IoT based Temperature, Movement and Light Monitoring System for Smart Building

[1] Khin Kyawt Kyawt Khaing, [2] May Thin Khine,
[1] University of Information Thecnology, Yangon, Myanmar
khinkkkhaing@uit.edu.mm, mtkhine.me@gmail.com

***Abstract*— Nowadays, many pollution monitoring systems are designed by considering different environmental parameters. In this system, the fundamental services needed in order to perform smart systems are provided by the conditions of temperature, movement and light conditions at a particular place and make information visible anywhere an android application. The technology behind this is Internet of Things (IoT), which is reliability, sustainability, and efficiency by improved access to information. The Things Node waterproof match box full of sensors has been used to sense light, temperature and movement of a particular place and the data through the Gateways to the Things Network (TTN). Devices use low power networks like LoRaWAN to connect to the Gateway, while the Gateway uses high bandwidth networks like WiFi to connect to The Things Network. The updated data from the implement system can be accessible on the TTN console via internet from anywhere in the world and stored database Firebase via Node-Red. And then users can display at sensor information on the smart phone application which is crucial helpful and importance in smart things.**

Keywords: - Internet of things (IoT), the Things Node, LoRaWAN, The things network, Firebase, Node-Red

I. INTRODUCTION

The modern people expect new devices and new technologies to simplify their day to day life. The innovators and researchers are always trying to find new things to satisfy the people but the process is still infinite. In the 1990s, internet connectivity began to proliferate in enterprise and consumer markets but was still limited in its use because of the low performance of the network interconnections. In the 2000s internet connectivity became the norm for many applications. Now, it is expected as part of many enterprise, industrial and consumer products to provide access to information. However, these devices are still primarily things on the Internet that require more human interaction and monitoring through apps and interfaces. One research reveals, the Internet of Things (IoT), which excludes PCs, tablets and smart phones, will grow to 26 billion units installed in 2020 representing an almost 30-fold increase from 0.9 billion in 2009 [1].

The Internet of Things is a new era of intelligence computing and it's providing privileges to communicate around the world. The objective of IoT is Anything, Anyone, Anytime, Anyplace, Anyservice and Anynetwork [2].

IoT describes a system where items in the physical world, and sensors within or attached to these items, are connected to the Internet via wireless and wired Internet connections. These sensors can be used various types of local area connections such as RFID, NFC, Wi-Fi, Bluetooth, and Zigbee. Sensors can also have wide area connectivity such as GSM, GPRS, 3G, and LTE. The Internet of Things will connect both inanimate and living things, using sensors for data collection and change what types of item communicate over an IP Network. IoT data differs from traditional computing. The data can be small in size and frequent in transmission. The number of devices, or nodes, that are connecting to the network are also greater in IoT than in traditional PC computing. Machine-to-machine communications and intelligence drawn from the devices and the network will allow businesses to automate certain basic tasks without depending on central or cloud-based applications and services. These attributes present opportunities to collect a wide range of data but also provide challenges in terms of designing the appropriate data networking [3].

Therefore, a typical IoT-enabled system consists of sensors, embedded system, (wireless) communication, data storage via Internet into a cloud server, an analytics software system to take informed decisions at the cloud platform, and an optional receiver end device (mobile). In few cases, the receiver end system will be an actuator that will execute certain actions on the targeted hardware. We can choose appropriate object(s) (such as lockers, curtains, consumer

electronics devices such as cookers) and interface it (them) with an appropriate sensor(s) [4].

II. Proposed System

An "IoT based temperature, movement and light monitoring system for smart building" is to develop a low cost, long-range and low-power flexible system which access through android application on smart phones, monitoring room temperature, gate and door open/close. The similar kind of project can be deployed for other real-life applications such hospitals and schools. A proposed system flow can be shown in "Fig. 1". In this propose system, sensor devices, microprocessor, wireless module, gateway are used. There are embedded devices, gateway, the things network (TTN) and application interface.

