

Smart Home Automation Using IOT and its Low Cost Implementation

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Abstract: The use of automation is emerging with the help of internet providing possibility of objects to work it-self. With recent advancements to the fast speed internet, IoT will be playing a vital role in our daily tasks in present and future. IoT is offering feasibility and effectiveness to the system that are based upon it. These modern technologies are creating comfort and standard way of living because of its time, energy and cost efficiency. In this modern world, where things are going to be on our finger tips, our daily household appliances will also be controlled with our smartphones. This will allow us to manage the usage smartly, and can help in building of an eco-friendly environment. This paper will conduct a study based on how household appliances may be automated smartly with software applications that are integrated with hardware board. It presents the complete architecture of the system with its working capabilities. Also, it explains the internal mechanism of the system which mainly considers the software application and hardware board interaction. As we know the smart home automation is a costly process, so in this paper we would be looking at its low-cost implementation.

Index Terms: Internet of Things, Current Transformer, Wireless Fidelity, General Purpose Input/Output.

1. Introduction

With the span of time passing, mobile applications industry has grown rapidly. In this century, the increase in the usage of mobile phones is tremendous. The increase in the usage of phones demands developers to create user friendly mobile applications. By merging the essence of mobile development accompanied by Internet of Thing (IOT) facilitate users in controlling or monitoring hardware devices by using mobile applications. Things that are working under IOT have the ability to sense, collect and share data over network from any part of the world where that data utilized for various purposes. Internet of things is making every possibility for the objects to work by its own [1].

Internet of things (IOT) is defined as an environment where all the devices communicate with each other without the interaction of human-to-human or human-to-computer [2]. IOT involves things that are connected with internet can interact, communicate and exchange data between them. By doing objects connectivity with internet, there are countless possibilities that can be done [3]. They are now having more importance as they are becoming the part of the system. It also involves the proficient way to collect and analyze data over a wireless connection that makes the communication between the objects faster. In controlling and automating the objects, the use of internet of things has provided a lot more flexibility, which is making this technology pervasive. IOT has makes our life easier by introducing the concept of Smart Homes. Smart home automation systems has given its users the power to control their electrical appliances with their single tap on their cellphones. Moreover, Smart homes also help you in maintaining home security. It will send alert to your phone if the entry of any intruder is detected. Internet of things is already implemented in many others areas and it is performing its work in a well-organized way. Internet of things support is already given in many applications, also helpful in building large embedded systems. Many automated systems for medical, commercial, transport and large industries are adapted the concept of internet of things [4]. After the implementation of smart home systems become common that are developed using IOT, the research on IOT with different implementation is experiencing and it is still going on [5]. A new era communication technologies has been started with the enhancements enabled by this [6].

One of the main advantages of introducing IOT based Smart home is user can save electrical power and energy. Furthermore, through smart home user can monitor energy consumption of appliances on daily basis. Once users know the status of unit consumption, they will put effort to reduce it ultimately result in less electricity bills [7].

Smart Home Automation System

Home automation was first used and implemented in the civilized countries by using infrared, Bluetooth and similar type of technologies. It was not become much popular due to several reasons. Its range is too limited, working speed is very low and it is also very much cost effective that no one can easy install this automated system [8]. But after the rapid increase in the modern technologies when devices connectivity is done with the help of internet, which also helps these systems to build using the internet and its development increases with a very high rate because of its wide range of usage, quick response, low power energy consumption and many other features which is generally now known as "Smart Home Automation" [9].

Smart home automation systems are defined as implementing the system within the home environment to facilitate its customers by providing comfort, convenience, and energy efficiency. The services it gives provide the more comfort zone. The speed of response is also improved. It completely changes the home environment that it allows intelligent communication between people, systems and things. The benefit of getting connectivity of smart devices with the internet creates easy way for devices of monitoring and controlling its state [10]. Smart Home Automation provides real time controlling of household devices. The smart phones we all carry in our pockets or in our hands are very powerful tools through which we stay connected with the whole World and it makes our life easier.

