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IoT Based Monitoring and Control of Appliances for Smart Home

Praveen Kumar, Umesh Chandra Pati

Abstract— **The recent technology in home automation provides security, safety and comfortable life at home. That is why in the competitive environment and fast world, home automation technology is required for every person. This purposed home automation technology provides smart monitoring and control of the home appliances as well as door permission system for interaction between the visitor and home/office owner. The control and monitoring the status (ON/OFF of the appliances) have been implemented using multiple ways such as The Internet, electrical switch, and Graphical User Interface (GUI) interface. The system has low-cost design, user-friendly interface, and easy installation in home or multi-purpose building. Using this technology, the consumer can reduce the wastage of electrical power by regular monitoring of home appliances or the proper ON/OFF scheduling of the devices.**

Keywords— Internet of things (IoT), Home appliances, Raspberry Pi2 model B, Arduino mega2560, Graphical user interface (GUI), Server, Door permission.

I. INTRODUCTION

The home automation system is one of the most crucial components of a luxurious home. The smart home technology is reliable, secure, user friendly and cheap as well as comfortable life. Nowadays, every person wants a secure and comfortable life at home. Various research works in home automation technology have been done. Gill et al. [1] projected a ZigBee-based home automation system. The core part of the development is the interoperability of different systems in the home environment. Smartphone and Wi-Fi as a communication protocol and raspberry pi as a server for monitoring and controlling the appliances of the home is shown in [2]. Kovatsch et al. [3] introduced the IPv6 and 6LoWPAN, a single network server for classical as well as emerging aspects of home automation, but the installation cost of this home automation is high. Wireless solutions like ZigBee and 6LoWPAN are deployed since no cables have to be laid. The real time information data monitoring of the energy consumption in the house using the internet of things (IoT) is found in [4]. Piyare et al. [5] purposed the design of home automation based on a stand-alone Arduino BT Board, which is the cell phone-based home automation system. Ramlee et al. [6] implemented remote control function by smartphone and Bluetooth technology that provides help and assistance to the physically disabled person.

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Bluetooth concept is suitable for control of devices within the home. Rawat et al. [7] gave an overview of wireless sensor networks and their application domains including challenges. Suryadevara et al. [8] carried out work on monitoring electrical parameters of household devices such as voltage current and subsequently calculated the power consumed by appliances. The power management in a home can be improved by this technique, which makes proper utilization of electricity in the home. Yuksekkaya et al. [9] implemented the concept of The Global System for Mobile Communications (GSM), the internet, and voice in the wireless home automation system, which used microprocessor and Short Message Service (SMS) control method by GSM module.

This system has two parts such as monitoring and control of the appliances and smart permission system. The appliances of the house can be monitored and controlled by different methods such as Graphical user interface (GUI) and World Wide Web (WWW). This automation system can send and receive data from the remote user via the internet. The user can monitor the status concerning ON/OFF and control the appliances of the home by online or offline. He can watch his family members, security guard etc from anywhere and anytime by using smartphone or Desktop/laptop. The door permission system gives the flexible choice to both the visitor and the homeowner for easy and secure interaction.

This rest of the paper is organized as follows. In Section II, system description is presented. The implementation of smart home system is given in Section III. The result and discussion are given in Section IV. The work is summarized in Section V.

II. SYSTEM OVERVIEW

This IoT-based smart home system is a combination of different components. The components selected are on the basis of requirement of the goal. In this system, the Raspberry Pi2 model B and Arduino mega2560 are the main components

Fig. 1 shows the Raspberry Pi2 model B board. This board is used for multi-purpose tasks because it has Broadcom BCM2836 Arm7 Quad Core Processor, which runs at 900MHz. That can be used as a mini computer by interfacing keyboard, mouse, speaker, camera, Ethernet cable and LCD monitor. This board also provides a 40 General purpose input output (GPIO) pins for digital input output. Similarly, Fig. 2 shows the parts of Arduino mega2560 board. This board has large number of digital and analog input output pins as well as In-Circuit Serial Programming (ICSR) header. This is cheap and easily available in market for hardware implementation. Its processing speed is slow compare to Raspberry Pi2 model B.

