IoT Enabled Smart Laboratory

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***Abstract*—Internet of Things is defined as a system wherever appliances are embedded with software system, sensors and actuators. The devices enable information transfer over a network and additionally communicate with one another. This system is incorporated in our labs to create the appliances convenient and automatic. During this epoch of Automation, it's been ascertained that a lot of the University and faculty Labs do not have IT automation capabilities up to the present industrial trendy standards. The most recent technologies are not being enforced in faculties and so the fellow students cannot enjoy them. Automation is a section that is gaining attention progressively day by day since last few years. The aim behind our project is to assist appliances to not only connect with one another, but also in a user friendly manner. Here we have a tendency to look forward a system which might offer the user complete management over all remotely governable aspects of the Laboratories. One can accomplish laboratory automation by merely connecting the appliances to a central network or cloud storage.**

***Keywords*—Internet of Things, Automation, Smart Laboratory, Cross Platform, Remote Control.**

I. Introduction

There are several devices in an exceedingly laboratory, like Lamps, Fans, Air Conditioners and Projectors. Laboratory automation will be represented as a technology that is employed within the campus setting to supply comfort, convenience and energy potency to its user and students. Automation may be a conception that involves real time management and observance of multiple appliances. Today, there's an increasing demand of machine-controlled systems so human intervention is reduced. The user will build use of this technique to regulate switch on of lights, fan, AC, etc. mechanically. The user will access complete IoT system from anyplace exploiting web. Raspberry Pi which is a tiny sized pc accordingly acts as a server for the system. A smart laboratory could be a place that has extremely advanced automatic systems for dominant and observance lighting and temperature, laboratory appliances, and security systems and lots of alternative functions. Through IoT virtually each object of our standard of labs will be connected to the net. IoT permits observance and dominant of all of those connected objects no matter time and site. IoT plays a very important role in building good laboratory.

As field grows each year, new management issues and energy problems arises. Managing the resources within the field has become a true drawback. Observance and dominant of the unused devices that consume power throughout human absence is additionally a serious inability. Additionally, to the current, coordinative the folks taking part within the daily activities of the laboratory is tedious, once population of the usage of the area out numbers a manageable threshold. Another drawback is power management. It's troublesome to watch all sub-systems like Lighting, Projecting and Air-con system. individuals cannot check the standing of the sub-system comfortably. The present usual thing to manage the appliances within the work is to manually toggle switches on the switch board of the actual work. However, that in itself may be a long task as someone needs to be out there to try and do therefore. Our planned system is geared towards developing an automatic resolution wherever even though the top - user/ admin is found remotely; the appliances will be turned on. The web site primarily converts smart phones into remote system for all appliances. The user will access complete IOT system from any place with the help of net. Therefore, the decisive motive behind making the system like laboratory automation is that you simply will direct and coordinate however a convenience have to be compelled to respond and why it has to respond. Your duty is to line the schedule and therefore the rest is machine-controlled and primarily based off of your required penchants therefore giving management or connect with the gadgets of work. All the appliances at intervals work will be joined along through a typical entree and devices are controlled via MQTT protocol enforced on ESP8266 mistreatment Node-RED. Raspberry Pi may be a tiny sized pc that acts as a server for the system.

Cloud will be a most promising and cost-efficient answer to connect, manage and track the IoT. Cloud computing could be a model for on-demand access to a shared pool of configurable computing resources (example - networks, servers, storage, applications, services, and software) that may be simply pro-

visioned as and once required. Cloud computing provides an abstracted interface aggregates the resources to achieve efficient resource utilization and permit users to rescale to resolve larger science issues. It permits the system software system to be designed as needed for individual application needs. For analysis teams, cloud computing can offer convenient access to reliable, high performance clusters and storage, without the necessity to buy and maintain subtle hardware.

Research has thrived from the rapid climb in machine power. With this, comes increased pressure on labs as information storage facilities ought to house the exponentially-increasing quantities of huge information sets, as huge information becomes an integral part of analysis. This poses an important drawback for labs, during which they will need an entire area dedicated to its on-the-spot storage. And thereupon comes maintenance, resulting in hefty up-front IT infrastructure prices. Cloud computing has helped to alleviate this burden, thereupon comes maintenance, resulting in hefty up-front IT infrastructure prices.

