European Journal of Technique

journal homepage:https://dergipark.org.tr/en/pub/ejt

Vol.12, No.2, 2022

IoT Based Home Automation System using a REST API Architecture

Zaw Lin Oo[1*], Theint Win Lai[2], Aung Moe[3]

[1*]Department of Atomic Energy, Ministry of Science and Technology, Yangon, Myanmar. (e-mail: kozawlinoo@gmail.com).
[2]Info Myanmar University, Faculty of Computer System and Technology, Yangon, Myanmar. (e-mail: t-winlei@imu.edu.mm).
[3]Department of Atomic Energy, Ministry of Science and Technology, Nay Pyi Taw, Myanmar.(e-mail: aung2011m@gmail.com).

ARTICLE INFO

Received: Nov., 02.2021
Revised: Jun., 26.2022
Accepted: Aug., 18.2022

Keywords:
Arduino MKR Wifi 1010
Home automation system
Internet of things (IOT)
REST API

Corresponding author: *Zaw Lin OO*

ISSN:*2536-5010* | e-ISSN: *2536-5134*

DOI: https://doi.org/10.36222/ejt.1018131

ABSTRACT

Internet of things (IOT) imagines a world where every device at any place can be connected. Home Automation system is growing rapidly and now becoming the requirement of the modern world. IoT based Home Automation System is getting more important as it increases security, comfort and improves the quality of life. In this paper, we have proposed the details of how we can automate the home appliances using ARDUINO and REST API architecture. The result also shows how the use of ARDUINO and REST API architecture is beneficial as client/server communication in the field of the Internet of Things. In this paper, the REST API architecture is implemented practically, tested, and gave the accepted results for controlling home appliances. Home appliances such as TV, lighting, Water pump, Fans and etc were controlled from the web page that was created in the XAMPP platform as a client-side. The aim of this study is to develop a home automation system for controlling electronic appliances from a far range by using the Internet of things (IOT).

1. INTRODUCTION

Nowadays, peoples created home automation systems with different designs based on their different needs. For example, some people need to control their home appliances wirelessly within their house but some want to control remotely from anywhere that they can get internet access. This research is commonly used to operate a device from an internet webpage and provide safety and convenience to the user. The user can control different home appliances like room lighting, air conditioners, fan, televisions, etc. from a webpage remotely by just clicking on and off buttons what they want it to do.

Many types of commercially home automation systems that are intended to control all lights and electrical appliances in a home or office can easily be available. But, they have challenges which are high cost, need to replace all legacy home appliances with new compatible ones, not user-friendly, limited range of control system and not easy to operate. Some requirements have proceeded for home automation system to satisfy their needs and comfort while for people who stay outside of the home and they want to control their devices for great assistance with easy user-friendly operation. This paper tried to develop a cost-effective, simple, and user-friendly system capable of automating home appliances. This is further improved because the client/server communication based REST API architecture is used in the field of the Internet of Things.

2. RELATED WORK

There have been several types of research and projects related to home automation systems. The home automation system with voice recognition and touch screen technology [1] uses a wireless home automation system to control lights and other electrical appliances at home or office using voice commands and touch screen responses. The Microsoft Speech API is running on the PC to recognize the voice commands. The RF transceiver is used to send these commands to the controller to control the various electrical devices. The use of the Voice Recognition Module makes this system more expensive and difficult to handle.

Arduino Based Home Automation System that Implementation on REST Architecture [2] proposed a system that uses Arduino UNO board with Ethernet Shield to provide local network connectivity and controlled by an android application. The Arduino gets the voice command and works according to the speak control of the users. This research project used REST Architecture for communication but voice control is not accurate for controlling home appliances.

Design and Implementation of Modular Home Automation Based on Wireless Network, REST API, and WebSocket [3] use Raspberry Pi 2 as a localhost server, XBee module as a wireless communication module between the Raspberry Pi with Arduino Uno, Arduino Uno which receives commands from Raspberry Pi and Android application for HTTP

requests. This paper [3] used two hardware devices, Raspberry Pi and the Arduino Uno, that make them more costly and difficult to maintain.

