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A generic and smart automation system for home using internet of things

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ABSTRACT

Home automation systems are expanding increasingly popular because they can conveniently be employed to manage devices and appliances via voice or focused on physical activity utilizing sensor. From the various research, it shows that affording cost in bringing smartness to small organizations as well as normal users is challenging and there is a requirement for a better obvious and convenient method of connecting and managing equipment with mobile applications. The proposed system is created and built with the aim of enhancing control system performance and reliability. This technology may operate on any system and manage devices by connecting with home appliances and connected devices via a Wi-Fi device. The system involves a central processing module to manage devices via a home Wi-Fi connection that is linked to the internet for internet of things operations. It is recommended that an application be developed to connect, and configure new and current home appliances for control, which will lead to the connection and handling of other third-party devices via their software development kits. The suggested system enables additional features via a mobile application that allows the user to install new features created by the user to execute any activity with the system.

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1. INTRODUCTION

The internet of things (IoT) is a network of devices such as cars, household appliances, and other devices embedded in electronics, applications, sensors, actuators, and networking that enables those devices to link, capture and share data [1]. Currently, IoT plays a huge role in monitoring and controlling devices according to the readings from the sensor and IoT systems connected to a network commonly a wireless network and send data to cloud-based storage and compute the collected data on a remote system and handle the controls accordingly [2]. IoT-based applications getting a lot of momentum in the present generation. These devices are relied on communication to send collected data and to make control decisions based on the response from the server via Bluetooth, Wi-Fi, ZigBee, light-fidelity (Li-Fi), near field communication (NFC), radio frequency identification (RFID), and Z-Wave [3]. IoT is a transformation that allows companies

to improve their organizational productivity. With built-in features such as artificial intelligence and deep learning, IoT security systems offer improved security for companies by enabling them to set up accounts and individual identities for any of their connected devices [4].

Figure 1 shows the general architecture of IoT, where sensors are linked to the cloud by different modes of communication and transmission, such as wireless networks, satellite networks, Wi-Fi, Bluetooth, wide area network (WAN), a low-power wide-area network, and several more [5]. IoT is commonly connected to a cloud service or server for storing data and analyzing those data to send control signals to IoT hardware and IoT hardware sends data collected from the sensors and sends those data via an internet gateway [6]. Cloud can be a remote server or cloud service or an application programming interface (API) gateway that handles data storing, and control decisions based on the data collected from the server, and the data is stored in a no-structured query language (No-SQL) database to handle a huge amount of real-time data [7]. The appropriate control signal is sent based on IoT hardware via an internet gateway to perform variation to physical world objects [8]. Through IoT it can vary, temperature measurements on devices such as AC and heaters are within a reasonable range [9].