Cloud computing has helped alleviating this burden, by removing the necessity for corporations to own their own data center. Instead, the information will be kept on the cloud. For laboratories, cloud computing centralizes information, assuring security, while facilitating collaboration. One among the advantages of cloud computing is unifying information. Cloud computing permits labs to collaborate without the excess cost and complexity of running onsite server rooms. Changing from an onsite resolution to the cloud alleviates the prices of IT infrastructure. Integrating all the devices, and appliances of the laboratory with the cloud infrastructure is another advantage which cloud computing provides. One amongst the most widespread product within the market is Cubus science lab, a plug-and-play resolution that is a laboratory execution system and collects instrument information in real time, remotely. Another necessary good thing about cloud computing is information safety. It may be possible that one may lose their laboratory information because of outages or cyber-attacks, or worst-case, a natural disaster. Deploying systems within the Cloud escapes the matter of data loss. If a cascading failure were to occur, the information will not be lost as most files are at different location. What appears to be holding back several labs is that the concern of losing information by change to cloud computing. In reality, it is a lot safer and reliable than on-site information storage. y. As expressed by Ranjan, Praful [6], the market for the home automation can increase based on many key enhancements within the technology offered in automation, like enhancements in wireless automation solutions as well as lowering of costs because the market simply begins to adopt home automaton usage in larger volumes.

II. Literature Survey

M. Poongothai, A. Rajeswari and P. Muthu Subramanian [1] talks about the benefits of IoT in general, how automation can be useful, and also the use of MQTT and Node-RED for automation. They stated that more than 85 percent of systems remains unconnected, and do not share information with one another or the cloud. One such technology that facilitates the interconnection is eventually Internet of Things. Application code written for interfacing IoT sensible hardware kit and MQTT broker, and for observance temperature, wetness and lightweight intensity within the laboratory. Developed Dashboard and mobile application by using Node-RED and Android Studio. A database set has been created for a paradigm switch to look at standing history. IOT reduces the human intervention by introducing device to device interaction. By using the projected system, the whole energy consumption is reduced in our field.

In the paper by R. K. Kodali and A. Anjum [2], an efficacious home automation system through affordable Wi-Fi development boards is projected. They explained how Node-RED can be used as a visual wiring tool that helps in associating gadgets simply bringing concerning quick and easy association setups. Gadgets are connected along to using Node-RED and an association is setup for remote ESP8266 and a mosquito primarily based MQTT broker observance and management. Node-RED could be a programming tool for wiring along hardware devices, on- line services and API's. Further they [2] explained: Varied parts in Node-RED are connected along to form a flow within the Node-RED editor. Message Queuing telemetry Transport (MQTT) provides a light-weight electronic messaging protocol that uses a publish/subscribe model attributable to that it's worthy to be used on all devices from low power boards to servers. A consumer will publish or take a subject or do each. Whereas as a broker receives all the messages, filters them and send them to the signed consumer. Node-Red is therefore an economical platform to link variety of IoT gadgets and may be controlled from any a part of the planet.

T. Malche and P. Maheshwary [3] bring into light about what is a smart home and what role it plays in the society. According to them, a smart home is a connected home (or E- Home), consisting of many technologies which enhances the quality of living, an area that has extremely advanced automatic systems for various functions of controlling and sensing, such as alert, monitor, control, Intelligence, and a system with IoT infrastructure as a prime base. Further they [3] talked more in depth about it as follows: An IoT primarily based smart home is rising as a very important a part of the sensible and intelligent cities that are being projected and developed round the world. the aim of a wise house is to boost living customary, security and safety still as save energy and resources. The smart home plays a very important role in development of society.

S. Somani, P. Solunke, S. Oke, P. Medhi and P. P. Laturkar [4] focuses on a system that gives options of Home Automation using Internet of Things via an android application, where an it (android application) acts as an interface between user and the IoT system to control and manage devices. The core components of this system are Raspberry-Pi, various sensors and appliances, where Raspberry Pi acts as a server which accepts requests from user, logs in the user by forming a client socket between the two, and in return, the server responds back

to the user if correct details are provided.

