A Mini-Project Report on

IoT Enabled Smart Laboratory System

Submitted in fulfilment of Mini-Project (ITM605) of

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Information Technology

By

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CERTIFICATE

This is to certify that

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has completed all the specified work for submission in Mini-Project (ITM605) of Semester VI, as laid down by University of Mumbai in satisfactory manner within the premises of Institute during the academic year 2019-20.

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Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included, we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic with honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in our submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

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Abstract

Internet of Things is a system where appliances are embedded with software, sensors and actuators. The devices are able to transfer data over a network and also communicate with each other. This technique is incorporated in our labs to make the appliances convenient and automated. In this modern era of Automation, it has been observed that many of the University and college Labs don’t have IT automation capabilities up to the current industrial modern standards. The latest technologies aren't being implemented in colleges and thus the students can't benefit from them. Automation is an area which is gaining popularity increasingly day by day since last couple of years.

The aim behind our project is to help different appliances to not just connect with each other, but with the user, in a simple, friendly manner. Here we are assuming a system which can give the user complete control over all remotely controllable aspects of the irrespective Laboratories. One can simply achieve lab automation by simply connecting the appliances to a central network or cloud storage.

CONTENTS

Introduction

There are many devices in a laboratory, such as Lamps, Fans, Air Conditioners and Projectors. Lab automation can be described as a technology which is used in the college environment to provide comfort, convenience and energy efficiency to its user and students. Automation is a concept which involves real time control and monitoring of multiple appliances. Today, there is a n increasing demand of automated systems so that human intervention is reduced. The user can make use of this system to control switching on of lights, fan, AC, etc. automatically. The user can access complete IoT system from anywhere using Internet. Raspberry Pi is a small sized computer which acts as a server for the system. A smart laboratory is a place that has highly advanced automatic systems for controlling and monitoring lighting and temperature, laboratory appliances, and security systems and many other functions. Through IoT almost every object of our daily life in a home can be connected to the Internet. IoT allows monitoring and controlling all of these connected objects regardless of time and location IoT plays an important role in building smart laboratory.

As campus grows every year, new management problems and energy issues appear. Managing the resources in the campus has become a real problem. Monitoring and controlling the unused devices that consume power during human absence is also a major inability. In addition to this, coordinating the people participating in the daily activities of the laboratory is tedious when population of the usage of the space out numbers a manageable threshold. Another problem is power management. It is difficult to monitor all sub-systems such as lighting, projecting and air conditioning system. People cannot check the status of the sub-system at ease. The current, usual way to control the appliances in the lab is to manually toggle switches on the switch board of the particular Lab. However, that in itself is a time-consuming task as a person has to be available to do so. Our proposed system is aimed at developing an automated solution where even if the end – user/ admin is located remotely; the appliances can be turned on. The website basically converts smart phones into a remote for all appliances. The user can access complete IOT system from anywhere using Internet. Therefore, the main motive behind creating the system like lab automation is that you can direct and coordinate how a gadget ought to respond and why it needs to respond. Your duty is to set the schedule and the rest is automated and based off of your desired penchants hence giving control or connect with the gadgets of lab. All the appliances within lab can be linked together through a common gateway and devices are controlled using MQTT protocol implemented on ESP8266 using Node-RED. Raspberry Pi is a small sized computer which acts as a server for the system.

Literature Review

1] Paper title: Design and Implementation of IoT Based Smart Laboratory.
Authors: M. Poongothai, A. Rajeswari and P. Muthu Subramanian.

More than 85% of systems are unconnected, and do not share data with each other or the cloud. One such technology that facilitates the interconnection is the INTERNET OF THINGS. The Internet of Things is a communication paradigm that refers to the idea of connecting the objects of everyday life to the internet. These objects are assembled with microcontrollers, transceivers to enable communication and configured with protocol stacks that will realize the interaction of the objects with one another to reach to common goals without human intervention. This paradigm gained its strength from the fact that it is interacting with a wide variety of devices such as: robots, drones, heating and air-conditioning systems, security alarms, household appliances, power generation systems, office equipment, college appliances and so on which generate a massive amount of data to provide new services to people and both public and private sectors.

Application code written for interfacing IoT smart hardware kit & MQTT broker, and for monitoring temperature, humidity and light intensity inside the laboratory. Developed Dashboard and mobile application using Node-RED and ANDROID STUDIO. A database has been created for a prototype switch to view status history. IOT reduces the human intervention by introducing device to device interaction. By employing the proposed system, the total energy consumption can be reduced in our campus.

2] Paper title: IoT Based Home Automation Using Node-Red.

