ARDUINO-BASED HOME AUTOMATION SYSTEM VIA ANDROID APPLICATION

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TABLE OF CONTENTS

LIST OF FIGURES

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ABSTRACT

In today's world, life is always on the move. With the advancement of technology, smart phones today have immense capabilities to provide rich user experience. Google came up with an innovative operation system termed as Android which is the first open source software toolkit for mobile environment and many projects can be made where smartphones are connected to microcontrollers to create tangible interface. This study was able to develop a Home Automation System using Arduino as its microcontroller, Android for the application, and SMS for communication. The application has the capability to check status and to turn on/off the devices it controls. After a series of tests, it is proven that the home automation application satisfied majority of the respondents despite network problems.

General Terms Android, Arduino, Home Automation System, SMS

1 Background of the Study

With advancement of technology things are becoming simpler and easier for us. Arduino is a tool for making computers that can sense and control more of the physical world than your desktop computer. It's an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. Arduino can be used to develop interactive objects, taking inputs from a variety of switches or sensors, and controlling a variety of lights, motors, and other physical outputs. Automation is the use of control systems and information technologies to reduce the need for human work in the production of goods and services. Automation plays an increasingly important role in the world economy and in daily experience. Android uses a fun, easy interface to organize and manage applications on some of the world's most powerful phones. In fact, carrying around an Android phone is like having a pint-sized laptop right in your pocket. Android smartphones are widely used by majority. It is considered to be cheaper when compared to any other smartphone with different Operating System.

The idea of interfacing a Home Automation System with the use of Android Application is a step ahead for the field of automation. With the use of SMS as means of communication for the Arduino and the Android Application, it provides a whole new idea of a simpler, easier, yet more accessible method for automation.

2 Technology Application Context

In order to achieve an Arduino-based Home Automation System via Android Application, the following technologies were used.

2.1 Arduino, an open-source physical computing platform based on a simple microcontroller board, and a development environment for writing software for the board. The Arduino programming language is an implementation of Wiring, a similar physical computing platform, which is based on the Processing multimedia programming environment and Java. It is called the Arduino IDE.

An Arduino board consists of an Atmel 8-bit AVR microcontroller with complementary components to facilitate programming and incorporation into other circuits. An important aspect of the Arduino is the standard way that connectors are exposed, allowing the CPU board to be connected to a variety of interchangeable add-on modules known as shields.

The GPRS Shield provides a way to use the GSM cell phone network to receive data from a remote location. The way to communicate it with the Arduino board is through AT Commands.

In computer telecommunication, the Hayes command set (AT Commands) consists of a series of short text strings which combine together to produce complete commands for operations such as dialing, hanging up, and changing the parameters of the connection.

The Relay Shield is an Arduino compatible smart module with 4 mechanical relays providing an easy way to control high voltage. It can be directly controlled by Arduino through digital IO.

2.2 Android, is a comprehensive software stack of mobile devices that includes an operating system, middleware and key application. This rich source of software bunch is used in Mobile Technology through its innovation module of The Android Software Development Kit (SDK).

Android Development Tools (ADT) is a plugin for the Eclipse IDE that is designed to give you a powerful, integrated environment in which to build Android applications.
ADT extends the capabilities of Eclipse to let you quickly set up new Android projects, create an application UI, add packages based on the Android Framework API, debug your applications using the Android SDK tools, and even export signed (or unsigned) .apk files in order to distribute your application.

3 Objectives of the Study

The general objective of this research is to develop an Arduino-based home automation system via Android application.

The specific objectives are:

- To implement a home automation system using Arduino as microcontroller, Android as platform, and SMS as means of communication

- To aggregate the home automation simulators(Arduino, Relay Shield, GPRS Shield, and the devices to control)
- To program the Arduino board through the Arduino IDE so that it can read through the mobile device and so that it can control the relay
- To develop a user-friendly Android application that: shows the parts of the house, displays the status of the appliances and lightings, and can switch them on/off through SMS to the Arduino

4 Significance of the Study

Most commercially available home automation systems are all-in-one solutions which require that all controllable appliances are from the same company, or must be approved as compatible with said company's system. Moreover these systems can only be controlled in limited locations. This complexity led to the idea of a typical Home Automation System with the twist of integrating Android application and the use of SMS. Through developing an Android application, users will find it easier to automate their houses because of the simple interface presented. SMS on the other hand is currently the easiest means of communication. Furthermore, to implement a Home Automation System that would not require close range access or Internet Technology will allow users to have more access to their houses. A home automation system can be used for safety purposes and for saving electricity. It can be used to check switched on appliances and it can be used to turn it off. Considering the mobility and portability known to mobile devices, it can be useful to people who lives alone and away from home.