In the paper by H. K. Singh, S. Verma, S. Paland and K. Pandey [5], they aim to develop an IoT based home automation system which is primarily based on Wi-Fi based microcontroller. Here, NodeMCU (ESP8266) microcontroller together with Relays is employed to manage electrical switches remotely from the server that is constructed on Node.js. User will manage switches employing an internet Application when authenticating. The projected system consists of internet server, internet interface, database, NodeMCU and Solid-State Relays. Server controls and monitors appliance state and user command, and designed to handle additional hardware interface module. The web server is running on NodeJS that in turn running on AWS (Amazon web Services). which may be accessed from a web browser remotely over internet. Furthermore, the log file will be generated as a result of dynamical state of appliances

III. Existing System Architecture

The existing system shown in the figure below consists of the administrator being supplied with a distant access to the web server, which he/she has to control using an android application, which requires separate programming as well as limits the cross-platform compatibility to a single platform.

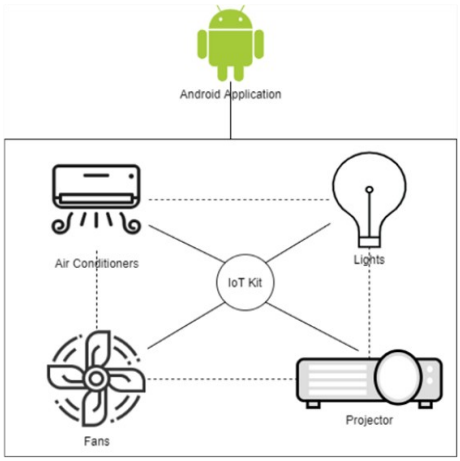

Fig. 1. Architecture of Laboratory Remote Interface Management

- **Android Application:**
  The Administrator use a smartphone, wherever he can have access to any or all the PCs, lights, fans, air-conditioners and projectors that are connected in network.

- **IoT Kit:**
  Typically includes an embedded board with Wi-Fi support like Arduino or Raspberry pi, which hosts the application and functions necessary

- **Appliances:**
  Lights, fans, projectors, air-conditioners and pc switches are connected through IoT kit.

IV. Problem Definition

Our institute has an abundance of laboratories and therefore, more staff. Some employees have totally different operating patterns than others. On every occasion if a laboratory session ends, sometimes the machines and appliances are left running. Physically toggling the individual lights, fans and systems within the starting of a lab session adds to the wastage of your time of the session. Also, If the individual is out of premises, and is not able to be present at the labs to physically turn off the devices, it will lead to a huge amount of power wastage in terms of electricity usage. To mitigate this issue, our system which is built with Node-Red helps controlling the devices remotely, irrespective of the location of the faculty, with the help of his/her smartphone or laptop connected to internet. This saves a lot of time, power consumption and additionally energy in terms of man power.

V. Objectives

- To minimize, monetary costs, user discomfort, delays, utilization of resources.
- To automatize the appliance dominant of Labs.
- To reduce the power consumption by economical usage of the appliances.
- To store data in cloud so that any device can access remotely regardless of being in same network or not.
- To attempt integration of laboratory timetable with the system.

VI. Proposed System Architecture

Figure 2 shows the planned system architecture style of IoT enabled smart laboratory system. All the appliances among the laboratory are connected to Relays, which are controlled using Node-RED and MQTT broker, hosted on Raspberry-Pi.

