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IOT Based Data Analytics and Web Monitoring of Energy Load Profiling for the Households

Suvidha Biradar[1], Prof. Rahul Hiware[2]

PG Student, Department of Electronics and Communication, Dayananda Sagar University, Bangalore, India [1]

Assistant Professor, Department of Electronics and Communication, Dayananda Sagar University, Bangalore, India [2]

ABSTRACT: In the Energy Management system, the main constraints are accurate metering, energy monitoring and implementation of visual data for consumer load profile. This Project is intended in designing a system at home which monitors the energy consumption of each device, along with the smart energy meter, which is designed to calculate the total energy consumption of the home. All the data calculations will be handled by the Arduino energy meter for the accurate readings. A server will be created with appropriate channels to monitor the energy consumption from each of the devices respectively. These data will be uploaded to the server at the monitoring end. Considering all these data individual energy load profile for each of the devices is displayed on the web-page.

Accordingly the analysis can be made for the precise usage or energy consumption of each device in order to further reduce the usage of the device which is drawing the maximum amount of energy. These monitoring reports can be remotely accessed and would help consumers to take the required action in order to improvise the energy usage.

KEYWORDS: Arduino, data analytics, load profile, raspberry pi, web-server.

I. Introduction

Nowadays, the concept of the IOT is gaining acceptance and a diverse range of applications will be developed over next years. Within this segment, we can highlight the development of smart meters. However, the employment of smart meters has only been made possible due to the evolution of digital electronics that allows the implementation of software in embedded hardware. All the energy consumption information collected from smart meters through the sensors.

The very first step in managing electric load demand is to know the general patterns of electricity consumption. Electrical power consumptions of end users generally vary due to behavior of customers, ambient conditions, etc. This knowledge about the behavior of the load is learned from experience with the use of consumer data and statistical analysis of consumption. In past few years, energy analytic is emerging and lots of research on electricity consumption analysis like consumer segmentation, characterization, predictions and knowledge extraction from smart meter had been done. The data mining techniques mostly used classification, clustering of electricity demand patterns and cluster analysis of smart metering data[10]. In this paper we target the consumers (household) as an active part.

II. Related work

A number of studies have focused on identifying load profiles in electrical systems. A system presents a method for the identification of consumer load profiles in a totally automatic way. The main objective was to develop an interface between utilities and consumers in order to obtain data from smart meters and identify the load profile. A database was created to store data related to consumers from which the utility software was able to furnish each consumer's load profiles and to use this information to make decisions [1]. Smart meters can be interconnected in a large network offering a potential value to implement energy savings and other energy-related services, as long as an efficient interface with the final user is implemented.

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The electronic meters for electricity (smart meters) are undergoing an increasing deployment in private homes all over the world, as a consequence of growing physical communication network with the energy distributors. Hence are enabled at simplified, more efficient, and less costly transactions with the customers, e.g. for meter reading, billing, and energy supply administration [2].

Implementation of smart meters increases the availability of detail level of consumer electricity load profile data. Based on consumers of electricity, the usage of electricity is different for each and every consumer resulting different load shapes due to different consumer behaviour, weather situations, different weekdays and time also matters. The primary objective of our load profiling task over a set of users having different recorded attributes and their half hourly demand over a period of month is to build models which approximate their load shapes for certain subsets of customers and self-reliance estimates for those load shapes, for different consumer weather conditions, times of year, and days of the week. [3].

Load profile analysis in different regions is very useful to power utilities for managing the load requirements in economic and efficient manner. For the demand side management and grid operation, the variation in demand is to be known. For different zones, typical load profiles based on similar consumption are obtained. Primarily, the load factor represents feeder demand variation, and loss factor helps average energy loss estimation in distribution power systems. Different types of customers have different peak requirements at different period of time. Residential customers have maximum demand in evening hours while commercial customers may need maximum power in early afternoon. In distribution system, level of current (i.e. load) is primary cause of power losses [4]. In addition, we also highlight the methods proposed for demand side management [5]-[8], which can be related either to load control at certain times of the day [5] or to the scheme (divided into different ranges) of pricing electricity during the day [6], [7]. Thus, it is important to mention that techniques for load profile identification aid demand-side management methods, which can be observed when the loads are controlled based on a list of priorities. Thus, the actual loads (list) connected to the residential electrical system could be provided by the method of load profile identification.

