

LORAWAN CERTIFIED PRODUCT TRENDS WITH A SPECIAL FOCUS ON SMART CITIES AND PROPERTY PROTECTION

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ABSTRACT

LoRaWAN technology is a leading IoT communication solution in the Low Power Wide Area Network market. In 2016, it dominated the market with a 71% share, but by 2020, NB-IoT will have taken the lead. Currently, 28% of Low Power Wide Area Network devices worldwide operate with LoRaWAN, while NB-IoT has a 54% market share, excluding China, LoRaWAN continues to dominate and is expected to maintain this leading position until 2027. LoRaWAN plays a significant role in developing smart cities and smart homes, as it provides coverage of large areas with low power consumption, and robust communication is essential for security applications. The article will examine the specifications of LoRaWAN, and the devices certified on the basis of these specifications, paying particular attention to the devices' functionality, frequency usage and application areas. The current research analyses 404 LoRaWAN-certified devices and compares them with 2020 data. The study aims to provide a comprehensive and analytical picture of the evolution of LoRaWAN technology and its prospects and challenges.

KEY WORDS

LoRa, LoRaWAN, certification, smart city, property protection

CLASSIFICATION

ACM: B.4

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INTRODUCTION

LoRaWAN communication is the leading IoT communication solution in the Low Power Wide Area Network (LPWAN) market worldwide. Statistics show it dominated the market with the highest percentage (71%) alongside NB-IoT, Sigfox, LTE-M, and other IoT communications in 2016. LoRaWAN maintained its lead until 2020, after which NB-IoT took over the market leadership. Currently, 28% of LPWAN IoT devices worldwide operate with LoRaWAN, and NB-IoT is the market leader at 54%. On the other side of the statistics, if China is excluded, LoRaWAN is currently still in first place with 40%, and is estimated to hold this position until 2027 [1]. All this shows that LoRaWAN communication has potential and is worth researching, and the present article discusses this topic.

Another topic of this article is the implications of LoRaWAN for smart cities. In 2020, the summary of current IoT trends [2] prominently featured smart city applications [3], as did the one for 2023 [4]. By 2024, the focus will have shifted towards machine learning and artificial intelligence [5], which also impact smart city solutions [6].

In terms of asset protection, there are a number of smart city and smart home solutions that are not only aimed at comfort, energy efficiency, and maintainability but are also related to the protection of buildings and homes. Such solutions could include a motion sensor [7] or even a fire alarm [8].

Several overview studies have been conducted on the features of LoRaWAN communication [9-11], and the related specifications and supplementary documents are also available. Therefore, this article summarises only the information relevant to the research.

In summary, LoRaWAN is a wireless network communication that allows long-distance (up to 10+ km) data transmission with low power consumption (up to 10+ years battery life). The frequency range used for communication may vary from region to region. The data transmission speed and the size of the transmitted data are limited. A significant advantage is communication robustness and the possibility of creating private networks. For typical IoT applications, LoRaWAN may be a desirable choice due to its positive characteristics [9-12].

The LoRa Alliance is responsible for developing the LoRaWAN Specifications and the certification processes [13]. The organisation has been in existence since 2015 and currently has over 100 member countries [14, 15]. The currently available specifications are the old versions 1.0 (January 2015) [16] and 1.0.1 (February 2016) [17], and the latest versions 1.0.2 (July 2016) [18] and 1.0.4 (October 2020) [19]. Specification 1.1 (October 2017) [20] is also more advanced than the others. Specification version 1.0.3 (July 2018) [21] is not specifically used. As the specification has evolved, content has been continuously updated, bugs have been fixed, missing parts have been filled in, and ambiguous information has been clarified.

The lowest level of network participants is the end-node, which is the subject of the present article. End-nodes can be divided into three classes based on the specifications: Class A, Class B, and Class C. In all three classes, the end-node is capable of two-way communication, initiating the transmission (uplink). There are differences between the classes in reception (downlink): duration and scheduling. Class A devices can downlink after uplink, Class B devices can downlink periodically, and Class C node can downlink outside the uplink. The class operation of each device may have an impact on the application area and consumption [10].