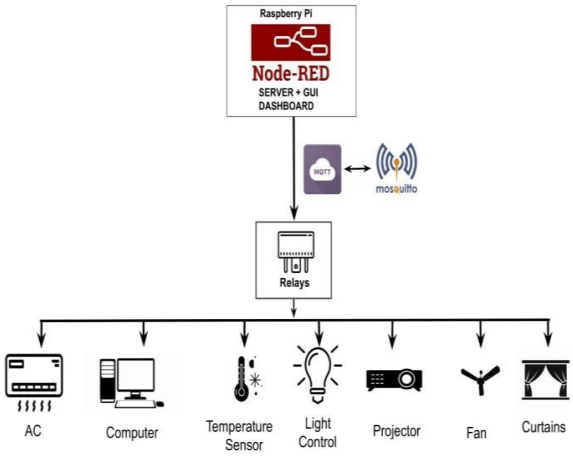

Fig. 2. Proposed System Architecture

- **Node-RED:**
  In our proposed system, rather than building an android application, Node-RED programming tool is used for wiring along hardware devices, APIs and online services. It provides us a browser-based editor which simplifies

wiring along flows using the big selection of nodes within the palette that may be deployed to its runtime during a single- click which could also be deployed to the runtime. Along with this, using Node- RED, the system will have a Graphical, User-Friendly interface dashboard, which is accessible via a browser, for managing and controlling the devices.Taking inspiration from Sfikas, Giorgos and Akasiadis, Charilaos and Spyrou, Evaggelos. [8], we can look into categorising various parts of our system supported sensors (S–type services) and actuators (A–type services), physically put in within the space, yet as processing units (P–type services) running within the cloud, and also locally.

- **MQTT:**
  For wireless devices, we will use MQTT as our protocol, which will be used to receive all messages and command from the client devices like lights, AC, Computers, Fan, curtains, etc. (called as MQTT Clients), which are connected to Raspberry Pi using Relays.

- **MQTT Broker:**
  To actually implement MQTT Protocol, we need a MQTT Broker. For that, Node-RED also provides an MQTT broker, both for publish and subscribe as nodes, so we do not need to implement it seperately. The ESP8266 based devices will be able to communicate with Node-RED wirelessly via WiFi.A real-time alarm system [7] that uses Wi-Fi as a communication medium between the raspberry pi and also the Node-Red platform is one of the examples of a ZigBee MQTT client.

- **Raspberry Pi:**
  The Raspberry Pi will be our choice of embedded board because of its versatility at a reasonable price. Here the Node-RED will be hosted on top of Raspberry-Pi OS, as well as it will act as a MQTT server for the connected appliances. In our system, we have chosen Raspberry-Pi 3 Model B.

- **Cloud Access via NGROK:**
  NGROK is a program which allows us to expose the local host to the public over secure tunnels. With NGROK, we can expose our raspberry pi, which is hosting Node-RED and all the connected appliances, to the internet and will allow the user to have access to the dashboard and editor from anywhere, being in any network. Users can use smart phones, laptops or computers to monitor and control lab device from anywhere. The main models of cloud

- **Smart NORA:**
  Node-RED home Automation (or NORA) is a Node-Red integration service for Google Home. Smart NORA is a rewritten, much improved Node-RED Google Home Integration service that will allow the devices to simply able to be controlled via the Google Home application as well as via Google Assistant.

- **Relay Modules:**
  Relays are a type of switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. The appliances will be connected to these Relays andthen controlled by Node-RED. There are many types of Relay Modules availabe in the market for cheap, ike 2 channe, 4 channe, 16 channe, as we as reays with built-in ESP8266 module integrated to it. Depending on the number of devices, we can choose the type of relays accordingly.

Below Figure 3 is the breadboard circuit diagram which shows how the 2 channel relays are connected with raspberry-pi. The Figure 4 is the schematic of the circuit.

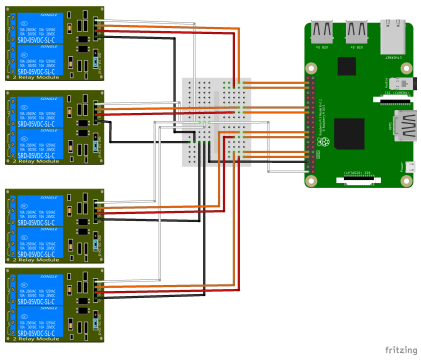

Fig. 3. Relay Connection with Raspberry-Pi

The black connections correspond to the grownding. The White connections correspond to 5V power (i.e. VCC). The Red connections represent Input-! of all the 4 relays. Similarly, the orange connections represent Input-2 of each of the 2-Channel Relay Modules.