III. PROPOSED METHODOLOGY

In the Energy Management system, the main constraints are accurate metering, energy monitoring and implementation of visual data for consumer load profile. This can be achieved by using Smart Meters. This Project is intended in designing a system at home which monitors the energy consumption of each device, and displaying the usage in a graphical way. The aspects of the proposed design will cover three categories where utility which represents a computational system installed where the data acquisition from consumers smart meters can be processed and analyzed. Network which is a bidirectional link to transmit and receive data of consumers through the internet enabled devices. Consumer active where they can online monitor the load profile created and take required actions based on data analytics done. The main improvement in this system as compared is to complete the loop and making the consumer as an active part of the system to take decision depending on the notifications/messages provided after data analytics.

Live energy consumption reading from the Smart energy meter is sent back to the web server periodically and details are updated in a central database. The web server is created and an interface is created for the users to track the consumption of each appliance in the home continuously from anywhere and anytime.

A. Architecture Detailing

This system is implemented to measure the power, thus the energy in terms of Kilowatt-hour so we need to measure the current and voltage from the mains supply. The voltage is measured from the lines passing through the step down transformer and a voltage regulator so that its give the regulated dc output that is in the acceptable range of the microcontroller i.e. Arduino Uno. Arduino is an open-source electronics platform based on easy-to-use hardware and software. It senses the environment by receiving inputs from many sensors, and affects its surroundings by controlling lights, motors, and other actuators. Arduino Uno is a microcontroller board based on the ATmega328P. It is an AVR based microcontroller with 5v supply, 8 bit and 16 MHz clock frequency. The software coding is done in Arduino programming language and using the provided Arduino Integrated development environment.

The current sensors are used to give the accurate current consumption values of each load connected. The current sensor used is ACS712. The Allegro ACS712 provides economical and precise solutions for AC or DC current sensing

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in industrial, commercial, and communications systems. The power calculation is done using the current and voltage values obtained from the supply and also the energy consumption for each of the devices is done in Kilowatt-hour.

These data will be sent wirelessly through the Wi-Fi module interfaced with the microcontroller. The ESP8266 is a low-cost Wi-Fi chip with full TCP/IP stack and MCU (microcontroller unit) capability supporting IEEE 802.11 b/g/n Wi-Fi standards.

