**Smart City Using loRawan**

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**Introduction**

As urbanization continues to increase at an unprecedented rate, cities around the world are facing a host of challenges such as congestion, pollution, and energy consumption. Smart city solutions have emerged as a promising way to tackle these challenges, leveraging the power of the Internet of Things (IoT), Artificial intelligence (AI), cloud computing, and data analytics to optimize urban infrastructure and improve the quality of life for citizens. LoRaWAN technology has emerged as a crucial enabler for smart city applications, providing a cost-effective and scalable way to connect IoT devices and sensors across large urban areas.

**What is LoRaWAN?**

LoRaWAN (Long Range Wide Area Network) is a wireless communication protocol that enables long-range, low-power communication between IoT devices and sensors. LoRaWAN is designed to operate on an unlicensed spectrum, making it accessible and affordable for cities to deploy. LoRaWAN networks consist of gateways, devices, and application servers. The gateways serve as the bridge between the devices and the internet, while the devices collect data and send it to the gateways. The application servers are responsible for processing the data and making it available for analysis. LoRaWAN technology allows for the creation of a network of connected devices and sensors that can provide real-time data on a variety of urban factors such as traffic patterns, air quality, and energy consumption.

LoRaWAN technology is ideal for smart city applications because it can support a large number of devices over a long range, with low power consumption. Devices using LoRaWAN can operate on a single battery for years, reducing the need for frequent maintenance or replacement. This makes LoRaWAN an ideal solution for smart city applications that require a large number of sensors to be deployed across a wide area.

**Smart City Applications using LoRaWAN.**

LoRaWAN technology is being used in a variety of smart city applications around the world, from waste management to transportation to energy management. Here are some examples of how LoRaWAN is being used to optimize urban infrastructure and improve the quality of life for citizens.

*Smart Lighting*

Smart lighting systems are being deployed in cities around the world to improve energy efficiency and reduce costs. These systems use sensors to detect the presence of pedestrians or vehicles and adjust lighting levels, accordingly, reducing energy consumption and improving safety. LoRaWAN technology is being used to connect these sensors, allowing for real-time monitoring and control of the lighting system across a large urban area.

*Traffic Management*

One of the most pressing challenges facing cities today is traffic congestion. LoRaWAN technology can play a crucial role in addressing this issue by providing real-time data on traffic patterns and helping to optimize traffic flow. For example, smart traffic lights that use LoRaWAN sensors can adjust the timing of the lights based on the presence of vehicles and pedestrians, reducing wait times, and improving safety.

LoRaWAN can also be used to monitor parking spaces in real-time, allowing drivers to easily find available parking spots and reducing congestion caused by drivers circling the block in search of a parking spot. Additionally, LoRaWAN-enabled vehicles can communicate with each other and with the infrastructure, providing real-time data on traffic flow and helping to prevent accidents.

*Environmental Monitoring*

LoRaWAN technology can also be used to monitor environmental conditions such as air quality and water quality. By providing real-time data on environmental conditions, cities can take proactive measures to address pollution and other environmental concerns.

For example, LoRaWAN sensors can be placed throughout the city to monitor air quality, providing real-time data on pollutants such as carbon monoxide and nitrogen dioxide. This information can be used to identify areas with high levels of pollution and take action to reduce emissions.

*Energy Efficiency*

Smart energy management is another critical component of smart cities, as cities strive to reduce their energy consumption and become more sustainable. LoRaWAN technology can help cities achieve these goals by providing real-time data on energy usage and enabling more efficient use of energy resources.

For example, LoRaWAN sensors can be used to monitor energy consumption in buildings and identify areas where energy can be saved. Smart lighting systems that use LoRaWAN sensors can adjust lighting levels based on the presence of people, reducing energy consumption and lowering costs.

**Challenges of Smart City Applications using LoRaWAN**

While LoRaWAN technology offers a cost-effective and scalable way to connect IoT devices and sensors across large urban areas, there are still some challenges to be addressed to fully realize the potential of smart city applications.

