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Energy Management Solution using Internet of things

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ABSTRACT*:* *Energy management is imperative at a time like this. Due to rising population and lack of adequate power supply to satisfy energy consumers, there is an urgent need to provide an efficient way to manage energy. This study proffers solution to the enormous challenge of managing energy by developing a model that helps both consumer and energy providers manage energy efficiently. This solution will enable monitoring of power over a specific period and intelligent switching of power sources. Thus, the energy consumer gets a detailed information of energy usage and specific time and duration of power switching between different energy sources. It assists energy providers such as the Electricity DISCOs (Distribution Companies) to monitor energy distribution. The study composes four distinct parts which are; the automatic transfer switch, the internet of things module, the mobile application and the cloud server. This study helps to intelligently chose between energy sources, observe and log power usage patterns of homes, provide analytics and insight to energy usage by consumers, provide ease, comfort and safety to users and optimally manage energy in homes.*

KEYWORDS: Electric energy, Internet of Things (IoT), energy management, mobile applications, cloud servers, automatic transfer switch (ATS).

INTRODUCTION

Electric energy was the bedrock on which the industrial revolution in the western world was built, industries need constant electricity to facilitate constant production, electricity is also needed in other to carry out domestic activities effectively. However, countries like Nigeria and other developing countries have been suffering from epileptic power supply which has been detrimental to both technological and economic growth of these nations.

The poor state of power supply in Nigeria calls for alternative source(s) of power generation as a back up to supply from the power grid. Across the globe, call for efficient use of energy has never been greater, with the rising cost of energy, ecological awareness, and a lack of significant advances in achieving a reliable source of clean and green energy in recent decades. Energy management

solutions provide several advantages to our cities and homes such as saving cost, reducing environmental carbon footprint, optimizing efficiency, safety and comfort.

Several solutions have been developed around industrial and domestic optimization of energy sources, amongst several attempts at this subject, a most promising enterprise is the rise of autonomous technologies, case in point, the **Internet of Things (IoT)**. An area where IoT plays a major role is in the monitoring of energy consumption *(*Haller *et al*., 2009*).* IoT technology (e.g. smart meters and sensors) provide awareness of energy consumption patterns by collecting real-time energy consumption data.

In Nigeria, even though the primary source of power remains the Electricity Distribution Companies (DISCOs), most households rely on self-generated electricity to maintain sufficient back up to power their operations in the event of power failure. The development had impacted negatively on the capacity utilization of cities, which had declined from 59.8 per cent in 2014 to 54.2 per cent in second quarter of 2015 and output with attendant loss of revenue. (Chukwueyem, *et al* 2015).

Recent developments in the area of information and communication technologies have provided an advanced technical foundation and reliable infrastructures for the smart house with a home energy management system. Development of low power, cost-efficient and high-performance smart sensor technologies have provided us with the tools to build smart systems.Hence, this study aims to develop a system that efficiently manages electric energy by automatic change of energy sources and seamless storing of power log in a cloud server in real time.

Objectives

The specific objectives are to:

i. Intelligently switch between two sources of power, with a set time usually in seconds.
ii. Record logs of power usage and duration of use of both power sources in real time.
iii. Ease in accessing power usage analytics by consumers at any time.
iv. Control of energy usage by consumers over the internet and in real time.

The indispensability in the use of electric energy and general consensus that available energy from the national grid is not enough for the ever-growing populace, the urgent need to reduce waste of energy which will help in saving cost, reduction of greenhouse gases and provide the needed balance in generation and use of energy justifies this study.

REVIEW OF LITERATURE

Energy Management System

An Energy Management System (EMS) is a system of computer-aided tools used by operators of electric utility grids to monitor, control, and optimize the performance of the generation and/or transmission system. Also, it could be used in small scale systems like micro grids. It is also referred

to as SCADA/EMS or EMS/SCADA (Energy Management System/supervisory control and data acquisition).

Energy management systems are often commonly used by individual commercial entities to monitor, measure, and control their electrical building loads. Energy management systems can be used to centrally control devices like HVAC units and lighting systems across multiple locations, such as retail, grocery and restaurant sites. Energy management systems can also provide metering, sub metering, and monitoring functions that allow facility and building managers to gather data and insight that allows them to make more informed decisions about energy activities across their sites. This system takes an analysis of the overall utility pattern and implements measures to reduce the energy usage.

Significance of Energy Management System ranges from cost reduction, risk reduction, reduction of carbon emission, future energy consumption projection to mention just a few.

Concept of Energy Efficiency in Energy Management

Energy efficiency consists of reducing the energy consumption, keeping the same energy services but using sustainable methods that protect the environment (Maria, 2016). The socio-economic factors concerned with energy efficiency are clearly the saving on the energy bill, reducing of climate change impact and also the reduction of the external energy dependency. However, the energy and environment benefits of the energy efficiency implementation are the CO2 reduction in the atmosphere. It is important to be conscious with the use of resources and to contribute towards sustainability.

Internet of Things (IoT)

According to (Maria, 2016), Internet of Things (IoT) is the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT have been associated with machine-to-machine (M2M) communications; hence, they are often referred to as being smart. It is otherwise referred to as the Internet of Everything (IoE).

The usage of modern technologies coupled with concepts coming from the Internet of Things and the Internet of Services will lead to a paradigm shift in the way energy is being generated and consumed. Innovative new technologies and concepts will emerge as we move towards a more dynamic, service- based, market-driven infrastructure, where energy efficiency and savings can be better addressed through interactive distribution networks. One example from the energy area that shows the importance of the Internet of Things is the creation of an advanced metering infrastructure (AMI), and a system that can track how energy is being consumed overtime. AMI refers to systems that measure, collect, and analyze energy usage from advanced devices such as electricity, gas, and water meters.

Internet of Things is a new revolution of the Internet. The goal is to facilitate connection among appliances at any point with anything and anyone using any path/network and any service.
The concept is defined into three categories as listed below.

i.People to people.
ii.People to machine/things.
iii.Things /machine to things/ machine, interacting through the internet.

Enterprise Internet of Things (IoT)

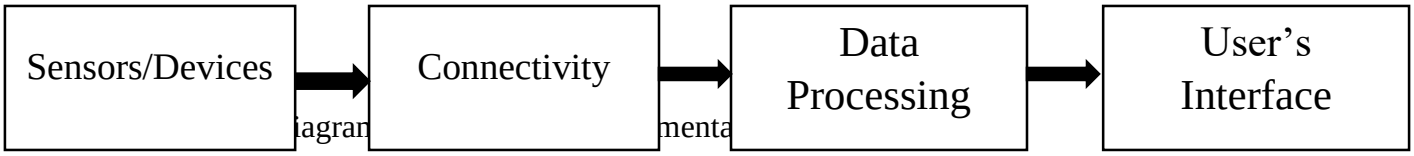
Enterprise IoT simply means many sensors that produce data within a smart building's infrastructure (daintree.net, 2015). It comprises wireless networks, devices and sensors that are controlled by intelligent software. This combination of technology allows companies to collect data, analyze what is happening across a building or portfolio of buildings and make ongoing improvements that have a tremendous impact on cost cutting, while at the same time increasing operational efficiency.

Fundamentals of how IoT Works

The Internet of Things (IoT), otherwise known as Internet of Everything (IoE), consists of all the web enabled devices that collect, send and act on data they acquire from their surrounding environments using embedded sensors, processors and communication hardware (Johnson, 2018). These devices, often called "connected" or "smart" devices, can sometimes interact with related devices, a process referred to as machine to machine (M2M) communication, and act on the information they get from one another. Humans can interact with the gadgets to set them up, give them instructions or access the data, but the devices do most of the work on their own without human intervention.

Fundamental Components of a Typical IoT Ecosystem

There are four basic components that paints a good picture of how internet of things works (https://dataflair.training/blogs/howiotworks/): sensors or device, connectivity, data processing, and user interface. These are briefly discussed below as well as it is being depicted by the block diagram below.



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Sensors/Devices

The first being sensors or devices, helps in collecting very minute data from the surrounding environment. This is fundamentally information gathering either from a standalone sensor or multiple devices. All of this collected data can have various degrees of complexities ranging from a simple temperature monitoring sensor or a complex full video feed. A device can have multiple sensors that can bundle together to do more than just sense things.

Connectivity
Consequently, the collected data is sent to a cloud infrastructure, but it needs a medium for transport. The sensors can be connected to the cloud through various mediums of communication and transports such as cellular networks, satellite networks, Wi-Fi, Bluetooth, wide area networks (WAN), low power wide area network and many more. Every option we choose has some specifications and tradeoffs between power consumption, range, and bandwidth. So, choosing the best connectivity option in the IOT system is important.

Data Processing
Once the data is collected and it gets to the cloud, the software employed processes the acquired data. This can range from something very simple, such as checking that the temperature reading on devices such as AC or heaters is within an acceptable range. It can sometimes also be very complex, such as identifying objects (such as intruders in your house) using computer vision on video.