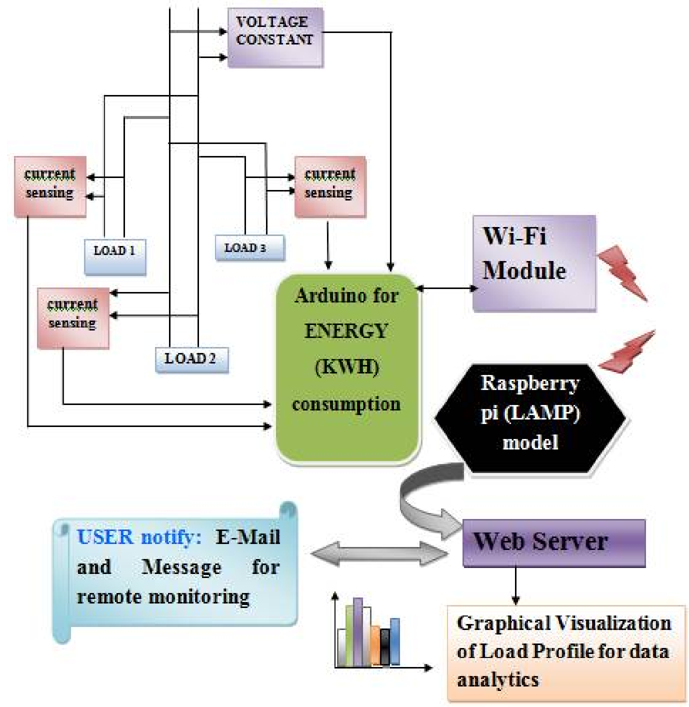

Fig 1: Architectural design of proposed system

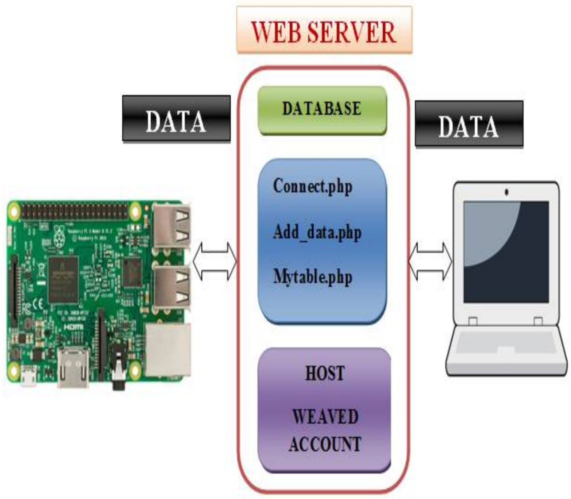

Fig 2: Data flow to web server

B. Software Detailing

The flow of data is passed through the layers built upon of TCP/IP stack following a machine-to-machine (M2M) or Internet of Things connectivity protocol. The live data from the sensors and controller through the Wi-Fi module is sent over to the database for storage. The Server is built so as to monitor the data and visualize these load graphs online. The Raspberry Pi 3 is used to build this server using the LAMP Software stack. LAMP is an archetypal model of web service stacks, named as an acronym of the names of its original four open-source components:

- The **Linux** operating system,
- The **Apache** HTTP Server,
- The **MySQL** relational database management system (RDBMS), and
- The **PHP** programming language.

The flow of data to the web server, its connection to the database etc is done using the php scripts. One php script is responsible for connecting to the database. It contains the configuration settings for the database. The Raspberry Pi sends the data to a simple PHP script which is called add_data.php. This script connects to the MySQL database and stores the data in the database. If we want to see the data from the database all we have to do is to visit the table file from a browser. The mytable.php script will connect to database, using the connect.php script and it will ask the database to return all the stored data. Then it will display all the data in an HTML table. The graphical visualization is done for each home can be seen on PhpMyAdmin page. Signatures for maximum power consumption can be seen using the API's linking from the Google Charts. The Change in the different values of the database creates the chart

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with accurate percentage of each appliances used. The data analytics is done so as to compare and notify the users that which home and which appliances are consuming the maximum power.

The monitoring reports are sent to the consumers on their webpage and can be monitored continuously using a weaved account on raspberry pi. SMTP protocol is used to send the mail as a notification to the user for online visiting. The text local API is used for sending SMS as a concept of notification on the regular basis. These are done by running a python script. Hence the required action is taken in order to improvise the energy usage.

IV. EXPERIMENTAL RESULTS

The system setup shown is a prototype implemented to measure the power, thus the energy in terms of Kilowatt-hour so we need to current and voltage from the mains supply. The complete hardware is shown in the fig 3. Depending on the data given for the consumption of power at different instances the load graph is drawn and simulated on PhpMyAdmin as shown in fig 4.

