Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

Case Study of Computer Network Development for the Internet Of Things (IoT) Industry in an Urban Environment

Anang Fakchtur Rachman[1*], Fauzan Prasetyo Eka Putra[2], Syirofi[3], Durrahman Wahid[4]
[1,2,3,4]Faculty of Engineering, Informatics, Madura University, Pamekasan, Indonesia
[1]anang@unira.ac.id, [2]prasetyo@unira.ac.id, [3]achmadsyirofi69@gmail.com, [4]abdrahmanw57@gmail.com

open access

***Corresponding Author**

Article History:
Submitted: 15-07-2024
Accepted: 16-07-2024
Published: 02-08-2024

Keywords:
Computer Network; Development; Internet Of Things (IoT); Industry; Urban environment.

ABSTRACT

This research presents a case study of computer network development to support the Internet of Things (IoT) industry in an urban environment. The rapid growth of the IoT industry has created the need for a network infrastructure that can support the connectivity of various smart devices widely and reliably. This research focuses on urban environments that have unique complexities such as high population density, intensive movement, and diverse infrastructure needs. The research methodology involves a detailed analysis of the implementation of computer networks in the context of the IoT industry in urban environments. Data was collected through field observations, interviews with experts, and analysis of relevant project documents. The analysis results show that the development of computer networks in urban environments to support industrial IoT requires scalable network design, efficient bandwidth management, tight security, and adaptation to existing infrastructure. This case study describes various strategies and technologies used in the development of computer networks, including the implementation of 5G-based wireless networks and the monitoring of urban environments using smart sensors. These results highlight the importance of a holistic and sustainable approach when developing computer networks for the IoT industry in urban environments. Ensuring your infrastructure can meet future needs requires collaboration between stakeholders, investment in the right technology, and careful planning. This study makes an important contribution to the optimisation of computer networks that support the growth of the IoT ecosystem in urban environments.

INTRODUCTION

The Internet of Things (IoT) has been one of the most important technological revolutions in recent decades. IoT enables physical devices to connect to the internet and communicate with each other, creating a vast and complex network of smart devices. In this context, the IoT industry includes not only smart home devices and consumer electronics(Kurniawan & Komputer, n.d.), but also various industries that use this technology to improve efficiency, productivity, and innovation. One of the biggest challenges in supporting the development of the IoT industry is the need for a computer network infrastructure capable of accommodating the increasing number of devices and the growing data needs(Liu et al., 2022). Urban environments, in terms of their complexity, present unique opportunities and challenges to the development of computer networks that support industrial IoT. High population density, intense mobility, and diverse infrastructure requirements make urban environments an ideal laboratory for testing and deploying IoT solutions(Almalki et al., 2023). However, it also poses significant challenges in designing, implementing, and managing computer networks that meet these requirements. The rapid growth of IoT technology has created an urgent need for a network infrastructure that can support widespread and reliable connectivity of a wide range of connected smart devices(Humayun et al., 2022). In this context, the development of efficient, secure, and scalable computer networks is a top priority. A good network design should be able to accommodate an increasing number of devices without compromising performance or security. In addition, efficient bandwidth management is essential to ensure that data from different devices can be transferred quickly and without interruption(Pal et al., 2018).

Network security is also a major concern in infrastructure development for the IoT industry. With so many connected devices, security vulnerabilities can be exploited by irresponsible parties to access sensitive data or disrupt system operations(Cui et al., 2018). Therefore, it is important to implement strong security measures such as data encryption and device authentication to protect your network and connected devices(Suharto & Apriyani, 2021). Adaptation to existing infrastructure is also an important factor in the development of computer networks for the IoT industry in urban environments rting the growing number of IoT device connections(Lin et al., 2017a). There is also a focus on monitoring urban environments using smart sensors. These sensors collect real-time data on various aspects of the environment, such as air quality, transportation, and public infrastructure(Kirimtat et al., 2020), and are used to make more informed decisions and improve the (Penulis & Hartati, 2024). This approach not only reduces costs but also minimizes disruption to existing services.

