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Internet of Things (IoT) Based Smart Energy Metering

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Abstract: Internet of Things (IoT) can be used to furnish intelligent management of energy distribution and consumption in heterogeneous circumstances. Over the past few years, by the growth of IoT and digital technologies, the smart grid has been becoming resourceful than before. The substantial increase in energy consumption has brought huge challenges to energy security and the environment, which, in the meantime, stimulate the development of energy networks towards a more intelligent way. Smart meters are the most crucial components in intelligent energy networks. Smart energy meters can reciprocate information about energy consumption and the status of energy networks between utility companies and consumers. Furthermore, smart energy meters can also be used to monitor and to control residential devices according to the individual consumer's instruction. This paper consistently reviews the event and preparation of good energy meters by exploring various functions and implementation of smart energy meters, as well as related benefits and expenditure. This paper provides vision and guidance regarding the future development of a smart meter.

Keywords: Energy Consumption, Smart Energy Meter, Power Consumption, Sensor node, smart energy, Energy Meter, Power Cut.

I INTRODUCTION

The utility sector in India has one National Grid with an installed volume of 330.86 GW as on 30th November 2017. Renewable power plants account for 31.7% of gross installed capacity. During the year 2016-2017, the gross electricity generated rated by services in India was 1,236.39 TWh and the gross electricity generation in the country was 1,433.4 TWh. In the year 2016-2017, gross electricity consumption was 1,122 kWh per capita. India is the third largest producer of electric power in the world and positioned the fourth largest in electricity consumption. The electric energy used by the agricultural sector was recorded at 17.89% in 2015-16 among all countries. Internet of Things (IoT) is an emerging field and IoT formed devices have created an outbreak in electronics and IT. The foremost objective is to make awareness concerning energy consumption and efficient use of home appliances for energy savings. Due to manual work, our existing electricity charge system has major drawbacks. The conventional meter has some of the common errors like

- Time-consuming.
- Chance of theft.
- Error while taking the information and extra human involvement.
- A consumer cannot have a daily update of his/her usage.

Thus, we proposed a smart system which enables the consumer as well as the producer to monitor and control the energy consumption on a more immediate basis. This system offers the knowledge on meter reading, power cut and also the alert system for producing an alarm when energy consumption exceeds beyond the specified limit. This project extends the

planning associate degreed implementation of an energy watching system with the pre-intimation of power agenda victimization Adriano microcontroller. The idea is being planned to cut back the human interference to gather the monthly reading and to minimize the technical problem problems regarding the billing process. From the electricity board section, the data concerning the bill quantity, payment and the pre-planned power shut down details are communicated to the consumer. If the customer does not pay the bill in time, the user is informed through a message using IoT. If still, the customer does not pay the bill, then as per designated consideration, one alert message will be sent the automatically power connection is disconnected from a remote server. It provides pre-intimation of power cut details and also the energy consumption on a daily basis. It provides alert if the energy consumption exceeds beyond certain limits. It also has the facility of terminating the power supply through a message when the residents are out of the station to minimize the wastage of energy**.** It is an effective way of greater accuracy, improved billing. In apartments, the energy meter is far away from the residents. An LCD display is placed in each residential house in the apartment to inform about the messages regarding the power cut, energy consumption on a daily basis, billing details and an alarm for the critical limit indication. These features are implemented using the ArduinoNodeMCU (esp8266) microcontroller and a GSM module.Esp8266 chip is the Wi-Fi module which helps in transferring the data through the internet. In case, if the internet does not work, a GSM is used for backup purposes. Using the proposed SEM, the following capabilities will be realized:

- Monitoring of the instantaneous power consumption of each home appliances connected to the system and calculating the power consumption, line voltage and power factor of each home appliance connected to the system.
- Providing timely information to the customers about their current power consumption and the cost of consuming electricity up to now.
- Sending useful information to the customers about their power consumption compared to other customers registered in the system. Each customer continuously observes its power consumption, the maximum, minimum, and average power consumption of other customers in the system.
- Processing the power consumption data to provide useful information for both customers and the utility companies.
- Better forecasts energy consumption in each specific area in the grid.
- Continuous monitoring of the power grid.
- Interacting with customers and managing consumption across the network.

II SMART ENERGY MONITORING (SEM)

In this segment, we introduce the projected Smart Energy Monitoring (SEM) in particulars the expected association can be used in occupied and industrial centers to estimate the sum of energy dutiful by each electrical device and to transmit various control on electrical appliances. The system can measure power consumption and power line parameters and send them to a central attendant in a different way. The data obtained can be used to predict customer consumption and consumption schedules. The system can manage the electrical equipment and, if needed, turn it off in the peak hours and turn it on at non-peak hours. The system is also able to to supervise and pile up other environmental parameters including temperature, humidity, brightness, and possible
gas outflow. It is probable to intend and execute various smart applications on this infrastructure. As shown in Fig. 1, the projected SEM system consists of three major components including sensor nodes, Gateway and Server. The sensor node sends its information to the gateway, and the Gateway connects to the Internet through a communication technology such as an ADSL modem or3G/4G/LTE network.

