

# **Internet of Things and Cloud Computing for Smart Home**

## **Abstract**

The adoption of automation is on the rise, facilitated by the internet, enabling objects to operate autonomously. With recent advancements in high-speed internet, the Internet of Things (IoT) is poised to play a crucial role in our daily routines both now and in the future. IoT provides convenience and efficiency to systems built upon it, fostering a more comfortable and standardized way of life due to its time, energy, and cost-saving capabilities. In this era where convenience is at our fingertips, household appliances are increasingly controllable via smartphones. This enables intelligent management of usage, contributing to the creation of an eco-friendly environment. This paper aims to explore how household appliances can be intelligently automated through the integration of software applications with hardware boards. It presents a comprehensive system architecture along with its operational capabilities, delving into the internal workings of the system, particularly focusing on the interaction between software applications and hardware boards. Recognizing that smart home automation can be prohibitively expensive, this paper examines methods for its implementation at a lower cost.

**Keywords**-Internet of Things, Cloud Computing, Smart Home

## **1.Introduction**

As time passes, the mobile applications industry has experienced rapid growth. In this century, there has been a tremendous increase in the usage of mobile phones. This surge in phone usage demands developers to create user-friendly mobile applications. By integrating mobile development with the Internet of Things (IoT), users can now control or monitor hardware devices through mobile applications. IoT-enabled devices have the capability to sense, collect, and share data over networks from any part of the world, which can be utilized for various purposes. IoT is enabling objects to function autonomously [1]. IoT is described as an environment where devices communicate with each other without the need for human-to-human or human-to-computer interaction [2]. It involves objects connected to the internet interacting, communicating, and exchanging data. The connectivity of objects to the internet opens up countless possibilities [3]. They are gaining importance as integral parts of systems. IoT facilitates efficient data collection and analysis over wireless connections, speeding up communication between objects. The flexibility provided by IoT in controlling and automating objects is making this technology ubiquitous. IoT has simplified our lives by introducing Smart Homes. Smart home automation systems empower users to control their electrical appliances with a single tap on their cell phones. Additionally, Smart homes enhance home security by sending alerts to users' phones if intruders are detected. IoT has already been implemented in various areas and is functioning effectively. Many applications already support IoT, aiding in the development of large embedded systems. The concept of IoT has been adopted in automated systems for medical, commercial, transport, and large industries [4]. As smart home systems developed using IoT become more common, research on IoT with different implementations continues [5]. A new era of communication technologies has begun with the advancements enabled by IoT [6]. One of the main advantages of introducing IoT-based Smart homes is the ability to save electrical power and energy. Furthermore, through smart home systems, users can monitor the energy consumption of appliances on a daily basis. Once users are aware of their energy consumption status, they are motivated to reduce it, ultimately resulting in lower electricity bills [7]. Home automation was initially introduced and implemented in more developed countries using technologies like infrared, Bluetooth, and similar technologies. However, it did not gain much popularity due to several limitations. Its range was too limited, working speed was slow, and it was cost-prohibitive, making installation difficult for many [8]. With the rapid advancement of modern technologies, especially with the advent of internet connectivity for devices, home automation has evolved significantly. This

evolution has led to the concept of "Smart Home Automation," which has gained popularity due to its wide range of applications, quick response times, low power consumption, and other features [9]. Smart home automation systems are designed to enhance comfort, convenience, and energy efficiency within the home environment. They provide services that create a more comfortable living space and improve response times. These systems facilitate intelligent communication between people, systems, and devices, allowing for easy monitoring and control of device states [10]. Smart Home Automation enables real-time control of household devices using powerful tools like smartphones, which are ubiquitous in today's society. With internet availability everywhere and Wi-Fi networks in every home, the adoption of smart home automation systems is becoming increasingly common [11]. In the realm of security, IoT plays a significant role. It transforms ordinary devices like doorbells into smart devices equipped with video cameras, allowing homeowners to monitor visitors and operate doors remotely via their smartphones [12]. Before IoT, smart home systems relied on Bluetooth technology, which had limited range and accessibility. However, IoT overcomes these limitations, providing users with greater control over household devices from anywhere using software applications. These systems have found applications not only in homes but also in hotels, restaurants, offices, and other establishments to enhance customer experience. The costs of smart home systems have reduced with the advent of wireless technology and inexpensive sensors, further promoting their development and adoption [13]. As technology continues to advance, there will always be possibilities for improvement and enhancement in home automation systems. IoT-based systems enable intelligent communication between devices and users, allowing users to monitor and control their devices remotely through software applications. By providing notifications and remote monitoring and control capabilities, smart home automation systems help users avoid unnecessary energy usage, thereby contributing to energy savings and efficiency.

