International Journal of Scientific & Engineering Research, Volume 7, Issue 5, May-2016
ISSN 2229-5518

REMOTE MONITORING OF AN ARDUINO BASED HOME AUTOMATION SECURITY SYSTEM

Nathan David, Henry Agbo, Greg Ezema, Amalachukwu Abafor
Department of Electronic Engineering, University of Nigeria

Abstract— Security in the home has become a very important necessity in recent times. Development and technology comes with increase in risks such as gas leakage, fire. There is also the issue of burglary and theft and these have made some of the most important home safety requirements for people. Detecting an intrusion or a hazard is secondary; however, taking the necessary action immediately is primary. In order to achieve this, the security system is remotely monitored. This paper presents a model for a home remote monitoring system using arduino microcontroller with an OPNET simulated wireless network system. Using various sensors and camera, the arduino microcontroller monitors the security of the environment and reports the results to a remote system over the internet. The wireless network system comprises the local and remote location to the arduino. The WLAN is responsible for connecting various modules on the arduino to the internet and the remote network addresses the access from this location to the arduino.

Index Terms— Arduino, Base Station, Bluetooth, Line of Sight, OPNET, Subscrier Station, Wi-fi, Wireless

---

1 INTRODUCTION

Home automation or Smart Homes can be described as introduction of technology within the home environment to provide convenience, comfort and energy efficiency to its occupants [1].

Monitoring systems are common in many areas of industry. It is also essential that home privacy is protected and no intruder can affect it by any means. A Home security system should provide safety and security features for a home by alarming the residents from natural, accidental and/or human dangers such as: fire, flooding, theft, animals invading etc. [2]. It therefore becomes necessary to design an efficient, cheap security system accessible from any part of the world through the internet that can be employed in every facet of the economy [3][4].

Remote monitoring is the ability to control or monitor a phenomenon, a state or a place from without being in its locality. There has been a significant increase in home automation in recent years due to higher affordability and advancements in Smart phones and tablets which allow vast connectivity. With the introduction of 'Internet of Things', the research and implementation of home automation are getting more popular [5]. Various wireless technologies that can support some form of remote data transfer, sensing and control such as Bluetooth, Wi-Fi, RFID, and cellular networks have been utilized to embed various levels of intelligence in the home [6].

In 'A Smart Home System' [7], a home automation system was designed with security features using the Bluetooth and Wi-Fi technologies.

The system uses the Arduino-Mega microcontroller which is used to interface the Bluetooth and Wi-Fi shield of the Arduino to make it possible for the microcontroller to provide both technology as media for communication and control and using Wi-Fi to remotely monitor the system.

1.1 WHY INTERFACE WI-FI AND BLUETOOTH

Bluetooth is a Wireless Personal Area Network (WPAN) technology; it is a network for interconnecting devices centered around an individual person's workspace in which the connections are wireless [8].

Accordingly, its radio characteristics include low power, short range, and medium transmission speed. Its low power consumption makes Bluetooth ideal for small, battery-powered devices like mobile phones and Pocket PCs that have little energy to spare. Wi-Fi depends on a higher energy intake to offer a 100-meterrange and 11 Mbps maximum transmission rate. Perhaps the best way to demonstrate how Bluetooth and Wi-Fi are complementary technologies is through successful examples of their simultaneous operation. This feature will be very important for remote control and monitoring over long and short distances. However, when Bluetooth and Wi-Fi are interfaced in the same device such as the Arduino microcontroller board, the signals transmitted tend to cause interference with each other, thereby disrupting the conversation [9]. This problem can be accommodated by giving them different communication channels on the same path.

