Fabrication and application of internet of things device using sigfox network and at commands

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Abstract: *In this study, the Sigfox network and the Internet were employed to develop an Internet of Things device equipped with temperature, humidity, barometric pressure, and other sensors to measure different physical data. In addition, we attempted to control Sigfox communication by employing AT commands using the Arduino UNOR4 Sigfox module, and social implementation of the proposed system.*
Keywords*: SIGFOX, ARDUINO, WIFI, MAC ADDRESS*

1. Introduction

Knowledge and information have not yet been exchanged in the information society (Society 4.0), which has resulted in issues due to a lack of interdisciplinary cooperation. Society 5.0 is expected to connect all people and things through the Internet of Things (IoT), which will enable the sharing of various types of knowledge and information.

Against From this perspective, using the Sigfox network and the Internet, we have developed an IoT device equipped with temperature, humidity, barometric pressure, and other sensors to measure different physical data [1–5].

In the current study, we attempted to control Sigfox communication using AT commands using the Arduino UNOR4 Sigfox module. In addition, we attempted social implementation using the proposed system.

2. Experimental

2-1 Sigfox module

A Sigfox breakout board (SBB) was used as the Sigfox module (Fig. 1).

Fig. 1 SBB 【BRKLSM100A】[6]

Key Features - Compact module 14 × 15 × 2.8 mm. (Typ.) - LoRaTM modulation technology. - Sigfox modulation technology. - Sensitivity down to −136dBm@LoRa (BW = 125 KHz, SF = 12) −124dBm@Sigfox (0.6 Kbps) - UART interface. - Low-Power Long Range Transceiver operating in the sub-1 GHz ISM band - Supply voltage range from 1.8 to 3.6 V. - RF interface optimized to 50 Ω. - Output Power Level up to +15 dBm - STM32WLE5CC

A program must be written to run the Sigfox module (Fig. 1) on a microcontroller, and a library for the microcontroller is generally required. To reduce the program's dependence on the microcontroller, we created the program using AT commands. In the future, we would like to work on creating a microcontroller and dedicated CPU that can run AT commands.

2-2 Arduino UNO R4 Wifi

We selected a highly versatile Arduino microcontroller to run the Sigfox module. In addition, it is necessary to perform Wi-Fi communication to obtain the router's MAC address; thus, we employed an Arduino UNO R4 WiFi device in this study.

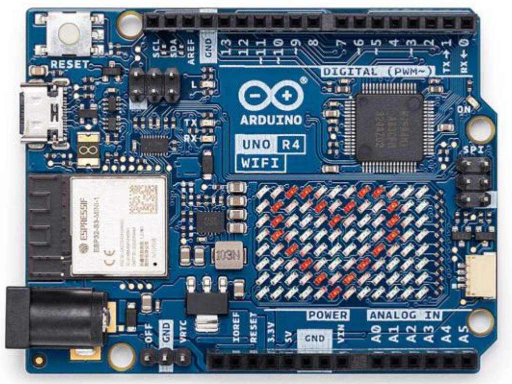


Fig. 2 Arduino UNO R4 WiFi device [7]

The Arduino® UNO R4 WiFi is the first UNO board to feature a 32-bit microcontroller and an ESP32-S3 Wi-Fi® module (ESP32-S3-MINI-1-N8). It features a RA4M1 series microcontroller from Renesas (R7FA4M1AB3CFM#AA0), based on a 48-MHz Arm® Cortex®-M4 microprocessor. The UNO R4 WiFi memory is larger than its predecessors, with 256 kB flash memory, 32 kB SRAM, and 8 kB EEPROM. The RA4M1's operating voltage is fixed at 5 V, whereas the ESP32-S3 module is 3.3 V. Communication between these two MCUs is performed via a logic-level translator (TXB0108DQSR).

Features

The R7FA4M1AB3CFM#AA0, often referred to as RA4M1 in this datasheet, is the main MCU on the UNO R4 WiFi, connected to all pin headers on the board as well as all communication buses.

