

An Effective Approach to Build Smart Building Based on Internet of Things (IoT)

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ABSTRACT

Internet of things (IoT) is network of devices which can communicate and transmit data with each other. Number of IoT devices is growing so fast. Today IoT devices are mostly used in healthcare, business and industrial unit. These IoT devices are playing important role in saving cost, improving efficiency and managing machines. In this research work a low cost and homemade method is proposed for smart buildings. The proposed method consist of wide area network (WAN) and personal area network (PAN). This technique can be implement on any embedded system like Arduino, Raspberry Pi and Beagle Bone by interfacing them with Laptop using PAN which can be established by Bluetooth or data cable. Outside the PAN an Android device is used to get remote-control access of Laptop from any part of the world using WAN with the help of remote control application like TeamViewer or any other. The proposed method is implemented on hardware and tested from the range of 5 Km with efficient results.

KEYWORDS: Internets of things, home automation, remote desktop services (RDS), Android, Arduino.

1. INTRODUCTION

Internet of things (IoT) is a processing idea that explain a future where physical objects can exchange and collect data using internet. Such physical objects can be electronics devices, building, vehicles, sensors, software and embedded electronics objects. Internet of things (IoT) connects vehicles and electronics devices using internet and electronic sensors [1]. It is predictable that there will be almost 30 billion IoT devices in 2020. Today's IoT devices are using in in healthcare, business and industrial unit for the purpose of saving cost, improving efficiently and reduce labor. 40.2% of IoT devices are using in manufacturing and business unit for robotic machinery, supply chains and equipment. 30.3% of IoT devices are using in healthcare unit for the purpose of electronic recordkeeping, Portable health monitoring and pharmaceutical safeguards. 8.3% IoT devices are using in retail for smartphone purchasing and Inventory tracking. 7.7% IoT devices are using for security purpose like in Biometric, remote sensors and facial recognition blocks[2]. Same as smart building there can be a smart city for this purpose IPv6 will be great opportunity to connect huge amount of IoT devices together.

The basic concept of a network of smart devices was deliberated first time in 1982. Research in field of Internet of things (IoT) has been started in last decade of 20th century. In's research paper on computing produced the modern perspective of IoT[3]. The idea of the Internet of things (IoT) became general in 1999, the credit of popularity of Internet of things (IoT) goes to Auto-ID Center at Massachusetts Institute of Technology and relevant publications [4]. Surveys and idea of Internet of things (IoT) has been analyzed by many researchers. According to Hsien-Tang Lin (2013) research work [5], in that research work an open source system design was proposed for implementation of smart homes. It consist of power and processor unit which pass by switch and relay connected to electrical appliances. Arduino Mega with Ethernet shield was used for interfacing and computing functions.

Internet of things (IoT) will change the world much it. In future robot will have ability to communicate with each other and exchange data, this can increase their efficiency to solve scientific problems. Modern IoT refrigerator also will be able to check the quantity of items inside it if they quantity is below then certain limit it will place order of these items. It will also be able to food inside it and suggest match recipes. Internet of things will improve efficiency and reduce cost. The number of IoT devices will in 2020 be double as compare to traditional connected devices.

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According to survey of Silicon Valley Thought Leaders Series [6] for 2020 the approximate population, approximate IoT devices and connected devices for every human is shown below in table 1.

Table 1. Future estimation of IoT Devices and world population

Year	Approximate Population	Approximate IoT Devices	Approximate connected devices
2016	7.4 billion	6.4 billion	0.86/human
2020	7.7 billion	30 billion	3.5 /human

World population is increasing with the annual growth rate of 1.07% and it is expected that approximate population of world will be 7.7 billion in 2020 and number of IoT devices will be 30 billion [7]. For 30 billion IoT devices there will be need of unique IP address but IPv4 has limited address space of 4.3 billion unique addresses. Growth of IoT devices will not be possible without the help of IPv6 which has 3.4×10^{38} addresses. Future of IoT devices is based on global adoption of IPv6.

In this paper an effective approach to build smart buildings is proposed and Arduino board is used as a controller and Android device is used as central device to control Arduino board. The obtained results are very acceptable because the proposed method attained great efficiency with 100% correctness.

2. RELATED WORK

Android device has ability to create a personal area network (PAN) with Arduino board using Bluetooth Module with the help of Android Applications. Such application are design according to connected devices with Arduino. A variety of Arduino Bluetooth application is available on Google Play store. Developing Application is also very easy it can be done by using HTML, APP inventor, Java etc. These applications are used to send and receive data between android and Arduino board [8-10]. For Example inside a PAN android device has totally remote control of Arduino board it is capable to turn ON and turn OF the appliances, control the fan speed, access to CCTV camera which are connected to Arduino board. A connection of Android device with Arduino board using Bluetooth module is show below 1.