1.2 HARDWARE ORGANISATION

The hardware requirements of the project include;

1. Arduino microcontroller
2. Bluetooth module
3. Wi-Fi shield
4. Alarm module
5. Internet protocol camera
6. Motion and proximity sensor
7. Gas sensor
8. Relay

ISSN 2229-5518

The circuit diagram showing the connection of these components is shown in figure 1.0 below with the components labeled with a corresponding number as the list above. The relay is used to switch devices with voltages above 5 volts

Here the Wi-Fi shield is mounted on the Arduino and the Bluetooth module is setup on the breadboard as shown in figure 1 above. Since information exchange in the Arduino is done using serial communication, the Bluetooth communication is known to conflict with the Wi-Fi communication. To avoid this; transfer (tx) and receive (rx) pin of the Bluetooth module is changed using an Arduino IDE header called "software serial.h" [10].

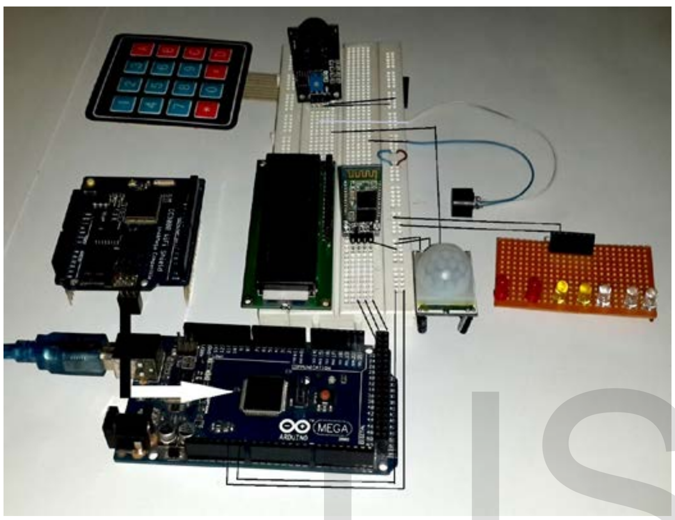


Fig. 1.0: Circuit diagram showing basic components for the remote monitoring security system

2.0 Networking the Components

The above components must be connected to the internet through an access point for remote control. To locate any device online, a public internet protocol address and an internet service provider connection must be provided. But for this project, an intranet will be set up to demonstrate the real time functionality of the project on the internet. For real ISP connection, the minimum bandwidth requirements has been simulated.

The intranet consists of a hotspot with internet connection and a static class c internet protocol address for the Wi-Fi shield which is acting as the web server. The SSID of the intranet with its password is configured in the Arduino IDE as shown below:

```
#include <SPI.h>
#include <WiFi.h>


char ssid[] = "SMARTHOME";      // your network SSID (name)
char pass[] = "henry123";    // your network password
int keyIndex = 0;                 // your network key Index

int status = WL_IDLE_STATUS;

WiFiServer server(80);

```

Fig. 2.0: Access point configuration in the arduino IDE

When the microcontroller is powered along with the components, an automatic request is made to the access point for connection and a successful connection screen is shown below. The IP address displayed is the static address which will be used to remotely log into the Arduino from any web browser.

The control interface for the remote monitory will constitute two interfaces, viz;

- Web interface which will exert control over the system through the Wi-Fi shield and
- Android interface which will exert control over the system through the Bluetooth module.

2.1 The Web Interface

A simple web interface can be designed in HTML format in the Arduino IDE through the 'client' command. An example of a simple led blink can be found in the Arduino examples under Wi-Fi. This block of code can fit any network and requires only addition of your network SSID and password in the code sketch.

The web interface for this project consist of an HTML page which collects logs from the sensors and alerts any remotely connected host when necessary. Access can also be granted remotely if need be from the web interface.

Figure 3.0 shows the simple web page for this project which can be accessed through 192.168.43.143 from any host wirelessly on the same LAN. On the sidebar, the microcontroller uploads all environmental readings to the web server (the Wi-Fi shield) and a button on the web page activates the IP camera which then streams the video feeds to the Page.