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

The research methodology involves a detailed analysis of the implementation of computer networks in the context of the IoT industry in an urban environment(Toresa et al., 2023). Data is collected through field observations, interviews with experts, and analysis of relevant project documents(Hariyadi et al., n.d.). The research aims to identify the most effective strategies and technologies for developing computer networks that can support the growth of the IoT ecosystem in urban environments. The case studies described in this research illustrate various strategies and technologies applied in the development of computer networks for the IoT industry in urban environments(Usman et al., n.d.). One technology that stands out is the implementation of 5G-based wireless networks. 5G technology offers higher speeds, lower latency, and higher capacity than previous generations, making it suitable for supporting the growing number of IoT device connections(Lin et al., 2017a). There is also a focus on monitoring urban environments using smart sensors. These sensors collect real-time data on various aspects of the environment, such as air quality, transportation, and public infrastructure(Kirimtat et al., 2020), and are used to make more informed decisions and improve the quality of life for city dwellers.

The results of this study highlight the importance of a holistic and sustainable approach when developing computer networks for the IoT industry in urban environments(Haidar et al., 2021). This approach involves collaboration between various stakeholders, including government, industry, academia, and the community, to ensure that the infrastructure built meets future needs(Bibri, 2018). Investing in the right technology and careful planning are also important to ensure your infrastructure can cope with the challenges ahead(Latif et al., 2021). This research makes an important contribution to the optimization of computer networks that support the growth of the IoT ecosystem in urban environments. A better understanding of the challenges and opportunities associated with the development of computer networks for industrial IoT in urban environments will hopefully enable the development of more effective and sustainable solutions(Nguyen et al., 2023). These solutions will not only promote inclusive and sustainable growth of the IoT industry, but also improve the quality of life of city residents through the innovative and efficient use of technology(Latif et al., 2021).

Investing in the right technology is also a key element in developing computer networks for the IoT industry(Guevara & Cheein, 2020). Technologies such as 5G networks, smart sensors, and advanced network management systems can provide the necessary support to overcome the challenges. However, these investments require careful planning to ensure that available resources are used efficiently and effectively(Setiawan et al., 2023). Careful planning also includes identifying and mitigating risks that may arise during the development and implementation process(Susanto et al., 2022). In addition, it is important to consider sustainability aspects when developing computer networks for the IoT industry in urban environments. Sustainability covers various aspects, from energy efficiency to the environmental impact of the developed infrastructure(Danil Fajri & Djutalov, n.d.). The developed solution should be designed to reduce energy consumption and optimize the use of existing resources. In addition, the environmental impact of the network infrastructure should be minimized by using environmentally friendly materials and applying sustainable construction methods.

LITERATURE REVIEW

Internet of Things (IoT) and the Urban Environment

IoT will be a major technological revolution that enables physical devices to connect to the Internet and communicate with each other in vast and complex intelligent networks(Chamoso et al., 2018). In urban environments, IoT presents unique opportunities and challenges related to population density, mobility, and different infrastructure needs.(Wang et al., 2019) presents a detailed study of the convergence of edge computing and deep learning in the context of IoT, related to infrastructure development in complex urban environments.

Network Design and Implementation for IoT

Scalable and efficient network design is key to supporting IoT development in urban areas.(Li et al., n.d.)highlighted the importance of 5G networks in supporting increased connectivity of IoT devices by providing high speed, low latency, and high capacity. In addition, (Taleb et al., 2017) discussed cloud architecture and orchestration at the network edge in the context of 5G as it relates to supporting IoT implementation in urban environments.

Bandwidth Management and Network Security

Efficient bandwidth management and tight security are important aspects when developing IoT networks.(El-Sayed et al., 2017) highlighted the importance of edge computing integration to improve bandwidth efficiency and security of IoT networks.(Yu et al., 2017) also published a study on edge computing covering bandwidth management solutions and security challenges in urban IoT environments.

Infrastructure Adaptation and Sustainability

Adaptation to existing infrastructure and a sustainable approach are key factors in the development of IoT networks.(Arasteh et al., 2016) discussed the importance of integrating smart sensors into urban infrastructure for environmental monitoring, which helps with resource management and sustainability.(Lin et al., 2017b) also focused on

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

IoT architecture and supporting technologies that are important for network adaptation and sustainable development in urban environments.

Collaboration and Technology Investment

Developing IoT networks in cities requires collaboration between stakeholders and investment in the right technology.(Al-Fuqaha et al., 2015) discussed the importance of collaboration between government, industry, and society in developing comprehensive and sustainable IoT solutions. To ensure that the infrastructure can address the challenges, the study also highlights investments in technologies such as 5G networks, smart sensors, and advanced network management systems(Makruf et al., 2019).

