**IOT-based Power Management System with Home Environment Control**

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*Abstract*— **People are being pressured to make jobs easier for them because time is of the essence in the modern world and it should not be wasted. The first step is to introducing smart home technology for ease of access to people's homes; a technique which grows day by day. Even though it may cost more in the form of electricity bills, it is beneficial to mechanize everyday tasks for the convenience of users. Recently, the demand for electricity has increased recently in households due to the use of various appliances, so much so that power generation has become a major issue in our country today due to lack of resources. Many measures have been taken to reduce electricity consumption in the country. For example, power consumption can be controlled by increasing the power line tax. Therefore, it is also important that people should be responsible and use resources such as electricity sparingly. This research work focuses on a system for distributing the electricity plan smartly and efficiently by giving statistical reports to the user for consuming their usage of electricity. Smart meters can help consumers monitor the power usage of electrical appliances in their houses. A Smart Meter helps consumer to know the information of consumption of electricity for appliances in their respective houses. The system suggested here also provides a more fitting solution to overcome security issues in IOT based communication using secure communication protocols in such a way that intruders cannot perform criminal acts. This design also employs a compact database design to have sufficient storage needs. The objective of this research work is to measure and analyze the power consumption of electrical appliances connected to the smart system in various households whilst giving the best security features to it. This system can manage electricity consumption by using a device, which identifies the status of power usage and sends an alert or notification to the user if power wastage occurs. This research can help people manage their day-to-day activities in a way that the power consumption is minimize. Using smart features such as this can lead to reduction in electricity bills and thus, saves energy. This effectively eliminates the power issues discussed earlier which can secure our economy and ensure that future generations will have no risk of experiencing power shortages.**

**Key words – IOT, Smart Meter, Smart Grid, Home Area Networks (HAN), Security, Clouds, Advance Electricity Metering.**

# Introduction

Home is an emerging concept that attracts the synergy of several areas of science and engineering [1]. The use of electricity is very important as one of the main source of energy that is vital in today modern life. Some kinds of mechanism using available technology could be used to reduce wastage in electricity usage.

A lot of research has been going on for more than a decade now to increase the power efficiency at the consumer level of the power management systems. Smart Home is the term commonly used to define a residence that integrates technology and services through home networking to enhance power efficiency and improve the quality of living [2]. Smart house is not a new term for science society but is still far more away from people’s vision and audition. Smart meters are able to provide real time pricing, customer’s equipment monitoring and control, and leak detection. Smart home meters are necessary nowadays to be included in any smart home.

Energy efficiency is becoming increasingly important in industry as well as in the residential sector. However, due to the complexity and diversity of computing devices, integrating energy efficiency into ubiquitous computing is still in its infancy. The electricity usage at residential buildings is increasing day by day. Many researchers investigate the percentage of electricity consumption and its impact. In recent years of our country, the demand for electricity has increased in households with the use of different appliances.so the power generation is a major problem in our country today, due to lack of resources, many measures have been taken to save electricity in the country for example, the electrical power is controlled by increasing the power line tax. The electricity usage in housing has been found to be more than 45% of overall electricity consumption in Sri Lanka. However day-by-day consumption of electrical powers increasing [3].

Sri Lanka used to generate electricity mostly using hydropower in the recent past, but currently new substitutes like solar power and wind energy. This excessive use of power would affect the country's economy very badly and it may cause electricity shortages to future generations.

This research work focuses on a system for distributing the electricity plan smartly and efficiently by giving statistical reports to the user for consuming their usage of electricity.

The main functionality of the proposed system is to measure and analyze the power consumption of home appliance and give effective power plan for the users. The proposed system can monitor and billing daily electrical power consumption of selected home appliance in different categories. Selected devices are categorized according to a device class based on the operation mode, availability and priority of the devices and based on that it is examines with the algorithms to get the maximum performance. Via the user-friendly cloud bases web interface, the central unit is control over the internet to see the system functions well as it should be.

This deals with hourly energy consumption values acquired from the energy provider. These standard values help energy utilities and consumers to know their energy consumption, which is reported on an hourly basis. In fact, behavior of the consumers can be studied, and results obtained can help the consumers in changing their behavior, in particular when correlated with a potentially varying price. This work explains a gap between the consumers and energy utilities so that they can communicate more efficiently through the implementation of conservation strategies. The consumers need to be educated with broader knowledge regarding the system and web application so that wrong perceptions can be altered.

