Additional wireless communication technologies that are used in LoRaWAN products and their importance in the field of personal and property protection

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Abstract: The LoRaWAN wireless communication technology has several advantages: a wide range, significant interference immunity, and low power consumption. There are many possible uses for the technology. In addition to LoRaWAN communication, other communications are used in LoRaWAN products. These communications can play a complementary role, but they can also have the same or a higher priority. Roles and priorities depend on the specific technology or application area. In addition to the LoRaWAN communication, WiFi, Bluetooth Low Energy, or some LPWAN (Low-Power Wide-Area Network) technology is usually used. The paper deals with the description of wireless communications used in LoRaWAN products. IoT, and thus LoRaWAN solutions, are now for our convenience and have become necessary. As a result, the solutions are also part of the protection of people and property. The goal is to see how they relate to the devices' use. Among the investigative aspects, the personal and property protection aspect of the topic is of paramount importance. The review covers BLE and WiFi communications and focuses primarily on tracking applications.

Keywords: LoRaWAN, tracking, IoT, personal protection, property protection

1 Introduction

Tracking systems can be found in many cases; they are no longer a novelty. It is usually used to track vehicles, people, animals, and other objects. Most of these systems are based on GPS [1][2]. The disadvantage of this is that it can be used outdoors effectively. Indoors, RFID technology is widely used for tracking tasks [3]. Another disadvantage of classical tracking systems is that they usually use GSM technology to send coordinates. There are many known features of GSM technology that make it not necessarily one of the best choices. Some of the more problematic features include the following:

-coverage problems can occur,
-its use is tied to a service provider and subscription,
-it is easy to shield or interfere with communication.

Fortunately, instead of the classic GPS + GSM solutions, we have several alternative options available to us. These include using some IoT (Internet of Things) technology, including LPWAN (Low Power Wide Area Network) technology [4][2].

The primary purpose of vehicle tracking systems is to reduce the detection time following a theft. Additional functions include the ability to indicate movement and even indicate that a car is leaving the selected area. Some systems offer more complex solutions that signal a door is opening, prevent a car from starting, or trigger alarms. This is a slightly different area; the paper does not address these features. Tracking individuals can have several purposes. One is to determine the state of the elderly, the sick, or the young to supervise their movements. The other purpose is to coordinate entry or monitor presence. In addition to these established uses, new areas and applications have appeared, but more on that later. Animal tracing is used for property protection, research, and monitoring purposes. Items are tracked to reduce theft, and such systems can also help with inventory and warehousing tasks.

From the above, it can be seen that several tracking tasks affect both personal and property protection issues. The overview covers how LoRaWAN technology, BLE, and WiFi relate to tracking. The first half of the article will describe the basic features of LoRaWAN technology, which will be followed by descriptions of WiFi and BLE technologies. Then, examples of applications will be presented. The second half of the article describes personal and property protection aspects, with an emphasis on tracing. There is a conclusion at the end of the review and suggested directions for further research.

2 Technology overview

2.1 LoRaWAN

LoRaWAN network communication is based on LoRa (long-range) radio communication. The basic features are the long distances over which data is transmitted and the low power consumption that results from its unique modulation. This modulation is called Chirp Spread Spectrum modulation (CSS). Communication in Europe typically takes place at 868 MHz, with bandwidths of 250 kHz and 125 kHz being used. Thanks to the ISM band used, it is also possible to set up private networks; no service provider is required. The data transfer rate is relatively not very high; it can be up to 50 kbps. Communication is two-way half-duplex; sending and receiving are also possible, but not simultaneously. [5][6]

In the case of LoRaWAN, the number of messages that can be sent per day is unlimited; the only limit is on transmission time. The transmission time limit is 1% of the time. The length of the payload of the messages that can be sent is not too long; it can be a maximum of 243 bytes. As previously mentioned, the data transmission distance can be up to 5–15 km and in cities up to several km. Positive communication features include the immunity to interference being relatively high and the communication being encrypted (AES128) [5][6]. The so-called adaptive data rate can be set for the devices, which automatically sets the communication to the best parameters. LoRaWAN communication supports the time difference of arrival location [7]. The LoRa Alliance handles specification development and certification [8].

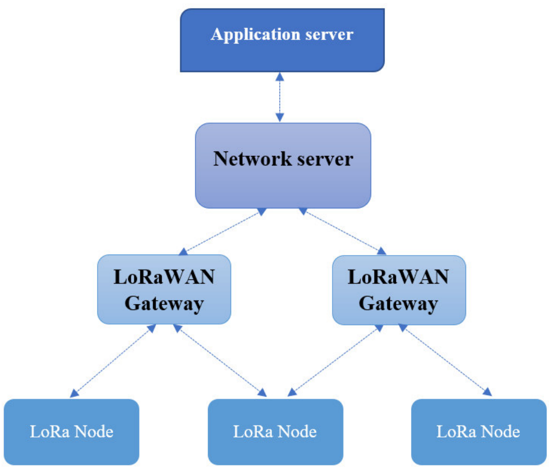

Figure 1

LoRaWAN network

LoRaWAN communication enables creating networks consisting of end-devices, gateways, network servers, and application servers based on the classic structure. The network topology is shown in the Figure 1.