Communication is free of charge in Industrial, Scientific and Medical (ISM) frequency bands ranges. In Europe, the EU863-870 MHz Band is used, usually referred to as EU, with a typical value of 868 MHz. There is also EU433, the European 433 MHz communication, but it is not typically used. The US902-928 MHz ISM Band, or the US for short, is used in America and Canada. In Australia, the AU915-928 MHz Band is used; in China, the CN470-510 Band

Channel Frequencies. Other bands are AS923 MHz Band, KR920-923 MHz Band, IN865-867 MHz Band, RU864-870 MHz Band [22]. The band of an end-node indicates the region in which it is intended to be used by the manufacturer.

The characteristics of LoRaWAN technology described in previous text are relevant to the present research.

METHODS

My earlier research [23] completed in November 2020 also evaluated certified devices shared on the LoRa Alliance website. The devices survey ended on 20 April 2020, when 177 LoRaWAN-certified products were available. The products were grouped by functionality, and eight groups were specified. The LoRaWAN specification which allowed the certification of each product and group was also investigated. Furthermore, the typical applications of the devices were summarised.

The present research also examines the certified devices published by the LoRa Alliance based on the criteria described in the previous research and other relevant aspects. The review of the products was completed on 27 July 2024. The 2020 results have been compared with the current results. The grouping of functionality in terms of the current product range will be examined to see if it needs to be modified or added to. The study also looks at how the proportion of products in each group has changed. Other aspects to be analysed and compared are grouping by specification of devices, grouping by Class, grouping by the frequency used, the date of specification, change trends and statistics, additional communication, and application area. The availability of newer specification certification for a given device will also be investigated.

The current research has studied the pages [24] of 404 LoRaWAN-certified devices and associated protocols. Incorrect or incomplete information was also found during the research and corrected where possible; otherwise, it was discarded.

LORAWAN DEVICES CATEGORISED BY FUNCTIONALITY

The 177 devices studied in the previous 2020 research [23] were divided into eight groups: module, development board, sensor node, actuator node, sensor interface unit, meter interface unit, tracker, and tester. No new grouping was necessary for the 404 devices currently available, but there is some overlap between groups, with interface units being a typical case [24]. Several products are available that perform not only the function of the sensor interface unit or meter interface unit but both simultaneously. The two categories can be treated as one if interface units are considered as one group, but they have been split because of the different fields of application.

Of the 177 products tested in 2020 [23], only 129 are available on the LoRa Alliance website [24]. There are several reasons for this: the product is no longer available or has been removed for other reasons. There is a significant increase in all categories, with some doubling the number of devices compared to 2020. The most minor change is in the number of development boards, trackers and modules. The increase in the number of modules and development boards is likely to have been small because the significant manufacturers launched their products after the launch of the communication. Since then, newer versions and only a few smaller companies have appeared with tools in these categories. The number of purely intervention devices remains negligible. LoRaWAN is suitable for two-way communication, but in most cases, only uplink is used at the application level; downlink is usually only used for control and feedback. The number of sensor nodes and interface units has increased significantly, and these are the typical smart city solutions. In the following, only the groups marked in grey will be considered for smart city and asset protection purposes: sensor node, actuator node, sensor interface unit, meter interface unit, and tracker. Table 1 shows the number of devices in each category.

Table 1. Certified device categories in 2022 and 2024.

Category	Module	Development board	Sensor node	Actuator node	Sensor interface unit	Meter interface unit	Tracker	Tester
20 April 2020.								
Number of devices	33	15	83	3	6	24	11	2
27 July 2024.								
Number of old devices	19	15	60	2	2	14	7	1
Total number of devices	49	17	237	9	20	52	15	5

Table 2 shows the distribution of categories by year. It is based on the date and the earliest protocol of the device. It should also be noted that no certification document was uploaded for 12 devices, and they are not included in the table.

Table 2. Certified devices categories by years.