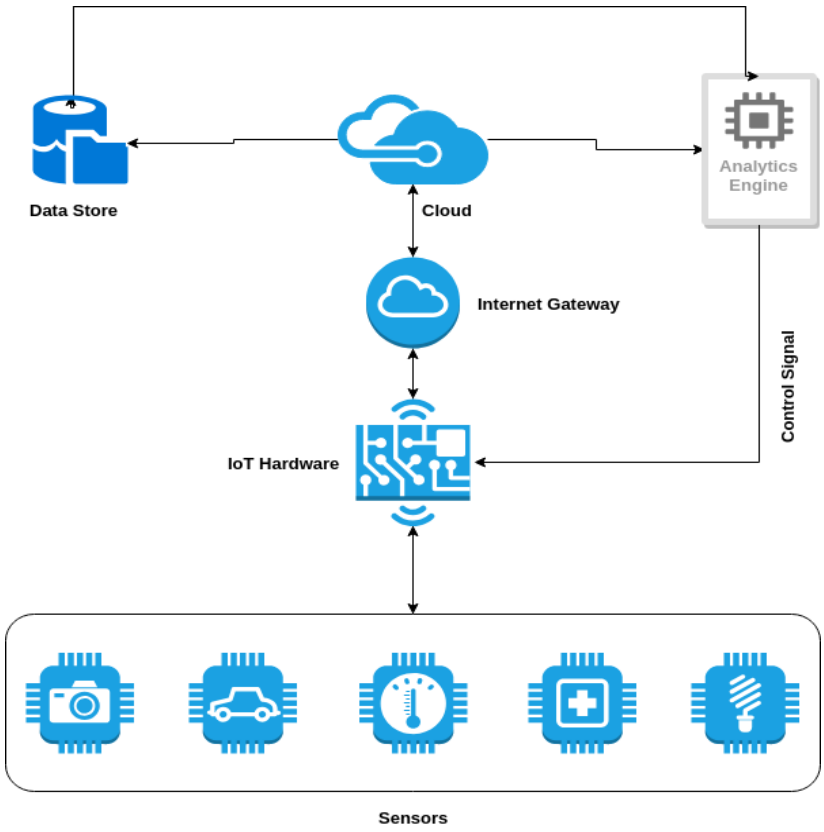

Figure 1. IoT architecture

With next-generation networking technologies like the 5G network, there are a lot of possibilities to achieve better living and automation with IoT. Recent development tells that always-connected device provides a way to generate behavior and environmental information in real-time and process it quickly for better handling of the operations and better-automated decision making [10]. The artificial intelligence (AI) assistants like Google Assistant and Amazon Alexa does control home automation systems in real-time. Generic automation systems become more powerful with high-speed network connectivity for real-time decision-making and optimizations. The structure of the paper is structured as follows. Section 2 presents the comprehensive review conducted over the recently contributed home automation approaches. Section 3 details the complete methodology of the proposed smart automation model for any general-purpose with complete control over the specific environment to make it handier for effective management. Section 4 demonstrates the implementation results and discussion with the benchmarked steps with proper justifications and inferences. Section 5 discusses the paper with major offerings and the future scope of enhancement of the proposed scheme.

2. RELATED WORKS

In this section, the comprehensive review conducted over the recently contributed smart automation system in the office and home appliances is presented with the merits and limitations. A real-time control scheme is suggested [11] for the management of home/office equipment from mobile devices via the general packet radio services (GPRS) network. An authorization system is proposed for the message queuing telemetry transport-based (MQTT-based) IoT to build to enforce an authorization framework and the architecture is based on OAuth 1.0a, an open authorization standard for web applications [12], [13]. The home automation framework analysis was suggested by [14] in which the IoT is a technology that provides the tremendous capacity for the advancement of numerous technologies, namely: e-government, environmental control, military applications, infrastructure maintenance, manufacturing applications, energy management, health monitoring, smart home, and transportation systems. From this work, it is found that, to gain more efficiency in the future when operating on both vendor platforms and versions of the linux and windows operating systems [15]. Currently, the globe is working in the fourth technological transition with the aid of accelerated technological updates, the life is getting more relaxed and smarter [16], [17]. The smart home automation system or home automation system grows to provide comfort in life and boost the quality of life. A prototype called IoT@HoMe [18] is built using an algorithm to track housing conditions and automate control of home appliances over the internet at any time and everywhere, and this device uses a node microcontroller unit (nodeMCU) as a Wi-Fi-based gateway to connect various sensors. The proposed architecture [19] uses the EmonCMS software to capture and simulate controlled data and remote control of home appliances and equipment.

In addition to the works based on smart home automation systems proposed by the various works, further, the products from top vendors like Google, Amazon, and Microsoft to small vendors like pert are all providing an automation system to control the home and these systems use Bluetooth connect to new devices and configure them via mobile applications [20]. Current automation solutions like Alexa and Google Assistant lack the flexibility to support the conventional home appliances that are cheaper and easily replaceable but provide support to the smart home appliances that are proprietary appliances like the Smart Bulbs and other Alexa enabled or Google Assistant-enabled devices from the vendors [21]. Some projects can provide control over home appliances over the internet, but they too require a static IP assigned to the home network which is not common for users to have a static IP for their home networks [22], [23]. Automating every home appliance that is not made to work with AI or a home automation system built-in and to provide cost-efficient and a completely automated or user-friendly way to control the environment through voice or mobile application over the internet from anywhere across the world [24], [25]. From the various studies and works, it is found that various issues should be concentrated in the existing system to make it more effective. Automating every home appliance that is not made to work with some AI-based or home automation system built-in and to provide cost-efficient and a completely automated or user-friendly way to control the environment through voice or mobile application over the internet from anywhere across the world where there is an active internet connection is available. The following are the findings that should be concentrated on to improve the efficiency and security in controlling systems from the literature survey: i) lacks the ability to automate conventional appliances within the budget, ii) lacks the ability to work offline, if the network is down, iii) lacks the ability to configure conventional devices with a mobile application, iv) higher price for automating even a small area, and v) lacks the ability to allow the user to create custom scripts in mobile app.

