A step towards Home Automation using IOT

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***Abstract*— 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. Today's houses are gradually transferring from ordinary/human's input-based appliances to smart/IOT enabled appliances to be controlled remotely. At Present, existing home automation systems use technology that is limited to only that device. So, in a nutshell, we are making our devices IOT enabled not our homes. As far as this paper is concerned, 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.**

Keywords*— *Home Automation; NodeMCU; microcontroller; IOT; Smart Switch

I. INTRODUCTION

We all just dream of having the entire task done automatically for us. Home automation system is one of the systems that fits well in this scenario. Home automation or smart homes can be described as a technology which is used within the home environment to provide comfort, security, convenience, and energy efficiency to its user or occupants. Home Automation is a concept which involves real time control and monitoring of multiple domestic appliances.

IOT is an environment of inter - connected physical objects that have been assigned an IP and have the ability to connect to a network without manual intervention of humans. It is able to transfer data over a network without requiring human-to-human or human-to-computer interaction. An IOT system consists of a set of hardware devices like micro-processors, sensors etc. which are responsible for communicating data to/from server and microcontroller. Time is a very much valuable thing. Everybody wants to save time as much as they can. To contribute for the same this paper is introducing Home Automation system using IOT. With the help of the proposed system the user can control all of its home appliances from his/her mobile/computer remotely from one place.

As technology is changing every second so, it is very important that our paper should use current technology (IOT). Most of the work on "IOT based home automation" are yet incomplete and requires a final implementation on field. These works are either on paper or only targeting small population that too for testing/development. However, IOT is still not so popular but has a vast scope in future. So, it is good to upgrade systems that are based on Bluetooth, ZigBee, GSM etc.
This paper comprises of brief description about the need of IOT based Automation for home and its comparison with the existing technology in terms of cost, compatibility, advantages and its drawback so that it is easy for a client to decide which model he should select.

The paper is organized as follows: section II represents the previous works on Home Automation system and their comparison, section III and IV describes the proposed work and its implementation details. In section V results are displayed followed with conclusion and future directions.

II. RELATED WORK

In this section, the paper briefly describes the existing work for automation system for home using IOT and based on there main contributions, tried to classify them into two types: Application and Technology, which they use as shown in Fig.1.

The home automation systems were developed to minimize the human efforts in managing their household activities like operating Washing Machines, Water Heater, A/C etc. This paper aims to controls our household appliances by a computer/microprocessor. The device can be an android device, a remote controller or a smart watch. It is good to say that with the change in technology, automation systems go upgraded. The common existing home automation systems use core technology such as Bluetooth, Wi-Fi, Zigbee, Arduino, GSM etc. Each technology has some advantages but drawbacks too. Research should be done to minimize and rectify their demerits.

Ransing and Rajput [1] used Zigbee protocol for temperature monitoring due to its less power consumption. Kumar and Lee [2] focused on smart home system implemented using Bluetooth and sensors integrated with system. They have used RESTful based web services as the interoperable layer. They have developed an android application in order to send and receive commands. Young-Guk Ha [3] has implemented a Zigbee based smart automation system that they have tested for security and alarming purpose. For the home security they have used magnetic sensors attached with a door or window. Stankovic and Kiran [4] have analyzed the need of sensors and advanced or smart nursing homes. These sensors, protocols and the collected data could be used to make the hospitals and nursing homes smart and more advanced to get faster

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diagnosis and treatment of disease. Noguchi, Mori and Sato [5] have briefly discussed the accumulation of sensor data and measuring human behavior using smart sensors. They have used the sensor data to predict human behavior and tried to validate it with original behavior. Brundha and Lakshmi [6] implemented the home automation system to enhance the security system. This system send the images captured by a camera integrated with the automation system to the owner in order to get the information of an unknown person entered in the room. Vikram, Harish and Nihaal [7] have focused to develop an automation system which is cost effective. A lots of sensors has been used in order to use it for security and monitoring. Soundhari and Sangeetha [8] developed a voice controlled android application for controlling the devices. In this case, a user has to download the android application and it cannot be control by other means. Chiao, Yuan and Shiau-Chin [9] proposed and implemented a Bluetooth based sensor application controlled by an android application. Fleury, Noury and Vacher[10] proposed a future possibilities of SVM based algorithms to be implemented in order to advance its behavior. Yang, Gao and Guo [11] proposed a Zigbee based design of home automation system that would promote the implementation of home automation and digital control. They have not implemented it practically but only proposed an idea with simple structure, high reliability.

