Application of Existing Network Methods in Low Power Long Range Wireless Communication

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Abstract *— Acquiring various data from a sensor device or an Internet of Things (IoT) device and transferring it to a server for use in analysis has attracted great attention in recent years. However, at present, the environment is still not ready in terms of communication speed and a huge communication fee with respect to the amount of data. A data transfer technique using long-range communication is expected to be one of the solutions to these issues, but there are various standards related to the communication device, and it is required that development follows those standards. This study uses existing conventional Wi-Fi in the short-distance area and a long range communication device for data transmission to a remote place. In this way, the article proses a method that is effective for data transfer, making use of each other's characteristics. In this research in particular, the character string is transferred to a server installed on a remote place using an ordinary User Datagram Protocol (UDP).*

The evaluation shows that although it is necessary to consider communication speed and the transmission interval, a general conventional programming method can be used. The study confirms that character strings can be transmitted and received using not only sensor devices but also common smartphones and tablets. Therefore, it is considered that the proposed method can be applied in a wide range of fields, including disaster situations.

Keywords — *Low Power Wide Area Network (LPWAN), Sub-GHz wireless network, Low powered sensors, User Datagram Protocol (UDP), Protocols.*

I. INTRODUCTION

The systems that manage a physical condition by uploading data to the cloud using wearable terminals, such as smart watches have attracted great attention in recent years. In addition, research on smart cities that automatically collect information on power and gas usage by means of small sensor devices is currently being conducted. Therefore, with the advent of the IoT era, the technology that aggregates data from various devices is necessary. However, on the other hand, it is expensive to create the required conditions, for example, to sign a new contract for the Long-term evolution (LTE) line [1, 2]. In addition, due to the inconsistent standards of IoT devices [3-7], it is necessary to develop systems that assume various environments.

The present study explores a method that can transmit and receive data without being conscious of a serial communication interface. Specifically, in a series of communications, a Wi-Fi device is used in a short-distance area, and a system using a sub-GHz band is established when transmitting over a long distance. As a result, although the purpose of the use is limited due to low throughput, it is considered that the application can be relatively easily used in the same manner as before.

II. RELATED RESEARCH

Unlike the wavelength used for Wi-Fi, the method using sub-GHz has the following characteristics: it has a strong diffractive property regarding obstacles, it has low-power consumption, and it is suitable for long-distance communication. For this reason, there are growing expectations related to its use in outdoor situations where communication and Wi-Fi access points are difficult to set up during disasters [8]. In addition, with the development of IoT in recent years, collecting data using various sensors has become more widespread. For example, in the field of agriculture, some researchers are experimenting with long-distance communication in greenhouses [9-11]. In addition, research has been conducted to obtain information on power and gas usage by IoT devices with transmit and receive [12-15].

There are numerous communication standards in these fields, which can be classified by transfer rate or frequency band and data [3, 4, 16]. In general, in the sensor used in IoT, from the balance of the transfer amount and the communication speed of the data, even if the transfer speed is relatively slow, attention has been paid to the standard that can be used over long distances (see Fig. 1) [3, 4, 16, 17].

Based on this, there are many devices for long-distance communication using low power.

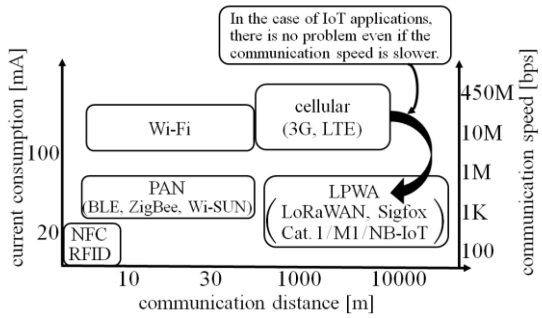


Fig. 1. Relationship between communication speed and power consumption

III. RESEARCH CONTENT

In this paper, communications are performed in a combination of short-range devices mainly by wired LAN, Wi-Fi, and Bluetooth and a server installed on a remote location used by sub-GHz long-range wireless devices (see Fig. 2).

The proposed method is based on using existing applications, the aim of which is to show that long-distance areas can be covered at low cost by using long-range communication methods without using external lines, such as LTE.

This research is realized by bridging the virtual network interface card and long-range communication devices, so that previous applications operate seamlessly.