Fig 3: Hardware Setup

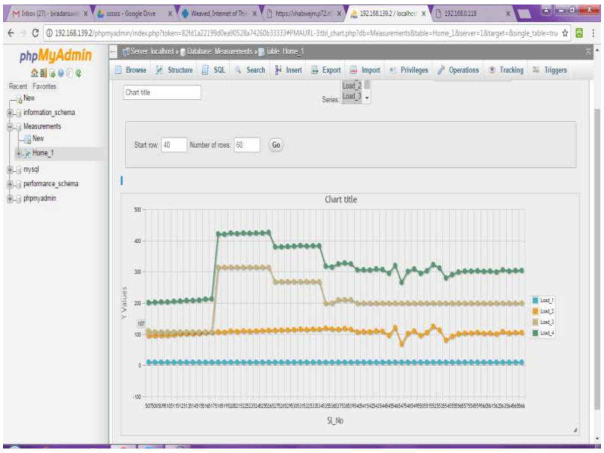
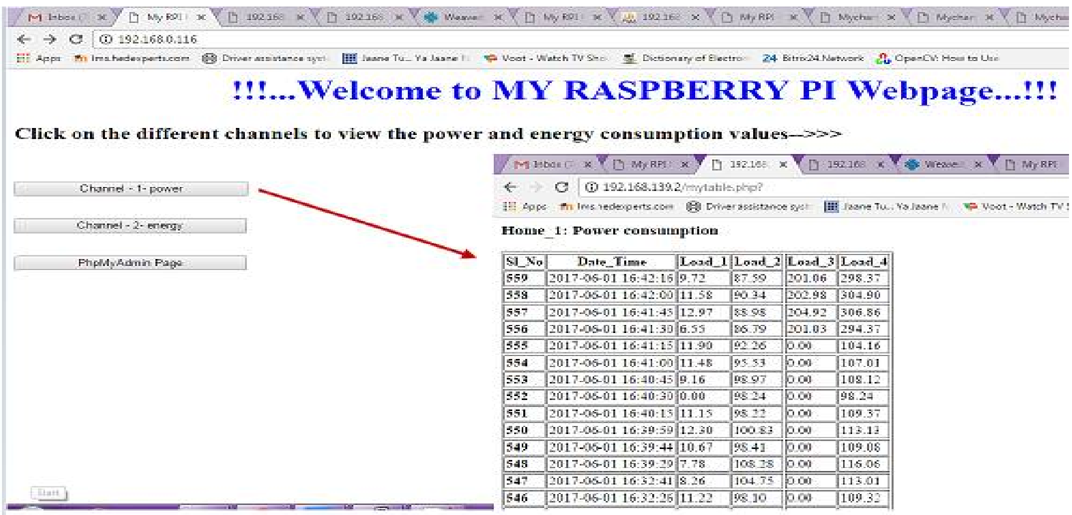


Fig 4: Graphical representation on PhpMyAdmin



SI_No	Date_Time	Load_1	Load_2	Load_3	Load_4
559	2017-06-01 16:42:16	9.72	87.59	201.06	298.37
558	2017-06-01 16:42:00	11.58	90.34	202.98	304.90
557	2017-06-01 16:41:45	12.97	88.98	204.92	306.86
556	2017-06-01 16:41:30	6.55	86.79	201.03	294.37
555	2017-06-01 16:41:15	11.90	92.26	0.00	104.16
554	2017-06-01 16:41:00	11.48	95.53	0.00	107.01
553	2017-06-01 16:40:45	9.16	98.97	0.00	108.12
552	2017-06-01 16:40:30	0.00	98.24	0.00	98.24
551	2017-06-01 16:40:15	11.15	98.22	0.00	109.37
550	2017-06-01 16:39:59	12.30	100.83	0.00	113.13
549	2017-06-01 16:39:44	10.67	98.41	0.00	109.08
548	2017-06-01 16:39:29	7.78	108.28	0.00	116.06
547	2017-06-01 16:32:41	8.26	104.75	0.00	113.01
546	2017-06-01 16:32:26	11.22	98.10	0.00	109.32

Fig 5: Web Server and different channels for accessing tables

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The results from the database will be also reflected on the webpage along with the different buttons created for the tabular view for easier access of the data and monitoring for the user. The frontend of the web page is done using HTML scripting and are as shown in Fig 5.