Year	Module	Development board	Sensor node	Actuator node	Meter interface unit	Sensor interface unit	Tracker	Tester	Total
2016	2	5	2	1	0	0	1	0	11
2017	7	3	10	0	2	1	1	0	24
2018	7	7	18	1	5	5	3	0	46
2019	3	0	22	1	11	1	1	2	41
2020	5	2	32	0	11	3	1	0	54
2021	5	0	35	2	10	5	4	0	61
2022	3	0	59	3	3	4	4	1	77
2023	5	0	25	0	5	1	0	1	37
2024	11	0	23	1	5	0	0	1	41

It can be seen that between 2016 and 2018, the number of certified assets increased each year, followed by a slight decrease in 2019. From 2019 onwards, the trend is increasing again. 2022 was the most significant year. 2023 shows a relatively dwindling number of new assets, and 2024 is still ongoing. The most productive years for sensor units were 2020-2022 and for meter interface units, 2019-2021. 2024 saw the entry of several new LoRaWAN module manufacturers, which is reflected in the numbers.

The trend clearly shows that the number of certified sensor units and meter interface units increased strongly during the COVID-19 period and then declined. During the pandemic, smart city solutions have appeared that are linked to presence monitoring, air quality monitoring, or other automation and monitoring tasks.

EVALUATION BY SPECIFICATION

As mentioned earlier, there are currently six LoRaWAN specifications available, where 1.0 and 1.0.1 are considered the old versions, and 1.0.2 and 1.0.4 are the current versions. The distribution of certified LoRaWAN devices by specification is shown in Table 3 [24].

Table 3. Number of certified devices by specification.

LoRaWAN specification	1.0	1.0.1	1.0.2	1.0.3	1.1	1.0.4
Number of old devices	6	31	87	0	0	5
Total number of devices	7	42	259	0	0	96

The number of devices has barely increased for 1.0 and 1.0.1, which are the old specifications. The device marked as 1.0.3 in 2020 is still on the list but has been upgraded to 1.0.1. The number of 1.0.2 devices has increased more than three hundredfold. Specification 1.0.4 was released in October 2020, meaning no device could be 1.0.4 in the previous search. Since then, 96 devices certified to the 1.0.4 specification have been added. It should be noted that three devices have both 1.0.2 and 1.0.4 specifications depending on the band; these have been included in the 1.0.4 column.

An important consideration is whether the devices have been updated over the years. Only six of the 177 devices on the 2020 list have been updated. Four devices have been updated from 1.0.2 to 1.0.4 and two devices from 1.0.1 to 1.0.4.

Table 4. Specifications of certified devices by year.

Specification	1.0	1.0.1	1.0.2	1.0.4
2016	4	6	0	0
2017	3	16	4	0
2018	0	6	38	0
2019	0	2	39	0
2020	0	1	50	2
2021	0	11	38	14
2022	0	0	62	18
2023	0	0	11	26
2024	0	0	7	34

The previous table (Table 4) shows the number of devices certified to a given specification, broken down by year. Each device has been considered for the earliest protocol under the latest specification. The trend is clearly visible in the values, with new specifications replacing old ones as time progresses. There is no doubt that specification 1.0.2 is the most popular. Since 2023, the new devices with specification 1.0.4 have been the most popular.

Nearly 90% of the devices are certified to the current specification. It is recommended that LoRaWAN-certified devices be purchased, as this will allow them to be verified as compliant with the specifications. Buying devices certified to old specifications, or starting the development with 1.0 or 1.0.1 modules or development boards are not recommended. Operation according to the version of the current specification helps avoid previous bugs and errors. It is currently advisable to work with 1.0.2 and 1.0.4 tools or to follow the specification requirements when developing in-house.

CLASS AND BAND RATING

The 2020 survey did not specifically examine the categorisation of devices by classes because, at that time, almost only Class A end nodes were included in the list [23]. Currently, devices are certified as A, A and C, and all three classes (A, B, C), as shown in Table 5 [24].

Table 5. Certified devices by Class.

Class	Class A	Class A, C	Class A, B, C
Number of devices	377	24	3

Table 6 shows that over 90% of devices are only certified for Class A operation. This does not mean they are incapable of Class C operation; it just means that they are not certified. The percentage of devices certified as capable of Class A and Class C operation is 6%. Only 1% of devices are certified for Class A, B, and C operations.

Table 6. Certified devices Classes by year.

Class	A	A, C	A, B, C
2016	10	0	0
2017	23	0	0
2018	44	0	0
2019	41	0	0
2020	52	1	0
2021	60	3	0
2022	78	2	0
2023	26	11	0
2024	31	7	3

Of course, Class A operation is available on all devices. The first device on the list to be certified for Class A and Class C operations was released in 2020 (Table 6). Only this year have certified devices to operate in Class B. Of course, it depends on the application to which Class of operation is required.

