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Home Automation Control System

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Abstract - *The past and the glorious future of Home Automation is becoming more practical than just popular due to its numerous advantages. This paper aims at designing a basic home automation system that can be monitored and accessed remotely worldwide which is convenient and secure, cost-effective, along with providing flexibility, scalability, effectiveness, and portability. The technology incorporates Raspberry Pi and the web server comprising a two-way communication to exchange electric charges as well as information to maximize the system's efficiency. The web page and the switches provided on the web page help us control the information. The data containing information about the control commands are transferred between the endpoints of communication using TCP (Transmission Control Protocol). The control system mentioned herein provides the liberty to control appliances from remote locations connected through Ethernet. A novel embedded system has been designed and implemented on Raspberry Pi and a small-scale prototype is developed and tested. The system is much more secure than all the previous systems because researchers are using dynamic IP (Internet Protocol) addresses. Thus, the appropriate usage of WSNs (Wireless Sensor Networks) lowers the rate of failures and the overall cost of the system while increasing the productivity & efficiency of automation operations. The main objective of the present work is to design a smart home using various sensors which can be controlled and monitored by the Raspberry Pi via the IoT (Internet of Things). This helps homeowners utilize a simple, fast and reliable way to automate their environment.*

Key Words: Home Automation, Smart Home, Dynamic Web, Embedded Web Server, Raspberry Pi, Appliance Automation, Internet of Things

1. INTRODUCTION

Home automation or Smart homes can be described as the introduction of technological advancements within the home environment to provide convenience, comfort, security, and energy efficiency to its occupants. The introduction of artificial intelligence to the home environment can increase the quality of life. The advent of the IoT (Internet of Things) has quite popularized the research and implementation of various kinds of intelligent home automation systems.

Home automation can be considered as an act of using electronic systems or devices and programming them to replace several human interactions for controlling essential home functions. This operates on the base of connecting sensors and devices to the IoT. IoT can be considered as a network of physical objects which can be accessed via the Internet. For objects to be considered IoT based,

A usual network of devices needs to be converted to an IP-based network supporting proprietary protocols for the devices connected within it to be considered IoT-based devices. The devices being connected to the internet can digitally represent themselves by being remotely controlled from anywhere across the world provided there exists an internet connection with the WWW (World Wide Web). These objects can transmit and receive data over a network without needing to deploy requiring any human-to-human or human-to-computer interaction. This also means that more data can be gathered from these devices and networks across many locations with real-time information being presented from these devices and networks. The advent of IoT devices and networks has the potential to increase efficiency, safety, and security. The

researchers in this paper plan to deploy the IoT devices in a smart home system.

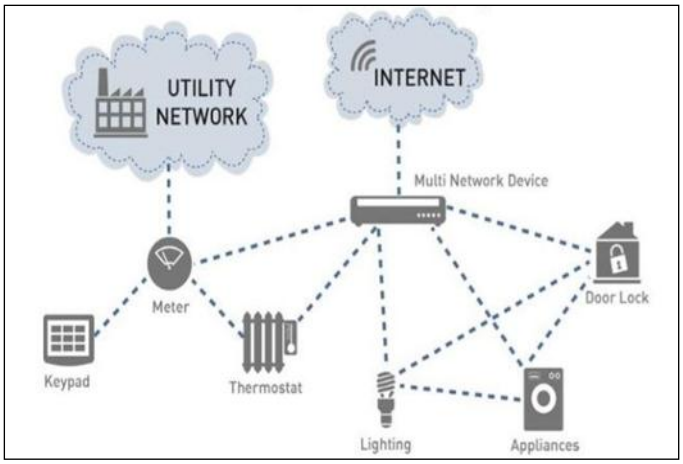

Fig -1: Inter-connection and Intra-connection of Home Appliances.

The smart home is supposed to be in regular interaction with its internal as well as external environments. The external environment consists of all the entities belonging to the smart grid and the internal environment consists of all appliances and devices belonging to the smart home, which are centrally managed by an entity in it. A smart home has an automated system that can be created to establish control of certain aspects or functions of a home. This enhances the security and efficiency of a home, which also gives real-time monitoring via the internet and the WWW. The Raspberry Pi and the subject of home automation is a remarkable one. The Raspberry Pi can be used to automate a home at a relatively low cost. It operates on the concept of the IoT. Numerous factors make the Raspberry Pi essential for the home automation system but the one that stands out the most has to be the remarkably affordable cost. The vast amount of sensors at an extremely low cost makes it superb for home automation. There are many methods by which we can implement a home automation system. Some of the methods are listed below: -

1. Home Appliances Control using a Remote Control.
2. Home Appliances Control using DTMF.
3. Home Appliances Control using Free Hand Gesture.
4. Home Appliances Control using Internet and Radio Connection.
5. Wireless Browser-based Device Control using Raspberry Pi.