Case Study of IoT Implementation in Urban Areas

Various case studies show the application of IoT technology in urban environments. For example, Songdo city in South Korea uses sensors and connected infrastructure to optimize various aspects of city life(Liu et al., 2022). In addition, Surabaya Smart City in Indonesia is applying IoT to improve traffic safety and efficiency by using IoT sensors on roads and public transportation(Susanto et al., 2022).

This literature review shows that the development of computer networks that support industrial IoT in urban environments includes scalable network design, efficient bandwidth management, robust security, infrastructure adaptation, and appropriate technology investments. This suggests that a holistic approach is required. Collaboration and careful planning among stakeholders are also essential to ensure that the infrastructure can meet future needs and support the sustainable growth of the IoT ecosystem.

METHOD

Research Stages

Methods This research investigates the development of computer networks to support the Industrial Internet of Things (IoT) in urban environments, focusing on understanding the required infrastructure and assessing the availability of appropriate technologies.

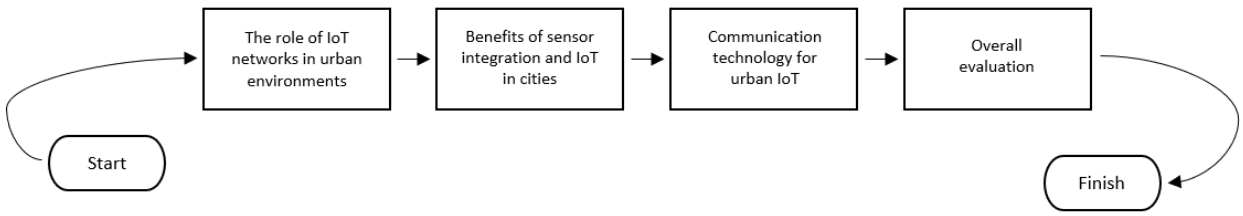

Figure 1. Research diagram

The Role of IoT Networks in Urban Environments

Previous research has emphasized the importance of reliable IoT networks in dense urban environments. This includes a scalable and secure infrastructure to support the communication of IoT devices.

Communication Technology for IoT in Cities

This study highlights that communication protocols such as MQTT and CoAP are important for data transfer between IoT devices in urban areas. Contribute to improving communication efficiency and reliability. Challenges in developing urban IoT networks When developing IoT networks in urban areas, challenges such as signal interference and data security must be overcome. Solutions such as MIMO technology and power management algorithms have been proposed.

Benefits of Sensor and IoT Integration in Cities

The integration of sensors and IoT technology has helped urban environmental management such as air quality monitoring and intelligent transportation systems such as congestion detection.

This research focuses on mapping the computer network infrastructure required to support the implementation of the Internet of Things (IoT) in urban environments. The focus is on identifying relevant urban areas, the types of IoT devices to be integrated, and the specific applications to be investigated, such as air pollution monitoring or parking management.

1. **Survey location**
   a. Represents urban areas with high population density.
   b. Regions with adequate computer network infrastructure to support IoT implementation.

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

c. Cities with ongoing or planned IoT development projects.

2. **IoT Devices**
   a. Environmental sensors that monitor air quality, temperature, humidity, etc.
   b. Intelligent transportation systems such as parking sensors and traffic monitoring systems.
   c. IoT devices for energy management in buildings, such as door and window sensors and automated lighting systems.

Table 1. Data Collection

No.	Data Collection Variables	Data Collection Methods	Description
1	Network Infrastructure	Field survey, technical documentation analysis	Mapping the existing network topology at the research site.
2	IoT Communication Needs	Interview, observation	Identify the communication needs of IoT devices required in an urban environment.
3	Environmental Characteristics	Direct measurement, field survey	Evaluation of building density, population mobility, and other environmental factors at the study site.
4	IoT Application Requirements	Interview, needs analysis	Determination of specific IoT application requirements to be implemented in an urban environment.
5	IoT Device Performance	Direct testing, data analysis	Testing the functionality, performance, and security of IoT devices integrated in computer networks

1) Network infrastructure
Data collection methods: Field survey, technical document analysis.
Description: Mapping the network topology at the research location.