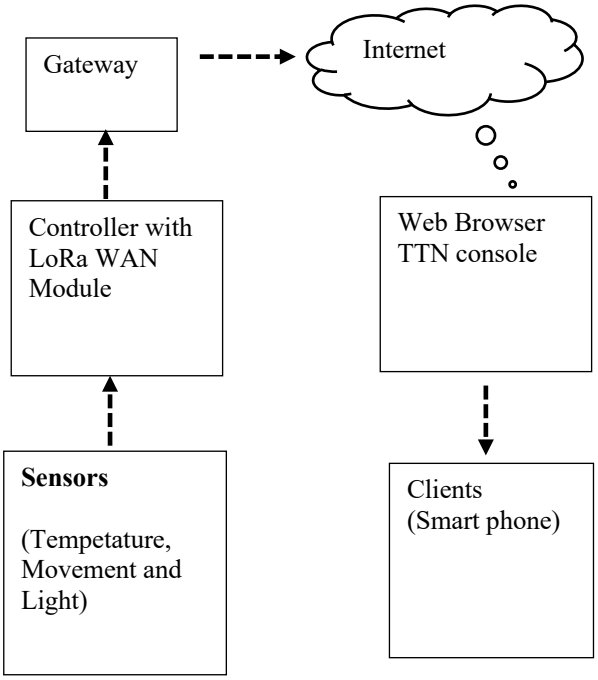

Figure 1. System Flow Diagram

A. The Things Node

The Things Node is based off the SparkFunProMicro with added Microchip LoRaWAn module and temperature sensor, digital accelerometer and a light sensor.

In many IoT systems, the sensors forward their data to a local computing system via short-range wireless communication protocol such as Bluetooth, Zigbee, and WiFi[4]. In the case of an IoT system, the inputs are replaced by relevant sensor(s). The Things Node is based off the SparkFunProMicro with added Microchip LoRaWAN module and temperature sensor, digital accelerometer and a light sensor. This designed by software approach is also kept in the Cloud and compute where the actual set point of each system is over the critical value. If the actual output is over the critical value, the system will send the information to the smart home user in real-time so that the users can have the chance to take proper actions to reduce power consumption [5].

In this system the things node is used to the embedded system attached with the object can sense the required data and monitor it continuously. At periodic, pre-defined time intervals, the necessary data is transferred to a remote location for storage using wireless communication protocols LoRaWAN.

B. The Things Network, LoRaWAN and The Gateway

The Things Network is an open Internet of Things infrastructure supported by its members. Members contribute by placing gateways or running network servers. Together we create a secure and redundant collaborative network. The Things Network is growing towards a robust and stable global network, providing connectivity where it is needed. The Things Network is the first open source, decentralized infrastructure for the Internet of Things. Before the device wants to communicate via The Things Network, it will be needed to register it. Currently, The Things Network supports LoRaWAN for long range (~5 to 15km), low power (months to years on battery), but also low bandwidth (51 bytes/message) communication. It can be support multiple Bluetooth Broadcast/Mesh networks and other networks as well [5].

The Long-Range Wide-Area Network (LoRaWANTM) is a relatively new protocol in the family of Low-Power WANs (LPWANs). LPWANs are designed to fill the gap between (a) short-range and typically high-bandwidth networks, like Bluetooth, WiFi, and ZigBee, and (b) cellular networks, like GSM, UMTS and LTE: networks with a fairly large coverage, but also high-power consumption. Since the Internet-of-Things will include many battery-operated or energy-harvesting devices, an additional requirement, which is realized by most LPWANs, is to have inexpensive low-power transceivers that are able to operate for long periods [6].

There are several gateways to choose from and LoRaWAN technology based gateway is used in this system. The gateway is an Internet-connected LoRa device that listens multiple LoRa channels and forwards packets between the things network and the end device nodes it hears. The data aggregated from various objects are stored in the things network (TTN). At periodic intervals, the aggregated data are analyzed/diagnosed using appropriate analytics software running in the server (cloud). The data can be read from TTN using Node-RED, a common tool for building IoT solution.

C. Google Firebase API for Android

The purpose of using Firebase is to introduce everyone with Google firebase API and its features. Firebase is a google provided API for database storage and syncing into an android, iOS or web application. A real-time database is the one which stores data to database and fetches data from it very quickly, but Firebase is not just a real-time database, it is much more than that [7]. Firebase provided features used in this system are analytics, authentication, messaging, real-time database and storage.