One of the major challenges faced by smart city applications using LoRaWAN is the limited range of the LoRaWAN gateways. LoRaWAN gateways are typically deployed on buildings or other high locations, and their range is limited by the line-of-sight and the presence of obstacles such as buildings or trees. This can lead to gaps in coverage in certain areas of the city, hindering the effectiveness of smart city applications. To address this challenge, LoRaWAN networks may need to deploy additional gateways or use other technologies such as mesh networking to extend coverage to areas that are currently out of range.

Another challenge is the need for effective data management and analysis. Smart city applications using LoRaWAN can generate large amounts of data, which must be collected, stored, and analyzed in real-time to provide meaningful insights. This requires sophisticated data management and analytics infrastructure, including cloud-based platforms and advanced machine learning algorithms. To address this challenge, LoRaWAN networks must have robust data management and analytics capabilities to ensure that the data generated by smart city applications can be effectively utilized to optimize urban infrastructure and improve the quality of life for citizens.

Overall, while there are some challenges to be addressed, LoRaWAN technology holds tremendous promise for smart city applications. As cities around the world continue to face the challenges of urbanization, LoRaWAN-enabled smart city solutions can provide a cost-effective and scalable way to optimize urban infrastructure and improve the quality of life for citizens. By addressing the challenges of secure communication, interoperability, range limitations, and data management, LoRaWAN networks can unlock the full potential of smart city applications and help create more connected, efficient, and sustainable cities for the future.

**LITERATURE REVIEW**

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| AUTHOR | TITLE | PROJECT | LIMITATION |
| Ashish Jha, Menuka Maharjan. | A Smart Lighting System Using The LoRaWAN Technology. | They proposed a system that provides conservation of energy and with efficient monitoring of light. | This technology is only compatible with streetlights. |
| Priyanka Chaudhari, Aman Kumar Tiwari, Shardul Pattewar, S. N. Shelke. | A Smart Infrastructure Monitoring Using LoRaWAN. | This is an online monitoring system for manhole covers in smart city environment. | This system is only limited to sewage or waste management infrastructure. |
| João Jaime, Ivo Sousa, Maria Paula Queluz, António Rodrigues. | Planning A Smart City Sensor Network Based On LoRaWAN Technology. | This proposed system collects data in order to manage assets and resources effectively. | Lack of an application server to make collected data or resources available to clients. |
| Ngo Thanh Tung, Le Minh Phuong, Nguyen Minh Huy, Nguyen H. P., Ta LE D. H., Nguyen D. T. | Development and Implementation of Smart Street Lighting System based on Lora Technology | The system provides remote lighting control that can better adjust the amount of time the lamp is turned on to minimize energy costs without reducing safety levels. | This project is limited only to streetlights in a smart city and hence difficulty in interfacing with other IoT devices. |
| Y. Wang, Y. Huang and C. Song | A New Smart Sensing System Using LoRaWAN for Environmental Monitoring | This paper proposes a new Internet of Things (IoT) sensing system for environmental monitoring |  |
| Thu, M. Y., Htun, W., Aung, Y. L., Shwe, P. E. E., Tun, N. M. | Smart Air Quality Monitoring System with LoRaWAN | This paper presents a scalable smart air quality monitoring system with low-cost sensors and long-range communication protocol. |  |
| Pasandi, B. H., Hagigat, A., Moradbeikie, A., Keshavarz, A., Rostami, H., Paiva, S., Lopes, I. S. | Low-cost traffic sensing system based on LoRaWAN for urban areas. | This paper explores the usage of LoRaWAN end nodes as traffic sensing sensors to offer a practical traffic management solution. | Lack of an application server to make collected data or resources available to clients. |
| Kannayeram, G., Madhumitha M., Mahalakshmi, S., Devi, M. P., Monika K., Prakash, N. B. | Smart Environmental Monitoring Using LoRaWAN | The motive of this paper is to monitor the environmental parameters using LoRaWAN technology. | This system does not communicate with different devices from different systems on the same network. |
| Sukhathai, N. and Tayjasanant, T. | Smart Street Lighting System with Networking Communication | This paper presents LoRaWAN based smart street lighting control system which allows to control night time street light autonomously with minimum energy consumption. | This system might not detect a faulty vehicle and keep the streetlights on at high intensity. |
| T. Addabbo, A. Fort, M. Mugnaini, L. Parri, A. Pozzebon and V. Vignoli | Smart Sensing in Mobility: a LoRaWAN Architecture for Pervasive Environmental Monitoring | In this paper, the authors present the architecture of a wireless sensing system for environmental monitoring, exploiting public transport as the instrument to pervasively collect data. | Relies on public transport for means of collecting environmental data and as such real-time data from a particular location will not always be available. |
| Attila, S., Dzitac, S., Dzitac, I., et al | Air quality assessment system based on self-driven drone and LoRaWAN network | This paper presents a low-cost air quality monitoring device that due to the communication technology (LoRaWAN) can be used on large geographical areas. | The monitoring devices were mounted on drones and not in fixed places as such requires constant flying of the drones throughout the region leading to high cost. |
| N. Saokaew et al. | Smart Street Lamp System using LoRaWAN and Artificial Intelligence | The smart street light system is able to detect 4 object classes (pedestrian, bicycle, motorbike, and vehicle) and control street lamps around the KMUTT football field at night. | This system requires a large data set to train an Artificially intelligent camera to detect objects. |