Authors: R. K. Kodali and A. Anjum.

In this paper, an efficacious home automation system using low-cost Wi-Fi development boards is proposed. Node-RED, which is a visual wiring tool that helps in associating gadgets easily bringing about fast and effortless connection setups. Gadgets are linked together to ESP8266 and a Mosquito based MQTT broker using Node-RED and a connection is setup for remote monitoring and control. The Internet of Things (IoT) now does not just mean ‘diverse things’, but has developed into ‘smart things’ which have onboard calculation and system associations. Node-RED is a programming tool for wiring together hardware devices, online services and APIs. Node-RED enables users to fasten together web services and gadgets by replacing common coding tasks and this should be possible with a visual drag-drop interface. Various components in Node-RED are connected together to create a flow in the Node-RED editor.

Message Queuing Telemetry Transport (MQTT) provides a lightweight messaging protocol which uses a publish/subscribe model because of which it is worthy to be used on all devices from low power boards to servers. A client can publish or subscribe to a topic or do both. Whereas as a broker receives all the messages, filters them and send them to the subscribed client. Node-Red is thus an efficient platform to link a number of IoT gadgets and can be controlled from any part of the world. With the rise in the number of gadgets on the cloud platforms, there is a requirement for refreshing firmware very often.

3] Paper title: Internet of Things (IoT) for building Smart Home System.

Authors: T. Malche and P. Maheshwary.

A smart home also referred to as a connected home or E-Home is an environment for living that has highly advanced automatic systems. A smart home ap pears " intelligent" because its daily activities are monitored by a computer. A smart home consists of many technologies via home networking for improving quality of living. A smart home is a place that has highly advanced automatic systems for controlling and monitoring lighting and temperature, home appliances,
multi-media equipment, and security systems and many other functions. A smart home system consists of applications built on top of IoT infrastructure. The smart home applications can have following main functions: alert, monitor, control, Intelligence. Although the application area of a smart home is only limited by human imagination, this paper illustrates some of them which are described below-smart lighting, smart appliances, intrusion detection, smoke/gas detection.

An IoT based smart home is emerging as an important part of the smart and intelligent cities which are being proposed and developed around the world. The purpose of a smart home is to improve living standard, security and safety as well as save energy and resources. The smart home plays an important role in development of society. The aim of this paper is to propose such system based on FLIP. The proposed system can be implemented as per user requirement.

4] Paper title: IoT Based Smart Security and Home Automation.

Authors: S. Somani, P. Solunke, S. Oke, P. Medhi and P. P. Laturkar.

This paper focuses on a system that provides features of Home Automation relying on Internet of Things to operate easily, in addition to that it includes a camera module and provides home security. The android app basically converts Smartphone into a remote for all home appliances. Following are the main components of the system: Raspberry Pi, sensors, appliances. Initially the user logs in to our android app by entering default credentials. There is facility for admin access to add/remove users and change the default username and password. A socket runs at server (Raspberry Pi), which is open constantly and waits for request from user.

When user clicks on login a client socket is created in android app and connection begins between Raspberry Pi and the android device. The encrypted data is passed through this socket to Raspberry Pi. At Raspberry Pi side decryption of the data takes place. This decrypted data is verified with the entries present in Raspberry Pi memory itself. If correct details are provided a response is sent back to device which starts a new activity. This new activity can then be used to control any home appliances with a simple on/off button UI. The requests are handled at server side by Raspberry Pi. Enhance the IoT's network security using encryption and decryption of the user's data.

5] Paper title: A step towards Home Automation using IOT.

Authors: H. K. Singh, S. Verma, S. Paland and K. Pandey.

The aim of this paper is to develop home automation system based on IOT using Wi-Fi based microcontroller. As scope of technology is widening every day, we are making our tech advance in mobile, robotics, Machine Learning, then why an exception for our home. NodeMCU (ESP8266) microcontroller along with Relays is used to control electrical switches remotely from the server which is built on Node.js. User can control switches using a Web Application after authenticating. The proposed system consists of web server, web interface, database, NodeMCU and Solid-State Relays. Server controls and monitors appliance state and user command, and can be easily configured to handle more hardware interface module. The web server is running on NodeJS which in turn running on AWS (Amazon Web Services). Beauty of this Automation System is that it can be accessed from the web browser remotely from any PC or mobile handled device connected to the internet. Wi-Fi is chosen to improvise system security, mobility and flexibility.