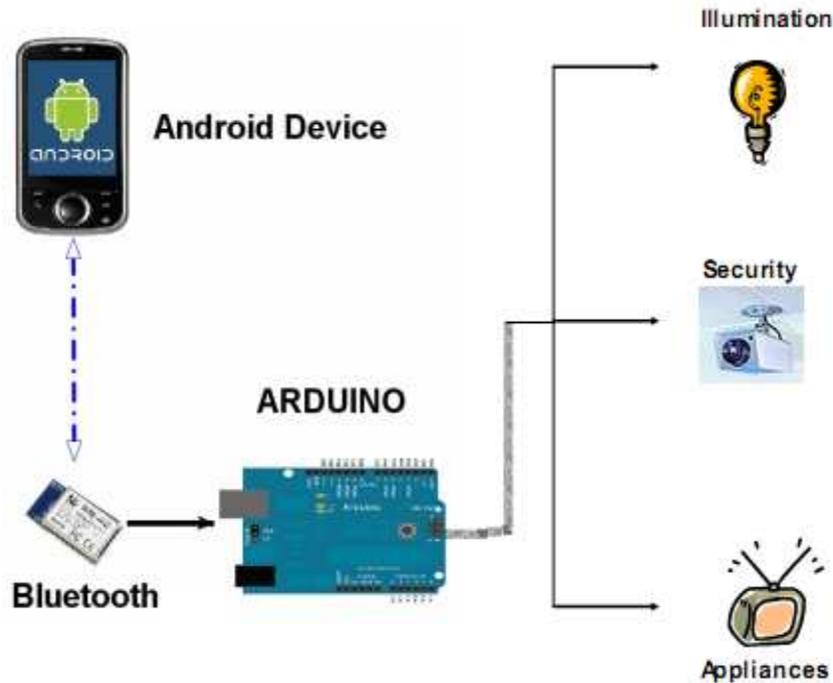


Figure 1. Bluetooth connection of Arduino board with Android

Inside a PAN android device is fully capable to control other devices which are connected with Arduino board. Normally Arduino Bluetooth module has a range of 10 meters to 100 meters that's why this project is only used to control devices inside a building. This is one of its shortcoming of this project.

3. PROPOSED METHOD

In this research work effective and low-cost idea is proposed for smart building. Idea of this method is based on Internet of things (IoT). Main rule of internet of things IoT will be done between Laptop and Android device. Proposed method consist two mods Automation mode and remote control mode. End-to-end connectivity of proposed method is shown below in figure 2.