Design and Implementation of an Internet of Things based Prototype for a Smart Home Automation System [4] is designed and implemented for IoT based prototype of a smart home automation system. The main controller ATmega16 and Android App is used for intra-home network and the interoperable layer. This prototype has been implemented for the status monitoring purpose and also used for demonstration of controlling the action.

The appliances employed in this project are Arduino MKR WIFI 1010 microcontroller and 5V Four-Channel Optical Isolated Relay Module as hardware devices. REST API and XAMPP are used for software development. REST API standardised the communication between Arduino and the external world via WiFi or Ethernet and XAMPP, a web server software package used for website development.

In this project, Arduino MKR WIFI 1010 performs as the server side and the web browser is used as the client side for client/server communication. The Arduino MKR WIFI 1010 microcontroller is a new generation of Arduino product and also cheap for use. Home appliances are controlled easily through the internet by opening a web browser and contain easy features for user-friendly design. No need to install special apps for Home Automation control and wide range control using internet connections are main developments of this project.

3. SYSTEM DESIGN

This paper will contribute to designing and developing IoT based Home Automation System with a REST API Architecture on client/server communication. The webpage created with HTML and CSS on the XAMPP package is used to control the devices and contains the interface. XAMPP is the software that has a complete PHP, Apache, and MySQL web development environment. In this project, A JavaScript file is also used to handle the commands coming from the interface of the HTML page. A PHP file is worked for communication function with the Arduino board by making REST calls. In this study, Arduino MKR WiFi 1010 Board microcontroller is used to connect with the webpage interface via WiFi connectivity for the IoT applications module. The overall design and architecture of the system is illustrated in Fig. 1, where the communication of web browser to the microcontroller via WiFi connection calling REST API and microcontroller also control home appliances using a relay as a switch are shown.

3.1. Arduino MKR WiFi 1010

MKR WIFI 1010 is the evolution of the MKR1000 and is equipped with an ESP32 module made by U-BLOX. The MKR Wifi 1010 aims to speed up and simplify the prototyping of WI-FI based IoT applications thanks to the flexibility of the ESP32 module and its low power consumption. The design includes a Li-Po charging circuit that allows the Arduino MKR WIFI 1010 to run on battery power or external 5V, charging the Li-Po battery while running on external power. Switching from one source to the other is done automatically.

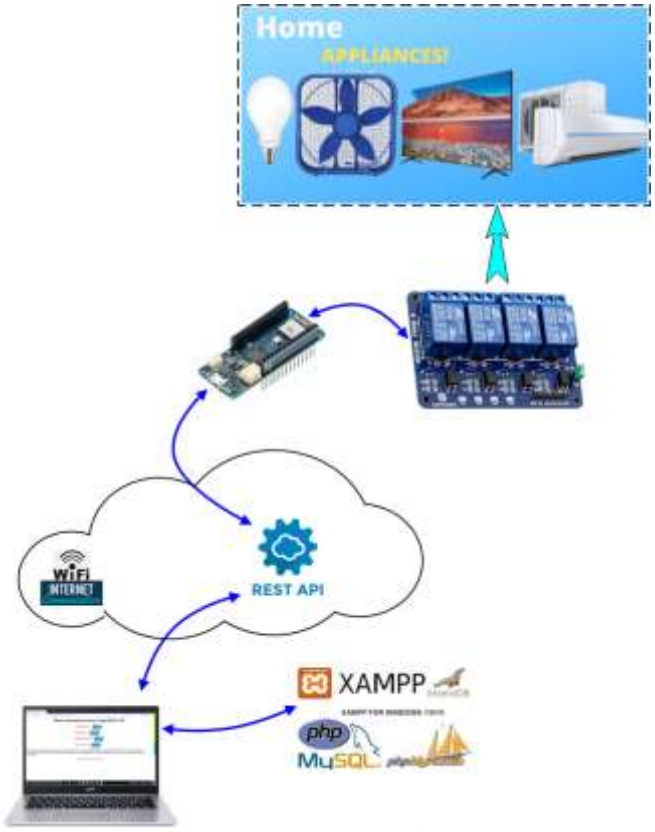

Figure 1. Overall Design and Architecture of the Proposed System

A good 32 bit computational power, the usual rich set of I/O interfaces, low power Wi-Fi with a Cryptochip for secure communication, and the ease of use of the Arduino Software (IDE) for code development and programming. All these features make this board the preferred choice for the emerging IoT battery-powered projects in a compact form factor. The USB port can be used to supply power (5V) to the board. The Arduino MKR WIFI 1010 is able to run with or without the Li-Po battery connected and has limited power consumption [5].

