Poweryno: A Household Power Consumption Manager Mobile Application through CO_2 Emission Detection Using Embedded Wireless Sensor Network

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***Abstract*—** As technology innovates, high energy consumption is at risk and so is the cost of electrical usage. With this, conservation and disciplinary measures is a must. This research introduces amobile application that helps the user in managing household power consumption through the carbon dioxide (CO_2) emission of their appliances, allow the user to check and monitor consumed power of loads in kilowatt per hour (kWh) and its equivalent production of CO_2. This study used wireless sensor network composed of Arduino, Bluetooth Module and Current Sensor. By connecting the Bluetooth Module and Current Sensor to the Arduino, this research was enabled to develop a mobile application which aids the user manage household power consumption. This study also included a scale model for the application testing and implementation.

***Keywords*—** global warming, arduino, alternative current, wireless sensor network, smart grid, smart metering, load/s.

I. Introduction

ABRUPT climate change is nothing new and imminent in this generation wherein it really became a global trend faced by humanity [1], and for years we have been experiencing different effect of it. The rapid changes have made a huge impact on everything for which living creatures struggle to keep up with climate shifts. An increase in the Earth atmospheric temperature causes corresponding changes in the surface such as extreme heat waves, rising of sea levels, disruption of habitats and any others. This is caused by the improper use of natural resources [2], such as burning of fossil fuels came from coal – burning of power plants to make electricity and burning of gasoline for the transportation sector. These produce a billion tons of carbon dioxide (CO2) emission, every year which is been added to other greenhouse gases. Moreover, generally speaking, users who are not willing to degrade their lifestyle by lessening the use of electronic devices are considered as another factor that contributes to climate change wherein a large number of toxic waste disposal [3], are mostly came from humans. In fact, a huge number of toxic wastes were improperly disposed leading into outgrowing pollution [4].

In addition, the rapid progress and innovation of technologies lead to high demand of energy consumption and generation [5, 6] which consumes and producesa lot of energy and carbon dioxide ($C0_2$) [7]. Therefore, the technological industry is considered as one of the contributor that causes degradation to natural and environmental resources.

However, technology can also be a solution in creating a sustainable value for achieving the goals of social and economic prosperity. Sustainable value is an economic value coupled with/and environmental value dimensions wherein it has a green capability or an ability to use its resources and conserve the natural environment [8], specifically, these are people or firms that creates technological solutions using the proper selection of environmental resources mainly known as Green IT.

As a result, this study proposes a flexible mobile application entitled "Poweryno: A Household Power Consumption Management Mobile Application through $C0_2$ Emission Detection Using Embedded Wireless Sensor Network", which main objective is to develop a mobile application that will aid the user to manages household power consumption through the use of statistical information given by the detected equivalency emission of $C0_2$. This project is presented and dedicated to encourage the less usage of energy, thus the cost, by providing accurate and reliable information regarding power consumption to the users. It is designed to aid the user to review energy usage of loads. With this, it can formulate a way of conserving energy and saving family income. Furthermore, it provides environmental awareness regarding on the emission of carbon dioxide ($C0_2$) and prevention of electrical circuit problems.

II. Related Works

This project mainly addresses the improper power consumption in a household. Power consumption in domestic sector has an enormous contribution to the total consumed energy of a country; its global average is around 30% [9]. Therefore, any development that could help to conserve energy would be a vital resolution. This research aim to resolve the existing problem through a timely power

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monitoring with a highly regards of detecting the emission of C02. Technology in the present times plays a vital role both personally and in society. Therefore, this research is intended to utilize the usage of power by proper monitoring and management using the provided information about the negative effects of emitting too much CO2. In this way, the research also contributes knowledge and consciousness in the domestic sector about environmental effects of the excessive consumption of power. Furthermore, this also help in making provisions of the desired consumed power within the specific time period and give additional information on how to conserve energy.

There is also growing a number of researches in this field of study. Predominantly, these researches innovated Internet-of-Things which is the integration of hardware and software technology to create a useful application. With regards to power monitoring, the related researches commonly a combination of Arduino microcontroller, current sensor and a wireless network. The wireless network they used can either be Zigbee [10], Raspberry PI server [11], Wifi module [12] or Bluetooth module [13]. With this, there can be a number of ways to develop a mobile application that monitors the power consumption. However, almost to none seemed to touch the encouragement of Green IT hence the researchers came up with the proposed study.