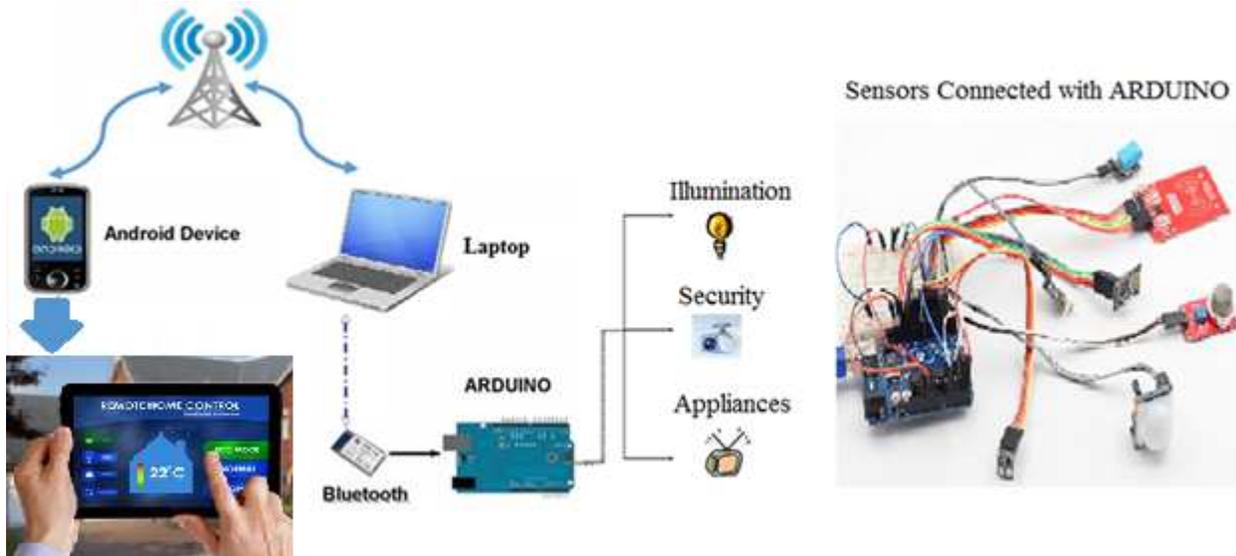


Figure 2. Connectivity of proposed method

3.1 Automatic mode

Sensors are used to in automatic mode to improve efficiency. Let's take an example a heat sensor, heater and Air conditioner are connected to Arduino board. Heat sensor sense the room temperature and sent it to Arduino board if it is less than 10 °C Arduino board turn ON the heater and heat sensor keep monitoring the temperature when it reach at level of 20 °C Arduino board turn OFF the heater and in summers if room temperature is above then 30 °C Arduino board turn ON the air conditioner. Block diagram of automatic mode is shown in figure 3.



Figure 3. Block diagram of Automatic mode

These sensors can be smoke sensors for fire alarm, level sensor to control water tank level and motion sensors for security purpose. This type of system helps to improve efficiency of system and reduces the cost by saving energy and human labor.

3.2 Remote control mode

Remote control mode has functionality to control the devices manually through remote control access using an application like TeamViewer, it is more beneficial for devices sensors like TV, LED, lights, digital lock etc. This method is based on wide area network (WAN) and person area network (PAN). Android device connected with Laptop using wide area network (WAN) with the assistance of a remote control application and Laptop connected with Arduino board through personal area network (PAN). Personal area network (PAN) between Laptop and Arduino board can be established by Bluetooth module or data cable. Usage of Bluetooth module has benefit over

data cable because of it Android and Laptop both can treat as a remote. Laptop can only work inside range of 10 meters to 100 meters while Android device will be able to control appliances from any part of world. A Bluetooth application installed on Laptop used to transmit and receive data in this PAN. A block diagram of proposed method is show below in figure 4.

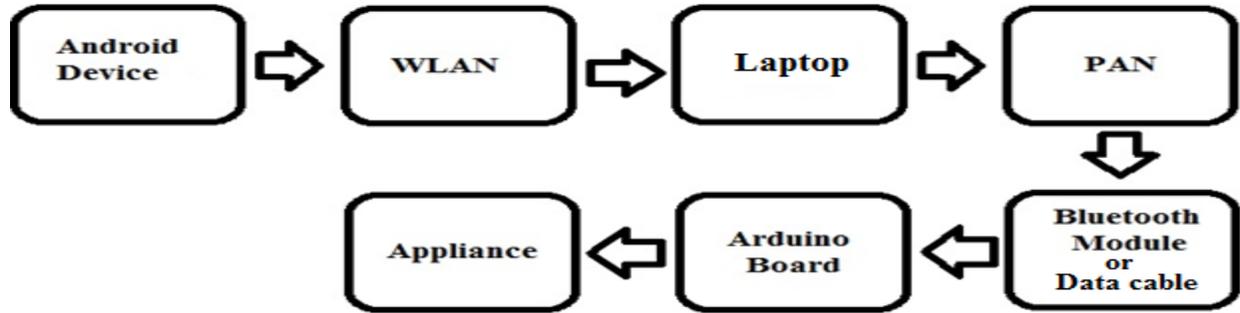


Figure 4. Block diagram of remote control

This method can be implement on any embedded system like Arduino, Raspberry Pi and Beagle Bone by interfacing them with Laptop using Bluetooth module and Bluetooth Application. Using such app Laptop communicate with Arduino board to control specific appliance which is connected to Arduino board, based on these and turn ON and OFF the selected appliances. In market a variety of remote control application are available. These application will be install on both Android devices and generate a tracking ID. With the help of tacking ID Android device will be capable to get remote control access of Laptop which is farther connected with appliances. Remote control application are similar like technology of remote desktop services (RDS). RDS provides user to access control of their computer from other location using this technology [11]. RDS also support remote desktop protocol (RDP) which is developed by Microsoft. With a help of RDP graphical interference of computer can be access by another computer in a network Connection. RDP used for communication between terminal server client and terminal server. Remote desktop protocol is shown in figure 5.

