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A research of the propagation of LoRa signals at 433 and 868 MHz in difficult urban conditions

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Abstract. The article examines the issue of investigating the propagation of LoRa signals at 433 MHz and 868 MHz in difficult urban conditions. A theoretical calculation was made, which showed that the signal propagation distance is about 1.8 km for the module with a frequency of 433 MHz and about 915 m for the 868 MHz frequency. Experimental studies show that the transmission distance of the 868 MHz module is approximately 660 m, module 433 MHz – 730 m. The discrepancy is due to the influence of interference, which is always present in the modern city, as well as with complex and diverse buildings, which is not taken into account in the parameter SOM when calculating the transmission range.

1 Introduction

The direction of the Internet of things in the last decade is one of the promising areas for the development of communication and information technologies. This is due to the increasing information needs of people and the growing complexity of modern information systems [1].

The Internet of things is a network of physical devices, vehicles, structures and other objects with built-in electronics, software, sensors and Internet connection. All this allows you to collect and share data, which in turn excludes from the part of operations and actions human participation in social and economic processes [2].

Thus, the concept of a network of computing devices equipped with built-in technologies for transmitting and receiving data between themselves and with the environment, represents the organization of such networks as a phenomenon capable of transforming social and economic processes, without human intervention [3, 4].

All these technologies, which allow a qualitative increase in the standard of living, are subdivided into methods of transmission and interaction (ZigBee, 6LoWPAN, WirelessHart, LPWAN), power supply methods for devices (solar batteries, windmills, etc.). All this is based on different physical phenomena.

LoRa ™ (Long Range) is a technology and the same modulation method. The LoRa modulation method is patented by Semtech, based on the technique of spreading and the variation of linear frequency modulation, in which the data is encoded by wideband pulses at a frequency that increases or decreases over a certain time interval. This solution, in contrast to the direct spread spectrum technology, makes the receiver stable to frequency deviations from the nominal value and simplifies the requirements for a clock generator, which makes it possible to use inexpensive quartz resonators. LoRa uses direct error correction, operates in the sub-Higahertz frequency range [5–7].

The Lora wireless system uses non-licensed frequencies that are available around the world. The most widely used frequencies are 915 MHz, 868 MHz, 433 MHz. Low power consumption and high stability of communication at a great distance are provided due to high sensitivity of –148 dBm [8].

The aim of the work is an experimental study of the propagation of the LoRa signal in complex urban conditions.

The tasks of the work include:

- develop a software and hardware system that allows data transfer using the LoRa standard;
- conduct research on data transmission at a frequency of 433 Hz and 868 MHz;
- compare the results obtained during the study.

2 Principle of operation

To solve the set tasks, a laboratory complex using the LoRa standard was developed. It should consist of a server device and several client devices. The hardware can be found in the form of ready-made development kits, but they do not fully allow you to study this technology in the form in which you can buy them, so they need to be finalized. As a consequence, there is a need to create your own devices. As a server device is the hardware platform Arduino pro mini - a programmable board based on the microcontroller Atmega328, with a radio module Lora and a screen 0.43 '. The connection to the computer is via the PL2303 chip. The client version of the device must contain a GPS module, in addition to a motherboard based on the Atmega328 microcontroller and the Lora module (Figure 1).