III. SYSTEM IMPLEMENTATION

In this system, 2-parts are shown in "Fig. 2". The stage 1 is the environmental sensor devices; embedded layer, stage 2 LoRa gateway, sensor data forwarder; in stage 3 TTN payload conversion are in part I. Application server and application development in part II. The embedded layer includes a group of sensors, controllers, processors and embedded devices that can perceive, detect objects, gather information, and exchange information with other devices through the Internet communication networks. "Fig. 2" shows the flow of the system implementation for IoT based temperature, movement and light system. Firstly, the proposed system has measurement system (sensor) and dynamically change in real-time will be sent as a sensor data to the things network with the help of the microcontroller-based, the things node circuit.

The implemented system consists of the things node as a main processing unit for the system and all the sensor and devices can be connected with the microcontroller. The sensors can be operated by the microcontroller to retrieve the data from them and it processes the analysis with the sensor data and updates it to the internet through Wi-Fi module connected to it. In the stage 1, the things node is to read temperature, movement and light intensity at the particular place to make the environment intelligent or interactive with the objects through wireless communication.

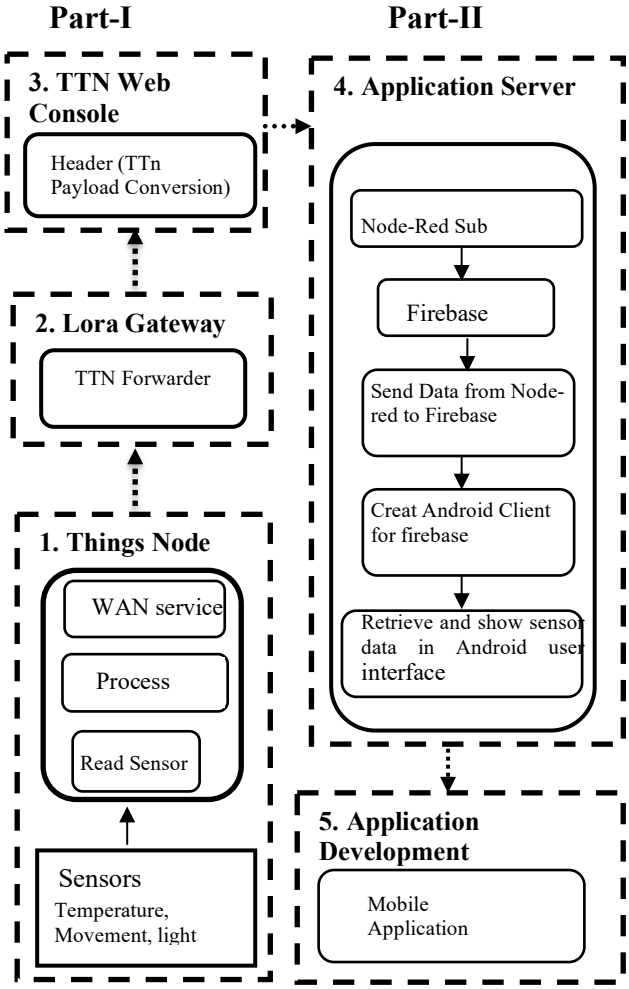

Figure 2. System Architecture

Here, it provides information about the parameters under the region which is to be monitored for temperature, movement and light. The things node is activated and registered to connect the things network. To connect end device the things nodes, it must be had to define an application in TTN. The thing network Arduino library comes with a class dedicated to the things node. An application has a name and a unique ID called an Application EU. It also creates an Application Access Key that is used to integrate service Node-RED. After creating a TTN application, the things node is needed to add to the application so that it wraps the commands to work with temperature, movement and motion sensors in APIs. It can be uploaded the code by using Application EUI, Device EUI and Application Key with the keys from the thing network console.

The functions of each individual module developed for temperature, movement and light monitoring. The sensor data send to the things network (TTN) and it can be seen the current temperature and values from the sensors on the Things Node after uploading the data as shown in "Fig. 3". The raw pay load data formatted in hex-formatted, space-separated bytes on the data page are decoded with meaningful fields.

