

International Journal of Computer Science and Mobile Computing



A Monthly Journal of Computer Science and Information Technology

ISSN 2320-088X

IMPACT FACTOR: 5.258

IJCSMC, Vol. 5, Issue. 4, April 2016, pg.245 – 253

Architecting Wireless Sensor Mesh Networks for Connected Home and Home Security- using Raspberry pi B+ and Zigbee

Ashwini V S¹, Bharathkumar G², Ravindra Prasad S³, Rajeshwari B S⁴

¹M.Tech 4thSem, Computer Science and Engineering, RRIT, Visvesvaraya Technological University, India

²M.Tech 4thSem, Computer Science and Engineering, BMSCE, Visvesvaraya Technological University, India

³HOD, Asso Professor, Computer Science and Engineering, RRIT, Visvesvaraya Technological University, India

⁴Asst Professor, Computer Science and Engineering, BMSCE, Visvesvaraya Technological University, India

¹ashwinivshankar@gmail.com; ²bharathbg123@gmail.com; ³rpsetturu@gmail.com; ⁴rajeshwari.cse@bmsce.ac.in

Abstract - The Internet of Things (IoT) has of late received significant interest from both academic world and industry to facilitate working on technologies to widen the future Internet. It is a combined and complex discipline which requires synergetic works from a number of communities namely device manufacturers, semantic Web, telecommunication industry and informatics and engineering. The aim of this project is to co-develop a Connected Smart Home and Safe Home as part of Samslogix team which provides remote control and scheduling of home appliances with the help of Smart Phone or Tablet using Raspberry pi B+, android and ZigBee. Home Automation industry is growing rapidly and entering quickly in the emerging market nowadays.

The need for Home automation system is undoubtedly not a standard of living product, not just turning light on/off, not for tech savvy guys. It's all about safety/security, handiness, ease, energy monitoring and saving. The solution for the proposed system comes with Raspberry pi B+,SD card, Power card, Wi-Fi router, Light automation, Geyser relay switch, Air- Conditioner relay switch, Intruder detection sensor, door sensor, smoke sensor, hooter, Android app. At the core of any home automation solution is the ability to manage and keep an eye on devices in real time. Smart Home is economical and efficient system. Complete solution is wireless, which is ideal for remodel or new construction. At the end of this project, architecture of Internet of Things with capabilities of sensor based mesh networks and applications of Connected Smart home will be demonstrated.

Keywords – Smart Home, Safe Home, Raspberry Pi B+, Zigbee, Android, smart phone.

I. INTRODUCTION

Internet of things can be defined as the interconnection between everyday objects such as smart-phones, internet TVs, sensors, actuators and the internet using sensing devices which are intelligently linked together to enable new forms of communication among things and people, and among things themselves[1]. IoT can also be defined as interconnection between object, animal or people that has the ability to exchange data over network without human-to-human involvement or human-to-computer interaction.

Home automation or smart homes can be described as introduction of technology within the home environment to provide convenience, security, comfort and energy efficiency to its occupants. The main intention of the proposed system is the provision for occupants to automate homes remotely. This work explores the use of Raspberry pi B+ model and ZigBee model for a safe and secured home. Along with this cloud implementation is yet another focused area of the proposed system in order to access the system from anywhere.

Different devices and the appliances in the home such as lightings, geyser, air condition, home security, intruder detection, smoke/fire alert, entertainment systems and door sensing are now being controlled remotely using the Smart Phones or Tablets. With the help of such system the energy consumption can be monitored continuously which contributes to overall cost reduction and energy saving which is the main concern these days.

This paper develops a system that allows user to control home appliances and to provide secured home ambience whenever he like and wherever he is. An example of remote monitoring, when home is in “safe mode”, our sensors detect intrusion or any fire outbreak in home which can be notified in many modes such as hooter , SMS, Email, Call, Lights on etc.

Raspberry pi B+

Raspberry pi is a low cost, small and portable size of computer board. Raspberry has built in software namely Scratch which enables programmers to program and design animation, game or interesting video. Adding to this programmers can also develop script or program using python language; which is the core language in Raspbian OS (operating system) [2].