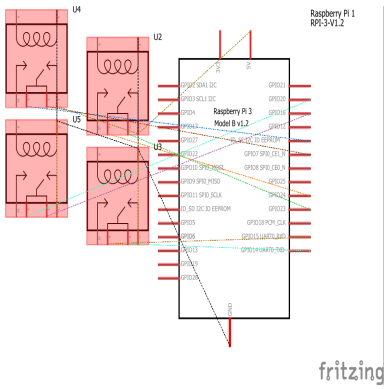

Fig. 4. Schematic Diagram of the Circuit Connections.

The Relays are powered by Raspberry-Pi itself, though it is advisable to power them externally. All the Inputs of the relay modules are connected to the GPIO Pins of the raspberry Pi in order to send the signals and communicate with it.

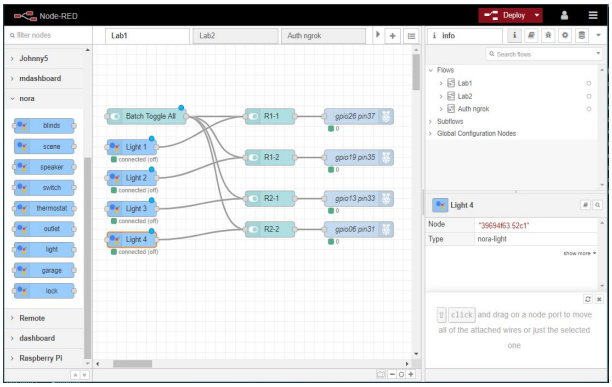

Fig. 5. Node-RED Editor.

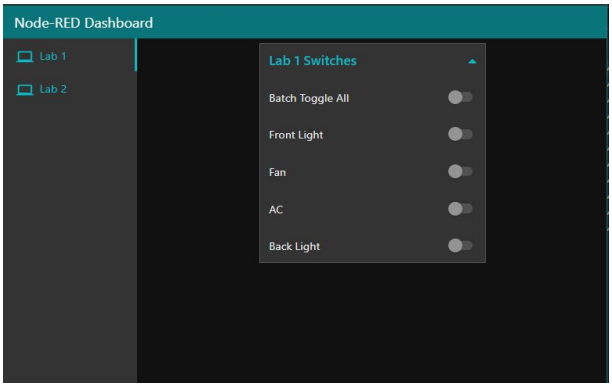

Fig. 6. Node-RED Dashboard.

The Node-RED Editor allows us to insert various palettes and connect them to create a flow of functions. In Fig. 5, the relays are being controlled via switch nodes, will be visible on the dashboard as toggle switches, shown in in Fig. 6. Also, the nodes with the Google Assistant icons are the NORA nodes, which will allow all the appliances to be visible in the Google Home app as well as controlled via voice. Each Lab can have its own flow to avoid confusion and keep them organized.

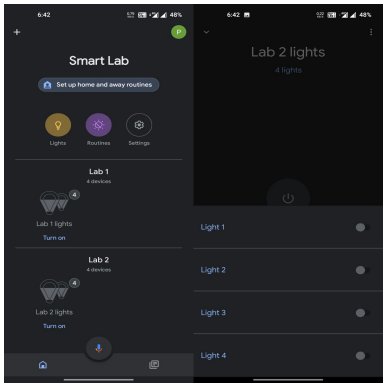

Fig. 7. Google Home Integration.

Conclusion

Considering the same issues in our university, we've listed the problems and located out the solutions to reduce the employment for the research lab assistants and college members to the utmost. The Node-RED user interface dashboard is accessible via browser, it ensures cross- platform compatibility. Adding some 'smarter' parts to our life makes our lives easier, and a lot of versatile in terms of day to day usage. the main objective of our project is to cut back the human efforts in labs, that we predict will be achieved using laboratory automation.

The Expected system can ease the complete automation method in labs and create the lab management easily. The projected system not only be used for schools and universities, but also at homes and studios. There are limitations of our system which include constantly connected internet service required for remote access. Also, the system requires continuous power to be supplied in order to function optimally.

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