

Healthcare Data Transmission by Using NB-IoT

Thitapa Prompinit, Amonwan Jenjirataworn, and Sarinporn Visitsattapongse

Department of Biomedical Engineering, Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang, Bangkok, Thailand

Email: {58010323, 58011421, sarinporn.vi}@kmitl.ac.th

Abstract—This project is to create a medical healthcare data transmission by using NB-IoT. The objective is to reduce step of working and redundant of collecting healthcare data from patients. And to collect data as a system for tracking the treatment of chronic patients who live in outskirts. Narrow Band Internet of Thing (NB-IoT) is used as an intermediary to send data to the database, for making healthcare information that can be used easily in the process of patient treatment and for development of service quality of staff. Processing of healthcare data transmission begin with set up and connect Bluetooth into healthcare instrument and into data transmission device or NB-IoT board for allowing data communicate between them. Then connect NB-IoT to database on server by using functional of Node-Red programming. In this project, the database is designed and tested with one person for bringing data to show in potable graph and to follow data trending on application. The result of the experiment, see that, NB-IoT can sent the data immediately to database, including with display the lasted data and trending on dashboard in real-time. So, the advantage of this project is to reduce step of work in data storage system, easy to access the database and easy to use the data for analyzing.

Index Terms—Narrowband Internet of Thing (NB-IoT), data transmission device, web application, bluetooth, NodeRed, Amazon web service

I. INTRODUCTION

In the present, the problem of personal medical data of the patient still unclear. Some patients have to record the diary data for report the doctor to improve the treatment method and some patients in the suburban area that supervised by health office, who take care about the initial treatment of each patient in the countryside. All the medical collective data that patient and health officer have to record might be disappearing or missing time to collect by human error, and furthermore, data transferring timing also effect to patient treatment. In Thailand, the lost of diary data chronic patient such as hypertension and diabetes patients is significant to design medication of chronic patients.

A wireless communication system is a huge key system of data transfer which can be connecting everything in the whole world to each other. For health management in Thailand, most of the hospitals in the capital city are using the internet and the intranet server to collect the patient data, whereas the countryside areas

are still operating by the paper-based. Some Hi-end hospital uses Tele-medicine for treatment and follows up the symptom of a specific patient who stays in a high signal of the internet. The data of weight, blood glucose, and blood pressure are the main data that effect to continuous treatment.

For this project, the main point is to focus on the collection of chronic patient data that effect to continuous treatment, NB-IoT was selected to use in this experiment. The data of the subject patient from weight meter can send to the specific server at the time by use NB-IoT system. The data in the server can be access on a specific webpage. For next experiment, the modification of the sphygmomanometer, and blood glucose meter were constructed to send the data to the server and the development system for use in the real situation of health officer in the countryside and chronic patient or bedridden patient.

II. MATERIALS

A. Narrowband Internet of Things (NB-IoT)

Narrowband Internet of Things (NB-IoT) [1]-[3] is a new wireless technology that was standardized by 3GPP in 2016. It is a low power wide area network (LPWAN) technology which not operates the license Long-term evolution (LTE). NB-IoT is specifically low cost, indoor coverage, high connection density and long battery life.

NB-IoT and other LPWAN [4] technologies will enable the connection of billions of devices in the internet network, it can be used in machine-to-machine (M2M) rather than in human communications. For the human connection has high throughput and low latency needs, such as conversation, real-time video and music streaming.

Whereas, M2M devices have low data transfer rates and no need high frequency of data sent. NB-IoT system use specific time to send data in two-way transfer.

B. Arduino

Arduino Uno R3 or Arduino Nano, an open source platform software and hardware, was selected as the main part of this research. The board designs use a variety of microprocessors and microcontrollers project. The board contains the different parts and a number of pins, which are used to connect with various components and other circuits. The code for Arduino is generally written in wiring, which is based on the processing C and C++ programming language.

C. Bluetooth

Bluetooth [5] is a type of wireless communication used to transmit data at high speed using radio waves. It is used for short-range radio communications between many different types of devices, including mobile phones, computers, and other electronics. Bluetooth module has a range of around 10 meters and the data transfer rate of 3 Mbps.

HC05 is a Bluetooth module that is used to connect to various smart devices. HC-05 Bluetooth module pair both of medical instrument and data transmission device. The Smart Device be able to communicate with the microcontroller via the Serial port. The HC-05 module can set to be used as a Master mode (allowing other devices to connect) and Slave mode (connected to other devices). Settings such as device names, passwords can be set via the AT Command, which requires special pins to allow the module to enter configuration mode.