User Interface
Eventually, the information is made available to the end user in some way. Depending on the IoT application and complexity of the system, the user may also be able to perform an action that may backfire and affect the system. For example, if a user detects some changes in the refrigerator, the user can remotely adjust the temperature via their phone.

Action and/or correction where necessary can be effected automatically. This is possible by establishing and implementing some predefined rules, the entire IOT system can adjust the settings automatically and no human has to be physically present. Also, in case if any intruders are sensed, the system can generate an alert not only to the owner of the house but to the concerned authorities.

Hardware and Software Components of an IoT Based Energy Management Solution
Software Components
Generally, two programming languages were used during the course of implementing this study. They are Arduino and node red.The Arduino environment is an open-source software which enables a user to write code and upload it to the I/O board. The environment is written in Java. The Arduino development environment contains a text editor for writing code, message area, text console, and toolbar with buttons for common functions, and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. Arduino programs are written in C or C++. Arduino features, capable of compiling and uploading programs to the board with a single click.

The software that are written using Arduino is called sketches. These sketches are written in the text editor. Sketches are saved with the file extension ". ino". It has features meant for cutting/pasting and for searching/replacing text. The message area gives feedback while saving and exporting and also displays errors. The console displays text output by the Arduino environment including complete error messages and other information. The bottom right-hand corner of the window displays the current board and serial port. The toolbar buttons allow you to verify and

upload programs, create, open, and save sketches, and open the serial monitor. As the Arduino platform uses Atmel microcontrollers, Atmel's development environment, AVR Studio or the newer Atmel Studio, may also be used to develop software for the Arduino (Arduino Development Environment -, http://arduino.cc/en/guide/Environment).

Node red is flow-based programming for wiring the Internet of Things. It is Written in JavaScript Operating system cross-platform. It was developed by IBM Emerging Technology- Nick O'Leary and Dave Conway-Jones (Source: https://github.com/node-red/node-red)

Statistics on the Applications of IoT

The connectivity advantage that IoT offers now goes beyond laptops and smartphones, it's going towards connected cars, smart homes, connected wearables, smart cities and connected healthcare. Basically, a connected life. According to Gartner report, by 2020 connected devices across all technologies will reach to 20.6 billion (Kashyap, 2016)

Real Life Applications of IoT

Internet of Things is not just a theoretical concept. It is practical as it has major applications in the most impacting areas of man's activities and life. Typical sectors of human life where IOT is currently being applied are briefly discussed subsequently. Not forgetting that IoT is also solving energy management problems which is the primary focus of this report.

Smart Home

Smart Home has become the revolutionary ladder of success in the residential spaces and it is predicted Smart homes will become as common as smartphones. The cost of owning a house is the biggest expense in a homeowner's life. Smart Home products are promised to save time, energy and money. Typical smart home companies include: Nest, Ecobee, Ring, and August
Smart homes make it possible to switch on air conditioning before reaching home or switch off lights even after you have left home; unlock the doors to friends for temporary access even when you are not at home (cnet, 2018).

Wearables

These are devices that employs IoT and can be worn on the body. Companies like Google, Samsung have invested heavily in building such devices Wearable devices are installed with sensors and software which collect data and information about the users. This data is later processed to extract essential insights about user. These devices broadly cover fitness, health and entertainment requirements. The prerequisite from internet of things technology for wearable applications is to be highly energy efficient, ultralow power and small sized.

Industrial Internet of Things (IIoT)

It is empowering industrial engineering with sensors, software and big data analytics to create brilliant machines. According to Jeff Immelt, CEO, GE Electric, IIoT is a "beautiful, desirable and investable" asset. The driving philosophy behind IIoT is that, smart machines are more accurate

and consistent than humans in communicating through data. And, this data can help companies pick inefficiencies and problems sooner. IIoT holds great potential for quality control and sustainability. Applications for tracking goods, real time information exchange about inventory among suppliers and retailers and automated delivery will increase the supply chain efficiency. According to GE the improvement industry productivity will generate $10 trillion to $15 trillion in GDP worldwide over next 15 years.

IOT in Healthcare

Connected healthcare yet remains the sleeping giant of the Internet of Things applications. The concept of connected healthcare system and smart medical devices bears enormous potential not just for companies, but also for the wellbeing of people in general. Research shows IoT in healthcare will be massive in coming years. IoT in healthcare is aimed at empowering people to live healthier life by wearing connected devices. The collected data will help in personalized analysis of an individual's health and provide tailor made strategies to combat illness.

WEB SERVER

A web server is a program that uses HTTP (Hypertext Transfer Protocol) to serve the files that form web pages to users, in response to their requests, which are forwarded by their computers' HTTP clients. Dedicated computers and appliances may be referred to as web servers as well.The process is an example of the client/server model. All computers that host web sites must have web server programs. Leading web servers include Apache (the most widely-installed web server), Microsoft internet information server (IIS) and nginx from NGNIX. Other web servers include Novell's Netware server, Google web server (GWS) and IBM's family of Domino servers.

Web servers often come as part of a larger package of internet and intranet related programs for serving email, downloading requests for file transfer protocol (FTP) files, and building and publishing web pages. Considerations in choosing a web server include how well it works with the operating system and other servers, its ability to handle server-side programing, security characteristics and the particular publishing, search engine and site building tools that come with it.

Various Digital Platforms and the typical IoT Webservers Employed

There are several web servers used in internet of things. The choice of the one that is eventually employed depends on some factors such as: size, simplicity, clarity, and licensing. Here are a number of digital service providers and the web servers that they employ.

- **Amazon Web Services IoT Platform**

Amazon Web Services (AWS) IoT is a managed cloud platform that lets connected devices easily and securely interact with cloud applications and other devices. AWS dominates the consumer cloud market. They were the first to really turn cloud computing into a commodity way back in 2004. Since then, they have put a lot effort into innovation and building features, and probably have the most comprehensive set of tools available. It is an extremely scalable platform, claiming to be able to support billions of devices, and trillions of interactions between them. AWS IoT makes it

easy to use AWS services like AWS Lambda, Amazon Kinesis, Amazon S3, Amazon ML, and Amazon DynamoDB to build Internet of Things (IoT) applications that gather, process, analyze and act on data generated by connected devices, without having to manage any infrastructure.

- **Microsoft Azure IoT Platform**

Microsoft-bot-framework is used. Microsoft is taking their Internet of Things cloud services very seriously. They have cloud storage, machine learning, and IoT services, and have even developed their own operating system for IoT devices. This means they intend to provide a complete IoT solution provider.

- **IBM Watson IoT Platform**

Watson is used. IBM is another IT giant trying to set itself up as an Internet of Things platform authority. They try to make their cloud services as accessible as possible to beginners with easy apps and interfaces. You can try out their sample apps to get a feel for how it all works. You can also store your data for a specified period, to get historical information from your connected devices.

- **Oracle**

oracle-min is used. Oracle is a platform as a service provider that seems to be focusing on manufacturing and logistics operations. They want to help you get your products to market faster.

- **Bosch**

Bosch-IoT-cloud-min is used. Bosch is a German based company IT company, who have recently launched their own cloud IoT services to compete with the likes of Amazon. They focus on security and efficiency. Their IoT platform is flexible and based on open standards and open source.

- **Cisco IoT Cloud Connect**

Cisco-min is used. Cisco is a global leader in IT services, helping companies "seize the opportunities of tomorrow". They strongly believe that the opportunities of tomorrow lie in the cloud and have developed a new 'mobility-cloud-based software suite'.

HEROKU

Heroku is a cloud platform that lets companies and services build, deliver. It focuses relentlessly on apps and the developer experience around apps. Heroku lets companies of all sizes embrace the value of apps, not the distraction of hardware, nor the distraction of servers virtual or otherwise.

Heroku is one of the simplest cloud hosting options available now, it is built around the Unix philosophy which states "you should do one thing and do it well". It has been around since around 2007, owned by salesforce.com, one of the oldest and largest cloud enterprise companies. Heroku touts itself as a polyglot platform as its support majority of the programming language and web framework available. It is built on top of Amazon web services one of the largest, oldest and widely used cloud platforms. Amazon web services is known for its speed, availability, and flexibility. The platform automatically buffers any incoming HTTP requests at the load balancer level to ensure no requests are dropped. Application that are run on Heroku typically have a unique domain (typically" applicationname.herokuapp.com") used to route HTTP requests to correct dyno. Each of the application containers, or dynos, are spread across a "dyno grid" which consists of several servers. Heroku's Git server handles application repository pushes from permitted users.

