Globally Accessible Machine Automation Using Raspberry Pi

Based on Internet of Things

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***Abstract*— In the present world, there are many high tech appliances in our homes that make our lives easier. It is necessary to control these appliances remotely. To automate a machine, a secondary brain (another machine) is required to 'Think' and control machines to do tasks as per the convenience of the user from long distances. An automation system is proposed for the users to control home electronic appliances with high mobility and security. A set of switches will be controlled by internet with the use of a Raspberry pi micro-controller board. A Raspberry pi micro-controller board obtains user input from a website that is accessed through a user name and password. The customized user friendly website has several buttons to control the appliances. A Raspberry pi will be located in a room and will be connected to all electronic appliances in the home with the help of electromagnetic relays. The Raspberry pi can be controlled from any distant place with the help of weaved cloud service. Webiopi framework gives us a platform to interact with Raspberry pi's General Purpose Input Output pins. The Raspberry pi then either passes or stops current through an electromagnetic relay connected to the intended switch and this closes/opens the circuit allowing the appliance to run or get switched off. Thus globally accessible automation of electronic appliances can be made possible with the use of a Raspberry Pi micro-controller board, an internet connection and relay switches in a user friendly way.**

Keywords—Automation; Raspberry pi; Weaved services

I. INTRODUCTION

To automate objects refers to the idea of devices and appliances working by themselves acting upon the command of the owner or user. In the present age, technology has become an integral part of everyone's lives to such an extent that smart phones and internet are a common necessity for many.

Girish Birajdar and Shrikant Mahindrakar have developed a way in [1] to automate home appliances using an Embedded Web Server combined with a Raspberry Pi.

The embedded system which can serve the web documents on request by a client from other systems. Such type of a web server is called as Embedded Web Server (EWS). It mainly deals with management of dynamic contents and is fast, compact, simple to use. EWS design includes a complete web server with TCP/IP support, running different OS, memory, application wise. Several EWS based systems are designed for automation and also in monitoring purpose. Data transmission system is presented using with ARM processor that contains internet software which suite for monitoring, controlling and remotely access the system.

Sarthak Jain et al. have mentioned in [2] that their paper aims at designing a basic home automation application on Raspberry Pi through reading the subject of E-mail. The algorithm for the same was developed in python environment which the default programming environment provided by Raspberry Pi as is given in [3] and [4].

The subject of the received e-mail is read by the developed algorithm fed into raspberry Pi and the system responds to the corresponding instructions. Sarthak Jain has coded the Raspberry pi so that it acts upon message codes fed to it by email.

Shaiju Paul et al. [5] implemented the home automation through the use of a raspberry pi controller via an android interface. It employs the use of a Wi-Fi Local Area Network to connect the controller to the android interface. Thus by connecting any mobile phone to a Wi-Fi network setup at our home, office or any other locality, it is possible to control electrical appliances or machines connected to the processor board. The mobile phone is interfaced to the Raspberry pi with the use of an android application using control buttons. They interfaced the Raspberry pi with the switches by using relay. The control can only be achieved with Wi-Fi and hence is not applicable at large distances but it gives sufficient control from nearby places.

A wireless sensor network (WSN) is composed of spatially distributed nodes equipped with sensing devices to monitor and measure characteristics of the physical environment at different locations. The Raspberry Pi micro controller is one such node. From various other nodes, the Raspberry Pi was chosen for automation by analyzing the data given by [6].

Sarthak Jain et al. have mentioned in [2] that the research available into home automation in public domain lies predominantly in the academic arena, with little industrial research being available in open literature. The adoption of home automation technologies into commercial systems has been limited, and where available consumer uptake has been slow. The aforementioned systems offer little in the way of interoperability. Attempts have been made to provide network interoperability and remote access

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to home automation systems through the development of home gateways. Kushirio et al. in [7] proposed a home energy management focused home gateway, which connects the home network with the Internet.