1.1 Home Appliances Control using a Remote Control

The lights and fans can be automatically turned ON/OFF with the help of a handheld remote incorporated with sensors. Hence, instead of going near a switchboard and putting ON/OFF the switch manually, one can perform the same operations remotely. Companies like Legrand and Gold Medal have already started manufacturing as well as selling these kinds of home automation control systems and they are presently available in the market.

1.2 Home Appliances Control using DTMF

Home appliances deployed via implementing this method can be remotely controlled by using the DTMF (Dual Tone Multi-Frequency). The DTMF tone gets generated when the user pushes the mobile phone keypad buttons of the mobile which are connected to the microcontroller of the home automation control system [1].

1.3 Home Appliance Control using Free Hand Gesture

Home appliances deployed via this method require a human to be present in the sight of the appliance that needs to be controlled and a predefined gesture must be used to turn ON the device and another gesture must be used to turn OFF the device [2][3]. The performance of such a system is measured by the hardware embedded in that particular device.

1.4 Home Appliance Control using Internet and Radio Connection

Appliances connected to a home automation system can also be controlled remotely by using the internet. This is usually accomplished from a remote location having a local server hosted with the ability to use the Internet and a radio connection. Researchers require a system that comprises personal computers and digital assistants, network interface cards, radio transmitters and receivers, microprocessors, AC (Alternating Current) phase control circuits, and likewise electronic hardware components. The software end of the same system requires an OS (Operating System) that contains a lucid GUI (Graphical User Interface) as well as microprocessor control software.

1.5 Wireless Browser-based Device Control using Raspberry Pi

Researchers in the past have demonstrated controlling the appliances from a GUI-based web browser interface which has been integrated with the ARM11 microcontroller [4]. This research paper demonstrates a prototype of a wireless browser-based device control implementing

Raspberry Pi in place of the ARM11 microcontroller. Researchers in this paper propose to use Raspberry Pi in place of the ARM11 microcontroller as Raspberry Pi is much more user-friendly as well as it is easily configurable. The Raspberry Pi is a credit-card-sized single-board computer developed in the UK by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools. The Raspberry Pi has a Broadcom BCM2835 SoC (System-on-Chip), which includes an ARM1176JZF-S 700 MHz, Video Core IV GPU, and was originally shipped with 256 megabytes of RAM, later upgraded to 512 MB. It does not include a built-in hard disk or solid-state drive but uses an SD card for booting and long-term storage. Researchers have used the Raspberry Pi Model B+ as a controller in this prototyping system. Researchers have vetted a list of Raspberry Pi models available in the market, such as Pi 1 Model A, Pi 1 Model B, Pi 1 Model B+, Pi 1 Model A+, Pi 2 Model B, Pi Zero, Pi 3 Model B, Pi Zero W, Pi 3 Model B+, Pi 3 Model A+, Pi 4 Model A, Pi 4 Model B, and Pi 400. The project guide has advised implementing the prototype on the Raspberry Pi 1 Model B+ due to its easy availability as well as cost-effectiveness in fitting into the budget.

2. HOME AUTOMATION

The introduction of home automation in the 1970s almost failed to improve the lifestyles of users for several reasons. First and foremost, the researchers could not put forth and the economists were clueless in determining the economic benefits of implementing home automation technologies. Secondly, the researchers failed to justify the high cost of implementing smart home technology since it did not include any metrics to measure the durability and provide the overhauling timeline as well as the lack of being user-friendly.

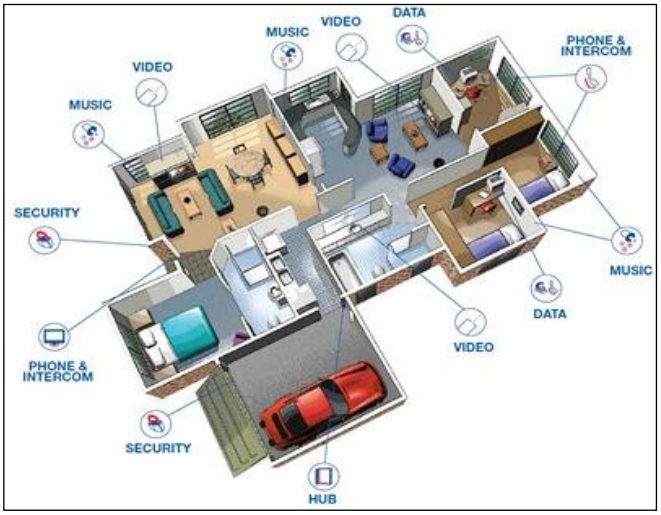

Fig -2: Smart Home Schematic.