Regarding the device for performing long-distance communication, it was decided to link to the control PC using serial communication, as presented in Fig. 3. However, since there is an upper limit to the size that can send data at a time, depending on data size, it is necessary to divide the appropriate frame. Therefore, for the data portion, it is required to embed the numerical value (order list) when compounding and return it to the correct frame, as presented in Fig. 4.

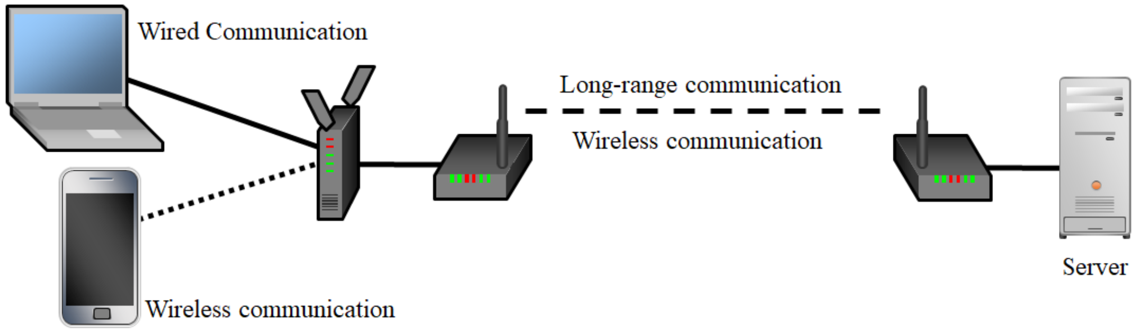


Fig. 2. Extending existing networks using long range communication devices and existing short-range devices