## **2.Related Work**

Internet of thing is becoming one of the emerging technologies from the last few years. It is the expansion of internet services, and it has changed the human's lifestyle by providing everywhere connectivity with anyone [14]. IOT is the combination of electronic devices connected with sensors, actuators, software's and a Wi-Fi that allow these objects to exchange information [15]. Some of work related to the field of Smart Home automation has been discussed here. In this paper, author proposed the design of smart home by using raspberry pi and computer vision technique. Raspberry pi manages devices control, video camera recording and motion sensing while computer vision techniques detect the presence of intruder. So, whenever invader enemy is detected raspberry sends an alert through message or other notification [16]. However, the same technique can also be implemented with the help of microcontroller that reduces the cost of the system, but it may have other limitations. In this paper, author proposed a friendly smart home that works on push notification and servers as Personal Assistants. Major components used in the architecture are Arduino-microcontroller and android phone. The design of this system can be divided into three sections Pi webserver manage overall network and database maintenance. Also, it sends request to cloud and sends response through push notification as a result of the user input. Sensor array with controller along with Arduino connected with all the sensors includes; Passive Infrared Motion Sensor (PIR), Light Sensor (LDR), Temperature and Humidity Sensor (DHT11), Magnetic Reed Sensor, Raindrop sensor (LM393), Soil Moisture Sensor, Gas<sub>SEP</sub> sensor (MQ5). Pi actuator containing 12V relay array module work as a switch that can send and receive messages simultaneously [17]. The whole system is dependent on the sensors, there is no interaction required from human. Once the sensors failed to work, the system will also stop working. In this paper, author proposed the design of smart home in which a CT sensor is used that keeps the record of unit consume by the home appliances and update in the database on regularly basis. This energy consumption detail will be sent to the user through alerts on every 15 days containing the detail about the energy consumption. This real-time application help user in monitoring record and he take particular action [18]. This system required a large amount of memory space as it stores records on regular basis so after a certain amount of storage, it might result in memory size exhausted. Moreover, load sensor connected with Arduino has been used that keep track about the LPG and when the cylinder reach to certain amount then gas booking agency received a message that is sent by the system and an alert will be send on the user's cell phone that generates and attached unique ID with every booking [16]. The purpose of this paper is to design a smart home monitoring system that works on data collector that collects data based on different sensors. Different units of data sensors are grouped in one unit such as audio

sensors; video sensor and smoke sensor are grouped to one data unit. All sensors in group are connected via wireless network. These systems provide assistance to user in case of emergency. Let's suppose if a house is on fire, the data collector receives data from smoke sensor, record audio and immediately sends alert to the user cell phone along with video. There are some cases in which data collector will not work well so, once user get notification from the data center via cell phone, he should check video manually and make decision according to that. Smart home also works on audio sensor that sends notification to the user if there is any abnormal noise is heard for e.g. someone in the house shout if there is any thief detected [19] [20]. In this paper, author proposed a smart home based on ZigBee Wi-Fi gateway. Sensors and actuators are deployed and received signals remotely through wireless network on a cubie board control unit operates through GUI and a gateway as well. Gateway is a bridge that develops a connection between different protocols result in the development of smart homes by introducing different sensors and actuators [21]. ZigBee based home automated system work only on limited memory communication between the appliances because it has a protocol with low power communication.

