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ADVANCED HOME AUTOMATION SYSTEM USING RASPBERRY-PI AND ARDUINO

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ABSTRACT

The rapid advancement of the internet of things (IoT), life is getting easier and simpler in all aspects. At present world, automatic systems are being favored over the manual system. Today's world automation has become an inseparable part of ordinary households and subjects to constant evolution. IoT is a growing network of conventional object- from industry to consumer that can share information and complete jobs while you are involved with other activities. A smart home automation system can help to have a centralized method to control all home appliances. In this paper, a cost-effective system is proposed to achieve such automation system based on IoT concept. All the devices of this system are connected to Raspberry Pi. The proposed system also provides a facility to control all home appliances locally without the internet via a local network. Raspberry Pi runs a web server to host a web -based control interface and a SQL database to maintain the current status of appliances. The interface can be accessed through the internet or locally without the internet. Besides our automatic re-start mechanism makes the system more efficient.

KEYWORDS: *Dataplicity, Home Automation, IoT, Raspberry Pi, Web Interface*

INTRODUCTION

How amazing it is to have control all of your appliances right into your pocket? Just think a different, heat up your food by the oven or turning on your air conditioner from outside of your apartment. What an amazing thing! Adding a smart security system to fire alarm, doing the very simple task to your high priority task, smart home automation is all about this and there is no end to its development and application. How about turning to activate and deactivate any device remotely by detecting the status, energy consumption level etc., of individual electrical appliances and equipment (Liu, Liu, & Pearson, 2011) without including any cost in doing it. A security system that will identify smoke and turn ON water outlets spontaneously rather than waiting to fire brigades (Alheraish, 2004). Actually, all we need in a smart home, are already developed that can maintain household items using technologies like Bluetooth, ZigBee, Wi-fi etc(Van Der Werff, Gui, & Xu, 2005). For energy monitoring and control systems(Ahmad, 2011), there are many other devices that can be integrated to the automation systems such as temperature sensors, light sensors, motion sensors, etc. to provide security,

fire protection, misuse protection and various other benefits to the users (Šuba, Prehofer, & van Gurp, 2008). Automation makes it possible to link entertainment, telecommunication, air conditioning and other facilities of the household into one centralized control system. Wireless home automation using IoT is a system that uses the computer or mobile devices to control home appliances automatically through the internet from anywhere in the world. It saves energy and time, helps old and disables people by providing remote control of home appliances as well.

In this paper, a smart Home Automation system is proposed to control all the appliances remotely using web-based interface or locally without the internet. The main goal of this work is to implement in economy yet efficient way to do this. Raspberry Pi(Pi, 2013) is used as the main part of the system. As it is a powerful computer and supports the latest web technologies and databases, there are a lot of potential scopes for expanding the project and integrate more features very easily and effectively. An automatic restart mechanism is implemented in this system which makes more efficient and gives the user best experience.

