IoT for Fault Detection in Thailand

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Abstract. Fault detection and notification in the distribution lines are very important for the operation of the power system. Due to the high cost of communication technology, largely rural area, and so many points of sensor installation, there are limited and difficult to monitoring and data sending. In this paper, we proposed concept using wireless sensor networks that could sense the faulty event in the distribution line, display to the web application as well as send an alarm notification to area distribution dispatching center and service crew, by LoRa network that a low cost, low power, and long-range communication via IoT.

Keywords: Fault detection · Distribution lines · Monitoring · Wireless sensor

1 Introduction

1.1 A Subsection Sample

Fault location and notification are one of the most challenges Provincial Electricity Authority (PEA) must develop, and in particular fault detection in a power distribution system that long line and so many locations. Power outage event after the drop out fuse device in the distribution line is a very necessary problem because in the distribution line fault often occur many times and a long time to fault section finding, these things making the power system unreliable.

This paper employs the current signal to locate the fault sector based on the wireless sensor network (WSN) and send the information [1–4] to monitoring centers or service team with newly implemented LoRa technology for massive and widespread installation.

This implementation used many devices, such as hall-effect current sensor, microcontroller, wireless networks, LoRa networks, IoT module and GSM module, and created the web server and web application for online fault monitoring. When the fault occur in distribution line this system will detect the signal with WSN client node, send the data to LoRa base station with WSN master node, send the data to GSM base station with LoRa base station, and displays the power measurements, status, and event on web browser screen [5, 6].

The objective of this paper is to provide with a new way to detect, send and monitor the fault signal and show the exact section of occurred fault immediately [7].

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2 Sensor and Communication Technologies

The devices are used in this system consists of sensors and various wireless networks. For example the hall-effect current sensor, the wireless sensor networks, the LoRa module, the GSM module, the microcontroller, the AC supply, the solar panel, the charge controller, the battery storage, and the data logger, etc. Each device has different functions and features but we describe the detail of the important device only and will be briefly explained in the following paragraphs.

2.1 Hall-Effect Current Sensor

The Hall Effect is an ideal sensing technology. The Hall Effect sensor is a magnetic field sensor and very popular. When a current-carrying conductor is placed into a magnetic field, a voltage will be generated perpendicular to both the current and the field. For the proposed system, we used the hall-effect current sensors to measure the current and detect fault currents [7] in distribution line.

2.2 Wireless Sensor Networks

The wireless sensor networks are a system composed of numerous computing and sensing devices distributed within an environment to be monitored. The wireless sensors have been intended for fault detection, location, and notification for this system. The wireless sensor networks are useful in reducing power outage duration in the distribution system, [5–7] especially in circuits with many branches.

2.3 LoRa

A LoRa network is wireless modulation technology with features are low power, low bit-rate and long range. The LoRa network uses unlicensed radio spectrum in the ISM bands to enable low power, wide area communication between remote sensors and gateways connected to the network. This system uses internet of things (IoT) technology to send the data from fault section in distribution line to GSM base station and send to the monitoring center.

3 Overview Designed

In this system, we design a communication for fault monitoring as shown in Fig. 1. The communication consists of three part; client node for detecting the fault current, the master node for record the measurement and event, locate section, and send the data to next step, and the base station for send the information to the monitoring center or the web server [4] (Table 1).

