Design of Cost Effective IoT based Remote Terminal Unit

Amol S. Gurnule and S. J. Sharma
Department of Electronics and Computer Science, RTM Nagpur University,
Nagpur-440033
asg.amolgurnule@gmail.com

Abstract

Remote Terminal Unit is a standalone data acquisition, control and monitor over a large geographical area, through wireless communication such as infrared, blue-tooth, WI-FI or Internet. Internet of Things (IoT) refers to the network of physical devices embedded with sensors, software and electronics to communicate with each other and exchange data over computer network, via various protocols for communication between the base station and RTU. In the present work, we have used MQTT in which messages are either subscribed or published from remote client. Adafruit IO broker is used to publish and subscribe messages. The message data is published on the remote Node-MCU device and appliances are controlled. Various services of Adafruit IO are used to send the message to make the appliances on/off. The designed IoT based RTU has been tested in our laboratory to switch on and off the four lights connected to the remote microcontroller.

Keywords: I2C, IoT, MQTT, Node-MCU, Remote Terminal Unit, TCP/IP, Wi-Fi

I. Introduction

Internet of Things (IoT) is the network of physical devices embedded with sensors, software and electronics, enabling these devices to communicate with each other and exchange data over a computer network. The things in the IoT refer to hardware devices uniquely identifiable through a network platform within the Internet structure. In other words, IoT is an extension of Internet that provides communication and interconnection among various devices or physical objects. Connectivity has seen a lot of focus in the recent past. Selecting a wireless network for an IoT device involves balancing multiple parameters such as range, battery life, bandwidth, density, endpoint cost and operational cost. Thus, the long-term goal of an IoT is to deliver data rates upto tens of kbps while consuming less power.

A smart home is a network of various sensors and controllers integrated together to provide the user with remote control of various devices within their home using IoT. The sensors sense various changes, monitor them, store the data and display them in order for analysis and control. Automation is the process of automatic control of any real time application. These applications are controlled through integrated electronic chips called microprocessor/ controller. These systems should be remotely monitored and controlled through the commands given by the user. The communication media in the automated control system plays a major role to operate the system remotely.

There are various protocols for communication between RTU and base station. People are becoming dependent on their smart phones. Therefore, the simplest solution is to connect devices to the smart phone. Using smart phone we can acquire real-time data and can take a decision according to the surrounding conditions. MQTT protocol has several advantages to b us in different types of embedded systems. This

protocol is used in different types of embedded systems. In the present work, MQTT is used as a lightweight TCP-based messaging protocol for M2M applications such as monitoring and distributed IO applications. It allows high latency. With the help of this device, we can control and monitor our home devices like fan, light, AC, or any devices. Also various sensors can be interfaced with the RTU depending on the type of application to be built.

II. Experimental

A. System Overview

Fig. 1 shows Block diagram of the designed system consisting of communication media, RTU and base station. Communication media plays a vital role in controlling the appliances remotely over the Internet. It consists of server that receives commands from the base station and sends to the RTU. RTU consists of a Node-MCU controller, 16x2 LCD, sensors and AC current driving components. As per the commands received from the base station, RTU takes action. Graphical User Interface, which has buttons and gauges has been designed for the base station. It provides flexibility to the user for controlling target devices over the Internet.

The system is configured with two modes of operation namely server mode and application mode. The dashboard is designed in the Adafruit IO website and home appliances are controlled and monitored. In server mode, control is accomplished from the server and in application mode, control is accomplished using MQTT Client application. In an application mode, the message is sent to the RTU and appliances are controlled (switch ON or OFF). In the present work, Google assistant is used to issue commands that are transferred to the AdafruitIO and the remotely located appliances are controlled.