A node can be connected to multiple gateways. The end-devices have three classes: A, B, and C [5]. Class A devices are typically used, but Class C devices are becoming more common. The Class A node has the lowest power consumption and can operate for up to 10 years on a simple button cell. However, the timing of the transmission of Class A devices is also the most limited. With three different profiles, it is easy to find the right one for a particular application.

All in all, it can be said that LoRaWAN technology is used in various applications and systems due to its long-range, low power consumption, high interference immunity, and the possibility of private networking. The application areas are specifically for machine-to-machine (M2M) and IoT solutions.

2.2 WiFi and Bluetooth Low Energy

One of the best known and most widespread wireless technologies is WiFi. The wireless data transmission protocol is based on the IEEE 802.11 standard. I would highlight the 802.11a / b / g / n / ac versions from this standard. The 802.11a standard [9] was issued in 1999 and is typically used for long-distance bridging for point-to-point connections. It uses the 5 GHz frequency band and has a maximum data rate of 54 Mbps. The modulation used is orthogonal frequency division multiplexing (OFDM). The 802.11a has a channel width of 20 MHz. The 802.11b standard [10] was also released in 1999, where communication takes place at 2.4 GHz with a maximum speed of 11 Mbps. According to the standard, the modulation used is direct sequence spread spectrum (DSSS) modulation; the channel width is 22 MHz. Older devices usually support this. The 802.11g standard [11] was released later in 2003. It combines the features of the previous two standards with some modifications. The data rate is up to 54 Mbps at 2.4 GHz, and the modulation used is ODFM and DSSS. The standard is backward compatible with 802.11b. Let us jump in time again; the 802.11n [12] standard was released in late 2009. The standard also allows 2.4 and 5 GHz communication, which is achieved with multiple-input multiple-output antenna (MIMO) technology. Here, the data transfer rate can be as high as 100 Mbps. The 5 GHz 802.11ac standard [13], released in late 2013, has already resulted in much higher data rates, capable of up to several 100 Mbps communications. It has also improved the stability of communication. With the passage of time and the emergence of new standards and increasing the data transfer speed and security, the data transfer distance also increased. Nowadays, perhaps the most common devices use 802.11n. [1]

In the world of IoT, the Bluetooth Low Energy (BLE) technology is becoming more prevalent. BLE came with the Bluetooth 4.0 specification, but it is independent of the Classic Bluetooth [2]. Furthermore, its name denotes that it is characterized by low energy consumption. BLE utilises the 2.4 GHz ISM frequency band, its data transfer rate is around 1 Mbps, and the data transfer distance is around 100 m [14]. It uses 40 physically independent radio channels with 2 MHz bandwidth for communication [2]. Its consumption and communication characteristics are mainly used in sensors or devices where smaller data have to be transmitted over relatively short distances.

3 Multi-Technology Solutions

Multi-technology or hybrid solutions are solutions that use several communication technologies. An example of this is the combined use of LoRaWAN, WiFi, and BLE.

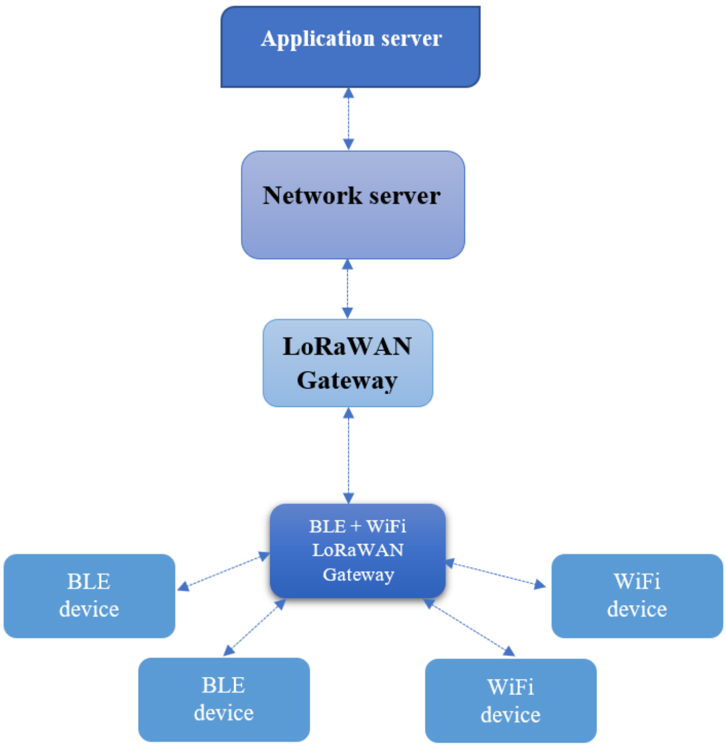

Figure 2

Multi-Technology network

The Figure 2 shows a schematic of a BLE + WiFi + LoRaWAN network. The block of BLE devices indicates BLE beacons, which are small devices that can use BLE to send their IDs and additional small data and sensor data to devices that can receive it. Their use is usually in the field of tracing. They are often made in a wearable design and no larger than a matchbox or a thicker plastic card. In the Figure 2, WiFi device blocks indicate WiFi-enabled devices. These are typically cell phones, tablets, and notebooks. The BLE + WiFi + LoraWAN gateway is a device that can receive data from BLE and WiFi devices and detect their proximity. After detection, the data is transmitted to LoRaWAN gateways via LoRa communication.