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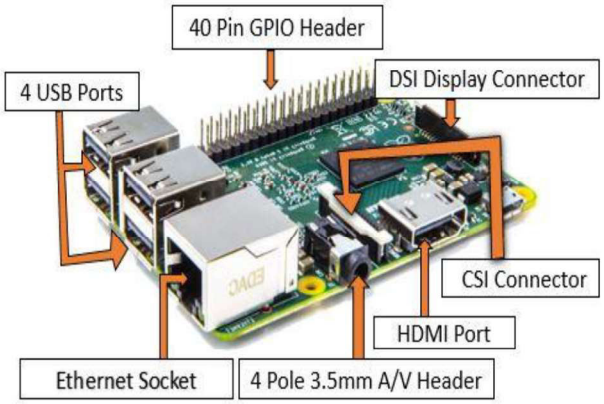

Fig. 1: Raspberry Pi2 model B

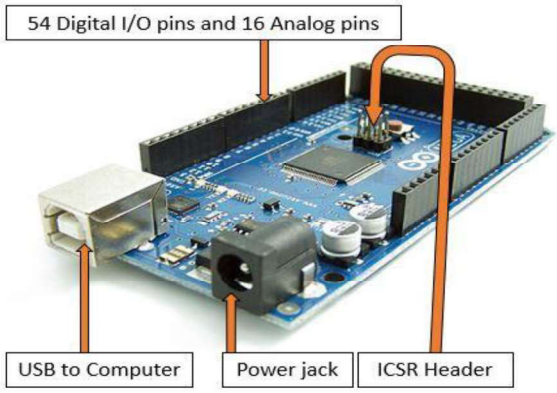

Fig.2 : Arduino Mega2560 board

Fig. 3 shows the configuration of smart home system. This is the interaction between system to system and system to the person. The multiple methods of monitoring and controlling of the appliances are used in this proposed system. The GUI interface method is good for elderly and less knowledgeable person. GUI interfaces implemented between Arduino and 2.4 inch touch screen. Using the GUI interface technique on the 2.4-inch display, we can monitor and control a large number of appliances. This home automation system also used electrical switch as a substitute. This provides an additional option for switching the appliances (ON/OFF) of the home, in case of the network failure and some other cause.

The most interesting and recent technology for monitoring and control of appliances is Internet of things (IoT). This provides remote data sharing facility to the smart home system user. The user can control either by laptop or smartphone. The set of software is used for setup and hosting Raspberry Pi as a server using apache2 and Node-RED for controlling the appliances and also created a client page for the user in bootstrap using Cascading Style Sheets (CSS), Java, Hypertext Markup Language (HTML), and Hypertext preprocessor PHP. The control system consists of Arduino mega2560, 2.4" Thin-film-transistor (TFT) liquid-crystal display (LCD) touch screen, relay board, Hall Effect sensor and staircase switch. The relay board is used to make and break the connection of home appliances with the power supply. The Hall Effect sensor senses the flow of current in devices.

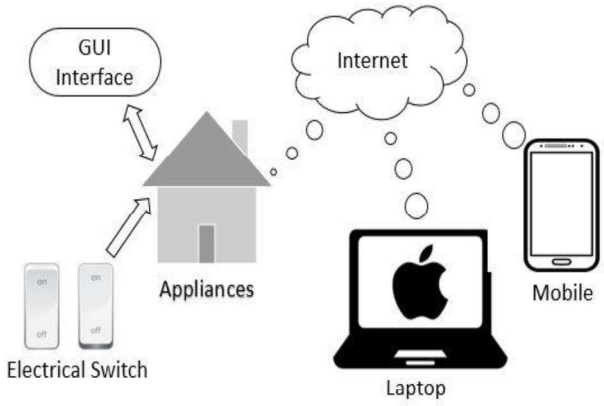

Fig. 3. Layout of IoT based smart home system

It provides ON/OFF status of the connected devices. The staircase switch is also used to make and break the connection of devices. In this technology, devices can be controlled by either using a touch screen or electrical staircase switches. The 2.4" TFT touch screen provides the GUI interface for selection of a device in the building to know the status as well as control of the devices of the home. Finally, Arduino is used as a processor to process the input-output signal of the appliances.