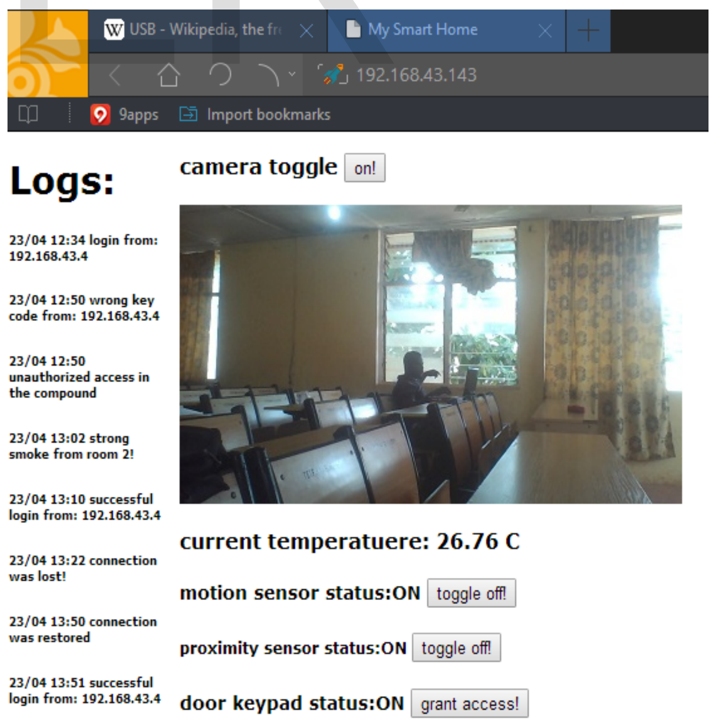


Fig. 3.0: Web control interface for the system attachInterrupt(0, setDoorStatus, RISING);

ISSN 2229-5518

3.0 Software Design

DESIGN AND IMPLIMENTATION

Interfacing a Bluetooth module and a Wi-Fi shield with arduino micro-controller for remote control involves the use of a mobile application to control an array of LED's which uses the Bluetooth module as a means of communication between the mobile device and the micro-controller. The number of points controlled can be extended using a decoder. The micro-controller receives data sent from the mobile device and converts it to an executable action using SPI communication which then switches the LED's or any other desired devices. The Bluetooth module has a limitation of 10 meters, therefore the switching can also be done through a web application which together with the wi-fi shield and an access point provides a means of communication over the web. Switching through the web allows access control from anywhere in the world.

The flow chart below in figure 3.1 illustrates the process flow of the design:

