Field of Invention:

This invention relates to the field of Home Automation Systems and Automation in general. More specifically the invention comprises of an expandable home automation system that can be controlled using software, in this case an android app, and at the same time be universally controllable and compatible.

Use of the invention:

With the increase in workload and other important activities in human life, unnecessary energy consumption by home appliances caused due to ignorance and carelessness of peopie, is increasing at an exponential rate. However, smart homes enable people to concentrate on more important work rather than worrying about their electricity bill. Thus with remote accessibility of appliances, it is possible to save tremendous amounts of energy every day. Apart from helping to conserve energy, it also acts as an aid to the differently abled people and senior citizens. It assists them to automate most of the work using a Smartphone, inside or outside their home without having to depend on others in case, they have to move around to toggle and control them.

Moreover, the system is compatible with all existing devices without many changes to the circuit connection. That is, the system can be interfaced directly with the existing electrical system environment rather than wanting us to buy new appliances to build a whole new set of appliances that are compatible only with its designated controller. Thus, the cost of installation is reduced. The system also eliminates the disadvantage of using only proprietary devices to control them. Using just a single smartphone, installed with the android application, all the appliances can be controlled in ease without the need to carry any additional devices for controlling the electrical appliances. The devices can be accessed from all over the world. The system is expandable, that is, any number of new devices can be added to the system without any major modifications to the system installed. The system also has a programmable Interface that is updated by the online web server, making the system user friendly.

Description of the Prior Art / Background of the Invention:

A home automation system in general, indulges in the automation of certain housework or household activity and also includes the centralized control of appliances and other systems. The popularity of such systems has been on the rise in the recent days due to the popularization of a concept called the "Internet of Things". Usually such systems have a software interface that is used by the users to give instructions and control the appliances remotely. Such system can make use of a host of communication methods such as Wi-Fi, GSM, Bluetooth, ZigBee etc. and can be made up of different controlling devices and configurations.

Some of the common modules that these systems comprise of, are, a basic underlying communications technology, a control circuitry that is used to interface with the electrical appliances, common command system that will be used to issue commands to the control circuitry, the user interface, security features to ensure only authorized access. Some of the most common and latest versions of Home Automation Systems includes GSM, Bluetooth, ZigBee based, wireless systems and a combinations of these as their basic communication protocol.

GSM systems primarily use SMS messages to communicate the commands issued by the user to the main control system at home. This system offers the ability to control the appliances from all over the world. However, the cost incurred can be large depending on the location. Another significant drawback is that the system lacks reliability. There is no assurance of the delivery of the message to the system. Thus such a system cannot be used as a real time system. However, GSM can be used as a method of Internet access and a web application can be used as a method of user interfacing.

A Bluetooth system may use either a mobile phone or a PC as the receiver. The Bluetooth system can offer comprehensive control of the home appliances as long as the user is at home. It can function as a real time system. The speed of communication is high. This means that the user can be alerted about events as and when required. There is also greater security in Bluetooth technology. However, it cannot offer control when outside home. The range of Bluetooth appliances is around 10 meters. This is a significant drawback of this system.

Phone based systems can use the dual tone multiple frequency to transmit commands. This system depends on the ability to make phone calls from a remote location to a phone line at home. This has the advantage of offering remote access from anywhere in the world from where they can make a call. This can offer an almost real-time system. The drawback here is that it limits the number of possible devices to the number of possible DTMF (Dual Tone Multi Frequency) tones. Also, it is hard for the system to give feedback to the user.

ZigBee is an alternate technology that is similar to Bluetooth. This has the same advantages and drawbacks as the Bluetooth based system. This is a fairly new technology. Wireless automation systems can use a host of wireless communication techniques. This may be radio frequency waves or infrared waves. This can also be used to power a real time

system. Similarly, a remote controller emitting unidirectional infrared (IR) light containing specific data is employed to remotely control short ranged electronic products without any obstacles. This limitation is overcome using a radio frequency (RF) remote control module based on a network. The RF remote control module operates by receiving data from a set-top box; determining whether or not the received data is remote control data and belongs to the specific manufacturer data. Consequently, performs the corresponding IR modulation operation.

The major downside here is the range and availability of the spectrum. Radio waves have a much larger range and offer good options for remote access. However, the availability of the spectrum has to be taken into account. Certain bands of the spectrum are in demand while the unlicensed bands are used by many other applications. There is the possibility of interference. This compromises the security of the system.