Raspberry pi B+ is evolution of Model B. B+ has advantages over model B, firstly more GPIO header PIN, more USB ports, low power consumption. B+ model is the latest version which is available in the market. B+ is a credit card sized sole board computer developed in UK. Since it does not include built in hard disk or solid state drive, we use an SD card for booting and long term storage.

Zigbee

ZigBee is a high level communication protocol which is used to build a communication network. Mostly used in low data rate application which does not require high power consumption and secure transmission. Due to its low power consumption, the transmission distance is up to 10 – 100 meter line of sights. yet, it increases the output power and less resistance in signal [3]. ZigBee has pre-defined rate of 250 kbits/s, which is best for intermittent data transmissions from a sensor or input device. ZigBee is better when compared to other technology i.e., Bluetooth or Wi-Fi because it is simpler and less expensive [4].

II. RELATED WORK

Baoan Li *et.al* [5] proposed the design of a smart home automation system based on Internet of Things (IOT) and service component technologies by using the SOA (Service Oriented Architecture) approach. In order to realize every changing dynamic semantic integration of the web services they proposed and applied the component technology. Here the authors will specify that Smart Home is the main component of Intelligent Residential District and the concept of IOT Technology is used to implement the smart home which includes family security, family business, family data processing, family entertainment and family medical treatment. Finally they discuss about the Heterogeneous information fusion technology of IOT that mainly deals with many data source and to get higher quality data information.

L Suresh *et.al* [6] designed a basic home automation application On Raspberry Pi by reading the subject of the E-mail and the algorithm for that has been developed in python language. Python is default programming language/environment provided by the Raspberry Pi. Here the proposed system will control the devices

connected to the ARM 11 based Raspberry pi board through the commands from email and it will also send the feedback email of the status of the device. They also included the A PIR sensor in order to detect the Human Motion this will provide an email alert of unauthorized motion detection. The control code or algorithm is proposed for implementing the control strategy for home automation and this code is very user friendly, generic, flexible and can be extended for future applications.

P Bhaskar Rao *et al* [7] provides a flexible and low cost home control and monitoring system using an embedded microcontroller and microprocessor. Here the authors proposed a system which no more requires a committed server PC with respect to similar systems and it will provide a novel communication protocol so that it can control and monitor the home environment with additional functions than just the switching functionality. Here the author uses the IP connectivity for controlling and accessing the appliances and devices remotely using Smart phone application. In order to explain the practicability and Successfulness of this system, the home control system can be integrated with devices such as power plug, light switches, temperature sensor and current sensor.

Cheah Wai Zhao *et al* [8] discuss the importance of Raspberry PI in developing the smart applications as it can be used to integrate with various components like sensors, cameras, LED lights, speakers and wireless communication units to develop smart applications. Here two ZigBee modules are used to communicate with two different devices raspberry PI and laptop. They also added the sensors to develop smart applications such as smart alarm system, population of consumer walk-in and walk-out, high temperature alert system and so on. This approach will show how files are shared between Raspberry pi and windows users. Here the Raspberry PI acts as server by using samba. This work by authors is basically to explore the various features and possibilities available in Raspberry Pi.

Monika M Patel *et al* [9] proposed a Home Automation system using Raspberry pi. Home automation means control of any electronics devices in our home and office whether we are inside home or away. For the users this system will provide the remote control of various lights and appliances within their home. Here we can control these devices using Raspberry Pi model either by webpage or by remote control and the system is low cost and expandable to various devices can be controlled. This type of smart home systems are important because human has the tendency to forget to switch off the appliances when they are not in use and in which case, they are useful in order to utilize the power efficiently and in a secured manner.

S.P Pande *et al* [10] presents a smart home automation system using brain-computer interface. This system is mainly used to control and monitor the home appliances from Graphical User Interface (GUI) by using brain-computer interface and this system will use an input source and it can be controlled wirelessly. This research is mainly based on application of knowledge mainly in the field of computer programming, microcontroller and radio frequency communication. Home automation system design is being developed for certain situations for those who need special attention such as old age person, handicapped person and sick patients. A brain-computer interface (BCI) is a device which helps severely disabled ones to interact and communicate with their environment using their brain waves. The main goal of this system is to detect the electric signal close to eye area and by using electrodes the system will try to spot the changes in electric pulse in order to conclude the action to be taken. As a POC (proof of concept) system will be enabled to control different platform and devices.