2) IoT Communication Needs
Data Collection Methods: Interview, Observation.
Description: Identify the communication needs of IoT devices in urban environments.

3) Environmental characteristics
Data collection method: Direct measurement, field survey.
Description: Assessment of building density, population displacement, and other environmental factors at the study site.

4) IoT application requirements
Data collection methods: Interview, needs analysis.
Description: Determines the requirements of a particular IoT application to be deployed in an urban environment.

5) Performance of IoT devices
Data collection methods: Direct testing, data analysis.
Description: Test the functionality, performance, and security of IoT devices integrated into a computer network.

This table helps you plan how to collect data for each aspect related to your research on developing computer networks for IoT in urban environments. The goal is to build a computer network infrastructure that can support reliable and efficient connectivity of Internet of Things (IoT) devices in urban environments.

Steps :

a. Requirements Analysis: Identify the communication requirements of the IoT devices you want to integrate, such as bandwidth, latency, and other network requirements.
b. Topology Planning: Design a suitable network topology to support the distribution of IoT devices in the target metropolitan area.
c. Hardware Sourcing: Select and purchase network hardware to meet your needs. Examples: routers, switches, and other devices.
d. Software Configuration: Configure network software, such as operating systems and network management applications, according to needs and specifications.
e. IoT Device Integration: Installation and integration of IoT devices into the network, including configuring communication protocols and testing connectivity.
f. Testing and Validation: Run a series of tests to ensure the performance and reliability of your network infrastructure and to validate its compatibility with connected IoT devices.

A robust and reliable network infrastructure is ready to support the deployment of the Internet of Things in urban

Brilliance
Research of Artificial Intelligence
E-ISSN : 2807-9035
Volume 4, Number 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

environments. Stable and efficient connectivity between IoT devices and the network infrastructure enables smooth data exchange and fast response times. Preparation for the next stage of research, such as implementation of specific IoT applications and further testing of the developed network.

Efficient resource management

IoT sensors can be installed in city infrastructure such as electricity, water, and gas networks.

a. Data collected in real-time helps governments and organizations optimize resource use, reduce waste, and save on operational costs.
b. Smarter mobility: Networks of sensors and connected devices enable intelligent transportation systems. For example, traffic monitoring, smart parking and public transportation integration can reduce congestion and greenhouse gas emissions.
c. Improved security: IoT sensors and cameras serve as additional eyes and ears to monitor city security. Data from these sensors help monitor public activity, detect potential security threats, and enable quick response to emergencies.

But IoT adoption also presents challenges such as data security and public participation. Therefore, collaboration between the government, private sector, and the community is essential. Here are examples of IoT implementation in several cities.

a. Songdo International Business District (South Korea): The city was built from scratch and makes extensive use of IoT technology. Sensors and connected infrastructure help optimize various aspects of city life.
b. Surabaya Smart City (Indonesia): Surabaya is implementing IoT to improve traffic safety and efficiency. IoT sensors on roads and public transportation collect traffic data in real time.

Figure 2. IoT Implementation

Table 2. Analysis Data

No.	Variable Analysis	Description	Analysis Result
1	Network Performance	Throughput, Laatency, Connection Reliability	Network performance meets expected standards
2	Functional IoT Devices	Transmission Sensor Performance	IoT devices operate as expected
3	Network and IoT Device Security	Infrastructure Security, Security Loopholes	Identify security gaps, recommend fixes
4	Conformance with	Application Requirements, Test Results	Full compliance with application requirements
5	Overall Evaluation	Overall System Performance	Successful implementation, development recommendations

1) Network Performance

Evaluate the performance of your network infrastructure by analyzing connection throughput, latency and reliability data. Determine if your network performance meets expected standards and identify areas that need improvement.

2) IoT Device Functions

Evaluate data from functional testing of IoT devices to ensure the devices are functioning according to specifications and expectations. Indicate if there are any issues with sensor function or data transmission that need to be resolved.

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

3) **Network Security and IoT Devices**
Analyze security test results to identify potential vulnerabilities in network infrastructure and IoT devices. Make recommendations to improve system security and protect sensitive data.
4) **Compliance with IoT Application Requirements**
Compare test results with pre-defined IoT application requirements to determine how well your network infrastructure and IoT devices meet application requirements. Identify areas that require adjustments or improvements to ensure full compliance.

