Design of a Home Automation System Using Arduino

Nathan David, Abafor Chima, Aronu Ugochukwu, Edoga Obinna

Abstract—This paper presents a low cost and flexible home control and environmental monitoring system. It employs an embedded micro – web server in Arduino Mega 2560 microcontroller, with IP connectivity for accessing and controlling devices and appliances remotely. These devices can be controlled through a web application or via Bluetooth Android based Smart phone app. The proposed system does not require a dedicated server PC with respect to similar systems and offers a novel communication protocol to monitor and control the home environment with more than just the switching functionality. To demonstrate the feasibility and effectiveness of this system, devices such as light switches, power plug, temperature sensor, gas sensor and motion sensors have been integrated with the proposed home control system.

Index Terms— Smart Home, Home Automation, Android Smartphone, Arduino, Light Dependent Resistor, Passive Infrared Sensor, Graphic User Interface

1.0 INTRODUCTION

In the present day, security systems play an important role in the protection of lives and investment. This is achieved by the incorporation of various subsystems into the security system with a single control unit such as surveillance, intruder control, access control, fire detection, etc. A smart home is one that is equipped with lighting, heating, and electronic devices that can be controlled remotely by smartphone or via the internet. An internet based home automation system focuses on controlling home electronic devices whether you are inside or outside your home [1]. Home automation gives an individual the ability to remotely or automatically control things around the home. A home appliance is a device or instrument designed to perform a specific function, especially an electrical device, such as a refrigerator, for household use. The words appliance and devices are used interchangeably.

Automation is today's fact, where things are being controlled automatically, usually the basic tasks of turning ON/OFF certain devices and beyond, either remotely or in close proximity [2]. Automation lowers the human judgment to the lowest degree possible but does not completely eliminate it. The concept of remote management of household devices over the internet from anywhere, any time in the world today can be a reality. Assume a system where from the office desk, the user could view the status of the devices and decides to take control by tuning his TV set to his favourite channel, turns on the cooling system, say the air conditioner, and switches on or off some of the lights. This user could walk back home and only find a very comfortable, pleasant home.

The recent developments in technology which permit the use of Bluetooth and Wi-Fi have enabled different devices to have capabilities of connecting with each other [3]. Using a WIFI shield to act as a Micro web server for the Arduino eliminates the need for wired connections between the Arduino board and computer which reduces cost and enables it to work as a standalone device. The Wi-Fi shield needs connection to the internet from a wireless router or wireless hotspot and this would act as the gateway for the Arduino to communicate with the internet. With this in mind, an internet based home automation system for remote control of home appliances is designed.

1.1 OVERVIEW OF THE SMART HOME

The basic block diagram of the smart home system is shown in figure 1. A micro-controller is used to obtain values of physical conditions through sensors connected to it [4]. These integrated sensors such as the temperature

sensor read temperature values, the gas sensor detects smoke and cooking gas to avoid fire outbreak. The automatic switching on and off of the light is controlled by the Light Dependent Resistor (LDR) which determines the day light intensity. Also to incorporate security in our design, a motion detector is integrated using Passive Infrared Sensor (PIR) to detect movement in the home when the security system is turned on.

A relay switch is used to send control signals from the micro-controller to the electronic device used to achieve the switching on and off action. A web portal is designed with a one-factor authentication system (username and password) to check authenticity of the home user. It acts as an input device to control the home appliances and also acts as an output device to read the values of the physical conditions. The mobile application also utilizes this same procedure to act as an input and output device.