R.S. Suryavanshi *et al* [11] proposed an automation system which is interfaced with android systems. Proposed system makes home intelligent enough to save electricity and is implemented all the way through onboard Wi-Fi which is inbuilt in the mobile devices/phones that has android as its system. This system has a security system that will give access to the system through password authentication. Then we have to switch on the Wi-Fi router. ATMega16 is an AVR that access the Wi-Fi. The dimmer circuits are used to control the speed of the appliances such as fan. With the dimmer circuit a device can be turned on and off. This system is better when compared to other similar developments made with the technologies such as Bluetooth, as it works on Wi-Fi. As a result they have provided a cost-effective and scalable Home Automation Systems (HASs).

Rajeev Piyare [12] presents a flexible and low cost home control and monitoring system which uses the embedded micro-web server, with IP connectivity for accessing and controlling the devices and appliances remotely using Android based Smart phone app. Here the author proposed a system which does not require a dedicated server PC with respect to similar systems and it will provide a novel communication protocol so that it can monitor and control the home environment with more than just the switching functionality. Here author will use the IP connectivity for controlling and accessing the appliances and devices remotely using Smart

phone application. In order to explain the practicability and Successfulness of this system, the home control system can be integrated with devices such as power plug, light switches, temperature sensor and current sensor.

Daniel Castellano *et.al* [13] proposed the fourth generation home automation system which uses open source JdeRobot framework. In this system, it has central node and a distributed set of ZigBee wireless nodes (sensor or actuator) and video camera nodes. A web interface has been deployed for the human user access and interactions with the system, so the user can remotely see statistics, read the current sensor data, receive alarms and deactivate them, watch the video in streaming and send commands to the actuators. This system has a star architecture with several satellite nodes distributed throughout the house, which communicate with the central node using ZigBee. A specific protocol has been developed over ZigBee to shape the wireless dialog between the satellites and the central node. The satellites include the most common sensors in home automation systems: gas, flood, temperature, vibration. Actuator satellites with relays have been also created. In addition video satellite nodes have been developed to receive in real time the images from cameras. The whole system is low cost.

Alaa Alhamoud *et al*. [14] developed a SMARTENERGY.KOM framework for energy efficient smart homes based on human activity detection and wireless sensor networks. This framework is based on the design that the majority of the user activities at home are interrelated to a set of electrical appliances which are needed to perform these activities. This framework will explain how to detect the user's current activity by looking into his fine-grained appliance-level energy utilization. The relation between electrical appliances and activities makes it possible to become aware of appliances which could be consuming energy unnecessarily *i.e.*, wasting energy at home. The framework is organized into two components. Primarily the activity detection framework which is solely responsible for detecting the user's up to date activity based on his energy utilization. Second is the Energy Advisor framework which utilizes the activity detection for the purpose of recognizing the appliances which are consuming energy unnecessarily *i.e.*, wasting energy at home and informing the customer about optimization potential.

III. PROPOSED SYSTEM

The proposed home automation system mainly relies on the following 3 significant areas which makes it different from other existing home automation system.

1. Mobile integration and cloud server
2. Applications of Internet of Things
3. Wireless Meshed Network and ZigBee

1. Mobile integration and cloud server

At present techno world preferences are expected at its best when safety is considered. Home safety is one of the prior basic requirements everyone would look for, provided more features at affordable cost. The technology has revolutionized to such an extent that a common man has accessibility and affordability at his finger tips through utilizing smart phones and apps. This further enhances utilization of technology at its best with low cost.

Some of the features that can be offered for home security include

Safety measures like: - Intrusion, LPG leakage, Electricity Short circuit.

Power consumption savings like: - Automatic switching on and off of lighting and heating devices (HVAC Systems), Water pumping and consumptions.

Comfort and ease: - Timely triggering Washing machine, Cooking (Oven / Toast maker / Coffee *etc.*).