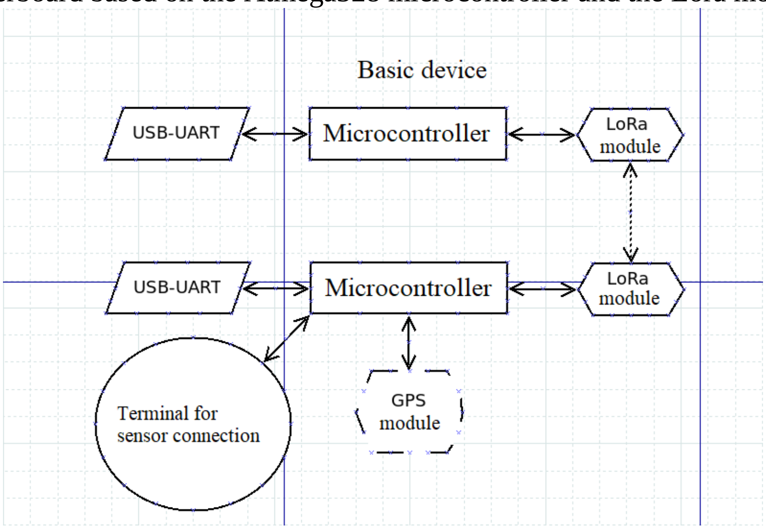


Figure 1. Diagram of system modules.

Figure 2 shows a block diagram of the operation of the device.

The principle of the device is as follows [9]:

• power is supplied and the server and client device is started;

• the client device receives data from the GPS module and transmits them via the radio channel to the server one;

• the server device waits for data from the client device;

• after receiving them, sends coordinates through the serial port to the application running on the computer. The level of the received signal is also calculated;

• the application running on the computer after receiving the data, processes them and draws the corresponding client device on the OpenStreetMap card;

• after receiving the data, the server device reads the values from the control unit, and then it is checked whether the received signal level indicator of the set threshold has exceeded the control unit.

If the threshold is exceeded, an audible alert is made.

The tasks of the main device are:

• indication of the current signal level in dBm;

• transmission of the exact coordinates of the auxiliary device to determine the distance between the devices;

• receiving coordinates in an encrypted form;
• Record the received data on the media. (when connecting to a PC).
The task of the auxiliary device is reduced to:
• Receiving coordinates from GPS module and sensor (optional);
• transmission of received data in encrypted form.
Images of the server and client devices are shown in Figures 3 and 4.