### **Functional Description**

Internet of things creates interaction between the user to object or the object to object. In a technical way, physical hardware object receives a request from the user device over the network with certain instructions and that hardware perform the action according to the instruction it received. The physical hardware object can be composed of any hardware board i.e. raspberry pi, Arduino, RFID etc. All boards have their own advantages and disadvantages. They almost have same working architecture but are differentiate in terms of features, cost and processing speed. By introducing these hardware boards, the working of internet things technology boost up with the very high level. After the advancement of wireless technology and the advantages of Wi-Fi Network on automation are given, the support of different technologies communication medium is introduced by all having its own unique specifications and working efficiencies [22].

a. Raspberry pi: Raspberry pi is a sort of minicomputer. It has all the features that computer has, even it has some additional features of controlling the devices that connected to their GPIO pins. It was first manufactured in the United Kingdom by the Raspberry Pi Foundation. Its

main feature is that it can run multiple programs as it came under general-purpose computer [23]. It uses the ARM (Advanced Instruction Set Computing Machine) technology on board which reduces power consumption [24]. This same working of raspberry pi board also helps in developing the large embedded systems. By using raspberry, people are inventing incredible things, and their working usage is increasing day by day with every updated version. Raspberry pi 3 B+ is the latest model among A, B and B+ available that contains processor with 512MB and have 24 GPIO (General Purpose Input Output) pins which means 24 electronic devices like lights, fans can be control connected with each relay module which works as a switch between the GPIO pins of raspberry pi board. It supports the Raspbian operating system which has working capability as same as/ the Linux operating system.

b. Arduino: Arduino is another type of hardware board available which is an open source generally considered as microcontroller provides for software hardware interaction. It is flexible and very easy to use but has low processing speed when it is compared to raspberry pi processing speed. It runs only one program at a time. It mainly uses C or C++ programming languages. Arduino board consists of different type of hardware, all boards have 14 digital input output pins except Mega2560 Arduino that has 54 pins which has same working as the raspberry pi GPIO pins [25]. The relay support for switching is given to Arduino digital input output pins that are connected with household's devices.

c. ZigBee Module: ZigBee module is another medium use for smart home automation system. It creates and manages the connection between the user application interface and system functions. The communication is done by passing the message between devices. It is responsible for the establishment of connection between the users through proper application interface and system functionality [21]. It mainly considered as alternative option of Bluetooth or Wi-Fi. Unlike Bluetooth functionality which works on point-to-point communication, ZigBee module follows the mesh networking protocol that broadcast whole data transmission. It produces a much better stability in terms of communication.

## **System Design**

In IOT automated systems, the architecture has 2 level of its design, the first level is hardware architecture, and the other level is software architecture. Hardware architecture is the most essential part of the system once it is configured correctly then software application can easily integrate with hardware architecture because the purpose of software application is to invoke

the request. The main output depends upon the hardware module. Both should be made sync with each other.

a. IOT home automation architecture: The architecture of IOT consists of software application that interact with hardware board connected with home devices using internet. For every single home device one input output pin of hardware board is connected with every single relay module which works as a switch for the devices. The static IP is assigned to the hardware board through which we can access the board or execute its stored scripts with the help of software application. The sensors are used to process or generate the appropriate environmental data on real time needed for the systems and they have the most significant role in providing the energy efficiency in IOT systems [26]. The sensors like motion detection and temperature camera sensor etc. can also connect with the hardware board. They normally have separate input output pin in different hardware board, but some board support the same input output pins which are used for smart home devices. Without the sensors used, systems can be implemented by it will not provide full support. The use of sensor technologies provides measurement and evaluation of environmental indicators, as the information shared over a sensor network [27].

b. Working: As discuss above the home automation architecture, the working of the system is mainly based upon architecture. Software application is responsible to provide the user interface to the users. Users must need to login to the system and then he/she can control or monitor the status of devices. Software Application receives the request generated from the user and passed it to hardware board. Application by means of IP Address access hardware board remotely and perform its execution with respect to user's input request. The working of software application defines with the help of flow chart in Fig [1].