Thus, this study develops a low-cost power monitoring mobile consumption with the addition of detection of carbon dioxide emission. This paper provides an application using Arduino, Bluetooth Module and Current Sensor. LED light bulbs are also included to test the appliances management in a scale model. The researchers originally used wifi module and raspberry pi v2 to upload the wattage detected in a database and later on retrieved in a mobile application. However, said methodology only cost too much time and minimal results with the incapability of wifi module to be parsed and flashed and the Raspberry Pi v2 slow uploading and retrieval of data to the mobile application.

III. Methodology

This project used agile software development method to meet the intended objectives comprising its hardware and software requirements, development and outcomes. In this methodology, the researcher first assesses the project they proposed, indicating the planning phase. Then, after making a firm concept about the project, the concept is analyzed for further review, modifying the proposed statements if it requires. Moving onto the design phase, the researchers intellectualize the idea into an architectural theory. Even so, the researchers, at some point, go back in analyzing the project over and over to achieve better design in the end. After so, the researchers implemented the analyzed data and designed structure but not without going back to analysis and design if it is needed. With all the information thoroughly processed, the researchers finally developed the system. However, the researchers maintain the system such that the system development goes back to analysis, design and implementation, when the user's need calls for it. Aside from the agile development methodology, the researchers also use quantitative method wherein interviews and surveys are conducted. The purpose for this is for the researchers to know what they projected users need and will the project really help them in their daily lives. Furthermore, this research used three different programming languages to accumulate the interconnection between the hardware and software modules. The languages are C++ which was used in programming the current sensor in Arduino in order to detect the power consumed; Java which was used in developing the mobile application which receives the data from the Arduino via Bluetooth. In addition, the study used a GraphView jar file in order to generate graphical representation of the wattage in timely basis. Lastly, this research was evaluated using ISO9126 criteria in software evaluation. The evaluation forms were distributed during testing stage. Following the Likert's Scale, the system was evaluated by its acceptance rate. The evaluation results of this research are presented in the latter part of this paper.

IV. Results and Discussion

This section presents the results of the study. Figure 1 shows the system architecture of the mobile application succeeded by the major components of the power consumption monitoring system.

The project used three tier architecture (seen in Figure 1) such as logic tier, server tier and client tier. The logic tier are compose of 20A current sensor which was attached into an extension socket and Arduino Mega 2560. This tier is responsible for gathering and processing of data wherein the current sensor was capable to sense and to read the input / output voltage of the plug – in loads. Meanwhile, server tier was composed of Bluetooth module which is responsible for sending of data back and forth to the Arduino and mobile application. Lastly, client tier was composed of the mobile application that provides a viewer interface to the client. Poweryno can communicate with the user through the use of remote application using the Bluetooth module HC-05.

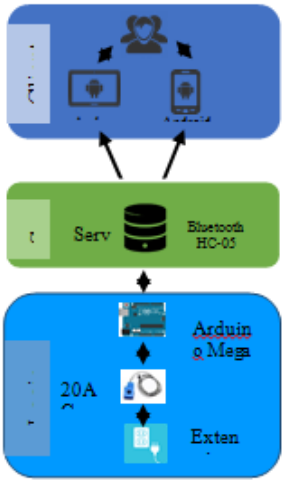

Fig. 1 System Architecture of Poweryno

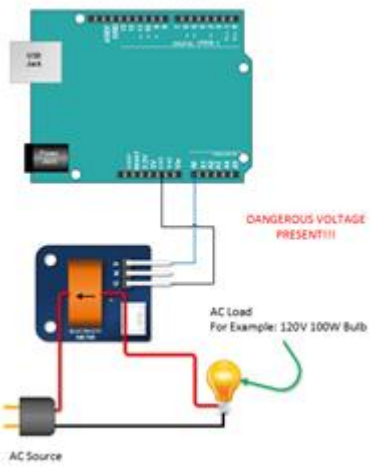

Fig. 2 The connection of Arduino, Current Sensor and Power Socket

The logical connection between the Arduino and Current Sensor is presented in Figure 2. The 20A current sensor is mounted to Arduino microcontroller through GND, VCC and A0 pin. On the other hand, the extension socket used in this research contained the current sensor through connecting wires mounted on both module. On the other hand, the Bluetooth module is mounted on the Arduino microcontroller through RX-TX, VCC, and GND pin.