The idea of controlling objects remotely is very interesting and advantageous. The motivation behind the goal is very simple, always it is not possible to be near to the home physically but it's very important to control the appliances for many purposes. So the remote controlling takes the control of the home. It would serve mankind well and make lives more safe and comfortable. Therefore, in this paper, automation of electronic appliances is implemented with the help of the internet, a raspberry pi micro-controller board and relay switches.

II. Hardware Prototype

Self-running or automated devices would require the use of a processor that processes the input supplied by the user and interfacing mechanisms to connect the processor with the input and output. The input interfacing is done with the use of Weaved services which enables a user to access the processor from anywhere in the world. The processing function is performed by the Raspberry pi and the output interface is the Relay system which consists of an Electromagnetic relay and Digiduino board to control the appliance. Specifications of the Raspberry Pi, Weaved services and electromagnetic relays will be described next.

A. Raspberry Pi Micro-Controller

It is stated in [3] that the Raspberry Pi is a series of credit card-sized single-board computers developed in the UK by the Raspberry Pi Foundation with the intention of promoting the teaching of basic computer science in Schools. The board is shown in Fig 1.

The Raspberry Pi is based on the Broadcom BCM2835 System on a Chip (SoC), which includes an ARM1176JZF-S 700 MHz processor, Video Core IV GPU and has 512 megabytes of RAM. The system is a Micro SD model and has sockets for boot media and persistent storage. The GPU (Graphics Processor Unit) is capable of Blu-ray quality playback, using H.264 at 40MBits/s. It has a fast 3D core accessed using the supplied Open GLES 2.0 (A graphics rendering application programming interface) and Open VG (Virtual Graphics) libraries. The chip specifically helps by providing HDMI (High Definition Multimedia Interface) and there is no VGA (Video Graphics Array) support.

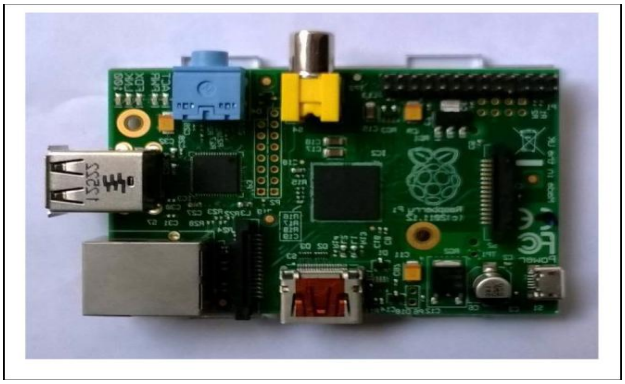

Fig. 1. Raspberry Pi Micro Controller Board

The foundation provides Debian and Arch Linux ARM distributions and also Python as the main programming language, with the support for BBC BASIC, C and Perl. The most distinctive feature of the Raspberry Pi is the GPIO (General Purpose Input Output) module, which allows interfacing with general purpose electronics. Each pin gives 3.3 volts of voltage.

B. Electromagnetic Relay

A relay is an electrically operated switch. Relays are used where it is necessary to control a circuit by a low-power signal or where several circuits are must be controlled by one signal.

A simple electromagnetic relay consists of a coil of wire wrapped around a soft iron core and a metallic switch. When current passes through the coil, a magnetic field is induced by the coil, hence closing the metallic switch. When no current is present, the switch is opened and circuit is disconnected.

This relay circuit was built by using a transistor and an electromagnetic relay. When Raspberry Pi supplies 3.3 V, the Digiduino board amplifies the voltage to 5V and supplies it to the relay. A magnetic field is induced which closes the key and when no magnetic force is present, the spring pushes the key back to open state. The transistor is connected to a GPIO pin of the Raspberry pi. When the pin is turned on, the transistor passes current to the relay allowing the switch to be closed. The circuit was built by using one single relay, but can be extended to any number of relays as per the user requirement.

C. Weaved services

It is stated in [8] that Weaved eliminates the need for in-house expertise in networking, services, mobile, security, and firmware development. At the heart of the Weaved technology is a sophisticated software-defined networking fabric that can be used with any hardware product. This fabric employs two levels of secure IoT (Internet of Things) cloud networking service to allow users a variety of services and features. Direct network connections are peer-to-peer, encrypted, and each connection session is protected using a unique security key.

