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LoRa and IoT tools usage possibility in the agricultural sectors

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A B S T R A C T

In this paper, I present a LoRa spread spectrum networking device that provides significant efficiency improvements over previously used techniques through digital techniques. Subsequently, the LoRaWAN network is presented, which can communicate with the network server available on the Internet through gateways. Their data rate and transmission power can be optimised depending on the distance from the base stations and the time required for communication can be measured in tens of seconds.
In the second major part of the article, Internet of Things devices that also communicate with each other using the LoRa network will be presented. It allows smart devices used in our everyday life to communicate, which are supported by sensors and transmitters to record states and perform actions.
IoT devices are also becoming increasingly common in agriculture. Farmers who are already using the technology can better monitor their livestock and crops. IoT can also be used effectively in many areas of agriculture, including dairy, vegetable, fruit and greenhouse operations.

1. Introduction

LoRa is an acronym for Long Range, a new radio modulation technique. LoRa modulation uses spread spectrum frequency modulated radio waves, which, using digital techniques, results in a significant improvement in efficiency compared to previously used techniques (Jejdling, 1998).

I would like to highlight six important features:

- The battery-powered devices can operate for more than 10 years.
- They can cover a large area with relatively few base stations.
- It can transmit data from a few hundred bits/s to a few kbit/s (292-10 937 bits/s).
- Communication modules are available for €5 or less.
- It can contain thousands of terminals per base station.
- There are lax response expectations.

For example, a LoRa radio using 25 mW transmit power on the 868 MHz ISM band, which can be used in Europe without a radio licence, will give a range of 15-20 km. LoRa radios using only one-fortieth of 1 W transmit power can achieve the same range as conventional radios using FSK modulation with 20 W transmit power (Károly, 2019). This means, in other words, that compared to conventional battery-powered radios that can operate for only a few days or a few weeks, LoRa applications can achieve similar distances with an operational lifetime of up to 10 years due to their significantly lower power requirements (IEEE, 2002. IEE WLAN, 2022).

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Some features of Lora:

- 148 dB transmit power capability,
- 148 dB signal-to-noise ratio,
- flexible parameterisation,
- error-correcting coding,
- high immunity to interference,

simultaneous reception and decoding of multiple signals (Semtech, 2022).

2. Components of LoRaWAN network applications

The low-power, long-range LoRa radio modulation for IoT applications and the LoRaWAN network standard based on it were described in the previous section. As I wrote about in the previous chapter, ChipCAD Ltd. set up a LoRaWAN network in Budapest in December 2015, and on 3 February 2016, in addition to the base stations installed at university sites, making it available to developers of domestic IoT applications. At that time, the network was already available in large parts of the capital. In March, in cooperation with the University of Debrecen, a base station installed on the roof of a ten-storey dormitory building brought Debrecen and its surrounding municipalities into the LoRa network. In recent years, many people have taken advantage of this opportunity to try out new technology and develop many products with their help (Farell, 2022).

In a LoRaWAN network (Holman & Márkus, 2019), terminal equipment uses gateways to communicate with a network server on the Internet. The terminals use unique encryption with LoRa-modulated radios and can communicate bidirectionally with the network server. The messages are short, a few bytes or a maximum of a few tens of bytes, and their data rate and transmission power can be optimised depending on the distance from the base stations. The time required for communication is a few tenths of a second or a few seconds at most. Simplex radios in the terminal equipment can transmit or receive data on a single frequency at a time, while data concentrators in gateways use high-capacity radios that can maintain a two-way link on multiple channels with terminal equipment using multiple LoRa modulations, up to nearly fifty simultaneously.

The radio transmission of terminal equipment and base stations in Europe is subject to the ETSI (European Telecommunications Standards Institute) and in Hungary to the NMHH (National Media and Infocommunications Authority) regulations for the use of ISM (Industrial, Scientific and Medical) bands. LoRa radios operating in the 868 MHz ISM band are not subject to specific authorisation, but they must of course comply with the relevant regulatory requirements. The harmonised regulation allows a maximum transmitter power of 25 mW for both terminal and gateway radios. In some parts of the band, the transmission loading factor is 0.1%, in others, it may be 1%. This limitation means that a 1-second message transmitted on a given frequency must be followed by a pause of 999 or 99 seconds. For a one-tenth of a second message packet, 99.9 and 9.9 seconds of transmission pauses are mandatory. This regulatory requirement is extremely important as it can ensure that none of the equipment installed in a fixed location can dominate the band.