In this work, a real- time home automation system has been successfully implemented which is quite effective in terms of performance and technology. The log file been generated as a result of changing state of appliances. It can be used to track the user's behaviour i.e. the time of controlling the appliances. Using this log file, we can apply Machine L earning to the system, through which the system will learn how the user operates the appliances in his house. According to the results provided by the ML, the system can automatically change the state of the appliances based on the behaviour of the user.

Existing System Architecture/Working

Here in the figure shown alongside, the administrator will be provided with a remote access and with the help of the internet it is connected to the web server and through that web server, a web application or android application will be hosted.

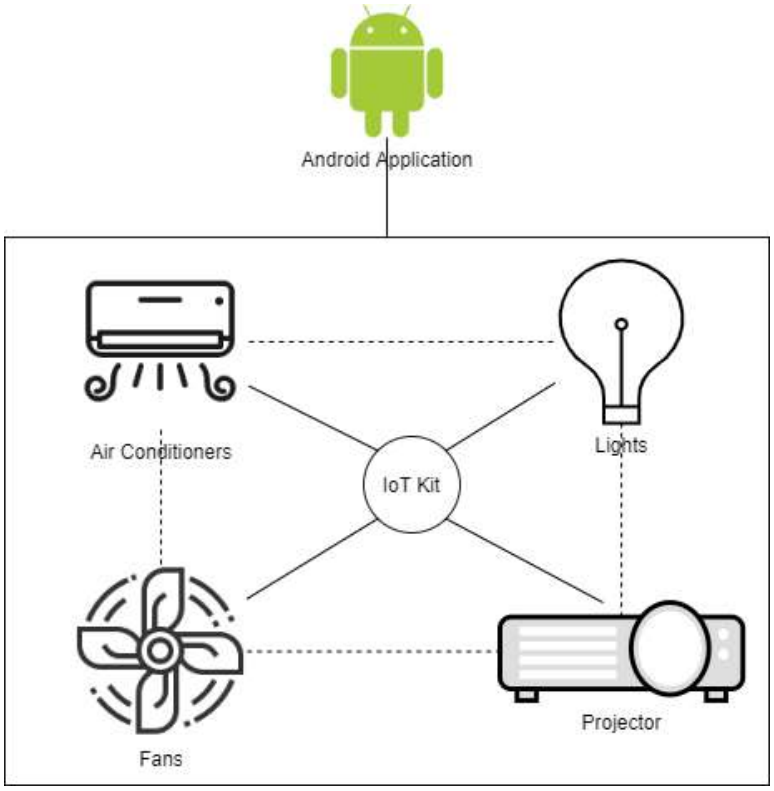

Figure 1 : Architecture of Laboratory Remote Interface Management

Android/Web Application:

- The Administrator will be provided with the PC, where he will have access to all the PCs, lights, fans, air-conditioners and projectors which are connected in network.

Appliances:

- Lights, fans, projectors, air-conditioners and computer switches will be connected through IOT kit.
- These systems should be connected to internet via WLAN

Problem Definition

Our institute has an abundance of laboratories and hence, more staff. Some staff have different working patterns than others. Every time if a lab session ends, more often the machines and appliances are left running. Physically toggling the individual lights, fans and systems in the beginning of a lab session adds to the wastage of time of the session. A solution should be developed where everything is controlled remotely to save time, power consumption and also energy in terms of man power.

Objectives

- To minimize, Monetary costs, User discomfort, Delays, Utilization of resources.
- To automate the appliance controlling of Labs.
- To reduce the power consumption by efficient usage of the appliances.
- To integrate lab timetable with the system.

Proposed System Architecture/Working

Figure 2 shows the proposed system Architecture of IoT enabled smart laboratory layout at our Institute. All the appliances in the lab are connected to the smart IoT hardware kit which includes Node-RED, SQLite for database and MQTT broker which is unique board exclusively designed for college laboratories.