3. PROPOSED SYSTEM

In this section, a device model that is referred to as vendors like generic smart automation system that can be operated by Google Assistant/Amazon Alexa/our voice system at the moment, but every assistant is scheduled to work and can also work without an assistant technology. The hardware that will operate the device may be a low-power advanced RISC machine (ARM-based) Raspberry PI that will run Java that is linked to the local network that the system can control. Figure 2 shows the flow diagram of the proposed system design which shows the working of the system. The device is designed to listen to the user's voice commands in the home or place where the system takes care to activate a specific action that the user has asked the device to take. Systems allow users to control the environment over the Internet. With such quick, slick system architecture, we can integrate the system to work alongside Google Assistant or Alexa as a backbone assistant to manage apps.

The generic home automation architecture which is shown in Figure 3 is designed to be more efficient and secure for the user to convert a regular home into an automated home. The devices are connected via Wi-Fi which has more connection and range with higher bandwidth to pass control signals easily. The Google cloud platform is used to handle user data and configurations over a secure storage location that is accessible to users across the world. The firebase real-time database is the core data storage

repository and acts as cloud publications and subscriptions for real-time data triggers for actuating devices in a matter of seconds. The devices are connected to a common Wi-Fi network to communicate with each other over the same network. The central hub device handles the overhead in passing control signals over the network to the appropriate devices under the controlled automation system.