The available channels are of course determined by the radio of the data concentrator in the gateways, which is the reference point when designing terminal equipment. For a typical gateway in Europe, this is currently 8 channels, for the newer generation of gateways it is 16 channels. The terminal equipment can of course transmit on any of these channels during network communication, but the base stations are still able to receive and even transmit to the network server. This LoRaWAN feature is exploited by the terminal equipment by randomly alternating the channels of consecutive messages. If each message interferes with the other at a given moment, the probability of a new packet collision occurring is negligible for the repeated message. Unfortunately, the LoRaWAN network protocol (Holman et al., 2019) does not guarantee that all messages will reach the network server, but it does guarantee that the most important types of messages will reach their destination. It is therefore advisable to design the applications in such a way that the recommended density of 5 000 terminals per square kilometre per gateway is not exceeded and that the message content is such that network communication remains reliable despite packet loss through repetition of redundant message content. Despite what may, at first sight, seem significant limitations, LoRaWAN (Márkus, & Jeszenszky, 2022) is the perfect solution for a very wide range of IoT applications (Márkus & Holman, 2017). It is very important to note that this is not about the online transmission of moving images or audio content but can be used for smart metering, smart cities and homes, building automation or even large-area networking for agricultural and industrial applications.

A LoRaWAN application consists of five parts (Holman, 2018):

1. IoT end devices.
2. gateways between the LoRa and IP space (so-called base stations).
3. Network server
4. application server
5. Applications

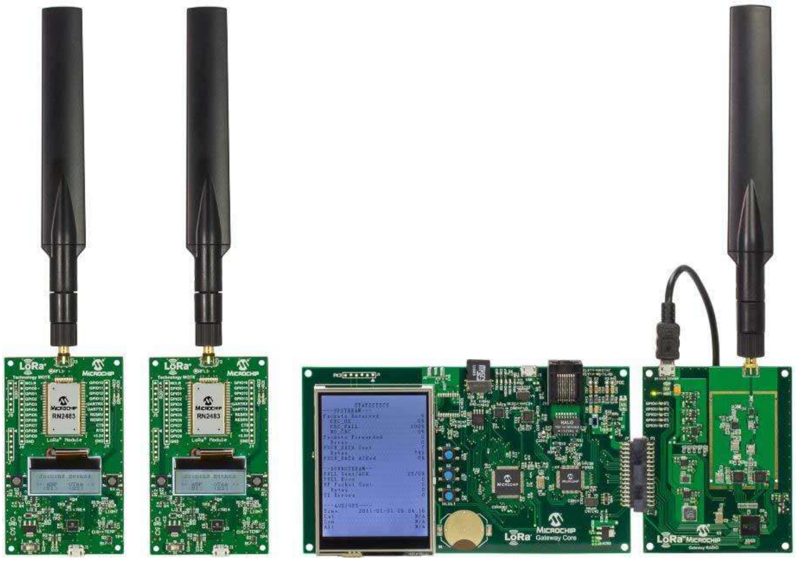

Figure 1: Parts of a typical LoraWan application

2.1. Internet of Things (IoT) and its potential uses with LoRa

Most companies have been involved with IoT from the beginning (Zigbee Alliance, 2022), or have connected different devices across the network. They have installed and operated camera systems, surveillance, remote monitoring and data collection systems. In effect, they were working with IoT systems, but of course, in the early days, the term was not used at all. The dynamic development of radio networks started at the same time, and the momentum behind the receptivity to new smart solutions led to the operation of LoRa networks and the wide range of applications that the Internet of Things could offer to meet emerging needs. In simple terms, data collected through LoRa-based communication services can be made available by companies to their users through their networks. Several pilot projects have been launched to develop this technology and to identify and detect problems in its use. The main aim of these projects was to enable the efficient modelling, in real conditions and with low financial input, of the work planned and to be carried out in the future.