Related Work

A significant amount of research has been performed in this field. In 1975 X10 industry standard was developed(Kim et al., 2012; Lin, Cheng, & Yuan, 2006; Walko, 2006). It is the oldest standard identified from the author's review (Withanage, Ashok, Yuen, & Otto, 2014). The most widely used technology in home automation systems is Z-Wave (Amaro, Cortesão, Landeck, & Santos, 2011; Knight, 2006; "Z-Wave devices and standards,"). The best feature of Z-Wave devices is their cross-compatibility among different branded systems ("Z-Wave devices and standards,") with security where each device had unique network ID and each network has a unique identification (Knight, 2006). INSTEON ("Insteon devices and standards,") is developed to integrate power line system with a wireless system. It was developed to replace the X10standard (Kim et al., 2012; Lin et al., 2006; Walko, 2006). One of the new technologies for automation is EnOcean ("EnOcean devices and standards,"), mainly aimed at zero energy consumption. A mobile-based home automation system was developed recently using java based board which connects all the devices physically with a central computer which runs a web server that gave remote access to the system (Van Der Werff et al., 2005). These systems required a highly dense wired network that includes expensive installation and high-end computer. Then, the Bluetooth technology was invented and soon enough integrated into Home automation systems (Kanma, Wakabayashi, Kanazawa, & Ito, 2003; Sriskanthan, Tan, & Karande, 2002). But, it needed to have a dedicated Bluetooth module for each homedevices. Therefore, the cost increases significantly (Van Der Werff et al., 2005). However, this method reduced the amount of physical wiring complexity. Another phone-based remote control technology was introduced for home and office automation (Teymourzadeh, Ahmed, Chan, & Hoong, 2013). This system does not require any internet. The system can be reached using any telephone that supports dual tone multiple frequencies (DTMF). The main disadvantage of this system is that user doesn't have any graphical user interface. Remembering the specific access code for devices is a little tedious. However, this technology didn't gain much popularity. Another technology was proposed which involves controlling the appliances using a hand gesture. It uses image processing for reading users command (Withanage et al., 2014). But the system can read gesture inaccurately which may lead to an unexpected action. A paper was proposed by Basil Hamed which objective was to design and implement a control and monitor the house devices using LabVIEW (Hamed, 2012). But LabView is very costly and costs around $320 - $5700 for different distributions. Deepali Javaleet al. proposed a system to assist handicapped/old people(Javale, Mohsin, Nandanwar, & Shingate, 2013). A user can interact with the android phone and send the control signal to the Arduino ADK which in turn will control other embedded devices/sensors(Javale et al., 2013). In 2015, Vinay Sagar K N, Kusuma S M proposed a way of achieving control over

appliances using internet by Intel Galileo that employs the integration of cloud networking and wireless communication (Vinay Sagar & Kusuma, 2015). But in contrast to Intel Galileo, Raspberry Pi is a form computer in the half of the Galileo board price giving more scope of expansion of the system. To our best knowledge, the most recent automation system is proposed for controlling home appliances using android application and Microsoft Azure cloud service in (Upadhye & Turkane, 2017). But maintaining Azure cloud is more complicated and there is no recommendation of it by raspberry-pi creators.

System Realization

The proposed system controls home appliances remotely using Raspberry Pi. The Raspberry Pi receives commands from the user through a web interface and executes a shell command to generate a control signal for Arduino. Then, relay switches are controlled by the Arduino according to the control signal. The system requires the following components:

- A hotspot (wireless internet connectivity or pocket router) to provide internet connection to the Raspberry Pi.

- A Raspberry Pi which acts as a web server, SQL server and also a control unit.

- Dataplicity to remotely access Raspberry Pi from anywhere in the world via internet without DynDNS, VPN, static IP or Port forwarding("Dataplicity: Remotely Control your Raspberry Pi ").

- Web-based graphical user interface (GUI) to control the system("Web Interface,").

- Arduino to control relay switch according to the control signal sent by the Pi.

Role of Raspberry Pi

The Raspberry Pi is a series of small single-board computers developed in the United Kingdom by the Raspberry Pi Foundation("Raspberry Pi,").
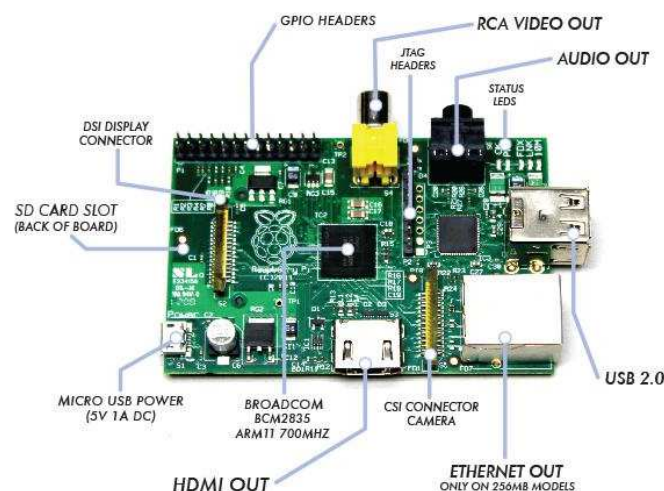