Overview

48 MHz Arm® Cortex®-M4 microprocessor with a floating point unit (FPU)

5 V operating voltage

Real-time Clock

Memory Protection Unit

Digital-to-analog Converter (DAC)

Memory

256 kB Flash Memory

32 kB SRAM

8 kB Data Memory (EEPROM)

Peripherals

Capacitive Touch Sensing Unit (CTSU)

USB 2.0 Full-Speed Module (USBFS)

14-bit ADC

Up to 12-bit DAC

Operational Amplifier

Power

Operating voltage for RA4M1 is 5 V

Recommended input voltage (VIN) is 6-24 V

Barrel jack connected to VIN pin (6-24 V)

Power via USB-C® at 5 V

Communication

UART (pin D0, D1)

SPI (pin D10-D13, ICSP header)

I2C (pin A4, A5, SDA, SCL)

CAN (pin D4, D5, external transceiver is required)

2-3 Assembling Sigfox module and Arduino

The SBB was placed on a custom manufactured printed circuit board (PCB). Figure 3 shows the IoT device configured by connecting a PCB to an Arduino UNO R4 WiFi device.

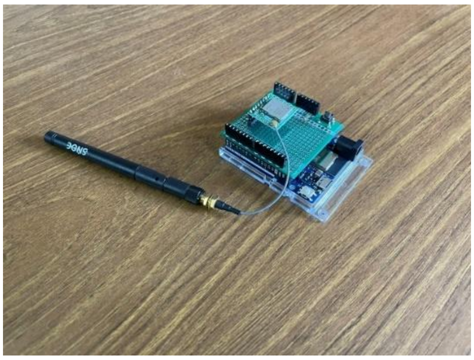


Fig. 3 Sigfox module and Arduino device

2-4 Scketch of Arduino UNO R4 Wifi

Using the IoT device with the Sigfox communication function (Fig. 3), we created a sketch to obtain the MAC address of the Wi-Fi antenna and transfer that value using Sigfox (Fig. 4).

Fig.4 Sketch program using Arduino UNO R4 Wifi

2-5 Sigfox Cloud

Hiroshima Institute of Technology is a Sigfox partner of KYOCERA Communication Systems Co., Ltd., so it can use the Sigfox Cloud[8].

2-5-1 End product certificate and prototype registration[9]

When registering a device in the Sigfox Cloud, an end product certificate must be input. Sigfox compatible commercial devices must obtain device certification, which is referred to as the Sigfox Ready Certification (formerly P2 certification).

Note that the settings for the end product certificate differ depending on whether you are registering a device that has obtained Sigfox Ready Certification or a device that has not been certified.

Fig. 5 Registering a Sigfox device to the Sigfox Cloud

2-5-2 Callback

The advantage of using Sigfox Cloud is that the data obtained from IoT devices can be processed and transferred to the cloud. Here, we show an example where the data obtained from IoT devices are transferred to email via the Sigfox Cloud.

3. Results and Discussion

Communication is performed after setting up the IoT device (Fig. 3) with the Sigfox communication function. The corresponding results are shown in Fig. 6.