5 Scope and Limitations of the Study

The study will generally focus on implementing the usability principles of Arduino and Android in order to develop an efficient home monitoring application. The study would generally be for homeowners in order for them to also have the capability to automate their home remotely anywhere they may go. For testing purposes, the proponents would connect the microcontroller to a relay and use the application to turn the connected devices and lightings on or off. The application uses SMS to communicate with the Arduino.

6 Review of Related Literature and Technology Applications

In this narrative review, the researchers sought to identify all related information that had been written about a home automation system. Most reference found was looked up online. There are already a lot of attempts that were made to assess different methods of making a home automation system, different types of microcontroller, different kinds of connections used, and many other different techniques achieved to finish the project. The researchers' protocol, therefore, was to identify the results and the different processes that were used based on the literature the researchers found, for them to conclude a better research.

Arduino simplifies the process of working with microcontrollers, but it offers some advantage for teachers, students, and interested amateurs over other systems because it is inexpensive and also open source. Android on the other hand, is also open source. The connection between the two has been proven to be efficient and effective.

[3] Aproject that they found was about an Android-Controlled Pneumatic Cannon Powered by Arduino. The project was a homemade contraption that is controlled using an Android phone. Rattner [2011] indicated that [4]"the project entailed a pneumatic cannon with valves controlled electronically. When the cannon electronics receive a certain message over Bluetooth, the appropriate barrel fires. On the other side, an Android app uses the phone's Bluetooth modem to send messages to the cannon. This approach allows the cannon to be fired from around a 30-foot range, line-of-sight." With this, they were able to see the different capabilities of Arduino. They also became more interested because they like to work with both hardware and software.

[11] The project by BodaVamsee, Krishna Babu and BajjuriPraneeth Kumar is an SMS Remote Controller [Vamsee, Babu and Kumar 2005]. The goal of the project is to design an embedded device which can control up to 8 devices by sending a specific SMS message from a cellphone. This controller is extremely handy at places where users have to control the ON and OFF switching of the devices but no wired connection to that place is available. To implement this, a GSM modem is connected to a programmed microcontroller which would receive the SMS from a reference cell phone. The control signal part of the received SMS is extracted and is changed to microcontroller-preferred format. In regular intervals, the modem would also send the local temperature. The monitoring is also done by interfacing a LCD to the microcontroller. AT commands were used for controlling the functionality of modem. This kind of project has a lot of similarities to the project proposed by the researchers. This project is plain simple. It is recommended that it will be improved by providing a better interface for users.

Another home automation project which is done differently is implemented by Kurian Abraham and K.P. Sandeep Rao [Abramah and Rao 2009]. Their project demonstrates a simple home automation system that allows the user to control it with a wireless device such as a Wi-Fi or Bluetooth enabled mobile phone. A desktop PC is used to run the server software. The system allows the user to control each of the lights and fans individually. It can automatically turn off the main lights and turn on a night lamp at a specified time. By measuring the signal strength, it can detect when the user enters a room and automatically turn on the light and fans, and then automatically turn them off when the user leaves the room. The system is comprised of five different modules in total; three of which are client modules for different platforms. Server for Windows, It sends commands to the microcontroller to control the relays, and accepts commands from clients connected to it. Second, the Embedded Program for Microcontroller, and Hardware Circuit, The microcontroller used is a PIC16F877A manufactured by Microchip Technology Inc. It communicates with the server using Serial communication via a USB-to-Serial Bridge. It has multiple outputs which are used to control the relays. A relay board with eight electromechanical relays is used to switch on and off the appliances. The relay board is connected to one of the output ports on the microcontroller. Bluetooth Client for J2ME mobile phones, once the mobile phone is connected to the server, it displays a list of appliances and their current status. The Bluetooth client was successfully tested on a multitude of different mobile phones from different manufacturers, thus proving its portability and wide compatibility. Wi-Fi Client for Windows laptops, the Wi-Fi Client for laptops is visually similar to the server module and is designed to run on Windows. Lastly is the Wi-Fi Client for Sony Playstation Portable, the Wi-Fi client for the PSP uses the PSP's built-in Wi-Fi adapter