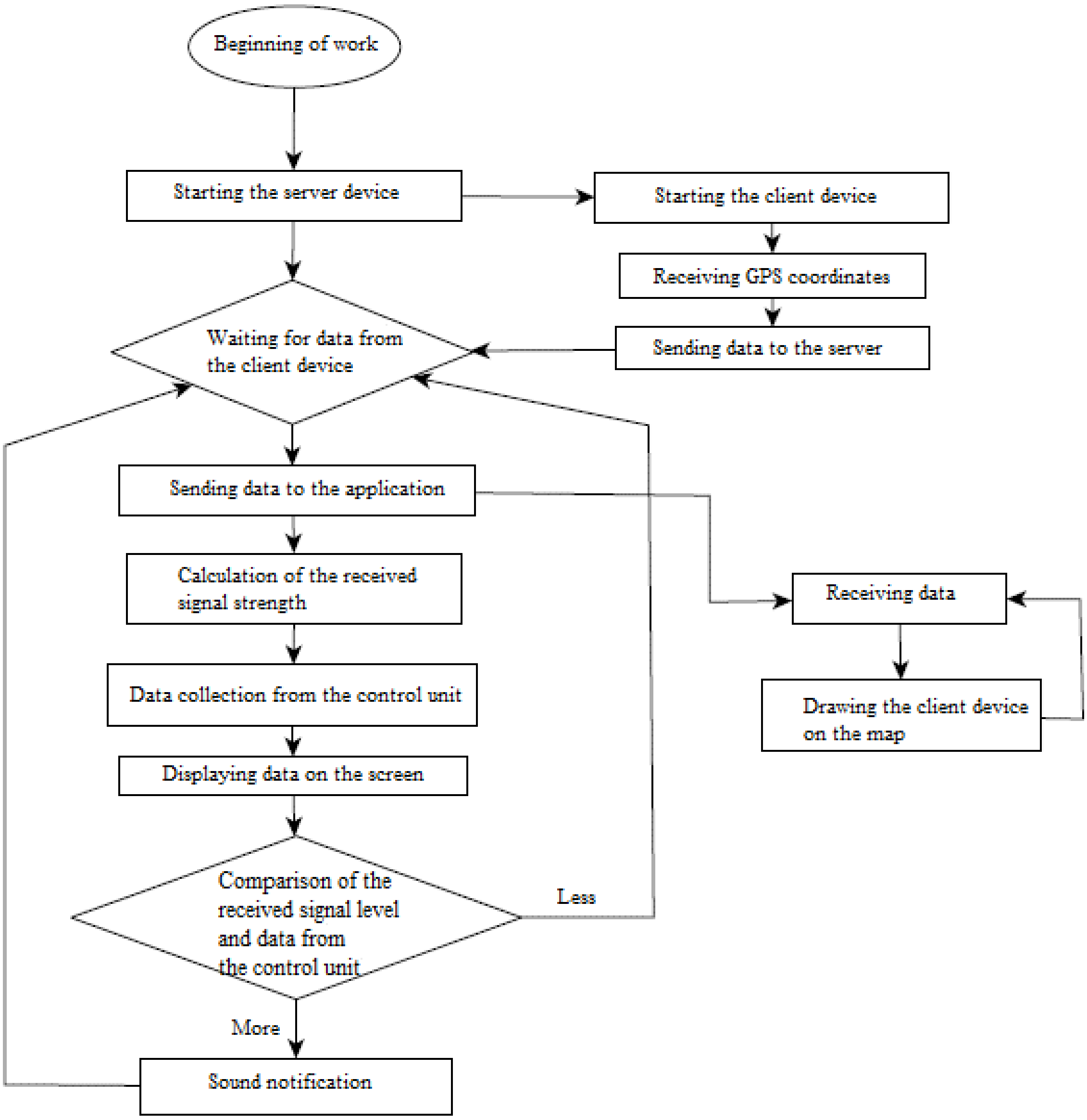


Figure 2. Block diagram of the device operation.

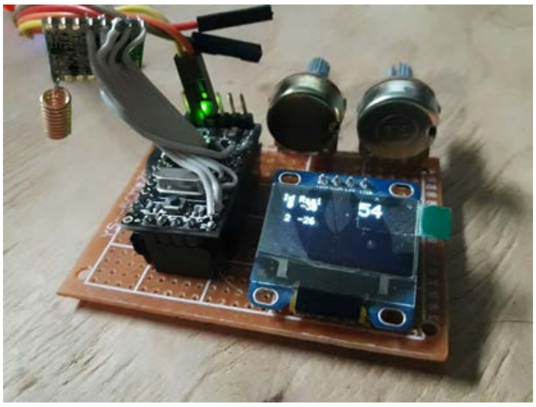


Figure 3. Prototype of the server device.

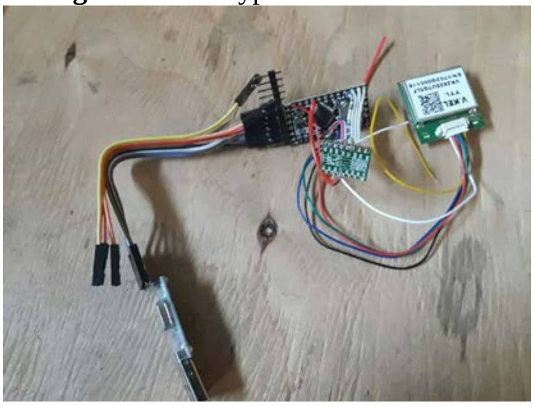


Figure 4. Prototype of the client device.

3 Results of device testing

To study the propagation of the signal, we calculate the transmission range of information. The formula for calculating the transmission range FSL is determined by the total gain of the system. The total gain of the system is considered as follows:

$$Y = P_t + G_t + G_r - P_{min} - L_t - L_r \ ,$$

where Y is the total gain of the system (dB), Pt is the transmit power (dBm), G_t is the transmit antenna gain (dBi), G_r is the receive antenna gain (dBi), P_{min} is the receiver sensitivity at this speed (dBm), L_t - loss of signal in the coaxial cable and connectors of the transmission path (dB), L_r - loss of signal in the coaxial cable and the connectors of the receiving path (dB).