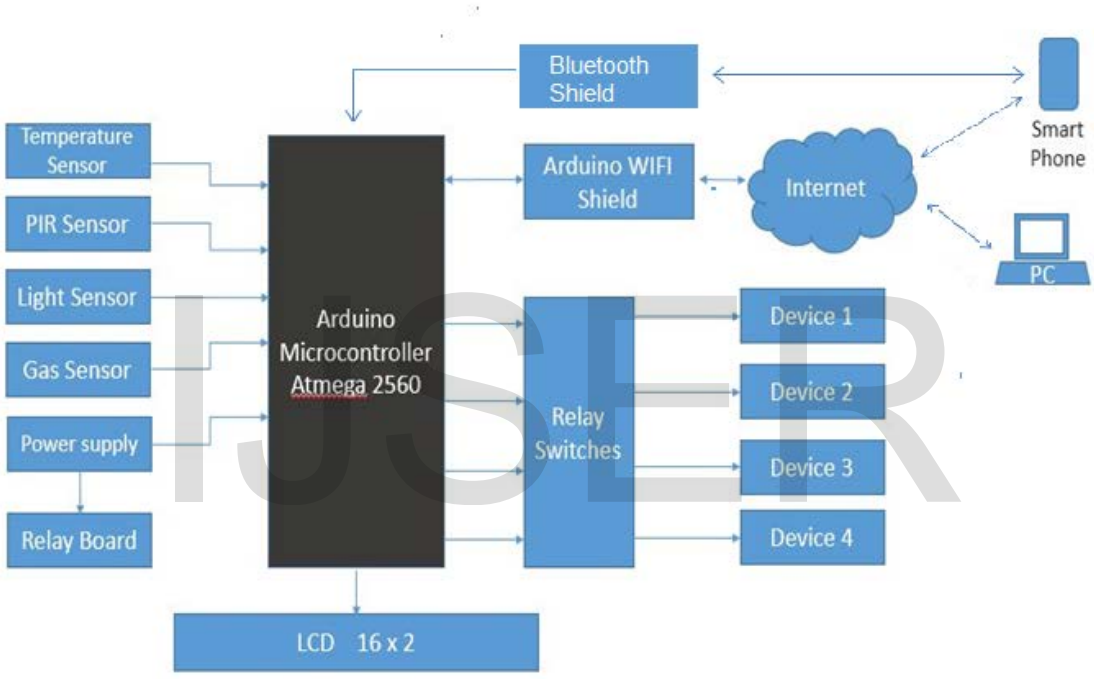

Figure 1: Block Diagram of the Smart Home System

2.0 DESIGN AND IMPLEMENTATION

A low cost and efficient smart home system is presented in our design. This system has two main modules: the hardware interface module and the software communication module. At the heart of this system is the Arduino Mega 2560 microcontroller which is also capable of functioning as a micro web server and the interface for all the hardware modules. All communication and controls in this system pass through the microcontroller.

As we can see in figure 2, the smart home system offers feature such as environmental monitoring using the temperature, humidity, gas and smoke sensors. It also offers switching functionalities to control lighting, fans/air conditioners, and other home appliances connected to the relay system. Another feature of this system is the intrusion detection which it offers using the motion sensor and all these can be controlled from the Android smart phone app or web application.