to connect to the Home Automation Server. The client is coded in C and is compiled as a native application. Hence it is possible to query low level information about the Wi-Fi connection such as the signal strength etc. Thus a low-cost home automation system was successfully designed, implemented and tested. The project's dependency to Wi-Fi and Bluetooth may cause future problems when neither of the two is present.

7 Project Methodology

7.1 Home Automation System Simulators

Home Automation systems consist of networked components that cooperate and that need to be coordinated somehow. Hence, they basically form a distributed system that, compared to typical distributed computing systems, has a number of particular features and requirements.

A. Arduino
The microcontroller board used. It communicates with the server using Serial communication via a USB-to-Serial Bridge. It has multiple outputs which are used to control the relays. The microcontroller is programmed such that if it receives a something from the GPRS shield, it executes the corresponding command that it contains.

B. GPRS Shield
The GPRS Shield is configured and controlled via its UART using simple AT commands. Based on the SIM900 module from SIMCOM, the GPRS Shield is like a cell phone. Besides the communications features, the GPRS Shield has 12 GPIOs, 2 PWMs and an ADC.

C. Relays
Relays are switches that open and close circuits electromechanically or electronically. Relays control one electrical circuit by opening and closing contacts in another circuit. In this study, the proponents used a Relay Shield for Arduino.

D. Transformer
The main source of power supply is a transformer. The maximum output power of power supply is dependent on maximum output power of transformer .

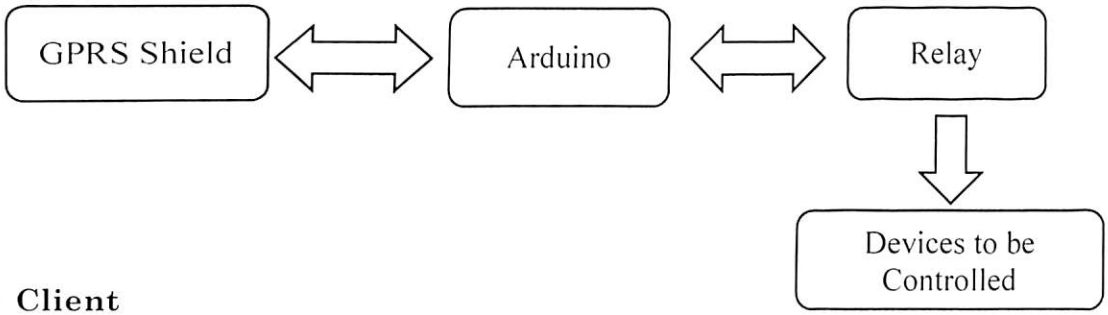
E. Devices to be controlled
These are the lightings and devices which will be automated.

7.2 Interface

A. Development Tools
- Eclipse IDE -Eclipse is a multi-language Integrated development environment (IDE) comprising a base workspace and an extensible plug-in system for customizing the environment. It is written mostly in Java.

- ADT Plugin - Android Development Tools (ADT) is a plugin for the Eclipse IDE that is designed to give you a powerful, integrated environment in which to build Android applications.
- Arduino IDE - The Arduino development environment contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them.

7.3 Aggregation



7.4 Client

The client developed in this study is an Android application, meaning that it has the capability to provide an easy to use and user-friendly graphical user interface. The application will have the features of showing the parts of the house. It will be the one responsible to send SMS to the Arduino when the user decides to check status of his/her devices and to turn on/off them.

A. General Features and Layout

The main screen shows the three buttons for the three locations in the house(Bathroom, Kitchen, and Bedroom). When each button is pressed, it then shows the devices that are located in the chosen location. The Check Status button is responsible for sending an SMS to the Arduino and then a notification will be shown whether the device is turned ON or OFF. The buttons Turn On and Turn Off are responsible for

turning on and turning off the device. To get back to the main menu, the user just have to click the back button which is always present in an Android device.