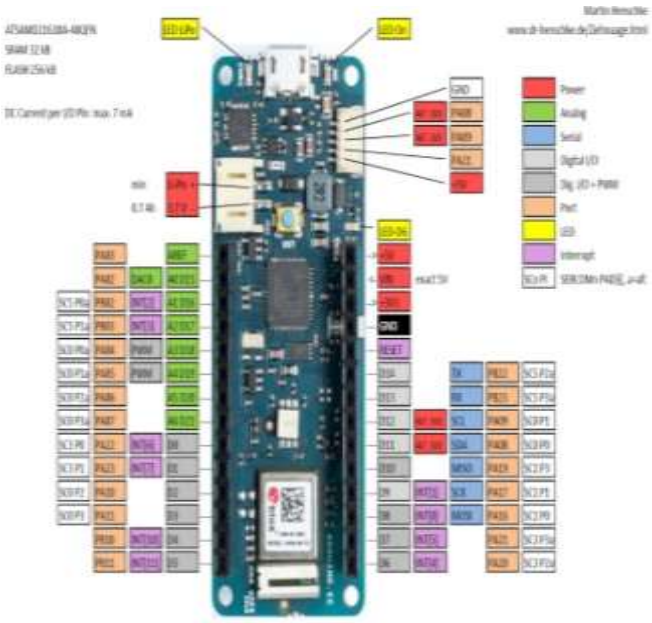

Figure 2. Arduino MKR Wifi 1010 Board
https://www.henschke-geraetebau.de/dr/MKR_WiFi_1010_Pinout.pdf

3.2. REST API

REST stands for REpresentational State Transfer, and is a communication architecture that was created back in 2000. The concept of REST that is widely used by many web applications like SaaS (Software as a Service) [6]. It uses HTTP protocol for data communication and all the components that are involved in the communication are accessed by the standard HTTP version. REST is web based architecture and it treats every component as a resource which is easily accessible by the HTTP Standards [7].

This allowed to standardise communication between web applications, and made them more scalable, faster, and simplified the development of more complex applications. And for our research projects, it allows to standardise the communication between Arduino and the external world via WiFi or Ethernet, and develop complex applications without having to modify Arduino sketch every time. With this REST API, it's easy to load a sketch once for all on the Arduino, and then only work on the interface on computer browser that makes REST calls on the Arduino board. And for now, this kind of interface was only available on the official Arduino boards, like the WiFi & Ethernet shields, and the Yun. The library that will handle the REST calls, which is called aREST. The sketch that will create a web server on the Arduino MKR WIFI 1010 board, and then accept REST commands from an external client, like from an interface running on the computer web browser [6].

