Applications of LoRaWAN

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LoRaWAN is a communication protocol designed especially for Internet of Things (IoT) applications that offers benefits such as long-distance connection and low power consumption. Due to the characteristics of LoRaWAN, this technology has gained great popularity in various IoT applications, such as environmental monitoring, smart agriculture, and applications in the areas of health and mobility, among others.

Keywords: LoRaWAN ; sensors ; applications ; LoRaWan devices

1. Introduction

LoRaWAN finds applications in diverse fields such as smart cities, industrial monitoring, agriculture, smart buildings, asset tracking, and environmental monitoring. In smart cities, it enables the efficient management of resources like lighting, waste, parking, and environmental conditions. In industrial settings, LoRaWAN enables remote monitoring of equipment, predictive maintenance, and supply-chain optimization. In agriculture, it facilitates soil and irrigation monitoring, crop management, and livestock tracking. In smart buildings, LoRaWAN is utilized for energy management, security systems, and occupancy sensing. Asset tracking across industries and environmental monitoring of air and water quality are additional areas where LoRaWAN plays a crucial role.

2. Agriculture

Agriculture is a sector of special importance due to the food demands of the growing population. In this context, different works have been developed to monitor various aspects that are required for agriculture, ranging from soil quality to crop monitoring. In [1], a remote crop monitoring system was developed using cost-effective sensors that measure parameters such as pH, temperature, and humidity; in this work, the gathered data are sent to a The Things Network (TTN) server. In [2], a prototype based on LoRaWAN was proposed that allows measuring the humidity, temperature, and electrical conductivity of the soil.

On the other hand, in [3], the importance of security in the field of agriculture was emphasized by implementing a hardware secure module (HSM). This module made it possible to manage the secret keys in a secure way.

In [4], the use of wireless underground sensor networks (WUSNs) was proposed, which provide coverage of a 7 km radius with a depth of up to 50 cm. The results indicate that WUSNs are not scalable if message-delivery-confirmation packets are required. When the nodes were buried 50 cm, the coverage distance was up to 160 m. Additionally, in [5], an air-quality monitoring system was implemented. In this work, nine gateways were placed in six different locations; it was shown that a packet reception could be obtained from 72.4% of the messages sent. The implementation of 100 air monitoring devices and four additional gateways is proposed to test the scalability of this system.

3. Environmental Monitoring

Environmental monitoring is the most frequent application of LoRaWAN among the previous works analyzed in this paper. Among these applications, it can be seen that the measurement of ultraviolet (UV) rays, the monitoring of air quality, and the monitoring of water stand out.

In [6], a monitoring system was created to assist in the prevention of diseases caused by solar radiation through Twitter alerts using LoRaWAN technology and ThingSpeak software. In [7], the UV-radiation measurement procedure was also performed using an ESP32 controller. In [8], commercial sensors were used to implement the measurement of ultraviolet radiation with an optimization of energy that allows them to work up to 14 days; communication was also optimized for distances greater than 0.7 km. In [9], the design of a device based on UV optical sensors that allows determining the existing radiation index was presented; ultraviolet radiation index (UVI) levels were displayed through a graphical user interface in real time, which also allowed generating a report in a .csv file. The study was carried out in the central patio of two educational units.

In another work, the authors created an air-quality measurement system taking into account parameters such as CO_2, No_2, PM (particle matter) levels, temperature, and humidity [10]. This was achieved using sensors and a communications module. The used sensors were inexpensive and required extensive calibration given the interactions of temperature and humidity. In [11], low-cost air-quality sensors were used, such as those for measuring the level of particles, SO_2, NO_2, CO, O_3, and CO_2; in this system, the sensors send the data directly to an application through the LoRaWAN network, and the collected data are presented through an interface that allows to see the evolution of the measured parameters through graphs with a granularity of day, week, or month. The results of the work confirmed that LoRaWAN is appropriate for this type of monitoring solution. On the other hand, in [12], an IoT system was proposed for monitoring environmental parameters such as temperature, air pressure, humidity, noise, and air quality; the collected data are sent to a cloud server that saves and displays the measurement data. On the other hand, in [13], two stages of an air-quality monitoring system were established to facilitate the environmental changes in the regional air condition and early warning system. First, the air-quality sensors from Arduino and LoRa were integrated; the sensor nodes were then deployed on a university campus. Another work is the one presented in [14]; in this work, the authors proposed a monitoring system for moisture in the wood of buildings with cultural significance. The sensing solution was composed of a LoRaWAN communication device and a cloud application that allows remote visualization and control of the building's nodes. The results showed that the proposed system can be applied inside buildings, despite obstacles such as thick walls and complex architectural structures. In [15], an environmental monitoring solution with parameters such as temperature, humidity, barometric pressure, and ambient light was proposed. The nodes were attached to a vehicle that shows the behavior in motion. The gateway was connected to the servers which deliver the gathered data to the end users.