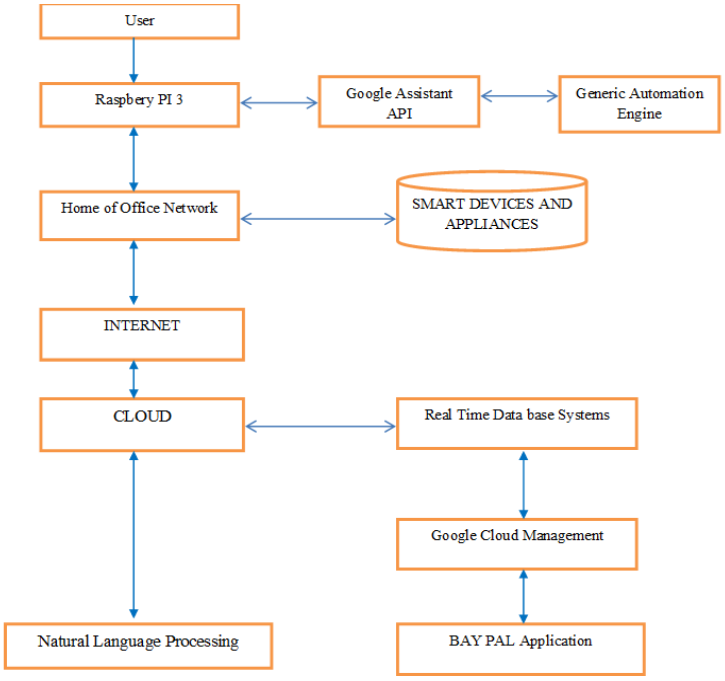

Figure 2. Flow diagram of the proposed system design

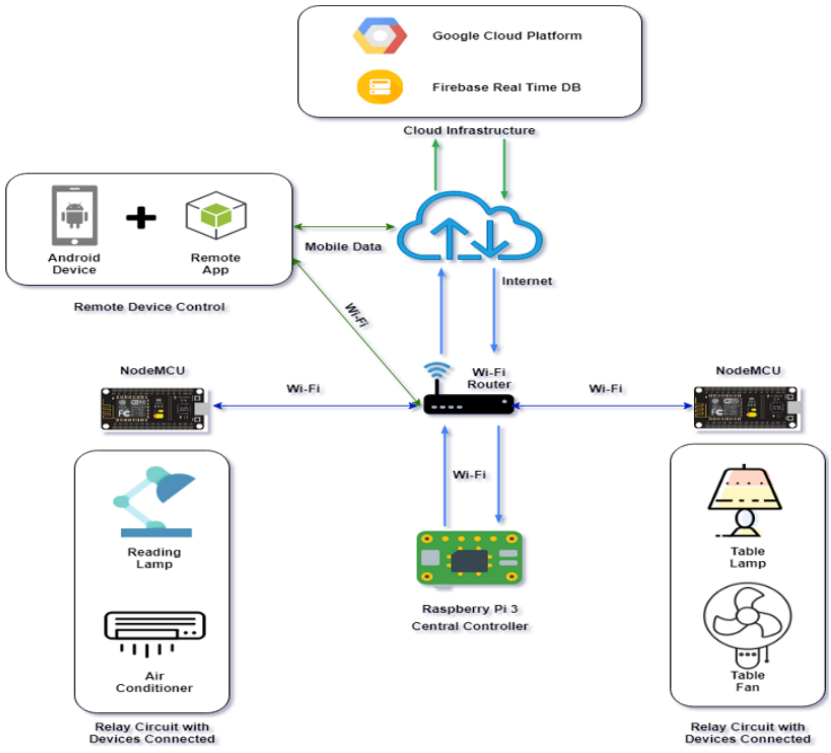

Figure 3. Generic home automation architecture

4. IMPLEMENTATION OF PROPOSED METHOD AND RESULTS DISCUSSION

In this section, the experimental setup and the implementation results of the proposed smart automation model and the benchmarked steps with proper justifications and inferences. The generic home automation system is implemented by breaking down the entire system into 8 distinct modules. These modules when combined will be the system core functionalities that handle all the control and automation activity for the user. The various functionalities of the proposed model are described.

4.1. Wireless device configuration

Wireless device configuration is a new device to the generic home automation systems that are present in the open-source community that is more complicated for non-technical users. Commercially available products like Amazon Alexa are providing Android and iOS apps for users to connect and configure new devices with ease. The user is provided with various options to choose from auto-configured to manual configure. The newly configured device information is stored in the android device securely for future restoration of the device configuration even when the android application is re-installed or installed on a new device. This functionality of the generic home automation system is to make a proof of concept that new devices can be wirelessly configured through Wi-Fi.

4.2. One to one device communication

The next one is device communication which should be done between one-to-one devices. Figure 4 shows the one-to-one device communication in which the central control hub and configured devices are needed to communicate with each other to control and automate the home eco-system. This is achieved by developing a way to send an efficient yet productive control signal over the Wi-Fi network. It has a lot of challenges that are needed to overcome to solve this problem. This includes identification of the control hub and other automation devices in the network. This module is crucial for enabling device control from further development and enabling secure device control and automation for the user convenience and ease of use automation eco-system.

Figure 4. One to one device communication

4.3. Local network connectivity

In this proposed system, Wi-Fi is used for connecting devices in the ecosystem. In the previous module, it is developed a method to connect the central control hub and device controller. The current module deals with connecting and identifying the devices that are configured for control in the eco-system. The devices must connect and share identity on a common shared pool of devices, to distinguish which device controller is responsible for a particular location. Mapping of home appliance and device controller for the particular location. To achieve this, it is proposed to develop a mapping technique that stores the device map to handle device control to appropriate devices and part of the home that belongs. Figure 5 explains how devices are connecting.

4.4. Offline remote control

The android application which is used to configure and manage existing devices is now updated to handle offline remote control. The android application with this new module can connect with the Wi-Fi network of the eco-system under control and communicate with the central control hub to control the devices in the eco-system. This is achieved by adding remote control techniques to android applications for ease of use and convenience. Figure 6 explains how the offline remote monitoring control is working it shows which devices are involved in offline remote control and data flows from the android app to the Wi-Fi router.

4.5. Online remote control

In this phase of the automation system called the online remote-control feature is shown in Figure 7 in which the android application is updated with a new module that allows users to connect with the cloud real-time database to control the home automation eco-system from a distance with the help of internet. The

central control hub is directly connected to the cloud and waits for control signals from the user. If a user sends a control signal the cloud triggers the respective central control hub and validates the request from the user. If the request is valid then the respective device controller is notified to update the status of the new device as per the request from the user.

4.6. User profiling and cloud configuration storage

The current generation automation system provides tailored service to users based on their activity and interaction with the system. To achieve a tailored user experience, we need to collect user data and process it in a secure location which is crucial for automation as shown in Figure 8. In this, the user is able to configure the cloud server with his profile by entering basic details that are required for creating profile and configuration. Moreover, the configuration and creation of the profile is achieved with the assistance of internet.