The consumption of power is an important aspect of electricity supply. People should be aware of preserving energy for future use. With daily usage of electricity, the energy patterns have been slowly varying. This variation of consumption patterns can be caused by weather conditions or unnecessary utilization of power by inhabitants such as increase of appliances in respective households and careless attitude in utilization for example not switching OFF the lights or television when not watching it. These factors may show greater impacts on end user. As the power supplied by energy companies is vast, most of the people are neglecting energy and its savings. The importance of consumption is declining in the mindset of utilities. The energy utilities should play a major role in advancing the Smart Meter technology and should make people participate in reducing energy consequences by creating awareness about the impact of their current level of consumption.

# Related Work

(Mieee, Mcdonald, & Makestas, 2017) proposed a system called “Home Energy Management System for Demand-Based Tariff towards Smart Appliances in Smart Grids” [5] in 2017 and the system has implemented gives the solution to achieve home energy management system to assists electricity users to reduce their maximum demand for the electricity which billing is happening considering the usage at a peek demand. This system consists of two types of loads which is loaded control by interface and load control via on off modules. User can select between comfort, economy, energy limit, power limits modes for operations, and control unit is there to limit the usage of devices under peak limitation. The system uses the AS/NZS 4755 Standard for demand response compatible appliance and heuristic algorithm to track household demand at all time. This system does not provide a way to check the appliance power need for the future. No way to detect whether switching off it power supply at a given time would lead to system malfunction.

(Swastika, Pramudita, Hakimi, & System, 2017) proposed a system “IOT-based Smart Grid System Design for Smart Home” [5] in 2017 which is based on IOT. This system allows the users to observe the use of electricity from anywhere in the world through internet. Because use of IOT this system gives good optimization for the process and ensure reliable transmission with easy control of comprehensive senses in addition to control the use of electrical appliance intelligent processing and capabilities to control remotely. Communication between power lines and utility can be done with much ease. The system authors have implemented uses ZigBee, Bluetooth Low Energy, Home plug, Lora WAN, XMPP and HTTP technologies. However, this system need fast internet connection because when it is slow electrical redistribution system will not run and it is vulnerable to cyberattacks and implementation cost is very high, and this system does not provide a way to give a power plan rather switch off or on when necessary.

(Song, Li, & Mei, 2016) have proposed a system “A Privacy Preserving Communication Protocol for IOT Applications in Smart Homes” [7] with a central controller, which analyzes the data reported by the sensors and send out the messages to electrical appliance and other sensors to ask them to behave accordingly. This system mainly analyzes the difference of security and privacy issues that lie in smart home systems, power management system and wireless sensor networks with authors own solution protocols. It has four major components the appliance, sensor groups the central controller and the user interface. This system allows central controller to automatically learn and adjust to create comfort living room and in order to do that machine learning is used and it is based on security model and assumptions.

(Ashibani & Mahmoud, 2017) the system “An Efficient and Secure Scheme for Smart Home Communication using Identity-Based Signcryption” [7] has implemented based on Identity-Based Signcryption scheme for smart home communication, which gives better authentication integrity and confidentiality. By using this method, it does not require access to third party to access. However, this system has major drawback if in the case of being attacked all the issued secret keys can be realized.

(Soetedjo & Lomi, 2016) proposed a system called “Implementation of Optimization Technique on the Embedded Systems and Wireless Sensor Networks for Home Energy Management in Smart Grid” [6] to optimize the power usage of Home Energy Management System. It uses the Raspberry Pi module, real time clock (RTC) module and ZigBee module to implement the system. Mixed Integer Linear Programming is used here to solve the optimization problem and Raspberry Pi module and local controller communicates within milliseconds. The proposed system running under three methods that are synchronization, learning and running. The objective of this system is to minimize the peak hourly load power consumption, which is good for minimize the cost for total electricity generate but as a home it does not help to effective billing plan.

# Methodology

**Part1**

1. **Designing the Current Measurement Device**

The Measure Device is design using the current sensor ACS712 to measure the current flow through the home appliances. It is directly connected to the plug base of the home and the devices are connected to it. The measure devices have a button to initialize the connection with the relevant authorities automatically. The Arduino capture the electric devices consumption behavior and it is send to the Raspberry PI, which is the smart meter, and store in the DB installed in it and send the data to cloud environment for further usage hosted in google cloud platform. Using the concept of movement of charge carries through a conductor towards the attraction of the magnetic field, which is the Hall Effect the systems measure the current flow going through home appliance devices.