2.2. Internet of Things report

The Internet of Things is an application area where intelligent objects and things are present and communicate with each other. IoT also refers to the interconnection of physical devices in an Internet-like network structure. This network connects things, and devices. It allows smart devices (such as household appliances, meters, cash registers, and cars) used in everyday life to communicate. Sensors and transmitters help to record these states and to carry out operations and options.

IoT devices can be used to extract data that would have been a more costly solution or not possible at all with other devices. Several results can be improved by using IoT tools, which are already being used by small and large farmers abroad.

Let's then look at some practical examples of where we can see these tools being used.

3. Possibility of agricultural usages of IoT and LoRa network

The IoT has a huge impact on agriculture, among others. Farmers who already use the technology will be able to better monitor their animals and crops. The IoT is also effective in carrying out tasks in smaller units such as dairy, vegetable, fruit and greenhouse farms, as has been proven by previous experiments. More and more farmers are working with IoT technology, which is not surprising as they have seen positive improvements.

Let's look at some examples of applications in agriculture.

- **Temperature control**

Greenhouses, it is mainly used to measure and control humidity and temperature. In addition, they are also used in many cases for data collection, as they can provide interesting information through various analyses (Lóderer & Rácz, 2011).

- **Irrigation control**

The primary objective of irrigation control is to determine the optimum amount of water. This is important because it ensures that the optimum amount of water reaches the roots of the plants. By monitoring only, the amount of water needed to reach the plants, it is possible to save water, which is becoming an increasingly important issue today (Lóderer & Rácz, 2011).

- **Weather Monitoring**

Sensors can be used to monitor the weather elements in the vicinity of the plants (e.g. rain, humidity, wind, soil and air temperature), so that the plant can be given the best possible effect and the optimum values of these elements can be adjusted (Kirovné Rácz, 2018; Rácz, 2010).

- **Beekeeping**

In beekeeping, there are also several applications (weighing transmitter panel, hive monitoring, hive tracking, smart camera management, etc.). The IoT sensor enables hive measurement without SIM cards and bee tracking. Measurement results can be tracked either by email or online. The online graph shows the weight, temperature and even the battery level used. In the event of weight loss (theft or swarming), the system sends an alarm to the beekeeper, who can intervene in time.

- **Smart greenhouses**

Greenhouses are designed for efficient, fast and versatile fruit and vegetable production, but maintaining them requires a lot of energy. One way to save electricity is to build smart greenhouses. Equipped with IoT technology, smart greenhouses can be remotely controlled, making the interior more adaptable to the environment. This in turn eliminates the need for constant manual control and data processing, which can lead to even more savings.

- **Cattle breeding**

Continuous monitoring of animal movements, health and feed intake. In addition to the above, their internal body temperature can be measured, from which information on their reproductive status can be extracted. A data storage system can record the data received into a database and use it to model the animal's movements. The use of intelligent algorithms gives different patterns and from these patterns, it is relatively easy to identify whether the cattle's movements are irregular or regular. If one or more animals are not moving with the herd, we can deduce, for example, that disease or injury may be the cause. This solution can be easily implemented using IoT trackers, which of course communicate with each other over an IoT network. And of course, communication requires some kind of network, which is what the LoRa network and its services offer.

- **Precision farming**

Precision farming is one of the most innovative and still evolving parts of IoT in agriculture. With precision farming, it is much easier to control farming (Hisham et al., 2018).

It may go some way to explaining why this technology has been able to become so widespread over the last decade or two. Nowadays, there is hardly a single field with homogeneous properties to the extent that the same productivity is achieved everywhere. The variation in soil properties within a field, therefore, requires differentiated management. With site-specific information, the amount of fertiliser, seed and pesticides to be applied to the different production zones can be planned in the office. Statistically validated remote sensing data can be used to infer fertility and nutrient requirements. With this information, the machinery can be precisely controlled within the field, saving material and money, and at the same time protecting the environment.

Irrigation sensors measure water levels and automate irrigation. The sensors monitor the water level and automatically turn off the valves responsible for preventing excessive watering of plants. They also play a very important role in frost detection and, of course, prevention.

