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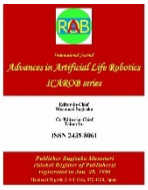

Research Article

Forest Management using Internet of Things in the Fushan Botanical Garden in Taiwan

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ABSTRACT

n recent years, the technology of the Internet of Things (IoT) has developed rapidly and has been successfully used in different fields. Moreover, the application context of the IoT will be extended more widely. This work applies the IoT technology to forestry management, including: 1. Transmission of sensing data about forest information using wireless network communication technology of Low Power Wide Area Network (LPWAN) such as LoRa and NB-IoT; 2. Apply different sensing technologies to survey resource of forest and monitor the microclimate changes in forest. In order to verify the proposed LPWAN communication technology, sensors, and sensor deployment, we built LoRa and NB-IoT communication equipment (including repeat equipment) and various sensors to transmit the real-time sensing data in the Fushan Botanical Garden with the most diverse and complex terrain in Taiwan. The returned data also proves the successful operation of various communication devices and sensors.

1. Introduction

The applications of Internet of Things (IoT) in forestry can be divided into four major aspects: forest environmental monitoring, forest resource monitoring, forest fire intelligent management, illegal logging prevention. Environmental and resource monitoring are a more successful part of the application of wireless sensing network (WSN) related to the forestry IoT. Zhang et al. [1] developed collection platform for forest environmental factors based on the ZIGBEE protocol. This platform has various terminal monitoring equipment such as temperature, humidity, water level, gas, micro-electromechanical system (mems), photoresistor (LDR) and human infrared sensor (PIR), which are all included in the platform's planning and application. Suciu [2] presented a architecture of wireless sensor network with a solution that effectively uses available resources; that is, it tries to optimize the duty cycle of a single sensor (but a single node) or maximize the service life of the network.

Kelvin Hirschet al. [3] built an ecosystem based on Canadian forest fire protection, as shown in Figure 7, which shows an useful method for sustainable forest management. The system aims to use forest management practices in an active and planned way to reduce the total area burned by wildfires and the risks associated with the use of designated fires. The authors in [4],[5] built a forest fire detection system, which consists of sensor nodes randomly deployed in the forest. Each node is

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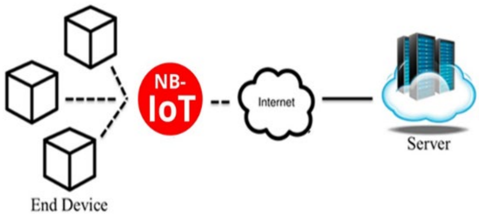
equipped with a temperature sensor, respectively. Each node can periodically determine whether there is an emergency around the environment. If some sensor node detects a significant change in temperature, they will broadcast a data packet containing their measured value and present the data on the computer web page and mobile phone page. Suguvanam et al. [6] presented a model to prevent the smuggling of valuable trees such as sandalwood and red sandalwood in forest areas. As shown in Figure 10, their model has three parts: 1. tree unit 2. sub server unit 3. forest officer.

In this work, we apply the IoT technology to forestry management in the Fushan Botanical Garden in Taiwan. In the areas having 3G/4G, we set NB-IoT-support sensors and continuously send out their sensing data by using NB-IoT communication technology. Because Fushan Botanical Garden has the most diverse and complex terrain without 3G/4G mostly, the real-time sensing data including illuminance, atmospheric pressure, ultraviolet light, and carbon dioxide are repeated to two repeat stations which is installed on hillside in order. Then, these sensing data are transmitted to LoRa getway connected with 3G/4G. Finally, the real-time sensing data are transmitted to web server.

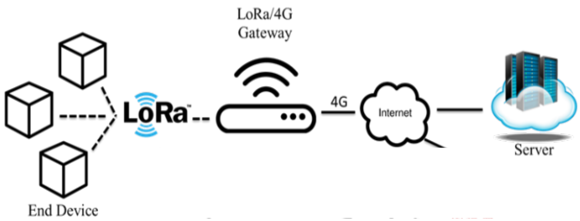
The rest of this work are as follows. Section 2 presents forest sensors and communication architecture. Section 3 illustrates the implementation and shows the experimental results. Section 4 has a conclusion.

2. Proposed Forest Sensors and Communication Architecture

This section presents forest sensors and communication architecture proposed for the Fukuyama Botanical Garden in Yilan County, New Taipei City, Taiwan. There are only a few areas with 3G/4G telecommunications signals in the Fukuyama Botanical Garden. In other words, most areas in the Fukuyama Botanical Garden do not have 3G/4G signals. Thus, as shown in Figure 1, we utilize two wireless network communication technologies of Low Power Wide Area Network (LPWAN), NB-IoT and LoRa, combined with their respective sensors to send the sensing data back to the Forestry Bureau of the Council of Agriculture of the Executive Yuan (Forestry Bureau). The detail is illustrated in subsections 2.1 and 2.2.



(a) NB-IoT communication technology and its respective sensors



(b) LoRa communication technology and its respective sensors

Fig. 1. Proposed communication architecture with two communication technologies, NB-IoT and LoRa, combined with their respective sensors.

2.1 NB-IoT communication technology and its respective sensors

In the few areas with 3G/4G, we adopt NB-IoT communication technology to continuously return the sensing data from NB-IoT-support sensors shown in Figure. 2.