Hence, there arose a need for smart home automation technologies to be cost-effective, easy to install-deploy-maintain, while also being scalable and compatible with numerous allied network infrastructures and appliances. The Housing Learning & Improvement Network published a Smart Home definition offered by Intertec in 2003 states that a smart home is a dwelling incorporating a communications network that connects the key electrical appliances and services, and allows them to be remotely controlled, monitored, or accessed. Researchers provide a summary of the previous research performed into smart home technology within the past decade. The advent of 1995 showed the world the construction of the Welfare TechnoHouses in Japan. The purpose of these experiments was to provide health monitoring for elderly people and disabled people in their homes by using fully automated machines that support their daily health care activities and thus improve the quality of their life. The University of Texas at Arlington has conducted the MavHome project over the past 7 years. The MavHome (Managing an Adaptive Versatile Home) is a home environment that detects various states of the environment through electronic sensors and intelligently acts upon the environment through controllers. The electronic sensors installed inside the smart home form an ad-hoc network with multiple interconnections that help them make appropriate decisions about controlling the environment.

3. PROBLEM STATEMENT

The focus of the project is on helping users to operate home appliances from their smartphones and to help the elderly or physically challenged people live a more independent life for as long as possible. The objective of this system is to take care of several individual domestic systems that might normally be difficult for those who are physically challenged or elderly to take care of. The proposed idea will allow a user with any android enabled device to run a piece of downloadable software on any mobile device such as a smartphone. This application will allow the user to control a device that is connected to any home appliance that is Pi enabled. The focus of this application will be to direct a security system with webcam surveillance, door sensor notification, and a light control system. Sensors will be connected to the home appliances with Pi so that they can be monitored and controlled.

Suppose an employee who has gone to work and during this period a thief sneaks up into the house breaking through a window. The proposed system would enable the client to monitor the home when a door or a window sensor triggers the alarm. The client monitors the home with a webcam and various sensory intelligence that helps immediately inform the local law enforcement authorities about the robbery. The client could also check the status of the various lighting systems and remotely turn ON and OFF the light without the need to get out of bed while sleeping

in the bedroom. These devices would also benefit those users who are suffering from various physical ailments and require to have very limited mobility that might give them a difficult time getting to or even reaching their switchboards. The researchers propose to accomplish these objectives requires a good tech stack as well as technological prowess. The user interface is to be kept as simple and user-friendly as possible so that could be operated dynamically.

4. EXISTING SYSTEM

SAP laboratories in Canada with research from the University of McGill presented a wireless solution for monitoring people in need of medical assistance. The application relies on the usage of cell phones as well as inexpensive sensors and is best suited for the elderly and homebound people. The main function of the project is to collect signals through a wireless sensor network using APIs and the analysis for data through an adaptive architecture that produces a Real-time health monitoring system to improve medical support for people in their homes and assisted living environments. Several groups have done extensive research into the use of smart home devices for the support of elderly and physically challenged people. The University Of Erlangen Nuremberg, Germany has described the challenges regarding smart homes, especially for supporting the elderly and physically challenged people. The purpose is to physically compensate for the handicaps and support the individual to help them accomplish a more independent life for as long as possible.

The paper does however reinforce the advantages of using a wireless standard. Bluetooth is one of the most prominent global standards used for connecting a wide range of devices [5]. It is available on most handheld devices. The technology is very easy to set up and use, as well as it provides security by encrypting the transmitting data using a 128-bit long shared key. However, its technology limits its ability to transmit data over long distances, and hence short-range communication is only possible. RF (Radio Frequency) systems have become increasingly popular recently with the advancements in RF technology such as Bluetooth and ZigBee [6][7]. These products offer a much more reliable short-range network than previous infrared devices which had interference and security issues. However, RFID (Radio-Frequency Identification) tags are more expensive, less reliable, and are application specific i.e. no one tag fits all.

Researchers in this project focus on device-enabled systems for smart home automation control to deploy Raspberry Pi for primary application usage. Although many systems have been researched and proposed in past research projects, very few among them have been prototyped and implemented. This project aims to build on the previous research described to implement a wireless sensor network to access and monitor appliances in the smart house. Researchers aim to provide an easy-to-operate and cost-effective approach that benefits users interacting with Home appliances remotely.

5. METHODOLOGY

Researchers have implemented an Operating System agnostic Browser-based Device Control using the Raspberry Pi Model B+. The Raspberry Pi Model B+ and Ethernet [8] are the primary components of the project. Raspberry Pi is the advanced version of the ARM11 processor. It uses circuit configuration which is interfaced on the computer and the commands are written using Python scripting language. Relays (or Relay Switches) are provided to connect the Raspberry Pi to the home appliances and facilitate their control. Web page design using HTML includes the information of the appliances that are controlled by the user. The Web page acts as an interface to connect to the Ethernet. Data acquisition through the respective sensors is asynchronously displayed on the Web page. Input through this web page is sent via a UDP (User Datagram Protocol) to the Ethernet IP address of the Module Board which process the input request and accordingly commands the respective devices connected to the Raspberry Pi Board. The various devices such as Lamps, Tube lights, Fans, etc., and other remotely controlled peripherals remotely receive ON/OFF requests via the Web Server-Raspberry Pi Relay Architecture. This elegant architecture provides simplicity and easiness in controlling the appliances and devices that are connected to the Raspberry Pi board and are kept in sync with the relaying architecture as well. Even a lay person entirely unaware of the knowledge of engineering disciplines of Electronics, Computers, etc. with limited knowledge of the internet and web pages can remotely access and control the appliances within the smart home from any part of the world.

