Home Automation and Monitoring System Using Raspberry Pi and Android

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Abstract - **In this paper, a system based on raspberry pi and android application specially designed for home automation has been proposed. It is proposed to control various home appliances like Tube light, bulb and fan using android application installed in multiple tablets or any other android platform based handheld devices. Raspberry pi board will control appliances through PIO ports. For wireless connection USB WiFi Adapter is used for connecting raspberry pi and Tablet with WiFi (IEEE 802.11 protocol). Appliances to be controlled are selected from the application and further commands are given to Raspberry pi. A driving signal from Raspberry Pi is generated to operate relay to turn ON/OFF particular electrical appliance. In monitoring system, it is proposed to have one pi-camera outside the main door which can be accessed from the tablet, using android application. It is also proposed to control speed of fan or intensity of light by interfacing thyristor module to raspberry pi. Database has also been proposed in PHP and MySQL for storing the status of appliances at particular time. So the proposed system can also be used for analog and digital data logger for industries with remote monitoring.**

Index Terms **- Raspberry pi, Android, wifi, usb, camera, automation**

I.INTRODUCTION

In this paper, first the problem has been defined, and then a cost-effective solution to that problem using Raspberry Pi has been proposed. The technical details of Raspberry Pi and illustration of how it will be used in the proposal, has been mentioned. Further, every step of the proposal has been mentioned in detail including the hardware details, android application details, database details, camera specification. The cost of this proposal, which is the most vital area of our concern, has also been estimated.

1.1 Motivation

The motivation for this paper is to facilitate the old age people to turn ON or OFF various appliances easily. This will also help and make life easy for any ordinary person if there is automation in home appliances. The home appliances control system with an affordable cost is built based on android tablet providing remote access to the appliances. The system also provides monitoring system with the help of camera which is located at the outside of the main door.

1.2 Objective

The objective of the system proposed in the paper is to control and monitor various appliances from multiple android device, multiple PC/Laptop and switch (manual), monitor analog inputs from multiple android devices, implement video door monitoring system in which camera captures the image from door and one can see it from multiple android devices, append appliance status and analog inputs reading in MySQL Database, create Web Server on raspberry pi and host Web page for monitoring of Home Appliance and for Analog Input from remote location in LAN area.

The system proposed in the paper can be used to control appliances using android devices and PCs remotely, Wireless robot can be controlled using android devices (By replacing 4 load with 4 motors of robot), analog and digital data logger for industries with remote monitoring. The proposed system is cost effective, luxurious to use and can be extended for multiple rooms as well.

II.DETAILS ABOUT RASPBERRY PI

2.1 Raspberry Pi - the device

Raspberry Pi is a credit card sized computer. It's basically a small PC which provides all the basic functions that are provided by a desktop PC. For example, it provides functions like word processing, gaming and playing audio/video. It has become a widely used device for learning programming since last one year. [1]

2.2 Specifications

The Raspberry Pi is a 3.370 X 2.125 motherboard with a 700 MHz CPU and a 250 MHz GPU. The Ethernet LAN port is present for internet and remote access. It also has an HDMI port, through which it can be connected to any display device, like the monitor or the projector. Another great facility which Raspberry Pi provides is the presence of two USB ports, where one can connect his pen drive or USB mouse/Keyboard. General Purpose Input/output (GPIO) are a set of generic pins on a Raspberry Pi whose behaviour can be controlled as well as programmed through software. The Raspberry Pi also has an SD card slot, which can act as an internal storage and can also store an image of Operating System. [2]

Raspberry Pi model B is to be used for this paper. The board is shown in figure below.