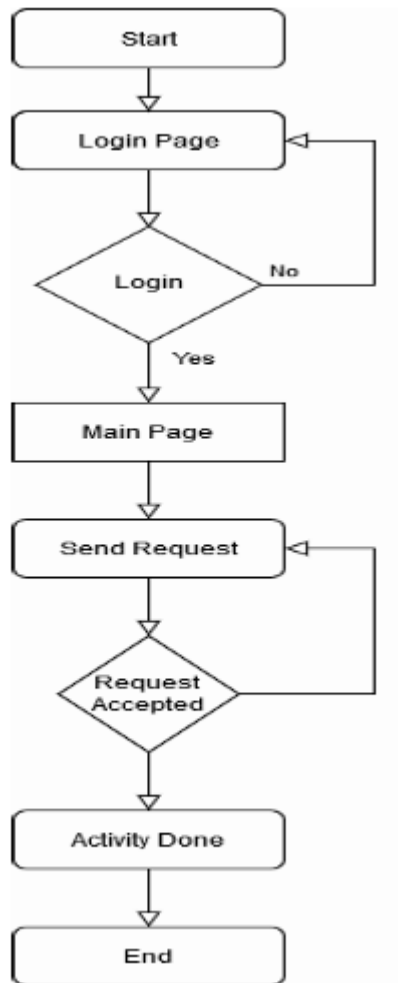


Fig.1. Concept-specific hardware trainers for Digital Fundamentals

Scripts are written and stored for every input output pins of hardware board that are connected to every single device like light, fan etc. via single relay module which works as a switch between the device and the hardware board pin. Mostly scripts are written in python language. But the support of JavaScript is also available on many hardware boards depending upon on which Operating system it is using. Once the user clicks on the any device button from the software application, the application program invokes and run the respected script of board which execute the command in result the status of device changed with respect to user performed action. This same whole working functionality performs by all other input output pins of hardware board. Fig. 2 shows the whole internal working of smart home automation. Application users can also control or monitor the smart home devices if he is not available within the specific domain or network. But it is mandatory for hardware board to contain a

specific static IP through which hardware board can access remotely anywhere from the World. By this Application can then run any scripts stored in hardware board that correspond to users performed activity. But it requires authorized users to access otherwise it will be a thread for the system that may cause a harmful result. Some level of security support is needed for authentication.

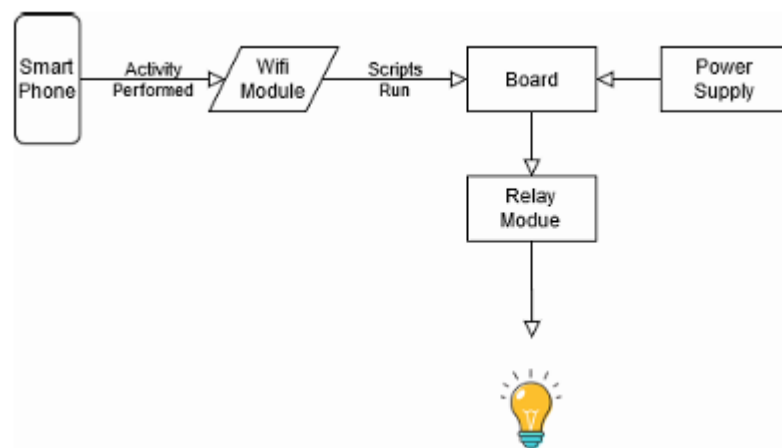


Fig.2. Internal working of the Home Automation System

c. Sensors: Sensors are very much productive in many Internets of things-based applications or systems. In 21st century, implementing sensors with different technologies provide the use of ubiquitous sensing in many living areas [27]. Once we talk about the internet of things-based automation system it mainly considered about the sensors usage, because none of the automated system can provide full support of its working without the use of sensors. It must include in the automated because they are the key source of building the systems that are based on internet of things. Sensors provide additional features that can be used for system protection and sometimes it performs different functionality in different environment. Some best examples of sensors used with internet of things technology are temperature sensor, motion detection sensor, pi camera etc. Sensors provide services of collecting data from environment and process them to give accurate result according to the surrounding [28]. Sensors are helpful in providing the current status of the system. It also gives the live streaming by using the IP or PI camera.

