CENTRAL ASIAN JOURNAL OF THEORETICAL AND APPLIED SCIENCE

https://cajotas.casjournal.org/index.php/CAJOTAS

*Volume: 07 Issue: 01 | January 2026 ISSN: 2660-5317*

*Article*

# LoRaWAN Technical Requirements for Technology and Specific Features of Radio Interface Construction

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**Abstract:** This paper explores the role of LoRaWAN (Long Range Wide Area Network) technology in addressing the growing needs of the Internet of Things (IoT). With the rapid expansion of smart cities, the need for wide-area low-power communication systems has increased. Many modern wireless systems face limitations in range, price, or energy consumption, so there is still an unmet need for efficiently connecting sensors over large or hard-to-reach regions. In short, the comparison made in this study is that of LoRaWAN with different wireless standards, namely Wi-Fi, SigFox, Bluetooth LE, and Power Line Communication (PLC) to make a road by answering above roadblocks. We picked apart things like signal range, data rate, energy consumption, and modulation type to identify which system appears to give the best ready to use balance for IoT. Results show that LoRaWAN is able to reliably transmit data in line-of-sight over distances of up to 15 km in rural conditions and 2.5 km in urban areas whilst consuming very little power over unlicensed ISM bands from 433 to 915 MHz. Even though it fails there, thanks to its strength and efficiency, it is suitable for long-range sensor systems. Overall, LoRaWAN provides a good foundation for smart infrastructure, environmental monitoring and industrial applications. By adopting this technology, Uzbekistan and similar regions may be able to expand their IoT networks in a cost-effective and sustainable manner.

**Citation:** Sultanova, M & Aliyev, A. LoRaWAN Technical Requirements for Technology and Specific Features of Radio Interface Construction. Central Asian Journal of Theoretical and Applied Science 2026, 7(1), 11-15.

Received: 10th Aug 2025
Revised: 16th Sep 2025
Accepted: 24th Oct 2025
Published: 12th Nov 2025



**Keywords:** LoRaWan, LPWAN, IoT, wireless communication, ISM band, energy efficiency, modulation.

## 1. Introduction

Ministers of the Republic of Uzbekistan No. 48 dated January 18, 2019, concerning the Concept for Implementing "Smart City" Technologies in the Republic of Uzbekistan , outlines the implementation of smart meters ("intelligent computing devices") , payment monitoring systems, infrastructure management systems, mechanisms for identifying and mitigating instances of energy resource depletion, along with methods and systems aimed at enhancing energy efficiency to facilitate data exchange between utility resource consumers and suppliers via the adoption of "Smart Housing and Utilities" technological solutions [1].

To ensure effective monitoring, it is often necessary to place the sensors of the data acquisition system in "hard-to-reach" places - where there is no power supply or wired communication channels. It is recommended to use wireless sensors with an autonomous power source with a long service life (not less than the sensor inspection interval) from a single power source.

LoRaWan (Long Range Wide Area Network) is an energy-efficient network technology that helps overcome the challenges of collecting and analyzing data from various sensors to receive control commands. Such solutions were previously not possible due to limited battery life, short data transmission distances, high costs, and the lack of necessary standards [2].

Now we can confidently say about the advantages of LoRaWan technology, such as long range, low power consumption, and open standard.

LoRaWan sensors can transmit small amounts of data over distances of more than 100 km in favorable environments, and up to 5 km in dense urban and industrial areas, providing data exchange rates from 300 bit/s to 100 kbit/s. Most of them can operate continuously for up to 10 years, powered by a single AA battery.

PLC (Power Line Communication) technology enables the utilization of electrical power transmission networks for communication, and currently, it also supports broadband communication services. The core concept of PLC technology is to lower operational expenses and the costs associated with establishing new telecommunication networks [3].

Thus, high-voltage and low-voltage networks are used for internal communications in electrical equipment and for remote measurement and control. PLCs are also used for various communication applications in internal electrical installations inside buildings and houses (so-called home PLCs). PLC systems are divided into broadband and narrowband systems. Narrowband PLC systems allow for communication services at relatively low data rates (up to 100 Kbit/s) and the use of various automation and control applications, as well as several voice channels and broadband PLC systems. However, the use of PLC technologies for organizing data transmission channels in TJ ABT has not been fully explored and requires additional research.