A. Sensor Node

To gather the customer's power consumption information, an IoT based smart plug has been implemented. The hardware is able to assemble the other environmental parameters such as temperature/humidity, gas and light sensor.
As shown in Fig. 2, the sensor node hardware consists of the different parts including Current sensors, Voltage sensor, Temperature and humidity sensor, Brightness sensor, Gas leak sensor, Relay, Microcontroller unit, and Wi-Fi module. In addition to the HTTP, for efficient data gathering and transmission, the COAP [7] protocol over Wi-Fi network which is a lightweight protocol and follows the REST has been implemented.

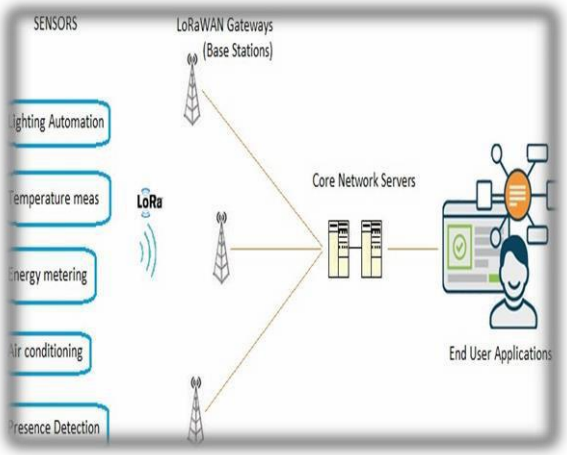


Fig. 1 The projected SEM

B. Gateway

We have developed an Android HTTP Gateway. The Gateway is responsible for config the sensor nodes and collects the sensor values by using the standard API RESTful commands. The collected sensor data is transferred to the specific server for permanent storage. Each Customer has a unique API key which is used for communication between the Gateway and Server. This API key is used for providing required security and authentication process. Each time which Gateway wants to establish a connection with the Server uses this API key in the messages. In the implementation of this web service, the service feature of Android has been used. The service is one of the components of the Android apps that can run long behind the scenes, so the web server is constantly running as a service on the Android operating system, and if it stops, Android will automatically start it.

C. Server

The main task of the Server is to correspond with the gateways to capture sensor nodes information as well as to send control commands and related data to the Gateways. It also provides a customer portal for instant right to use to the Gateway control instructions. To build up the Server, the PHP programming language on the Laravel framework has been used. The Server uses SQL and the MySQL database and uses the Eloquent and ORM (Object Relation Mapping) technology to communicate with the database. For the panel's design the HTML, CSS, JavaScript languages, and bootstrap library on the AdminLTE framework has been used. The HTTP protocol and JSON data structure are used to transfer data between the Server and the Gateway. To secure this connection, each user has an own API-Token that can be generated on its panel and, if disclosed, can quickly remove it from its panel and build a new token. This token is used to communicate between the Server and the gateway for verification. The Server then responds to Gateway by transferring some community statistics data such as maximum consumption, minimum consumption, average consumption, and user consumption and user cost. The Server also sends the commands that the user has configured their panel for the Gateway, and Gateway implements these commands in the sensor nodes.

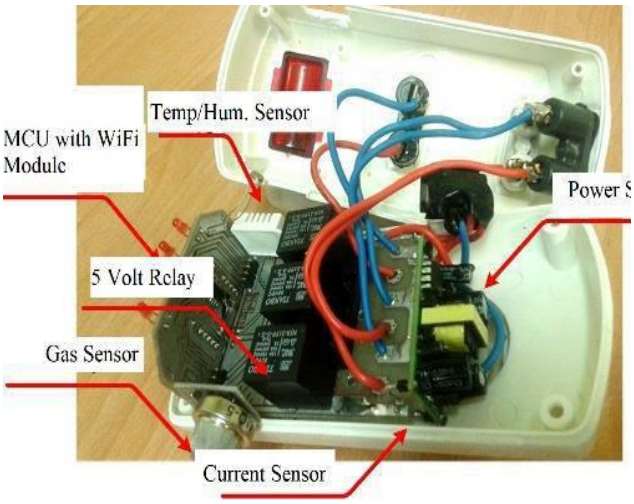


Fig. 2. The structure of a sensor node

III OPERATION OF SEM

In this scheme, a unique identification is given for each energy meter. This unique Id number is interlinked with the customer's unique mobile identification number. It constantly monitors the energy meter. The energy consumption from each house is sent to the control station via web server and the billing and power cut information are sent from the control station to the residential energy meter.

A. Energy consumption on a daily basis

In the existing energy meter, the meter shows the energy consumed from the date of setting up. In this system, the daily energy consumed is calculated using the Arduino microcontroller and it is displayed in the LCD. It is also communicated to the consumer's mobile using IoT.

B. Billing and Payment through IoT

The billing detail for the energy consumed is Communicated to the consumer monthly through the web server using IoT and as a message through the GSM module. The payment is also made through the web server. This helps in eliminating the manual dependency to collect the reading.