Fig. 4 shows the layout of the door permission system. It consists of two controllers and designed hardware permission system for the visitor and the homeowner. The visitor can choose either push-button for permission or leave the voice message for the home owner. Similarly, the homeowner has also multiple-choice of messages such as "Come", "Come Later" and "Wait" for the visitor. The permission system includes the Raspberry Pi (RPi) camera for capturing the image of the visitor. The door permission system also saves the image of the visitor with date and time for knowledge of the home owner and sends the real-time video for few minutes to LCD screen inside the door with buzzer sound for the attention of the person in the home.

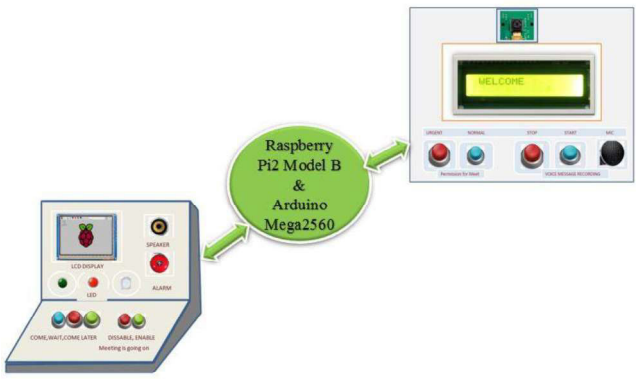

Fig. 4. Layout of Smart Communication for home use

III. IMPLEMENTATION OF SMART HOME SYSTEM

The experimental setup, which is used for testing and observing the performance of the home automation and permission system, is given in Fig. 5. This section mainly discusses the hardware construction of IoT based monitoring and control of appliances for smart home. The Pi camera, speaker, mic and LCD screen are connected to Raspberry Pi2 model B and touch screen, relay board, as well as the Hall Effect sensor, are connected to Arduino mega2560.

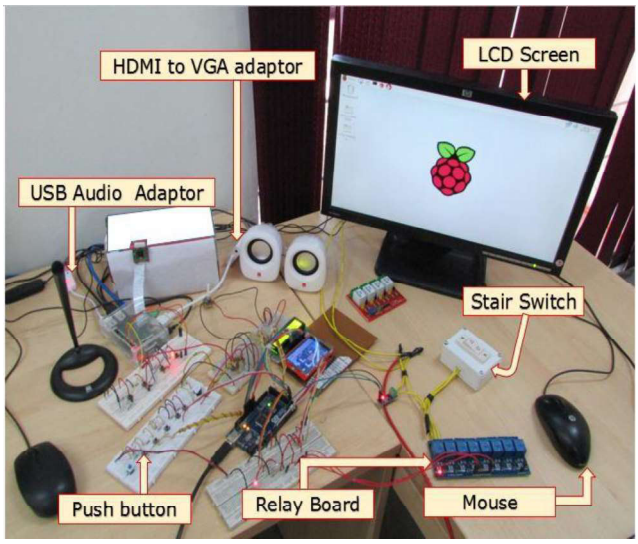

Fig. 5. Hardware implemented system view

Fig. 6 shows the block diagram of IoT based monitoring and control of appliances for smart home. It consists controllers such as Raspberry Pi2 Model B and Arduino Mega2560 with its peripheral devices. In this, Arduino processes the control signal for appliances as well as the text message to the communication system. It takes input from 2.4" TFT, push button as well as Hall Effect sensor and the output passes to the relay board and LCD.