The existing automation systems based on Bluetooth are cost efficient and easy to implement/install but aren't flexible enough with the environment or simply lacks the ability to use them beyond a limit.

Generally, a Bluetooth system operates under range of 0 to 15 meters. Moreover, from user point of view Bluetooth is an outdated technology and presumably has compatibility issues. ZigBee based systems also have the similar problem of range as their application is limited to indoor use. These systems are generally used for LAN. In GSM based home automation system, it is not only limited to smart mobile phone instead, you can use a normal featured phone. However, the system is network dependent and a specific format is required to send the message in order to control the appliances.

Implementation of automation system with Z-wave is less complicated and has greater range than automation system implemented with ZigBee. So, it is good to say that using a simple protocol such as Z-wave, the development of automation system is easy and simple.

Existing Home Automation Systems has following major challenges: - High Cost of Deployment, Lack of flexibility with user demand and Poor manageability.

The main objective of this paper is to develop a system using IOT which is capable of controlling our household appliances via a user-friendly web interface. The proposed system has a great compatibility and flexibility with the existing infrastructure using Wi-Fi to connect home appliances with the server. The proposed system will minimize the installation cost and will enhance the ability of upgrading the existing system.

The objective of this paper is to provide relevant, feasible, compatible solution to the above mentioned problem that existing home automation system generally face.

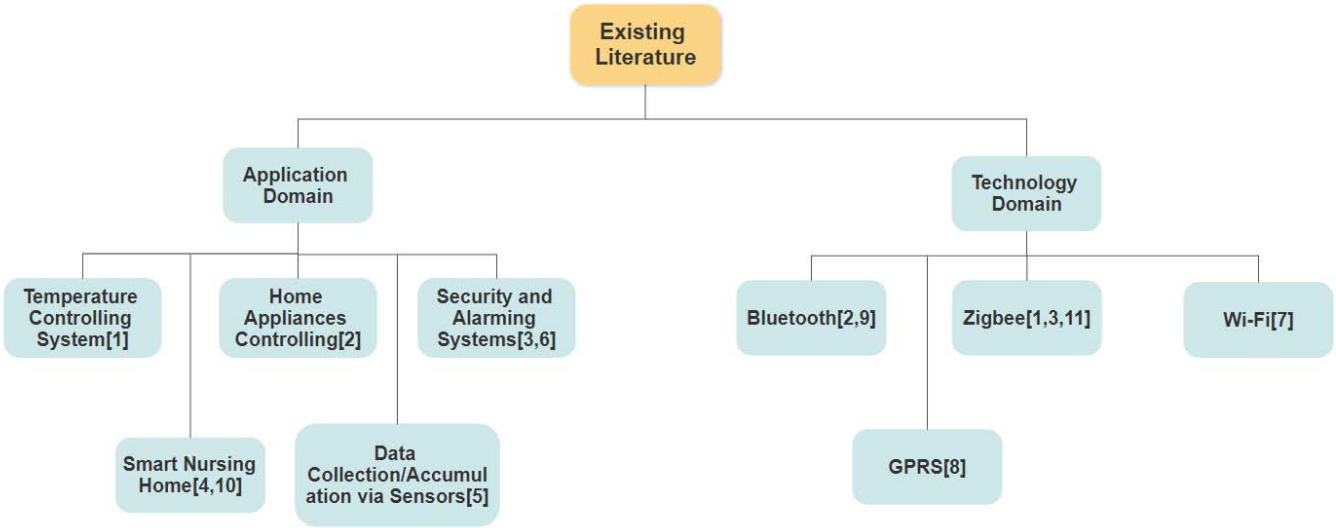

Fig. 1. Classification on Application and Technology

III. PROPOSED WORK

Before moving onto the proposed solution, it is necessary to know the novelty and the need of this work. In all the systems designed till date for Home Automation, there is a lack of one common feature that is a proper user friendly application/portal which can be used to control the whole system without the assistance of the developer. Not only a user friendly application but also the application should be

accessible from anywhere so as to not limit the user to operate the system from a single location or home.

If a user wants to install the already designed switch based automation system, then all the devices needs to be connected to the system; therefore, only the system will be able to control those devices. Failure of such system will leave the attached devices useless. After proper installation of such systems, if a user wants to expand the already installed systems then the whole system need to be redesigned in order to serve the required demand of the user which not only requires money but also a technical person which can install the modified system. Redesigning the existing electrical system to fit with newly installed system will basically make the user to re-think of the expansion. So, these are the main problems a user can face and hence, this paper proposes following solutions.

