

DESIGN AND IMPLEMENTATION OF SMART HOME AUTOMATION SYSTEM IN NIGERIA

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ABSTRACT

Over the years, they have been lots of researched carried out to improve home automation in other countries of the World. However, little or no research at all has been done to improve the home automation system in Nigeria. The smart home automation system using Arduino and an Android device is primarily aimed at creating a convenient platform where users can control devices in their homes with ease.

The project will be created using an Arduino board containing a micro controller that will be programmed with C++ programming language. An android application will also be created to control the hardware. Hardware and software will be connected together using the Bluetooth technology.

The platform will be developed using a methodology called prototyping method where the design team focus is to produce an early model of the new system, software or application. This prototype

will not have full functionality or be thoroughly tested but it will give external customers a sense of what is to come.

Currently, well developed countries already use smart home control system widely but the reverse happens to be the case in Nigeria. It is therefore recommended that student and researchers in this part of the world should carry out more research on fields such as; Internet of Things (IoT), Robotics, Artificial Intelligence etc.

INTRODUCTION

The era of having only smart devices are over. We are gradually moving to smart buildings (any structure that uses automated processes to automatically control the building's operations) like companies, school and even our homes. According to (Rouse, 2017). Smart home technology, also often referred to as home automation or domotics (from the Latin word "domus" meaning home), provides home owners security, comfort, convenience and energy efficiency by allowing them to control smart devices often by a smart home application on their smart phone or other networked device (Tracy, 2016).

This system specifically answers the problem of security, inconveniences, connectivity and Home energy vampires.

The aim of this project is to design and construct a home automation system that will remotely switch on or off any household appliance connected to it, using a microcontroller and smart phone. This will be achieved through the following activities; Develop Bluetooth appliance, develop an application for a mobile device, Integrate the device to the controller and Test the setup and Analyze the data.

KEYWORDS: Arduino, Arduino Uno, Domotics, Android, Android Application, Internet of Things (IOT), Relays.

2.1 Arduino

Arduino is a single-board microcontroller meant to make the application more accessible which are interactive objects and its surroundings. The hardware features with an open-source hardware board designed around an 8-bit Atmel [AVR microcontroller](#) or a 32-bit Atmel ARM. Current models consists a USB interface, 6 analog input pins and 14 digital I/O pins that allows the user to attach various extension boards.

In a nutshell, an Arduino is an [open hardware](#) development board that can be used by tinkerers, hobbyists, and makers to design and build devices that interact with the real world. While Arduino refers to a specific type of board design, it can also be used to refer to a company which manufactures a specific implementation of these boards, and is typically also used to describe the community around compatible boards made by other people or companies which function in a similar way.

The Arduino Uno board is a [microcontroller based](#) on the ATmega328. It has 14 digital input/output pins in which 6 can be used as PWM outputs, a 16 MHz ceramic resonator, an ICSP header, a USB connection, 6 analog inputs, a power jack and a reset button. This contains all the required support needed for microcontroller. In order to get started, they are simply connected to a computer with a USB cable or with an AC-to-DC adapter or battery. Arduino Uno Board varies from all other boards and they will not use the FTDI USB-to-serial driver chip in them. It is

featured by the Atmega16U2 (Atmega8U2 up to version R2) programmed as a USB-to-serial converter.



Figure 2.1: An Arduino Board

2.2 Features of the Arduino Uno Board

1. It is an easy USB interface. This allows interface with USB as this is like a serial device.
2. The chip on the board plugs straight into your USB port and supports on your computer as a virtual serial port. The benefit of this setup is that serial communication is an extremely easy protocol which is time-tested and USB makes connection with modern computers and makes it comfortable.
3. It is [easy-to-find the microcontroller](#) brain which is the ATmega328 chip. It has more number of hardware features like timers, external and internal interrupts, PWM pins and multiple sleep modes.
4. It is an open source design and there is an advantage of being open source is that it has a large community of people using and troubleshooting it. This makes it easy to help in debugging projects.
5. It is a 16 MHz clock which is fast enough for most applications and does not speeds up the microcontroller.
6. It is very convenient to manage power inside it and it had a feature of built-in voltage regulation. This can also be powered directly off a USB port without any external

- power. You can connect an external power source of upto 12v and this regulates it to both 5v and 3.3v.
7. 13 digital pins and 6 analog pins. This sort of pins allows you to connect hardware to your Arduino Uno board externally. These pins are used as a key for extending the computing capability of the Arduino Uno into the real world. Simply plug your electronic devices and [sensors](#) into the sockets that correspond to each of these pins and you are good to go.
 8. This has an ICSP connector for bypassing the USB port and interfacing the Arduino directly as a serial device. This port is necessary to re-boot load your chip if it corrupts and can no longer used to your computer.
 9. It has a 32 KB of flash memory for storing your code.
 10. An on-board LED is attached to digital pin 13 to make fast the debugging of code and to make the debug process easy.
 11. Finally, it has a button to reset the program on the chip.