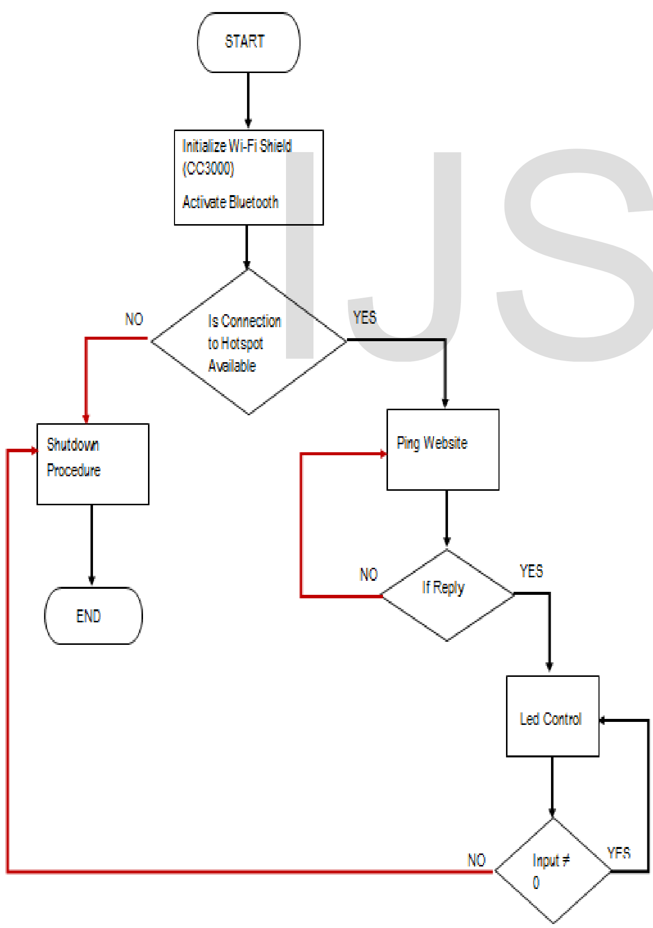


Fig. 3.1: flow diagram of the system

3.1 SWITCHING WITH THE MOBILE APP

THE BLUETOOTH CONFIGURATION

The Bluetooth Module used here is a HC-06 which has just the slave mode. The work operation of this mode is just to be discovered by other Bluetooth devices and be connected, so the Android application will be the Client. The Specific steps required for the connection is as shown in figure 3.2.:

1. Launch the android app and a dialog box will appear and request user permission to enable Bluetooth.

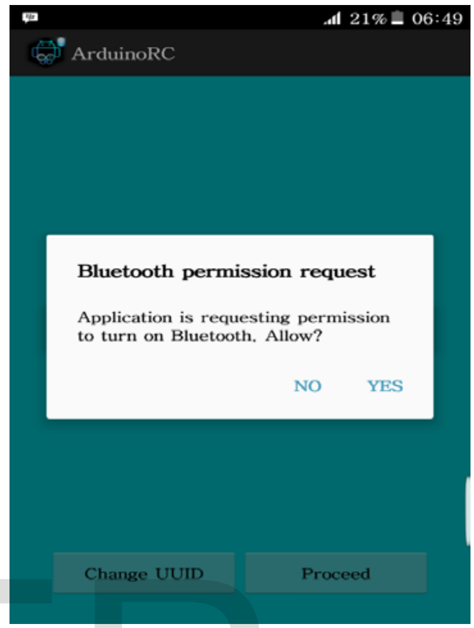


Fig. 3.2: setting up the Bluetooth on smartphone

2. Once the permission is granted, the app searches for available Bluetooth devices. A connection will be established between the android phone and the Bluetooth module on selecting the HC-06 shown in figure 3.3.

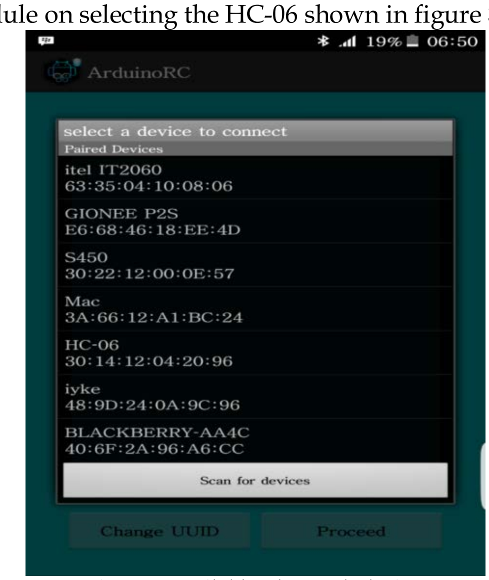


Fig. 3.3: available Bluetooth devices

3. The android device can now send data to the micro-controller through the terminal mode of the android app. From the terminal mode in figure 5.2, the LED's or any other output end can now be switched or controlled within a 10m radius.

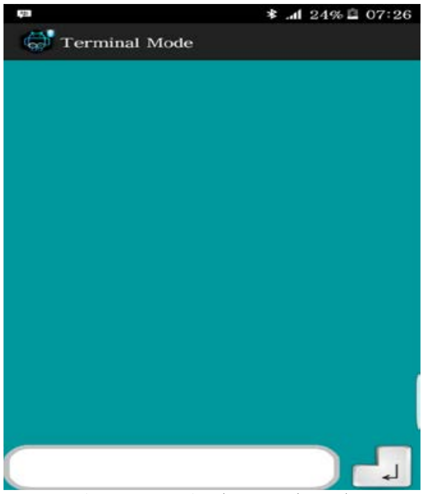


Fig 5.2 terminal control mode

3.2 Application

Wi-Fi and Bluetooth remote control system when integrated to a microcontroller has a wide range of application.