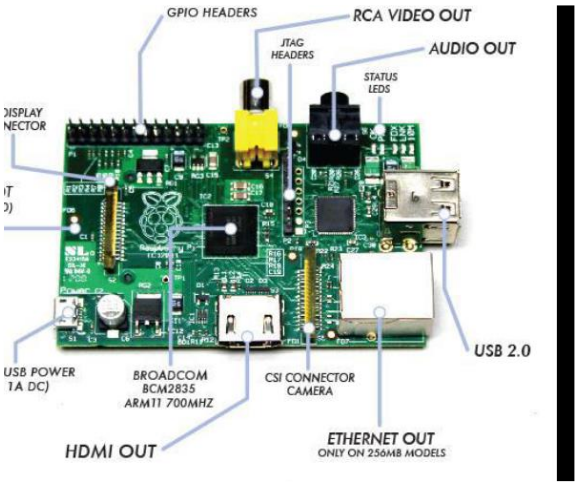


Figure 1 Raspberry pi Model B

2.3 Raspberry Pi: A Cost-effective Solution

The problem which is addressed by the proposed system involves cost reduction. This will be achieved when we consider the cost of all the hardware and software components comprised in this system.

Table 1 Cost Estimation Table

Item	Cost in Rs in Jan 2015
Raspberry Pi Model B	2500
8 GB SD Card	200
Pi Camera	2500
HDMI cable	200
Other	100
Total	5500

III.ARCHITECTURE OF THE PROPOSED SYSTEM

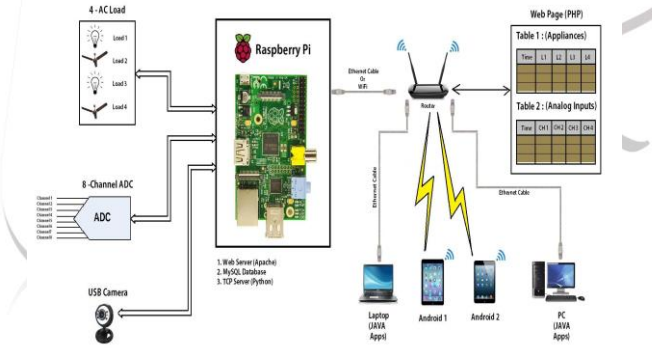


Figure 2 Block diagram of Proposed System

The System has following Main components.

1. Raspberry Pi:

It is the main core of whole proposed system. It is used to get command from either android tablet or PC and according to the command, control the appliances connected to it on the output port. It is connected to android tablet or PC via a router by using wifi or Ethernet cable. It is also used as a webserver to store to status of appliances in the database and give it to the php web application to display on the webpage.

2. Android Device or PC:

These devices are used to control the appliances connected to it from the remote places. It is connected to raspberry pi via a router by Ethernet cable or wifi. The Android application was built for android device and Java application was built for Desktop Computer. Both Applications used the TCP protocol to communicate with Raspberry Pi.

3. Pi Camera:

It is connected to raspberry pi for monitoring on the door. When there is someone on the door, by using Android application it can be used to take snapshot and display it in the application.

4. Analog to Digital Converter:

The Raspberry Pi has no built in analogue inputs which mean it is a bit of a pain to use many of the available sensors. So MCP3008 was used. The MCP3008 is a 10bit 8-channel Analogue-to-digital converter (ADC). It is cheap, easy to connect and doesn't require any additional components. It uses the SPI bus protocol which is supported by the Pi's GPIO header. This enables the Raspberry Pi to interpret analog voltages that are in turn typically emitted by analog-based sensors to reflect a measure of a physical characteristic such as acceleration, light intensity or temperature.

5. Database and Web application:

It is built using PHP and mysql. It is used for storing the status of appliances at a particular time. Also web application is developed to query in the database and display the results on webpages.

The implementation of proposed system is divided in to five parts. First part is to establish TCP connection between Android device and raspberry pi. Second part is to turn on/off appliances using Android application. Third part is to interface ADC to get inputs from various analog Sensors. Fourth part is to interface pi camera with Raspberry pi for Monitoring. And last part is to build database and web application to get status of appliances on a particular time. In the next section all parts are discussed one by one with the implementation details and snapshots of results.

IV. IMPLEMENTATION AND RESULTS

4.1 TCP/IP socket connection between Raspberry pi and Android:

Raspberry pi and Android devices are connected using TCP/IP protocol in a client server Architecture. Raspberry pi is acting as a server and Android devices are acting as a client. When client wants to communicate it initiates a request and server acknowledge with the appropriate response. The block diagram is shown below.