2.3 Android Operating System

Android, a mobile operating system whose original creator was Andy Rubin and not Google has been with us in one form or another for over six years. Within this time, there has been an absolute breathtaking operating system development cycle that has never existed. Although lately, Android has been running on a one year unheard development cycle which is slower than it used to be as compared to Windows and Apple operating system (Amadeo, 2014).

According to (Hildenbrand, 2016), Android user interface is mainly based on direct manipulation using touch gestures that loosely correspond to real-world actions such as swiping, tapping and

pinching, to manipulate on-screen objects, along with a virtual keyboard for text input. In addition to touchscreen devices, Google has further developed Android TV for televisions, Android auto for cars, and Android wears for wrist watches, each with a specialized user interface. Variants of Android are also used on notebooks, game consoles, digital camera and other electronics. Android's source code was released by Google under open source licenses which makes it popular with technological companies that require a ready-made, low cost and customizable operating system for high-tech devices.

2.4 Android Applications

Android applications add more functionalities to Android devices. Some commonly known Android applications includes; social media platforms such as Facebook, 2go, WhatsApp and other common applications such as Calendar, contacts etc. These Applications also run on other Operating systems such as Apple IOS if the application was also written to run on those operating systems (Scott, 2016).

Android Applications are also written using the Android Software Development Kit (SDK) and the Java programming language. They include a comprehensive set of development tools including a debugger, software libraries, a handset emulator based on QEMU (Quick Emulator) documentation, sample codes and tutorials (Kadariya, 2013). According to (Staff, 2015) Google initially supported Eclipse as its Integrated Development Environment (IDE) using the Android Development Tools (ADT) plugin until in December 2014 when Google releases Android studio based on IntelliJ IDEA as its primary IDE for Android Application Development.

2.5 Major Home Automation Systems Using Cell Phone

1. **Bluetooth based home automation system using cell phones:** In Bluetooth based home automation system the home appliances are connected to the Arduino BT board at input output ports using relay. The program of Arduino BT board is based on high level interactive C language of microcontrollers; the connection is made via Bluetooth. The password protection is provided so only authorized user is allowed to access the appliances. The Bluetooth connection is established between Arduino BT board and phone for wireless communication.
2. **Wi-Fi based home automation system using cell phones:** Wi-Fi based home automation system mainly consist three modules, the server, the hardware interface module, and the software package. Wi-Fi technology is used by server, and hardware Interface module to communicate with each other. The same technology is used to login to the server web based application. The server is connected to the internet, so remote users can access server web based application through the internet using compatible web browser. Software of the latest home automation system is split to server application software, and Microcontroller (Arduino) firmware. The Arduino software, built using C language, using IDE comes with the microcontroller itself. Arduino software is culpable for gathering events from connected sensors, then applies action to actuators and preprogramed in the server.
3. **Cloud Based home automation system:** Home Automation using cloud-based system focuses on design and implementation of home gateway to collect data about data from home appliances and then send to the cloud-based data server to get store on Hadoop Distributed File System.
4. **Raspberry pie home automation with wireless sensors using smart phone:** Home Automation System has been developed with Raspberry Pi by reading the algorithm and

subject of Email. Raspberry Pi guarantees to be an efficient platform for implementation powerful, and economic smart home automation. Home automation using Raspberry pi is better than any other home automation methods in several ways.

3.1 Analysis of the Present System (Using Nigeria as a Case Study)

There has been an evolution across various spheres of life with every new stage made better than it previous. We have moved from the time where electricity did not exist, to the time when electrical appliances were first seen, to the era of smart product like smart phones etc. A typical Nigerian home has not reached the Apex of a smart home. Many homes still run on a manual system where everything in the home is controlled manually, one after the other. Some homes have tried approaching the smart home system by installing solar home system that automatically switches to the solar energy when power is out. This however does not satisfy the characteristics of a smart home.

The current manual system present in homes has the following characteristics;

1. Individual control of the system: The entire system is controlled one after the other. The bulb has to be switched off before moving over to turn off the cooker or heater etc. There is no central source use in controlling the system making it even stressful for larger houses.
2. There is no use of smart devices: The current manual home does not rely on the use of anything smart for its existence. A smart phone, smart watch or connectivity systems like Bluetooth and WIFI is not needed here.
3. Devices are controlled based on user actions: In a manual home system, everything is controlled because someone put in an effort to do so physically. This is not so in a smart

home where there are some preset settings and automatics put in place example; turn off the security light when its morning.