- Remote temperature control system: this system consists of Arduino board, Wi-Fi shield with internet connectivity, a web interface, a good relay module and air-conditioning system. With the type of integration explained in this work, a relay module can be switched remotely with the help of temperature sensors which tells the user when a desired temperature is exceeded or not attained. So far the user is connected through the internet to the Wi-Fi shield, local condition of the surrounding reported by the sensors can be manipulated remotely using the Wi-Fi shield IP connectivity.

- Security system: this includes remote monitory, remote alarm systems, remote access control, etc. This system may comprise of IP camera for remote monitoring, security keyboard system with exceptions, electric fence controlled by a relay system and electric door system.

- Remote electric appliance switching system: some electric appliances when powered on needs some time to attain desired operating conditions. Example of such system include the DSTV decoder system which takes approximately 10mins to refresh saved channels, cooling systems which may require some time attain require temperature. Such system is best powered on prior to the time of usage, may be before entrance to the compound, before packing the car at the garage, or before leaving the office for the house.

- Remote report system: a remote control system such as the one described in this work can go a long way in assisting in some projects like reporting the level of humidity of a remote location, reporting the temperature of a desired environment, etc.

4.0 Network Based Simulation for the Arduino Home Automation

The following network simulation is carried out to investigate the minimum bandwidth requirement of the network for a good streaming quality of the video and other multimedia data that is proposed to be sent over the internet.
The network consists of a three separate network connected together through the internet which are:

- The Arduino server local area network: this network comprises of nodes like the Wi-Fi-shield which will function both as file and web server, the Arduino microcontroller, the router and an internet service provider connection with a public internet protocol address. This network segment is responsible for sending protected information to the internet which will be accessed by the next two network segment.
- The mobile user network: this network subnet covers remote access to the Arduino network from a base or subscriber station. Network access from the modems are also included in this network segment.
- The stationary /non roaming user network: this network segment covers user in a confined area and consist of a fixed router, an access point and isp connection.

4.1 OPNET Modeler

OPNET simulator is a tool to simulate the behavior and performance of any type of network. The main difference with other simulators lies in its power and versatility. This simulator makes possible working with OSI model, from layer 7 to the modification of the most essential physical parameters [11]. OPNET provides a wide-ranging development environment for modelling and routine evaluation of communication networks and distributed systems. The simulation tools consist of a number of tools focusing on particular aspects of the modelling task [12].