The different buttons created on the webpage on clicking lead to the different tables created within from the data uploading from the database connected to the live sensor data. On the simulation basis, a number of homes can be created under a database so as to make a comparative analysis and provide the signature results. The table for first home power consumption can be seen below Fig 6. Linking with the Google charts and Text local API, the results are shown below after sending the SMS notification to the registered user as in Fig 7.

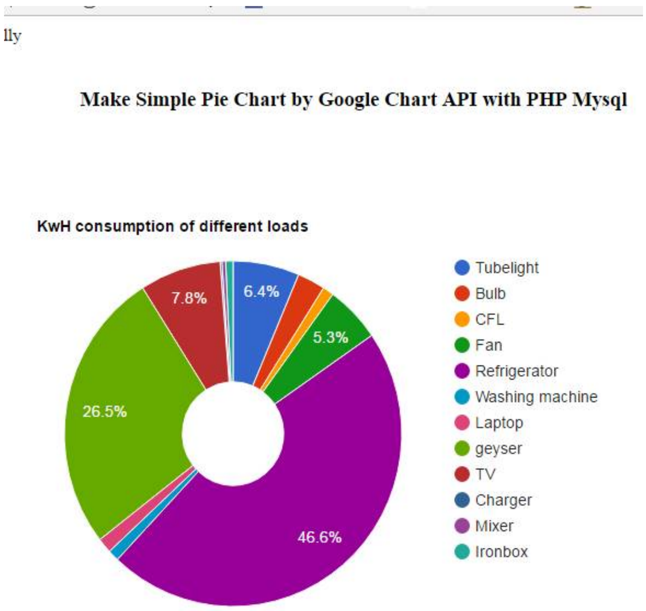

Fig 6: KWH consumption using Google charts

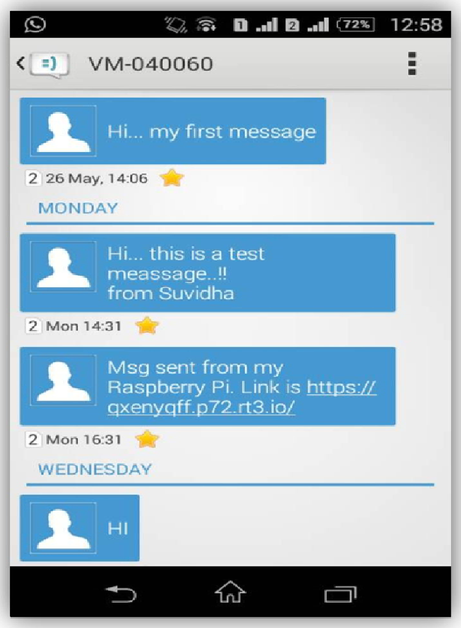

Fig 7: SMS notification from Text local API

V. Conclusion and Future Work

In this paper, a study concerning the acquisition and identification of data provided by different loads and consumers has been presented. The identification of consumer load profiles was the main objective.

The experimental tests furnish real data concerning the loads commonly used by residential consumers, which is made possible by applying the data analytics over the results obtained for the graphical visualization of each appliance usage. Usage of the smart metering technique allows for the accurate readings and un-tampered data for the proper calculation to monitor the energy consumption of each appliance. Drawing the signatures from the charts, data analytics provide the maximum and minimum usage of each appliance under each home. Thus helping the consumers to visualize, monitor and act accordingly for further energy usage improvisation.

The performance of the proposed design can be improvised in future with some modifications in design considerations and AI can be used so as to make a single sensor capable of measuring, alerting and notifying the user all together.

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BIOGRAPHY

Suvidha Biradar has done her Bachelor's in Electronics & Communication from Visvesvaraya Technological University Belgaum and is currently pursuing Master's in Embedded Systems from Dayananda Sagar University Bangalore.

Rahul Hiware has completed his M.Tech in Embedded Systems from Shivaji University, Kolhapur. His areas of expertise are Embedded Hardware Designs, Embedded Software Development, Wireless Technologies and Internet of Things. He has over 7 years of industrial experience. He has worked as a Lead Technical Consultant. He has done industrial training and good working experience in ETAS software.