4. The system does not require constant power: The effectiveness of the manual home system is not dependent on constant supply of power.
5. It can be easily altered: Anyone can use any household appliances by controlling it to its taste without the knowledge of the next person in the home. Smart home however has the ability to Log activities.

3.6 Problems of the Existing System

The manual home control system is not a perfect system because it has some problems. This is the more reason why the smart home control system must be put in place. These problems includes;

1. The inconveniences surrounded by the manual home control system
2. The security challenges faced with the system
3. The inability to control the appliances centrally
4. The high cost of energy loss.
5. Inability to prevent an outbreak that occurs when no one is home. Example; fire outbreak.
6. Burglars can have easy access to such homes
7. Home appliances can only be controlled when you are physically present unlike a smart home where you can switch on appliances using the internet from any location of your choice.

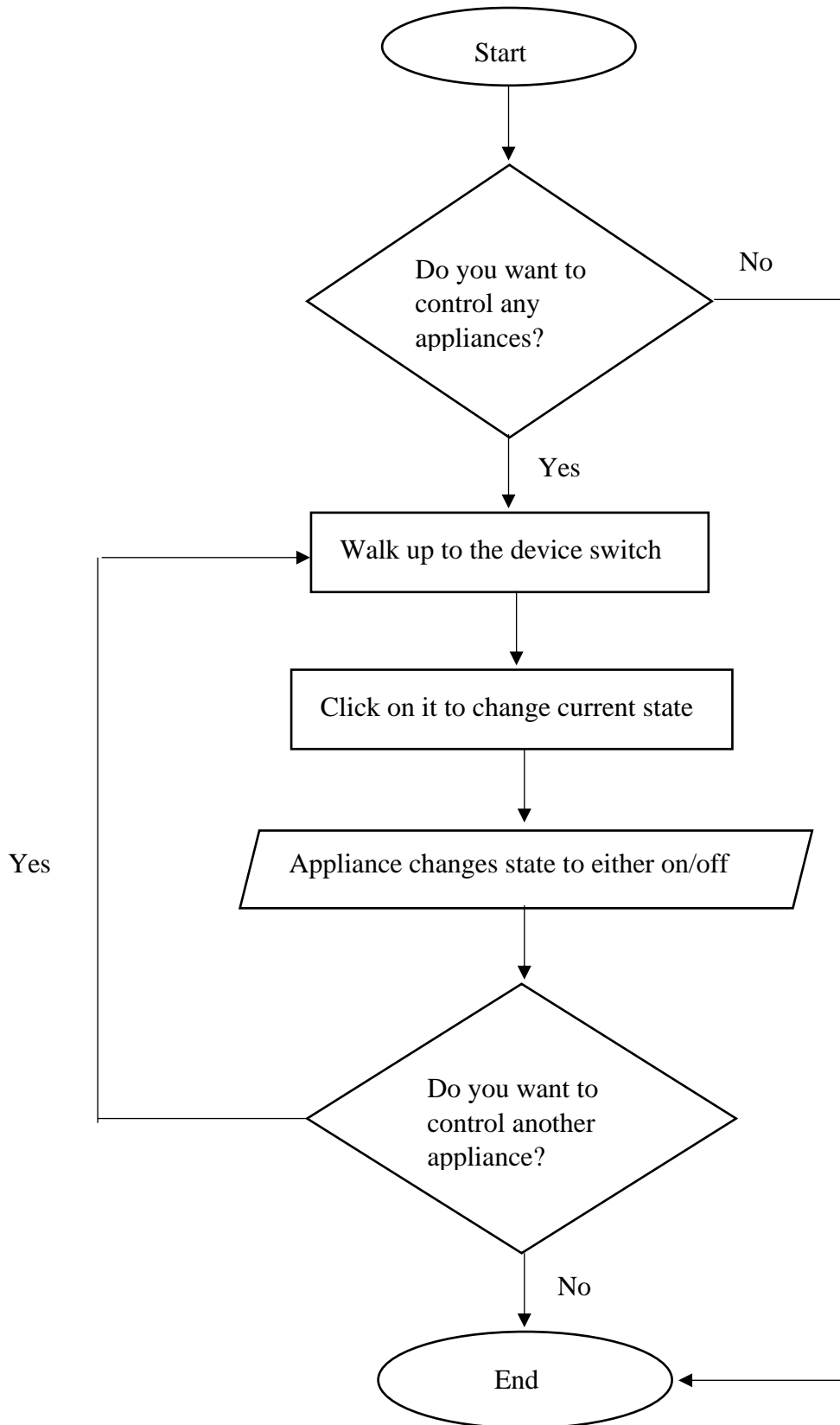
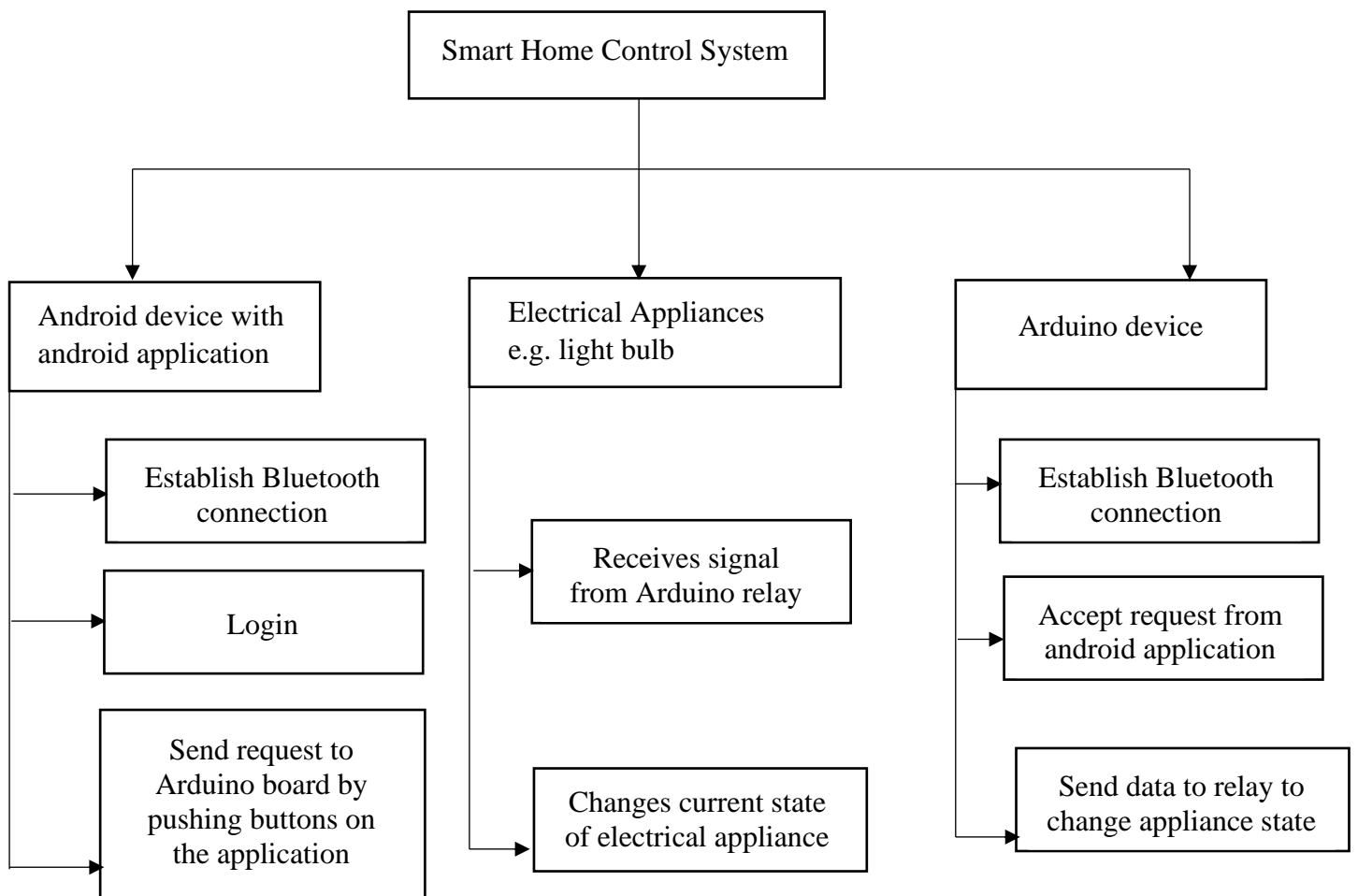


Figure 3.1: The organization of the present system using a flow chart

3.7 High Level Model of Proposed System

This section identifies all the modules in the new system design. Each module performs operations that are distinct from the operations of other modules. These modules work together as a system in order to achieve the objectives of the overall home automation process.



4.0: SYSTEM DESIGN

User Interface (UI) design is the process of making interfaces in software or computerized devices with a focus on looks or style (Calvin, 2019). The main aim here is to create designs users will find easy to use and pleasurable.