6. TECHNOLOGY

6.1 Hardware Components

6.1.A Raspberry Pi Model B+

The Raspberry Pi Model B+ is a credit-card-sized single-board computer developed in the UK (United Kingdom) by the Raspberry Pi Foundation to promote the teaching of basic computer science in schools. The Raspberry Pi has a Broadcom BCM2835 SoC, which includes an ARM1176JZF-S 700 MHz, Video Core IV GPU, and was originally shipped with 256 Megabytes of RAM, later upgraded to 512 MBs. It does not include a built-in hard disk or solid-state drive but uses an SD card for booting and long-term storage.

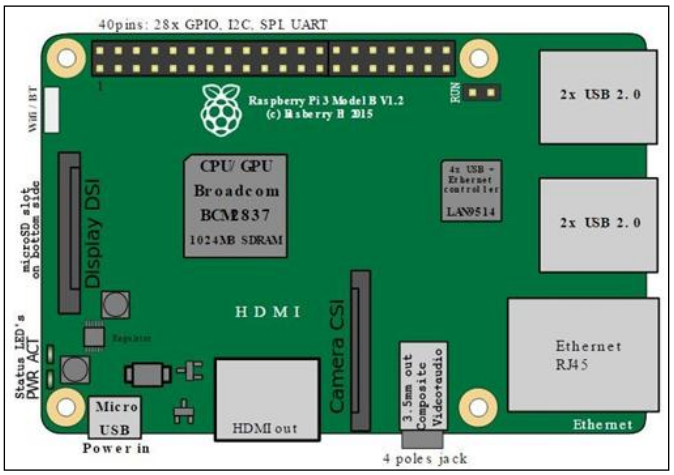

Fig -3: Raspberry Pi 3 Model B+ V1.2 (2015) [9].

Researchers have to periodically perform a ping test to verify that the Raspberry Pi Model B+ board is functioning well and connected to the Internet. Again, this depends on the configuration (Ethernet or Wi-Fi) and the router but is usually really easy. Checking the connection using a Wi-Fi (Wireless Fidelity) dongle is the easiest solution directed by the GUI that comes along with the Raspbian OS (Operating System) to search for the wireless network and enter the WEP/WPA (Wired Equivalent Privacy / Wi-Fi Protected Access) password.

6.1.B Relay Circuit

A Relay is an electrically operated switch, which allows the low power circuits to switch to a relatively higher voltage or current on getting ON or OFF. Relay switches consume less power thus making them an ideal choice to be deployed inside sophisticated technologies. These electronic components are known to work well with stability under high temperatures as well. For a relay switch to operate, a suitable pull-in and holding current is required to be passed through its coil. Relay coils are designed to operate at a pre-defined particular voltage, often it is 5V (Volts or Voltage) or 12V. Figure 4 well illustrates the working of the relay switch used by researchers in the project.

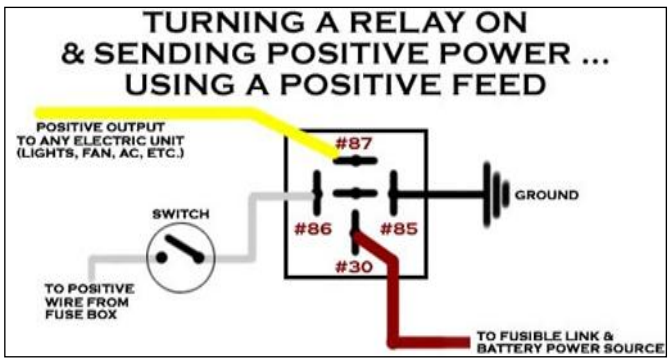

Fig -4: Relay Switch Schematic.

The function of the relay driver circuit is to provide the necessary current to energize the relay coil when a LOGIC 1 is written on the PORT PIN thus turning the relay ON. The relay is turned OFF by writing LOGIC 0 on the port pin.

6.1.C Rectifier

The power supply setup of the system contains a step-down transformer of 230/12V, used to step down the voltage to 12VAC (Volt Alternating Current). To convert it to DC (Direct Current), a Bridge rectifier is used. Bridge rectifiers are well suited to be used in high-voltage environments as they have a high peak inverse voltage.