Further the above set examples can be controlled and monitored with the help of smart phones / tablets which has android apps which are connected to a cloud system which provides remote accessibility from anywhere at any time. According to a research by ABI Research, a New York based firm, nearly 240 million businesses are using cloud services through mobile devices at the end of 2015. Having all these pros in our mind about smart phones and cloud system, we have implemented our Smart Home System with mobile integration by using android app and reaching the Smart Home system from anywhere in the world with the help of cloud system.

2. Applications of Internet of Things

IOT Stands for Internet of Things. In this Physical World IOT describes a system in which the sensors are attached to the items. These Items can be connected to the wired and wireless internet Connections. Here The Sensors have wide area connectivity such as GSM, GPRS, 3G, and LTE (4G) and they can also use different types of Local area network connections such as Bluetooth, WI-Fi, Zigbee, Radio Frequency Identification (RFID), and Near Field Communication (NFC).

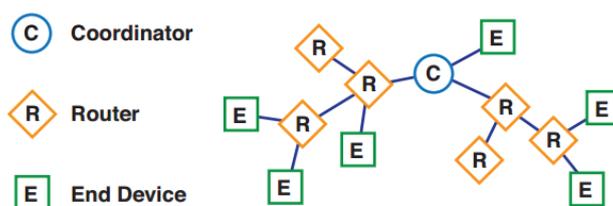
The Internet of Things Will

1. Connects both Living and non-living Things.
2. Change what types of items communicate over an IP network.
3. Use sensors for data connections.

3. Wireless Meshed Network and ZigBee

Wireless Mesh network is a powerful Networking technique to route the data. Its range is expanded by allowing data to hop node to node. In mesh Networks reliability is increased by “self-healing”. This means that mesh networks have a capacity to take turns when one node fails or a connection is lost.

One of the popular mesh networking protocol is ZigBee. It is designed for low-power applications, low-data rate. The major technologies used to implement Wireless home automation systems are Bluetooth, Wavenis, Z-Wave, WiFi, Insteon, and ZigBee. Among these technologies the ZigBee based Wireless home automation systems have become very popular because of its low cost, low power consumption, Robust, Mesh Networking and Interoperability. ZigBee was built on the top of IEEE 802.15.4 standard.



ZigBee Nodes

ZigBee technology offers reliable and robust solution for noisy radio frequency (RF) environments. ZigBee features include clear channel assessment, energy detection. The channel dexterity help devices to pick the best possible channel and keep away from other wireless networks such as Wi-Fi this will happens when the message acknowledgement tells that the data is delivered to its destination correctly. One of the best ZigBee's key features is to ability to cover large areas with routers. This feature helps ZigBee to differentiate from other technologies. Mesh networking will expands the range of the network by routing and self-healing increases the reliability of the network by re-routing a message in time of a node failure.

ZigBee technology has two features sets .one is ZigBee Feature Set and other is ZigBee Pro Feature Set, which concentrates on specific markets. The "ZigBee" feature set mainly used for light and home commercial environments which are designed for simpler plug and forget networks. The "ZigBee Pro" feature set consists those features that improve the ZigBee feature set and adds the elements designed for more complex and larger networks such as automated address management, network scalability, group addressing and centralized data collection.

In this proposed system we will remotely control, schedule and manage the home appliances by using

- **Raspberry pi b+ model(latest version of raspberry pi)**
- **Zigbee model**
- **Android App**

We have implemented our Smart Home System with mobile integration by using android app and reaching the Smart Home system from anywhere in the world with the help of cloud. We can schedule the home appliances to switch on and off through the Android app.Cost Reduction (40% - 70% lesser when compared to other systems)

Advantages of Proposed system

- It allows more flexibility through android device.
- It provides security and authentication.
- Additional appliances can be easily added.
- It can be installed for home under construction or for rented home at affordable price

IV. ARCHITECTURE

Fig.1 will show the architecture diagram of our proposed system. In this figure user can access or control the home appliances using an Android app on their smart phones or tablets. Here the cloud subscription is optional for the user, if user wants to control, manage or schedule his home appliances anywhere at any time in the world then he has to subscribe for the cloud services. In this system every home appliances are connected to the relay switch in their main board. This switch will opens and closes the circuit. The smoke, door, motion sensors are integrated in home.