In Patent 211651, home automation system using GPRS mobile phones is employed. In this system, the web server is updated with the command information from the user interface. However, the status change of the device in the database caused by mechanical switches is not stated. This introduces inconsistency amongst the various components of the system. For example, if the device is switched on using the app and then switched off using its corresponding mechanical switch, the status of that device in the database continues to remain in switched on state. Thus, the real time status of the device is misinterpreted to the user.

Out of all the systems discussed above, each version had its own advantages and drawbacks, based on all this; we try to combine the best features to build an ideal system for home automation. Though, many systems exist, that use a combination of the methodologies to compensate for the drawbacks of each, there is no perfect system proposed yet. This is exactly what we wish to solve, through this invention.

This invention proposes a system which overcomes all the above stated disadvantages. The system incorporates a reverse mapping concept for preserving consistency of the real time device statuses. Furthermore, the system is expandable and compatible with existing home appliances at a low cost. The limitation in the access range is overcome by using an online server and Raspberry Pi to facilitate communication between the appliances and the user.

Summary of Invention:

In summary, this invention relates to a system that is universally compatible with, and capable of remotely controlling, all appliances from anywhere on this planet, using software applications such as mobile apps (i.e.)an Android application, for the Conservation of Energy and to aid the Differently-abled. It is basically, a hardware and software coupled system, that is equipped to be able to automate the process of controlling appliances remotely from anywhere on this planet. The nature of the appliances being controlled is non-proprietary, (i.e.) the devices need not be bound to any manufacturer in particular for our system to work, our invention is device independent and compatible with all devices. The appliances are remotely controlled using a GUI, built as an Android application, however, these appliances are not always bound to be controlled from this GUI, rather, the invented system supports the devices being controlled through the mechanical switch as well. The invented system also supports expansion, with an easy to use plug and play feature for dynamically adding more devices. Moreover, this invention also has a consistent and centralized database in the internet cloud to enable our system, to keep track of the current statuses of the devices in any home, even when they are being controlled from more than one remote or through the mechanical switch.

Detailed Description of the Invention:

The Invention can be split into, and has four major modules, the Raspberry Pi, the Control circuitry, the Centralized Web Server with the consistent database in the internet cloud and the Android application. Before getting into the overall functioning of the invented system as a whole, the following paragraphs will explain, what is the job of each of these modules and what do they comprise of.

The **Raspberry Pi**, this module is located inside each and every home, whose devices are to be controlled remotely through the mobile app, and basically, it is the command centre of the home, more like a brain. It is directly responsible for being able to modify the current status of the devices and appliances that are present within the home. The Raspberry Pi has back-end web server that is running 24/7, locally, within each home, this web server should not be confused with the online Centralized Web Server. This locally hosted web server is unique to every house and is responsible for actively receiving control commands from the Centralized Online Web Server that is hosted in the cloud and is responsible for forwarding the respective control commands received from the mobile app, to these local servers in each home. This locally hosted web server is coded using *Python* along with *CherryPy* module, that is responsible for hosting apache like back-end servers in Python and at the same time is also capable of handling multiple requests / messages from the centralized online web server based on the Asynchronous I/O handling paradigm. The control message received by the local server, is a tuple of the form, (Room Number, Device Number, Change to Status). The house to which these messages are being forwarded, is controlled from the online centralized web server. Based on this control message received, in-order to toggle the respective device, in the respective room, to the required state, we use the Raspberry Pi GPIO pins coupled with the *RPi.GPIO* module of Python, to send inputs to the control circuitry through the GPIO pins, from the local CherryPy server. When a particular device has to be toggled, the Pi sets the corresponding pins to either high or low as per the requirements. One point to be noted is that, the Pi should be connected to the internet either through GPRS, Wi-Fi or Ethernet.

The **Control Circuitry** (refer **Drawing 1**), is individual to every house and is responsible for interfacing between the Raspberry Pi and the electrical appliances, and communicating the control signals or messages from the Raspberry Pi to the respective devices in the home. It comprises of multiplexers/demultiplexers, D flip-flops and relays and their functions are as follows: (1) A Demultiplexer is used to select the various devices in a room. The selection lines are used to denote the devices number in that room. This helps eliminate the need for different lines for different devices in the rooms. (2) Another Demultiplexer is used for selecting the room. Its output activates the enable input of the multiplexer assigned to that particular room. The inputs to all the rooms' multiplexers are from a set of common GPIO pins of the Raspberry Pi. (3) The output lines of the demultiplexer are connected to a D flip-flop's input. The D flip-flop is a basic memory element and it reads its input only on a positive edge of clock cycle and maintains that constant output, until changed by simultaneously changing the GPIO state and stimulated by

