Development of an Android Application for Power Consumption Management System Using Programmable Toggle Switch

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Abstract - Constant increase in power rate in the Philippines is attributed to the lack of supply to meet the consumer's demand. As a result, high consumption cost is added to the household budget especially when measures on conserving power are neglected. Such scenario inspired the researcher in creating a home automation technology to manage household power consumption applying current technology trends like the massive usage of internet and smart phones, at a minimal and reasonable cost. In order to attain the objectives of the study, affordable and quality technologies were considered. The android application was developed using MIT App Inventor. The android smart phone serves as the graphical user interface. The Arduino WiFi shield and the code written in C Language programmed in the Gizduino microcontroller make the wireless data communication between smart phone and the Programmable Toggle Switch (PTS). The device with patent title Programmable Toggle Switch and patent number PH/1/2009/272 is a smart device capable of automatic or manual control of connected electrical loads. The PTS is where the home appliances are connected that interprets the command from the microcontroller and executes possible action to the command executed in the android application. As a result, control to the home devices or appliances such as lights, TV and aircon, and power consumption management in the household were made possible at a minimal cost.

Keywords - Programmable Toggle Switch (PTS), Android, Smart phone, Microcontroller, and Power Consumption Management.

I. INTRODUCTION

In the Philippines, one of the prevailing problems in every household today is the continuous raise of power rates. This is believed to be one of the consequences of the fact that the country's power supply is not sufficient to meet the consumers' demand. The worst thing is that, the situation may carry on for a long period of time despite the efforts of the government to resolve the matter. Aside from the increase of power rates, electrical power consumption is also highly dependable on the household usage. The scenario in every household today is the propensity to neglect the fundamental nature of conserving energy especially now that variety of electrical appliances, machines, lightings, gadgets, and the like which believed to provide numerous advantages and comfort in every individual or household. The tendency is that at the end of the billing period the household is faced with a relatively high electrical bill which takes away a big part on the family income.

There have been several strategies considered by consumers to help cut off high power consumption such as home automation technology, also known as intelligent house technology or smart home system which automatically, manually, or remotely control the lighting, and other electrical appliances. However, several situations, reasons and behaviors deter the effectual utilization of such strategies like resources constraint considering the cost of installation of available home automation technology in the country and the unwillingness of consumers to sacrifice the comfort derive from utilizing electrical appliances, machines, lightings, gadgets, and the like over saving electrical power [1].

With these limitations, the development of a localized and low cost technology for home automation is a challenge that motivated this research that even a low-income individual or household can avail.

Hence, localized and low cost technology for home automation through the design and development of an android interface for a Programmable Toggle Switch or PTS. The device with patent title Programmable Toggle Switch and Patent number PH/1/2009/272 is a smart device capable of automatic or manual control of connected electrical loads that can easily be integrated into existing electrical wiring in the household.

II. METHODOLOGY

The research study involved three phases namely, software development, developed android application and PTS integration, and testing which include simulated and actual testing as shown in the developmental procedure flowchart in figure 1.

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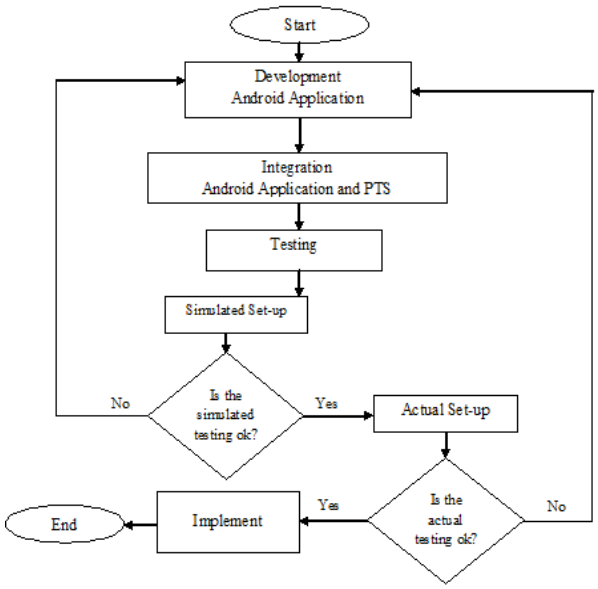

Figure 1: Developmental Procedure Flowchart

A. Software Development

Using MIT App Inventor that uses web browser for its blocks-based programming, the android application was realized [2]. It is a dependable android application tool that is user friendly and very simple to use. It is recommended for those that are new in android application development or programming and can work online and even offline whatever is more convenient to the user.