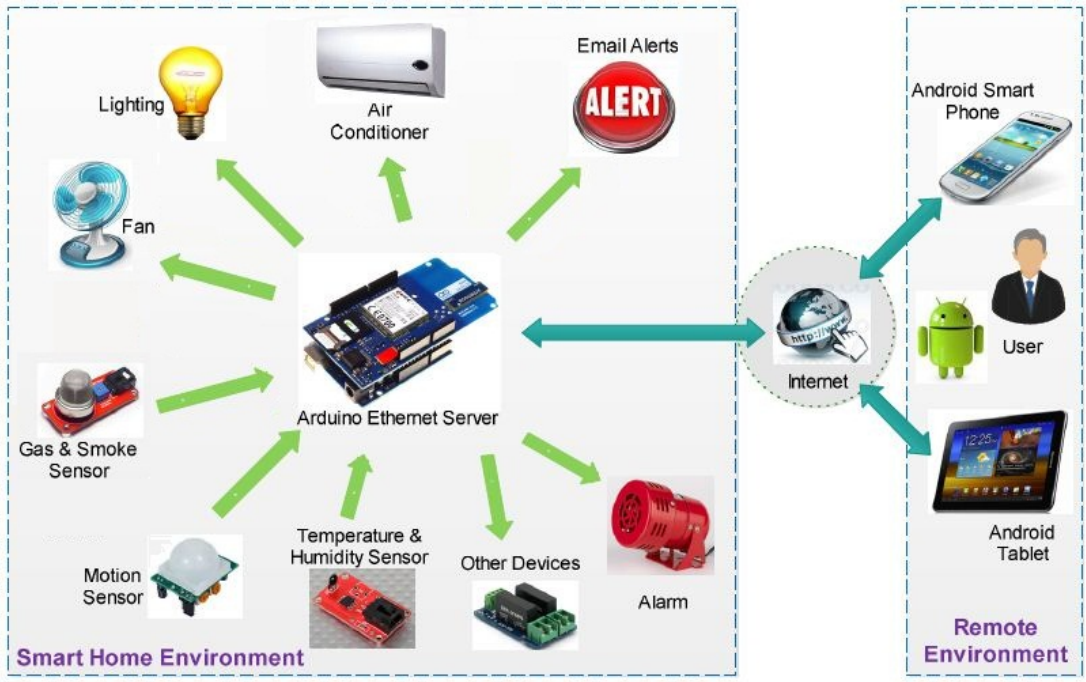

Figure 2: System architecture of the smart home system.

2.1 HARDWARE MODULE

Arduino can sense the surroundings by receivinging air, and spits out a digital signal on the data input signal from a variety of sensors pin (no analog input pins needed) and is and can affect its environment via actuators [5].illustrated in figure 3. It is fairly simple to use, but An analog temperature sensor is a chip that tellsrequires careful timing to grab data. The only real you what the ambient temperature is. The DHT11downside of this sensor is you can only get new is a basic, ultra low-cost digital temperature anddata from it once every 2 seconds, so when using humidity sensor [6]. It uses a capacitive humidityour library, sensor readings can be up to 2 seconds sensor and a thermistor to measure the surround-old.

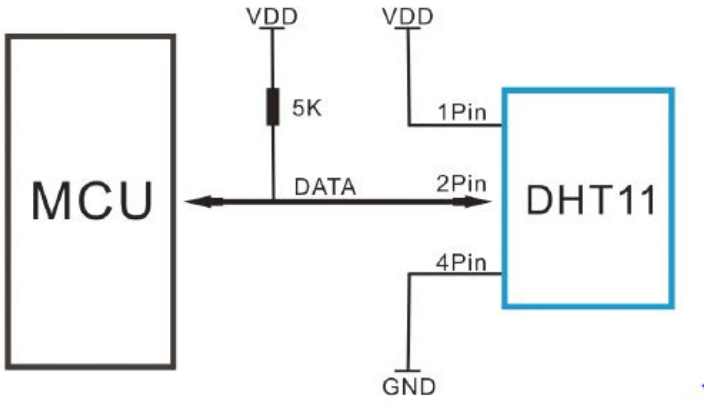

Figure 3: Pin connection of DHT11 Sensor.