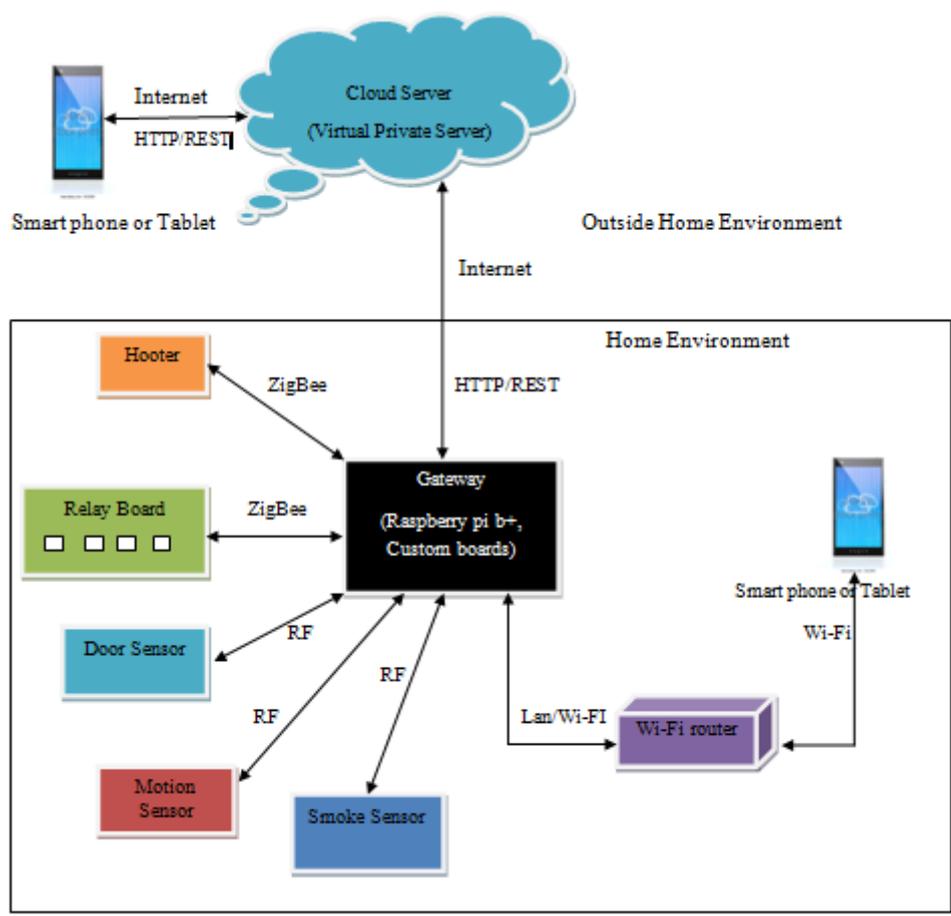


Fig.1 Architecture diagram of proposed system

The Gateway will communicate with them through Radiofrequencies. Hooter also integrated and the gateway will communicates with hooter and relay board through Zigbee. Here the Gateway includes Raspberry pi b+ and custom boards (Zigbee, RF).The gateway is connected to the Wi-Fi router through LAN or Wi-Fi. Within the home environment the user can login into the app, can control, schedule and manage the home appliances through his smart phone or tablet. Outside home environment the user has to subscribe for the VPS (cloud

server) with proper credentials he can login to the cloud and he can access, control, schedule and manage his home appliances through his smart phone or tablet anywhere at any time in the world. In case of home environment whenever the user give an instruction to on or off home appliances from his mobile through the app, this instruction is forwarded to the gateway through Wi-Fi(internet is not required for this) then the gateway will instructs the relay board to open(off) or close(on) the circuit. In case of outside home environment whenever the user give an instruction to on or off home appliances from his mobile through the app, this instruction is first forwarded to the cloud through internet then the cloud will forward that instruction to the gateway through internet then the gateway will instructs the relay board to open (off) or close (on) the circuit.

V. IMPLEMENTATION

Software

Python code is used for the client and server application as the interface for Raspberry Pi to connect to sensors and lights. Software of the proposed HAS is broadly categorized into two: Microcontroller firmware and server application software. The server application software is a library implementation of a micro Web-server running on Gateway using the Ethernet/Wi-Fi protocol. This Wi-Fi protocol has the capability to use both as a server or a client. All the operations required to remotely control, schedule and manage of the home appliances are coded in python and deployed in a memory card and plugged into gateway.