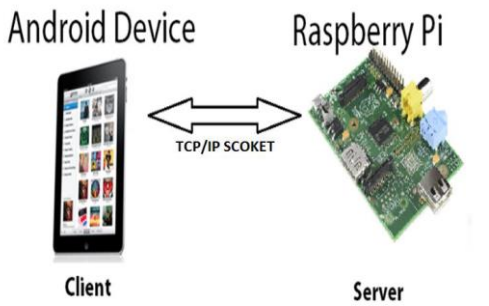


Figure 3 TCP/IP socket connection block diagram

The flow chart of TCP/IP communication is shown below.

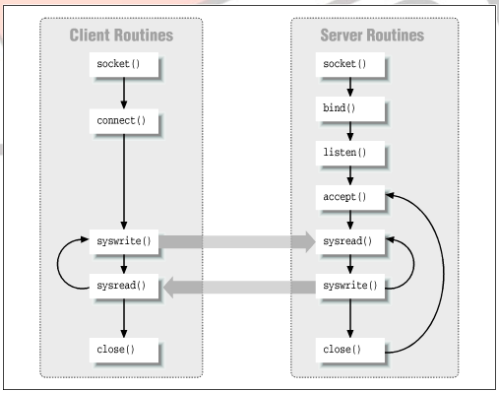


Figure 4 Flow chart of TCP/IP Communication

4.2 Appliances Control:

The second part is to control appliances using Android device. In this, relay drivers and xor gate has been used so that appliances can be controlled via application and it can be controlled manually also via switches. The block diagram of the connections is shown below.

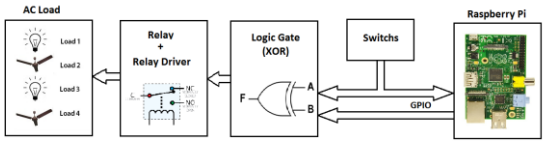


Figure 5 Block diagram of Appliances control

To sense the status of switch following circuit has been used,

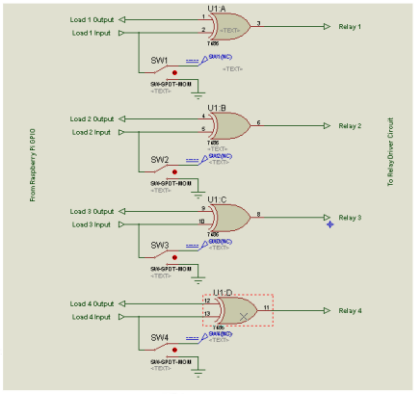


Figure 6 Switch Sensing Circuit

The overall connection to control appliances with relays is shown in the following figure.

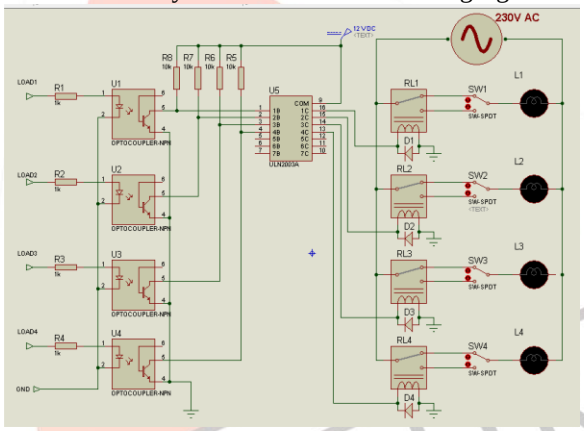


Figure 7 Appliances Control circuit using Relay

The snapshot of Android application used to control the appliances is shown below. By pressing ON/OFF the appliances can be controlled. By pressing the refresh button it will display the current status of Appliances.

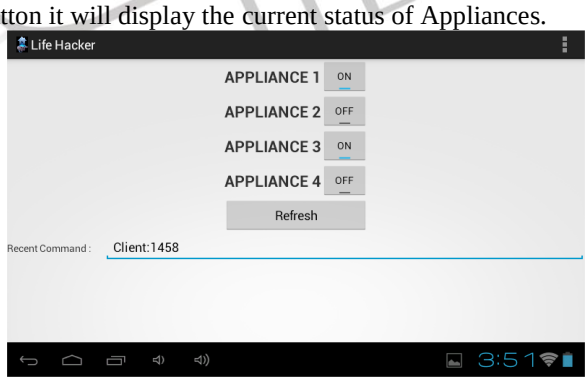


Figure 8 Android App page for Appliance Control

The snapshot of hardware result is shown in the following figure.