6.1.D Regulator & Capacitor

To remove the ripples, a capacitive filter is used. A 7805 voltage regulator to regulate the voltage to +5V is required to ensure a smooth operation of the Raspberry Pi and other components. A regulator offers a rapid voltage correction capability with negligible restrictions on the voltage correction cycles.

6.1.E LCD Display

An LCD (Liquid-Crystal Display) numeric-cum-text display is used to display the commands transmitted and received through the IoT Dynamic web application.

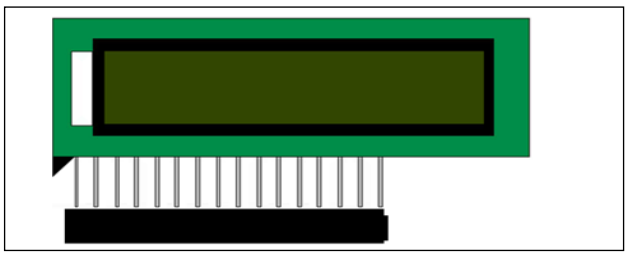

Fig -5: 5 LCD Display.

The LCD Display can be programmed by attaching it to the Raspberry Pi Board. The LCD Panel is divided into small matrices. Each matrix needs to be programmed accordingly to achieve the display of the commands that are transmitted from the IoT Dynamic Web application to the Controller Board.

6.1.F Appliances

Lamps, Fans, Tube-lights, and likewise appliances are taken into consideration and are connected to the board so to prototype the control system for the smart home automation system.

6.1.G Wi-Fi Connection Modem

Wi-Fi or Ethernet Connection is required to connect the Raspberry Pi Model B+ to the internet. The IoT Dynamic

Web application can access the Raspberry Pi board embedded architecture through this Wi-Fi Connection.

6.1.H Raspberry Pi enabled Home Automation block diagram

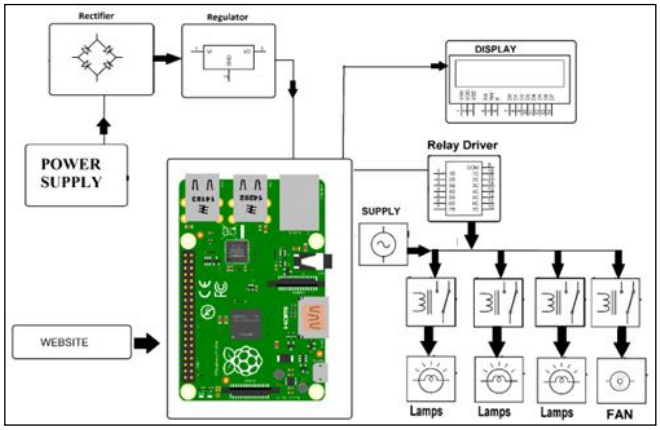

Fig -6: Raspberry Pi enabled Home Automation Schematic.

6.2 Software Components

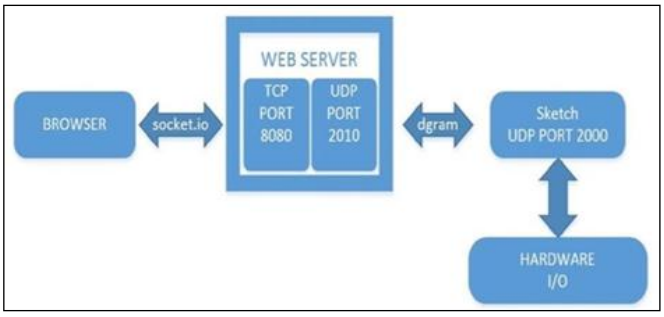

Fig -7: Communication between the Web Server, Browser, Sketches, and Hardware.

6.2.A Linux OS

Raspbian is a free OS (Operating System) based on Debian optimized for Raspberry Pi hardware. Raspbian OS is the set of basic programs and utilities that make the Raspberry Pi run smoothly. However, Raspbian is much more than a standard OS. It comprises over 35,000 packages and pre-compiled software bundled in a user-friendly format for easy installation on the Raspberry Pi boards. The initial build of over 35,000 Raspbian packages, optimized for the best performance on the Raspberry Pi, was completed in June of 2012. However, Raspbian is still under active development with an emphasis on improving the stability & performance of as many Debian packages as possible.

6.2.B HTML

HTML (Hyper-Text Markup Language) is a specific type of universal language used for digitally and visually decorating a web page. Hypertext is the text that has been used up with extra specifications such as formatting, image multimedia, etc. Markup is a process of adding extra symbols. HTML comprises syntax and rules. It is a universal language used for classifying the various functions across different sections of a document. It indicates which part of the document is the title, which is the authors' name and address, which part should be emphasized and which part should include an image, and so on. HTML features the use of various tags like the Frames tag, the Header Tag, etc. It comprises of format type instructions that are taken into consideration like <head>, <title>, <body>, etc. A button tag is also used in this project.