All Heroku services are hosted on Amazon's EC2 cloud-computing platform. The working can be summarized into two major categories

1. Deploy

The main content of the development is the source code, related dependencies if they exist, and a profile for the command. The application is sent to Heroku using either of the following: Git, GitHub, Dropbox, or via an API. There are packets which take the application with all the dependencies, and the language runtime, and produce slugs. These are known as build-packs and are the means for the slug compilation process. A slug is a compilation/bundle of the source code, built dependencies, the runtime, and complied/generated output of the build system which is ready for execution. Next is the config vars which contains the customizable configuration data that can be changed independently of the source code. Add-ons are third party, specialized value-added cloud services that can be easily attached to an application, extending its functionality. A release is a combination of a slug (the application), config vars and add-ons. Heroku maintains a log known as the append-only ledger if releases the developer makes.

2. RUNTIME

The main unit which provides the run environment are the dynos which are isolated, virtualized Unix containers. The application's dyno formation is the total number of currently executing dynos, divide between the various process types the developer has scaled. The dyno manager is responsible for managing dynos across all applications running on Heroku. Applications that use the free dyno type will sleep after 30 minutes of inactivity. Scaling to multiple web dynos, or a different dyno type, will avoid this. one-off dynos are temporary dynos that run with their input/output attached to the local terminal. They're loaded with the latest release. Each dyno gets its own ephemeral file system with a fresh copy of the most recent release. It can be used as temporary scratchpad, but changes to the file system are not reflected to other dynos. Logplex automatically collates the entries from all the running dynos of the app, as well as other components such as the routers, providing a single source of activity. Scaling an application involves varying the number of dynos of each process type.

Relevance of IoT in Energy Management

Among the numerous applications of IoT is its relevance in energy management. A good number of energy consuming devices (e.g., switches, power outlets, bulbs, televisions, etc.) already integrate Internet connectivity, which enables them to communicate with utilities to balance power generation and energy usage (Parello *et al*, 2014) and optimize energy consumption as a whole (Ersue, 2014). These devices allow for remote control by users, or central management via a cloud-based interface, and enable functions like scheduling (e.g., remotely powering on or off heating systems, controlling ovens, changing lighting conditions etc.). (Ersue, 2014).

MOBILE APPLICATION (APPS)

A mobile application, most commonly referred to as an app, is a type of application software designed to run on a mobile device, such as a smartphone or tablet computer. Mobile applications frequently serve to provide users with similar services to those accessed on PCs. This use of app software was originally popularized by Apple Inc. and its App store, which offers thousands of applications for the iPhone, iPad, and iPod touch.

Mobile applications are a move away from the integrated software systems generally found on Personal computers (PCs.). instead, each app provides limited and isolated functionality such as a game, calculator or mobile web browsing. Although applications may have avoided multitasking because of the limited hardware resources of the early mobile devices, their specificity is now part of their desirability because they allow consumers to hand-pick what their devices are able to do. Among others, mobile application development challenges include the following:

- No “standard” device.
- Low bandwidth input.
- Limited screen size.
- Integration tradeoffs with cloud and enterprise services.

Review of Previous Related Projects

Peter *et al*. (2012) designed an automatic switching mechanism that transfers the consumer loads to a power source from a generator in the case of power failure in the mains supply. It automatically detects when power has been restored to the mains supply and returns the loads to this sourcewhile turning off the power from the generator set. However, the incorporation of an overload protection circuit will help improve the overall performance of the system. Furthermore, the inclusion of an IoT web server which stores the record of period of power outage from a particular power source and duration of power availability will be of immense importance. Jonathan (2017) designed and constructed an automatic power changeover switch that switches power supply from public supply to generator once there is public power supply outage. This was achieved using integrated circuits that have timing abilities and relays to effect switching.

MATERIALS AND METHODS

The purpose of this study is to create a smart Energy management solution that comprises of all parameters that efficiently helps to switch and store power logs from both the mains and the alternate source. This section gives a detailed explanation of every device used in the study and the method of connection and implementation.

Arduino Platform

Arduino is an open-source electronics, prototyping platform based on flexible hardware and software. The Arduino is a simple yet sophisticated device which is based on Atmel’s AT mega microcontrollers. The Arduino software is supported by windows, Macintosh OSX and Linux

operating systems despite the fact that most microcontrollers are limited to windows operating systems. The software language is based on AVR C programming language and can be expanded through c++ libraries.

Arduino NANO Board

This is a compact board similar to the UNO. It is a small, complete and breadboard-friendly board based on the ATmega328(Arduino Nano 3.x). It has more or less the same functionality of the Arduino Duemilanove, but in a different package. It lacks only a DC power jack and works with a Mini-B USB cable instead of a standard one, 6-20v unregulated external power supply (pin 30), or 5v regulated external power supply (pin 27). The power source is automatically selected to the highest voltage source.

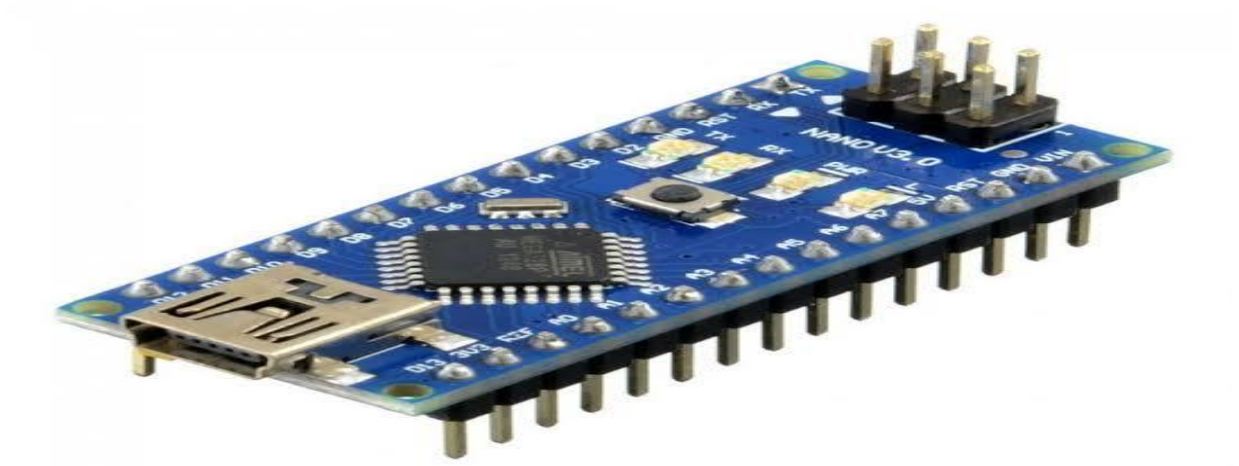

Fig. 1 An Arduino Nano Board.

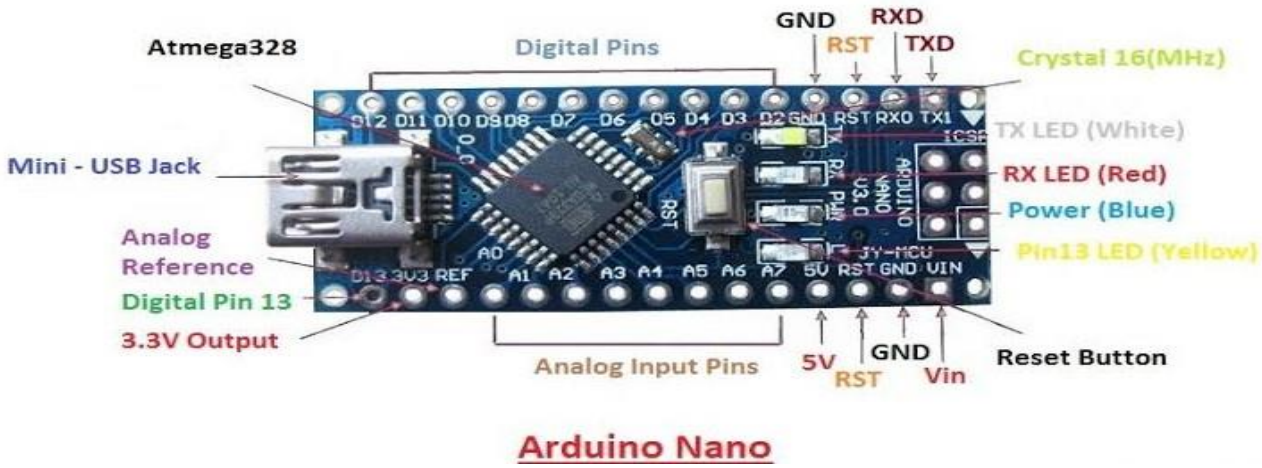

Fig. 2 Labelled Diagram of an Arduino Board.

ATmega328 Microcontroller

The Microcontroller is a low-power CMOS (Complementary Metal Oxide Semiconductor) 8-bit microcontroller based on the AVR (Automatic Voltage Regulator) enhanced RISC (Reduced Instruction Set Computer) architecture. The powerful execution of instructions in a single clock cycle leads to the achievement of 1 MIPS per MHZ throughputs allowing the designer to optimize power consumption versus processing speed.