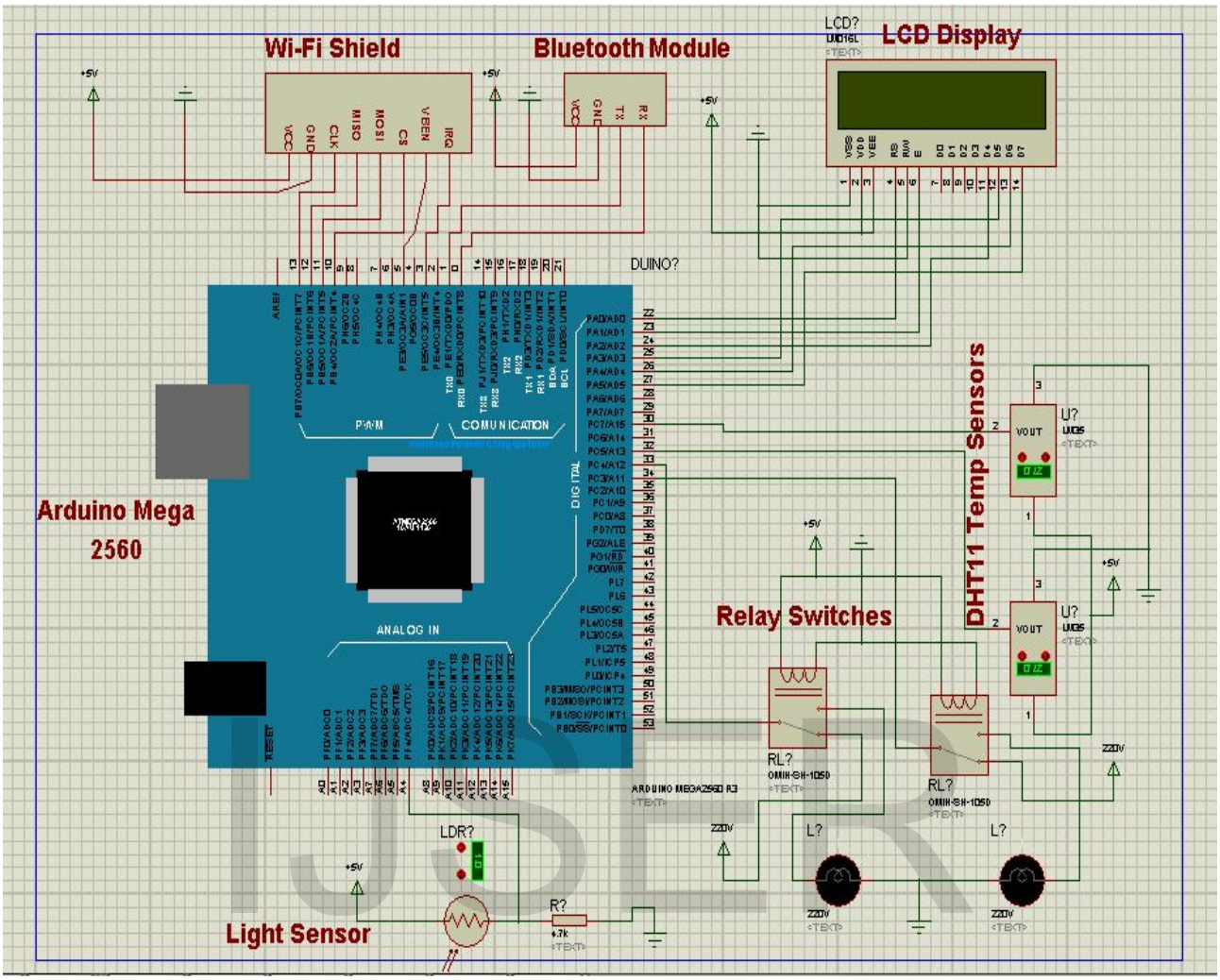

Figure 4: Circuit diagram of Home Automation System with proteus

The Passive Infra-Red (PIR) sensors allow one to sense motion, almost always and is used to detect whether a human has moved in or out of the sensors range. The PIR sensor is a pyroelectric device that detects motion by measuring changes in the infrared level emitted by surrounding objects. This motion can be detected by checking for a high signal on a signal I/O pin [7]. They are small, inexpensive, low-power, easy to use and don't wear out. For that reason they are commonly found in appliances and gadgets used in homes or businesses.

MQ2 is a semiconductor type sensor, which can appropriately sense the presence of smoke, LPG, methane, butane, propane and other hydrocarbon combustible gases. The sensitive material in this sensor is tin-dioxide (SnO2), [8]. When it comes in contact with the gas to be monitored, the electrical resistance of the sensor decreases; enabling the microcontroller to respond to the situation. When it detects the concentration of combustible gas in the air it outputs its reading as an analog voltage. The sensor can measure concentrations of flammable gas of 300 to 10,000 ppm. The sensor can operate at temperatures from -20 to 50°C and consumes less than 150 mA at 5 V.To allow connection for power plugs and switching of electrical load within the home, relay switches are used. The relay switches have capability to carry a maximum load of 10A at 240V. This is sufficient to carry any household ap-

pliance as these devices do not draw much current. To enable connectivity on the microcontroller, a Bluetooth module and Wi-Fi shield is used. The Bluetooth provides connectivity via the serial I/O pins on the Arduino through which the Android based mobile application communicates with the microcontroller. The Wi-Fi shield provides internet connectivity for the embedded micro web server which allows internet access and controls from a web application. The circuit diagram of Home Automation System with is illustrated in figure 4.