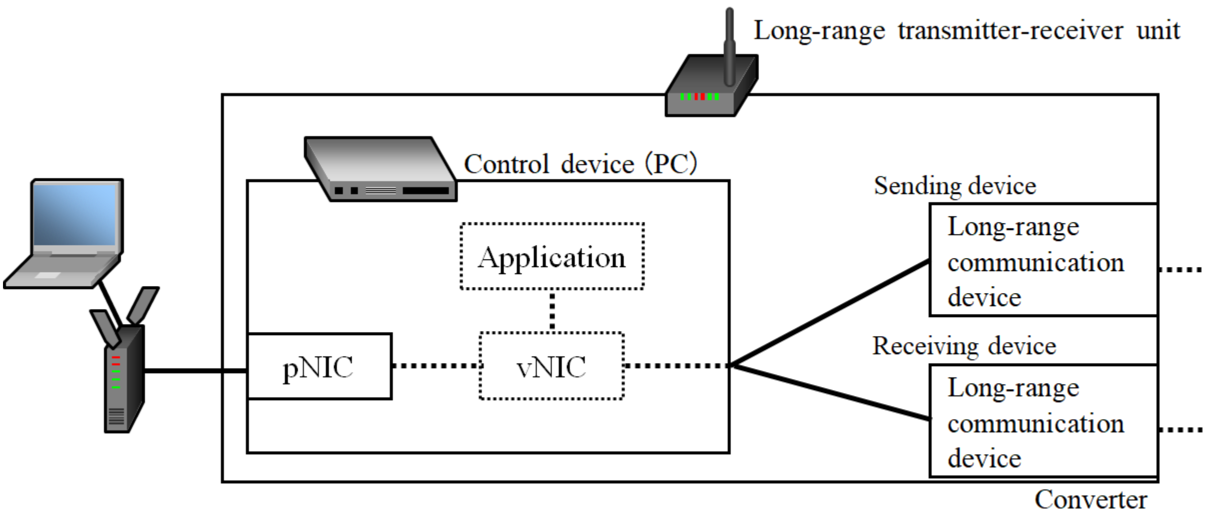


Fig 3. Components required for long range communication

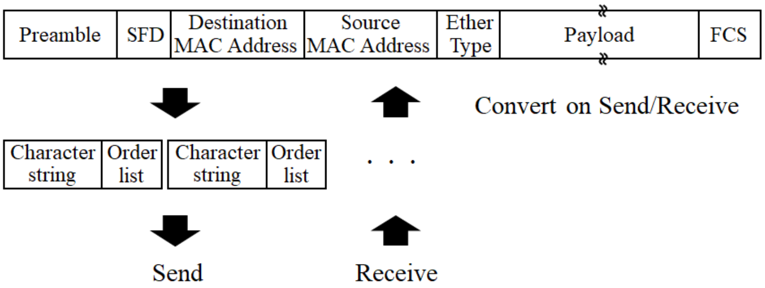


Fig. 4. Split and merge method used for sending and receiving

IV. EXPERIMENTS

In order to demonstrate the effectiveness of the proposed method, two experiments were conducted. IM920 [18] by Intercom (see Picture. 1) was used in the experiment because it can communicate with an IM920 installed at a long distance by serial connect to a PC [11, 19-21] (see Fig. 5). Depending on the communication mode setting, IM920 has a mode with a communication distance of about 7 km and communication speed of 1.25 kbps, as well as a mode with a communication distance of about 400 m and communication speed of 50 kbps (Table 1). This experiment used the long-distance mode (7 km and 1.25 kbps), and it was conducted in a building with a communication distance of 60 m, whereby long-distance communication was performed by using two IM920s (for transmission and reception) and Raspberry Pi 3 as a control PC (see Picture. 2). Table 2 presents the performance of Raspberry Pi 3 Model B.

Picture. 1. Device used in this experiment (IM920)

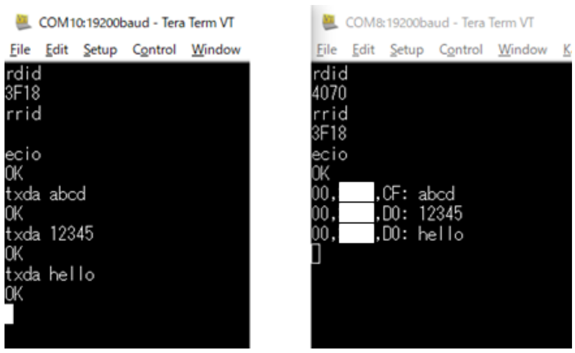
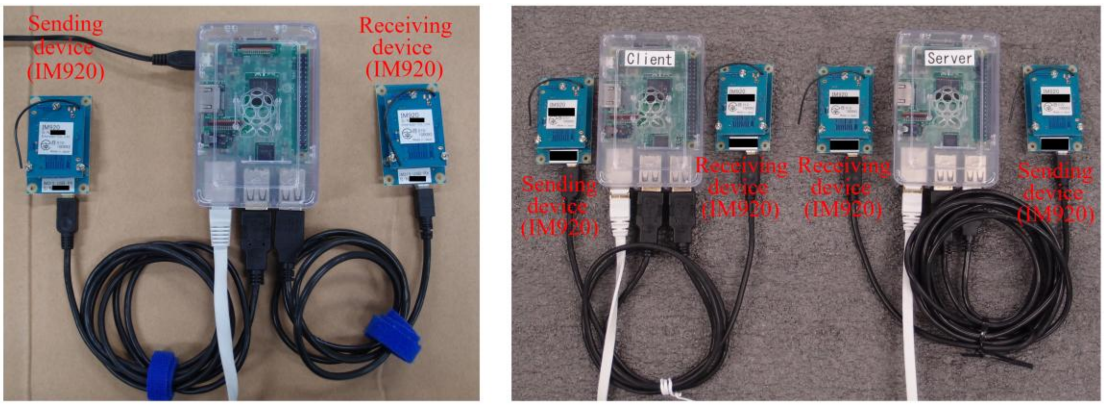


Fig. 5. Example of communication with paired devices



(a) Long-range transmitter-receiver unit (b) Communication with paired devices

Picture 2. Proposed device (long-range transmitter-receiver unit)

For convenience of the device to be used, BASE 64 was used for communication, and transmission and reception was performed as a character string. In addition, the size of character string (BASE64) was 60 bytes, and the size of order list was 4 bytes. We prepared the environment as described in Table 3.

TABLE 1. Main specifications of IM920

	Specification
Frequency	Sub-GHz, 920 MHz (920.6-923.4 MHz, 15 channels)
Receiver sensitivity	About -112dBm (Long-range mode)
Spatial data rate	High-speed mode: 50 kbps, Long-range mode: 1.25 kbps
Voltage	Standard operating voltage: 3.3 V
Line-of-sight distance	High-speed mode: about 400 m, Long-range mode: about 7 km