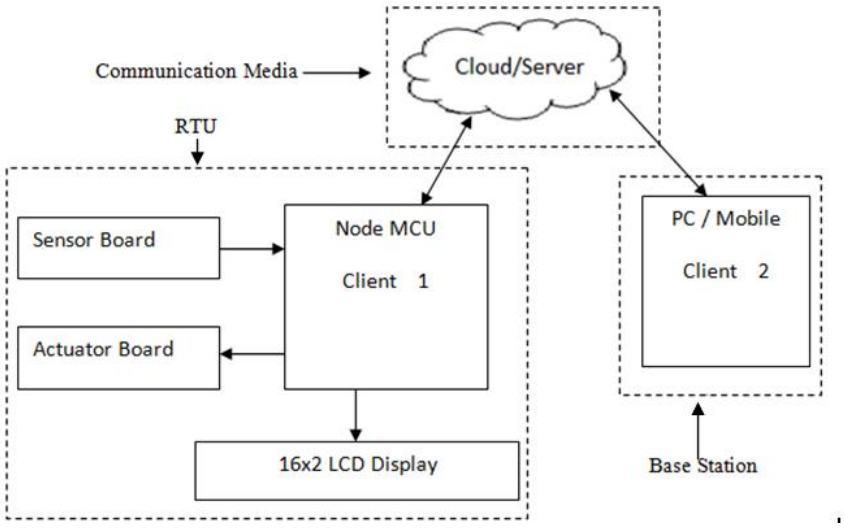

Fig. 1: System block diagram with RTU, Communication Media and Base Station

A.1 Communication Media

For Internet communication, we need a protocol for communication. Among the various protocols MQTT is a widely used application protocol. Each client can be a publisher that sends a message to the broker and subscriber that receives automatic message every time on the topic subscribed.

There are various brokers available for free. In the present work, AdafruitIO and MQTT broker are used for providing Dashboard and other services to the client. It provides unique AIO key to identify the client. When connection is established with the MQTT server, feed values are published on the broker. When client makes a particular device off, the message is send to the RTU and devices are controlled. Using MQTT Client data can be published and subscribed to a feed to send and receive feed data.

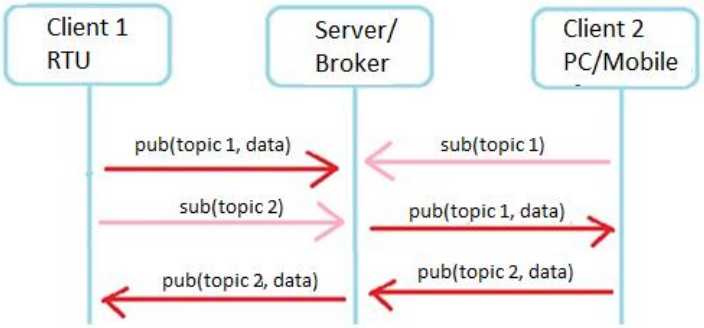

Fig 2: Data transmission in Communication Media

A.2 Remote Terminal Unit

Fig 3 shows the circuit diagram of designed RTU. Node-MCU which is microcontroller with Wi-Fi capability helps to connect to the internet using standard protocol. Node-MCU is first connected to the nearest Wi-Fi and then to the internet. After connecting to Wi-Fi, the RTU tries to connect to the MQTT server using authentication key and gets connected if there is no network issues. After connection it sends data on the server and checks for the status of buttons on the server and updates the status of lights. When the button is pushed ON, the status updated on the server and then it is published on the RTU and target device turns ON.

RTU monitors the field parameters in either digital or analog form and transmits data to the Central Monitoring Station. It contains software to connect data input streams to data output streams, defines communication protocol. RTU may consist of one complex circuit consisting of various sections required to perform a custom fitted function or may consist of many circuits including CPU or processing with communications interface(s), and one or more of the following: (AI) analog input, (DI) digital input, (DO/CO) digital or control (relay) output.