The Weaved Fabric is different from all other current IoT connectivity solutions which either rely on security-vulnerable port-forwarding or hub-and-spoke connectivity. The alternatives to Weaved both requires an always-on Internet connection and raises the privacy concern of running data through a third party server. Weaved's approach allows developers to choose to use standard TCP (Transmission Control Protocol)/IP (Internet Protocol) connectivity, without concerns typically associated with remote connectivity. The open Weaved technology also allows developers the choice to avoid proprietary closed 'walled garden' approaches taken by closed platforms.

A website has been created using weaved services for acquiring user input. Weaved is an online cloud server that has been used to transfer data from the user to the Raspberry pi. The website has been given user access through a simple

user name and password criteria and it shows the user a set of buttons that can be pressed. This service has been interfaced with the Raspberry pi and a bulb was lit.

D. Digiduino Micro controller Board

The output of the Raspberry pi is 3.3 V and must be boosted to supply enough voltage to the relay. So, a Micro Controller board is needed to perform this function. One such Micro Controller board is the Digiduino board. It uses an ATMEGA 32 processor. The boosting is done by the L293D driver on the board. This is done using L293D driver present in the Digiduino. It was used to connect the Raspberry Pi's GPIO pins to the relay circuit. It is shown in Fig 2.

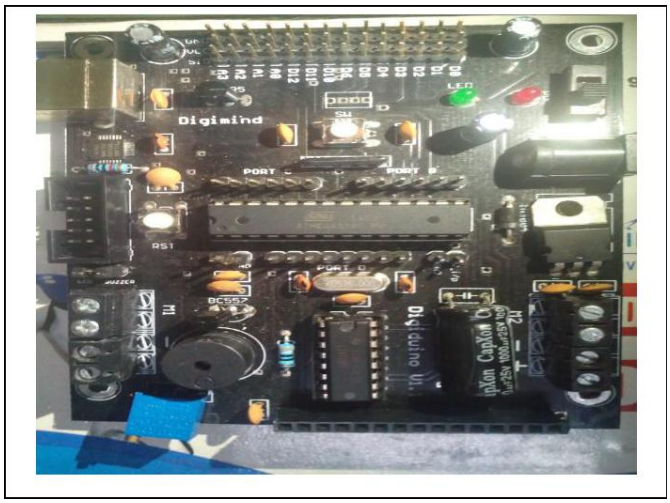

Fig. 2. Digiduino Micro Controller Board

III. Proposed System and Hardware Implementation References

The main aim of the proposed system is to control appliances remotely. This is an application of Internet of Things. In the first step, a LAN cable of a Modem was connected to the Ethernet module of the Raspberry pi to gain access to the internet. As the Raspberry pi works on a Linux Operating System, Raspbian which is a Linux based Operating System was installed.

Webiopi was the framework used to interface the Raspberry pi with user input and which was installed and updated. This framework allows a very user friendly mechanism to control the GPIO pins of the Raspberry pi. A "sudo webiopi" code was run in the Raspberry pi terminal (code block).

The server needed to host the transfer of data is not an external server. It is present within the Raspberry pi itself. When the "sudo webiopi" command runs in the terminal, the HTTP (Hyper Text Transfer Protocol) server generates a public IP (Internet Protocol) address such as "192.168.42.218". The CoAP (Constraint Application Protocol) server facilitates data transfer. When the public IP address generated is put in the URL of a web browser in a computer and browsed for, it shows the Webiopi framework of buttons that control the GPIO pins of the Raspberry pi. For example, when GPIO pin 2 is pressed in the browser, pin 2 of the Raspberry pi outputs 3.3 volt.

