



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

# IJIRSET

International Journal of Innovative Research in  
**SCIENCE | ENGINEERING | TECHNOLOGY**



# INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 2, February 2022

**ISSN** INTERNATIONAL  
STANDARD  
SERIAL  
NUMBER  
INDIA

Impact Factor: 7.569



9940 572 462



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# Effective Power Management in Smart City

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**ABSTRACT:** The development of automatic metering system and power management is presented in this paper. The system consists of Zigbee Digital Power meters installed at every consumer's unit and an automatic e-Billing system at the energy provider's side. The Zigbee Digital Power meter (ZPM) is a single phase digital kWh power meter with embedded Zigbee modem which utilizes the Wireless sensor network to send its power usage reading and the electricity bill back and forth wirelessly. At the power provider side an e-billing system is used to manage the received zigbee meter reading, compute the billing cost, and to publish billing notification to its respective consumer through wireless modem. Also the circuit is designed to manage power, when the generation of power is less available at the electricity board. The controller prioritizes the electrical appliances in each node (i.e. houses) similar to that of a mesh network. Then it gives the highest priority to the most necessary appliance needed by the user then in the same way it gives priority to all other appliances connected to the node. When the power value reaches below a threshold, the PC at the power provider section gives a command to the controller, to supply the power only to the higher priority appliances and stop providing power to the lower ones. Likewise depending on the availability, power is equally distributed to all the nodes connected to the energy provider so that each node can at least make use of the most used appliance without total power shutdown.

**KEYWORDS:** AMI, GSM, MDMS, Zigbee.

## I. INTRODUCTION

Automated metering is expected to be an integral part of the modern energy grid. Automated metering entails transport of metering data from the consumer's premises to the data management systems of the energy provider and potential information in the other direction. The power management system consists of Zigbee Digital Power meters installed in every consumer unit and an e-Billing system at the energy provider side. The Zigbee Digital Power meter (ZPM) with embedded Zigbee modem which utilize the Wireless sensor network to send its power usage reading to the energy provider wirelessly. At the power provider side an e-billing system is used to manage a received zigbee meter reading, compute the billing cost, update the database, and to publish billing notification to its respective consumer through wireless network. The concept of dynamic assignment of power transfer to the prioritized appliances is discussed which reduces the entire power shut down for hours together and cuts off only for the lower priority tasks, which under some circumstances becomes a higher priority task. Slicing of reading timings is also discussed which can be used to improve the performance of the proposed system. The highest priority task is serviced more than the lower priority task. Hence it need not wait for the slack time of other previously higher priority interrupts. If power will be less in power grid, automatically power will be manage using RTOS.

## II. RELATED WORK

There are alternative approaches which may be used to implement smart metering solutions using different Communication technologies such as GPRS, 3G and PLC. In the case of cellular, the utility provider will have to sort out agreements with the cellular operator which may cost implications. Cellular penetration may be another factor that needs to be considered to ensure coverage is adequate. Broadband technology is another alternative wherein the data can be securely tunneled over the broadband network. However, broadband penetration issues need to be considered. PLC appears like an attractive choice given the seamless penetration of power lines in the consumer premises. This method also involves complications since power and the billing information has to travel on same line. Thus zigbee

seems to be an attractive mode of data transfer, since the amount of data transferred (meter reading) is less and the time slice used for the meter reading (once in a month) is high.

### III. OVERVIEW OF PROPOSED SYSTEM

#### A. Introduction

Motivated by the need to improve energy efficiency and reduce the impact on the environment, we see efforts being directed towards enabling a 'Smart Grid'. One of the fundamental elements of the Smart Grid is the Automated Metering Infrastructure (AMI), envisaged to be a network of meter and concentrator nodes wherein meter readings are automatically sent by smart meters located at the customer premises to the Meter Data Management System (MDMS) through concentrators provisioned by the utility provider. This is done by providing a controller based circuit at every node. The controller makes sure that after each predetermined slot the power consumption is noted. The time slicing is done based on the energy provider's convenience. For example in Chennai the meter reading is taken once in a month. Likewise the controller is responsible to collect the power reading in a set of nodes adjacent to it and transfer it to the nearest electricity office, usually called a concentrator by the network.

Along with the automatic metering system the energy is managed by the circuit. The proposed system is used to manage power when the available power is less present to the electricity board, the controller at the consumer side first priorities the electrical appliances connected to it. Then it gives the highest priority to the most necessary appliance needed for the user (e.g. fan) then in the same way it gives priority to all other nodes connected to the controller at each house. When the power value reaches below a threshold value the pc at the admin section gives a command to the controller to supply power to the higher priority appliances and stop providing power to the lower one. At this time as soon as the controller receives an interrupt the power line of the lower priority appliances is shut down. The system consist of a set of threshold values based on which the appliances and power given to them is managed.

The highest priority is based on the most necessary appliance that is used.

For example if a house (i.e. node) consist of the three categories of appliances such as highest priority is given to fans at the house, next intermediate priority to television (not much used) and lowest priority to air conditioner(used mostly at nights). If the power is below the first threshold power given to air conditioner is cut down, and other appliances work well, when the power goes beyond second threshold then power to television is also removed. Like the same way according the availability the power is equally distributed to all the nodes connected to the energy provider so that each node can at least have the most used appliance without total power shutdown.

#### B. Disadvantages of Existing System:

Till today Meter reading is taken manually by humans that can cause fatal errors, these errors occur due to less concentration which cannot be avoided. Lesser accuracy may lead to confusions for both consumers and energy providing authorities. Huge Manpower is needed as population rate and new power line connections to each houses increase. Work can be delayed due to external conditions such as weather, natural calamities etc. inefficiency in reaching rural areas of observation. Power cut is done manually due to lack of payment. Total power shutdown in case of less available power generation. Uneven distribution of power having higher power shut down time for rural areas and less timings at the cities.