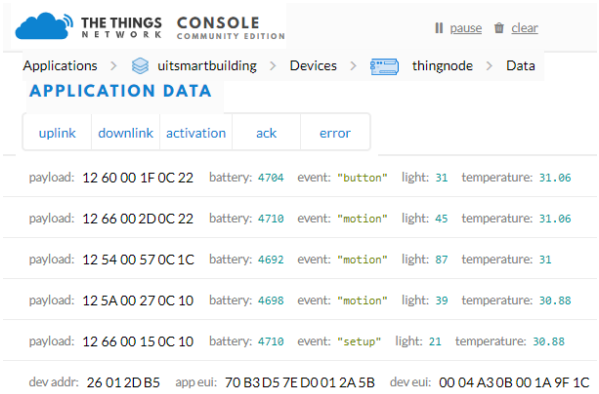

Figure 3. Monitoring things node data on the things network (TTN).

The things node with suitable characteristics, features and each of these sensor devices are operated and uploaded based on their sensitivity as well as the range of sensing. The sensing data on the things network how to uplink, how to do and how to unify application interface as shown in "Fig. 4" and discuss in the next titles.

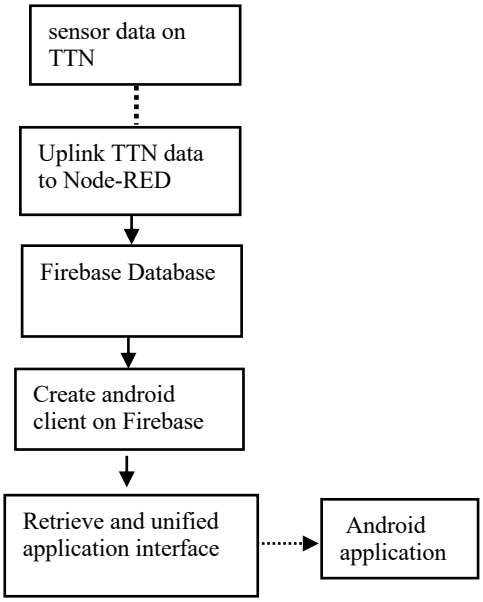

Figure 4. The sensor data on things network (TTN) how to do retrieve and unified application interface.

A. Uplink TTN Data to Node-RED

To make use Node-RED first it should be installed in the PC. The data acquisition from sensor devices data is representing which parameter to uplink data from TTN to Node-RED, Node.js and Node-RED are needed to be installed. Node-RED is a flow-based development tool for visual programming developed originally by IBM for wiring together hardware devices, APIs and online services in new and interesting ways as part of the Internet of Things (IoT). It provides a browser-based flow editor that makes it easy to wire together flows using the wide range of nodes in the palette that can be deployed to its runtime in a single-click. The following steps are required to uplink data from TTN to Node-RED:

- Installation of Node-RED
- Running Node-RED client in browser
- Adding TTN on Node-RED
- TTN Configuration on Node-RED

Node-RED is installed in PC then open the browser enter this http://127.0.0.1:1880/. for running Node-RED client in browser. And then to add TTN on Node-RED, 'node-red-contrib-ttn' is needed to install. After TTN Configuration on Node-RED the node "TTN uplink" is needed to be configured by setting its App ID, Access Key and Discovery Access received from The Things Node.

B. Real-Time Data Sending Node-RED to Firebase Database

After receiving the data from the Node-RED, these data will be stored in the Firebase. Firebase is a mobile and web application development platform developed by Firebase. To store real time data received from sensor, the real time database supported by Firebase is used. After creating a Firebase, the data in Node-RED will be stored in the Firebase. There are step by step procedure by sending data from Node-RED to Firebase: Adding Firebase on Node-RED, Uplink Data to Firebase. Firebase configuration to Node-RED. After installation, the data will be uplinkeding to Firebase. To uplink data, another node of Firebase is added and connect with "ttn uplink" node.

C. Create Android Client for Firebase

To make enable Firebase Realtime Database for Android in the PC it should be done before proceeding further: Connect the application to Fire base need to install the Firebase SDK and add the application to the Firebase in the Firebase console.