- **Agricultural Vehicle Fleet**

Tracking has been used to measure the efficiency and movement of agricultural vehicles during the summer agricultural work period. Instead of using a mobile card, the devices, manufactured by Zane System (Belső et al., 2022), operate on a LoRa network, making it a more cost-effective solution. With an integrated device, the current location of the tractors can be monitored online, and the current speed and direction of travel can be monitored using the system. The trail can be queried at any time via a map interface. It is also a useful tool for monitoring working time and checking that it is being used efficiently. It can also be used for precision agriculture measurements (Rácz, 2011).

Of course, IoT tools are not only used in agriculture but also, as mentioned in the introduction, in cities, as everyone has heard about the smart cities projects, in which Debrecen, among others, has participated or is currently participating. In these projects, we will mention some of the applications, such as smart parking, traffic counting, lighting, building monitoring, waste management, air quality monitoring, etc.

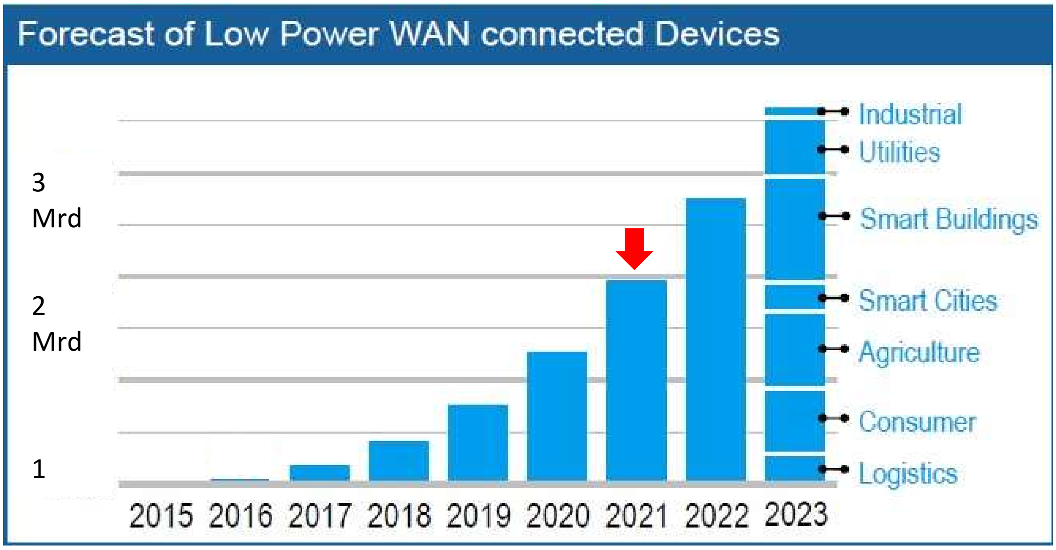

Figure 2: Exploding number of connected devices

As the figure shows, there is an explosion in the number of connected devices in several areas. On the vertical axis, the data is in billions of pieces and currently shows trend changes between 2015-2023. The figure shows that the biggest interconnections are in smart cities and smart buildings in 2023, but agriculture is not far behind.

Summary

LoRa modulation uses spread spectrum frequency modulated radio waves, which, with the help of digital techniques, offers significant efficiency improvements compared to the techniques used so far. In a LoRaWAN network, terminal equipment communicates with a network server on the Internet using gateways. The messages are short, a few bytes or a few tens of bytes at most, and their data rate and transmission power can be optimised depending on the distance from the base stations. The time required for communication is a few tenths of a second or a few seconds at most.

In the Internet of Things applications, intelligent objects and things are present and communicate with each other. IoT also refers to the interconnection of devices in an Internet-like network structure. It allows smart devices (e.g. household appliances, meters, cash registers, cars) used in everyday life to communicate. Sensors and transmitters help to record these states and to perform operations or to collect data.

The IoT is also having a huge impact on agriculture. Farmers who are already using the technology will be able to better monitor their livestock and crops. The IoT is also effective in performing tasks in smaller units such as dairy, vegetable, fruit and greenhouse farms, as has been proven by previous trials, and as a result, more and more farmers are using IoT technology.

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