FSL is calculated by the formula:

$$FSL = Y - SOM \ ,$$

where *SOM* (System Operating Margin) - reserve in the energy of radio communication (dB).

The SOM parameter is usually taken equal to 10 dB. It is believed that a 10-decibel margin for amplification is sufficient for engineering calculation.

As a result, we obtain the communication range formula:

$$D = 10^{\left(\frac{FSL}{20} - \frac{33}{20} - lgF\right)},$$

where D is the communication range in meters.

For the study, a LoRa data transmission module based on the RFM96W chip was chosen. The transmitter's declared transmitter power is 20 dBm at 100 mW, the sensitivity is -148 dBm.

The transmission range was calculated for the case with a standard antenna without gain.

By default, the transmitter power is set to 100%. Declared by the manufacturer, the transmission distance in urban conditions is 1–2 km.

When calculating the signal attenuation, it turns out that with a standard antenna FSL = 151 dB.

Then the transmission distance is: for a module with a frequency of 433 MHz - about 1.8 km, and for a frequency of 868 MHz - 915 m [10].

To confirm the calculated data, a full-scale experiment was carried out. The general view of the hardware and software complex is shown in Figure 5.

Figure 5. Schematic diagram of the laboratory complex.

The results of the experiment are shown in Figure 6.

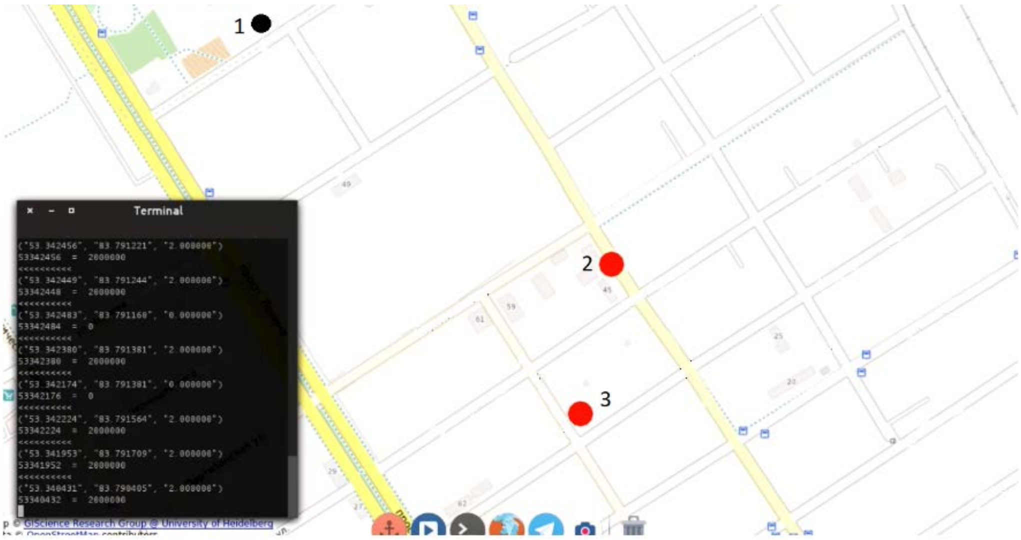
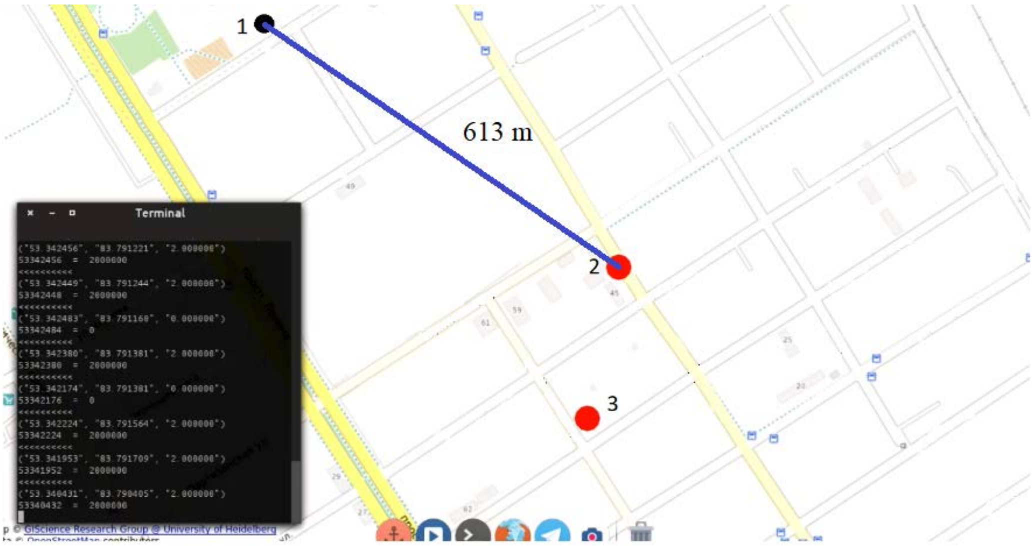