Figure 9 Hardware snapshot for Appliance Control

4.3 Interfacing ADC for Analog Inputs:

Next task is to interface Analog to Digital Converter for getting input from Analog Sensors. The block diagram for this is shown the following figure. MCP 3008 ADC is used for this purpose. 8 potentiometers are used to sense input from eight channels and output is displayed on Android Application. It is a 10 bit ADC so output is between 0 to 1024.

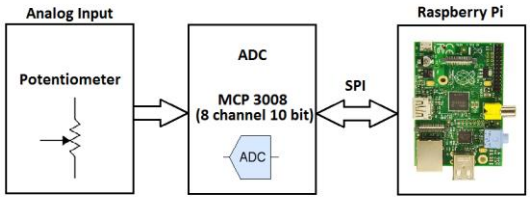


Figure 10 Block diagram of sensing Analog Inputs

The connection of MCP3008 with Raspberry pi uses SPI protocol and breadboard and PCB connection for the same are shown in following figure.

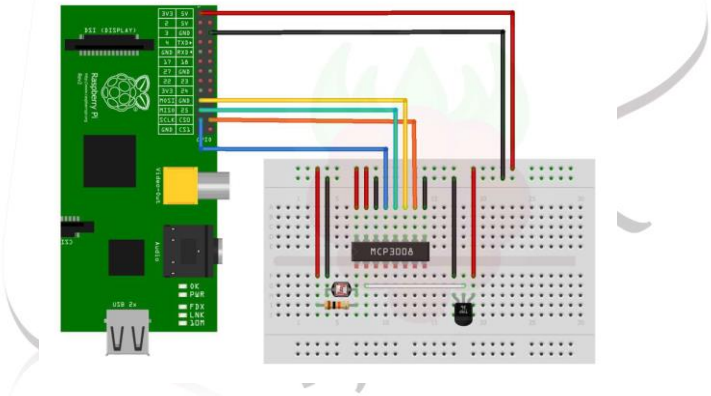


Figure 11 Breadboard Connection of ADC interfacing with Raspberry Pi

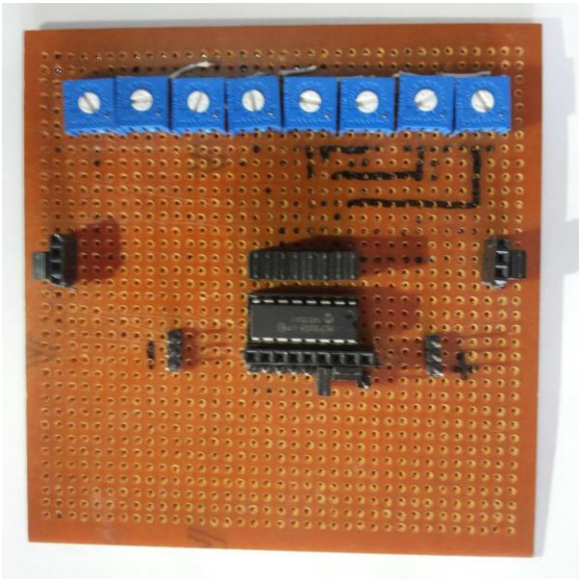


Figure 12 PCB Connection for ADC interfacing with Raspberry Pi

The input from the sensor is fed through ADC and raspberry pi and it is displayed on android application. The result is shown in following figure.The inputs from sensors are also stored in database.