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 as shown in fig.2. 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.

Initially the microcontroller connects to the internet through Wi-Fi. When the connection is established it will start sending appliance state requests of that particular device Id to the server then the server responds to the request by fetching the switch state from the database. As soon as the data is fetched from the database, the server sends the data back to NodeMCU in the JSON format. When the data is received by the NodeMCU, it parses the required information from the response and then triggers the relay according to the data received. The data in the database can be changed from anywhere any time by the user after proper authentication and the microcontroller will continuously send the request to the server in the time interval of 2-3 seconds and the required action will be done for the controlling of the appliances as per the received parameters.

The user can log into the web portal and can easily control the appliances connected to the system. The user is flexible to map the layout of the electrical devices to the portal as required and if the lights or any electrical appliances are left ON can be checked and turned OFF remotely through logging into that web portal which is designed in NodeJS, Web Application in angular and Mongo DB as the database.
The system also provides user, the flexibility to switch their system from IOT mode to manual mode in case of system failure or technical error which is one of the key factor of the proposed system.

For unauthorized access to user data or appliance state, we have used JWT (JSON Web Token) for authorizing request.

"JWT is an open standard (RFC 7519) that defines a compact and self-contained way for securely transmitting information between parties as a JSON object. This information can be verified and trusted because it is digitally signed. JWTs can be signed using a secret (with the HMAC algorithm) or a public/private key pair using RSA or ECDSA.", as mentioned on the official website.

The claims in a JWT are encoded as a JSON object which is used as the payload of a JSON Web Signature (JWS) structure or as the plain text of a JSON Web Encryption (JWE) structure. The user sends request with required credentials such as email and password to the server. The server checks to see if the credentials are valid. If they are, the server creates a token using the user id and a secret key. This string of characters that results from the encryption is called a token. Then the server sends it back to the requesting application. The application, in turn, saves the token to use it in every other request the user will send. The practice of adding a token to the request headers is as way of authorizing the user to access resources.

Now every time a user wants to change the device state or want to view the data, the application will automatically add token to request header for server to authorize the request.

IV. Implementation Details

A. *Proposed System Functionality*

Each NodeMCU will have its own unique device id which will be listed on server. When a user installs this system in his/her house, the user will be prompted to enter the device id along with the user information so that the server can attach the device to the user and thus the device will be accessible only by the authenticated user.

After user will login with its credentials, it will be shown with the rooms and their devices which are attached to the IOT system and will be able to control from the shown panel. A user can customize its home layout as per their requirement any time by adding and removing rooms and appliances.

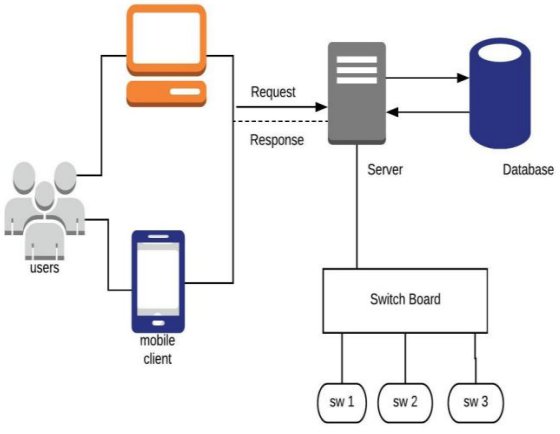

Fig. 2. Flow Diagram of Proposed Automation System

B. *Software Design*

Node.js – Node.js is an open-source and cross-platform run-time environment executing JavaScript code outside the browser. Quite often NodeJS is use to build back-end services also called APIs. Node is ideal for building highly scalable data-intensive and real time applications.
Node is easy to get started and can be used for prototyping and agile development. It is use in production for large companies such as PayPal, Uber etc.

Express.js – Express.js or Express is a flexible Node.js web application framework that provides a robust set of features or APIs for web and mobile applications. Express uses and relies on middleware which intercepts the incoming request and throw them to their respective APIs (if available). It offloads all the tedious job of writing same code for configuring server, serving static files, custom headers etc.

Mongo DB - Mongo DB is an open-source no SQL, document-oriented database program. MongoDb uses JSON-like documents to store data and is flexible to data structure in contrast to SQL based databases. It is scalable and allows sharding.