Software Module: Android application

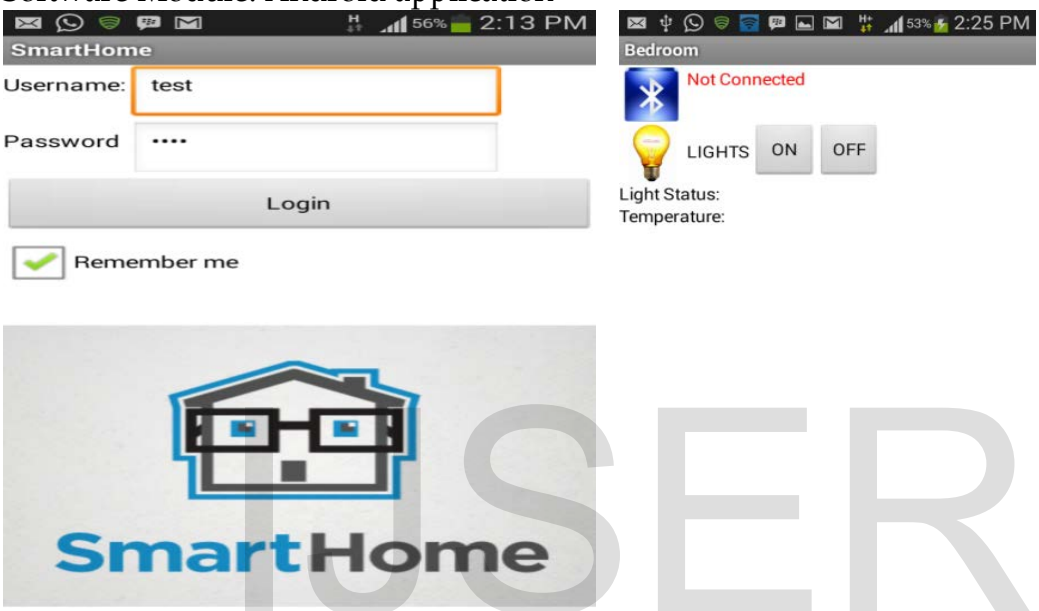

Figure 5: Smart phone app login page and bedroom page after login

The android application was designed using the Google App-Inventor Integrated Development Environment (IDE) and Java programming language. The application contains both a Bluetooth module and a Wi-Fi module which interfaces with the micro-controller and allows the android smart phone to communicate with the micro-controller effectively and efficiently.

The android application allows the user to control devices and monitor conditions in the home using the Bluetooth connection. The android application is efficient, flexible and has a user friendly Graphic User Interface (GUI). The application has a user authentication page to verify that the authorized user is logged in and has full control of the home-appliances. The authentication page and the bedroom page after login are shown in figure 5.

3.0 WEB APPLICATION

The internet is great source of information and communication in this information age. Communication with things via the internet also known as Internet of Things (IoT). Bland by name and superficially viewed as gee-whiz technology never to be realized, the IoT has significant potential to transform business. IoT is a developing technology which allows different things and devices to be controlled via the internet. At its heart, IoT is a wide-ranging ecosystem of everyday physical objects connected to the Internet, capable of identifying themselves and communicating data to other objects on the net-

work [9]. In this work it is implemented using the Arduino as a micro web server through which we can connect to the hardware modules, receive status updates from them and also send control information to the microcontroller.