Knowledge in programming using C language was as well utilized for the microcontroller which is the Gizduino and the convergence of the smart phone and the PTS.

B. Developed Android Application and PTS Integration

This phase proved the compatibility of the developed android application and PTS.

The android application will work hand in hand with the PTS through ArduinoWiFi shield (CC3000) to attain its purpose. ArduinoWiFi shield is responsible for the communication of the android application and the PTS. The ArduinoWiFishield is under 802.11b/g standard protocol. It operates at 11Mbps and 54Mbps. Signal range is good and not easily obstructed [3]. Its main purpose is to let the communication between the Android Application to the PTS.

The PTS is capable of turning on or off an electrical load and may give indicators for each switch [4]. Generally:

- All ON/OFF switching capability.
- Easy integration with sensors, PC, and cellular phone for automatic and remote switching.
- Low voltage and current switching operation which results into lower power consumption.
- Power Management capability
- Short/open circuit isolation.
- Rapid switching rejection.

C. Testing

Simulation testing was undertaken first to analyze the capacity of the system, as well as to demonstrate its functions such as turning on/off home devices and planning, budgeting, monitoring energy consumption in the household before proceeding to the actual setup for further testing.

Actual testing was conducted in a bungalow type house. The research included 7 lamps, 2 convenience outlets for television and Aircon, PVC pipes, and others to simulate a dwelling unit where the PTS was installed.

All wiring methods and materials were in compliance with the Philippine Electrical Code (PEC).

D. Determining the Success Rate of the Application

The developed android application is expected to control home devices, and manage power consumption specifically to read energy consumption, acquire update on the energy consumption, instantiate warning, and set desired energy consumption

The reliability of the system is determined by the success rate. The success rate is calculated by dividing the total number of successful attempt (yes) by the total number trials multiplied by 100 percent as shown below:

$$\text{Success Rate} = \frac{\text{Number of successful attempt}}{\text{Number of trials}} \text{ x } 100\%$$

To verify the functionality of the wireless connectivity between the android application and the PTS, different location or area inside and outside of the house was considered, including the possible interferences like wall, noise and electromagnetic interferences caused by microwave oven or any household devices.

To further validate the success rate of the research study, twenty five user-respondents were considered to gather their feedbacks about the usage of the system. Also, test case was conducted. In software engineering, this test is vital to determine whether an application or software system or one of its features is working as it was originally established for it to do

III. RESULT AND DISCUSSION

A. System Architecture

The architecture of the system exhibits the relationship of each component and how the different components work together to control home appliances and manage household energy consumption as shown in figure 2.

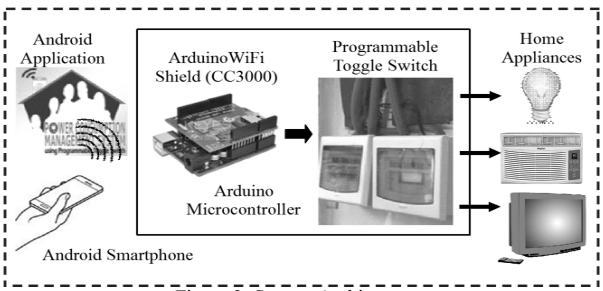

Figure 2: System Architecture

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The android smart phone is where the developed application is being installed that will serves as the Graphical User Interface (GUI). The code written in C Language programmed in the Gizduino microcontroller will make the wireless data communication between smart phone and ArduinoWiFi shield and serial communication between the Gizduino microcontroller and the ArduinoWifi shield.

The developed android application will communicate to the Arduino WiFi shield through web browser with the format http://ipaddress/digital/pin/r to read updates from Gizduino microcontroller, http://ipaddress/digital/pinno./1 indicating that the user wants to enable the device, and http://ipaddress/digital/pinno./0 indicating that you want to disable the device.