D. Load Cell

A load cell is a transducer used to create an electrical signal from the measured force. The load cell is specially shaped metal parts that consist of the strain gauges. The strain gauges are resistors that change their resistance when they are bent. Thus, the resistance of the load cell will depend on how the metal part bent.

E. HX711 Module

HX711 module microchip is specially made for amplifying the signals from load cells and reporting them to a microcontroller.

F. Cloud Server

Cloud is file storage service in NB-IoT system. The advantage of cloud is no data error and no data loss from private setting by user. User can access the data everywhere and every time with electronic device through the internet network. It is created to receive the data from Medical instrument via Bluetooth, and then the data is stored on server (cloud storage) via NB-IoT, that can be displayed on web application.

III. METHODOLOGY

Fig. 1 shows the overview of Healthcare data transmission by using NB-IoT. In this project must have a medical instrument or instrument that is able to use to measure the healthcare data of the patient, which is an important part to retrieve data for use in the experiment.

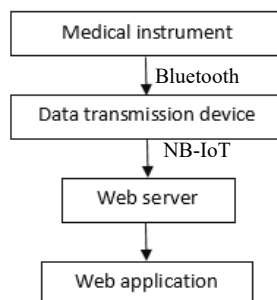


Figure 1. Overview of data transmission system.

For this project, we selected data from weight scales and created a new prototype that be able to retrieve the data by interfacing circuit in Fig. 2. When measuring data from patients, the data is send to the data transmission device (NB-IoT) by Bluetooth communication. Then the data will be sending to the web server for collecting on the database by NB-IoT and can also display on various applications at any time.



Figure 2. Weight scale.

A. Weight Scale Stimulation

Fig. 3 shows a wiring diagram for stimulating weight scale, consist of the 50 kg load cell (x4), which connected to the HX711 sensor module for amplifying the signals from load cells and reporting them to a microcontroller. Some of the load cell wires are connected together to form a Wheatstone bridge. The load cells plug into the Arduino Nano and work as the measurement. Finally, this circuit is connected to the HC-05 Bluetooth module for communicating the data. After connecting the circuit, then proceeding the calibration of this scale and setting the Bluetooth function to be in the master mode.

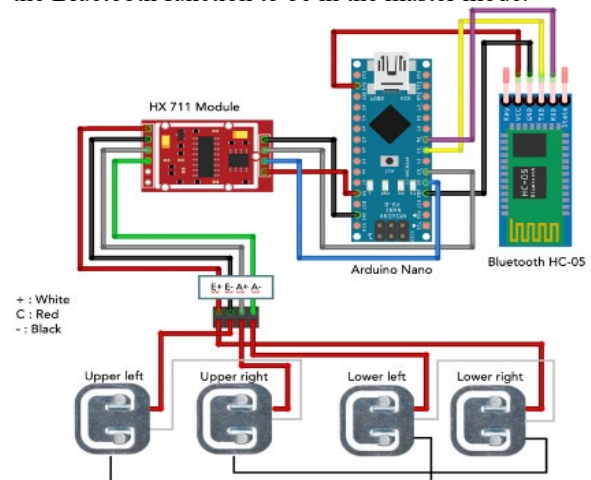


Figure 3. Wiring diagram for connect the Load cells, HX711, Arduino and Bluetooth.

B. Data Transmission Device

Data transmission device consists of NB-IoT shield as show in Fig. 4, connected with Arduino Uno R3 board and Bluetooth module. NB-IoT shield is deigned to connect with Arduino Uno R3 board as show in Fig. 5, it

is connect directly on Arduino port. And connect with Bluetooth HC-05. In this part, the Bluetooth function is set to be in slave mode.

In the part of data communication between weighing scales and data transmission device, Bluetooth function was set in scales to be in a master mode for sending the data from scales to data transmission device and set slave mode Bluetooth in a data transmission device for receiving the data to collected and displayed on the web server.



Figure 4. NB-IoT shield board.

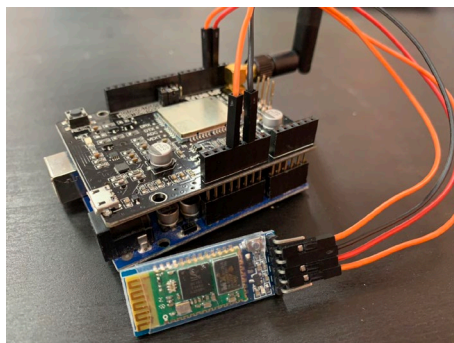


Figure 5. NB-IoT shield connected to Arduino and Bluetooth module.