The results show that most devices are certified for the EU band. Figure 1 summarises the bands [22-24].

There are 266 devices certified for the EU band only, but there are 347 multi-band nodes that are EU-capable in total. The second in line is the US band, with 55 devices individually and 123 in total. The number of other single or multi-band devices is negligible compared to the EU and US. The results show that manufacturers have designed their devices for use primarily in Europe and secondarily in the US. More than 85% of the devices may be suitable in Hungary.

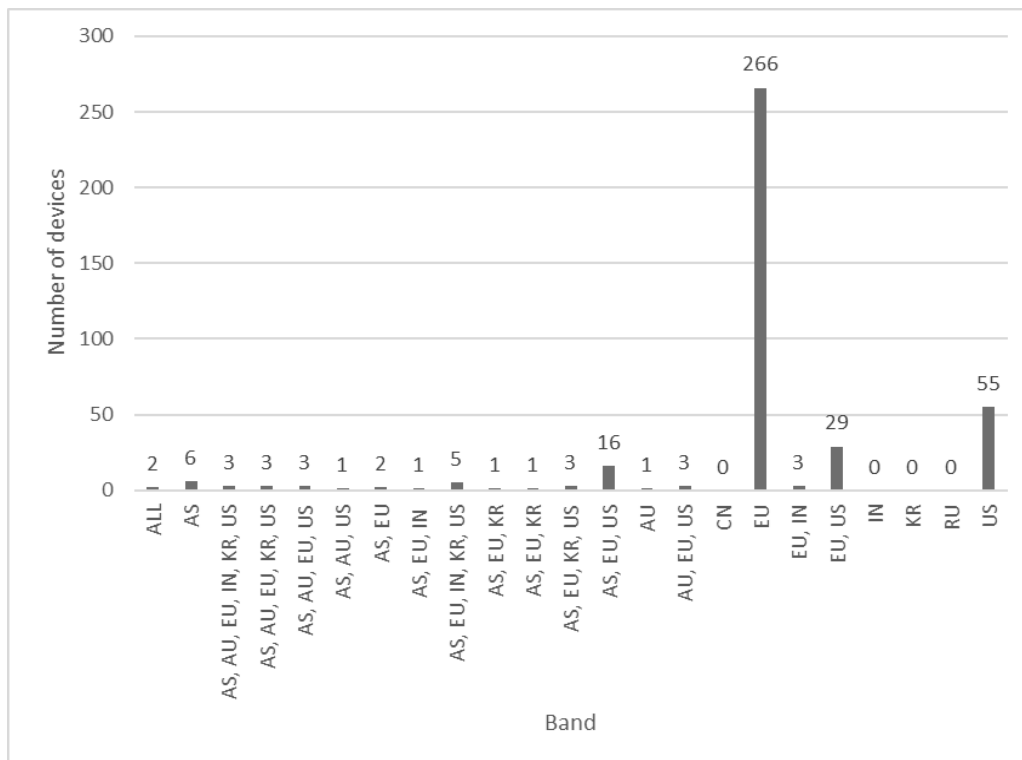


Figure 1. Bands of certified devices.

SMART CITY ASPECTS OF CERTIFIED LORAWAN DEVICES

Almost all 404 products can be used in some smart city applications. Even if we exclude development tools and modules which can only be used indirectly after development, there are 338 different products to use. Based on the analytical study, the following groups can be identified [12, 24].

One of the largest groups of devices is meters and meter interface units, which cover electricity, water, gas, and heat. Smart meters can be used to continuously monitor consumption data and increase system optimisation and energy efficiency.

The next group includes presence and motion detectors. They have a simple application in lighting control but can also be used for security purposes. In addition, presence sensors can tell if someone is in an area, allowing for occupancy monitoring.