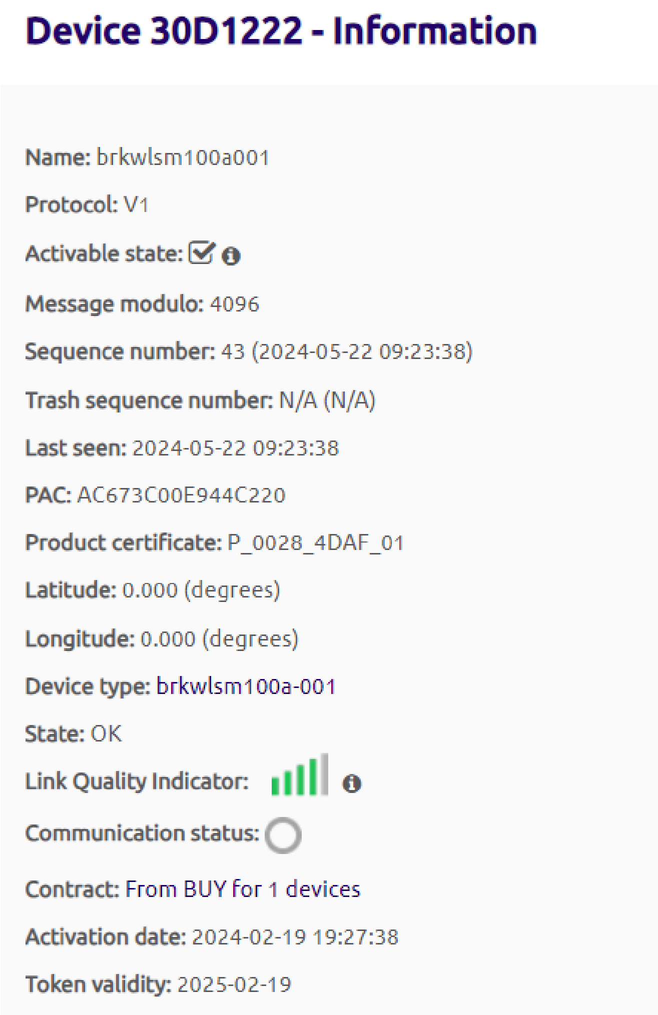
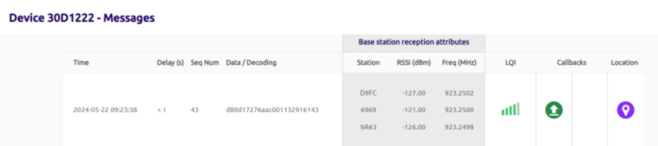


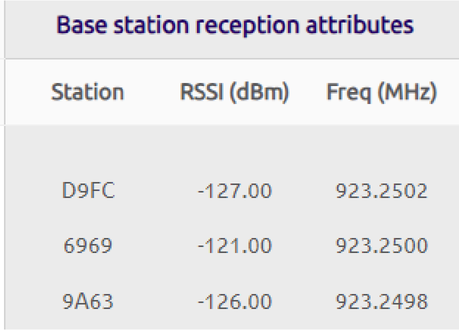
Fig. 6 Information about device 30D1222

Note that the Link Indicator (Fig. 6) was displaying the strength, indicating that it was receiving data from the IoT device. The corresponding data message is shown in Fig. 7.

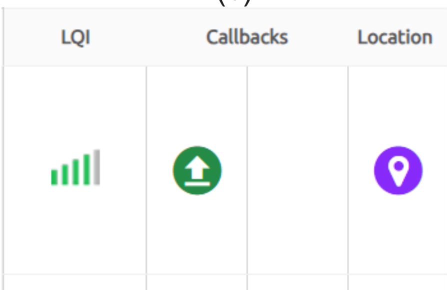


(a)

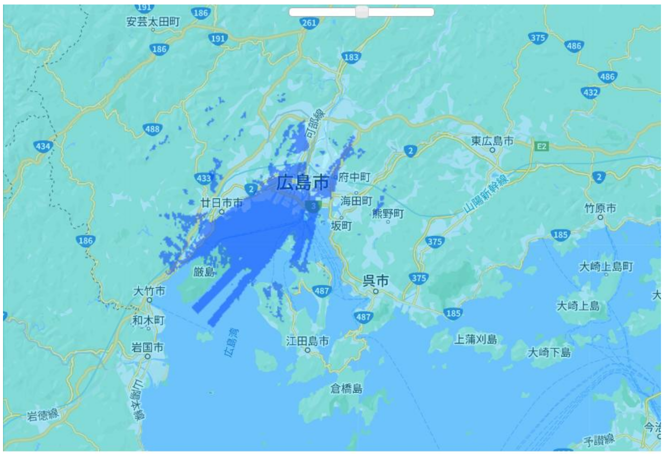
(b)



(c)



(d)



(e)

Fig. 7 Data message from device 30D1222. (a) The entire message. (b) Expanded message time, delay, serial number, and data. (c) Base station number, strength, and frequency when receiving the signal. (d) Link quality indicator, callback, and device location. (e) Device location is highlighted in blue on the map. Its width is approximately 20 km.