TABLE 2. Main specifications of Raspberry Pi 3 Model B

	Specification
OS	Cent OS 7 (CentOS-Userland-7-armv7hl)
CPU	Broadcom BCM2837 1.2 GHz ARM Cortex-A53
RAM	1 GB LPDDR2 (900 MHz)
Ethernet	RJ-45 x1:100 BASE-TX 10 BASE-T
Development environment	gcc 4.8.5 armv7hl wiringPi 2.46
Storage	Micro SD card slot
Power supply	+5 V (2.5 A) micro USB socket

TABLE 3. Specifications of the PC

	Specification
OS	Cent OS 7.4-1708
CPU	Intel Core i7-8750H
Compiler	Open JDK (java-1.8.0_161)
Memory	16 GB (DDR4 2400 MHz)
Storage	SSD 240 GB

A. Transferring string data using UDP from a control PC to a remote control PC

The character string data is transmitted from the control PC to a similar control PC installed on a remote place using UDP. For transmission and reception, a network programming was performed using a normal UDP Java program.

After transmitting a character string from the control PC to the remote control PC, the experiment measured the time required for it to return from the remote control PC to the transmission source, as presented in Fig. 6. The length of the string used in the experiment was 10, 20, 30, 50,100, 200, 300, 500, and 1000 strings.

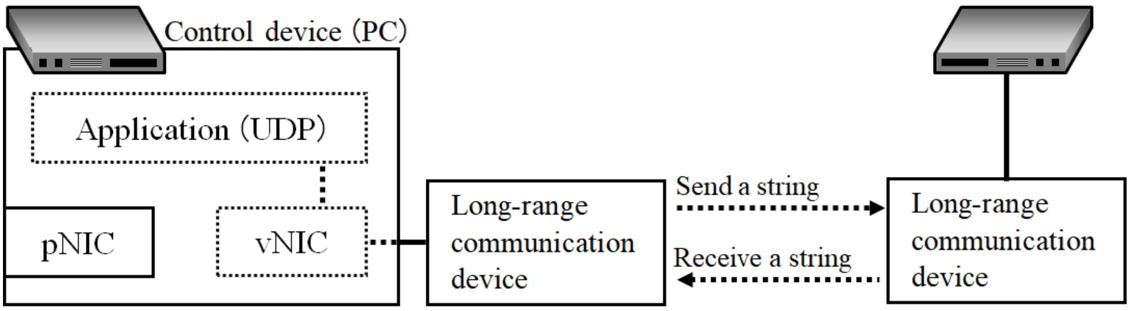


Fig. 6. Measuring the time needed to receive the sent string again (echo Server)

B. Transmitting data using a sensor device

Data is transferred from a sensor device CC2650STK [22] (Picture 3) located in a short-range area to a receiving device OpenBlocks IoT BX0 [23] (Picture 4) by Bluetooth, after which it is transmitted to a server installed on a remote place (Fig. 7).

The items to be obtained and transmitted are presented in Fig. 8. Further, the acquired data was transmitted from the receiving device to the server using UDP as text, as presented in Fig. 9. The interval between data acquisition from the sensor device was 5, 10, 20, and 30 seconds, and transmission was performed every time the data was acquired. In addition, the acquisition time was 10 minutes.

Picture 3. Sensor Device (CC2650STK)

C. Sending character strings to general-purpose devices installed over a long range

In order to show the effectiveness of the proposed method, a character string was transmitted to a general communication terminal installed at a long distance, as presented in Fig. 10. Here, to receive the character string, the data transmitted from the IM920 was converted via the control device, and the reception was performed using Wi-Fi. In this experiment, Apple's iPad, iPod touch, and iPhone were used for reception.

Furthermore, an experiment was conducted using an android device, whereby transmission and reception was performed using Python 3 on a publicly available application QPython 3 [24]. This terminal functions as an echo server, and the string received on the client side is returned as it is, as presented in Fig. 11. The device and software used in this experiment are presented in Table 4.