a positive edge clock cycle. This is used to store the input to be given to the relay which determines the state and hence the position of the relay coil in the relay. (4) The relay is used to control the devices by mainly converting the software changes to hardware mechanical switching. It is organized and structured so that, the manual switches already in-place can be used along with the automation system, just like how a 2-way switch operates. This is achieved using the organization of the relay and mechanical switch as shown in **Drawing 2**. The main concept of reverse mapping these mechanical changes to the database, in-order to maintain consistent information, is discussed in the future paragraphs. The above discussed configuration and structure of wiring enables this invention's implementation without too much rewiring to the existing circuitry and at the same time makes it compatible with the existing devices in the home, thus avoiding the need for proprietary devices.

Apache based **Online Centralized Web Server,** there is only one such centralized server and is not to be confused with the local web server running in the Raspberry Pi of each house. This web server dispenses control commands / messages to the the Raspberry Pi and also exposes an API that can be used by the remote clients (Android Applications) to update, as well, get the current state of each device in a house, this API is built using PHP. Moreover, this Server has a MySQL database in its back-end, and this database is used to maintain consistent information w.r.t. the status of the devices in each home. The database also stores user details and also the respective details to map the users to their appropriate houses. It serves as an interface between the android app and the raspberry pi controller at home. Data is exchanged in JSON format between them. When the server receives a request from the android app in JSON format, it forwards this to the CherryPy server of the appropriate Raspberry Pi as a POST request with the command message encoded into it. The database entries are simultaneously updated so as to maintain consistent information across remotes.

The **Android Application,** provides a simple GUI for the users / clients to make use of the home automation system, anywhere from the world, using an Android Smartphone. The smartphone must be connected to the internet by any means, maybe through Wifi, GPRS, etc. The app is built in such a way, so as to allow the users to select the rooms first and then view details of the devices there. Each and every user get their own home's device statuses. The app contacts the Centralized Web Server for data from the Pi server in the home and toggles switches for the users rooms and devices appropriately. When the user toggles a switch in the GUI, it sends a request to the server giving the room and device number as a JSON data packet. The app can also refresh its current status by sending a request to the server and processing the JSON response sent by the server. This can be done as and when the user wishes. The toggle buttons on the user screen will change based on the current device status at any given time, asynchronously. The app has a provision to register the home server and the centralized server's ip addresses to get and post updates.

Reverse Mapping is one of the unique features of this invention and it is a process of mapping the current state(ON/OFF) of a device to the pins of the Pi and in-turn update the same to the database, residing in the online Centralized Web Server. The aim of this is to be able to keep track of any changes made manually in the switch and in-turn update it in the database for maintaining consistent information about the current state of all devices in the home, across remote devices. This feature has been implemented in our invention, by making use of a D flip-flop connected, directly to the device. The input to the flip-flop will be from the direct power line of the device. The outputs from all the flip flops are connected via a multiplexer to select the different devices. These are polled by the Raspberry Pi at regular intervals. If any state change is detected, then the server will be notified to update the database. The reverse mapping can be easily extended to any number of rooms and devices by adding many more multiplexers in different layers. The addition of this feature will cause changes in the control circuitry. The modified control circuit is as represented in **Drawing 3**.

Therefore, the final working and structure of the invented system (refer **Drawing 4**) is as follows, firstly, the control circuitry is set up with the already available devices. The connections are made with the devices and the switches as in **Drawing 1**. The raspberry pi is booted and the CherryPy server is initialized. The online centralized web server is initialized and is kept running 24/7, to manage and control the entire system. The user details are entered in the database. The details of the number of rooms is entered along with the number of devices in each room. The user installs the android application on their smartphone. Now the setup is ready and the user can connect to the internet and get the current state of the devices in the home, on the app. By using the toggle controls, the user can switch the states of the required devices. The app will communicate with the online centralized web server. This will cause a change in the device's status. If the user uses the manual switch to toggle the device, the state can be changed and the updates are periodically posted to the centralized database. Thus the users will be able to access the devices from anywhere in the world, when connected to the internet.

Main Components Used

1. Raspberry Pi B+
2. 8 Relay board (8 Devices can be fit in)
3. Multiplexer / Demultiplexer (IC 74HC4052)
4. Positive edge triggered D flip flop (IC 7474)