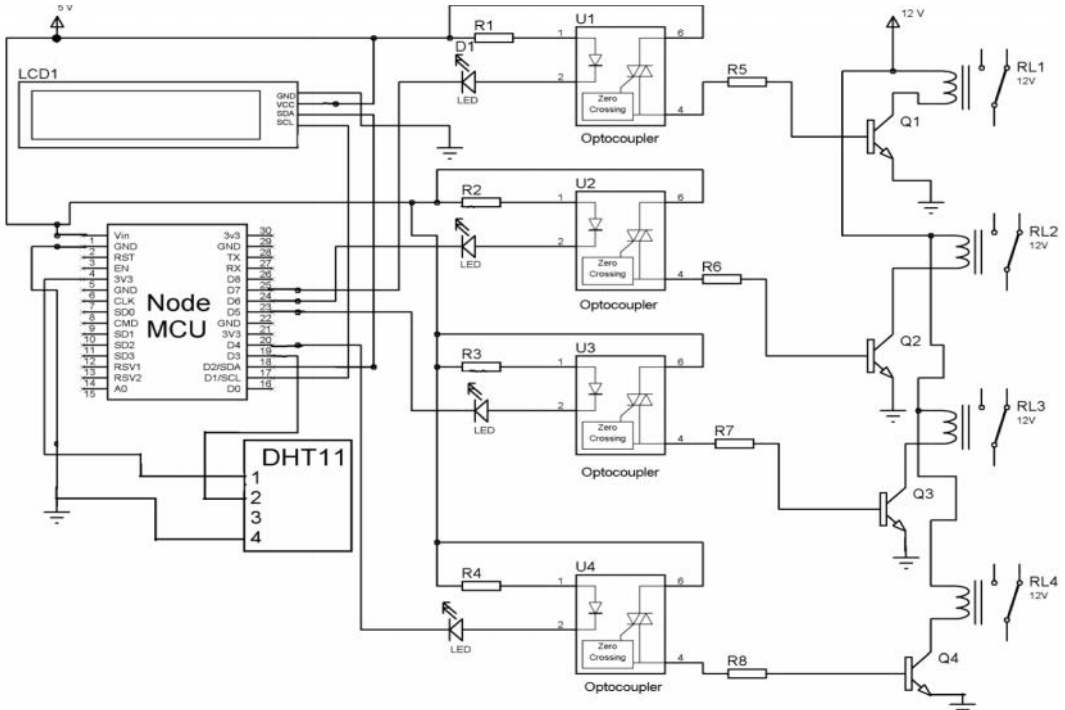

Fig. 3: Circuit Diagram of RTU

A.3 Base Station

A Graphical User Interface (GUI) is developed using dashboard of AdafruitIO server. The user interface is developed using several buttons and gauges. The dashboard is available on the Internet. Hence it can be used from anywhere. It is observed to be more user friendly. Google assistant is one of the most popular AI assistant provided by android phones. Google assistant transfers given commands to the MQTT server to control target devices.

Base station contains some gauges and buttons to monitor and control the appliances. If the value from the sensor is uploaded on server then the value on the gauge changes. If the buttons on the dashboard are pressed towards "1" and "0" then light is turned ON and OFF respectively.

Fig 4: GUI of Base station with gauges and buttons

Software

A program is written in C++ and verified on Arduino IDE, a java based programming platform. It supports C and C++ under special rules of code structuring. It is easy and flexible to use as it provides various libraries for different services.