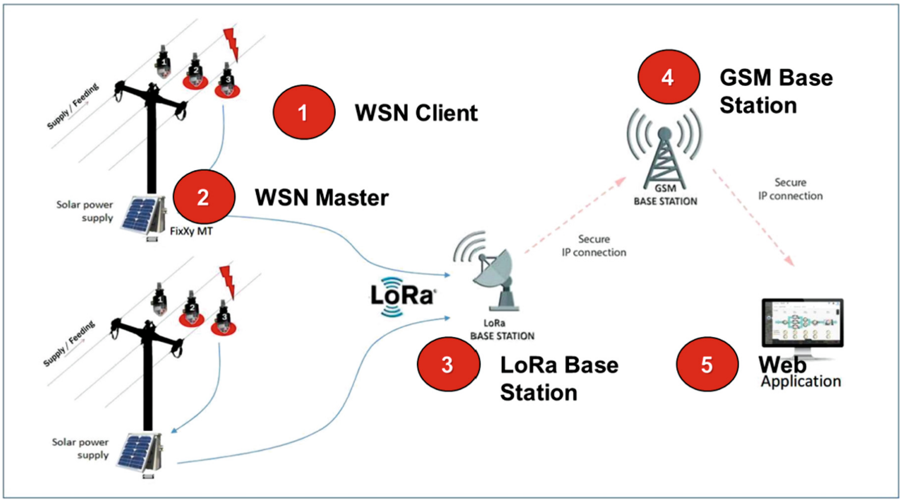

Fig. 1. The overview of this system

3.1 Design of Client Communication

The main of this part is the wireless sensors that used in this system is the Hall Effect current sensor as shown in Fig. 2.

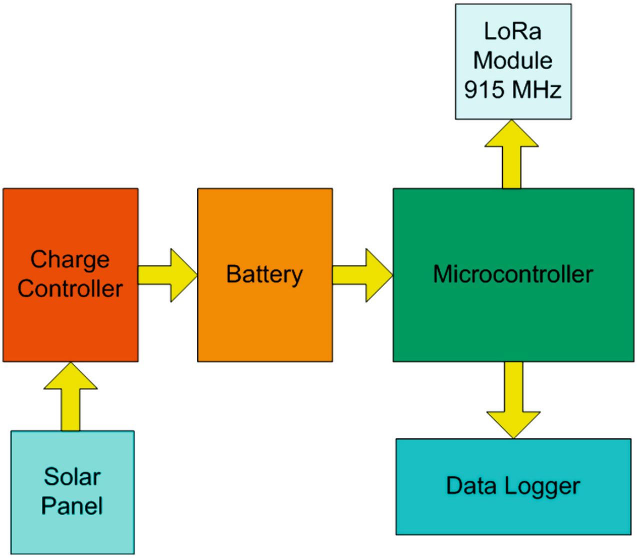

Fig. 2. Block diagram of client node

Table 1. The Equipment used in client node

Type	Operating
ATmega328P	8 MHz/16 MHz
Module 433 Wireless	3.3/3.35–5 V
Battery (Li-ion)	2700 mAh
3D Filament	ABS (g)
Solar Module (Polycrystalline)	80 mA (3 V)
Step-up Module	0.9–5 V
Light	LED
Rubber Seal	Waterproof
Support	Nut/Spring

3.2 Design of Master and Base Station Communication

The master communication used the wireless sensors to get the data from client and send the information to the base station by LoRa technology as shown in Fig. 3. In the base station will forward the information to GSM base station with IoT module via LoRa network for transfer information to the internet as shown in Fig. 4 (Tables 2 and 3).

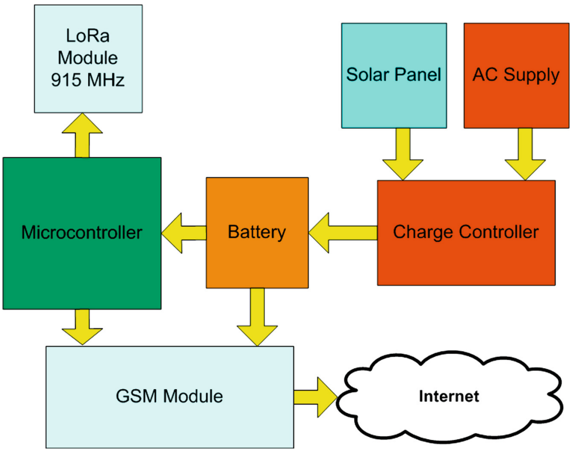

Fig. 3. Block diagram of master node

Table 2. The Equipment used in master node

Type	Operating
ESP-8266EX	80 MHz/160 MHz
Battery (Li-ion)	6 Ah
3D Filament	ABS (g)
Solar Module (Polycrystalline)	80 mA (3 V)
Solar Charge Controller	DC 12 V 10 A
LoRa Module	915 MHz
WiFi Module	5 V 4G LTE
Web Application	Online