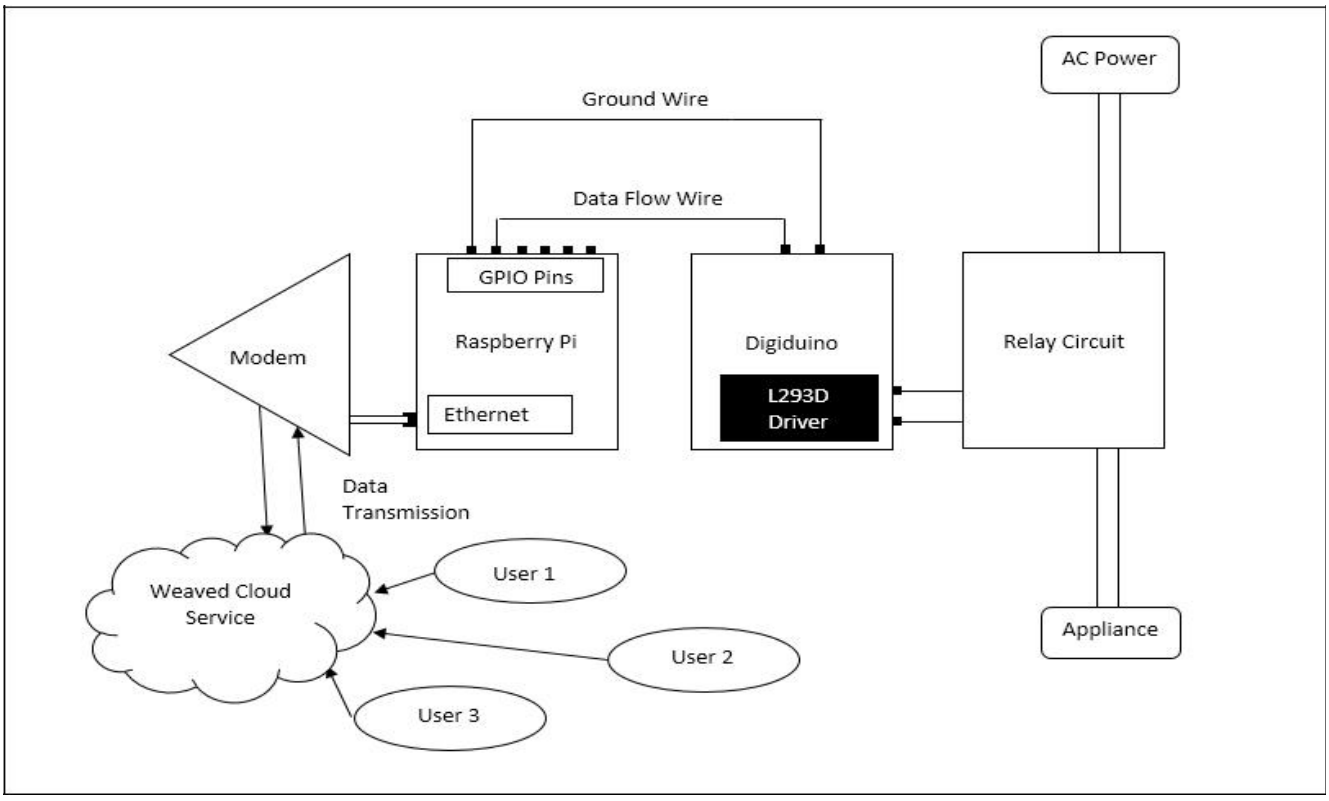

Fig. 3. Block Diagram of the Proposed System

The electromagnetic relay needed for the next stage would need a 5 V DC power supply. The output of the GPIO pin of Raspberry pi cannot supply enough voltage to the relay and hence an intermediate Micro Processor is needed for boosting the 3.3 V to 5 V needed by the relay. This is where the Digiduino board comes handy.

The Digiduino was connected between the Raspberry pi and the relay. When the GPIO gives 3.3 V, the appliance is turned on (in this instance a light bulb).

The next stage involves the extension of controlling the appliance from the Local Area Network to any location in the world. The main problem lying in access of the Raspberry pi from the internet is that it cannot be controlled by a public IP address and needs a static IP address. For this, Weaved cloud services is used. The task of Weaved cloud services is to bind the public IP address of the Raspberry pi with the static IP address provided by the service.