7.4,1 Research Framework and Design

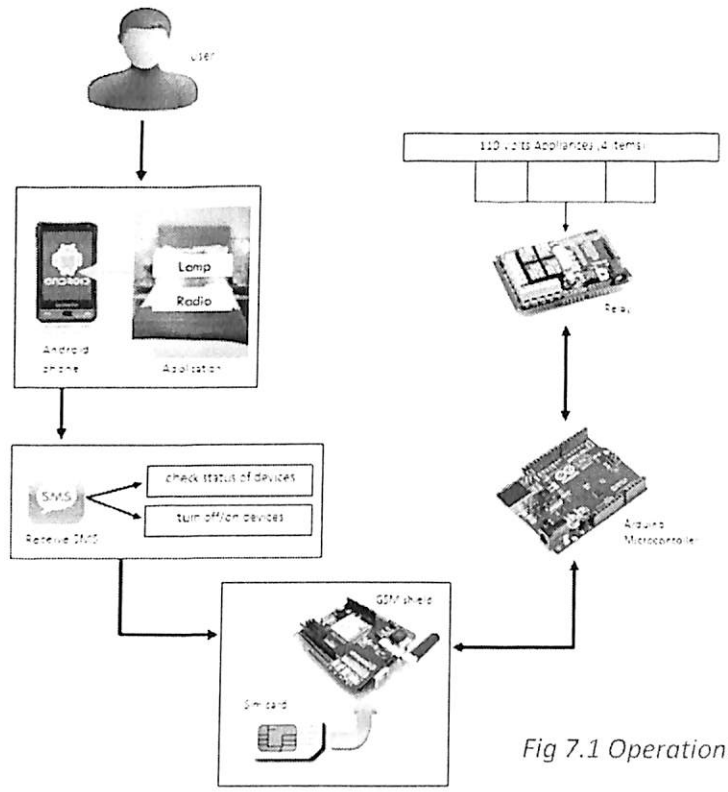


Fig 7.1 Operational Framework

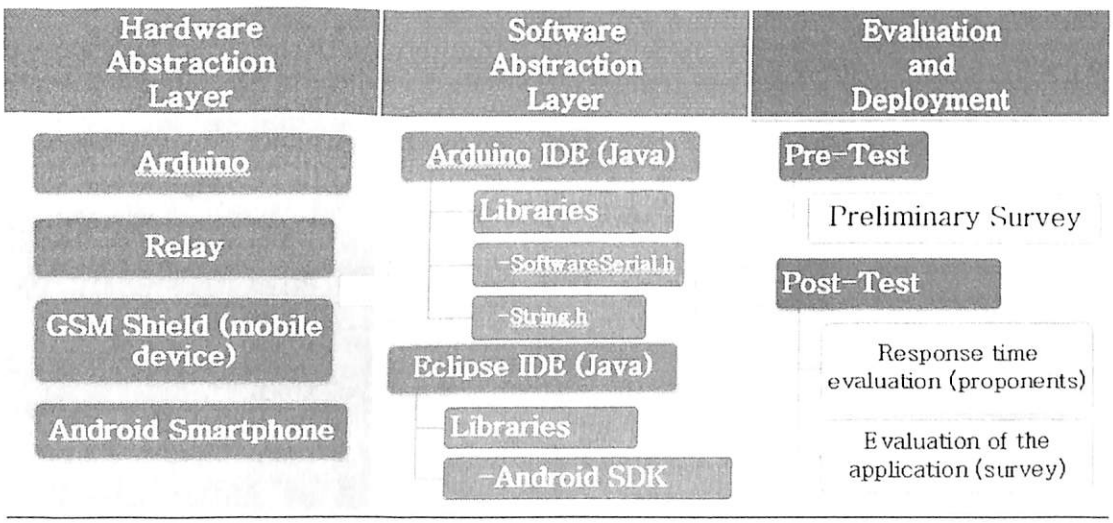


Fig 7.2 Research Design

8 Discussion

8.1 Arduino Programming:

```
void setup()
{
  Serial.begin(4800);
  pinMode(4, OUTPUT);
  pinMode(5, OUTPUT);
  pinMode(6, OUTPUT);
  pinMode(7, OUTPUT);
  Serial.println("AT+CMGF=1");
  delay(1200);
}
```