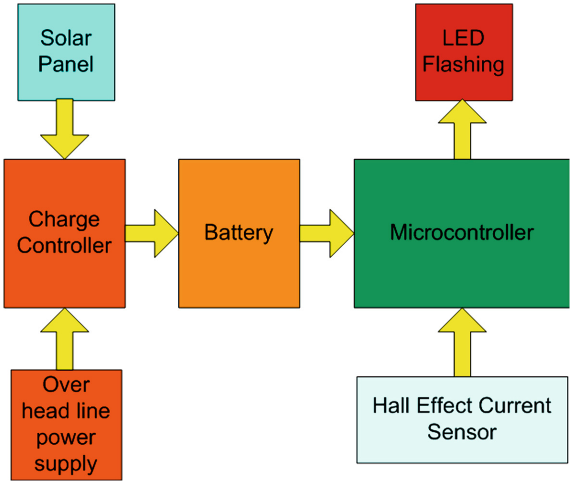

Fig. 4. Block diagram of LoRa base station

Table 3. The equipment used in LoRa base station

Type	Operating
ATmega328P	8 MHz/16 MHz
Module 433 Wireless	3.3/3.35–5 V
Battery (Li-ion)	6 V 6 Ah
3D Filament	ABS (g)
Solar Module (Polycrystalline)	22.2 V 10 W
Solar Charge Controller	DC 12 V 10 A
LoRa Module	915 MHz

4 Implementation

This system used in real in PEA central 1 region 3 in Phra Nakhon Si Ayutthaya Province, Thailand, the device each part as shown in Figs. 5, 6 and 7.

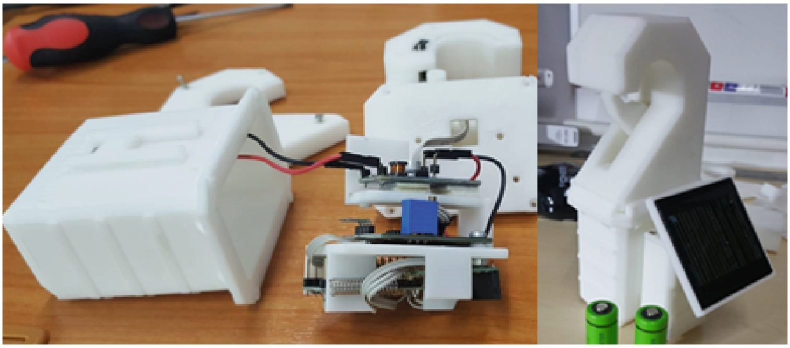

Fig. 5. The client node in cover and solar panel

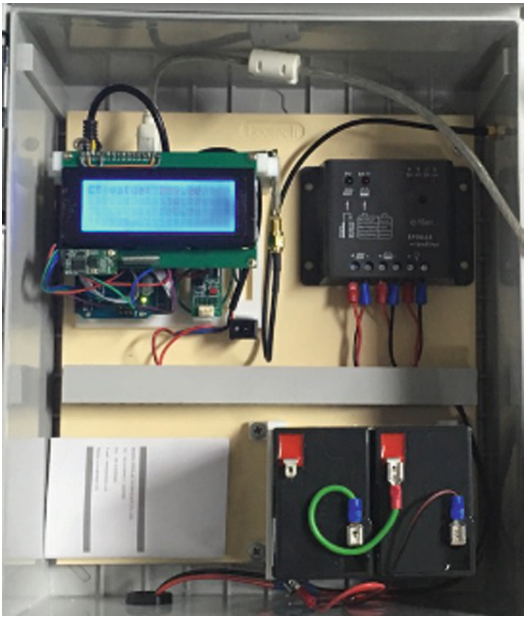

Fig. 6. The master node in cabinet

Fig. 7. The LoRa base station

Fig. 8. The disconnect stick for installation

This client node installation of the system is installed on a high-voltage cable with the use of a disconnect stick as shown in Fig. 8, and in the Fig. 9 shows the client node on high-voltage cable after installation.