C. Data Collecting

After the data retrieved from weight scale, NB-IoT will transfer the data from the weight scale to collect on the database that runs on a private server. The private server was created by using the Amazon Elastic Compute Cloud (Amazon EC2). Amazon EC2 is a web-based service that allows to run application programs in the Amazon Web Services (AWS) public cloud. Amazon EC2 allows a developer to spin up virtual machines (VM), which provide compute capacity for IT projects and cloud workloads that run with global AWS data centers. In the process of data storing, we use Node-Red to manage the data transferring. Node-Red [6] is a Flow-Based programming interface that used to connect hardware devices with APIs (Application Programming Interface) by creating in a JavaScript function and flow base block as show in Fig. 6, it was used to send weight data to the

database of phpMyAdmin according to time and date of operation measure. The database was designed table to record the data that can be stored in order. For accessing the database later, the user has to log-in on the webpage according to the code or password that has been set. In addition, the dashboard that design by node-red, is retrieving the data from the database to show on plot table graph in order to analyzation by doctor for the next step.

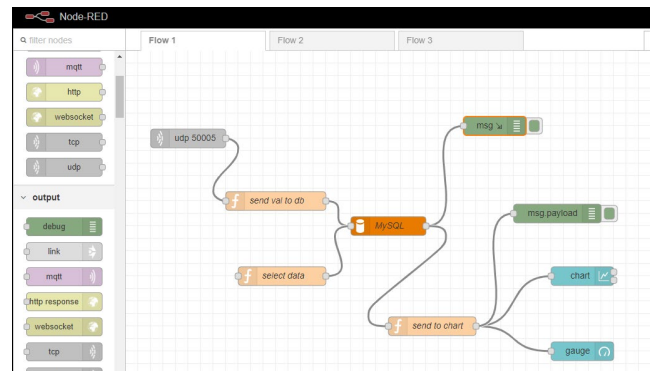


Figure 6. Flow base diagram on Node-Red

From the diagram in Fig. 7 when weighing, NB-IoT will send the data via UDP Protocol into Node-red that running on server 13.229.229.xxx. After that, the data sent to the database of phpMyAdmin and displayed on the dashboard in real time.

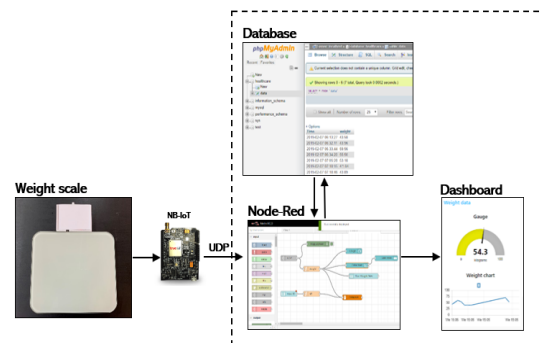


Figure 7. Diagram of data collecting.

IV. EXPERIMENTAL AND RESULTS

In the experiments, the server completely connected with weight scale prototype to prepare for collecting weight data. Then test the weight scale with different subjects include with the opening web server to check the data receiving.

The result in part of weight scale prototype found that measured weight value is nearly actual weight although there is a little precision error. Part of data transmission, the weight was sent instantly to the database but there is slightly delay in showing the weight on the monitor for 2-3 seconds. Maybe caused by the protocol of NB-IoT. Fig. 8 shows the database of weight data that showing weight revealed with the order number, time, date, month and year.

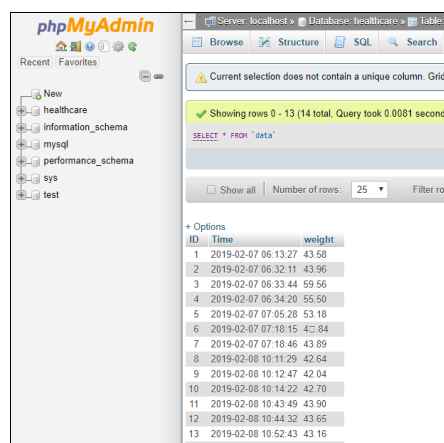


Figure 8 shows the phpMyAdmin interface. The left sidebar shows the database structure with 'healthcare' selected. The main panel shows the 'data' table with 14 rows. The columns are ID, Time, and weight. The data is as follows:

ID	Time	weight
1	2019-02-07 06:13:27	43.58
2	2019-02-07 06:32:11	43.96
3	2019-02-07 06:33:44	59.56
4	2019-02-07 06:34:28	55.50
5	2019-02-07 07:05:28	53.18
6	2019-02-07 07:18:15	45.84
7	2019-02-07 07:18:46	43.89
8	2019-02-08 10:11:29	42.64
9	2019-02-08 10:12:47	42.04
10	2019-02-08 10:14:22	42.70
11	2019-02-08 10:43:49	43.90
12	2019-02-08 10:44:32	43.65
13	2019-02-08 10:52:43	43.16
14	2019-02-08 11:00:33	46.92

Figure 8. Database on phpMyAdmin.