4.2 The Network Model

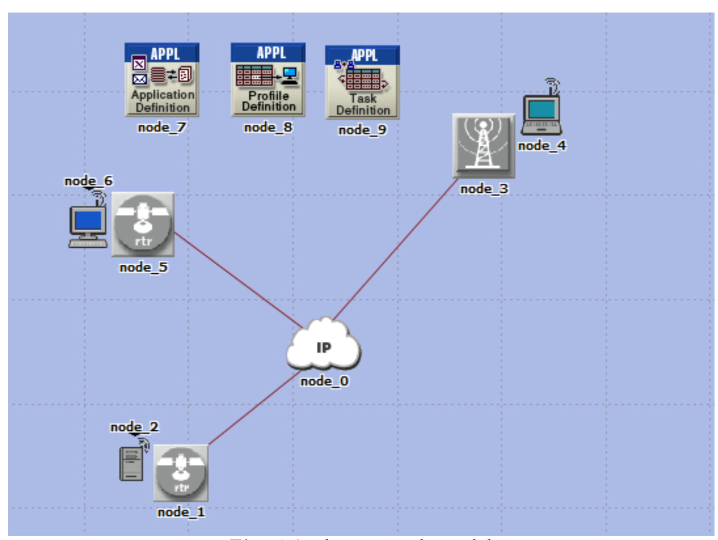


Fig. 4.0: the network model

From the network topology shown in figure 4.0, the three

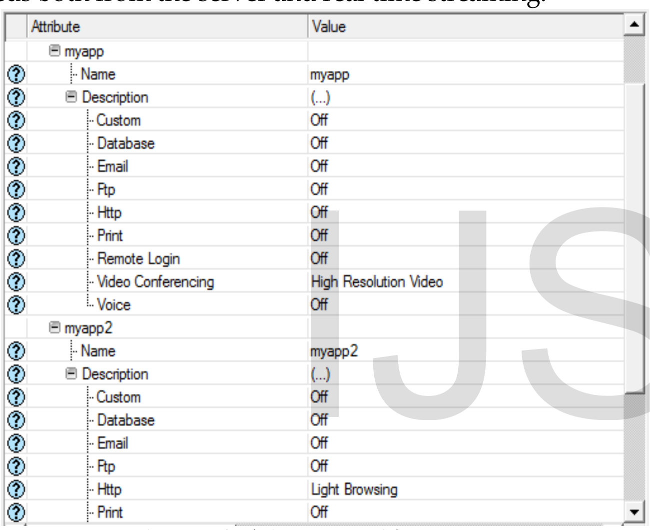
ISSN 2229-5518

network addressed earlier is shown connected in the OPNET modeler at the server side using the T1 line which will be capable of handling both clear text traffic and video streaming capabilities.

4.3 IMPLEMENTATION AND RESULTS

With respect to the topology shown in fig. 1, the server side is configured with video and text capabilities, as shown in fig. 4.1. The Arduino IP camera and the environmental conditions captured by the sensors will be sent over the internet as text, picture and video.

This simulation aims at determining the minimum bandwidth required by the server side (the Wi-Fi shield, the router and the isp connectivity) to successfully transfer data without a noticeable delay to access nodes (the stationary and mobile user) through the internet. The data transfer will be real time. Hence no delay should be experienced while streaming video feeds both from the server and real time streaming.



Attribute	Value
myapp	
Name	myapp
Description	(...)
Custom	Off
Database	Off
Email	Off
Ftp	Off
Http	Off
Print	Off
Remote Login	Off
Video Conferencing	High Resolution Video
Voice	Off
myapp2	
Name	myapp2
Description	(...)
Custom	Off
Database	Off
Email	Off
Ftp	Off
Http	Light Browsing
Print	Off

Fig. 4.1: Arduino server side parameters

SIMULULATION RESULT AT 0.5Mbps

For all the simulation speeds (0.5Mbps, 1Mbps and 2Mbps) the constant traffic will be developed at the server side, i.e. the server will be loaded as shown in the figure 4.2.

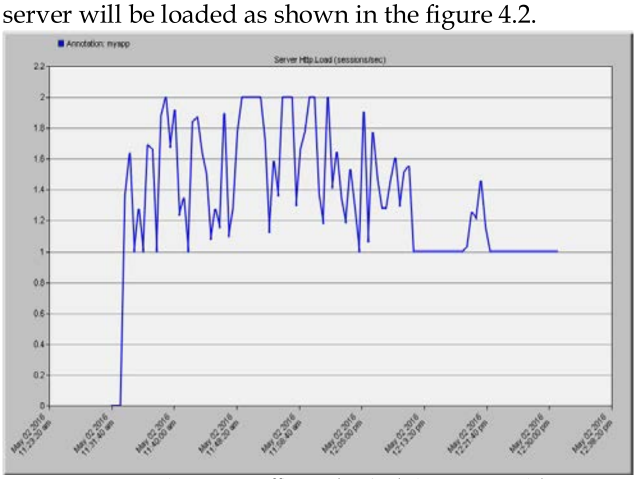


Fig. 4.2: traffic at the Arduino server side.