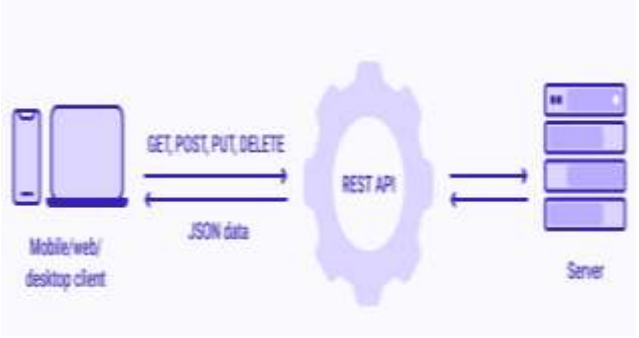

Figure 3. REST API communication architecture

3.3. XAMPP

In this research work, XAMPP is installed and tested on a local PC using the Apache HTTP server component of the XAMPP package. XAMPP, a free, open-source software package produced by the non-profit organization Apache Friends, is the most popular web server software package used for website development. XAMPP is (X) cross-platform, and, at minimum, contains the (A) Apache HTTP server, and supports the (M) MySQL database, (P) PHP scripts, and (P) Perl scripts. XAMPP distribution packages are available for Windows, Linux, and OS X system operating environments. Officially, XAMPP's designers intended it for use only as a development tool, to allow website designers and programmers to test their work on their own computers without any access to the Internet. To make this as easy as possible, many important security features are disabled by default. XAMPP has the ability to serve web pages on the World Wide Web. A special tool is provided to password-protect the most important parts of the package. XAMPP also provides support for creating and manipulating databases in MariaDB and SQLite among others. Once XAMPP is installed, it is possible to treat a localhost like a remote host by connecting using an FTP client. Using a program like FileZilla has many advantages when installing a content management system (CMS) like Joomla or WordPress. It is also possible to connect to localhost via FTP with an HTML editor [8].

XAMPP is used that to build a simple web application that will run in the browser, with buttons to control the home appliances that are connected to the Arduino board.

For this part, a working web server (like Apache) is needed for running on the computer with appropriate web page, and also required to put all the files at the root of the web server's main folder.

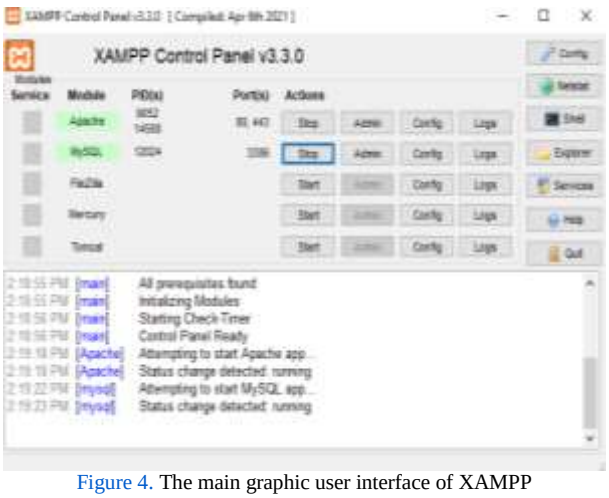

Figure 4. The main graphic user interface of XAMPP

3.4. 5V Four-Channel Optical Isolated Relay Module

This is a LOW Level 5V four-channel relay interface board, and each channel needs a 15-20mA driver current. It can be used to control various appliances and equipment with large current. It is equipped with high-current relays that work under AC250V 10A or DC30V 10A. It has a standard interface that can be controlled directly by microcontroller. This module is optically isolated from high voltage side for safety requirement and also prevent ground loop when interface to microcontroller [9].

Relay Maximum output: DC 30V/10A, AC 250V/10A [9]. Four Channel Relay Module with Opto-coupler. LOW Level Trigger expansion board, which is compatible with Arduino control board [9].

Standard interface that can be controlled directly by microcontroller (8051, AVR, *PIC, DSP, ARM, ARM, MSP430, TTL logic) [9].

Relay of high quality low noise relays SPDT. A common terminal, a normally open, one normally closed terminal [9].

Opto-Coupler isolation, for high voltage safety and prevent ground loop with microcontroller [9].

The switching transistors act as a buffer between the relay coils that require high currents, and the inputs which don't draw much current. They amplify the input signal so that they can drive the coils to activate the relays. The freewheeling diodes prevent voltage spikes across the transistors when the relay is turned off since the coils are an inductive load. The indicator LEDs glow when the coil of the respective relay is energized, indicating that the relay is active. The optocouplers form an additional layer of isolation between the load being switched and the inputs. The isolation is optional and can be selected using the VCC selector jumper. The input jumper contains the main V-CC, GND, and input pins for easy connection using female jumper wires [10].

Figure 5. 5V Four-Channel relay module https://components101.com/sites/default/files/components/Four-Channel-Relay-Module.jpg