Picture 4. Sensor data receiver (OpenBlocks IoT BX0)

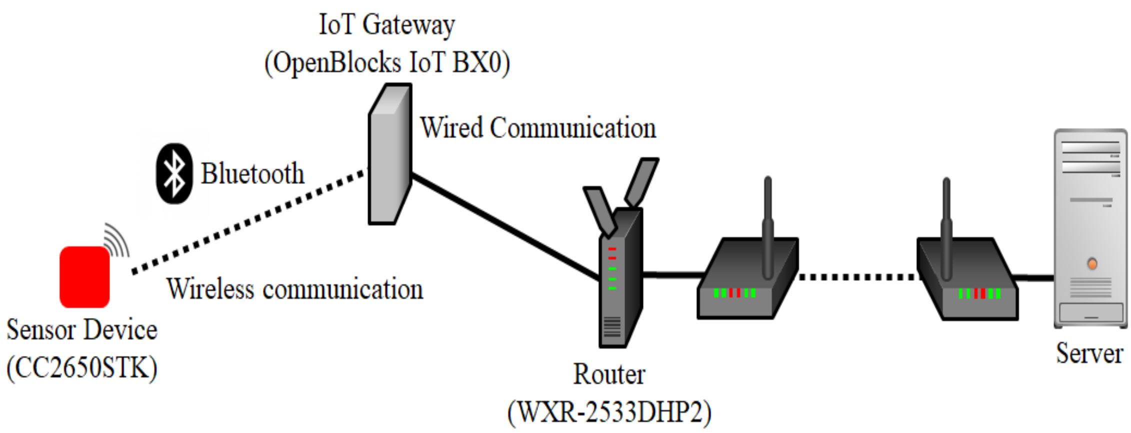


Fig. 7. Transferring sensor device data to remote servers

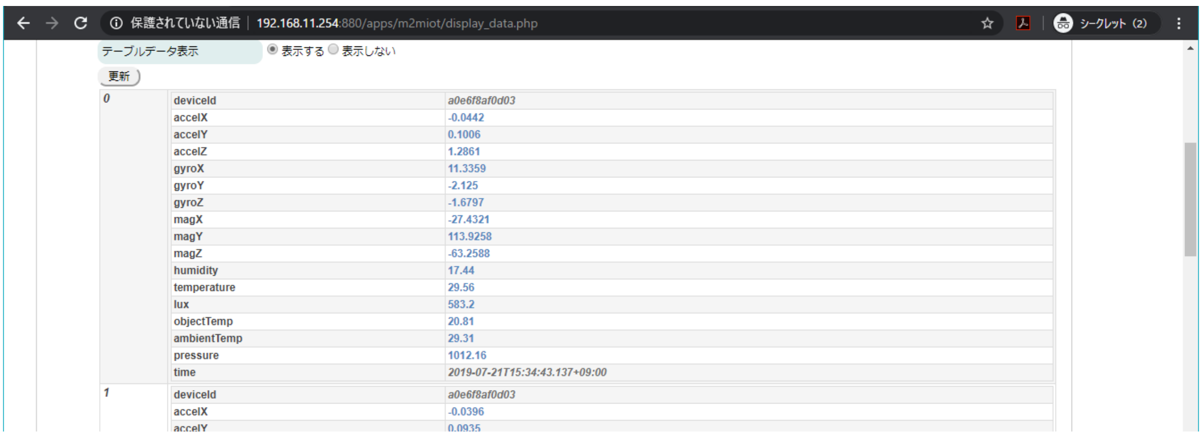


Fig. 8. List of data to be obtained from sensor devices

Fig. 9. Example of a character string sent to the server

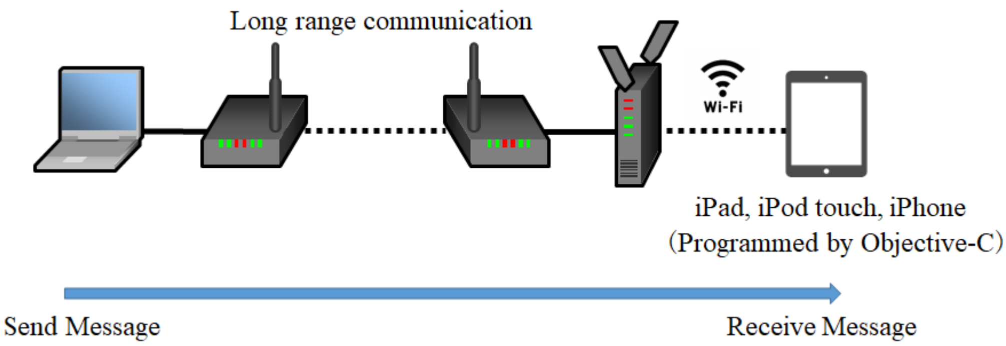


Fig. 10. Sending strings to remote smartphones and tablets

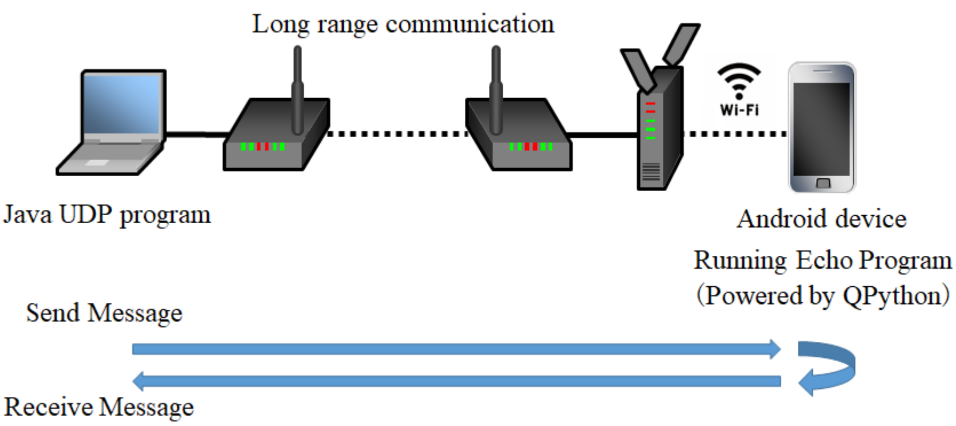


Fig. 11. Transmission/reception test using echo program

TABLE 4. Communication equipment used

	Features and version
Send device (PC)	Cent OS 7.3, Java (Open JDK 8)
Tablet (iPad mini 4)	iOS 10.0.1, Wi-Fi (5 GHz), XCode 9.0
Music Player (iPod touch)	iOS 9.0.1, Wi-Fi (2.4 GHz) , XCode 9.0
Smart Phone (iPhone 5s)	iOS 9.3.1, Wi-Fi (5 GHz) , XCode 9.0
Android device	Version 9 (Pie), Wifi (5 GHz), QPython 3

V. RESULTS

A. *Transferring string data using UDP from a control PC to a remote control PC*

