extensive scope within the framework of intelligent urban areas.

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