Figure: ACS 712 Internal Diagram

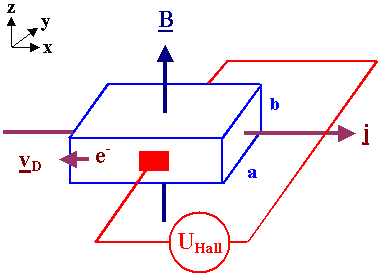
The Measure Device capture the AC current from the ACS712 current sensor, which gives the waveform of a sinusoidal wave with clear understandable graph and using the variable resistor, system controls the power to the devices according to the load balancing of the system. Each device give raw data for the Arduino and the raw data from these electric devices are filtering from the filters of the Arduino and convert them in to meaning full data. The converted meaning full data feeds to the Raspberry PI micro controller, which is the smart meter and its function from the data fed to it.

Figure: Hall Effect



Figure: Sample Current Usage Graph

1. **Design the sensor network**

The proposed system has used temperature and humidity sensors to increase the accurate level of the data generated by the home appliances. Humidity and temperature sensors are used to detect the temperature of the room in the house and its sensed data is send to the smart meter, and the meter decides how to allocate the load to AC based on the algorithms created for each device. The load for the Fan of the home is also decided based on the sensitivity of the temperature of the room and following diagram gives understanding about the sense network.



Figure: Sensor Network

**Flow of Measure Device works**

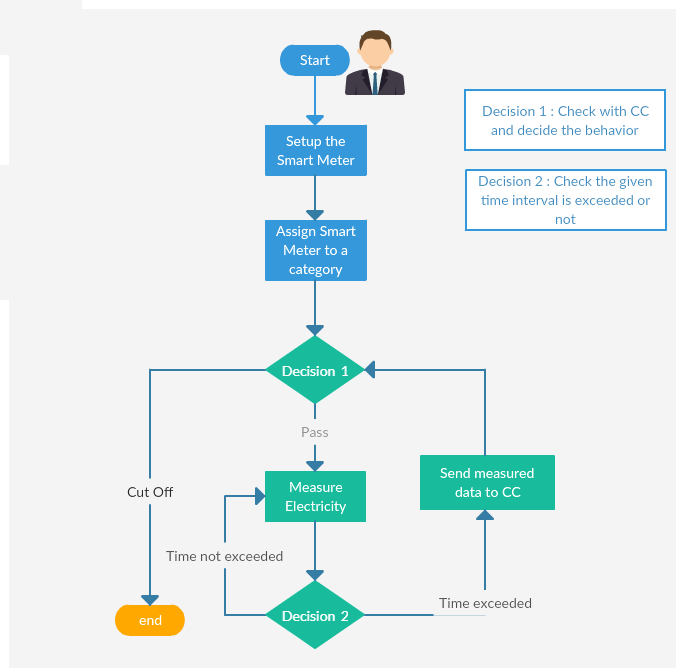
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Figure: Flow Chart

**Part 2**

The functions of the main communication and the power system can be divided in to two sections as mentioned follows.

1. Secure the communication between smart meter with devices and control unit
2. Creating the backup redundancy system to ensure availability.

Since IOT based smart homes systems are vulnerable to hackers even today even if they pretend it is not, the statistic report says all over the world most system can be compromise within hours. The systems have implemented does not support backup redundancy system to make sure the systems available at any critical point due to many reasons. The following methodology suggest a way to secure the communication of the home against identified four main internal threats and how the backup system is to be implemented.

**Secure Communication**



**Devices authenticates to the system**

When a smart meter initially installs at customer residence it is given a pre-configured password, which should be entered manually to Measure Device. Then it is verified with the Smart Meter (Raspberry PI) and authenticate. Here it is using a channel for authentication and another channel for communication. Here the authentication procedure is happening by pressing a button after entering the password to the Measure Device and it’s automatically create a private key and a public key with SSH connection and the keys can be used to generate preferred password for further use.



**Algorithm for Device Impersonate**

Device impersonate is a serious issue for the smart home controlling systems because it is the way of assigning high power consuming devices to the system as it consumes low power which will mislead the current load of the system and causes the power controlling plan impossible to achieve. A user can assign a AC to Measure Device manually pretending it as a TV and then power scheduling will go wrong affecting the system. Hence, algorithm is created to categorize each device to four different classes and the load is replicates according to each device category. The following figure shows the sequence of the steps that will take. After updating the loading table send the loading model to the Measure Device to and it will check against the pattern created through power outlet with pre-configured patterns and if found a mismatch Measure Device does not allows to operate the device. 