Figure 8 shows the arrangement of the router and IoT devices. Figure 10 shows the email that was forwarded using this arrangement using the MAC address obtained by the IoT device employing the callback function in the Sigfox Cloud (Figure 9).

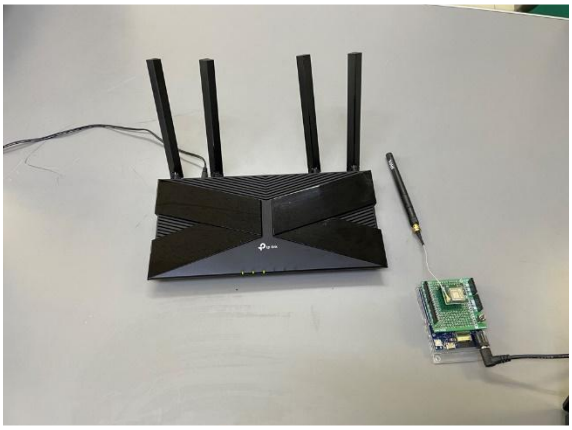


Fig. 8 Callback used to process messages

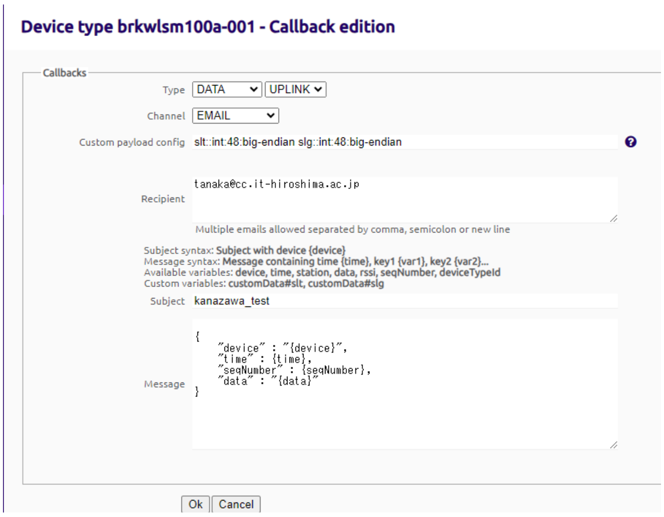


Fig. 9 Callback function to process messages


```
{
  "device" : "30D1222",
  "time" : 1716970277,
  "seqNumber" : 51,
  "data" : "d807b6c70e7b0810868199fc"
}
```


Fig. 10 Email forwarded using Sigfox

Note that the first half of the data (d807b6c70e7b2c1a056815c3), i.e., d807b6c70e7b, is the router's MAC address.

4. Application to society

A router with a known MAC address can be placed at an evacuation center during a disaster, and IoT devices with Sigfox communication functionality can be provided to the evacuees in the area. Then, who is there and when did they get here? Such information is accumulated on the network.

Using such a system, it would be possible to determine who has moved to evacuation centers without human intervention. Thus, it would be possible to obtain useful information about the damage situation, which could be used to support disaster response efforts.

5. Conclusion

Knowledge and information have not yet been exchanged in the information society (Society 4.0), leading to issues due to a lack of interdisciplinary cooperation. Society 5.0 connects all people and things with the IoT to share various types of knowledge and information.

Against this background, using the Sigfox network and the Internet, we developed IoT devices equipped with temperature, humidity, barometric pressure, and other sensors to measure different physical data [1–5].

In this research, we attempted to control Sigfox communication using AT commands using the Sigfox module Arduino UNOR4. We also attempted social implementation using this system.

Acknowledgments

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