Fig. 9. The client node on high-voltage cable after installation

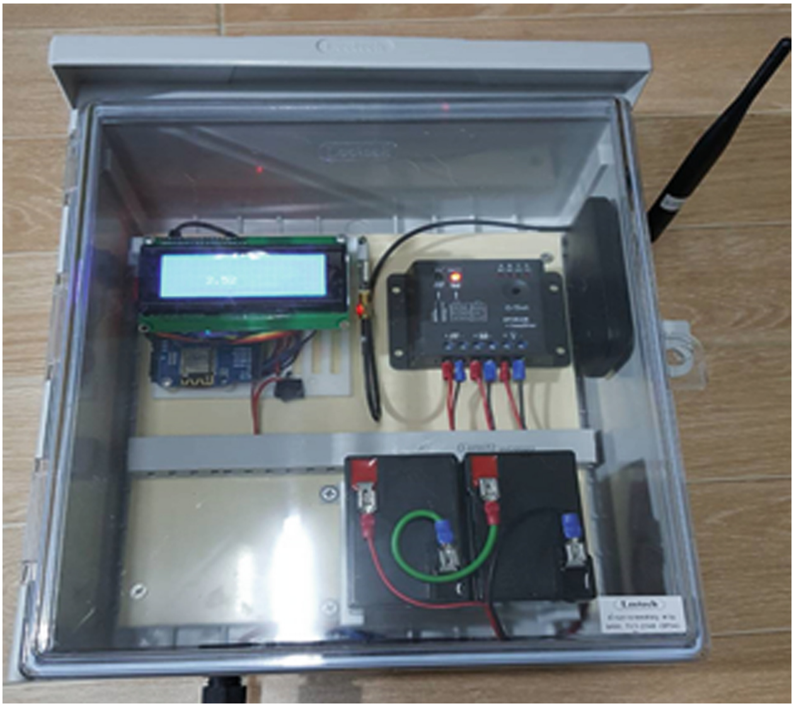

Fig. 10. The master node with solar panel on high-voltage

Fig. 11. The overview of actual sensor installation

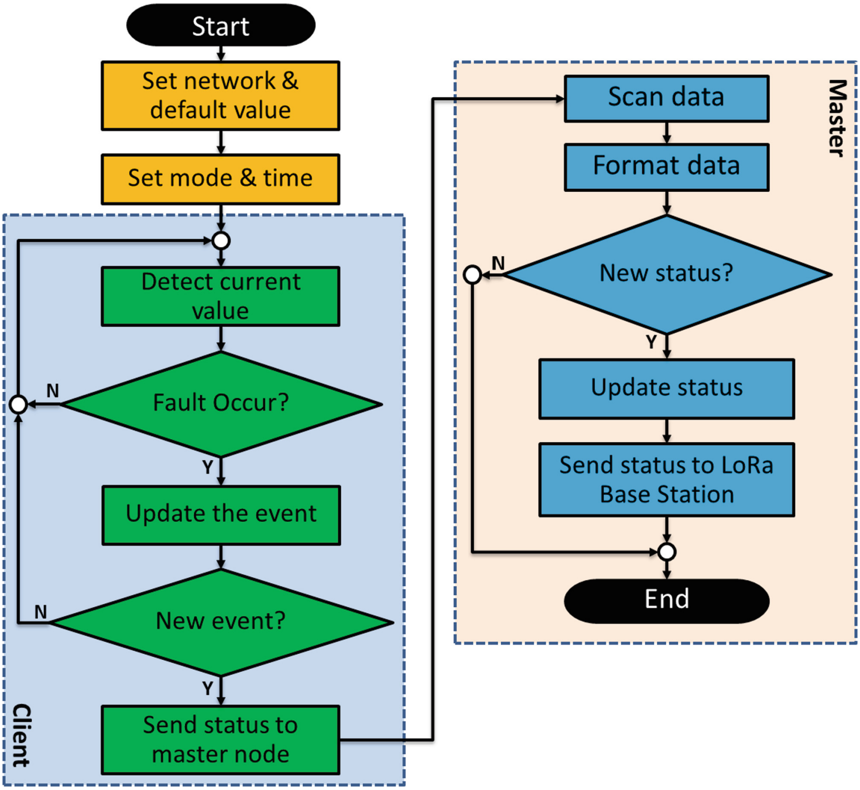

Fig. 12. The flow chart of this implementation

The contribution addressed a real smart grid application, where autonomous sensors monitor current. In the Fig. 10, you can see that this system is designed to be independently powered from solar panels. This work has real practical relevance as shown in Fig. 11. The statements made are well proven by long term trials (Fig. 12).

5 Experimental Results

The test was conducted by applying a user request rate of thousand per minute. A linearly increasing rate of 40/s was applied to test the system performance. This performance guarantee of the server is needed. The result is shown in Fig. 13. The response time is the main performance parameter that the end user can experience directly for the available services. The average response time obtained in this test was 35.94 ms.