Figure 5. Local network connectivity

Figure 6. Offline remote control

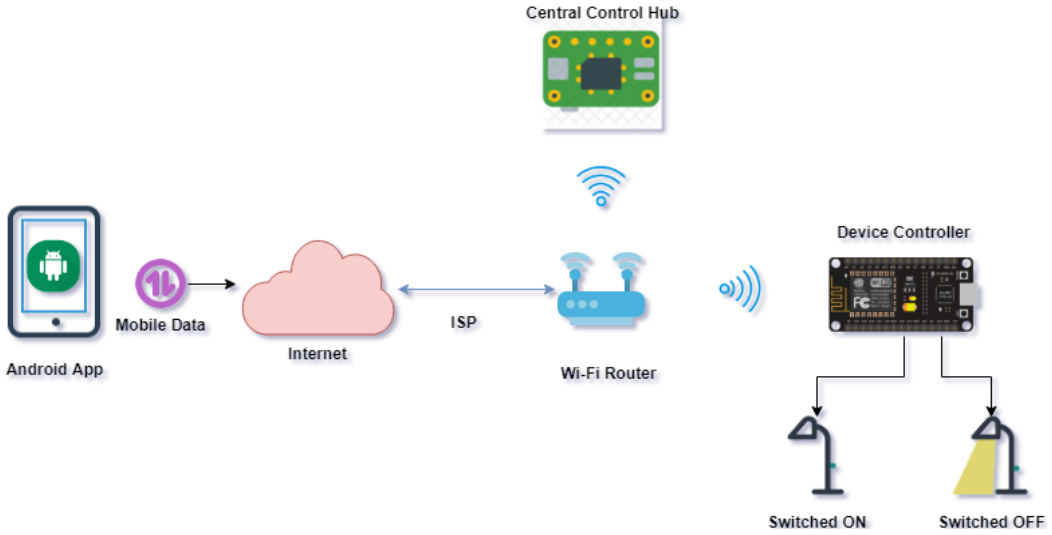

Figure 7. Online remote control

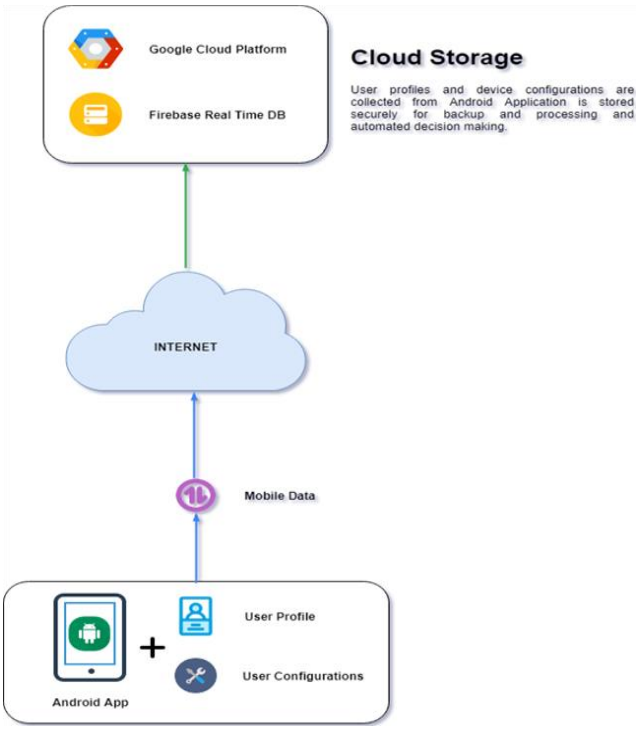

Figure 8. User profiling and cloud configuration storage

5. CONCLUSION AND FUTURE WORK

Current IoT development had given us a way to get an idea of creating an economical home automation system for society. The generic home automation system at its current stage of development is good for use in the home eco-system. Still, it needs a lot of improvements starting from the end–to–end advanced encryption standard (AES) 256-bit encryption while connecting either online or offline. Move from database as a backend to fully-fledged representational state transfer (REST) services model for porting the system to the other entire platform including iOS, windows, and web. Develop or use a lightweight encryption algorithm for encrypting the communication between device controllers and the central control hub. Automated inactivity detection and device shutdown facility. Allow users to develop custom scripts that can run on their devices. Develop automated network failure detection and create an emergency mesh network to take over the eco-system network for uninterrupted eco-system management. Hardware support

for monitoring power usage at each device under the automated eco-system. Based on user preference update the encryption key on a periodic interval. Adding end–to–end AES 256-bit encryption between android app, cloud, and central control hub. Lightweight encryption algorithm over communication between device controllers and central control hub.

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