Character strings could be transmitted and received using the UDP application in the control PC, as presented in Fig. 12. There was a large difference in transfer time, depending on the size of the character string to be transmitted. Figure 13 presents the changes in the size of the character string and the time due for transmission and reception. It should be pointed out that no data loss occurred in the environment where the experiment was conducted.

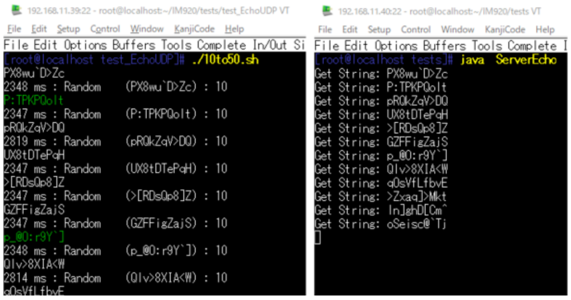


Fig. 12. Communication between the client and the server through the server until the client receives the string again

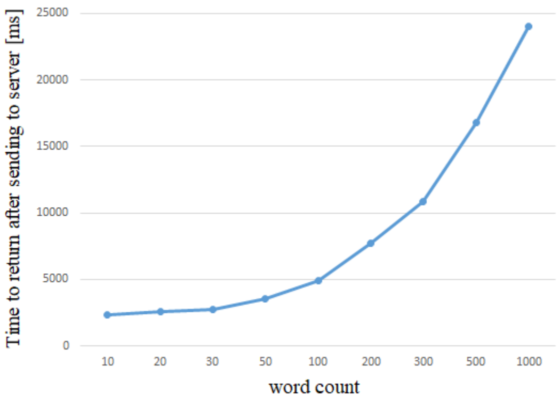


Fig. 13. Measurement results for time by data size (returning to the client through the server)

B. Transmitting data using a sensor device

In the experiment in which data acquired by a sensor was transmitted to a server installed on a remote place, data was sometimes lost, depending on a transmission interval. At intervals of 20s or more, it was possible to send sensor data successfully. However, at intervals of less than 10s, data loss occurred, as presented in Fig. 14.