C. *Hardware Design*

NodeMCU – An open source IOT platform generally programmed with Lua scripting language which is a programming language for programming ESPs. The Lua scripting language is use by the firmware. We are using NodeMCU to control relays which are responsible for controlling our AC supply. The server emitted events resulting in respond of NodeMCU and can also send data of the appliance, if needed, to the server.

Relay – Relay is an electrically operated switch use to protect electrical appliances. 5v/12v is generally used relay modules. It uses an electromagnet to mechanically switch electric appliances. The main function of relay is to control the high electric voltage and to make appliances work in low voltage. Due to no direct contact between NodeMCU and appliances, they are considered safe to use.

V. RESULTS

After successfully implementing the above mentioned system. We tested the prototype from hardware as well as software point of view. Each microcontroller will be having its unique device Id which will be provided to the user and will be used for all the purposes as mentioned above.
In the web portal, the user was greeted with the following login screen as shown in Fig.3.

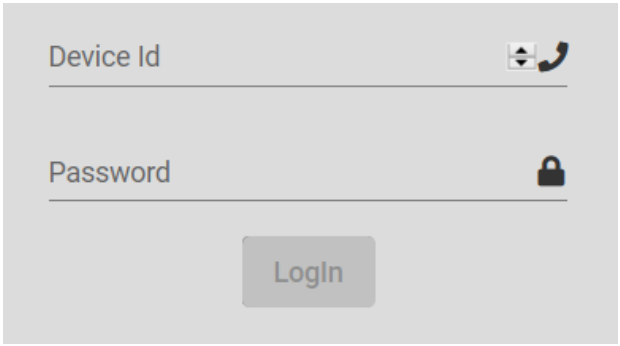

Fig. 3. Login Screen

After user successfully login, the server had successfully generated the token id for the user. The user was able to change the layout as well as control the appliances attached. User's action of changing appliance state was successfully getting logged to the server as well as in separate file on Amazon S3.

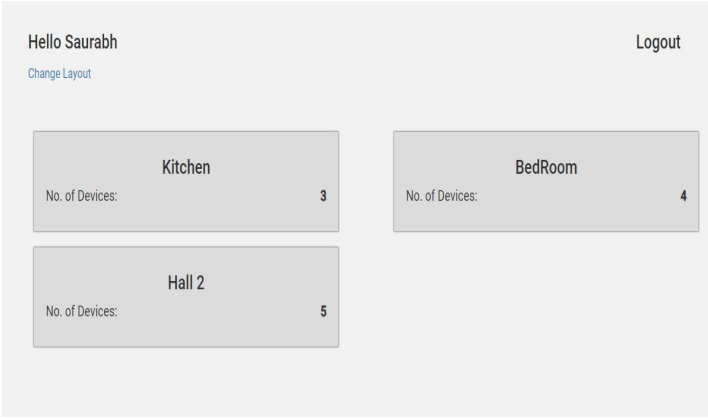

Fig. 4. Room Layout

Fig.4 shows user's room layout to control its appliances

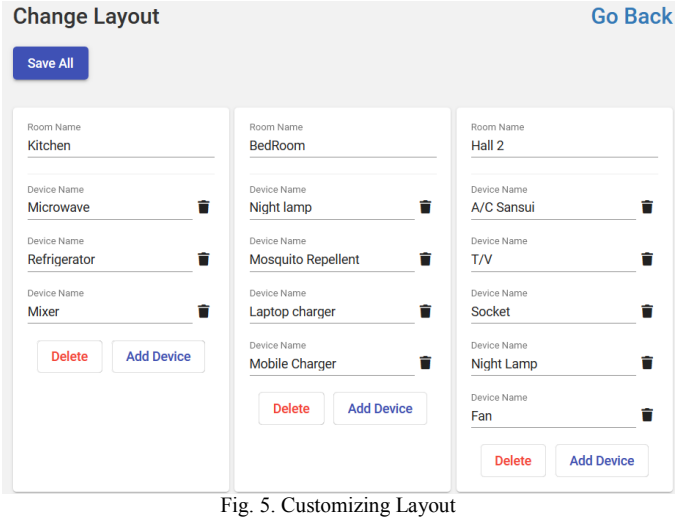

Fig. 5. Customizing Layout

Fig.5 shows that the user is flexible to customize its layout as required.