V. DISCUSSION

Although weight scale prototype was completely calibrated, there is a slight precision error of measured weight value, possibly due to error from weight scale which is caused by the type and instability of load cell or position of the subject during the experiment. Meanwhile, the main problem of this work is unstable of data collecting on the web server that caused by instability of

the internet used to open the server and protocol type of this NB-IoT. UDP protocol [7] was designed for a device that focuses on the data communication and energy saving, which based on high-speed transport. UDP avoids the overhead of such processing in the network stack and suitable for sending small data in real time.

Therefore, some lost data or delayed data will be ignored. However, this NB-IoT board is left to develop in the future.

VI. CONCLUSION

The Objective of this project is to reduce unnecessary care activities of data storage by using NB-IoT to transfer the healthcare data from medical instruments to the web server. Thus, the weight scale was stimulating to make it be able to retrieve the data and sent the data for collecting on cloud storage and show on the dashboard.

From NB-IoT used in data transmission, when testing weight scale the subject data is sent to server collection at that time. The advantages include, reduces the process of data collecting, reduces transcription errors and reduces duplication of information entries.

In the future, the expectation of this project is to develop with another medical instrument or using another cloud storages and to identifying the personal data.

For the future work, this project is expected to extend the work process as following:

First, stimulating a new medical instrument such as blood pressure monitor that be able to retrieve the data and using the same method of data collecting by NB-IoT. Second, designing an application to be able to separate and identify patient data. Third, using the password or identification number of patients to access the database.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Thitapa Prompinit and Amonwan Jenjirataworn conducted the research; Sarinporn Visitsattapongse analyzed the data, wrote the paper and approved the final version as corresponding authors.

ACKNOWLEDGMENT

This work is supported by Faculty of Engineering, King Mongkut's Institute of Technology Ladkrabang under the contract. Grant No. 2562-02-01-016.

REFERENCES

- [1] Rf Design. (2017). Narrowband IoT (NB-IoT). [Online]. Available: <https://rf-design.co.za/narrowband-iot-nb-iot-2/>
- [2] B. Ray. (2017). What is Narrowband IoT (NB-IoT)?-Explanation and 5 Business Benefits. [Online]. Available: <https://www.iotforall.com/what-is-narrowband-iot/>
- [3] M. Chen, Y. M. Miao, Y. X. Hao, and K. Hwang, "Narrow band Internet of Things," *IEEE Access*, vol. 5, pp. 20557-20577, Apr. 2017.
- [4] S. Kavanagh. (2018). What is Narrowband IoT? [Online]. Available: <https://5g.co.uk/guides/what-is-narrowband-iot/>
- [5] A. Cotta, Miss. N. T. Devidas, and V. K. N. Ekoskar, "Wireless communication using HC-05 bluetooth module interfaced with arduino," *International Journal of Science, Engineering and Technology Research (IJSETR)*, vol. 5, no. 4, pp. 869-872, Apr. 2016.
- [6] P. Fuchs and J. D. Parra. "DoS Detection in NodeRED," thesis, University of Passau, 2015.
- [7] P. P. K. Lam and S. C. Liew. "UDP-Liter: An improved UDP protocol for real-time multimedia applications over wireless links," in *Proc. International Symposium on Wireless Communication Systems*, 2004.

Copyright © 2020 by the authors. This is an open access article distributed under the Creative Commons Attribution License ([CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/)), which permits use, distribution and reproduction in any medium, provided that the article is properly cited, the use is non-commercial and no modifications or adaptations are made..

Thitapa Prompinit is a fourth-year student in Department of Biomedical engineering, Faculty of engineering, King Mongkut's Institute of Technology Ladkrabang (KMITL). Her advisor (Dr.Sarinporn Visitsattapongse) was support in this way and advise her to research and assemble knowledge about medical healthcare for create this project.

Amonwan Jenjirataworn is a fourth-year student in Department of Biomedical engineering, Faculty of engineering, King Mongkut's Institute of Technology Ladkrabang (KMITL). Her advisor (Dr.Sarinporn Visitsattapongse) was support in this way and advise her to research and assemble knowledge about medical healthcare for create this project.

Sarinporn Visitsattaongse is a lecturer in department of biomedical engineering, Faculty of engineering, King Mongkut's Institute of Technology Ladkrabang. She received a bachelor's degree of science in major of biology, master's degree of science in major of molecular genetic and genetic engineering and philosophy of doctoral degree in medical technology. She used to work in medical technology field in image processing, and work in molecular biology of proteins. Now current focus is about medical that may be healthcare device, home healthcare or healthcare technology.