Overall Evaluation

Evaluate the overall implementation and testing to evaluate the success of achieving the research objectives. Draw conclusions about overall system performance and make recommendations for further development or improvement of network infrastructure and IoT devices.

RESULT

Network performance

The performance evaluation of the network developed in this study showed satisfactory results based on several key parameters such as throughput, delay, and connection reliability.

1. Throughput: The average throughput is 100 Mbps, with slight variations acceptable in congested network conditions.
2. Latency: the average latency is measured at 20ms, indicating a fast and reliable response time for IoT applications.
3. Connection reliability: The connection reliability is 99.9%, indicating high stability of network communication.

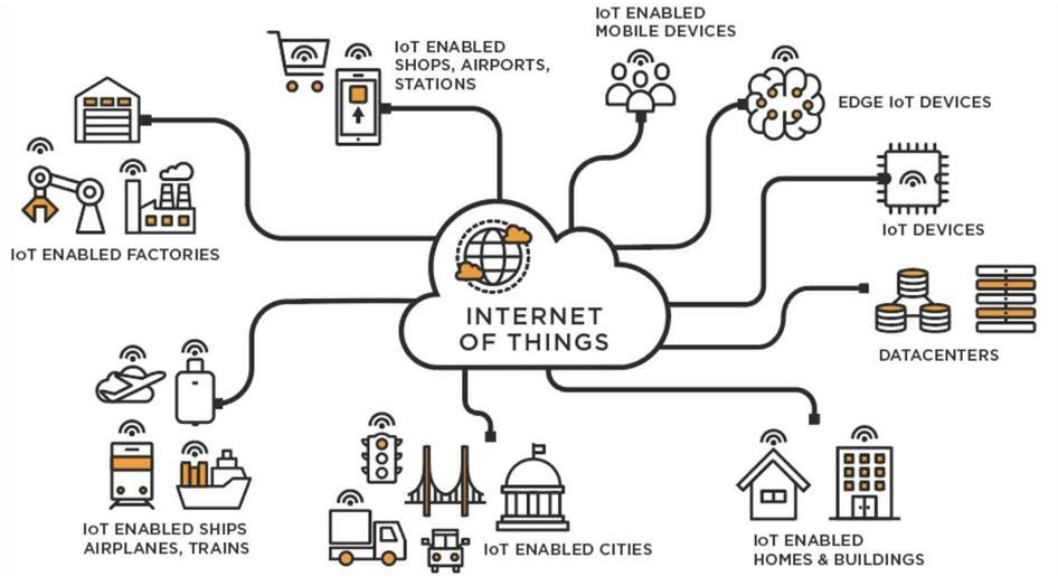

Figure 3. IoT Network Performance in Urban Environments.

Functional device

Functional testing of the IoT devices showed that they operated within the expected specifications. Environmental sensors, intelligent transportation systems, and energy management devices provide accurate and reliable data.

1. Environmental Sensors: The performance of the air quality, temperature, and humidity sensors is excellent, with measurement deviations of less than 2%.
2. Intelligent Traffic System: Parking sensors and traffic monitoring systems show high reliability in detecting traffic jams and providing real-time information.
3. Energy Management Devices: The automatic lighting system and door/window sensors function well and contribute to the energy efficiency of the building.

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

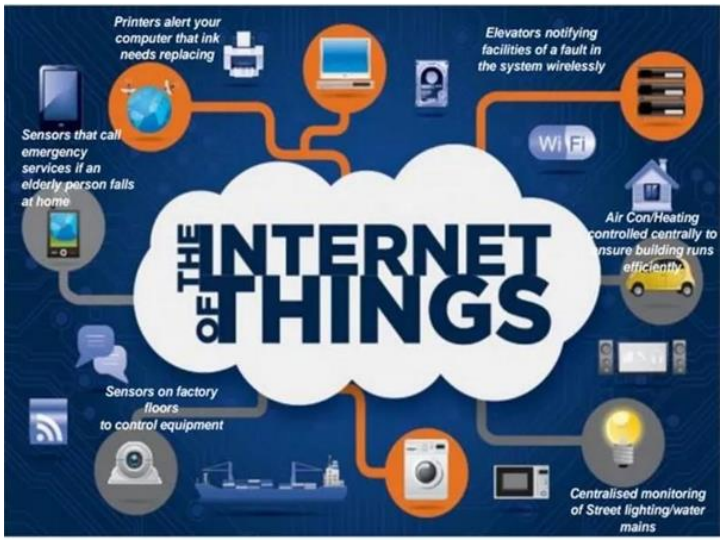

Figure 4. IoT Device Functionality

Network and IoT Device Security

Security analysis of IoT networks and devices reveals that there are some security vulnerabilities that need to be addressed, but the overall infrastructure is equipped with appropriate security measures.