Figure 1: Raspberry Pi

As it is a very small in size yet powerful and low-cost computer. It is warmly adapted to robotics and different embedded system project. It is a Linux base computer and with Raspbian operating system, it supports technologies like Apache, MySql, PHP, and others. Actually, our designed system needed to host into a web server in a cost-effective way and also a computer is needed for monitoring and controlling the Arduino. Raspberry Pi is chosen because it can serve all

of these purposes. Besides, no other devices can serve the same security, reliability, computational power in such economy way. In the proposed system, Raspberry Pi mainly acts as a web server. MySQL, Apache, and PHP are installed to provide web services. A website that contains the user interface for controlling appliances is hosted in the Raspberry Pi. It is also connected to the Arduino using serial communication so that any control signal can be sent to the Arduino over the serial port.

Dataplicity

The aim of the Dataplicity is to simplify the process of connecting your devices over the internet("Dataplicity: Remotely Control your Raspberry Pi "). The concept behind Dataplicity is to simplify the process of making your Pi available over the internet. Previously we had to deal with IP addresses and router port forwarding or a static IP if we wanted to put the Raspberry Pi online. This was hard to manage as the process varied depending on ISP and router setup. But dataplicity is essentially a VPN for Raspberry Pi. It not only lets you connect to your Pi remotely but you also can "wormhole" a web server through the system, allowing you to run a mini website from the comfort of your all-in-one computer. Most importantly, a free account can do pretty much all the job including SQL database support. It is secure, reliable and recommended by Raspberry Pi community ("Raspberry Pi,"). Another advantage of it is that if somehow power goes off and Raspberry Pi shut down, it automatically connects Raspberry Pi and initiates a current state of the appliances when the power is back.

Web-Based Interface

We made a web-based GUI show in figure 2 which helps to communicate with the Raspberry Pi("Web Interface,"). This is the user interface where a user can see and control their appliances by checking the current state of the appliances.
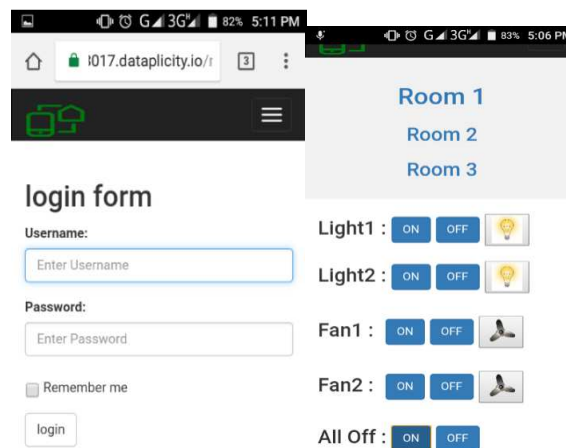

Figure 2: Website View

A Wireless Internet Connectivity

A hotspot internet connectivity (Wi-Fi or wireless cellular router) is needed for connecting the Pi. Pi doesn't need any broadband connectivity but supports port-forwarding. Therefore bandwidth will not be expensive because the raspberry pi server consumes a very small amount of data to keep the server in online. Also, there is no need to use the internet if a user is at home. Users are connected with the hotspot and control appliances without having any data within the Wi-Fi zone.

Figure 3: Pocket Wi-Fi Router

Arduino Uno

The Arduino Uno is anATmega328 AVR microcontroller based board. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). Programs can be loaded into it from the easy-to-use Arduino computer program. The Arduino has an extensive support community, which makes it a very easy way to get started working with embedded electronics.
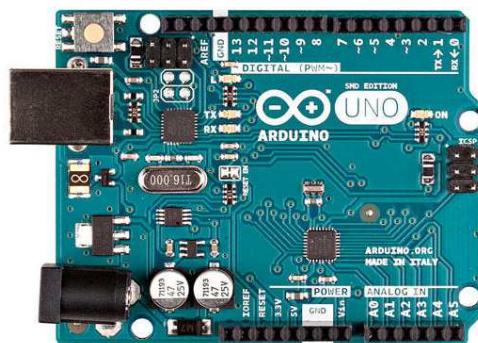

Figure 4: Arduino Uno

For controlling a set of appliances (e.g., appliances of each room within a flat) an Arduino is used. Multiple sets of appliances (multiple rooms) require multiple Arduino. All Arduinos are connected with the Raspberry-pi and generates control pulse according to the shell script executed in the Raspberry-pi server.