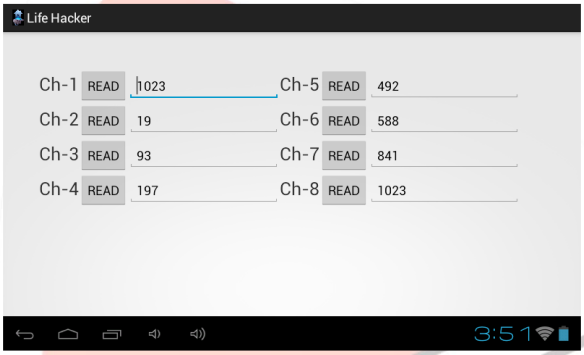


Figure 13 Android App page to view Analog Sensor Results

4.4 Interfacing Pi camera with Raspberry Pi:

For Door monitoring pi camera is interfaced with Raspberry pi. The image can be captured by clicking in the android application. The procedure to interface and install pi camera is shown in following figures.
Web camera in interfaced with Raspberry pi via a USB cable.

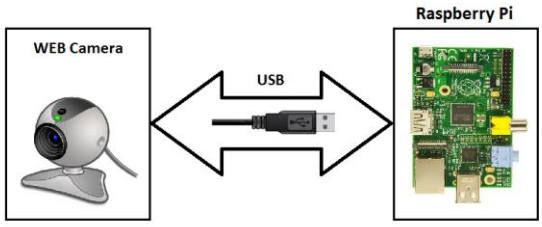


Figure 14 Interfacing camera with Raspberry pi

To install camera support on Raspberry pi following steps are followed.
Step 1:Install Raspbian on Rpi.
Step 2: Attach camera to RPi
Step 3: Enable camera support.
sudo raspi-config
Step 4: Update RPi with the following commands:
sudo apt-get update
sudo apt-get upgrade
Step 5: After the setup finishes, restart the RPi.

Than following figure shows the android application snapshot used to capture image. By clicking on Inage button it will capture image via camera and display the image on this application.

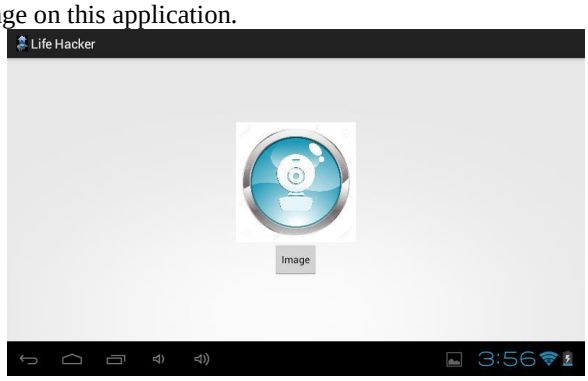


Figure 15 Android App page for capturing image from camera

4.5 Database and Web application:

To keep the record of appliances status and analog inputs database has been built in MySQL. To install MySQL database on raspberry pi following command are used.

–sudo apt-get install mysql-server

–sudo apt-get install php5-mysql

To Access MySQL following command has to be used.

•mysql -p -u root

Following figure shows the structure of Database Table for Appliance Status. It contains six columns. Two are for date and time and other four shows the status of four appliances connected. One shows that appliance was on at that particular date and time and zero shows it is off.

```
mysql> use APP
Reading table information for completion of table and column names
You can turn off this feature to get a quicker startup with -A

Database changed
mysql> select * from HAS;
+------------+----------+------+------+------+------+
| ddate      | ttime    | L1   | L2   | L3   | L4   |
+------------+----------+------+------+------+------+
| 2015-04-25 | 13:19:07 |    0 |    0 |    0 |    0 |
| 2015-04-25 | 13:19:19 |    1 |    0 |    0 |    0 |
| 2015-04-25 | 13:19:23 |    1 |    1 |    0 |    0 |
| 2015-04-25 | 13:19:24 |    1 |    1 |    1 |    0 |
| 2015-04-25 | 13:19:25 |    1 |    1 |    1 |    1 |
| 2015-04-25 | 13:19:25 |    1 |    1 |    1 |    0 |
| 2015-04-25 | 13:19:26 |    1 |    1 |    0 |    0 |
| 2015-04-25 | 13:19:27 |    1 |    0 |    0 |    0 |
| 2015-04-25 | 13:19:27 |    0 |    0 |    0 |    0 |
```

Figure 16 Database for storing Appliance status

In the same way table is built for analog sensor inputs. It has ten columns with date, time and eight sensor outputs at that particular date and time.