This project is an android application with various interfaces made up of interactive colours to make the application user friendly. The android application will contain different pages as shown below;

- i. The Landing page: This is the first page that welcomes the user after installing and launching the application. It will have an experience that happens when the user first opens the application. It will also contain some information about the downloaded application.
- ii. The Registration page: This page will allow the user enter his/her personal details that will be stored in the database.
- iii. The Login page: The user after a successful registration will be directed to this page for proper signing in.
- iv. Menu Page: This is the main menu with all the major activities in the application. From here, the sub menus of the application can be reached to control the smart home system.

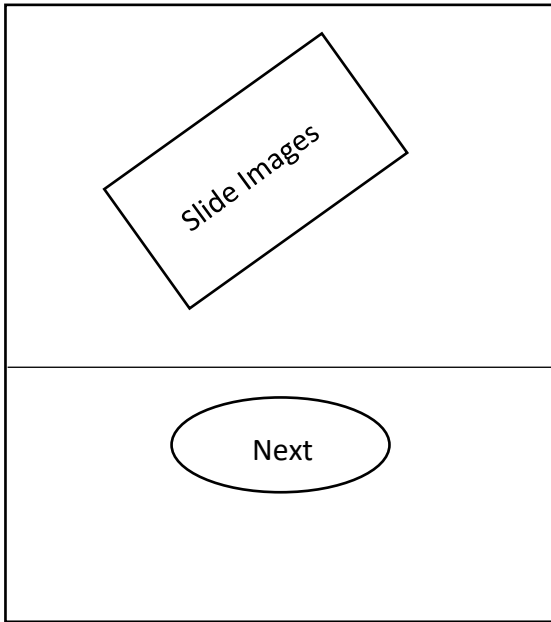


Figure 4.1: Landing Page

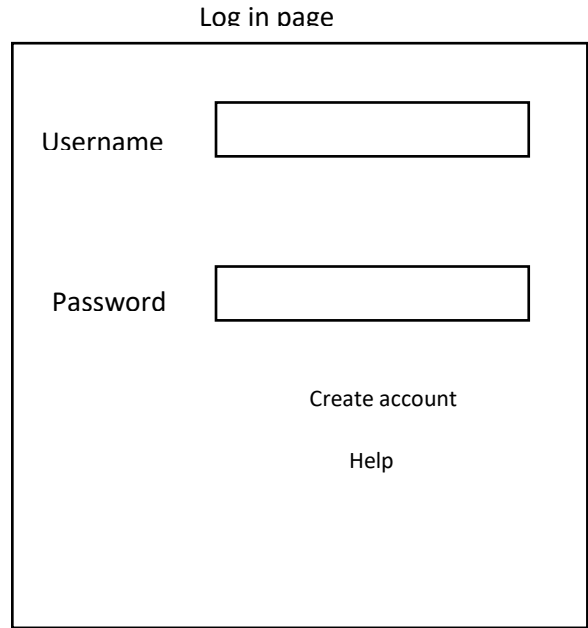


Figure 4.2: Login page

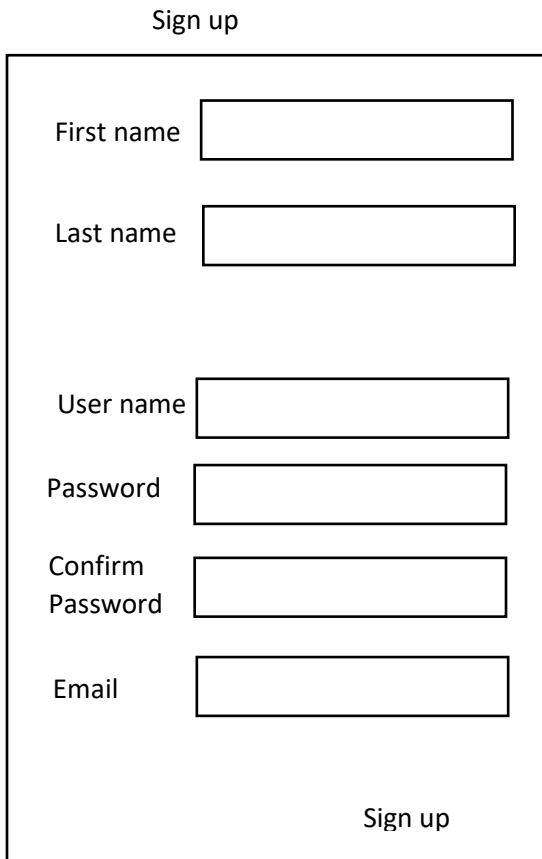


Figure 4.3: Register Page

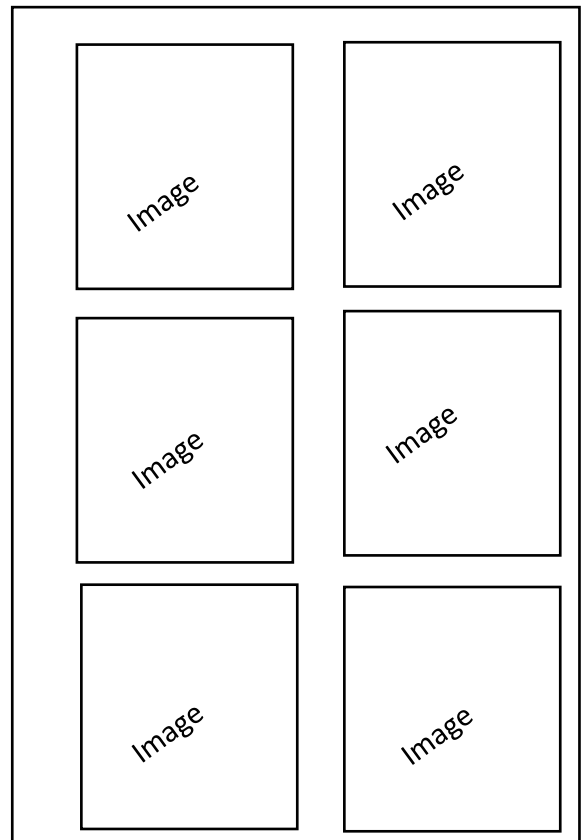


Figure 4.4: Main menu page

4.1 Database Design

The android application, Smart CSC will have a database majorly for storing information gotten from the user. The database has only one table and is called a flat file database (Techopedia, 2017). The database will be designed using the various design specifications below;

Entity Relationship Diagram:

An Entity Relationship Diagram shows the graphical representation of a database. It shows the tables and relationships between the tables in the database (SmartDraw, 2019).