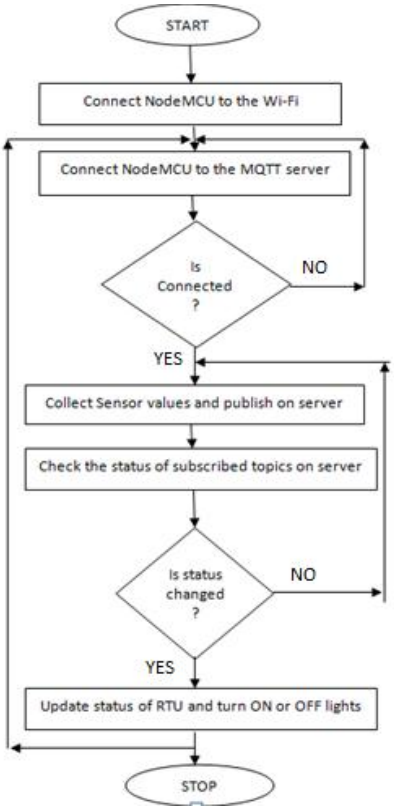

Fig 5: Flowchart of RTU Operations

B. Results and Discussion

Table 1 shows the values of relative humidity and the time lag in data transmission. The values of temperature and relative humidity for 10 minutes are monitored on the server. The system is tested in a computer laboratory and network having 1.18 MBPS uploading and 9.18 MBPS downloading speed. 4 bytes of data are uploaded on the server for every 6 seconds as delays are introduced in program downloaded in NodeMCU and there is time lag for data transmission from RTU to server.

Table 1: Sensor Output and Lag in Data Transmission

Sr. No.	Transmit Time (H:M:S)	Transmitted Parameter		Received Time (H:M:S)	Received Parameter		Time Deviation (s)
		Relative Humidity (%)	Temperature (°C)		Relative Humidity (%)	Temperature (°C)	
1	03:06:15	51	25	03:06:20	51	25	5
2	03:06:47	51	24	03:06:51	51	24	4
3	03:07:04	51	24	03:07:08	51	24	4
4	03:07:41	50	24	03:07:44	50	24	3
5	03:07:59	52	24	03:08:02	52	24	3
6	03:08:22	52	24	03:08:26	52	24	4
7	03:08:51	50	24	03:08:56	50	24	5
8	03:09:12	49	24	03:09:14	49	24	2
9	03:09:35	50	24	03:09:38	50	24	3
10	03:09:58	50	24	03:10:01	50	24	3
11	03:10:25	50	25	03:10:29	50	25	4
12	03:10:49	50	24	03:10:53	50	24	4

13	03:11:07	50	24	03:11:11	50	24	4
14	03:11:31	50	24	03:11:34	50	24	3
15	03:11:43	49	24	03:11:47	49	24	4
16	03:12:01	50	25	03:12:05	50	25	4
17	03:12:19	50	24	03:12:23	50	24	5
18	03:12:25	50	24	03:12:30	50	24	5
19	03:12:46	47	24	03:12:49	47	24	4
20	03:13:18	49	24	03:13:21	49	24	3

Fig. 6 shows the variation of transmitted and received relative humidity with respect to time. Fig. 7 shows the variation of transmitted and received temperature with respect to time. It is observed that there is time lag between transmitted an received parameters (relative humidity and temperature).