The internet availability is present everywhere, each home contains its own Wi-Fi Network with every single person has its own smart phone. By having these facilities available, the use of smart home automation systems is becoming very common. With the increase in crime rate managing security in our homes is getting very difficult. The role played by IOT in this area is very significant, it converts an ordinary doorbell into a smart bell along with video camera embedded so that home owner can get the video of the person coming on the door and he can operate the door through his cell phone [11]. Smart home automation refers to high-tech functionality and provides luxurious comfort that was not available in the past. Smart home systems are energy efficient provide that fully support of automating the household devices and are useful on maintaining or saving the energy power consumption which helps to achieve a certain level of comfort [12]. Before IOT, these systems are implemented through Bluetooth devices but they didn't become very famous because it only access within a specified given range. The internet of things overcome this limitation and provides a great way to the human for controlling of every aspect of household's devices on just single click by using software application from anywhere. These types of systems also have been applied in many hotels, restaurants, houses, offices etc. just to facilitate the customers.

After Wireless technology and cheap sensors takes place in internet of things, the costs of smart homes reduced and promote the development of these systems [13]. As technology growth expands, the possibilities in improvement and enhancement of system will always be there. The internet of things based system allows intelligent way of communication among things and the users. The smart automation tracks the whole system by its software application that helps users to control their devices whether he/she is not available within the place where the hardware system is implemented. If a user forgot to close all devices of home and he/she left the home, he/she will not able to get status of devices and can't able to make them switch off. But using smart home automation system the user will get notifies or he can monitor and control its devices status by software application which makes them help to overcome unnecessary usage of energy. So, these systems also help to overcome unnecessary use of electricity.

2. Related Works

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_{SEP} 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 send 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 cubieboard 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 like the Linux operating system.

b. Aurdino:

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].

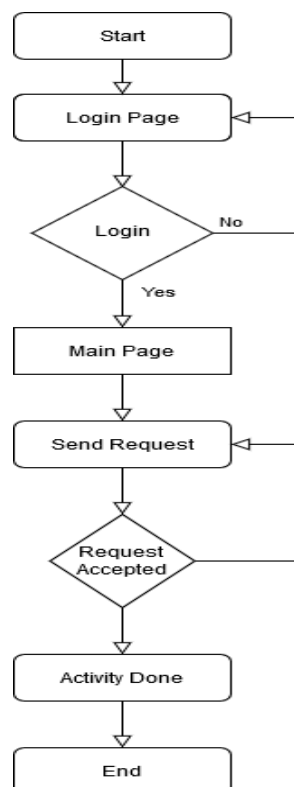


Fig.1. Concept-specific hardware trainers for Digital Fundamentals

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 click 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.

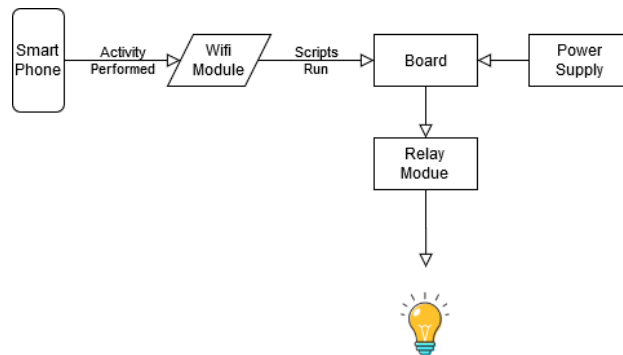


Fig.2. Internal working of the Home Automation System

c. Sensors:

Sensors are very much productive in many Internet 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.

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

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.

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. Low Cost Implementation

The cost of an IoT implementation is depended on multiple aspects, such as the hardware and the software cost. The software cost for a smart home automation system is not that much. A simple application to on/off switch using a web app would require about 80 man hours. A server would be required to host that application and the IoT hardware, i.e. the board, controller, switches and relays would be required. To achieve the goal of low cost implementation of IoT, one of the most important thing to do is to use Aurdino instead of Raspberry pi. [31]

Below we have compiled some major differences between microprocessor and microcontroller, to keep in mind for a low cost implementation on IoT.