The central processing unit (CPU) is the brain of the microcontroller which controls the execution of the program. The MCU (Microcontroller unit) consists of 4K/8K bytes of in-system programmable flash with read-while-write capabilities, 256/412/1K bytes EEPROM along with the 512/1K/2K bytes of SRAM. Along with this, the MCU consists of many other features which include 23 general purpose I/O lines and 32 general purpose working registers, 3 flexible timers/counters with compare modes, internal and external interrupts and a serial programmable USART, a byte-oriented 2-wire serial interface, an SPI serial port, a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages), a programmable watch- dog timer with an internal oscillator and 5 software-selectable power saving modes.

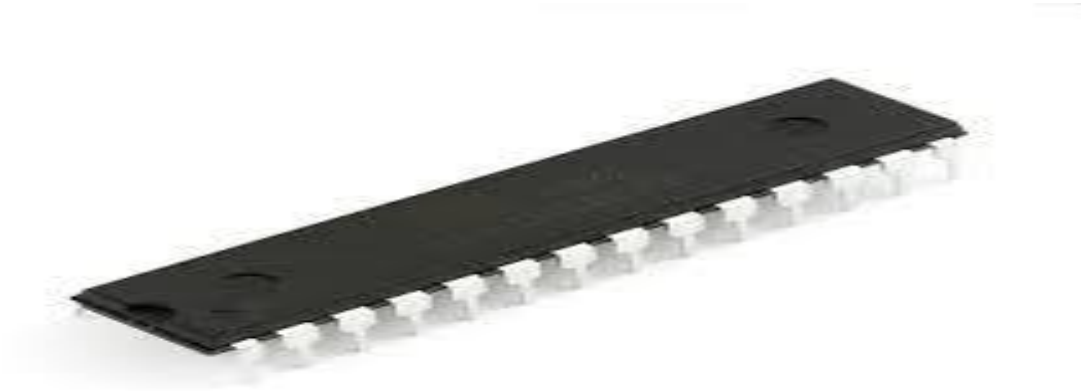

Fig. 3 ATmega328 Microcontroller

GSM Sim 900

GSM/GPRS Modem RS232 is built with dual band GSM/GPRS engine- SIM900, works on frequencies 900/ 1800 MHz, the modem comes with RS232 interface, which allows connection to a PC as well as microcontroller with RS232 chip (MAX232). The baud rate is configurable from 9600-115200 through AT command. The GSM/GPRS modem is having internal TCP/IP stack to enable it connect with the internet via GPRS. It is suitable for SMS, Voice as well as Data transfer application in M2M interface. The onboard regulated power supply. Using this modem, you can make audio calls, SMS, read SMS, attend the incoming calls and internet connection through simple AT commands.

Features of this device includes, dual band GSM/GPRS 900/1800 MHz, Configurable baud rate, SIM card holder, built in network status LED, inbuilt powerful TCP/IP protocol stack for internet

data transfer over GPRS, audio interface connector, SMA connector with GSM L type, built in RS232 level converter (MAX 3232), most status and controlling pins are available at connector. Normal operation temperature is -20^{o}C to +55^{o}C, input voltage 5V -12 V DC

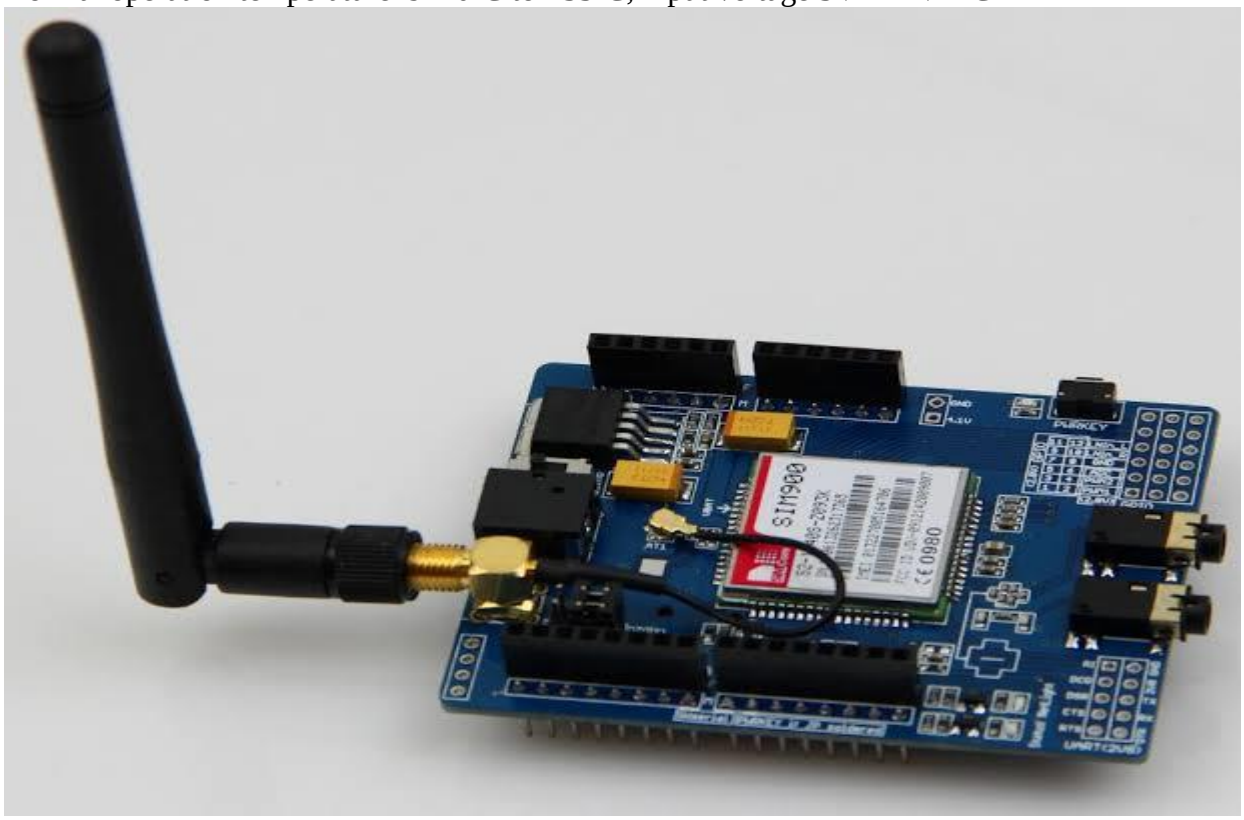

Fig. 4 GSM sim 900

Channel 12V Relay Module.

This is a 4-channel Relay Interface board that allows you to control various appliances, and other equipment's with large current. It can be controlled by a microcontroller (Arduino, Raspberry Pi, AVR), in this study, the relay module is controlled using the Arduino Nano Microcontroller.

Its specifications include 4-channel Relay Interface board, and each one needs 15-20mA Driver current both controlled by 12V and 5V input voltage, a high- current relay, AC250V 10A; DC30V 10A, standard interface that can be controlled directly by microcontroller, opto-isolated inputs, indication LEDs for relay output status.

Table 2 Pin-out Instruction for a 4-Channel 12 V Relay Module

Pin Name	**Description**
"Vcc."	Power (5V DC)
"GND"	Gnd.
"in1"	Singal pin, connected with Arduino and control relay 1.
"in2"	Singal pin, connected with Arduino and control relay 2.
"in3"	Singal pin, connected with Arduino and control relay 3.
"in4"	Singal pin, connected with Arduino and control relay 4.
"COM"	Common pin, which usually directly connect with the"Gnd" unless you want to change the TTL model (default the HIGH level activate).
"NO"	Normally Open Connection.
""NC"	Normally Closed connection.
"c"(middle pin)	Common connection, which connected with the power of the load.