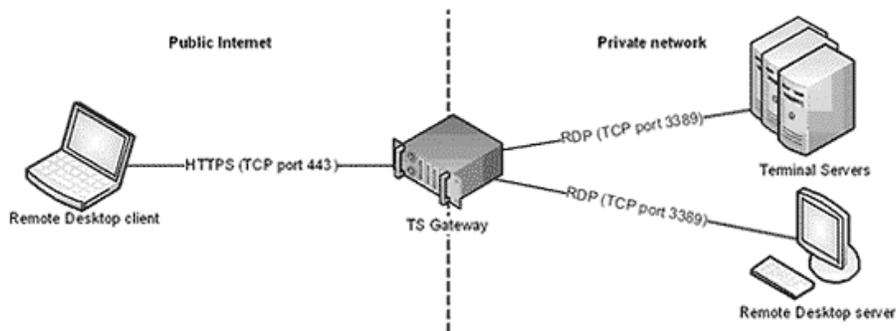


Figure 5. Remote desktop protocol (RDP)

Some commonly used remote control applications are TeamViewer, Chrome Remote Desktop, Splash top, Any Desk and Real VNC. Proposed method can be used to control devices remotely and automatically with the help of sensors.

4. RESULTS AND SUMMARY

Proposed method was implement by using bread board, Arduino board, and Laptop and Arduino device. LEDs were used as appliances. Different colors of LEDs were placed on bread board and connected with Arduino Uno PORTB digital output pins (8-13) using jumper wires. After that a personal area network (PAN) was established between Arduino board and Laptop using USB 2.0 A to B. Serial Port Utility software was used to check connectivity of this PAN and Arduino Uno was programed to read and write data. Sent and received data by Laptop using Serial Port Utility is shown in figure 6. The LEDs connected with Arduino UNO were also control by Serial Port Utility. After checking connectivity of PAN Arduino Uno was programed to receive data serially from Laptop, Arduino received character byte from the Laptop and change that character into integer byte, this integer byte was

actually represented the port number of Arduino board which are connected with LEDs. The specific LEDs were turn ON and OFF according to received integer. For the serial communication between Laptop and Arduino Uno Baud rate was set to 9600 in Arduino program. The entire programming was done in Arduino Integrated Development Environment (IDE). A Delphi to Arduino application “Comtest.exe” [12] were used as a helping tool in Laptop to control Arduino output through serial communication. User interface of “Comtest.exe” is shown in figure 7.