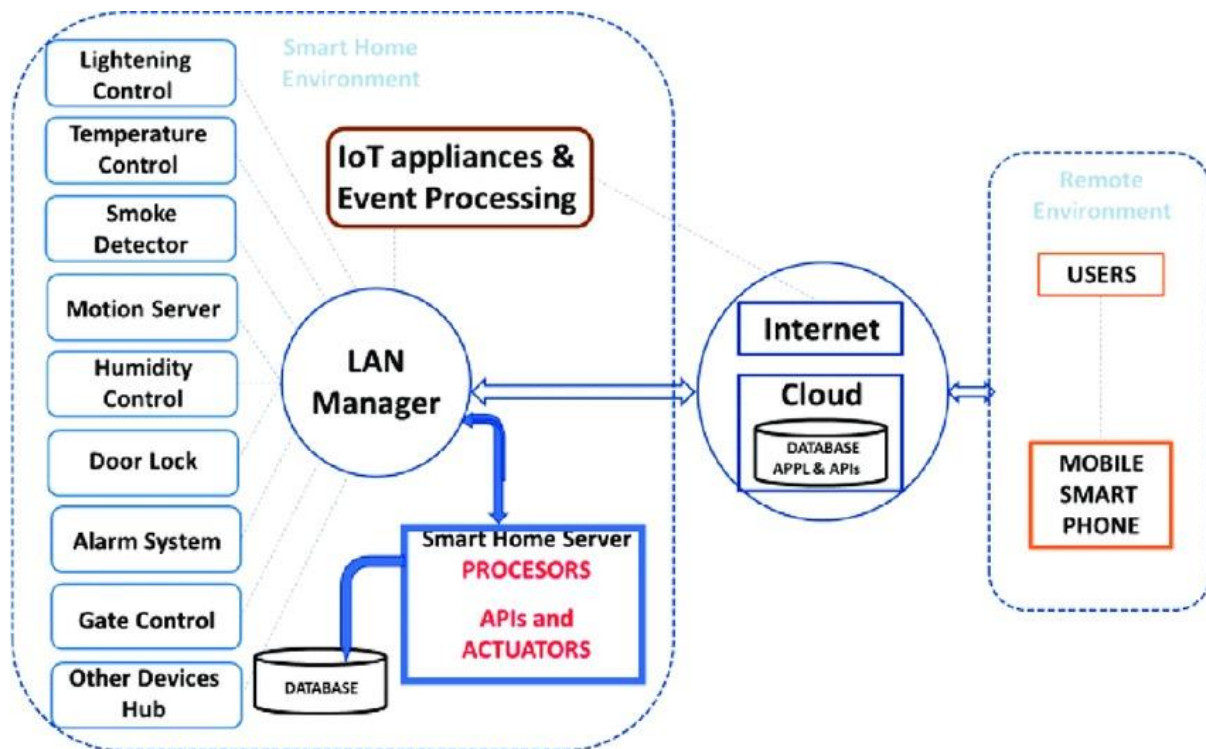
Raspberry Pi	The maximum distance supported by Wi-Fi is up to 100m. The maximum memory supported by raspberry pi is very limited it can support up to 512 MB and it can't be further extended. There is no integrated calculation in GPIO pins just like Arduino. An ADC chip is required to deal with analog signals in order to find more accuracy.
Aurdino	The maximum distance supported up to 100m. It is used to perform repetitive task but Multitasking is not supported in Arduino. Maintaining security in Arduino is very challenging as it is an open source prototyping platform.
Gateway or Router	This type of interface is not user friendly for all types of users.

Table 1. Comparison of IOT Based Smart Homes on the basis of Mode of Transmission

The comparison table stated above give a concise idea about the limitation in the architecture of existing IOT based smart home. The appropriate choice of hardware and IOT protocol is very necessary because it will increase the effectiveness of current home automation architecture and reduce the drawback of existing systems. A home automation system, whose architecture consists of raspberry pi as a central unit, a friendly user interface such as MQTT protocol as a transmission mode is a recommended choice [29]. A survey is conducted for Smart Home using Internet of things in which central controllers work as a communication interface between everyday devices and Internet server. These devices will be connected to a switching module in such a way that when the state of switch is change even the state of device is change [30].

### 3.Methodology

The system assists and takes in-time decision through data collected by different sensors located at home. Rule-base knowledge representation system accompanied with IoT and cloud computing is employed to build fully functional classic smart home.



## 4. Conclusion

This paper delves into the process of remotely operating and controlling various equipment, machinery, and electrical appliances through different control systems. This approach, known as automation, has become indispensable in our daily lives. Our focus lies on home automation, aiming for optimal efficiency. Our designed model is based on an IoT platform, enabling devices to synchronize with it for remote control. Leveraging IoT technology, the platform establishes a network between a central server and household appliances, transforming homes into smarter living spaces. With a single admin overseeing the entire network, our model ensures security, granting the admin sole access to all nodes under each user. Despite the potential complexity of a network with multiple users, our model remains cost-effective. Looking ahead, our future endeavours include expanding the scope to encompass entire city automation through IoT by increasing the number of networks under a single server.

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