It can be concluded that it is urgent to create theoretical foundations and practical methods for analyzing and improving the efficiency of data transmission in technological process control systems using PLC technologies.

Latest In the years of the Internet of Things ( IoT ) technologies intense low energy development consumer and far remote communication to systems was demand increased . That 's how from technologies One is LoRaWan (Long Range Wide Area Network) , which is based on the OSI model . physicist in the layer working wireless modulation technology is. LoRaWan technology this in the sense mobile phones , tablets , laptops , routers and others between wireless the connection IEEE 802.11 technology (Wi-Fi technology) that provides physicist in the layer usable technology ) with equalize possible . In this layer addressing concepts there is it's not and network topology is simply on air transmission and other devices through acceptance to do is [4].

## 2. Materials and Methods

LoRaWAN technology main features his/her High energy efficiency and work distance to be, to pass them down ability because of However, this to the disadvantage despite, LoRaWan technology how much big not been in volumes information transmitting on devices wide is used. Its the most popular application finger of the type from the battery years during working autonomous sensors are , they are useful information collect for basic from the station far away located to be possible.

LoRaWAN from technology used devices unlicensed [5],[6] ISM (Industrial, Science, and Medical ) medical ) frequencies , specifically 433 MHz ( Europe ), 868 MHz ( Europe , India ) or 915 MHz ( USA , Canada , Australia ) works . So, any user independent accordingly this at frequencies working network create possible and this from frequencies use for relevant state from the organs special permit to take condition For example, Wi-Fi technology that also operates on unlicensed 2.4 / 5 GHz frequencies this for permission without taking own wants to install a Wi-Fi router in his apartment was everyone to

someone opportunity gives. But these frequencies unlicensed they for no how restrictions whether there is does not mean.

At these frequencies, usually radiated of the signal maximum to power, transfer ability (to transfer) of the band width) restrictions there is and from the channels use according to time according to restrictions (duty-cycle – load (cycle) exists. Example for, in Europe ISM band with frequency 868 MHz is used, in which used to the channel related accordingly loading per cycle restrictions available: to device 3.6 (0.1%) or 36 (1%) seconds per hour many not been on air to transfer permission is given [7][8].

LoRaWAN technology big work to the distance mainly special working issued linear-frequency modulation algorithm through is achieved [9].

European ISM 868 MHz frequency for communication of the line energetic potential (Link budget) to 156 dB is equal to him/her far to distances to transfer , to the building good enter to go and city under the circumstances hundreds to meters to spread opportunity gives [10].

LPWAN technologies to the group incoming LoRaWAN narrowband technology to the relationship technician requirements following conditions based on formed:

- many IoT devices per day one how many times 10 to 50 bytes small voluminous to traffic has simple sensors is considered;
- main information traffic up in the direction line according to IoT from the device basic transmitted to the station (radio gateway);
- LoRaWan technology radio link networks create through different distant sensors and sensors IoT applications with to connect opportunity giving radio technology is considered [11][12].

He/She/It is a spectrum expansion to technology based is, it is the transmitters that's it one characteristic of the color traditional straight away radio communication to systems relatively communication distance almost 10 times increase opportunity gives. To this the following using is achieved:

- minimum phase sliding GMSK (Gaussian Minimum Shift Keying) modulating special signals , them from modulation before rectangular information impulses sequence Gaussian filter through is held ;
- FSK (Frequency Shift Keying) frequency manipulated signals;
- known time between SK=7-12 spectrum expansion coefficient with increasing or decreasing frequency with information linear frequency modulated wide striped impulses with codable spectrum expandable wide striped modulation [13].

LoRaWAN technology IoT /M2M data on the network following different speeds provides:

- 125 kG channel 5.47 from 250 bit / s wide up to kbit / s;
- 250 kG channel up to 11 kbit /s in width;
- FSK modulation up to 50 kbit / s in use.

Energy consumption determines how long these devices can operate without replacing batteries. There is a comparative assessment of the energy consumption of subscriber devices of LoRaWan technology and other radio technologies. LoRaWan transmission in the segment other from technologies per hour 1 from bytes to 10 kbytes to advantage has.