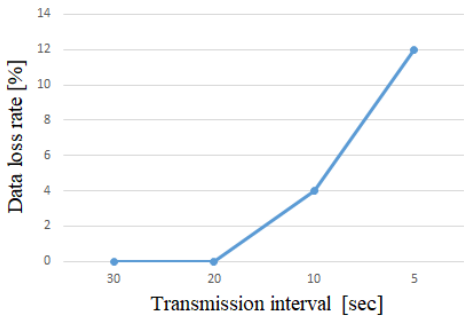
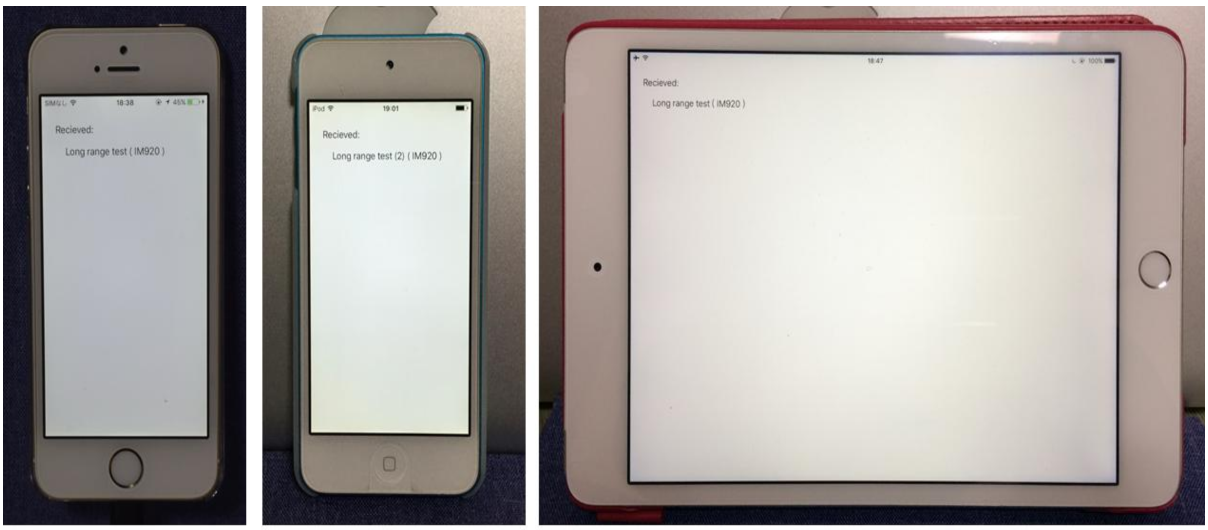


Fig. 14. Data loss due to transmission interval

C. Sending character strings to general-purpose devices installed over a long range

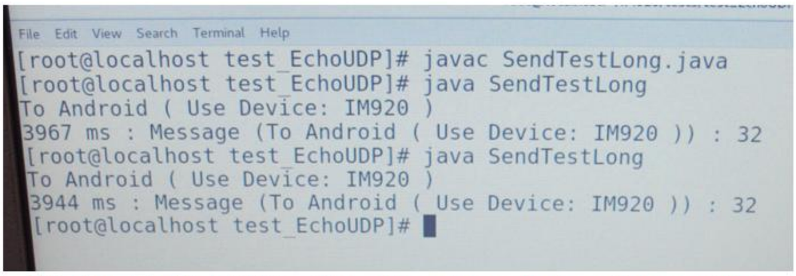
In the experiment of transmitting a character string to a general device, it was confirmed that even a relatively old device can receive a character string using Wi-Fi (see Picture 5). Moreover, the echo program was able to run properly on Python 3, which was running through application QPython 3 on an Android device (see Picture 6).



(a) (b) (c)

(a) iPhone 5s (b) iPod touch 5Gen (c) iPad mini 4

Picture 5. Receiving on a generic device



(a) Client (CentOS) : Receive string again after sending

(b) Server (Android Device) : Send the received string after receiving

Picture 6. Running the echo program

VI. CONCLUSION

This study explored a method that enables relatively easy long-range communication by automatically converting serial communication to general UDP communication. As a result, it was found that although the method is not practical for data of large size or data that is continuously processed in a short time, it is efficient for small data that is obtained by a sensor device and then transmitted and received.

In this experiment, character strings were transmitted and received using a general program coding by UDP for a general device equipped with Wi-Fi. Therefore, since there are many devices equipped with Wi-Fi, the purposed approach is considered to be applicable to a system capable of transmitting a string even in disaster situations.

In the future, it is necessary to improve communication speed by using diverse long-distance communication devices and to study various forms of communication using TCP and the like.

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