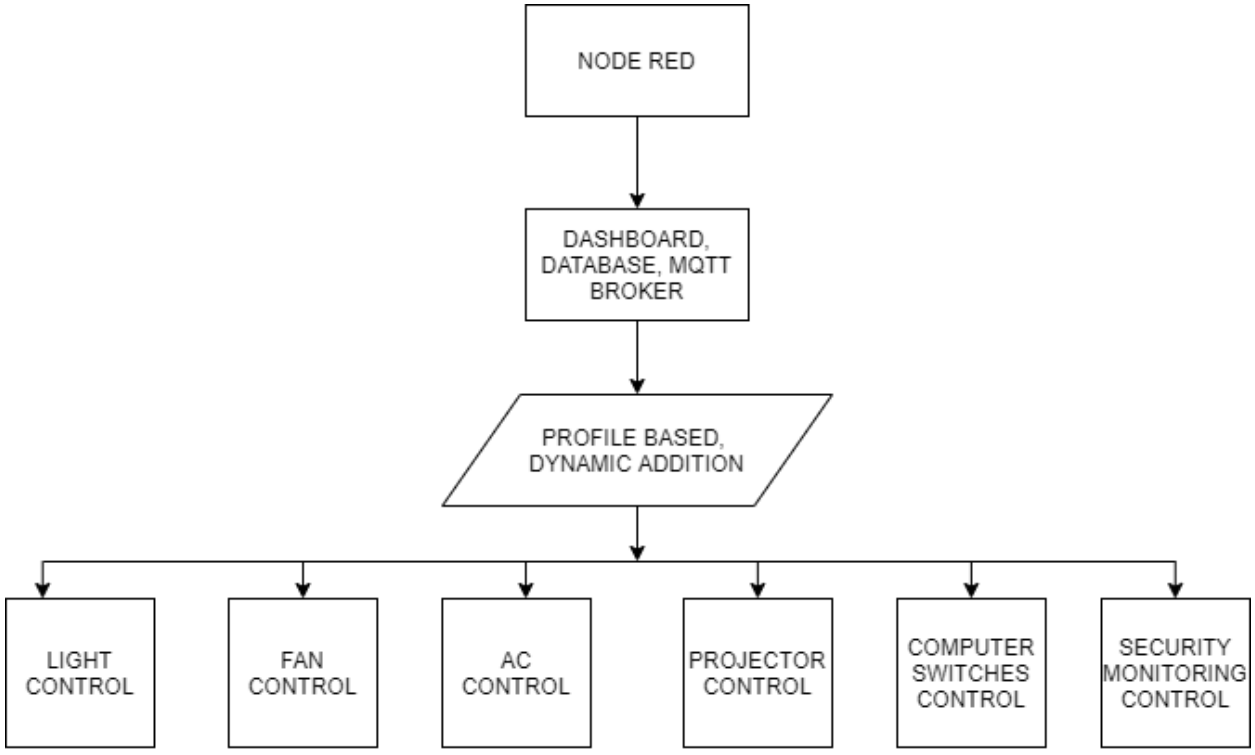

Figure 2 : Proposed System Architecture

Node-RED: Using Node-RED various hardware devices, API's and online services are wired together. Node-red for front end, programming and hosting. Flows can be then deployed to the runtime in a single click.

MQTT Broker: MQTT Broker is the channel that made this system flexible when transferring data or commands which was done by the user. The systems are connected to ESP8266 which act as MQTT clients. An online server act as an MQTT broker. SQLite for storing IoT data.

Web application: The web server will host the required Web application which will be connected to all the lab devices and can be easily managed and controlled via a user-friendly GUI.

IOT interface: The required components such as embedded processors like NODE MCU, Relays, Arduino and Raspberry Pi will be used for interfacing the lab automation system with the electrical appliances .

Remote Devices: Desktops and mobiles will be useful for managing the lab which will be further connected to the main web server via internet medium.Here both web based GUI as well as an android application will be developed for more flexibility.

As we are using a free open source platform for our system, many labs can be automated using the same architecture at a very feasible price. Node-RED, MQTT broker, Raspberry Pi and Arduino allows you to automate your IT infrastructure. The 220v that comes from the main power supply is reduced to 5v by step down transformer. It is then regulated and given to the Arduino UNO and ESP8266. If user wants to turn on /off devices, command is sent from mobile phone to MQTT server. The server then publishes the command to the respective ESP8266 module present in an IoT kit to which that the particular device is connected. After the reception of the command by ESP8266 relay gets turned on, thereby providing the supply to that device and the device gets turned on. Current transformer is used in the IoT kit which checks the actual flow of current. It sends the actual status of device (ON/OFF) to the Arduino which is determined by the amount of current flow. Arduino, then sends that device status to ESP8266 through serial port. ESP8266 sends that data to MQTT server and actual device status can be viewed in Node-RED dash board.

Raspberry pi 3 is connected to a network, and run this application in it. The control signals can be sent from any device connected in the network to the MQTT broker. And, clients publish the status of the devices and energy consumed by individual appliance to the broker and can be viewed in the dashboard. Thus, all devices can be controlled universally, and the status of the devices can be visualized.

Proposed Technology Stack

- Embedded boards like Arduino, NodeMCU or Raspberry Pi for programming appliances.
- Node-red for web interface and cross-platform compatibility.
- SQLite for storing IoT data.
- MQTT For Communication.
- Machine Learning to change the state of the appliances based on the behaviour of the user.

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