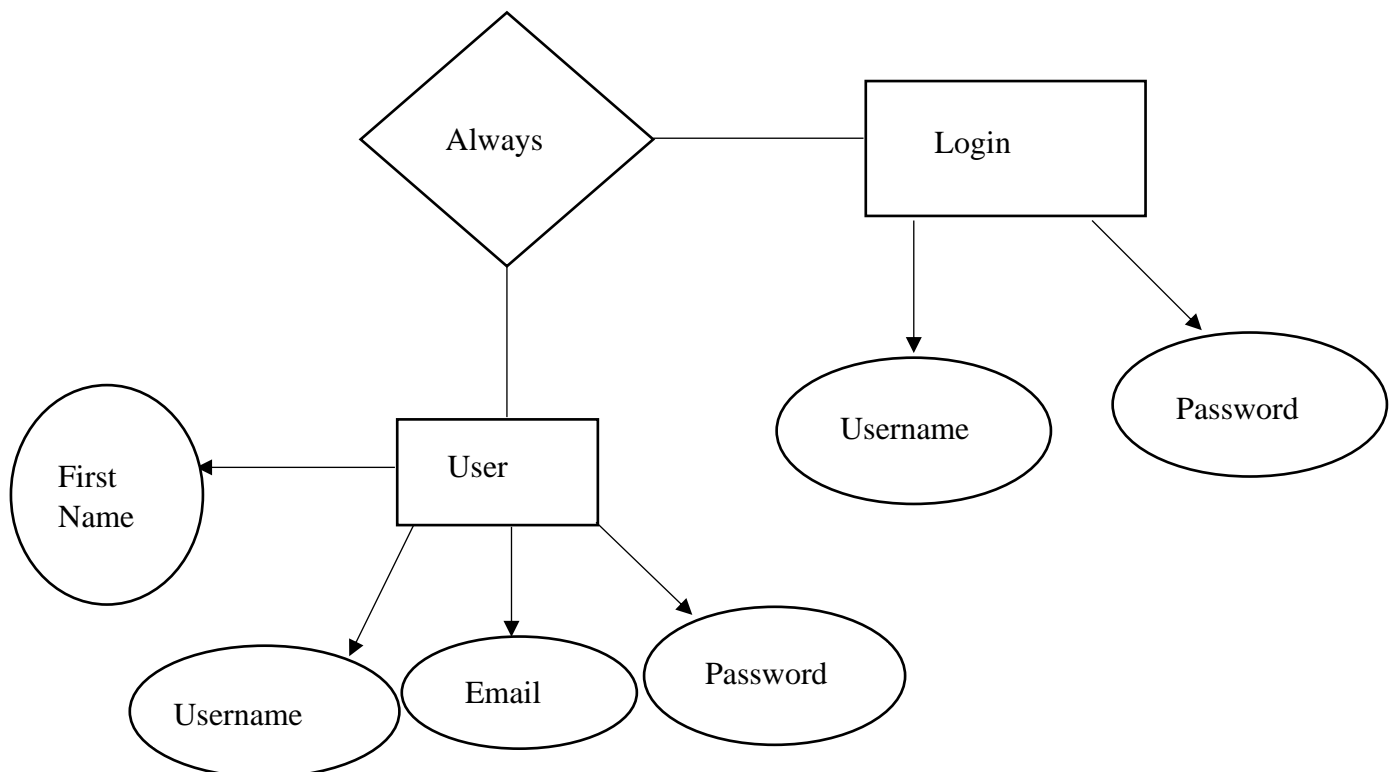


Figure 4.5: Entity Relationship Diagram

Table 4.1: Test Plan for Smart CSC Database Design

| Test for adding a record | | |
|---------------------------------|--|-------------------------------------|
| Users table | | |
| 1. | When a text is entered in the First name field | It saves the record on the database |
| 2. | When the first name field is left empty | It gives an error message |
| 3. | When a number is entered in the first name field | It gives an error message |
| 4. | When a text is entered in the Last name field | It saves the record on the database |
| 5. | When the last name field is left empty | It gives an error message |
| 6. | When a number is entered in the last name field | It gives an error message |
| 7. | When a variable character (text/number) is entered in the username field | It saves the record on the database |
| 8. | When the password entered matches with the confirm password | It saves the record on the database |

Table 4.2: Data Dictionary

| Table name\Entity | Field name\Attributes | Data type | Length | Default field value | Description |
|--------------------------|------------------------------|------------------|---------------|----------------------------|--------------------|
| | | | | | |

| | | | | | |
|------|------------|----------|----|------------------|-------------------------------|
| User | User ID | Number | 10 | | Primary key on the user table |
| User | First name | Text | 30 | | User's first name |
| User | Last name | Text | 30 | | User's last name |
| User | User name | Var char | 30 | | User's username |
| User | Password | Var char | 30 | | User's password |
| User | Email | Var char | 30 | lluste@gmail.com | User's Email address |

4.2 Program Specification

The requirement gathering stage includes the overall planning for the project and identifying all the project requirements such as hardware and software requirements. These processes are done by collecting data from many sources. At this stage plans were done about the project's resources and requirements, literature studies and schedule to get more information about the project. Materials were gotten basically using the internets on websites and YouTube, as well as books and research papers.

Within the data collection period, research shows that Android Operating System is the most common mobile operating system used in this part of the world and the creation of an Android application rather than iphone Operating System (IOS) or Windows is more preferable.

The following are the system requirements needed for the propose project;

- i. An operating system like Windows.
- ii. Database
- iii. A laptop or desktop computer
- iv. A virtual environment to test the application
- v. An android device to test the application
- vi. Massachusetts Institute of Technology (MIT) Application Inventor

The project required the specific hardware and software below;

- i. A laptop or desktop with at least 4 gigabyte RAM
- ii. A laptop or desktop running with a processor speed of at least 2.0 Giga hertz.

Software requirement for the project

- i. Massachusetts Institute of Technology (MIT) App Inventor
- ii. Fire base

Client-side System requirements:

- iii. Operating System: Android Operating System (from version 4.0 above)
- iv. Device: Android devices
- v. Internet access.

Input / Output Specification

The Program will have an input structure from the registration page where user's inputs will be gotten. The input and output specification are as shown below;