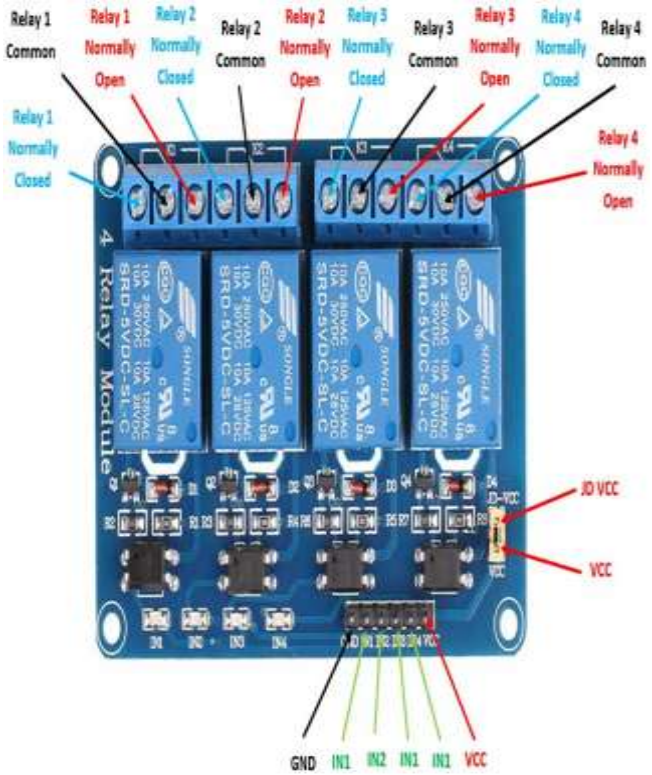

Figure 6. 5V Four-Channel relay module pinout https://components101.com/sites/default/files/component_pin/Four-Channel-Relay-Module-Pinout.jpg

3.5. WiFiNINA Library

This library enables network connection (local and Internet) with the Arduino MKR WiFi 1010, Arduino MKR VIDOR 4000, Arduino UNO WiFi Rev.2, and Nano 33 IoT. This library can instantiate Servers, Clients and send/receive UDP packets through WiFi. The board can connect either to open or encrypted networks (WEP, WPA). The IP address can be assigned statically or through a DHCP. The library can also manage DNS. The WiFiNINA library is very similar to the Ethernet and the library WiFi, and many of the function calls are the same [11].

Arduino MKR WiFi 1010 is used an ESP32 module made by U-BLOX for connecting of Wifi network. WiFiNINA Library is helping to enable the network connection of Arduino board with the local network to control home appliances via the internet.

Figure 7. WiFiNINA library for Arduino IDE

4. IMPLEMENTATION OF SYSTEM

The proposed system allows users to control their home appliances remotely at any desired time, using smart phones, tablets, and PCs via a web browser application. Using REST API and IoT platform, the user can control their home appliances easily through the internet by remote access.

For web interfacing, HTML with CSS is used in developing the web page on the XAMPP cross-platform software. The main section of web pages has a very simple interface and is easy to control the desired home appliances. Firstly, The HTML part that interfaces for control consist of eight buttons which are defined by the id code. These id codes need to assign for each button for "on" and "off" states of home appliances control. So, each click of the button is passed with "this.id" argument that contains HTML codes.

Secondly, the JavaScript file handles the commands coming from the web interface to control the devices correctly. So, a JavaScript file manipulates the command that to guide the Arduino board by using the REST API. For this particular button, pin number and state are handled by the JavaScript file. So, this is the important part of REST API Architecture for connection with Arduino and hardware devices. Finally, The PHP file named "curl.php" is created to use when each button is pressed. This PHP file contains a set of functions to make the REST call to the Arduino board. This PHP file starts by getting the pin and state assigned with the JavaScript file to be sent to the Arduino board. And then the cURL object is initialized and executed to make the REST call. So, A web-based app and the Arduino IoT board can make a standard way of communicating using the REST API library over the wireless communication platform.

On the other side, Arduino MKR WiFi 1010 microcontroller is connected with a 5V four-channel optical isolated relay module's input pins. VCC and GND pins of the relay module are connected with 5V and GND pins of Arduino respectively to get the power of the relay breakout board. The next step is the individual trigger terminals of the relay module that are needed to connect with Arduino output pins for switching on and off actions for home appliances.

Arduino Digital Pin 6 will be connected to the pin "IN1" on the relay breakout board, Arduino pin 7 to "IN2", Arduino pin 8 to "IN3", and Arduino pin 9 to "IN4" connect with different wire color disciplines. The relay module output pins COM and NO are joined with the home appliance to get a normally open connection. This situation sets no contact between COM and NO pins when the corresponding IN pins of the relay module has a LOW state. Circuit diagram for IoT-based home automation system with hardware components shown in Figure 8.