In the outlined system, the role of BLE and WiFi is to perform in-building positioning or positioning-related tasks, while the LoRaWAN technology is responsible for transmitting data, allowing remote monitoring.

When it comes to WiFi, the use of two types of location is common. One is supported to read the received signal strength indicator (RSSI) range [1]. The other is a time-based approach. The basis for positioning here is monitoring the arrival of RF signals (TOA) and transmitted signals (TOT) [1]. With these two methods, it is possible to implement positioning using WiFi technology. In addition to these, there are more straightforward solutions for determining stay based on proximity perception. Using BLE is a bit of a newer solution in positioning. Like WiFi, fingerprinting, signal propagation analysis, and proximity sensing are commonly used for location [2][15]. The study background does not include a detailed description of the technological background of these solutions.

4 Personal and property protection aspects

One area of property protection is the topic of patrol control. Widespread patrol control systems operate with barcode, magnetic stripe, and proximity card identification [16]. An excellent alternative to this is the BLE + LoRaWAN solution. The guard wears a BLE beacon on his body or clothing, and his visible presence, movement, and route can be determined by passing near the checkpoints. Transmitters are usually designed to have a so-called panic button, which may be suitable for sending additional signals. Some devices can emit an audible signal or can signal with a vibration. These tools can also be used for vigilance monitoring.

Another area of property protection is the issue of entry. The purpose of entry is to regulate persons, vehicles, and possibly other objects or animals [16]. There can be several approaches to admission. One is to prevent unauthorized persons from entering a particular area. The other is that it is necessary to know how many are in a given building, area, and room. The combined use of BLE and LoRaWAN can also be suitable for this, although a BLE transmitter can be used for identification in the same way as, say, a magnetic card or an RFID card.

It is not precisely the subject of admission, but related to it, residence and monitoring people's flow. In community areas where many people turn up, such as halls, stations, festivals, and malls, it can be essential to know how many people are in each area. This can be used to organize the living force effectively. It is easier to plan if it is possible to estimate how many people will be distributed in which areas at different times of the day. Moreover, it can even be used for immediate response. This does not require special devices, just the WiFi LoRaWAN network and the signal of WiFi-enabled devices in "passersby". In addition to organizing protection, in case of an unexpected event, it is also useful to know the number of people present and their approximate location. In the event of a fire or similar unfortunate incident, the evacuation can be organized.

With the emergence of the current COVID-19 epidemic situation, additional applications for tracking have emerged [17]. These include monitoring distance, contact tracing, proximity detection, signalling, monitoring, and limiting the number of people. The system outlined earlier may also be suitable for these tasks. In places where employees cannot or are not allowed to use a cell phone, BLE may be the solution, and in other cases, WiFi + LoRaWAN applications may be the solution. Of course, the combined application of the three technologies will cover a broader range of applications. Moreover, cleanings scheduled based on the number of visitors can be implemented.

In addition to following people, items cannot be left out of line. Using BLE + LoRaWAN technology, the number and location of products and equipment can be monitored, facilitating inventory. With the help of the BLE beacons applied to the objects, the devices' movement can be monitored, and their design can be indicated. It is also possible to report theft and restrict access. The BLE transmitters placed on the devices are already within reach, but goods are still relatively expensive to equip all objects. Their purchase is around one to three US dollars[2], which is still quite expensive compared to traditional solutions. As a result, it is applied to high-value or vital assets or where it has relevance.

Conclusion

LoRaWAN technology's role was explicitly limited to signalling and data collection in the multi-technology systems and solutions related to the outlined tracing. The location and tracking examples were based on BLE and WiFi technologies. LoRaWAN technology is used in such solutions due to the possibility of private network design, long data transmission distance, and high interference immunity. Building and setting up a network can be relatively quick and straightforward all in such a way that the possibility of further expansion is not a problem either.

The overview described the introduction of tracing and the basic features of the three technologies (LoRaWAN, BLE, WiFi), presented a multi-technology system, and highlighted the personal and property protection aspects. It can be said that the application of the described solutions is especially typical in the field of patrol control, entry control, presence monitoring, and asset management. In addition, due to the current pandemic situation, areas of application related to defence have also emerged.

In the other phase of the research, it is worthwhile to carry out measurements and further studies related to the mentioned technologies by highlighting an application or an area. The study did not address this, but it is possible to do so. The investigation of the location possibilities of the LoRaWAN technology itself could be a further research direction.

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