Similarly, Raspberry Pi processes the voice and image of the visitor, which takes input from Pi camera, push button and I-ball mic and passes the output to LCD screen as well as speaker. It saves the voice and image on LCD monitor with date and time. The block diagram is a representation of data sharing between components and also gives the information about components behavior in the experimental setup i.e input device, output device and input output devices. For example speaker is a output device, mic as a input device and 2.4 inch touch screen as a input output device. As per compatibility of controllers such as Raspberry Pi and Arduino mega2560, peripheral devices are connected. The code has been written in Python and C language.

V. RESULTS AND DISCUSSION

The home automation system can be accessed on a smartphone using IP address 192.168.50.154/login.html. The server of the smart home is hosted on raspberry Pi2 model B, which sends and receives the data from the remote user. The user can monitor the status and control the appliances using smartphone or laptop on above IP address.

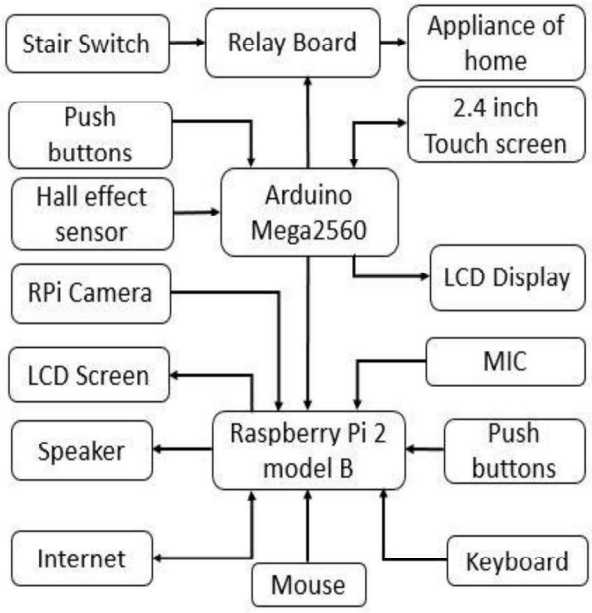

Fig. 6. Block diagram of smart permission and control system

The appliances can also be controlled using graphical user interface in 2.4 inch TFT touch screen. This method makes comfortable and easy access to a particular appliance from a building. The homeowner can also interact with the visitor without the reaching to the door.

The Fig. 7 represents the login page, home page, list of room and contents of the home page. The login page requires the user id and password for authentication of the user. This system prevents the unauthorized access of the smart home system. The home page contents are organized in such a manner that contents auto adjusts on all size of the screen of the smartphone. That is why user can opt any smartphone of different screen size. Similarly list of room and contents of the home page are also auto adjustable as well as it has an optimum arrangement of contents of the different web page. That is why the response of network is fast. The user can easily understand and accessed the contents of smart home via internet.

Fig. 8 shows the set of screenshots of internet page of smart home on the desktop such as home page, a list of appliances of Bedroom and live video. The server i.e Raspberry pi fetches the HTML page on request of client or user of the smart home system. The home page gives the option such as the home for accessing the appliances of the home, messages option gives the audio, video and text messages and camera option give live video streaming from smart home.

The home automation user can remotely watch the family and security personnel of smart home without any intervention from anywhere anytime using either laptop/Desktop or Smartphone and also, the user can monitor and control the appliances of the home.

Fig 7. Output on mobile using internet

Fig. 9 shows the set of screenshots of the touch screen, which is obtained during monitoring and control of the appliances of smart home. The control step 1 shows the home page of monitoring the status and control of the home appliances. The control step 2 gives the list of rooms in building for selection of a place of the appliances such as bedroom, living room or kitchen. The bedroom is selected for control and monitors the status of the appliances of a bedroom. After that, the list of appliances of bedroom is obtained in control step 3 for selection of a device such as fan, bulb, refrigerator, cooler, water heater. The lamp is selected to know the status (ON or OFF). The control and status window page of a selected device is obtained in step 4, where "ON" is chosen to switch on the bulb. Finally, selected lamp glows. The control and status window page, which is obtained in control order 4, also shows the status of the device concerning ON or OFF, and the same control order are applied to all equipment of the building for controlling and monitoring the status.