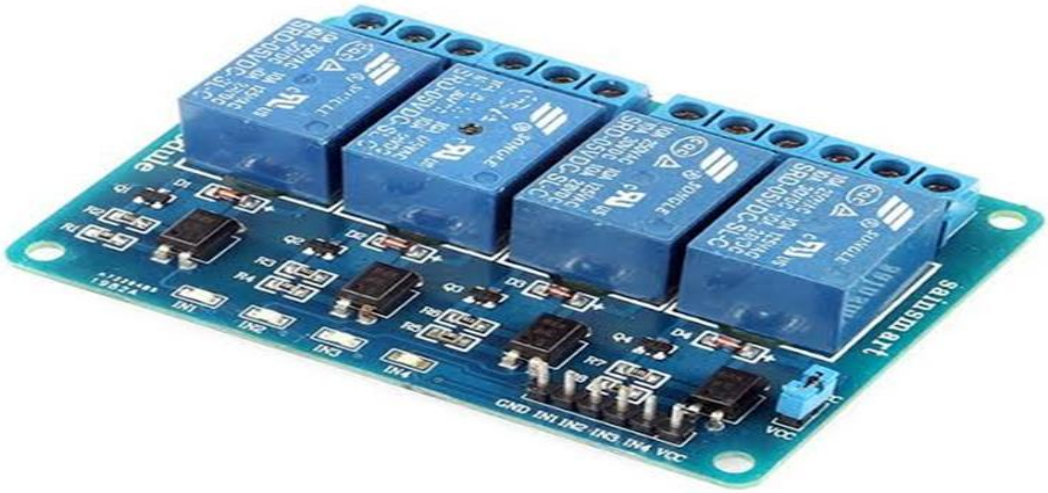

Fig. 5 Channel 12V Relay Module

Automatic Transfer Switch

An Automatic transfer switch (ATS) is an electrical/electronic switch that senses when the mains or public utility supply is interrupted and automatically starts up a secondary supply (i.e., a generator) if the utility remains unavailable. ATS also known as "Generator Transfer Switches, it has an additional circuit component which is normally in the form of a computer that monitors the incoming power supply. The circuitry in an ATS also monitors voltage sags, power surges, power spikes, brownouts. It also initiates the changeover action when there is complete power loss. Whenever a fault is being detected, the automatic transfer switch starts up the alternative power supply.

The ATS developed in this work consist of the materials listed in the table below.

Table 3. Components of ATS

ITEM	QUANTITY
60A 2 poles Circuit breakers	2pcs
230V 8 pin Relay	1pc
Timer Relay	1pc
2.5A 3 core cable	15 meters

DIN Rail	20 Pins
Contactors	2pcs
Panel Box	1pc
230v Indicator LED	4pcs
Connectors	25pcs

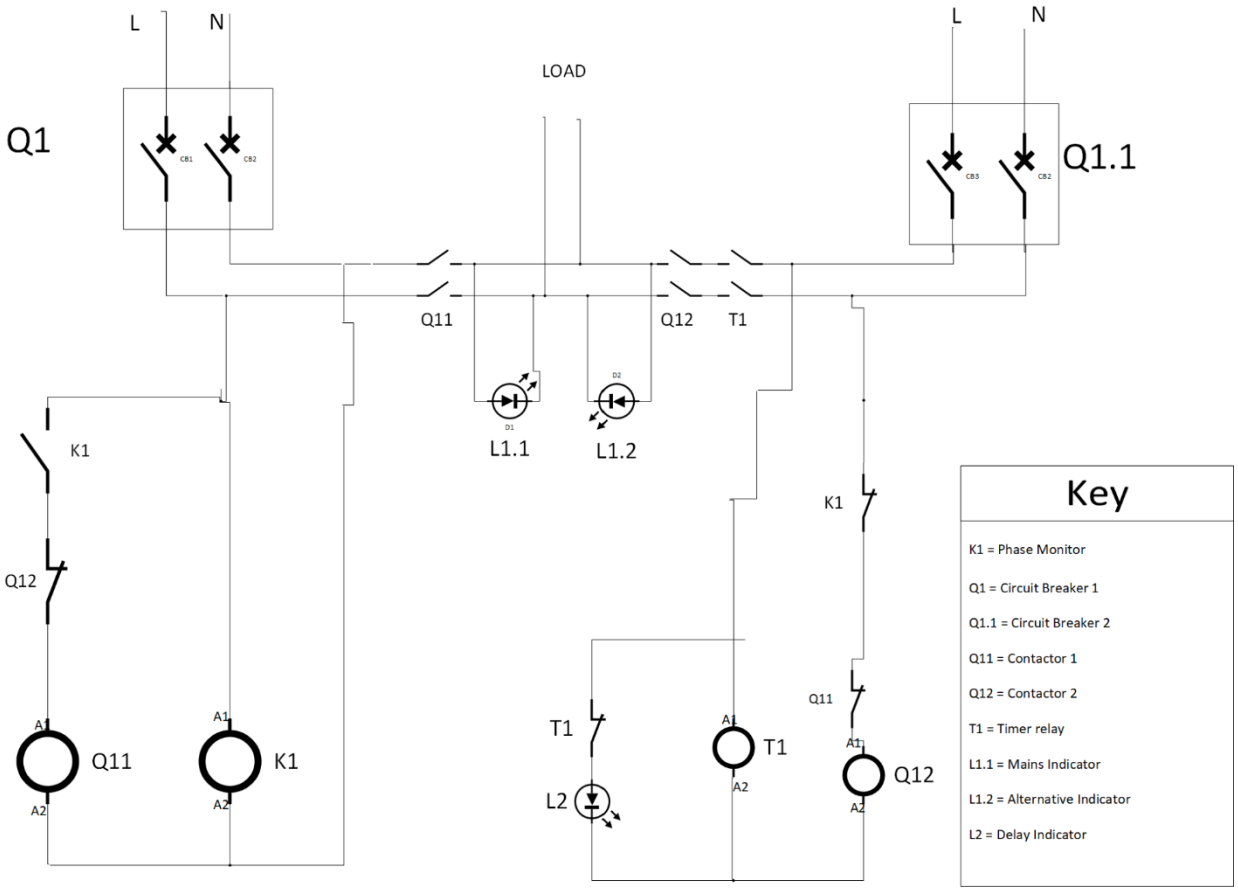

Fig 6 Circuit diagram for ATS

Time Delay Relay

Time Delay is defined as the controlled period the functioning of two events. A Time Delay relay is a combination of output relay and a control circuit. In other words, they are simply control relays with a time delay-built in. Their purpose is to control an event based on time. The difference between relays and time delay relays is when the output contacts pen and close. On a control relay, it happens when voltage is applied and removed from the coil; on the time delay relays, the contact will open or close before or after a pre-selected timed interval. Typically, time delay relays are initiated or triggered by one of two methods:

i. Application of input [on delay, interval on, flasher, repeat cycle, delayed interval and interval/flasher].
ii. Opening or closing of a trigger signal [off delay, single shot and watchdog]

These trigger signals can be one of two designs:

i. A control switch (dry contact), i.e., limit switch, knob, push button, float switch, etc.
ii. Voltage (commonly known as power trigger).

Input Voltage: control voltage applied to the input terminal. depending on the function, input voltage will either initiate the unit or make it ready to initiate when a trigger signal is applied.
Trigger signal: on certain timing functions, a trigger signal is used to initiate the unit after input voltage has been applied. This trigger signal can either be a control switch or a power trigger.
Output Load: Every time delay relay has an internal relay with contacts that open and close to control the load. The user must provide the voltage to power the load being switched by the output contacts of the time delay relay.

Fig 7 timer relay

Circuit Breaker

Simply put, this is a device which breaks (opens) circuit under abnormal condition and protect the system from hazards. The function of a circuit breaker is to isolate the faulty point of the power system in case of abnormal conditions such as faults. A circuit breaker is required in the power system to give rapid fault clearance, in order to avoid over current damages to the equipment and loss of system stability.

Fig. 8 Circuit breaker.

Power Supply Unit

A power supply is a device that supplies power to another device, at a specific voltage level, voltage type and current level. They are referred to as the backbone of every electric gadget, a good power supply will make an electronic project perform optimally. In general, power supplies do the following in electronics: They convert AC (alternating current) power to DC (direct current), they regulate the high voltage (120-220V) down to around 5V (te common voltages range from 3.3V to 15V), they may have fuses or other overcurrent/overheat protection.

Fig. 9 Power Supply Unit

CONTACTORS

These are relays which are used to switch a large amount of electrical power through its contact. The most common industrial use of contactors is the control of electric motors. A contactor consists of 3 (three) subsystems

i. Electromagnet system
ii. Contact and Arc quenching system
iii. Housing

Fig 10 A contactor

Voltage Monitoring Device.

Voltage monitor devices provide protection to equipment where an over or under voltage condition is potentially damaging. They monitor either AC single phase(50-400Hz) or DC voltages. No supply (input) voltage is required. The pick-up voltage setting is user-adjustable from 85%-115% of the nominal voltage rating.

Fig. 11. A 3-phase Voltage monitoring device.

METHODS

This study is made up of four distinct parts, these parts are connected together in a manner which makes them work in synchronization with each other, the entire system functions optimally when all the parts communicate together, this gives an efficient smart management of household energy. The Automatic Transfer Switch works in synchronization with the IoT module, data is sent from the ATS to the IoT module, the data sent includes the type of energy use at an instance, the period in which a switch occurs, the ATS is connected to the IoT through wires, the terminal connected are the Load, Mains power supply, Alternate power supply and a common neutral for all the sources. The IoT module communicates with the Cloud computing platform, thus all data gotten from the ATS are stored in the cloud, the means of connection between the IoT module and the Cloud is through a GSM sim 900 module. The Mobile Application is connected to the Cloud computing platform, the consumer can issue commands to the IoT module through the cloud platform. Thus, the whole system can be changed, monitored through the mobile Application. The interconnection between these four parts causes a perfect synchronization between the entire system which enables it to give an optimal result.