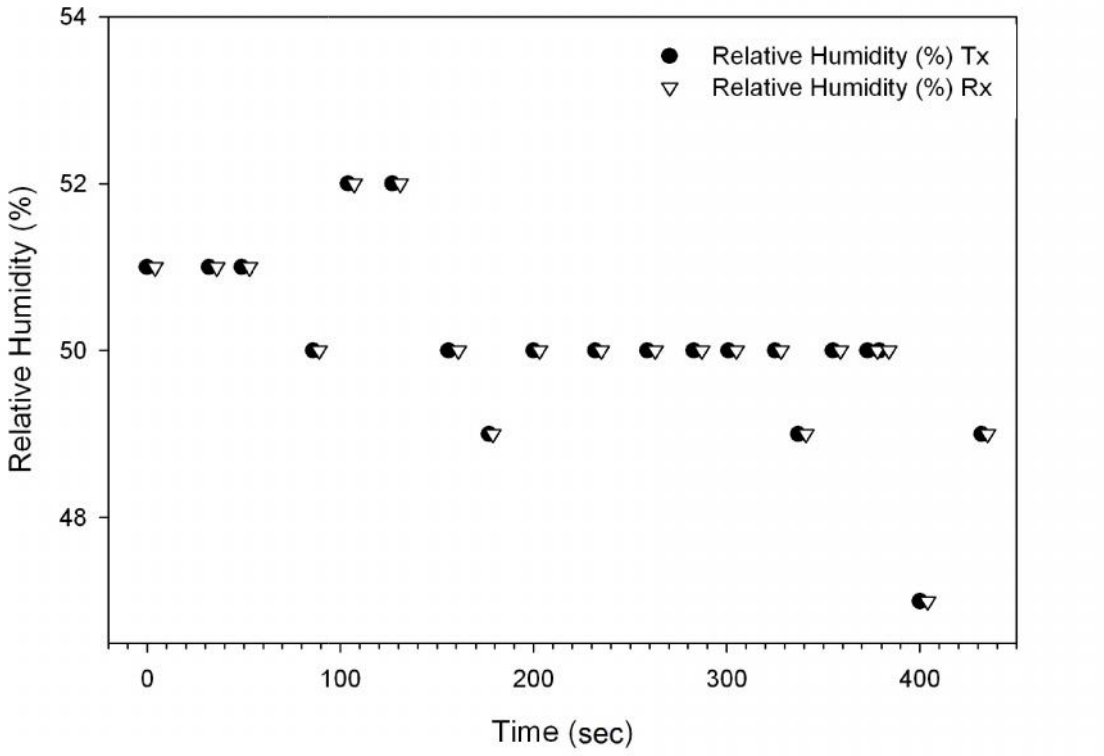

Fig 6: Time Lag in Transmit Relative Humidity and Received Relative Humidity

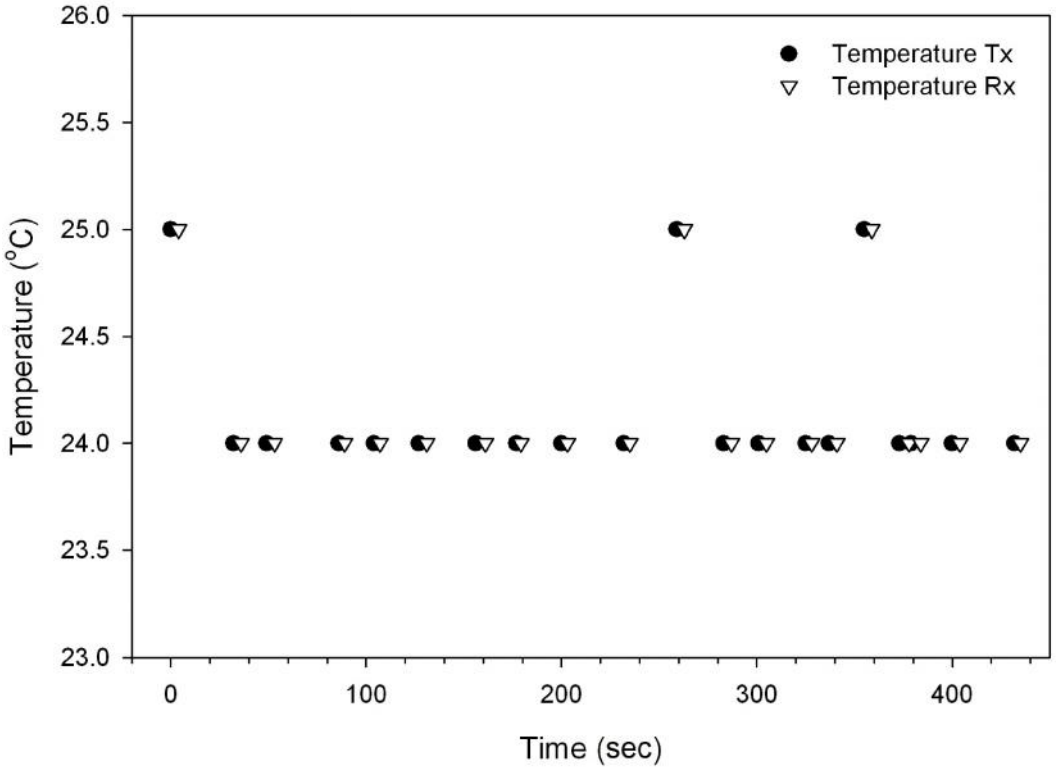

Fig 7: Time Lag in Transmitted Temperature and Received Temperature

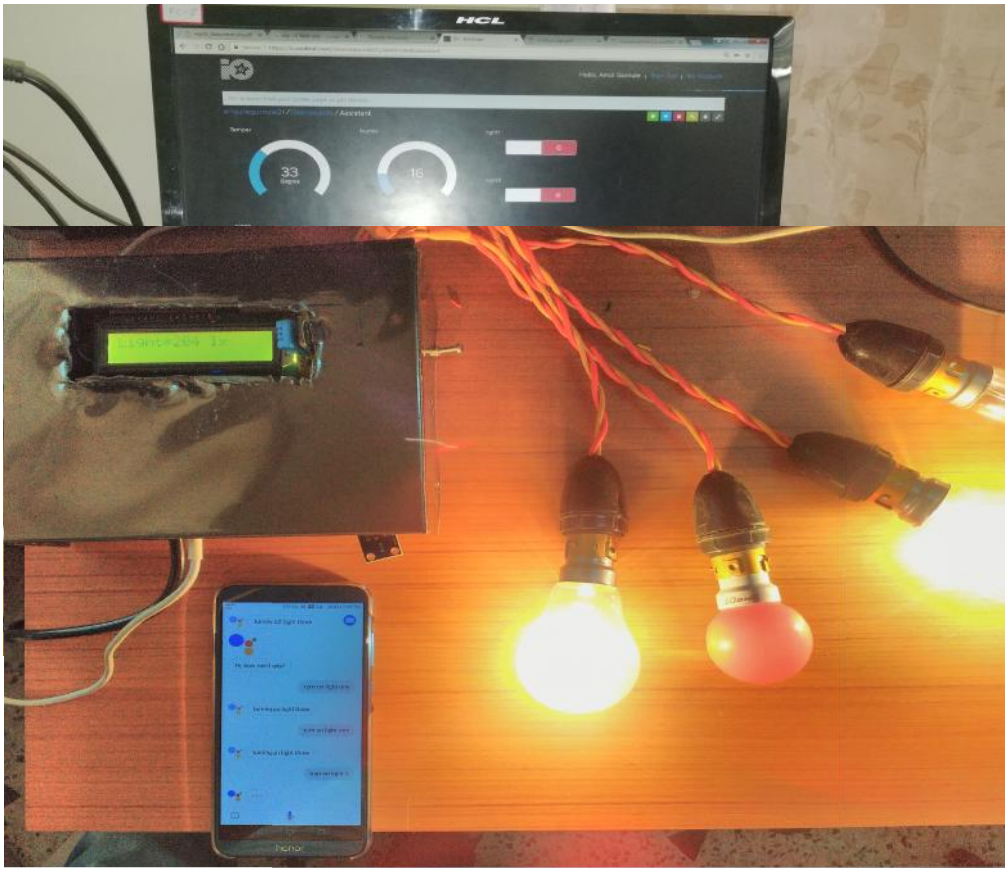

Fig. 8: Light

controlling using server

Fig. 9: Appliance control using Google Assistant

C. Conclusion

Implementation of embedded devices in an industrial environment for monitoring or processing paramtrs minimizes the involvement of human beings. To implement such device we need to deploy the sensors for collecting the data and analyze them for further requirements. By implementing sensor devices in the field, we can bring the field into the realness of real life. Sensor devices can interact with the human being through the network. Data collected by sensors and its analysis will be available to the client on the internet. The smart way to monitor parameters in industry field and an efficient, low cost system is presented the present work. Sensor parameters can be known to the user, if client asks for it. This data will be useful for analysis and it can be easily shared with others.

D. References

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