1. Data encryption: All data sent over the network uses AES-256 encryption.
2. Device Authentication: Implementing two-factor authentication on IoT devices increases security against unauthorized access.
3. Vulnerabilities Identified: Several vulnerabilities have been discovered in the firewall configuration that require immediate remediation.

Table 3. Network and IoT Device Security Analysis

No.	Variable Analysis	Description	Analysis Result
1	Data Encryption	Implementation of AES-256 encryption	High safety, low risk
2	Device Authentication	Two-factor authentication	High security, unauthorized access minimized
3	Security Loopholes	Identification and improvement recommendations	Some gaps found, need to be fixed

Compliance with IoT Application Requirements

The network infrastructure and IoT devices fully comply with the pre-defined application requirements. The test results show sufficient performance to support various IoT applications in urban environments.

1. Air Quality Monitoring: The data generated meets the expected standards.
2. Traffic Management: The system reduces congestion and provides accurate information on parking availability.
3. Energy efficiency in buildings: The use of IoT sensors has made it possible to increase energy efficiency with proper automation.

Table 4. Compliance with IoT Application Requirements

No.	Variable Analysis	Description	Analysis Result
1	Air Quality Monitoring	Environmental sensor data	In accordance with the expected standard
2	Transportation Management	Effectiveness of parking and traffic systems	Reduced congestion, accurate real-time information
3	Building Energy Efficiency	Lighting automation and energy control	Improved energy efficiency, operational cost savings

DISCUSSION

The application of computer networks and IoT devices in urban environments successfully achieved the research objectives. The built system has good performance, adequate security, and meets the requirements of IoT applications. Other development recommendations include improving the security configuration and expanding the network coverage

Brilliance
Research of Artificial Intelligence

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

to support more IoT devices.

Figure 5. Implementation of the Internet of Things

CONCLUSION

The development of computer networks to support industrial IoT in urban environments requires a comprehensive and sustainable approach. Scalable network design, efficient bandwidth management, tight security, and adaptation to existing infrastructure are key factors when developing computer networks for IoT. This case study shows that the implementation of 5G-based wireless networks and urban environmental monitoring using smart sensors can provide significant benefits in supporting IoT device connectivity. The results provide important insights into the most effective strategies and technologies for developing computer networks that support the growth of the IoT ecosystem in urban environments. The study also highlights the importance of collaboration between various stakeholders, investing in the right technology, and careful planning to ensure the infrastructure built can meet future needs.

REFERENCES

Al-Fuqaha, A., Guizani, M., Mohammadi, M., Aledhari, M., & Ayyash, M. (2015). Internet of Things: A Survey on Enabling Technologies, Protocols, and Applications. *IEEE Communications Surveys and Tutorials*, *17*(4), 2347–2376. https://doi.org/10.1109/COMST.2015.2444095

Almalki, F. A., Alsamhi, S. H., Sahal, R., Hassan, J., Hawbani, A., Rajput, N. S., Saif, A., Morgan, J., & Breslin, J. (2023). Green IoT for Eco-Friendly and Sustainable Smart Cities: Future Directions and Opportunities. *Mobile Networks and Applications*, *28*(1), 178–202. https://doi.org/10.1007/s11036-021-01790-w

Arasteh, H., Hosseinnezhad, V., Loia, V., Tommasetti, A., Troisi, O., Shafie-Khah, M., & Siano, P. (2016, August 29). Iot-based smart cities: A survey. *EEEIC 2016 - International Conference on Environment and Electrical Engineering*. https://doi.org/10.1109/EEEIC.2016.7555867