Graphical user interface or GUI is a type of interface that allows the user to interact with electronics devices through the graphical icon and visual indicators. GUI makes easy monitoring and control of appliances for the user. The control step is a set of instruction for monitoring and control of appliances for the user.

The control steps 1, 2, 3, and 4 are the screenshot of graphical user interface in 2.4 inch TFT touch screen. These steps helps the user in selection of a particular room and appliance for monitoring and control.

The screenshot of 2.4" TFT touch screen is shown in Fig. 10. It displays the list of appliances such as a bulb, fan, cooler Et cetera of four different rooms like bedroom, kitchen, living room and bathroom. This graphical user interface is obtained, during the selection of different devices of the room. The graphical user interface is implemented in 2.4 inch TFT touch screen for easy monitoring and control of appliances by person of the house, without physical effort.

Fig. 10(a) poses a list of appliances of the living room similarly Fig. 10(b), Fig. 10(c), and Fig. 10(d) shows the list of appliances of the bedroom, kitchen, and bathroom.

VI. CONCLUSION

This paper presents a low-cost and flexible solution to the smart home. The appliances of the home can be controlled by different methods such as GUI interface and World Wide Web. The person of the house can watch his family, security guard and the building from anywhere and anytime as per his interest or requirement. It improves the security of the building, and the person can alert as well as can take necessary steps toward family safety. The system reduces the effort of the person of the house for monitoring and controlling of the appliances as well as handling of the visitor in the most respective way by authenticating and proper response. This system can also be used for reducing the wastage of electrical energy in the house by proper scheduling and monitoring of the appliances. The system response is good and sustainable for long time operation.

Fig. 10. Screenshot of 2.4 inch touch display GUI interface a) Living room b) Bedroom c) Kitchen d) Bathroom.