Hardware

Integration of electronic components into our Gateway and setting it up for remote access will be the next step. Through Wi-Fi the hardware interaction takes place. The integrated peripherals such as camera, Door sensors and Lighting devices are been controlled by Android Application.

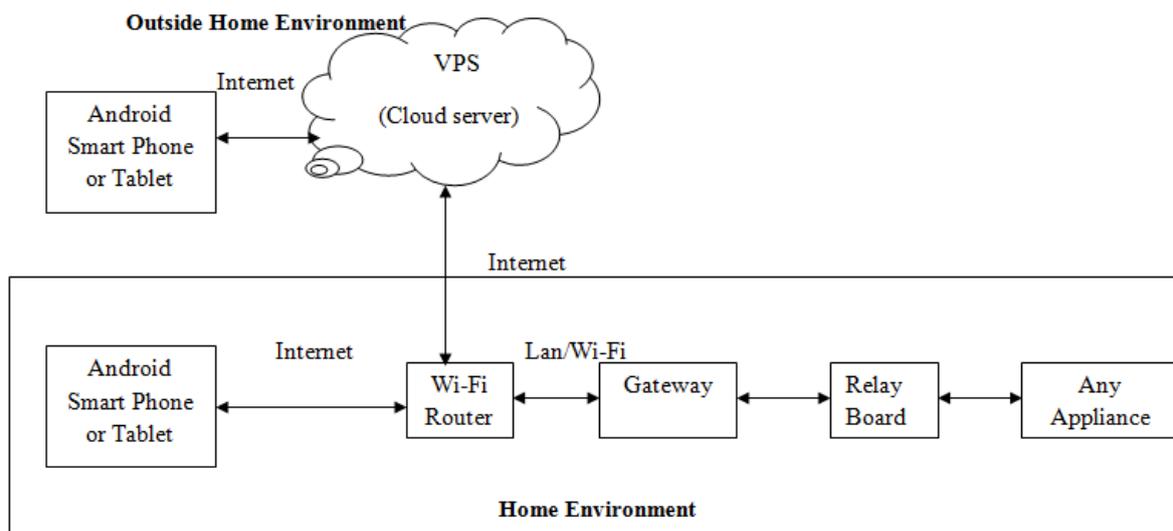


Fig.2:-System Design of the proposed system

VI. RESULTS AND DISCUSSIONS

USER INTERFACE DESIGN

The client software comes as android application which is available in the Google play store. Authorized user can download the app with proper login credentials. Below figure.3 shows the prototype design of android application development. This app will provides very good user interface where the user can easily control and schedule the home appliances. In this app there is a menu where we can see the home appliances list that we can remotely control and schedule. At first the smart phone from which you want to control the appliances, should be registered with the gateway. This app will also provides the notifications at each time any home appliance is controlled and these notifications can be viewed in the events option. Another important feature that we included in this app is a Safe Mode option for intruder detection. In case of short circuit, Gas leakage or Intruder

entry in the home an immediate serine is activated and a sms, email is sent to the user. In connected group option we can add the email-id, name, phone number of our relations or neighbours to whom the alert sms email should send by the gateway.

Home Automate App		Lights	
Lights		Passage Light	<input type="checkbox"/> ON <input type="checkbox"/> OFF
Fans		Dining hall light	<input type="checkbox"/> ON <input type="checkbox"/> OFF
Geyser		Main hall light	<input type="checkbox"/> ON <input type="checkbox"/> OFF
Air-Cons		Bed room light	<input type="checkbox"/> ON <input type="checkbox"/> OFF
Scheduler			
Events			
Safe Mode			
Device list			
Connected group			

Fig.3:-Android application prototype

VII. SUMMARY & CONCLUSION

The produced device helps in enabling user with power to control multiple appliances with the help of existing devices like smart phones & Tablets which are Android based. The device produced are having interfaces which are flexible to use, provides more capability to access home based devices at ease and without any discomfort and can integrate with the present applications which need minimum expertise in installation. In our research we show various applications to implement home automation which is not limited to those discussed earlier in paper, however requires sensors and respective appliances to achieve. Our existing system demonstrates a successful design that can communicate with Android based smart phone/ Tablets using gateway which controls HVAC systems (Geyser, Lighting, AC) and alerts in the event of intruder detection and smoke.