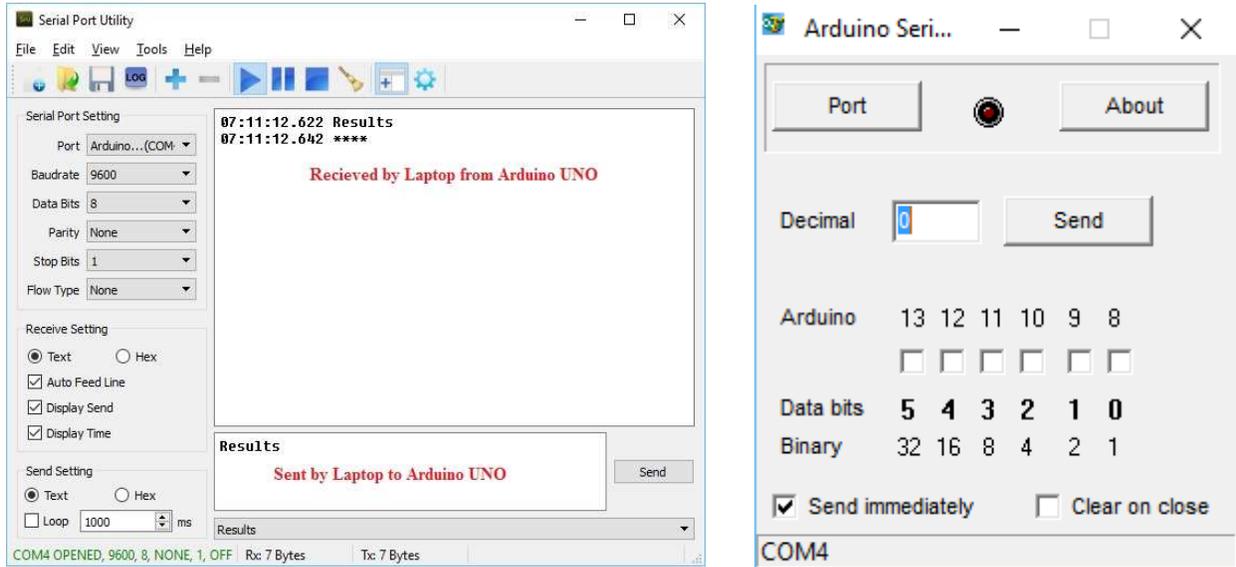


Figure 6. Serial communication between Laptop Arduino Uno Figure

7. User interface of “Comtest.exe”

Inside this personal area network (PAN) Laptop was fully able to control to output of Arduino Uno through serial communication. Remote control mode of proposed method was tested from the distance of 5 km. According to the proposed method a remote control application (TeamViewer) was installed in Android device and Laptop. Android device was connected to wide area network (WAN) using 3G internet and with the help of remote control application tracking ID, Android device got the remote control access of Laptop which was farther connected with LEDs. Android device turned ON and OFF the LEDs successfully which were 5 km away. An Android device with complete remote control access of Laptop is shown in figure 8. To check automatic mode of proposed method a light dependent resistor (LDR) was used and LDR was connected with Arduino Uno digital output pin 13. Arduino Uno was programed to enable the automatic mode by making LDR input pin high. LDR sense light level and turned ON and OFF the LED automatically. LDR connected with Arduino Uno is shown in figure 9. Remote control and automatic mode of proposed method achieved 100% efficiency and accuracy.



Figure 8. Laptop remotely control by Android device



Figure 9. LED controlled automatically via LDR

5. DISCUSSION

From the above results it can observe that the proposed method has ability to control the appliances connected with Arduino board from any part of world. This approach is 100% effective, robust and low cost to build smart buildings. One of benefit of proposed method is that there is no need to provide Individual IP address to appliances and Arduino board because Arduino board is directly connected with Laptop so only Laptop IP address is enough to connect with Android device through wide area network (WAN). Propose method can be use in digital locks, doors can be remotely locked and unlocked by using smart phone. This technology is much beneficial for the businessmen they can change key codes from any part of the world and make their stuff protected. Smart building can be build up from proposed method which will have ability to manage, maintain and monitor it remotely Lighting, ventilation, heating and security locks, air conditioning, CCTV system of building system can be control remotely. With the help of proposed method device in a smart buildings can communicate with each other and exchange data. In automatic mode sensors are used which increase performance of system and decreases cost by saving energy. For example if temperature of building is above then certain limit turn on the fan and if it is below then a certain limit turn ON the heater. With the help of motion sensor lights can be ON and OFF. The collective result of all these devices will reduce human labor and makes human life much easier. Such control system can save energy consumption of building.

6. CONCLUSION

Internet of things(IoT) enlarge proficiency and reduce cost. Usage of sensors increase throughput and save energy. The proposed method has ability to remote control these appliances inside and outside the personal area network (PAN) by using wide area network (WAN).Automatic mode reduce human labor and expenses. I hope this research work will be useful for individual to control their home appliances remotely inside and outside the home. This type of system can be implemented on industries because it is easy to maintain. Annual growth rate of internet of things (IoT) is 15-20% which a great challenges for IPv4.

REFERENCES

- [1] Daniele Miorandi , Sabrina Sicari , Francesco De Pellegrini , Imrich Chlamtac, "Internet of things: Vision, applications and research challenges", ELSEVIER, ,10(2012), page 1498-1516.
- [2] A guide to the internet of things infographic, Where the wireless things are-and why, Intel
- [3] Mark Weiser, the Computer for the 21st Century, Scientific American, September, 1991
- [4] <http://autoid.mit.edu/about-lab>
- [5] Hsien-Tang Lin" Implementing Smart Homes with Open Source Solutions" International Journal of Smart Home Vol. 7, No. 4, July, 2013.pp 289-295.

- [6] Alex Blanter Partner, Mark Holman Partner, “Internet of Things 2020: A Glimpse into the Future” A.T. Kearney Internet of Things 2020 Presentation
- [7] Future World Population Growth, <http://ourworldindata.org>
- [8] J.K.W. Wong, H. Li, S.W. Wang, “Intelligent building research: a review, *Automation in Construction*, 14 (2005), page 143-159
- [9] Yi-Jen Mon, “The Bluetooth Based LED Control for Arduino Test Platform by Using Mobile APP”, *International journal of scientific & technology research* volume 4, issue 06, June 2015, page 330-332.
- [10]D. Contreras and M. Castro, Experimental assessment of the adequacy of Bluetooth for opportunistic networks, *Ad Hoc Networks*, Vol. 25, Part B, pp. 444-453, 2015.
- [11]Dr. Khanna SamratVivekan and Omprakash, “Concept of Remote controlling PC with Smartphone Inputs from remote place with internet”, *International Journal of Advanced Research in Computer Science and Software Engineering*, Volume 2, Issue 1, January 2012
- [12]Delphi to Arduino application “Comtest.exe” <http://www.vwlowen.co.uk/arduino/usb-digital/pc-control.htm>