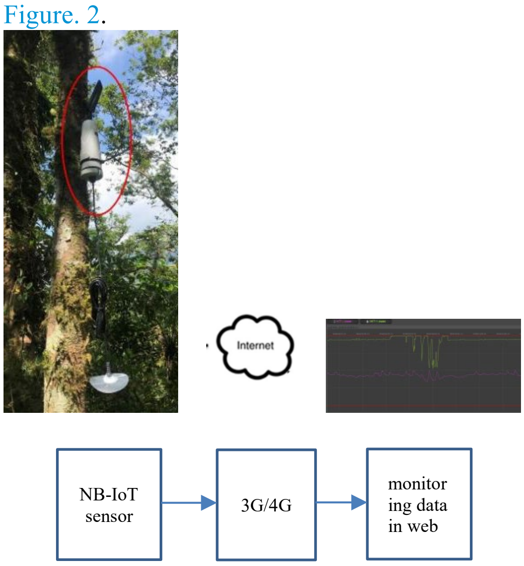


Fig. 2. Flowchart of NB-IoT technology for returning the sensing data.

2.2 LoRa communication technology and its respective sensors

Due to the complex and diverse terrain of the Fushan site and most areas have no 3G/4G signal, the proposed LoRa signal repeat method continuously returns the sensing data of the LoRa-support solar micro-weather station shown in Figure 3.

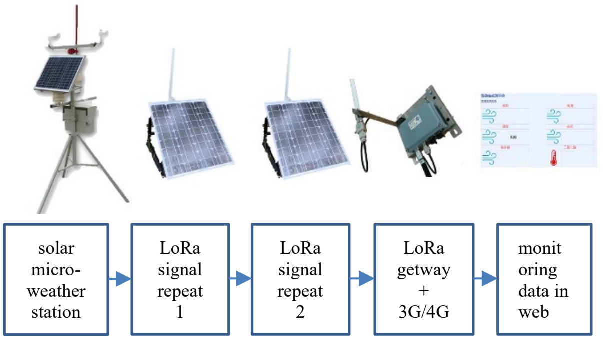


Fig. 3. Flowchart of LoRa signal repeat tecnology for returning the sensing data of the LoRa-support solar micro-weather station.

3. Implementation and Experimental results

This section presents the implementation of forest management using the proposed IoT architecture and the respective experimental results.

3.1 Implementation and Experimental Results of NB-IoT Planning

In the areas with 3G/4G, as shown in Figure 4, we first set NB-IoT-support sensors as shown in Figure 5 and continuously send out their sensing data by using NB-IoT communication technology. Next, the real-time sensing data such as temperature and humidity are connected with 3G/4G and finally transmitted to web server as shown in Figure 6.

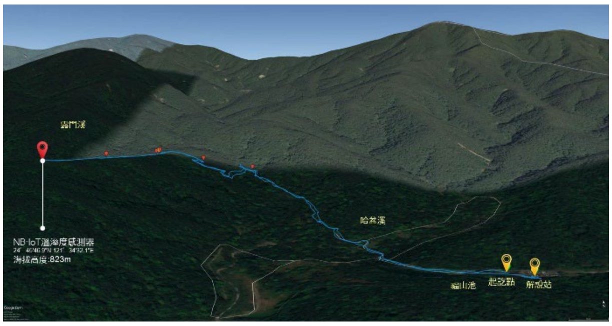


Fig. 4. Implementation of NB-IoT-support sensors and communication technology.

Fig. 5. NB-IoT-support temperature and humidity sensors.

No	Device Type	Device Name	Device MAC	Voltage	Report Time	Bat.low
1	Sensor	-	7D6C603A00002026	5.50	2018-11-13 11:09:21	
2	Sensor	-	7D6C603A00002544	5.50	2018-11-12 23:20:36	
3	Sensor	-	7D6C603600004A2F	4.50	2018-11-02 10:10:59	
4	Sensor	-	7D6C603600004B24	5.50	2018-10-31 18:09:09	
5	Sensor	-	7D6C603D00004D2E	5.50	2018-10-27 03:03:14	
6	Sensor	-	7D6C603C00001B3D	5.50	2018-09-20 12:06:10	

Fig. 6. Real-time data of temperature and humidity.

3.2 Implementation and Experimental Results of LoRa Repeat Planning

In the large areas without 3G/4G, we first set LoRa-support solar micro-weather station in the top of some mountain as shown in Figure 7 and continuously send out sensing data by using LoRa communication technology. Next, the real-time sensing data including illuminance, atmospheric pressure, ultraviolet light, and carbon dioxide are repeated to two repeat stations which is installed on hillside in order. Respectively, these sensing data are then transmitted to LoRa getway which is connected with 3G/4G. Finally, these real-time sensing data are transmitted to web server as shown in Figure 8.

Fig. 7. Implementation of LoRa-support solar micro weather station, two repeat stations, and communication technology.

Fig. 8. Real-time data of illuminance, atmospheric pressure, ultraviolet light, carbon dioxide.

4 Conclusions

In this work, we implement forestry management in the Fushan Botanical Garden in Taiwan using the proposed IoT technology. In the few areas with 3G/4G, we set NB-IoT-support sensors and continuously send out their sensing data by NB-IoT communication technology. Due to the fact that Fushan Botanical Garden has the most diverse and complex terrain without 3G/4G, the real-time sensing data including illuminance, atmospheric pressure, ultraviolet light, and carbon dioxide are repeated to two repeat stations which is installed on hillside in order. Respectively, these sensing data are then successfully transmitted to LoRa getway which is connected with 3G/4G. Finally, these real-time sensing data are transmitted to web server.

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