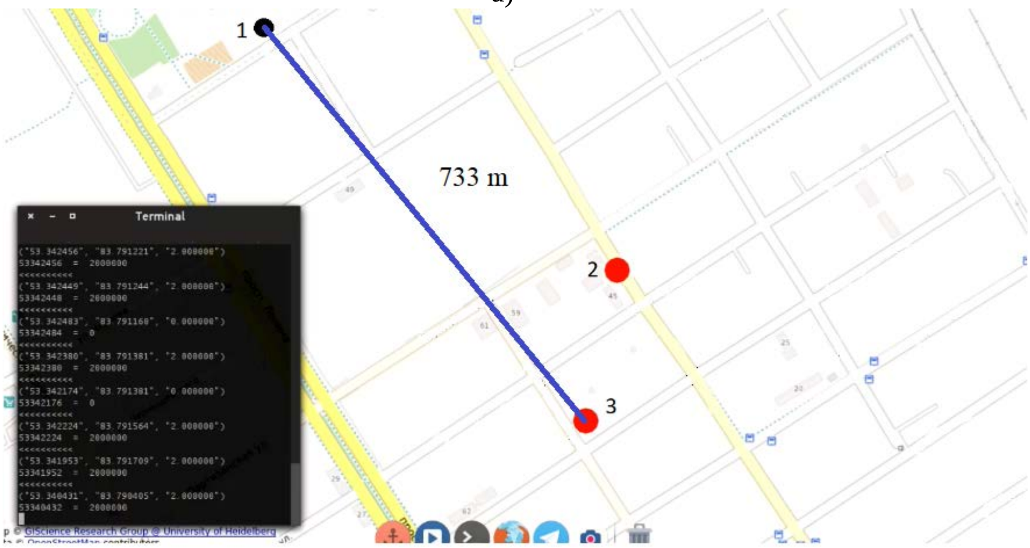
Figure 6. Results of the experiment: 1 – Transmitter, 2 – Receiver 868 MHz, 3 – Receiver 433 MHz.

The transmitter was at a level of 10 meters from the ground. With a further increase in range, the data is unstable, until the signal is completely lost.

The distance traveled is shown in Figure 7.



a)



b)

Figure 7. Distance traveled by receivers: a) the distance traveled by the 868 MHz receiver, b) the distance traveled by the 433 MHz receiver

These figures show that the transmission distance of the 868 MHz module is approximately 660 m, the module 433 MHz – 730 m.

This is because the SOM parameter does not take into account interference from devices operating at 433 and 868 MHz, for example, car alarms, and does not fully take into account the complexity and frequency of urban development.

4 Conclusion

When comparing the calculated values of the transmission range in the LoRa wireless channel at 433 and 868 MHz with the experiment performed, it can be concluded that there is a significant discrepancy between the theoretical calculation and the practically obtained data. This is due to the influence of interference, which is always present in a modern city, and also with a complex and diverse build-up, which is not taken into account in the SOM parameter when calculating the transmission range.

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