METHODOLOGY AND METHOD

The whole process can be described as the following three steps.

- Receive commands from the user.

- Execute shell for sending a signal to Arduino.

- Trigger relay switch by Arduino.

- Restart mechanism.

Receive Commands from User

For controlling the appliances remotely or locally, a user needs to browse the specific URL (unique for each Pi and obtained from Dataplicity) and initially verify the user's authentication. Then, user can view all appliances' status from

web interface shown in Figure 2.User can control all of the home appliances from this GUI. If the user presses the ON/OFF button, a signal is sent to the Pi. The states of the appliances are stored in a SQL database of Pi server. This database is synchronized with the website. The user can also use the voice commands specifically (e.g., room no 1, light no 2 OFF) without pressing the buttons.
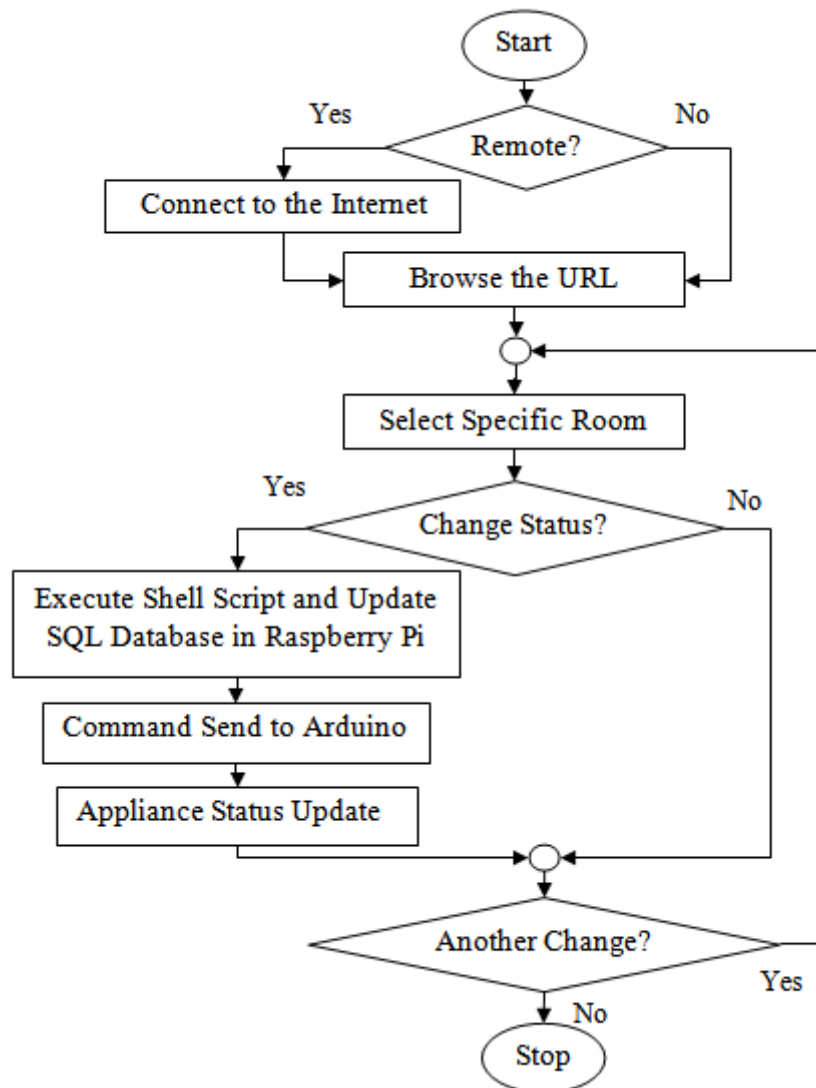

Figure 5: Activity Flow Chart

Execute Shell for Sending Signal to Arduino

After receiving the signal from the user a python shell is executed in Pi. This shell command issues a signal to the Arduino. The Arduino is connected with Pi by serial communication. With the help of this serial communication, Pi can send any command to the Arduino.