The overall network transmission protocol is user datagram protocol in order to maximized network resources. The video streaming can be queued; hence no packet is lost on the cost of transmission as shown in figure 4.3.

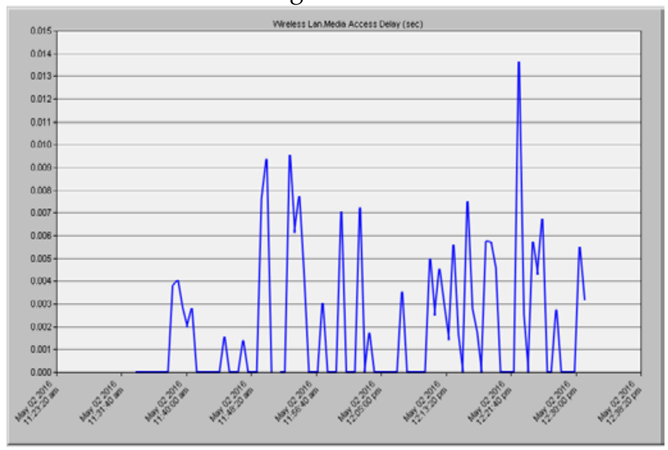


Fig. 4.3: media access delay (at 0.5 Mbps)

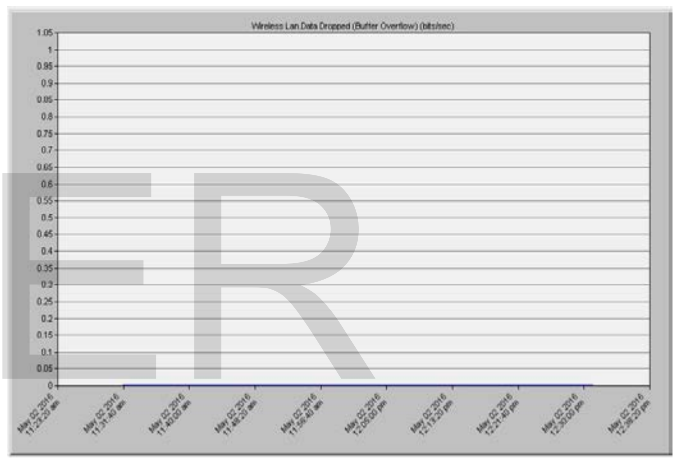


Fig. 4.4: data dropped/buffer overflow

SIMULULATION RESULT AT 1 Mbps

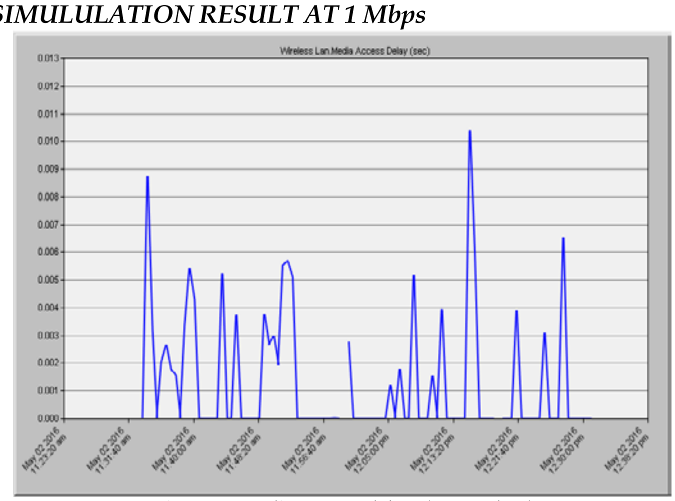


Fig. 4.5: media access delay (at 1 Mbps)