Table 2. Microprocessor vs Microcontroller

Microprocessor	Microcontroller
High processing power	Low processing power
Versatile	Single purpose
Instructions set focused on intensive processing operations	Bit level operations
Typically 32/64 bit	Typically 8/16 bit
Variable RAM, ROM and I/O ports	Fixed on-chip ROM, RAM, I/O ports

For the implementation of smart home automation based on IOT, we can use arduino board instead of using Raspberry which is more expensive. The main difference between arduino and raspberry pi is that arduino boards are microcontroller whereas raspberry pi boards are microprocessor and for implementation of smart home automation, we just wanted to have board which have bit pins working in it and arduino board supports this feature. In arduino board, every single bit pin called GPIO (General purpose input/output) pins are connected to every physical device through relay. These pins are controlled programmatically. JavaScript and python are most commonly used. Each script is written for every GPOI pins. The software mobile application access these scripts and allow to run these scripts to enable or disable bit pin which in return performs physical device to switch off or on with the help of relay. [32]

So, without using microprocessors boards, arduino board can be used to design the structure of IOT based smart automation which is very cost effective solution to implement.

4. Challenges and Security

The role of architecture in IOT systems has very importance with respect to develop secure system because security has become a major issue, any criminal activity can be done so these systems should be made protected unethical activities [33].

As smart home environment is increasing day by day which has created a lot of relaxation in the lifestyle of the user but on the other hands it is not easy for the developers to develop the functionality that support for every application and the hardware board it contains. There are some challenges in developing and designing fully supportive home automation system that can work well in every environment.

Whenever data stored, access, exchange is done on the cloud it means it is public and can access globally from anywhere then there is always a risk factor for the data from the hackers. They attempt to steal a data so security precautions have been taken or data should be protected from them. These same instructions follow for smart home automation that the system should protect from other unauthorized users. So increase in IOT devices means an increase in security as well which can be taken through a lot of ways and keep the smart homes secure. It can be done by placing an additional authentication apart from the password, which includes receiving of a code or a phone call on entering the password which could keep the smart devices free of hackers.

Another factor includes that whenever a new device needs an update, it should be updated at that instance. This would keep the dangerous malware and intruders away from the devices and secure it. For the security purposes a secure auto-configuration approach should be taken so that it can simplify the installation of smart home automation as well as for the maintenance purposes and would also increase the security in configuration process [34].

All data must be transferred through any secured protocol. SSL certificates must be installed on the servers to keep the data transition encrypted. Passwords must be encrypted and authorization should be done on every HTTPS request between the devices and the server. Furthermore, the web application used to control the appliances will be password protected.

5. Future Scope

The IOT based systems are actually considered with low budget because hardware prices are not increasing too much. This is main reason it is now implementing in many areas because it provides the users of doing anything by means automation. Smart home automation systems uplift the living standards of the people and also give pleasant

environment in which a person can take relax without any worries of any mishaps. Future work of internet of things in home automation includes:

- The expansion of mobile platform to IOS (iPhone operating System) as most of the systems is not supporting android application because of not getting full platform support from hardware board.
- A user can understand the module perfectly for this a speech-to-text module can be integrated so that the user can interact verbally.
- A voice recognition system could be added as a new feature.
- As security is the most essential element of any module so for that purpose a low-cost camera can be added for the feature of face recognition which can improve the security.
- A sensor like heart beat sensor could be added to this system which may help in checking the heartbeat of the patient in case of an emergency and would serve a great deal.
- Improvement in the lifestyle of a user can be suggested through the implementation of machine learning algorithms which would track sleep patterns and activity of the user etc.
- Future IOT sensors must have enhanced security to prevent cyber-attacks which can be prevented by implementing number of security features in IOT sensor hardware and stack and by adding more layers of security which include private keys, number generators etc. which would keep the attackers away from breaching the network.
- Features such as power monitoring of appliances and temperature control could be added.
- The inclusion of GUI interface could create more attraction of the project.

6. Conclusion

In today's era of digitalization, everyone is opting towards automation. Smart Home Automation is an innovation in living standard that makes home more easeful, comfortable and economical. Once devices are connected with internet, their monitoring and controlling can be done from any part of the world. Smart home automated systems can be operated remotely from anywhere. In this paper, we have discussed a few home automation examples that had been proposed by different authors, architecture and basic working. A very simple model that we discussed comprises of a web application, processor preferably Aurdino, relay, sensors and the device switch, which is a low-cost solution for smart home automation. Moreover, there are so many advantages of Home Automation but contrary to this there are some security threats that we should deal with. Machine learning and Artificial Intelligence techniques can also be implemented in future to make these systems more efficient and reliable.

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