6.2.C Python

Python is a high-level programming language. The design and philosophy of Python provide code readability, and its syntax allows programmers to express the concept in fewer lines of code than would be possible in languages such as C. It features a dynamic type system and automatic memory management and has a large and comprehensive standard library. Researchers have used various Python instructions to run using the configurations on the platform. It can also be used for booting up the Raspbian OS. Python scripting and programming language is an open-source project.

6.2.D Embedded Web Server

The implementation of embedded internet technology is accomplished with the help of embedded web servers. An embedded web server provides remote access to devices from a web browser. An embedded web server is an integral part of an embedded network that consists of an ARM processor [10]. ARM processor contains internet software & application code for monitoring & controlling the systems. An embedded server is a single-chip implementation of the Ethernet networking standard. The client computer sends or receives data to and from the ARM microcontroller using the TCP/IP (Transmission Control Protocol / Internet Protocol) packets [11]. The client has to enter the IP address to access this server. The IP address of embedded devices is available on the client side to directly access the system. Users can connect and access the information from a remote location by using this IP address. The Hyper terminal is used to boot the target board. After the target is successfully booted with an RTOS (Real-Time Operating System), it is tested over the network using the ping command [12]. The OS manages the request of the client and forwards it to the LAN (Local Area Network) controller of the client system. The LAN controller sends the request to the router which processes and checks for the system connected to the network with that particular IP address [13]. If the IP address entered matches that of the server, a request is sent to the LAN controller of the server to the client and

hence a session is established between the server and the client and the server starts sending the web pages to the client. Researchers have utilized both types of IP addresses viz. Static IP & Dynamic IP. Dynamic IP is assigned through the DHCP (Dynamic Host Configuration Protocol) server of the GSM (Global System for Mobile) communication provider for every connection established [14]. The embedded system updates the IP information on the server upon every reboot, which causes an IP refresh from the GSM service provider [15]. Researcher A. W. Ahmed implemented the Dynamic IP address and hence concluded that it is of great use as it provides more flexibility and good secured results [16]. Web pages are designed using HTML that presents the user with a page of the system information. Researchers use HTML to build embedded web pages. Embedded web servers have a lot of advantages such as low cost, support for real-time web applications, and low overhauling required; are user-friendly, have high reliability, security, durability, and likewise.

7. FEATURES

7.1 Interoperability

The beauty of an automation system is its ability to tie diverse electronic devices together so they can perform as one unified system. Researchers have accomplished these devices to cohesively work. However, the cohesive operation can be simple or complex, depending on the openness of the automation system. The more open a system is, the easier it becomes for the lights, thermostats, audio /video equipment, security devices, motorized shades, and other electronics to communicate with each other. Manufacturers and vendors of smart home automation systems often form connectivity partnerships or alliances with similar other manufacturers or vendors to support the interoperability between multiple electronic devices. They foster interoperability through their adherence to various technological standards. The more connectivity or alliance partners a manufacturer has formed and standards they have adopted and implemented, the more choices a Consumer has while choosing their products.

7.2 Remote-Access

Automation is all about being able to control things in the home and part of that is being able to change the settings quickly and easily if the users' plans change on the go. More often than not, plans change when no one is at home, so being able to communicate those changes with the home automation system remotely is one of the most revered features of an automation system. Remote access capabilities allow users to monitor their smart home's environment and alter the settings of the lights, thermostats, and other gear if necessary just from a laptop, a cell phone, or PDAs (Personal Digital Assistants). Remote monitoring features should be a service that manufacturers, vendors, and installers must provide free of charge. Remote access allows the Installation provider to tweak the system without having to make a house call, which is always cheaper and more convenient.

7.3 Scalability

The way one lives in the home five years from now will probably be much different from the way one lives in the home today. Moreover, technology will continue to evolve, introducing a completely new generation of products to the marketplace. The futuristic smart homes may see users wanting to add new dedicated spaces or rooms — like a recently finished basement or an addition to the backyard — to the user's automation network. A few of them might simply want to start with just a few features when they initially deploy the system and later on add new capabilities as users have more money to invest in the same. Hence, a smart home automation system must be capable of easily expanding both vertically to incorporate additional products and horizontally to support additional rooms. Manufacturers can support vertical as well as horizontal scalability by designing their systems to work on a common network language that is similar to the IP (Internet Protocol). The application of IP offers wireless retrofittable products to communicate with a smart home's existing network of wired products.

7.4 Upgradability

The touchscreens and black boxes might look impressive, but it is what one does not see that holds the true power of an automation system. Software is the driving force of an automation system. The more sophisticated that software is, the more operations the system can perform. As technology changes, so must the software. The user has to ensure that the manufacturer (or the installer) would be able to unlock and download the software updates automatically before procuring any home automation system.