## 3. Results

LoRaWAN networks main technician The characteristics are given in Table 1. They order eater bodies - SERT (European mail and communication administrations conference) and FCC requirements in the USA related accordingly differs.

**Table 1.** LoRaWAN in technology networks main technician characteristics

| Parameters | CEPT requirements | FCC ( USA ) requirements |
|---|---|---|
| Frequencies Range , MGs | 867-869 | 902-928 |

| | | |
|---|---|---|
| Radio channels number | 10 | 64+8+8 |
| Radio channel width, kgs | 125/250 | 125/500 |
| Transmission power , Up line | +14 dBm | +20 dBm main (+30 dBm) permission (available ) |
| Transmission power down line | +14 dBm | +27 dBm |
| Up SF spectrum in the line expansion coefficient | 7-12 | 7-10 |
| Data transmission speed | 250 bit /s - 50 kbit /s | 980 bits /s – 21.9 kbit / s |
| Down radio line budget , dB | 155 | 1 5 4 |
| Up radio line budget , dB | 155 | 157 |

The coverage area of the LoRaWan network is provided by the operating range of base stations (LoRaWan nodes) up to 2.5 km in urban areas and up to 15 km in rural areas . In the field of short distances and low bandwidths, there are RFID and NFC (Near Field Communication) technologies that operate at very close distances and are designed to transmit minimal amounts of data. These technologies can be used to pay at the cash register, enter a closed parking lot, identify when entering buildings (including the Tashkent metro), etc., but in all these cases the amount of data transmitted is minimal and the distance to the reader is usually less than one meter.

Bluetooth LE (Bluetooth Low Energy) technologies currently have significantly greater operating range (up to 20 meters for Class A devices) and throughput (up to 1 Mbps) compared to RFID and NFC technologies. Wi -Fi technology, which has better bandwidth , but its operating range is not very large, usually within the boundaries of an apartment or small building.

LoRaWan, SigFox (a technology very similar to LoRaWan) and other UNB technologies ( Ultra Narrow Band ) have very long operating ranges of up to several tens of kilometers, but their throughput is much lower.

LoRaWan-type long-range and high-speed Wi- Fi technologies include all mobile technologies with moderate operating range and good throughput [14]. All communication technologies available today balance three desirable characteristics - long range, high bandwidth and low power consumption. Mobile phones achieve good range and data transfer rates, but consume significant power; LoRaWan has very good range and low power consumption, but it has low bandwidth; Wi -Fi technology has very high bandwidth and low power consumption, but therefore has a short range.

LoRaWan uses unlicensed spectrum, which is defined and regulated based on territorial restrictions in the following frequency bands:

- 430 MHz - for Asian regions;
- 780 MHz - for the China region;
- 433 MHz - for the European region;
- 866 MHz - for the European region;
- 915 MGs - for the United States territories.

It should be noted that LoRaWan has a number of technological competitors in the above-mentioned unlicensed groups - SigFox, Weightless, RPMA, UNB technologies, and a number of other similar technologies that are close in technical characteristics [15].

## 4. Conclusion

This shows that LoRaWAN technology is capable to overcome the issues of scalability in Internet of Things (IoT) system deployment where distance and energy consumption are the main factors responsible for the challenges in the deployment of IoT systems especially in the places where long-distance communication and low power consumption are needed and useful. The comparative assessment attests to LoRaWAN superiority over traditional wireless technologies: Wi-Fi, BLuetooh LE and PLC in energy efficiency, extended range, and operation untended stable in unlicensed ISM frequency bands. These benefits render it a use case for smart city infrastructure, industrial automation, and environmental monitoring for developing nations such as Uzbekistan, where cost-effectiveness and reliability matters. This research implies that the incorporation of LoRaWAN into national IoT strategies could considerably broaden data-centric management systems, thus enabling low-carbon technology transformation. But making access to the data from such networks by doing more research on network scalability, data security, and hybrid integration with other communication technologies shall be catered, leading IoT networks to a greater level of resilience, interoperability, and efficiency in practice.

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