SIMULULATION RESULT AT 2 Mbps

ISSN 2229-5518

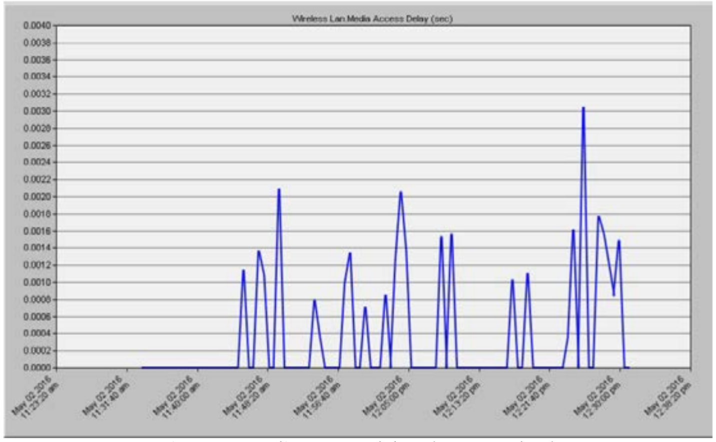


Fig. 4.6: media access delay (at 0.5 Mbps)

From the simulation results shown in figures 4.2 to 4.6, it can be deduced that as data rate is increased from 0.5 Mbps to 1Mbps and 2Mbps the media access delay moves from 13.8ms to 3.2ms. A media access delay of 3.2ms and above can support video quality up to 720fps as configured earlier in the server. Hence for a high quality remote video monitoring through the arduino wifi shield, the minimum recommeneded data rate is 2Mbps.

5.0 CONCLUSION

Video feed streaming is bandwidth intensive but with the simulation done above, it could be concluded that for normal operation of the remote monitoring and sensing system the minimum bandwidth requirements is 2Mbps. And for optimum performance, bandwidth requirement will be above 2Mbps for both mobile user connected to a BS or SS and for a user connected to an access point in an area like the office.

REFERENCES

1. Rajeev Piyare,Seong Ro Lee, Smart Home-Control and Monitoring System Using Smart Phone, The 1st International Conference on Convergence and it's Application, Nikhil, 2013. onlinepresent.org/proceedings/vol24_2013/23.pdf
2. Agarwal, G.Subramanya Nayak; Microcontroller based Home Security System with Remote Monitoring, International Conference on Electronic Design and Signal Processing, 2012
3. Genesis Ajah, Nathan David, Abioye, AyodejiOpeyemi, Web Based Security System, Scholars Journal of Engineering and Technology, ISSN: 2321-435X. http://saspublisher.com/wp-content/uploads/2013/09/SJET13112-116.pdf
4. Nathan David: Design of an Internet Based Security System, NIJOTECH, Vol.29 No.2 June 2010 http://nijotech.com/index.php/nijotech/article/view/71
5. Y. Liu, "Study on Smart Home System Based on Internet of Things Technology," Informatics and Management Science IV. vol 27, vol. 207, pp. 73-81, 2013.
6. M. A. Al-Qutayri and J. S. Jeedella, "Integrated Wireless Technologies for Smart Homes Applications," Smart Homes Systems, 2010
7. Nathan David, Abafor Chima, Aronu Ugochukwu, Edoga Obinna: Design of a Home Automation System Using Arduino. International Journal of Scientific and Engineering Research 06/2015; 6(6). http://www.ijser.org/researchpaper/Design-of-a-Home-Automation-System-Using-Arduino.pdf
8. http://searchmobilecomputing.techtarget.com/definition/WPAN
9. R. Chokshi, "Marvel WiFi-Bluetooth Coexistence," Marvel Semicconductor, Inc., 2010
10. https://www.arduino.cc/en/Reference/softwareSerial
11. users.salleurl.edu/~zaballos/opnet_interna/pdf/OPNET%20Simulator.pdf
12. Nathan David, Chukwunonye Anyakoha, Henry Agbo, Opnet Based Simulation for Rural Connectivity, International Journal of Scientific and Engineering Research, Vol. 6 (4), 2016, http://www.ijser.org/onlineResearchPaperViewer.aspx?OPNET-BASED-SIMULATION-FOR-RURAL-EDUCATIONAL-ICT-CONNECTIVITY.pdf