7.5 Variety of Interfaces

Researchers in the past have demonstrated several different methods a user can control the electronic systems inside a smart home, such as pressing the buttons of a hand-held remote or a wall-mounted keypad or even by touching the colorful icons on a portable touch panel and by sliding the fingers. Users usually utilize a variety of different controllers to make sure the automation manufacturer offers a wide selection of interfaces that depends on the family dynamic, budget, and preferences.

7.6 Time Tested

The very serious early adopters only like themselves to be the guinea pigs. So users are known to select an automation system with a proven track record. The same goes for the person who installs the system into the user's home. Users should be able to gather some historical background and reviews about the manufacturers, vendors, and/or installers from their official company websites and social media platforms to complete their due diligence.

7.7 Strong Dealer Network

Good home automation manufacturers go above and beyond to create a strong dealer network, by offering continuing education and training and by supporting multiple dealers in a single geographic area. Consumers must have the option to choose more than one dealer. When more than one dealer carries a particular product in the area, pricing is more competitive, and should one dealer go out of business, there's someone else the user can call to perform overhauling and continue servicing the system.

7.8 Energy Savings Commitment

One of the hottest topics in consumer media is energy conservation [17]. Automation systems can help save energy by turning OFF electronic devices automatically, and some do this better than others. Users are advised to check out the energy consumption and energy-saving features of a home automation control system before procuring the same.

7.9 Protection Layer

Everyone always wonders what happens to an automated house when the power goes out. Does the automation control system forget how to operate the lights when the power is restored? Any home automation control system having the appropriate backup protection won't worry the user about the resumption of operations after power restoration.

7.10 Can do Attitude

The installer and the manufacturer or vendor are both responsible for customizing the needs and requirements of customers and clients. Automation is only beneficial and practical if it fits the users' lifestyles. Since everyone has a different lifestyle, the manufacturer or vendor must provide its installers with the tools to customize the system to users' specific needs and requirements. If there is something that the user wants the system to do and the installer says it is impossible, either the installer or the manufacturer has failed either delivering or conveying the appropriate application of the system to the user.

8. FUTURE SCOPE

8.1 Digitization of home automation system

Home automation is an industry that largely started with the X10 devices in 1980. Researchers believe futuristic home automation will very much ride the digital age and develop along with the digitization of control systems. The home automation industry has leveraged Web 2.0 technologies and now it's time to leverage Web 3.0 technologies as well in a similar fashion. Initially, it appeared, companies such as Microsoft and Exceptional Innovation with their Life/ware software were positioning the Windows Media Center PC as the heart and soul of a complete packaged solution for home automation relying on web services to seamlessly interface with lighting controls, climate controls, security panels, and IP surveillance cameras to compliment the digital media management capabilities of Windows Media Center. However, Exceptional Innovation stopped selling its systems for residential installations, and Microsoft Media Center capabilities have disappeared in the Windows 8 OS.

8.2 Improved network speed and bandwidth

Advances in home networking technology using both wired and wireless Ethernet have enabled the addition of more devices to the network at an affordable incremental cost. Users building new homes today should consider installing Cat6 cable wiring throughout the home to support a Gigabit Ethernet bandwidth which will improve the performance of digital video streaming among the devices in the home. The IEEE 802.11n standard for home Wi-Fi networks has provided similar improvements in wireless bandwidth. The 802.11n specification has been released and wireless routers delivering more than 300 Mbps of bandwidth are available in the market. They offer significant advances in signal strength throughout the home. This improvement in bandwidth bodes well for existing homeowners wanting to retrofit a home automation solution without knocking down walls or tearing up drywall.

8.3 Radio communications incorporating ZigBee

Coupled with the above advances the Ethernet technology is the emergence of RF communication protocols such as the ZigBee (IEEE 802.15.4 standard) and Z-Wave developed by Zen Systems. RF communications provide an advantageous speed over the Ethernet for small amounts of information which is typical of the command sequences required for controlling the lights or thermostats installed in the smart home. Researchers have specifically chosen to highlight the industry-leading Control4 product line because the system architecture is built on a communications infrastructure that utilizes the strength of the Ethernet for digital audio/video streaming and ZigBee

for controlling information flowing between the system controller, its allied devices, and its user interfaces in the system. These mature RF protocols also enable wireless contact and motion sensors to be deployed in the security systems.

8.4 Plug-n-play home automation control system

Analogous to the computer and networking industries, the degree to which smart home functionality is adopted in the mainstream highly depends on the systems and software developed to enable a plug-n-play environment. Systems offering plug-n-play compatibility features are in high demand and are readily purchased by homeowners such as lighting devices or thermostats which can easily be integrated into a proprietary home automation system without engaging a custom installer/integrator solution.