The programmable toggle switch is where the home appliances are connected. It interprets the command from the microcontroller and executes possible action to the command.

Communication between the Arduino WiFi shield and the Gizduino microcontroller uses serial communication. The program cc3000.ino for the arduino microcontroller is written in C language and compiled using arduino IDE. The program uses the aRest.h as a library to let the program communicates with the Arduino WiFi Shield and the developed android application via http. Functions like Serial.begins( ) which helps to initialize the serial part with a given baudrate. Serial.write ( ) to send a data to the serial port, Serial.available ( ) and serial.read ( ) functions to read from the serial port, atoi ( ) and atol ( ) function was also used to convert array to integer and array to long for the manipulation of data.

The Tx pin of the Gizduino microcontroller is connected to the Rx pin of the ArduinoWiFi shield and the Rx pin of the Arduino microcontroller is also connected to the Tx pin of the ArduinoWifi shield.

This makes possible the ability of the android application to queue in task to control and determine and active or inactive report status of home appliances and manage household energy consumption.

B. Feature of Android Application

The designed and developed application is suitable for android operating system only particularly from Ice Cream Version (API level 14) to Lollipop Version (API level 21) hence it is operational in a wide range of android based smart phones from the cheapest to the most expensive kind depending on the preference of the user. Once the application has been installed in the android smart phone it will perform its function.

Figure 3: Android Application Home Screen

It is capable in controlling home appliances, constantly read and display the actual power usage, setting the desired power consumption and instantiate warnings when 25%, 50%, 75% and 90% of the target is consumed.

C. Success Rate of the Application

The outcome of the research study is positive and flattering. The success rate in executing the different functionality of the developed android application surprisingly acquired 100% rating, both research and user-respondents experiences.

Unit testing was also conducted to confirm the individual units of the program. As shown in table 1, it implies that the program meets software requirements and behaves as the developer planned.

Table1: Unit Testing

Item	Name	Test Case Description	Test Step	Expected Result	Actual Result	Remark
1	Settings Screen	Set IP Address	1. Enter Invalid IP Address 2. Enter Valid IP Adress	1. Show Home screen, No control on devices, No data update 2. Show Home screen, Can control devices, Can aquire data	1. Show Home screen, No control on devices, No data update 2. Show Home screen, Can control devices, Can aquire data	Passed
2	Comsumption/ Energy	Power Consumption Management System	1. Enter cost of current per KWH(Php) 2. Enter Desired power consumption per month 3. Press the update button for the consumed energy.	1. Replaces the old value in to a new one 2. Replaces the old value in to a new one 3. Shows the computed KWH base on the amount of power consumption	1. Replaces the old value in to a new one 2. Replaces the old value in to a new one 3. Shows the computed KWH base on the amount of power consumption	Passed
3	Custom	Configuration of time for shutoff	1. Set the time for all devices to shutoff 2. Set the time for the TV outlet to ON/OFF 3. Long Press the "Shutoff" button	1. Can Set time 2. Can Set Time 3. Can Shutoff all devices	1. Can Set time 2. Can Set Time 3. Can Shutoff all devices	Passed
4	Living Room, Dining Room, Outdoor, Master Bedroom, Bedrooms, Bathroom	Turning On/Off the devices	1. Tap the device to control	1. Activate device 2. Deactivate device	1. Activate device 2. Deactivate device	Passed

IV. CONCLUSION

Based on the results and testing and analysis that have been done on the research study it can be concluded that the successful realization of the study proves the possibility of utilizing new technologies in conserving household consumption at a very minimal mechanism cost.

Furthermore, the android application is user-friendly and easy to use, valuable in terms of functionality and the success rate of the study is favorable. It is also effective and efficient in power consumption management in the

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household with the aid of PTS and provides ease in terms of the capacity to control the switches of home devices or appliances, worry-free in the household in terms of the ability of the application to read actual power consumption, plan desired power consumption for a certain period, and provides updates and warnings on power consumption, so current bills for the household can be constantly monitored and controlled.

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