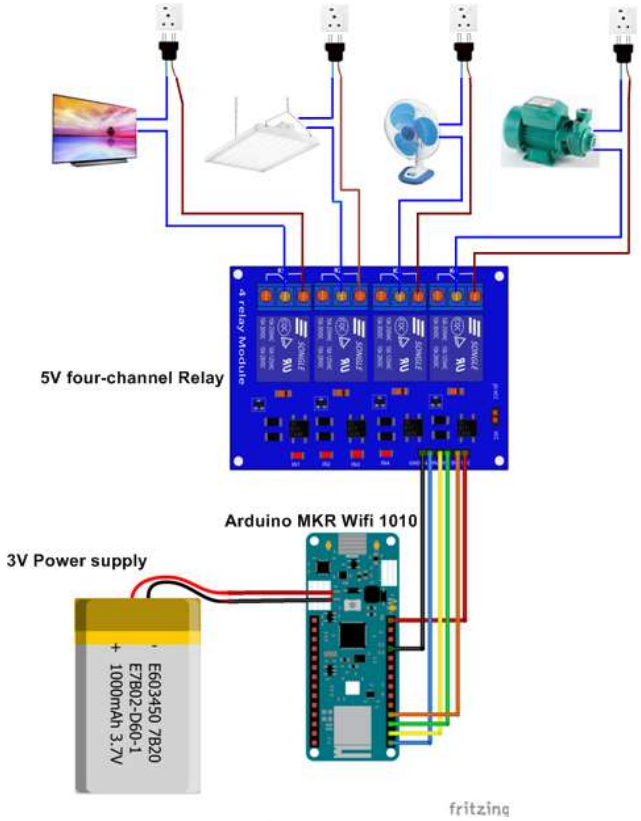

Figure 8. Circuit diagram for IoT-based home automation system

5. RESULTS AND DISCUSSION

The project implementation includes aREST library installation, testing the project with basic functions of the REST API from the browser address bar, and testing from a simple web application that will run in the XAMPP platform. The aREST library is directly installed from the Arduino library manager. Figure 9 shows the aREST installation for Arduino IDE to make a client/server communication.

Figure 9. aREST library installation

For testing the project with basic functions of the REST API from the browser address bar, the sketch is compiled and uploaded to the Arduino board. And then, one of the Arduino pins is set as an output by typing http://192.168.100.19/mode/7/o from the address bar of the favourite browser. Figure 11 shows confirmation printed for the output setup of the Arduino D7 pin. In this step, the IP address of the Arduino board can get from the connection details of the serial monitor shown in Figure 10.

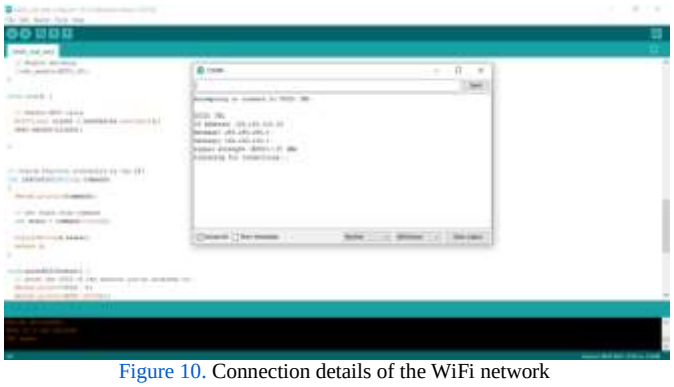

Figure 10. Connection details of the WiFi network

Figure 11. Output setup confirmation printed of the Arduino D7 pin

For testing from a web application included building a simple web application on an Apache web server that runs on the XAMPP platform and testing completed interface with the web server and Home appliances. In this step, An HTML page that contains the CSS interface, a JavaScript file for handling the commands, and a PHP file for communicating with the microcontroller board by making REST calls are used for Home Automation System.