Figure 1

The setup() function is called when a sketch starts. It is used to initialize variables, pin modes, start using libraries, etc. The setup function will only run once, after each power-up or reset of the Arduino board. In the above code, a Serial is initialized with a 4800 baud rate. Serial is used for communication between the Arduino board, the relay shield, and the GPRS shield. The pins 4, 5, 6, and 7 are the pins for the relay. To activate the SMS mode of the GPRS shield, through the Serial command, an AT command which is the AT+CMGF=1 is sent. A delay is placed to give time for the response.

```
void loop()
{
  if(Serial.available())
  {
    char fromSerial;
    fromSerial = Serial.read();
    msg += String(fromSerial);

    if(msg.indexOf("+CMTI:")>= 0)
    {
      counter++;
    }

    if(counter==8)
    {
      counter=0;
      int comma = msg.lastIndexOf(",");
      lalagyan = msg.substring(comma+1);
      msg="";
      Serial.println("AT+CMGF="+ lalagyan + ",0");

    }
```

Figure 2

Inside the loop, the Arduino reads from the Serial. As mentioned before, the communication of the Arduino and the GPRS Shield is through Serial. All outputs from the Serial is saved in the string msg. New SMS are signalized by +CMTI: "SM",1; where SM = memory location, 1 = index. The counter is used to get the location of the SMS so the Arduino can open and read it. The AT+CMGR command is then sent to open it. The purpose of this part of the code is to be able to get the memory location of the SMS received.

```
void checkMem (){
  if (lalagyan.equals("9"))
  {
    Serial.println("AT+CMGD=1,4");
    msg="";
  }
}
```

Figure 3

As seen in Figure 2, only the first digits of the memory location are obtained that's why a function for checking the memory space is present. This function checks if the memory location equals to 9 then an AT command for deleting messages will take effect so the memory locations 1 to 9 are the only ones that will be used.

```
  if(msg.indexOf("chka")>=0){
    state = digitalRead(4);
    sendState(state);
    msg="";
  }
```

Figure 4

Upon opening the SMS, the body of the SMS will already be found in the string msg. This is the code for checking the status. "chka" is the SMS that is sent to the Arduino by the application. This part of the code will be executed depending on the SMS received. It can either be "chka", "chkb", "chkc", or "chkd". The digitalRead function reads the value from a specified digital pin, either high or low. It is to check if the device is turned on or off. High if turned on and Low if otherwise turned off.

```
  if(msg.indexOf("ona")>= 0) {
      digitalWrite(4, HIGH);
      sendState(9);
      msg="";
  }
```

Figure 5

```
(msg.indexOf("offa")>= 0) {
    (4, LOW);
    sendState(6);
    msg="";
}
```

Figure 6

On the other hand, the above figures are the codes to turn on/off the device. The digitalWrite is a function that writes a HIGH or a LOW value to a digital pin. Since, Pin 4 as remembered in the setup, is configured as an OUTPUT, its voltage will be set to its corresponding value. "ona" and "offa" are the message that is sent by the application.

```
sendState( a){
  (a==1){
    sendText("Device is ON.");
  }
  (a==0){
    sendText("Device is OFF.\r");
  }
  (a==9){
    sendText("Device turned ON.\r");
  }
  (a==6){
    sendText("Device turned OFF.\r");
  }
}

sendText( a){
    Serial.print("AT+CMGS=\"+639327870023\"\r");
    delay(1000);
    Serial.print(a + "\r");
    (1000);
    Serial.write(0x1A);
}
```

Figure 7

The above figure is the code for sending the SMS. In the sendState function, an int is required. The int used depends on the command done. 1 and 0 are both from checking the status while 9 and 6 are from turning the device on and off respectively. The sendText function is for sending an SMS to the application. AT+CMGS=<number><CR><message><CTRL-Z> is the format for sending an SMS.