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| Abdoulaye, B. P., Zennaro, M., Degila, J., Pietrosemoli, E. | A Smart Cities LoRaWAN Network Based on Autonomous Base Stations (BS) for Some Countries with Limited Internet Access | In this paper, they propose a LoRaWAN network with autonomous base stations that can work without Internet connectivity for essential services, while being able to provide additional features whenever Internet access becomes available, even in an intermittent fashion. | Individual or clients can only access the data at base stations. |
| Seid, s., Zennaro, M., Libsie, M., Pietrosemoli, E., Manzoni, P. | A Low Cost Edge Computing and LoRaWAN Real Time Video Analytics for Road Traffic Monitoring | In this paper, they propose a novel real-time video analytics using low-cost IoT devices and LoRaWAN networks to realize new services and applications that include traffic management through IoT edge computing. |  |
| Ali, S., Glass, T., Parr, B., Potgieter, J., Alam, F. | Low Cost Sensor With IoT LoRaWAN Connectivity and Machine Learning-Based Calibration for Air Pollution Monitoring | This article reports the development of a novel low-cost sensor node that utilizes cost-effective electrochemical sensors to measure carbon monoxide (CO) and nitrogen dioxide (NO2) concentrations and an infrared sensor to measure particulate matter (PM) levels. | The system is bulky and not portable since it has solar recharged battery and main supply. |
| Rakshit, R., Mukunth A., Atluri, H. K., Chetan K. S., et al. | LoRaWAN for smart cities: experimental study in a campus deployment | In this paper, they describe their experiences in deploying such an interoperable long-range wide-area network and management aspects of it in a campus environment | Inconsistencies in data transfer rate leading to reliability issues. |

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| Wei Li, Guanxi Shen, Jinbo Zhang | An indoor environmental monitoring system for large buildings based on LoRaWAN | This paper focuses on the characteristics and advantages of LoRa technology, studies the indoor environment monitoring system based on LoRaWAN, the system architecture. | This system was only used for indoor environmental building and as such was only useful for individuals in that building. |
| Hsin-Yuan, M., Chao-Tung, Y., Kristiani, E., et al | On Construction of a Campus Outdoor Air and Water Quality Monitoring System Using LoRaWAN | This paper proposed implementing a water and air monitoring system using sensor development and a LoRa Network. |  |
| Boonyopakorn, P., Thongna, T. | Environment Monitoring System through LoRaWAN for Smart Agriculture | The result of this paper is a prototype equipment for measuring the environment and the weather statistics of the installation area for use in creating the model for forecasting the environment in each period. |  |
| Aneiba, A., Nangle, B., Hayes, J., Albaarini, M. | Real-time IoT Urban Road Traffic Data Monitoring using LoRaWAN | This paper presents an innovative, effective and reliable end-to-end inductive loop monitoring solution using a low-cost dual-loop detection board integrated with low power wide area network (LPWAN) connectivity technology. |  |