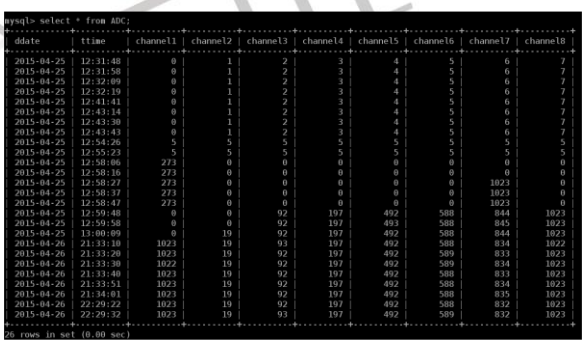
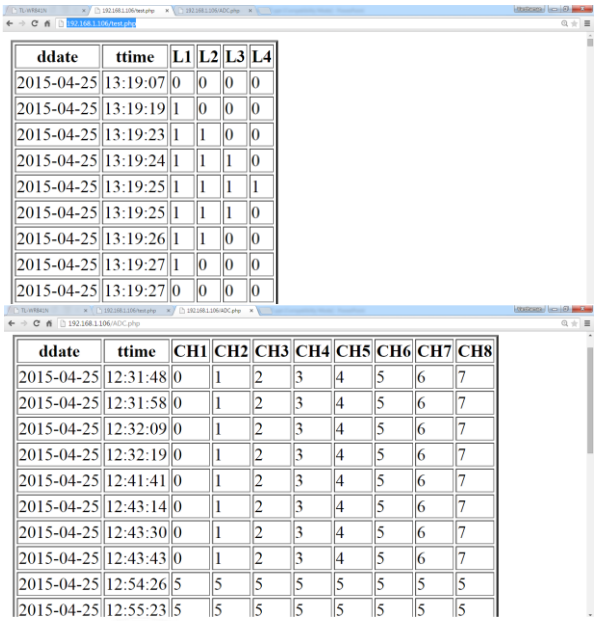


Figure 17 Database for Analog Sensor Results

Raspberry pi is used as Web server and two PHP web pages are hosted that shows the status of appliances
And shows Reading of 8 Analog input channels.
Following are the snapshots of PHP webpages for appliances and analog inputs.



ddate	ttime	L1	L2	L3	L4
2015-04-25	13:19:07	0	0	0	0
2015-04-25	13:19:19	1	0	0	0
2015-04-25	13:19:23	1	1	0	0
2015-04-25	13:19:24	1	1	1	0
2015-04-25	13:19:25	1	1	1	1
2015-04-25	13:19:25	1	1	1	0
2015-04-25	13:19:26	1	1	0	0
2015-04-25	13:19:27	1	0	0	0
2015-04-25	13:19:27	0	0	0	0

ddate	ttime	CH1	CH2	CH3	CH4	CH5	CH6	CH7	CH8
2015-04-25	12:31:48	0	1	2	3	4	5	6	7
2015-04-25	12:31:58	0	1	2	3	4	5	6	7
2015-04-25	12:32:09	0	1	2	3	4	5	6	7
2015-04-25	12:32:19	0	1	2	3	4	5	6	7
2015-04-25	12:41:41	0	1	2	3	4	5	6	7
2015-04-25	12:43:14	0	1	2	3	4	5	6	7
2015-04-25	12:43:30	0	1	2	3	4	5	6	7
2015-04-25	12:43:43	0	1	2	3	4	5	6	7
2015-04-25	12:54:26	5	5	5	5	5	5	5	5
2015-04-25	12:55:23	5	5	5	5	5	5	5	5

Figure 18 PHP webpages for Appliances control and analog sensors

V.FUTURE SCOPE

In future, this system can be extended for multiple rooms as well. Also the status of appliances can be monitored if the webpages are hosted using public IPs.

VI.CONCLUSION

Raspberry Pi is a high quality, high performance, convenient and compact electronic device which is used to develop cost effective automation systems. In this paper, the proposed system architecture is used to control home appliances, sense analog inputs, door monitoring using pi camera and data logging.

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