A large group of environmental sensors monitor one or more features of our environment. The simplest versions are temperature and humidity sensors. Another simple version is light sensors, whose typical application is to control lighting. However, during COVID-19, increasingly complex solutions have been added to the range of certified LoRaWAN products, collectively called air quality sensors. The air quality sensors on this list measure temperature, humidity, CO₂, possibly Volatile Organic Compound (VOC) and Particulate Matter (PM). They are also often complemented by the presence monitoring of air quality devices, possibly with panic buttons. Other examples include smart weather stations that measure weather-related data and agricultural sensors that monitor soil and air parameters.

The next group of sensors tracks and locates devices. These devices allow traffic monitoring. However, there are also specialised devices for tracking objects, which have an additional logistical role. A group of smart parking sensors can be linked to vehicles to effectively monitor the occupancy of parking spaces, which contributes to reducing traffic and making more efficient use of parking spaces.

A smaller group includes waste management sensors. Waste-level sensors can be used to accurately determine the fullness of waste bins, thus optimising the logistics of waste collection and costs.

The next group consists of infrastructure monitoring devices that can play a key role in a smart city. Fire detectors and water leakage detectors should be highlighted here. Both applications can be critical for operations and users.

The last group is for smart lighting and emergency lighting control devices. The list includes several examples of both. These lighting control devices mostly interact with other sensors.

These categories illustrate the versatility of LoRaWAN products and how they align with the concept of an efficient and sustainable urban environment, the smart city. Each category contributes to a better functioning of a city, an efficient resource use, and improved quality of life for its residents.

PROPERTY PROTECTION ASPECTS OF CERTIFIED LORAWAN DEVICES

The devices listed in the table include several items that can be used directly or indirectly for property protection. As in the previous section, 338 devices have been examined from an asset protection perspective. These can be grouped into the following main categories [23, 24].

The list includes several certified LoRaWAN devices suitable for motion or presence detection. In addition to the classic passive infrared (PIR) sensors, more extreme solutions stand out because of their sensor combination or shape and application. All these devices can form part of a complex property protection system.

Classic intrusion detection opening sensors are also included. They can trigger an alarm event when a door or window unexpectedly opens. Opening sensors can also be used for monitoring and automation tasks as part of a smart building concept. The list also includes a device that the manufacturer claims can trigger an alarm before a break-in occurs.

Tracking devices can help us monitor our vehicles, valuables, or even people. In case of unauthorised theft, the location of objects can be tracked. For people, it is possible to track their movements and manage their access rights.

The certified devices include solutions for protecting persons: panic buttons and fall detectors. These devices allow early detection of threats and timely intervention, and they are indirectly linked to asset protection.

Leakage and fire detectors can detect problems at an early stage, and prevent significant property damage or loss of life.

The last category is for security interfaces, tools that help integration. These interfaces connect different security devices.

Individually or in combination, these devices can play a crucial role in creating a comprehensive, integrated property protection system that effectively protects the assets, inhabitants and infrastructure of the urban environment.

CONCLUSION

LoRaWAN technology is currently playing an essential role in the LPWAN market, in both of the studied areas: smart cities and property protection. Although NB-IoT has taken over the market leadership in recent years, LoRaWAN technology still has a significant share worldwide and has remained dominant in the market, except in China. The advantages of LoRaWAN, such as low power consumption, long range, and robust communications, make the technology particularly suitable for large-scale, low data-demand smart city applications.

The analysis has shown that the number of LoRaWAN-certified devices has increased significantly in recent years, especially in sensor units and metering interface units, which are crucial to the efficient operation of urban infrastructure and for increasing security. The trends show that LoRaWAN remains a stable choice for developers and operators, especially regarding energy efficiency, reliability, and wide applicability.

In the future, the evolution of LoRaWAN technology will be closely linked to the development of specifications and devices. The continued emergence of newer specification-compliant devices will help expand the technology's scope, while the obsolescence of old specification-certified devices is a warning that continued innovation is essential. The research results suggest that LoRaWAN technology will remain a relevant and viable solution in the long term, both for the smart city applications and for the property protection systems under investigation.

Of course, in addition to the 404 LoRa Alliance LoRaWAN-certified devices under study, many other products are available on the market that are either not certified or not listed on the website for some reason. In the future, the research could be extended to products not on the list, but the trends and proportions can be seen from the aspects examined. More than four years have passed between the current and previous research. The research is proposed to be repeated with a few years' intervals.

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