To add the Real time Database to the application, add the dependency for Firebase database to the application level. Retrieve an instance of your database using getInstance() and reference the location want to write to. A range of data types can be saved to the database this way, including Java objects. When an object the responses are responded from any getters will be saved in this location.

And then, to read from the database to make the app data update in real time, it must add a ValueEventListener to the reference is just created. The onDataChange() method in this class is triggered once when the listener is attached and again every time the data change.

Finally, to prepare for launch before launching the application, it is recommend walking through the launch checklist to make sure the application is ready.

E. Retrieve and Show Sensor Data in Android User Interface

In android application can be designed for this system after the foregoing step, there are two screen definitions such as current environmental and dashboard about the application as shown in “Fig. 5” and “Fig. 6”.

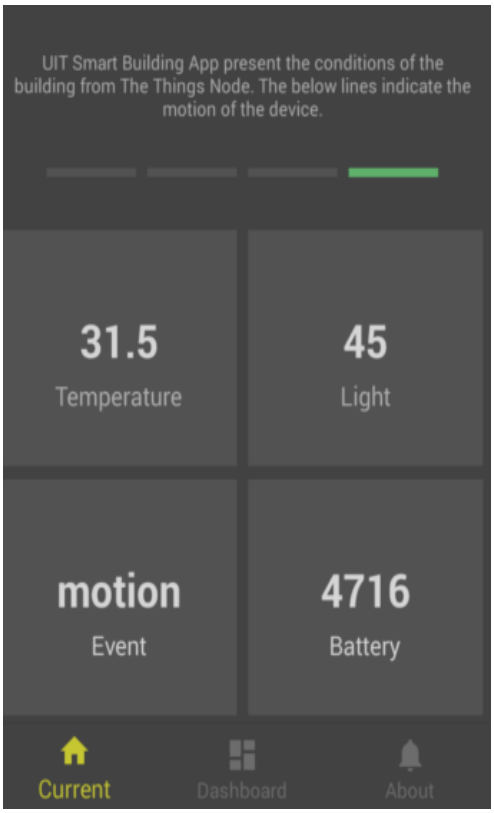

Figure 5. Monitoring current environmental data on application.

For the first screen of current, shows the current conditions of all the sensors. It will show about the current temperature, and lighting condition and motion event exists or not. The user can easily check the temperature, motion, light and also battery. The data updated from the implemented system can be accessible on the android with app via internet from anywhere in the world.

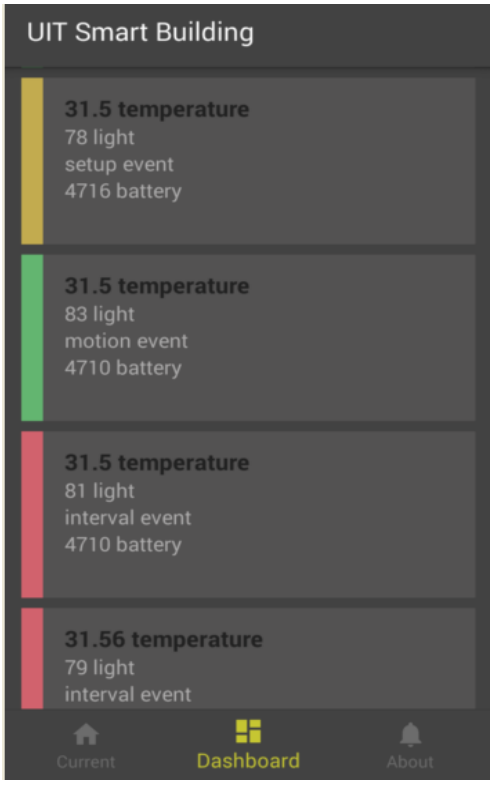

Figure 6. Monitoring daily environmental data on application

IV. Conclusion

The smart way to monitor environmentally and efficiently, low cost embedded system is presented in this paper. In this system, using Internet of Things has been experimentally proven to work satisfactorily by connecting simple appliances and the appliances were successfully monitored through internet. This is intelligent, low cost, long range, low-power monitoring designed system not only monitors the sensor data, like temperature, light, movements, but also to improve or actuate a process according to the requirement, for example switching on the light when it is getting dark. It also stores the sensor parameters in the cloud (TTN) in a timely manner to forecast the parameters based on the historical data. It will also help the user to analyze the condition of various parameters in the home anytime anywhere. This concept can be used for any big as well as small organization such as Hospitals, colleges, schools, university can also use this

concept the most important thing is, it can be scaled up for the requirement in distributed systems environment. In future work, by deploying sensor devices in the environment into real life i.e. it can interact with other objects through the Wi-Fi, 3G, 4G, etc.