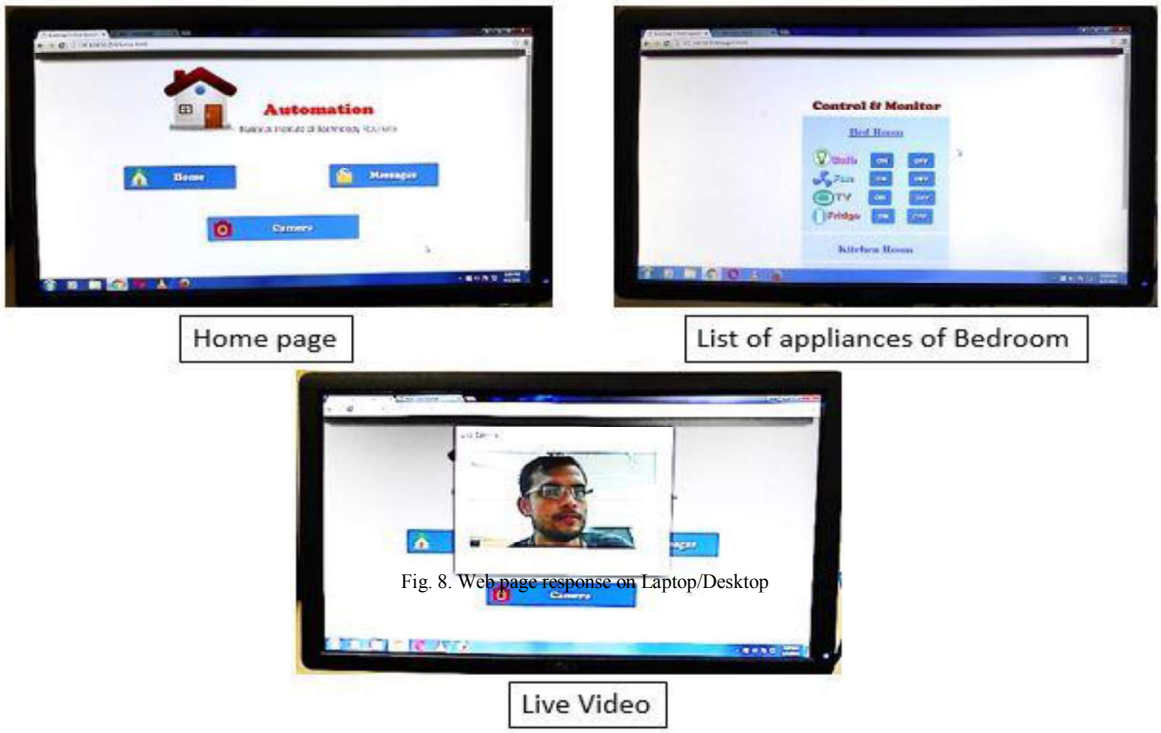

Fig. 8. Web page response on Laptop/Desktop

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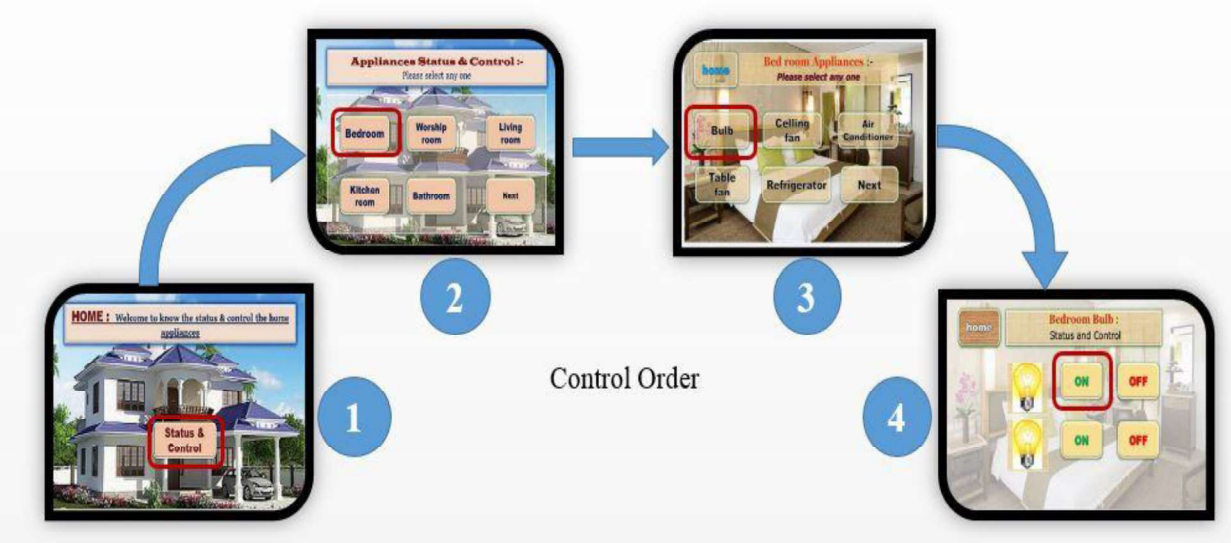

Fig. 9. Control steps of smart home using GUI interface

Table.1 : Comparison with existing systems

Sl No.	Parameters	Existing System	Proposed System
1	Cost of the system	High	Low
2	Way of control method	Internet , Electrical Switch	GUI, Internet, Electrical Switch
3	Circuit complexity	High	Comparatively less
4	Integration of appliances	Less	High
5	Live video streaming	No	Yes
6	Audio and video processing speed and quality	Good	Better

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