Triggers Relay Switch by Arduino

Arduino Triggers the relay switch according to the command received from Pi. Arduino is reset after each serial communication. To prevent this problem a capacitor is used so that it cannot be reset after each serial communication.

Restart Mechanism

All of the appliances are connected with the Arduino. So, if Arduino is reset, all appliances will be turned off automatically. When the power goes off, the Pi will be off. That means the server will go offline. The appliances will not get into their previous state after restarting the server. To prevent this problem a python script is used. When the server will reboot this script will run automatically and restore the previous state.
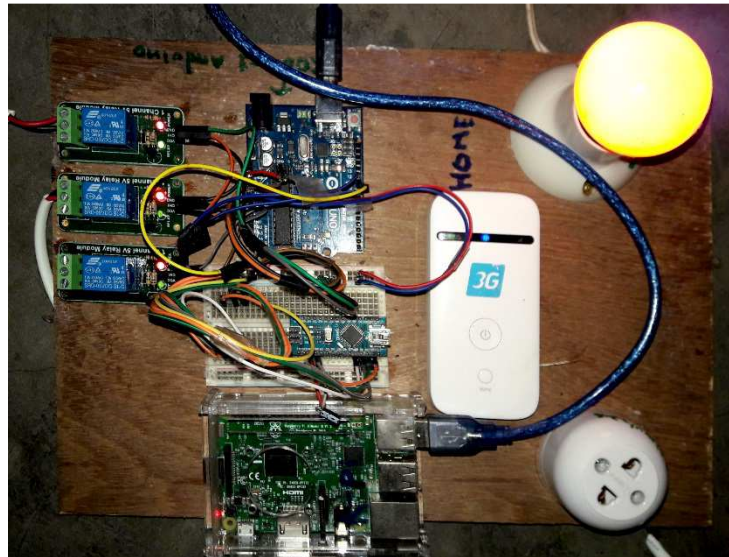

Figure 6: Demo Setup of the System

RESULTS AND DISCUSSIONS

Form the experience of implementation, it reveals that the proposed system is more convenient, easy to use, low-cost than the current state-of-the-art. Our system needs very low bandwidth to synchronize with a user. Here, Raspberry Pi works as an embedded web server("Web Interface,") to host a device control panel via Dataplicity. The port forwarding capability is achieved with the help of Datplicity. It is a more efficient way than other port forwarding methods, it is reliable and almost free ("Dataplicity: Remotely Control your Raspberry Pi "). When using port forwarding to access devices on the local network without the internet, each will require a separate inbound TCP port through the router. This is not required for Dataplicity. When switching on Wormhole, it places the web service hosted on the Pi directly on the wider internet. Then, the security question will arise. In this case, NGINX is running on port 80 directly from your Pi. A wormhole listens only on localhost, so you don't need to have port 80 open directly from your Pi to the wider world even though this is not inherently insecure("Security considerations,"). The system Depending on the application we enable HTTP basic-authentication from the NGINX configuration and require a password for website access("Web Interface,"). To the best of our knowledge, Microsoft Azure is used in IOT based home automation technology (Upadhye & Turkane, 2017). In this system, a database is stored in the Microsoft Azure cloud. By doing so, the system cannot be accessed locally without the internet. This drawback decreases its efficiency and makes the system inaccessible. The proposed system gives better performance because our device can be accessed without the internet locally via the local network. Moreover, the system is secure enough because everything is stored and manipulated through Raspberry Pi.

If unfortunately, power cut off and when the power will be back, our server will automatically be online within short times (45 to 90 seconds). Because initially it depends on Dataplicity response. Using only a 5volts backup battery,

always server can be maintained alive.

CONCLUSIONS

The proposed system is economy, convenient and user-friendly. The whole system is designed in such a way that it can be scalable according to user desire. Besides, a disabled person can easily control this system by voice commands as well. The advancement of this system can be obtained by integrating with more features like adding security camera, smart door lock, fire alarm notification, and many other things. We can keep the controls' of every electric device within our hand.

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