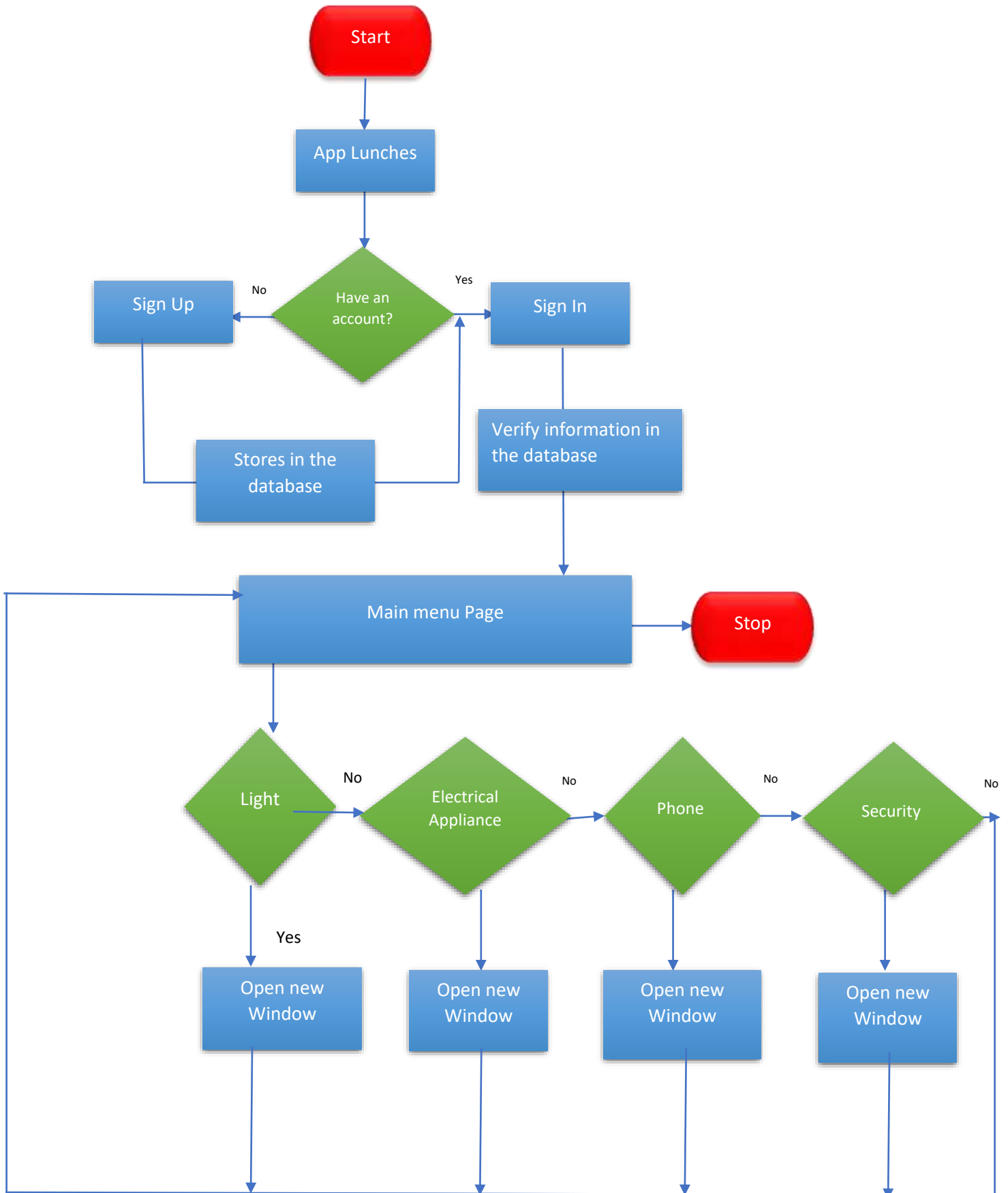
Sign up

| | |
|-------------------------------------|----------------------|
| First name | <input type="text"/> |
| Last name | <input type="text"/> |
| User name | <input type="text"/> |
| Password | <input type="text"/> |
| Confirm Password | <input type="text"/> |
| Email | <input type="text"/> |
| <input type="button" value="Sign"/> | |

| First Name | Username | Email | Password |
|------------|----------|--------------|----------|
| Stella | StellyA | St@gmail.com | ***** |

Figure 4.7: Output Scre

4.6 Overall System Flowchart and Block Diagram



4.7 Choice of programming Language

Programming language is a formal language which comprises of a set of instructions that produces various kinds of output. They are used in computer programming to implement algorithms. In developing the smart CSC system the C++ and MIT Block based programming language was used in the project implementation.

C++ is a powerful programming language that is quite stable and fast. In Arduino programming, the programmer does not program the Arduino board itself but the microcontroller inside the board. C++ programming language because of its stated features is of no doubt one of the best in programming micro controllers. MIT block based programming was used in creating because of the simplicity and benefit of fewer lines of codes it offers (Wikipedia, App Inventor for Android, 2016).

Conclusion

Smart home control technological system falls into the brand of new inventions and its importance cannot be over emphasized. No wonder it is widely used in more advanced countries.

It is high time we take the step ahead in ICT in this part of the world, looking away from some barriers that can hinder us.

5.3 Recommendation

Africa as a continent should not be left out in the flow of ICT. Many homes in other parts of the world already have these systems incorporated but the reverse is the case in Africa.

Nigeria as a hold needs to work on their electrical system (PHCN). This is because Smart CSC functions effectively when a house has electrical supply.

Students in computer science department should be encouraged to carry out more research in fields such as Internet of Things (IoT), robotics, artificial intelligence etc.

Finally, Citizens of Nigeria should do well to incorporate project such as Smart CSC in their homes without any fears to the best of their capacity.

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