ACKNOWLEDGEMENT

We would like to thank Samslogix for providing such a healthy environment for the successful completion of this work and express our gratitude to Pradeep S (Chief Architect, Samslogix, Bangalore) for providing continuous support and encouragement. The work reported in this paper is supported by the college [BMSCE] through the TECHNICAL EDUCATION QUALITY IMPROVEMENT PROGRAMME [TEQIP-II] of the MHRD, Government of India.

REFERENCES

- [1] G. Kortuem, F. Kawsar, D. Fitton and V. Sundramoorthy, "Smart Objects as Building Blocks for the Internet of Things," IEEE Internet Computing, Vol. 14, No. 1, 2010, pp. 44-51. doi:10.1109/MIC.2009.143
- [2] Anonymous, (n.d), Raspberry Pi [ONLINE] Available: <http://my.rs-online.com/web/generalDisplay.html?id=raspberry>
- [3] Anonymous, (n.d), XBEE [ONLINE] Available: <http://www.geeetech.com/wiki/index.php/XBee>
- [4] David Baker, (15 August 2013). How ZigBee Compares in Wireless Home Automation, [ONLINE] Available: <http://www.control4.com/blog/2013/08/how-zigbee-compares-in-wireless-home-automation>
- [5] Baoan Li, Jianjun Yu, "Research and Application on the Smart Home Based on Component Technologies and Internet of Things," Procedia Engineering, Volume 15, 2011, Pages 2087-2092, ISSN 1877-7058
- [6] S. Benjamin Arul, "Wireless Home Automation System Using Zigbee," International Journal of Scientific & Engineering Research, Volume 5, Issue 12, December-2014, ISSN 2229-5518
- [7] P Bhaskar Rao and S.K. Uma, "Raspberry Pi Home Automation With Wireless Sensors Using Smart Phone," International Journal of Computer Science and Mobile Computing, Vol.4 Issue.5, May- 2015, pg. 797-803.
- [8] Cheah Wai Zhao, Jayanand Jegatheesan and Son Chee Loon, "Exploring IOT Application Using Raspberry Pi," International Journal of Computer Networks and Applications Volume 2, Issue 1, January - February (2015).
- [9] Monika M Patel, Mehul A Jajal and Dixita B vataliya, "Home automation using Raspberry Pi," International Journal of Innovative and Emerging Research in Engineering Volume 2, Issue 3, 2015, e-ISSN: 2394 – 3343.
- [10] S.P.Pande, Pravin Sen, "Review On: Home Automation System for Disabled People Using BCI," IOSR Journal of Computer Science (IOSR-JCE), e-ISSN: 2278-0661, p-ISSN: 2278-8727 PP 76-80.
- [11] R.S.Suryavanshi, Kunal Khivensara, Gulam Hussain, Nitish Bansal and Vikash Kumar, "Home Automation System Using Android and WiFi," International Journal of Engineering And Computer Science, ISSN: 2319-7242 Volume 3 Issue 10 October, 2014 Page No.8792-8794.
- [12] Rajeev Piyare, "Internet of Things: Ubiquitous Home Control and Monitoring System using Android based Smart Phone," International Journal of Internet of Things 2013, 2(1): 5-11 DOI: 10.5923/j.ijit.20130201.02.
- [13] Daniel Castellano and Jose Maria Canas, "Home automation system with web interface in the JdeRobot framework," Xv Workshop of Physical Agents, June 2014, Leo N (Spain).
- [14] Alhamoud A, Ruettiger F, Reinhardt A, Englert F, Burgstahler D, Bohnstedt D, Gottron C, and Steinmetz R, "SMARTENERGY.KOM: An intelligent system for energy saving in smart home," in Local Computer Networks Workshops (LCN Workshops), 2014 IEEE 39th Conference on , vol., no., pp.685-692, 8-11 Sept. 2014. doi: 10.1109/LCNW.2014.6927721.