In [16], WaterGrid-Sense is used, which is an intelligent interface platform; this platform has an integrated LoRa module that uses class A LoRaWAN protocol and has two sensor slots: one for a pressure sensor and the other for a pulse sensor. This intelligent platform was used for the management of a real-time intelligent water system, which was implemented at the Council for Scientific and Industrial Research (CSIR) campus. Another work is [17], in which a device was created to help monitor water quality in real time and identify abnormalities through a phone application. The device was created with the purpose of helping fish farmers; the device has different water sensors such as pH, water level, temperature, dissolved oxygen, total dissolved solids, oxidation, and turbidity sensors. The anomalies detected by the sensors activate different actuators such as the aerator, water filter, peristaltic pump, water pump, fish feeder, and heater to solve the problem. On the other hand, in [18], a comparison of LoRaWAN, Sig-Fox, and NB-IoT technologies is made; for this, a smart water grid is simulated using the NS-3 simulator. In this work, several problems in the water infrastructure were detected through the use of sensors; an example of these problems was the pipe leaks. With the results of the simulation, the conclusion was reached that NB-IoT has better scalability compared to the other two technologies.

4. Mobility

Mobility is another area that benefits from LoRaWAN technology. Applications range from motion-sensor data communication to driving assistance using the movement detection of animals and people.

In [19], a project was developed in which it was planned to monitor garbage trucks in real time. To monitor them, four devices were used: two commercial and two assembled ones.

In [20], a LoRaWAN-based tracking system was implemented for the vehicle fleet of the municipality of Kozani, Greece. An experimental study was carried out with the objective of comparing the LoRaWAN network developed using two GPS trackers: an industrial solution and a customer solution. For this, a comparison is made between two types of sensors, RAK7200 and TTGO-TBeam, in terms of the number of packets and signal strength. The result shows the benefits of using external antennas; the most effective was the RAK7200 sensor with a 3dBi external antenna.

In [21], a service based on the use of parking sensors buried in the asphalt is presented to be able to detect if there is a vehicle at a certain distance above the sensor. The sensors were placed in two different geographical areas. In the first zone, 45 sensors were placed at a range of 250 and 385 m, while in the second, 24 sensors were placed at a distance between 25 and 60 m. The first scenario showed higher packet losses due to the distance from the gateways and the different obstacles presented in the way.

In [22], a road-condition monitoring system was proposed. For this, mobile sensors connected to a LoRaWAN network were used. The accelerometer and GPS of a smartphone were also used to measure vibrations in order to know the road conditions. The results allowed obtaining the classification of potholes, speed breaks, and damaged or patched streets. In [23], a solution for detecting and recognizing animal or people movement on the roadside to prevent accidents was proposed. This solution was focused on autonomous vehicles. LoRaWAN mesh technology was used to provide the data transmission of the remote networks and the main station, and the data were analyzed in a microcloud infrastructure.

5. Health

Health is another area in which LoRAWAN technology is frequently applied. In [24], the use of LoRaWAN is proposed to monitor the health of workers and maintain efficiency during their work activity, analyzing working environment factors such as temperature, light, CO_2 concentration, pressure, etc. On the other hand, in [25], a theoretical model is proposed to create a wireless monitoring device, which sends electrocardiogram and other data by applying machine-to-machine communication. Further, in [26], the creation of a device that monitors physical activity in elderly people is proposed, integrating an IMU (inertial measurement unit) to the sensors. Also, in [27], the implementation of an alert system for mine workers is proposed, taking into account the data obtained from smoke sensors and using respiratory and cardiac data. The study presented in [28] deals with a solution based on IoT devices and the deployment of several LoRaWAN gateways to geolocate vulnerable people, in which the location can be obtained at a range of 40 to 60 m.

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