C. Pre-Intimation of Shut Down

The unexpected power cut causes major issues in hospitals, industries and publicly sectors. So as to bear in mind of to create safety precautions in hospitals, the facility cut is declared ahead. The facility cut details are sent from EB internet server to the consumer's distinctive ID exploitation Iota and it is conjointly sent to the consumer's mobile as a message through the GSM module. The main points also are showed within the digital display when associated in nursing alarm. The alarm is employed to point the residential that a replacement message has been received.

D. Alert Systems

Our electricity billing system has a format that when the energy is consumed beyond the certain limit, double charge are collected i.e. they are charged twice the normal rate. In order to create awareness to the public, an alarm will be provided when the energy consumed by the consumer reaches the nearer value of the critical limit. The message is also displayed in the LCD display.

LCD Display

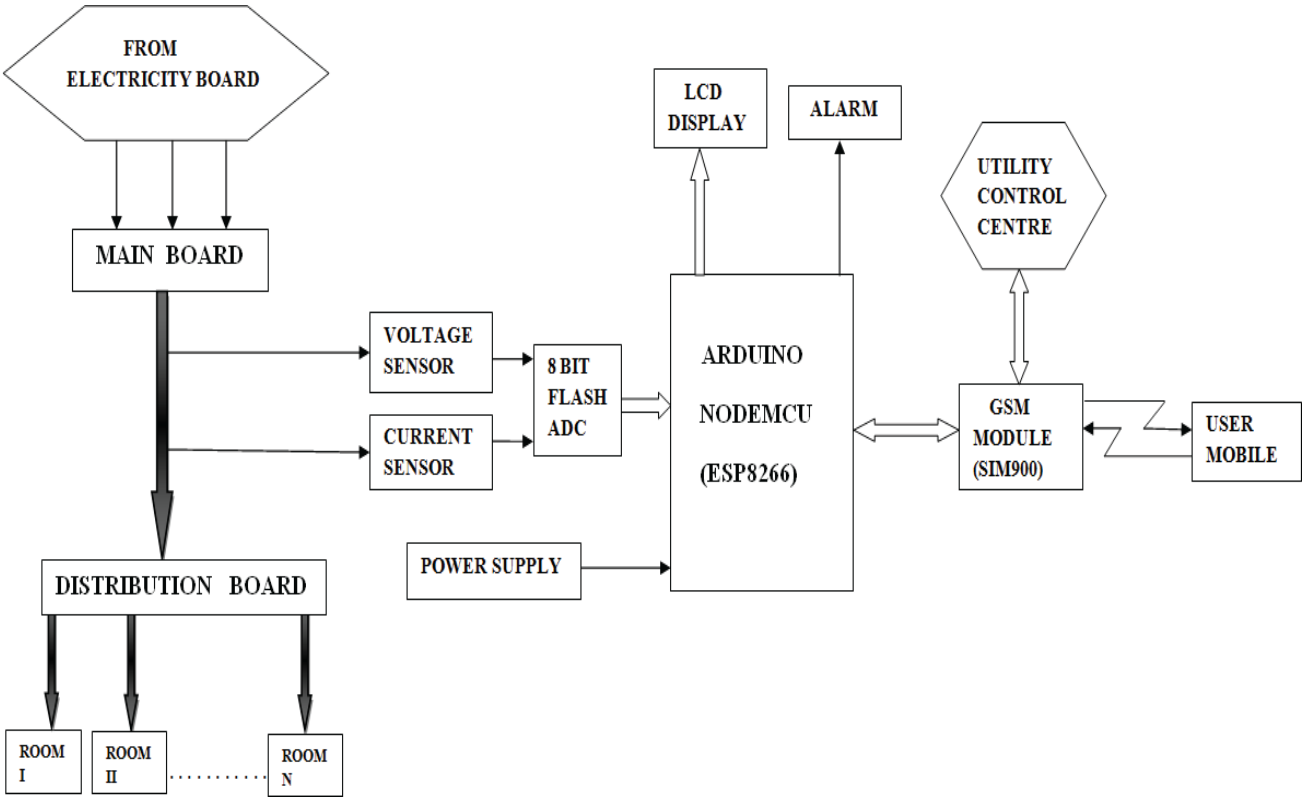
E. Power Disconnection through a message

When the residential are out of a station and if they have forgotten to off the power, it can be disconnected by sending a message through the GSM module. This helps to prevent the wastage of energy if any equipment has been forgotten to off.

Our power charging framework has a configuration that when the vitality is devoured past as far as possible, twofold charge are gathered for example they are charged double the ordinary rate. So as to make attention to the general population, a caution will be given when

the vitality devoured by the buyer comes to the closer estimation of as far as possible. The message is likewise shown in the LCD show.

•The alarm helps to make awareness to the general public relating to their energy consumption and therefore the corresponding charges.



IV CONCLUSION

•This system shows the energy consumed on a usual, thence it helps to cut back consumption by comparison the daily usages.

•It reduces human interference to gather the monthly reading and it additionally saves time and cash.

•The pre-announced termination details facilitate to require necessary preventive measures and additionally help to charge the essential varieties of instrumentation.

•It prevents the wastage of energy by disconnecting the ability through a message once the residents are out of the station.

•The liquid crystal {display|LCD|digital display alphanumeric display} display, located within the distribution board helps the residents within the residences

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