8.5 RF-based technologies in home automation

One reason the X10 technology enjoyed a 30+ year ride was the simplicity of adding X10 devices in smart homes at a cost affordable to all homeowners. A large variety of X10 devices previously available allowed the homeowners to address a few novel areas that could not be controlled by the older technologies. Since the product manufacturing of the X10 technological devices has been discontinued by companies such as X10 USA, homeowners will have to switch to one of the RF-based technologies. This transition is probably best managed by replacing the failed X10 devices with Insteon equivalents from Smart-home which can be assigned an X10 address and controlled by X10 devices in addition to other Insteon devices.

8.6 The advent of Cloud technologies

Researchers have discussed the potential of a smart home automation control system via leveraging the novel cloud technology which could have the ability to extend smart home technology to a much larger market if a central server with the thin home-controller client architecture is fully developed and deployed [18]. While Apple and other big techs have been advocating the Cloud as a repository for all the multimedia files, it is not clear whether any of the top HA (High Availability) companies are looking at the central server or the remote client approach.

8.7 Comprehensive appliance interface

The proliferation of household appliances available with an Ethernet connection has facilitated adding audio or video devices having this novel connection feature. This futuristic automation has become feasible nowadays with the plug-n-play capability enjoyed in today's computers that is extended to other allied home devices and appliances. This of course requires manufacturers and vendors to have a compelling reason to include the appropriate chipset and firmware in these appliances to enable them to support the process of recognition of the same by other controllers on the smart home automation control system network.

8.8 Home automation embedded in SoC

The speed of digitization incurs an incremental cost that might be insignificant when combined with a chip that provides the essential functions embedded. This reduces the hassle of dealing with multiple chipset architectures across various kinds of devices and appliances installed in the smart home. Also, researchers in this paper aim to publish their future work that combines SoC with certain security features embedded within the SoC to protect the chipset architecture from various cyber vulnerabilities and attacks.

9. LIMITATIONS

9.1 Equipment and Installation Costs

The automation of houses and residential areas is widely related to financial costs. The total cost depends on the equipment installed in the smart house and on the expenses it takes to install and deploy those systems. A few trusted vendors provide the installation service for free to their customers. The more advanced the system is, the more expensive it becomes to procure and install the same. Although, the gradual growth in research and development, as well as the rise in popularity of home automated devices, has resulted in a reduction in their expensive cost. But as of now, because of the hugely rare implementation of such systems, the cost is still out of reach of middle-class homeowners who are looking for cost-effective automation solutions.

9.2 System crashes due to any damage in the Inter-connections and Intra-connections

Damage due to rupturing of cables or fibers causes the entire system to crash. This will not be the case with radio signals or other communication signals. Signal receptivity is a very crucial problem that needs to be addressed. However, the haphazard wiring or cabling of the system results in a crash in most of the systems installed.

9.3 Human Errors

Human errors occur when users fail to handle the home automation kit safely or fail to use the correct keys/buttons to perform the operations. Human errors also can lead to the malfunction of the installed machinery. Eventually, there is a definite possibility of a huge system crash.

9.4 Reliability

The reliability of the home automated systems highly varies across several parameters and factors. It depends mostly on the technology used and the advancements being done to secure and make the system reliable.

9.5 Security Threats and Vulnerabilities

Home automation control systems usually have a limited level of self-aware intelligence and hence are more susceptible to committing errors outside of their immediate scope of knowledge. For example, the smart home automation control system post-deployment is typically unable to apply the rules of simple logic to general propositions.

10. CONCLUSION

Futuristic advancements will show the traditional homes of today evolving into robust, effective, environment-friendly, and energy-efficient Smart Homes with Smart Grid. Houses will undergo their transformation towards smart homes that will be in constant interaction with the grid in an effort for better energy management and full home automation to ensure comfort, security, and privacy. Researchers in this paper aim to design and prototype a smart home using various sensors that can be accessed, monitored as well as controlled by the Raspberry Pi board via IoT technology. It is focused on two aspects of the smart home i.e. home security and home automation. This system is also equipped with automated lights and virtual switches for controlling lights and appliances in the home remotely using external and/or internal networking with the Raspberry Pi via an HTML/Python web page. The full-fledged functionality of the prototype indicates that devices like Raspberry Pi can play a very important role in designing the smart home of the future at a very low cost. An energy-aware smart home can be developed using the Raspberry Pi board and allied sensors. Raspberry Pi proves to be a smart, economic, and efficient platform for implementing home automation via a web server where users can analyze and control the various appliances installed in their homes from anywhere in the world. This technique, therefore, provides worldwide home access for the user more than any other home automation system. Researchers believe the project prototype in this paper can form the basis for upgraded, enhanced, and futuristic applications of the system used for security surveillance and espionage, industrial automation, and likewise easily.

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