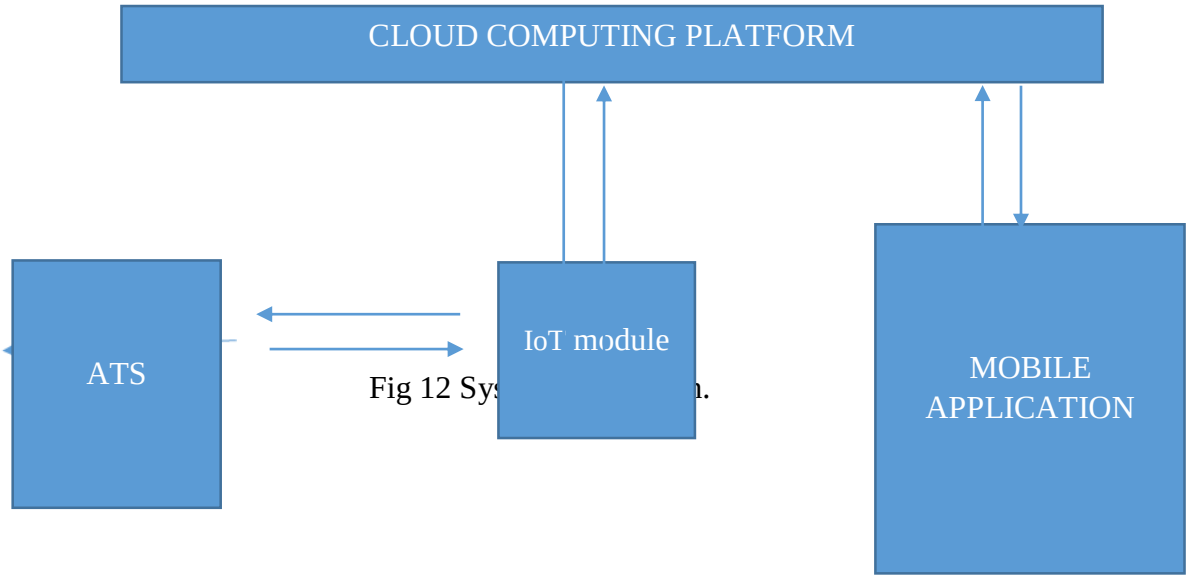

Fig 12 Sys n.

RESULTS AND ANALYSIS

In this chapter, results of careful implementation of this work are obtained and illustrated in pictorial form and discussed.
The wired connection of all elements of the Automatic Transfer Switch (ATS) is shown below.

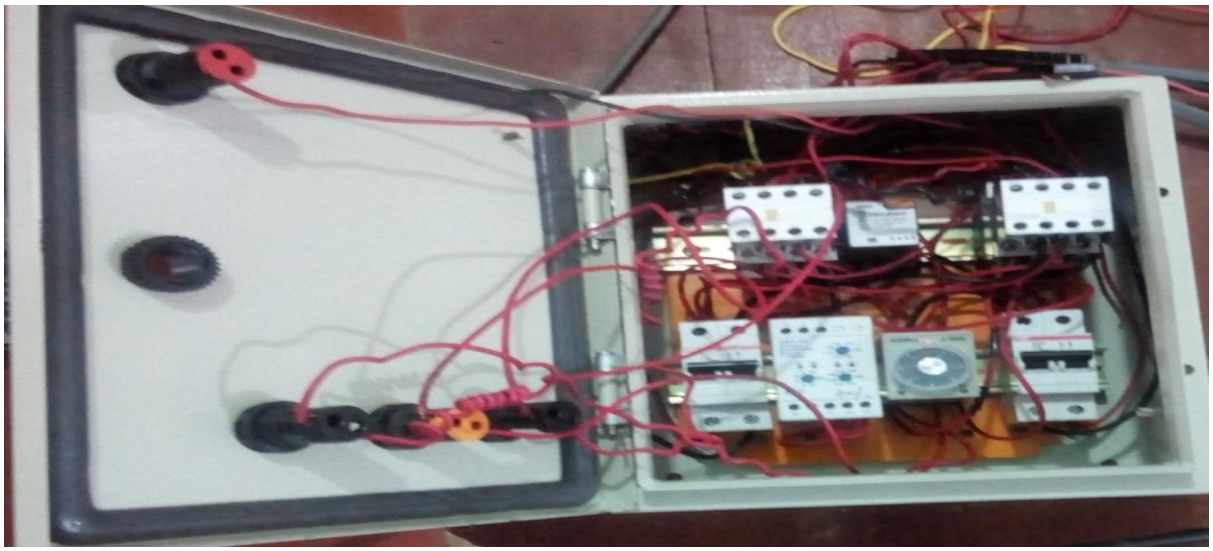

Plate. 1 Internal connection of different Elements in the ATS

The Plate 4.1 shows in detail how all components of the ATS are connected, the mains supply comes into the ATS and it is connected to the circuit breaker on the left, the red wire carries the live current, the black wire carries the neutral current. The circuit breaks on the right serves supply from the alternative source of power supply (Generator), the red wires also carry the live current while the black carries the neutral current. At the output terminal if the of both circuit breaker connection is made to the contactor and the voltage monitoring device, the contactor on the left serves supply from the mains while the contactor on the right serves supply from the alternative source, alternate current (ac) relay which lies in between the two contactors is connected to both contactors and the voltage monitoring device, the timer relay which lies between the voltage monitoring device and the contactor on the right is connected to both circuit breaker and the contactors. The job of the time relay is to cause a delay for few seconds, this depends on the time in seconds set on the timer relay, before switching powers between contactors. Both contactors cannot be opened and closed at the same time, it is either the contactor on the left is open and the contactor on the right opened or vice-versa. There will be supply from a particular source of power only when the contactor is closed.

Plate .2 ATS Indicating mains supply.

The Plate 4.2 shows the ATS closed and a green led indicator on, this green led indicates that power supply from the mains is available for use, this tells the user that the power supply available for use is that supplied by the electricity distributors, the led also indicates the voltage of the power supplied, it can be seen in the above plate that the voltage of power supply at the instance of taking this picture is 196 volts, the output voltage reading by the LED is not statics, but changes as sinusoidal waveform of power oscillates.

Plate 4.3 below shows that the system is powered by the alternate power source, this occurs when supply from the mains is unavailable. It can be seen that only the red led is on at the instance of taking the picture, the red led on the right indicates power from the alternate supply, the led in the middle is a yellow led which indicates delay. The red led also shows the voltage of the power supply at that instant, it shows that power supplied by the Alternate source at that instant is 196 volts. The red led will only come on when the green led is off, meaning that power supply from the mains is unavailable and immediately after the yellow led goes off, meaning the delay time in second has elapsed.

Plate 3 ATS Showing Alternate supply.

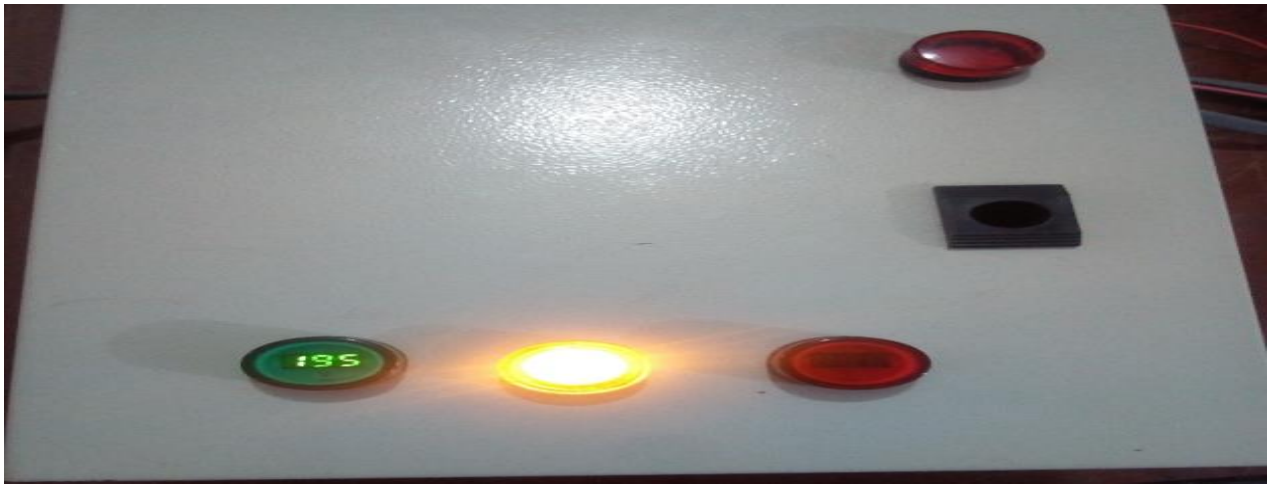

Plate 4 ATS showing Mains restored but Alternate supply still running.