Figure 12. Simple web application on an Apache web server for home automation system

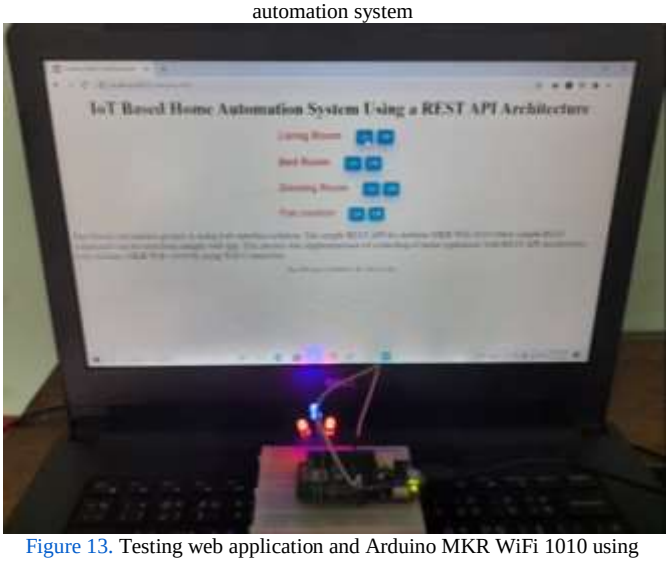

Figure 13. Testing web application and Arduino MKR WiFi 1010 using REST API architecture

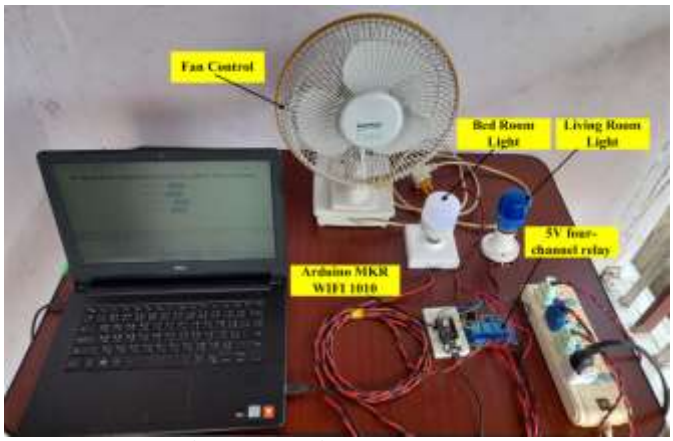

Figure 14. Set up for prototype of IoT based home automation system

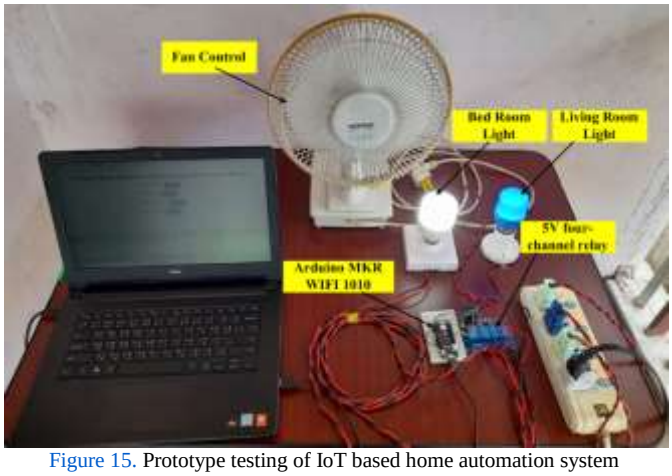

Figure 15. Prototype testing of IoT based home automation system

6. CONCLUSION

Presently, the Home Automation project could be used to control three rooms' lighting and fan for prototype testing. In the initial stage, the prototype was tested with LED for safer testing of REST API architecture. The system was successfully tested with a chrome web browser on a local PC using the Apache HTTP server. This system implements the WI-FI based IoT applications and low power consumption using Arduino MKR WIFI 1010.

The network security protection system is still needed for this project. So, the system needs to develop a good network security part for a Secure Home Automation System. We need a secure login page for specific users or visitors that will be assigned the needed login credentials before they can log in to the dashboard area of the Home Automation Web page.

REFERENCES

[1] T. Kirankumar and B. Bhavani, "A Sustainable Automated System for Elderly People Using Voice Recognition and Touch Screen Technology". International Journal of Science and Research (IJSR), Volume 2, Issue 8, August 2013, pp. 265-267.