This system can be further expanded to monitor the developing cities and industrial zones for monitoring, collecting the data and analysis.

ACKNOWLEDGMENT

We express our deep appreciation and sincere thanks to Dr. Saw Sanda Aye, Rector of the University of Information Technology for her extensive personal and professional guidance and life in general and Dr. Myat Thida Mon, Dean of Faculty of Computer Systems and Technologies who have been supportive me to pursue those goals. I am grateful to all of those with whom I have had the pleasure to work during this and other related projects.

REFERENCES

[1] P. Magrassi, T. Berg, "A World of Smart Objects", Gartner research report R-17-2243, 12 August 2002.

[2] White Paper: "Internet of Things Strategic Research Roadmap", Antoine de Saint-Exupery, 15 September 2009.

[3] Lopez Research LLC, "An Introduction to the Internet of Things (IoT)", Part 1. Of "IoT series", Nov 2013.pdf.

[4] B.K. Tripathy. J. Anuradha "Internet of Things (IoT) Technologies, Applications, Challenges, and Solutions", CRC Press, Taylor and Francis Group.

[5] https://www.thethingsnetwork.org/docs/devices/node/

[6] N. Sornin (Semtech), M. Luis (Semtech), T. Eirich (IBM), T. Kramp(IBM), and O.Hersent (Actility). Lora specification. Technical report, LoRa Alliance, Inc., Jan 2015. www.lora-alliance.org/portals/0/specs/LoRaWAN%20Specification%201R0.pdf.

[7] N. Singh, "Study of Google Firebase API for Android", IJIRCCE, Vol. 4, Issue 9, Setemper 2016.

[8] B. Shivarudraian, R.K. Gupta,"Internet of things based on home automation and Surveillance System", SSRG-IJIRCCE, Vol.4, Issue 3, March 2017.

[9] S. Umber, T.Yasuo, "Stability analysis for smart Homes Energy Management System with Delay Consideration", Journal of Clean Energy Technologies, Vol.2, No.4, October 2014.

[10] http://www.rfwireless-world.com/ Aticles/LoRea WAN-smart-parking-system.html.

[11] L.Gao, Z. Wang, "Design of Smart Home System Based on ZigBee Technology and R&D for Application", Science and Research Publishing, Energy and Power Engineering, 2016,8,13-22.

[12] M.R.kumar,T.Rannith, "IoT Based Physiological Stress Monitoring and Managing Device", IJIRAE, Vol 6, Issue 03, March 2019.

[13] A. Agarwall, R. Singh"IoT enabled Home Automation through Nodered and MQTT", IJCTA, Vol 10, Number 18, 2017.

[14] N.Singh, "Study of Google Firebase API for Android", IJIRCCE, Vol.4, Issue 9, September 2016.

[15] R. B.Srinivas, R.K. Srinivas, "Internet of Thngs (IOT) Based Weather Monitoring system", IJARCCE, Vol. 5, Issue 9, September 2016.

[16] M.Sangeetha, C.Udhayanila, "Smart Home Control System by IoT based on WiFi module",IJIRCCE, ISSN-2320-9798, Vol. 5, Issue 3, March 2017.

[17] J. Sunkpho, and C.Ootamakorn, "Real-time Flood Monitoring and Warning System"SJST journal, 33(2), 227-235, March-April 2011.

[18] X. J. Yi, M. Zhou, "Design of Smart Home Control System by internet of things based on ZigBee", IEEE 11th Conference on Industrial Electornics and Applications (ICIEA), June 2016.

[19]S. Pandikumar, R.S. Vetrivel, "Internet of Things Based Architecture of Web and Smart Home Interface Using GSM", IJIRSET, Volume 3, Special Issue 3, March 2014, (ICIET'14), on 21st & 22nd March.