The Plate 4.4 above shows both the green Led and Yellow Led on, this occurs when the mains supply is restored, the contactor immediately switches from that controlling the alternate supply to

that which controls the mains supply, but the Alternate supply (Generator) still running is indicated by the yellow led, the alternate supply goes off after delay for few seconds as set on the timer relay or can be switched off by the user through the mobile app.

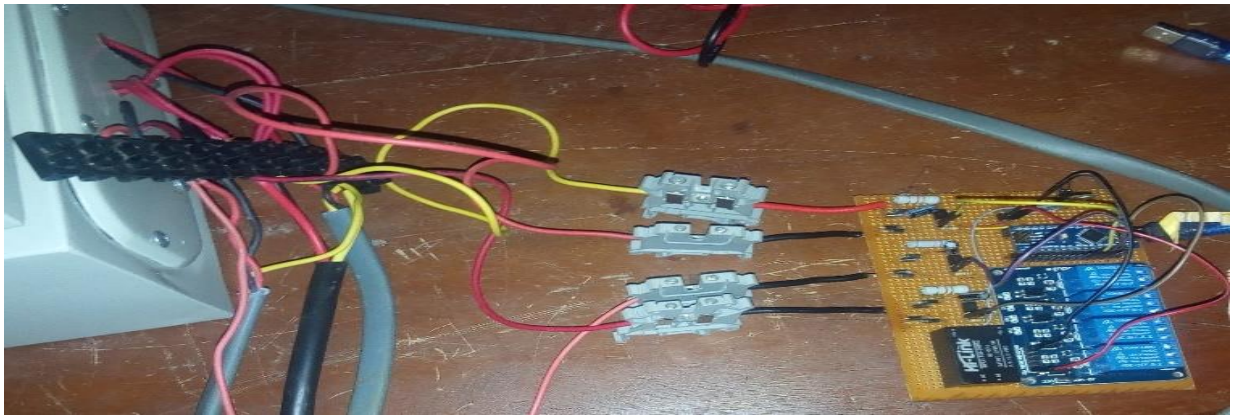

Plate 5 ATS to IoT module Connection.

The connection between the Automatic Transfer Switch (ATS) and the IoT module is showed in the picture above, it can be seen that the ATS is connected to the IoT module through wires which are in four terminals, the load, mains, alternate power supply and the neutral. The load is the output point to which the distribution board of the house is connected. The IoT module shown here has yet to be pack in its compartment, the picture was taken after connection and immediate multiple tests, all components of the IoT are soldered together on a Vero board, it consists of the Voltage regulator circuit, the power supply unit, the 4-channel 12V relay module, the Arduino Nano board.

The IoT module serves as a watch dog that's relates what goes on to the in the Automatic transfer switch (ATS) to the cloud platform, the mobile application can then access this information by logging into the cloud.

The plate 4.6 below shows a complete packaged implementation of the system, the large compartment houses the ATS, while the small boxed compartment houses the IoT module, the 3-pin plugs indicate the connection of the ATS to both power sources, the 13A wall socket is the outlet to which the load can be connected.

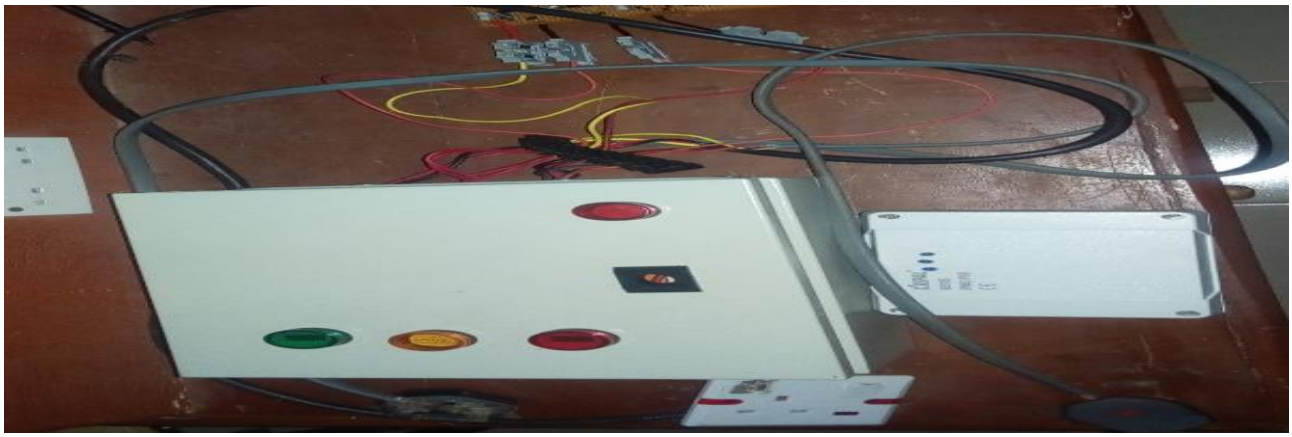

Plate 6 ATS and IoT module (full system connection)

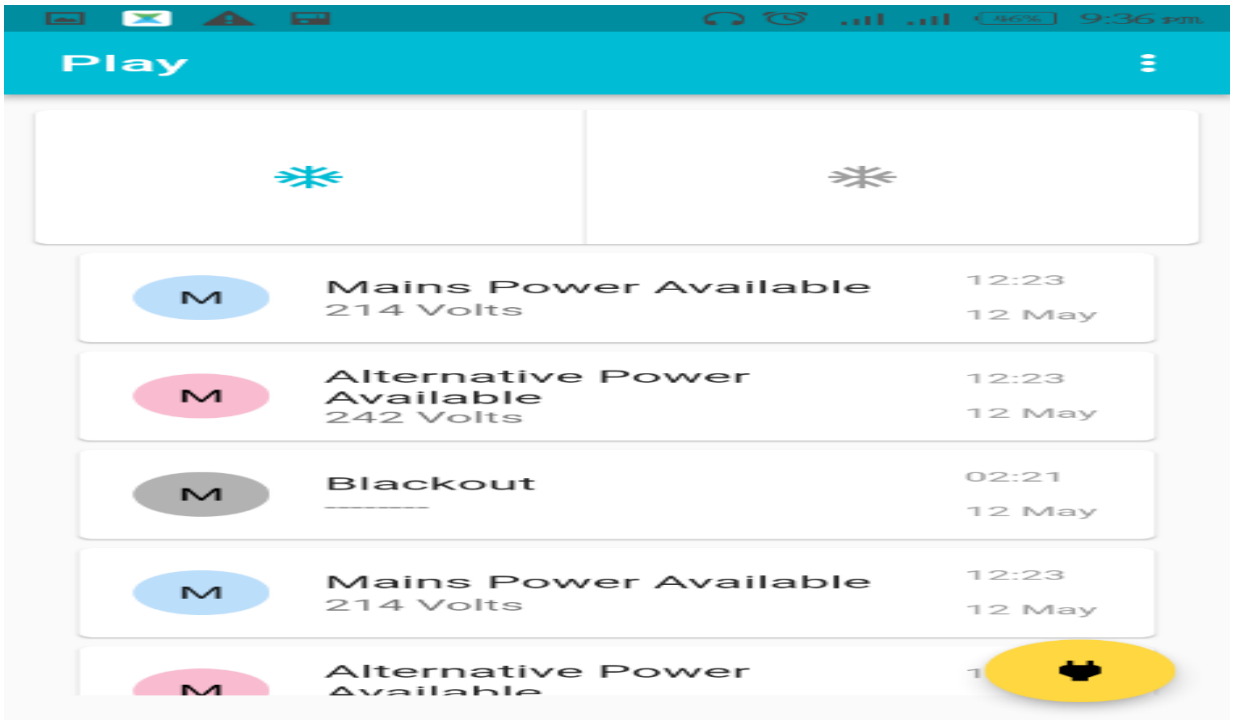

Plate 7 Mobile App Interface

Plate 4.7 above shows the interface of the mobile application, developed for this project, it can be seen that the last date and time for which each power source is available is indicates also the period which blackout occurs is also indicated. The voltage of each power source is shown as well.