[2] Shankey Garg and Mohd. Shajid Ansari, "Implementation of REST Architecture in ARDUINO Based Home Automation System" International Conference on Innovations in Control, Communication and Information Systems (ICICCI) 2017, 12-13 Aug. 2017. DOI: 10.1109/ICICCIS.2017.8660936.

[3] Atas Hasibuan, Muhammad Mustadi, Dr. Ir. Eniman Y Syamsuddin, Ir. M. Anis Rosidi, "Design and Implementation of Modular Home Automation Based on Wireless Network, REST API, and WebSocket", 2015 International Symposium on Intelligent Signal Processing and Communication Systems (ISPACS) November 9-12, 2015. DOI: 10.1109/ISPACS.2015.7432797.

[4] Kshirod Kumar Rout, Samuchita Mallick, Sivkumar Mishra , "Design and Implementation of an Internet of Innovations in Electrical, Electronics & Communication Engineering (ICRIEECE), 27-28 July 2018. DOI:10.1109/ICRIEECE44171.2018.9008410.

[5] Zaw Lin Oo, Theint Win Lai, Aung Moe, "Iot Based Low-cost Physical Protection and Alarm System for Gamma Irradiation Facility". Conference on Science and Technology Development (CSTD-2019), Oct 31- Nov 1, 2019.

[6] Marc-Olivier Schwartz, "A REST API for Arduino & the CC3000 WiFi Chip". Adafruit Learning System, [online]. Available: https://learn.adafruit.com/a-rest-api-for-arduino-and-the-cc3000-wifi-chip.

[7] Zhang Xinshuang, Wen Zhigang, Wu Yuexin, Zou Junwei, "The Implementation and Application of the Internet of Things Platform based on the REST Architecture". International Conference on Business Management and Electronic Information 2011, 13-15 May 2011. DOI:10.1109/icbmei.2011.5917838.

[8] Zaw Lin Oo, Theint Win Lai, Maung Maung Than, "Web Server Base RFID Attendance Record System". International Conference on Recent Innovations in Nanoscience and Technology 2018 (ICRINT2018), December 26–28, 2018.

[9] User Guide for 4 Channel 5V Optical Isolated Relay Module, [online]. Available: https://www.handsontec.com/dataspecs/4Ch-relay.pdf

[10] Datasheet for 5V Four-Channel Relay Module, [online]. Available: https://components101.com/switches/5v-four-channel-relay-module-pinout-features-applications-working-datasheet

[11] WiFiNINA arduino libraries, [online]. Available: https://github.com/arduino-libraries/WiFiNINA

BIOGRAPHIES

Zaw Lin Oo obtained his B.E (Bachelor of Engineering) and M.E (Master of Engineering) degrees in Nuclear Engineering from Yangon Technological University, Yangon, (Myanmar) Burma, in 1999 and 2003, respectively and a Ph.D. degree in Nuclear Engineering in the year 2007 from Yangon Technological University, Yangon, (Myanmar) Burma. His research interests include computer science and engineering- embedded systems, cloud computing, artificial intelligence, Electrical and electronic engineering- electronic, control system.

Theint Win Lai is presently associate professor at the Faculty of Computer System and Technology, Info Myanmar University, Yangon, (Myanmar) Burma. She received the B.S. degrees in Physics from the Pathein University, in 1999 and the M.S. degree in computer Hardware Technology from Yangon Technological University, Yangon, (Myanmar) Burma, in 2002. She received the Ph.D. degree in computer Hardware Technology from University of Computer Studies, Yangon (UCSY), in 2006. Her research interests are computer science and engineering- embedded systems, cloud computing, artificial intelligence, Electrical, electronic engineering- electronic, control system and IoT based control system.

Aung Moe is presently Director in the Myanma Scientific and Technological Research Department at the Ministry of Science and Technology. Nay Pyi Taw, Myanmar (Burma). He obtained B.Sc and M.Sc degrees in Physics from University of Yangon, Yangon, (Myanmar) Burma, in 1992 and 1997, respectively. He received the Ph.D. degree in Nuclear Engineering from National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), in 2006. His research interests are computer science and engineering- embedded systems, Advanced diagnostic systems, and Advanced Information System Modeling Technologies.