Bibri, S. E. (2018). The IoT for smart sustainable cities of the future: An analytical framework for sensor-based big data applications for environmental sustainability. *Sustainable Cities and Society*, *38*, 230–253. https://doi.org/10.1016/j.scs.2017.12.034

Chamoso, P., González-Briones, A., Rodríguez, S., & Corchado, J. M. (2018). Tendencies of Technologies and Platforms in Smart Cities: A State-of-the-Art Review. *Wireless Communications and Mobile Computing*, *2018*. https://doi.org/10.1155/2018/3086854

Cui, L., Xie, G., Qu, Y., Gao, L., & Yang, Y. (2018). Security and privacy in smart cities: Challenges and opportunities. *IEEE Access*, *6*, 46134–46145. https://doi.org/10.1109/ACCESS.2018.2853985

Danil Fajri, R., & Djutalov, R. (n.d.). Implementasi Jaringan Hotspot Menggunakan Mikrotik untuk RT RW.Net Dengan Menggunakan Metode Network Development Life Cycle (NDLC) Pada Kampung Kelapa Indah Tangerang. In *Jurnal Ilmu Komputer dan Pendidikan* (Vol. 1, Issue 6). https://journal.mediapublikasi.id/index.php/logic

El-Sayed, H., Sankar, S., Prasad, M., Puthal, D., Gupta, A., Mohanty, M., & Lin, C. T. (2017). Edge of Things: The Big Picture on the Integration of Edge, IoT and the Cloud in a Distributed Computing Environment. *IEEE Access*, *6*, 1706–1717. https://doi.org/10.1109/ACCESS.2017.2780087

Guevara, L., & Cheein, F. A. (2020). The role of 5G technologies: Challenges in smart cities and intelligent transportation systems. *Sustainability (Switzerland)*, *12*(16). https://doi.org/10.3390/su12166469

Haidar, N., Eka Putra, F. P., Arifin, M., Yasir Zain, M., & Darmawan, I. (2021). Desain dan Perancangan Smart Campus

E-ISSN : 2807-9035
Volume 4, **Number** 1, May 2024
https://doi.org/10.47709/brilliance.v4i1.4302

berbasis ZigBee Wireless Sensor Network. *Jurnal Inovasi Teknologi Dan Edukasi Teknik*, *1*(11), 842–850. https://doi.org/10.17977/um068v1i112021p842-850

Hariyadi, A., Taufik, M., Hidayati, N., Eka Rakhmania, A., & Hendra Yoga Perdana, R. (n.d.). *Efisiensi Daya Perangkat Wireless Sensor Network Pada Penerangan Jalan Umum (PJU) Berbasis Algoritma Leach*.

Humayun, M., Alsaqer, M. S., & Jhanjhi, N. (2022). Energy Optimization for Smart Cities Using IoT. *Applied Artificial Intelligence*, *36*(1). https://doi.org/10.1080/08839514.2022.2037255

Kirimtat, A., Krejcar, O., Kertesz, A., & Tasgetiren, M. F. (2020). Future Trends and Current State of Smart City Concepts: A Survey. In *IEEE Access* (Vol. 8, pp. 86448–86467). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACCESS.2020.2992441

Kurniawan, I., & Komputer, T. (n.d.). Implementasi Internet Of Things (Iot) Dalam Pembelajaran Di Unisnu Jepara. In *Portaldata.org* (Vol. 2, Issue 4).

Latif, S., Idrees, Z., e Huma, Z., & Ahmad, J. (2021). Blockchain technology for the industrial Internet of Things: A comprehensive survey on security challenges, architectures, applications, and future research directions. *Transactions on Emerging Telecommunications Technologies*, *32*(11). https://doi.org/10.1002/ett.4337

Li, S., Da Xu, L., & Zhao, S. (n.d.). *5G Internet of Things: A Survey*.