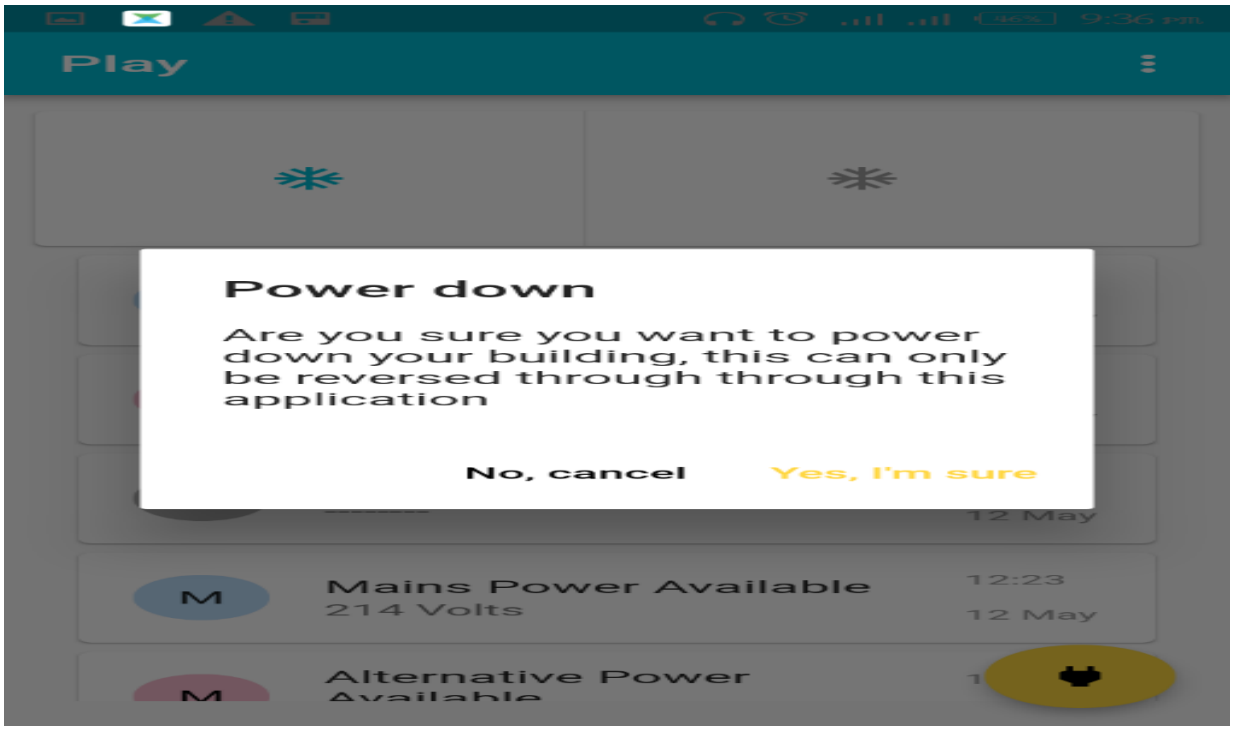

Plate 8 Mobile App. Interface showing option to power down.

An amazing feature of the mobile application is an option to power down a whole building through the app, as shown in the picture when the yellow plug icon is clicked on, it shows a pop-up message ascertaining if the user wants to power down the building using the app.


```
_id: ObjectId("5bc03567c0ab3c7359c7c3fb")
Timestamp: 3440000003304566784
Mains: 0
Alternative: 0
Load: 0
Voltage: 208
XOFF: false
ALT_START: false
device_id: "SHEMS-001"
```


Plate 9 Power Log at an Instant of time

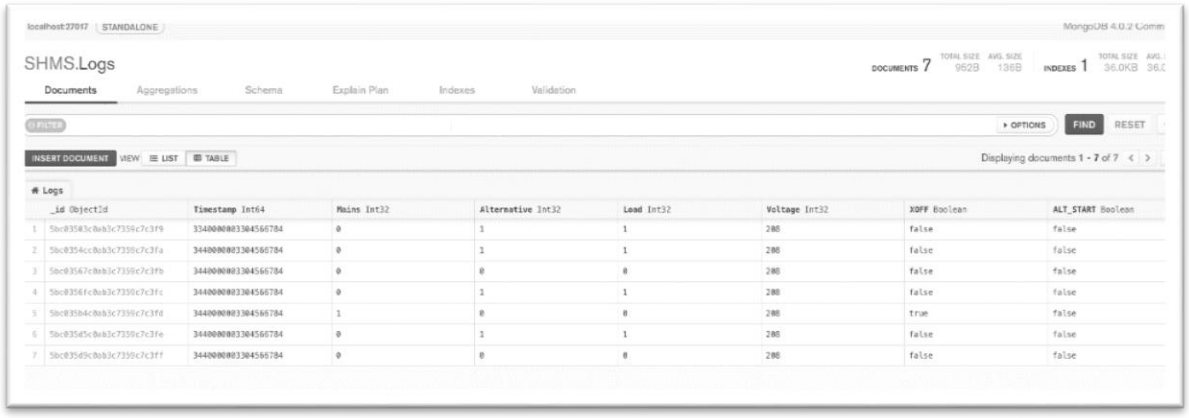

Plate 10. Power logs on the cloud Platform

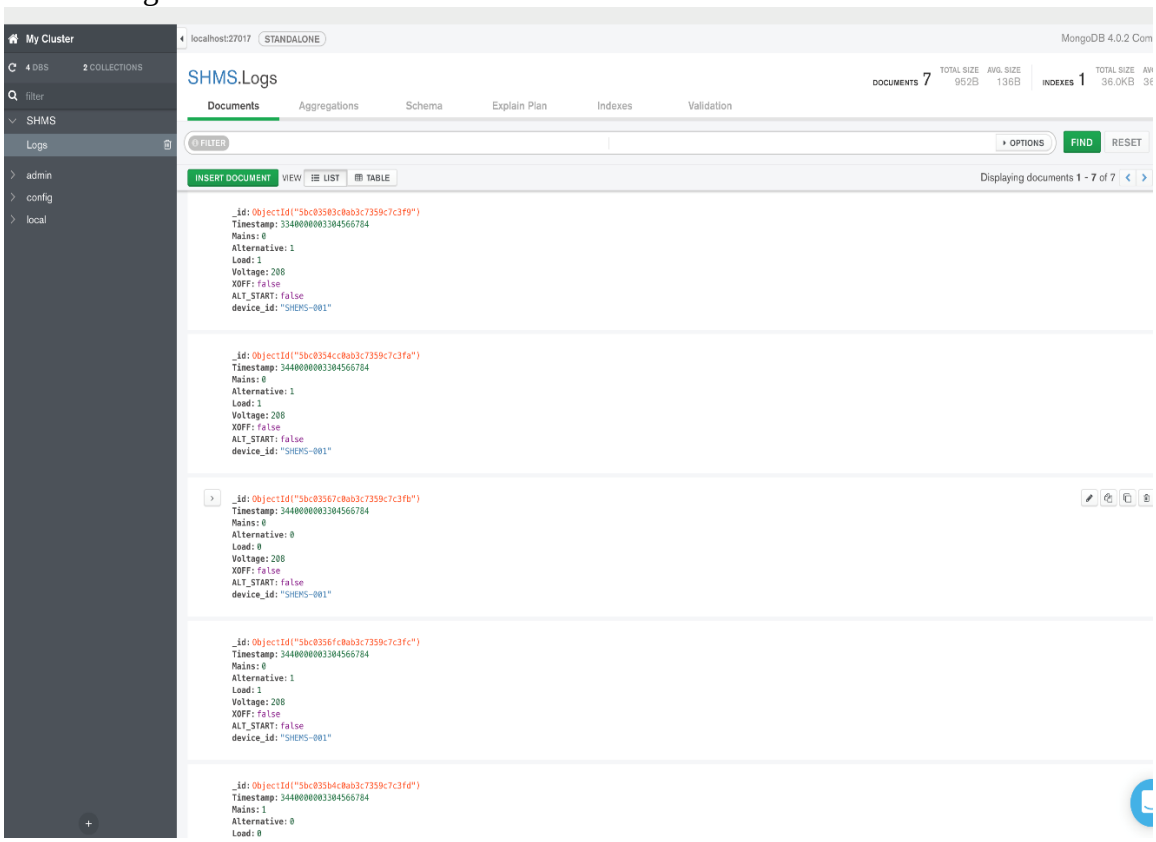

Plate 11 Power logs at several Instance of time, each block represent an Instant.

Plate 2 Power logging unto Mongo DB, database for the cloud platform.

CONCLUSION AND RECOMMENDATION

Conclusion

The aim of this study was to develop a solution that efficiently manages energy in households, the solution developed and tested shows that energy management is achievable and at an affordable cost. This study has been able to provide an overview of energy management in homes and cities, presenting a framework that helps to unify IoT with automatic means of changing energy sources, thereby providing a smart model which helps to manage and optimize energy.

Recommendation

Having been able to develop solution that efficiently manages energy in households through this study, this is a clarion call to both government and users of energy that the need to efficiently manage energy is now. This work can be furthered by integrating the system with artificial intelligence, so that the system learns energy patterns, thus enabling it autonomously offer predictions, detect anomalies, provide energy billings in real time and help energy providers accurately distribute energy according to consumers' usage patterns

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