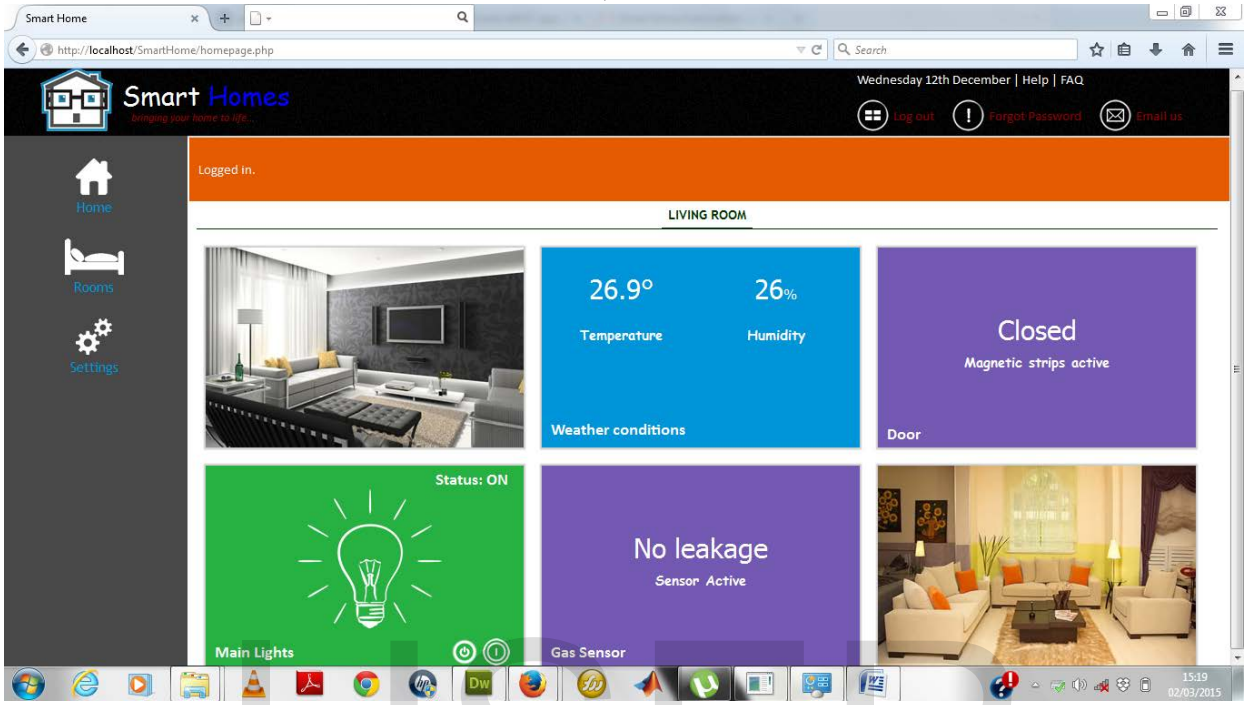

Figure 6: Showing a logged in user profile.

For our web application, which in this text is a website, we used Adobe Dreamweaver as our programming environment and we used Hyper-text Pre-Processor (PHP) and also JavaScript (JSON) and also Ajax for our programming languages. The website will control the Arduino by passing information to it as codes. In this case, The web page will display all the variables being read from the Arduino micro-controller and also be able to perform the functions as the mobile application. The Wi-Fi shield connected with the Arduino board will be the link between the web pages and the Arduino. When connected to the IP address of the Arduino, the PHP and the Ajax http request will be able to send information over this IP address which in turn is interpreted by the Arduino.

the Arduino micro-controller acts as a client and the PHP will act as a server (Wamp, IIS or Apache servers can be used) because PHP is not a client based programming language. The design of the web pages was chosen to be in metro style as it gives user friendliness and also a colorful display of the web items as in figure 6.

4.0 CONCLUSION

In this paper, a novel architecture for low cost and flexible home control and monitoring system using Android based Smart phone is proposed and implemented. The proposed architecture utilizes a micro web server and Bluetooth communication as an interoperable application layer for communicating between the remote user and the home devices. Any Android based Smart phone with built in support for Wi-Fi can be used to access and control the devices at home. When a Wi-Fi connection is not available, mobile cellular networks such as 3G or 4G can be used to access the system. The system also uses the Google speech recognition engine thus eliminating the need for an external voice recognition module. Prospective future works include incorporating SMS and call alerts, and reducing the

wiring changes for installing the proposed system in pre-existing houses by creating a wireless network within the home environment for controlling and monitoring the smart home environment.

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