Fig. 3 Home Page, and Appliances Panel

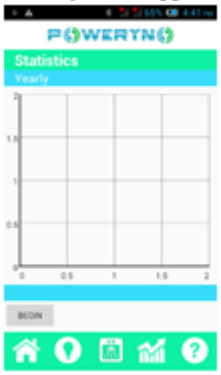

Fig. 4 Statistics Panel

Figure 3 shows the home page panel serves as the main panel of the mobile application wherein it aids the user to select his suggested consume power. The user will be asked to turn on the Bluetooth in order to receive the wattage. The user doesn't need to choose which device to be connected to for the application automatically connects itself to the bluetooth module in the prototype via its MAC address. Meanwhile, appliances panel allows the user to view the appliances' power consumption individually in details and in addition, allows the user to switch the appliances on and off. Figure 4 shows the statistics panel where the user can view his/her periodic power consumption to aid him/her decide how manage household consumption. The researchers embedded an additional GraphView jar file into the application in order to generate the intended graph.

Figure 7 Extended view of Appliances Panel (left) and Tips Panel (right)

Figure 7 shows the detailed consumption of a particular appliance and statistical information about the CO_2 emission as supplied by the Association of Electricity Producers. The extended view of appliance panel also indicates the amount of carbon dioxide (CO_2) emitted by the appliance – television for this instance. On the other hand, tips panel gives helpful information on conserving the power consumption of television.

Fig. 8 The Research Prototype implemented in a Scale House Model

Figure 8 shows the implementation of the study in a scale model. LED light bulbs are used to test the switching on and off of appliances using the application. This prototype can be controlled effectively by the mobile application as discussed earlier.

TABLE I
SUMMARY OF SOFTWARE EVALUATION RESULTS

Criteria	Mean	Interpretation
Functionality	4.59	Highly Acceptable
Relilability	4.61	Highly Acceptable
Usability	4.41	Acceptable
Efficiency	4.47	Acceptable
Maintainability	4.41	Acceptable
Portability	4.40	Acceptable
Overall Weighted Mean	4.48	Acceptable

The table shows the results gathered in the software evaluation based on the Likert's scale which discussed the acceptability and productivity of the system. The functionality of the system got a total mean of 4.59 which proves that the system's functionality along with its specified task is properly working and affirmed to be highly acceptable. The reliability of the systemgot a total mean of 4.61 which proves that the system's reliability in terms of storing and retrieving of datais highly acceptable. The usability of the system got a total mean of 4.41 which was asserts as acceptable and simply indicates that the GUI is user – friendly and displays an accurate information. The efficiency of the system got a mean of 4.47 which was also interpreted as acceptable and indicates that it has an allocated memory space for the application and its database. It also reflects that the system optimizes the least space required to execute its maximum potential. The maintainability of the system reached the mean of 4.41 which was marked as acceptable wherein it refers to the capability of handling and determining the root cause of errors. Lastly, the portability of the system reached a mean of 4.40 which was also marked as acceptable and is refers to the compatibility of the system and the ability to perform its function along with the environment. Summing it up, the total mean was 4.48, which remarked the entire system as acceptable.

V. CONCLUSION

This study aims to develop a mobile application that will aid the user to manages household power consumption and to display the equivalent emission of $C0_2$ using the gathered data in the wireless sensor network. The research concluded the effectiveness of using low-cost prototype such as Arduino microcontroller, Current Sensor and Bluetooth module. With the stated hardware used, the project was able to develop a supplementary application which notifies the user regarding his/her power consumption reaching the target limitation in order to help the user conserve energy. The research is intended to use Raspberry Pi v2 and Wi-Fi module. However, there had been situation wherein the data retrieved through Raspberry in the application is slow and the connection through Wi-Fi is unstable. Thus, the research used alternatives while lessening the cost. In addition, the project evaluation resulted in "Acceptable" rating which specifies the functionality, usability, efficiency, maintainability and portability of the system, giving the user a perception about this research. To conclude, the study was able to develop a mobile application that monitors the power consumption in kilowatt per hour, indicates its equivalent emission of carbon dioxide and in turn, aid the user in managing household power consumption. However, this study also recognized some recommendation for the enhancement of the project including: (a) the integration of embedded wireless sensor network in a wider range enabling the communication of modules available outside; (b) the development of iOS version of Poweryno mobile application for iOS users and; (c) innovation of Poweryno to companies and firms to promote green technology.

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