Figure: Flow Chart

**Replay Attacks**

The Replay attacks can be caused by unauthorized party to overload the system by sending request captured from the owner, which will result the micro controller to perform inappropriately. To avoid this, attack the system suggested here use a mechanism to add sequence numbers for the packets (commands) send by the customer. If there is a packet significantly different from the sequence number order, it can be ignored.

**Non-Repudiation**

In here, the system and the customer both party cannot refuse what each has done on the level of their participation to the process the mechanism. To ensure that the system gives the customer and the smart meter unique encryption key pairs for encryption. The micro controller stores the communication logs for several days and send to cloud database, which can be track down if any party complaints.

**Backup Redundancy System**

In any case of power issue or any breeches happens to the system redundancy system is turned on and it takes the states of the original where it leaves functioning due to any reason, so the user can access the same system remotely without any problem. The backup redundancy system always updated from hour to hour and the original system synchronize the changes done by the customer to the backup system. The whole system is powered with battery and the battery is connected to AC current all the time. Due to any reason if the existing system down the backup system will power on with charged battery and its works for several hours supporting the other system like Wi-Fi etc.to proceed the process of the system.

**Part3**

**Web Application**

The web application accesses the operational database through different web services implemented using PHP in Larval framework. These services are used to transmit data to and from the database and send it back to the requester. The client web application is developed that gives access to every consumer a different view to the data analytics according to his privileges. Once a user logs in, a service will run to get the user privileges and the user interface components that he/she will be able to see consequently. The electrical components such as fan, light, TV, air conditioner and the motor are controlled and monitor through this web application. This web application relates to the Internet. Through this web application the electrical components can be controlled from anywhere. For example, for the home owner, there are two services available; first is monitoring power consumption data of each house device and second is remote control services (ON/OFF) for house devices.

Detailed investigation to identify major problems faced by the public (Residential electrical power consumers) has been carried out. According to the information we analyzed and decided to give a solution to their issues.

In here consumer can set budget which he wants to spend in current month, once the budget exceed system will notify to the user’s mail. and also consumer once entered amount, system will generate instruction report to the user how many hours he wants to use each and every electrical appliances per day for electricity bill. To write this algorithm system will get previous month power consumption details from the database and analysis and calculate average usage hours per day for each and every appliances. This calculation details will be generate as an instruction report to the user. When consumer feel that much of usage hours he don’t need per day there are options to select that appliances. Once he select one or more appliances system will regenerate the instruction report by reducing usage hours for the particular appliances within the budget.

**Part4**

**Algorithm development**

Design a new several algorithms are created to make the better and efficient electrical consumption of various categories electrical appliances. To make better than the previous smart meter products. The reason behind the creation of uses a several algorithms is in practically only one algorithm is not suitable for controlling the electrical appliances. Because we are using various category electrical home appliances, that appliances electricity consumption mechanisms are quite different in each other appliances that is why this research will decide to design a various power-consuming algorithm for various category appliances. For example, the mechanism of controlling the television and the mechanism of the control the air conditioner is quite different. Here we considering the TV&AC Designing an Algorithm for TV Category appliances we need to pay attention for the peak times slots and Human Movement or availability of that area Because some time no one is not there in the living area but TV will running alone in this scenario make an energy wastage that’s why we using Motion deduction sensors to this algorithm development and Designing an Algorithm for AC Category appliances we need to pay attention for the Room Temperature, Humidity of that time and Users availability of the room or that area Because sometimes the climate is cool but AC works unnecessarily and sometime no one is not in the area but AC will running alone in these scenarios make an energy wastage that’s why I’m using Motion deduction, Temperature, Humidity sensors, to this algorithm development.

# Limitations

The entire performance of the flow of the system and response of, devices generated data depends on hardware devices capabilities and the sensitivity of the sensors. Assuming the user is trusted and follows the system as agreed and no physical devices tampering to devices. The main limitation to the system is that it must be assume devices can bear the power variations, overload, and fluctuations when functioning and there should be smooth Wi-Fi connection with reasonable speed to access and function the system. No-delaying happening when sharing data to ensure time sensitivity of commands.

# Conclutions and futer works

In this paper the design and implementation of a control and monitor system for smart house has been established. The proposed models and the study in this research can also encourage users to shift their consumption and optimize the cost constraint. The system is also connected to a wireless Bluetooth technique to monitor and control the electronic house appliance from anywhere using Arduino. The experiments have been implemented and results shown that devices have been operated over the network using web application through, laptop. furthermore, web application will be developed as a mobile application for user friendly in future. This has been demonstrated that it will decrease the human workload and the electricity consumption.

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