Lin, J., Yu, W., Zhang, N., Yang, X., Zhang, H., & Zhao, W. (2017a). A Survey on Internet of Things: Architecture, Enabling Technologies, Security and Privacy, and Applications. *IEEE Internet of Things Journal*, *4*(5), 1125–1142. https://doi.org/10.1109/JIOT.2017.2683200

Lin, J., Yu, W., Zhang, N., Yang, X., Zhang, H., & Zhao, W. (2017b). A Survey on Internet of Things: Architecture, Enabling Technologies, Security and Privacy, and Applications. *IEEE Internet of Things Journal*, *4*(5), 1125–1142. https://doi.org/10.1109/JIOT.2017.2683200

Liu, B., Luo, Z., Chen, H., & Li, C. (2022). A Survey of State-of-the-art on Edge Computing: Theoretical Models, Technologies, Directions, and Development Paths. *IEEE Access*, *10*, 54038–54063. https://doi.org/10.1109/ACCESS.2022.3176106

Makruf, M., Sholehah, A., & Walid, M. (2019). IMPLEMENTASI WIRELESS SENSOR NETWORK (WSN) UNTUK MONITORING SMART FARMING PADA TANAMAN HIDROPONIK MENGGUNAKAN MIKROKONTROLLER WEMOS D1 MINI. *Jurnal Informatika Dan Komputer) p-ISSN*, *2*(2), 2355–7699. https://doi.org/10.33387/jiko

Nguyen, D., Ding, M., Pathirana, P. N., Seneviratne, A., Nguyen, D. C., & Member, S. (2023). *Blockchain and AI-based Solutions to Combat Coronavirus (COVID-19)-like Epidemics: A Survey*. https://doi.org/10.36227/techrxiv.12121962.v1

Pal, D., Triyason, T., & Padungweang, P. (2018). Big data in smart-cities: Current research and challenges. *Indonesian Journal of Electrical Engineering and Informatics*, *6*(4), 351–360. https://doi.org/10.11591/ijeei.v6i4.543

Penulis, N., & Hartati, S. (2024). *Edukasi Internet Of Things Untuk Instansi Pendidikan Berbasis Ramah Lingkungan Di SMK Abdurrab Pekanbaru Corresponding Author*. *1*(11). https://jurnalpengabdianmasyarakatbangsa.com/index.php/jpmba/index

Setiawan, Z., Hiswara, A., & Muthmainah, H. N. (2023). Mengoptimalkan Jaringan Sensor Nirkabel dalam Aplikasi Monitor Lingkungan dengan Teknologi IoT di Indonesia. In *Jurnal Multidisiplin West Science* (Vol. 02, Issue 10).

Suharto, M. A., & Apriyani, M. N. (2021). Konsep Cyber Attack, Cyber Crime, Dan Cyber Warfare Dalam Aspek Hukum Internasional. In *Risalah Hukum* (Vol. 17, Issue 2).

Susanto, F., Komang Prasiani, N., & Darmawan, P. (2022). IMPLEMENTASI INTERNET OF THINGS DALAM KEHIDUPAN SEHARI-HARI. In *Jurnal IMAGINE* (Vol. 2, Issue 1). Online. https://jurnal.std-bali.ac.id/index.php/imagine

Taleb, T., Samdanis, K., Mada, B., Flinck, H., Dutta, S., & Sabella, D. (2017). On Multi-Access Edge Computing: A Survey of the Emerging 5G Network Edge Cloud Architecture and Orchestration. *IEEE Communications Surveys and Tutorials*, *19*(3), 1657–1681. https://doi.org/10.1109/COMST.2017.2705720

Toresa, D., Putra, P. P., Febriadi, B., & Handayani, S. (2023). PELATIHAN DASAR JARINGAN KOMPUTER UNTUK SISWA TEKNIK KOMPUTER DAN JARINGAN (TKJ) SMK MIGAS INOVASI RIAU. *Journal of Computer Science Community Service*, *3*(1), 27–32.

Usman, S., Rozie, F., & Negeri Ketapang, P. (n.d.). *Desain dan Implementasi Jaringan Sensor Nirkabel berbasis IoT dengan komunikasi LoRa untuk Sistem Monitoring Kualitas Daya dan Energi Listrik*.

Wang, X., Han, Y., Leung, V. C. M., Niyato, D., Yan, X., & Chen, X. (2019). *Convergence of Edge Computing and Deep Learning: A Comprehensive Survey*. https://doi.org/10.1109/COMST.2020.2970550

Yu, W., Liang, F., He, X., Hatcher, W. G., Lu, C., Lin, J., & Yang, X. (2017). A Survey on the Edge Computing for the Internet of Things. In *IEEE Access* (Vol. 6, pp. 6900–6919). Institute of Electrical and Electronics Engineers Inc. https://doi.org/10.1109/ACCESS.2017.2778504