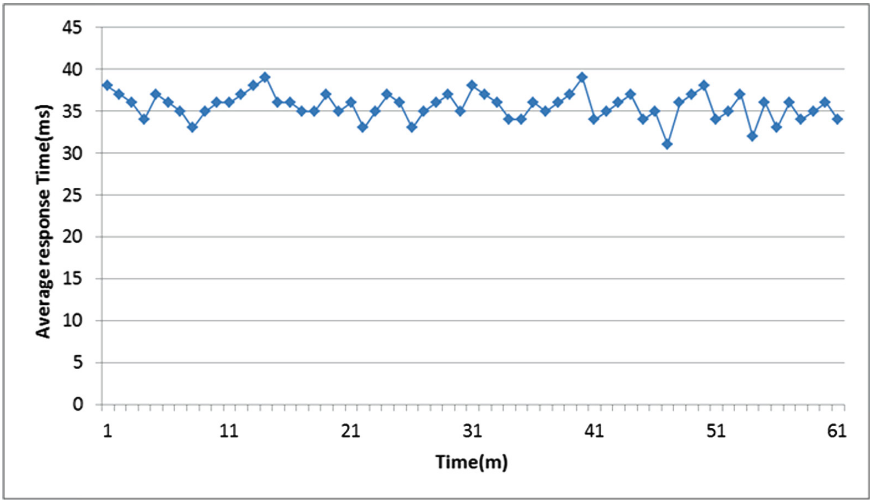

Fig. 13. The performance result of testing

The computation for wireless sensor network part can detect the signal from the distribution line, and send the measurement data to master node for forward the information to the web server within 2.7 s, and in the computation for base station part can send all information to the web server within 3.4 s.

When an event has been updated, the web application at monitoring center will identify the data, such as fault status, device status, etc. If all constraints are satisfied, this system will send the updated digital data to the web server via TCP/IP protocol, and then the web service will check mapping data of the database from web server, if the data is match, the web service interface will be updated the new status and value automatically and immediately.

The web application will repeat this loop until all the data has been changed. For this reason, user can access the web application system for monitoring with web browser as shown in Fig. 14.

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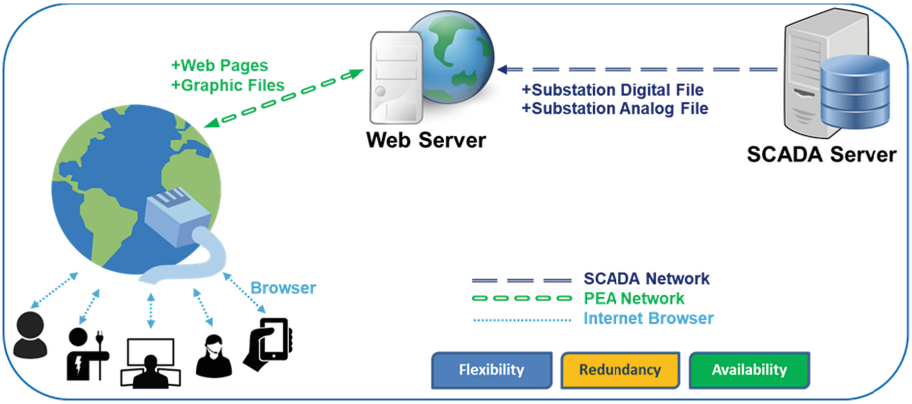

Fig. 14. The web application diagram of this system

6 Conclusion

This proposed system relies on an advantage of the wireless sensor network and the LoRa technology that low cost, low power, and long-range via internet of things for solving fault location in distribution line problem which so many points and far away from the monitoring center.

In this paper, we designed a wireless sensor network and LoRa technology for the online fault monitoring system. This concept successfully locates the fault which occurs in the distribution line and can send the data to the monitoring center or web server which far away.

According to almost one year trial period, this online fault monitoring system is implemented practically, and accurately. This implementation will help service crew or operator to identify the fault section or find the exact fault location. It can be used to monitor the distribution line form anywhere at any time through internet connection, and it can reduce the duration of distribution power outage, increase stability, and enhanced organization standards.

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