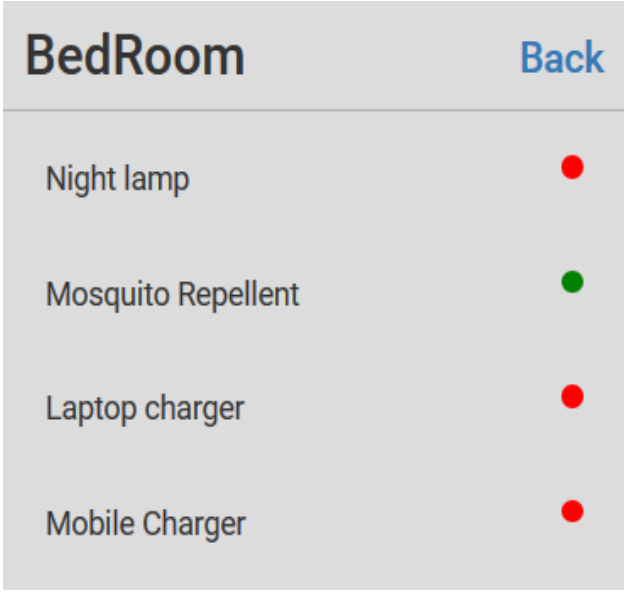

Fig. 6. Appliance state view and control

Fig.6 shows the appliance's current state as well as provides the button to control the same.

VI. Conclusion And Future Possibility

In this work, a real-time home automation system has been successfully implemented which is quite effective in terms of performance and technology. Home automation systems are not so popular yet. But, there is a very large probability that it will be the trend in future.

The log file been generated as a result of changing state of appliances. It can be used to track the user's behavior i.e. the time of controlling the appliances. Using this log file, we can apply Machine Learning 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.

References

[1] R. S. Ransing and M. Rajput, "Smart home for elderly care, based on Wireless Sensor Network," 2015 International Conference on Nascent Technologies in the Engineering Field (ICNTE), Navi Mumbai, 2015, pp. 1-5.

[2] S. Kumar and S. R. Lee, "Android based smart home system with control via Bluetooth and internet connectivity," The 18th IEEE International Symposium on Consumer Electronics (ISCE 2014), JeJu Island, 2014, pp. 1-2.

[3] Young-Guk Ha, "Dynamic integration of Zigbee home networks into home gateways using OSGI service registry," IEEE Transactions on Consumer Electronics., vol. 55, Issue. 2, pp.470-476, May. 2009.

[4] J. Stankovic, Q. Cao, T. Doan, L. Fang, Z. He, R. Kiran, "Wireless Sensor Networks for In-Home Healthcare: Potential and Challenges," Proc. of the Workshop on High Confidence Medical Devices Software and Systems, June 2005.

[5] H. Noguchi, T. Mori and T. Sato, "Human daily behavior accumulation in real home environment via distributed sensors in a long term," 2011 IEEE/SICE International Symposium on System Integration (SII), Kyoto, 2011, pp. 368-374.

[6] S. M. Brundha, P. Lakshmi and S. Santhanalakshmi, "Home automation in client-server approach with user notification along with efficient security alerting system," 2017 International Conference on Smart Technologies for Smart Nation (SmartTechCon), Bangalore, 2017, pp. 596-601.

[7] N. Vikram, K. S. Harish, M. S. Nihaal, R. Umesh, A. Shetty and A. Kumar, "A Low Cost Home Automation System Using Wi-Fi Based Wireless Sensor Network Incorporating Internet of Things (IoT)," 2017 IEEE 7th International Advance Computing Conference (IACC), Hyderabad, 2017, pp. 174-178.

[8] M. Tharaniya soundhari and S. Brilly Sangeetha, "Intelligent interface based speech recognition for home automation using android application," 2015 International Conference on Innovations in Information, Embedded and Communication Systems (ICIIECS), Coimbatore, 2015, pp. 1-11.

[9] C. Chiu-Chiao, H. C. Yuan, W. Shiau-Chin, and L. Cheng-Min, "Bluetooth-Based Android Interactive Applications for Smart Living," in 2nd International Conference on Innovations in Bioinspired Computing and Applications (IBICA 2011), 2011, pp. 309-312.

[10] A. Fleury, M. Vacher and N. Noury, "SVM-Based Multimodal Classification of Activities of Daily Living in Health Smart Homes: Sensors, Algorithms, and First Experimental Results," in IEEE Transactions on Information Technology in Biomedicine, vol. 14, no. 2, pp. 274-283, March 2010.

[11] L. Yang, M. Ji, Z. Gao, W. Zhang and T. Guo, "Design of Home Automation System Based on Zigbee Wireless Sensor Network," 2009 First International Conference on Information Science and Engineering, Nanjing, 2009, pp. 2610-2613.