Using this static IP address, we can gain access to the Webiopi framework of buttons and when a button is pushed, the signal is sent to the Raspberry pi through satellite communication with the help of cloud service. This is transmitted to base station and then to Local Area Network of Raspberry pi triggering the GPIO pins.

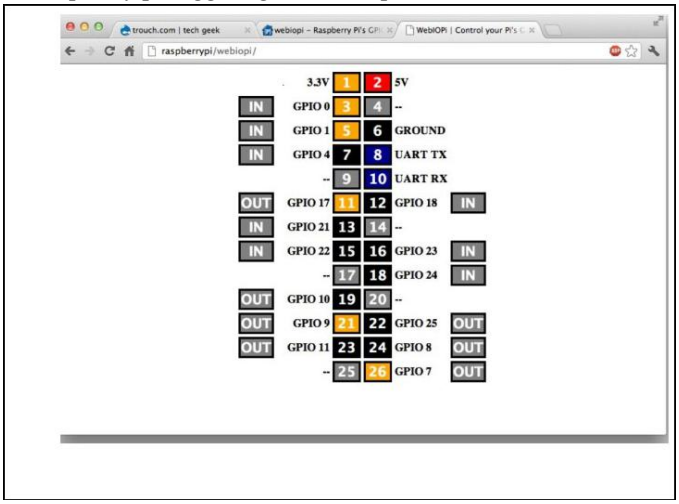

Fig.4. Webiopi Button Framework

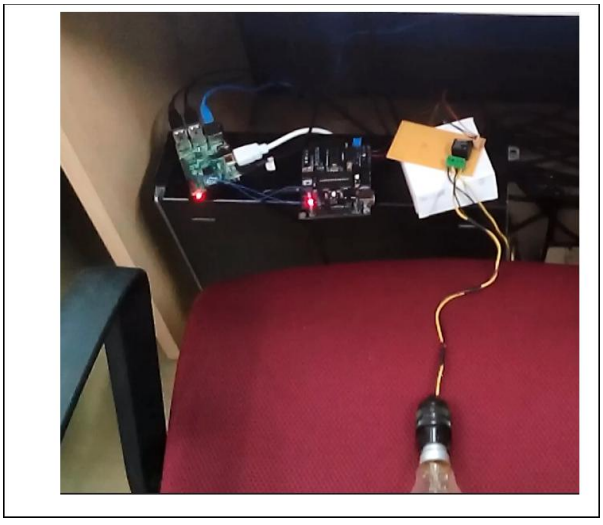

Fig.5. Prototype of the System

IV. Performance Comparison with Existing Systems

Sarthak Jain et al [2] have designed a basic home automation application on Raspberry Pi through reading the subject of E-mail. The system described in [2] allows for a user to control appliances by sending appropriate codes to the system. This would be very difficult if the number of devices increases as the user must either remember or have a catalogue of all the codes for each appliance on him/her at all times. The proposed system effectively removes this obstacle with the help of a custom designed web page that has user friendly button interface to control the appliance.

Home automation system designed in [5] uses the raspberry pi controller via an android interface. It employs the use of a Wi-Fi Local Area Network to connect the controller to the android interface. This system provides a way to control appliance with the use of a Local Area Network. The limitation of this system would be that, any Local Area Network is limited within the range of the Wi-Fi. The proposed system deals with this limitation by the control of appliances through the internet. Our proposed wireless based home automation system decreases installation cost and effort, and enhance system flexibility and scalability.

V. Conclusion

A novel architecture for a home automation system is proposed using the raspberry pi board, Weaved services and electromagnetic relay. Raspberry pi micro-controller board is used to control the switches of appliances through internet. A website has been created using weaved services for acquiring user input. When the GPIO pin of the Raspberry pi pin is activated, relay closes the switch which controls the appliance. The implemented automation system provides an efficient, comfortable and flexible user interface for controlling electric appliances remotely.

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