#### C. Advantages of Proposed System:

Meter reading is taken automatically. Power cut achieved from EB office through wireless. Work cycle is not stopped due to time and external conditions. Less manpower is involved in case of collecting energy consumption at each consumer premises. High Accuracy meter reading. Customer service is achieved at its best. Power management is achieved at the time of less power generation.

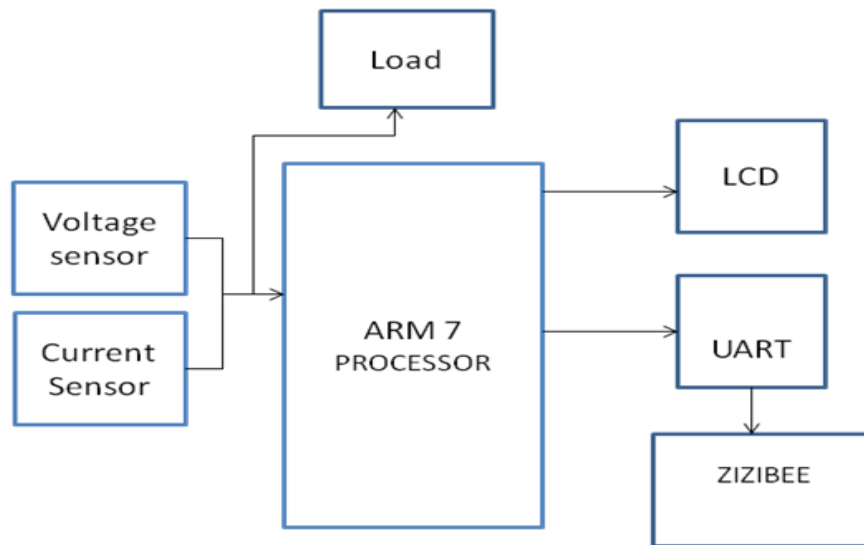


Fig 1. Block Diagram of Proposed System.(Admin Section)

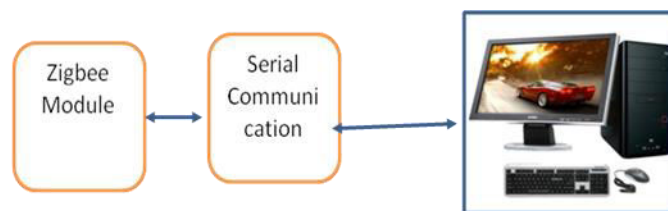


Fig 1. Block Diagram of Proposed System.(User's Section)

#### IV. EXPLANATION OF BLOCK DIAGRAM

##### A. Potential Transformers:

In electrical engineering, a current transformer (CT) is used for measurement of electric currents. Current transformers, together with voltage transformers (VT), are known as instrument transformers. When current in a circuit is too high to directly apply to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments. The current transformer also isolates the measuring instruments from what may be very high voltage in the monitored circuit. Current transformers are used here for metering purpose, which calculates the amount of current consumed by the user.

Voltage transformer is also known as potential transformers. These are a type of instrument transformers that gauge and protect the safety levels in high-voltage circuits. Their designs allow presenting a negligible load to a supply that's being measured and for creating a precise voltage ratio for stepping down high voltages accurately. It allows operations at lower potentials. The voltage transformer is used for the same purpose as that of the current transformer. It measures the amount of voltage consumed and gives it to the controller. The controller calculates the power from the readings of the voltage and current transformers and manipulates the e-bill.

##### B. ZIG BEE

**Zigbee** is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. Zigbee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones. This allows Zigbee networks to be formed ad-hoc, with no centralized control or high-power transmitter/receiver able to reach all of the devices. Any Zigbee device can be tasked with running the network. Zigbee is targeted at applications that require a low data rate, long battery life, and secure networking. Zigbee has a defined rate of 250 Kbit/s. The technology defined by the Zigbee specification is intended to be simpler and less expensive than other WPANs, such as Bluetooth. Here it is used to transfer the meter reading calculated by the controller to be transmitted to the admin (nearby electricity office) for calculating the electricity bill and also the admin to transfer the control signals to the user side to enable and disable the corresponding loads according to the power that is present at the electricity board. The zigbee used is 32-bit



architecture enables intelligent wireless networks in industrial and control applications, Single-chip wireless microcontroller or co-processor configuration, 16 MIPS processing power, large memory resources and comprehensive set of on-chip peripherals

### C. Microprocessor

A Microprocessor is a small computer on a single integrated circuit containing a processor core, memory, programmable input/output peripherals, program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microprocessors are designed for embedded applications, in contrast to the microcontrollers used in personal computers or other general purpose applications. Microprocessors are used in automatically controlled products and devices, such as automobile engine control systems, implantable medical devices, remote controls, office machines, appliances, power tools, toys and other embedded systems. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes. Mixed signal microcontrollers are common, integrating analog components needed to control non-digital electronic systems.

## V. SCENARIOS AND PERFORMANCE ANALYSIS

The following chapter presents the analyzed scenarios together with the conducted performance analysis.

### A. Scenario Description

Scenario 1: Small-scale scenario with 350 meters.

Scenario 2: Full-scale scenario with 17,181 meters.

Scenario 1 is used for validation purposes to confirm proper functionality of geographical routing algorithm, whereas the second scenario is used to derive statistics for complete scenarios. Both scenarios are evaluated for a simulation time of 24h. Each node sends a data packet towards the data Collector every four hours with a uniformly randomized starting time

### B. Performance Analysis

The results of the simulation runs for different reference scenarios are presented in the following section. The results focus on the success rate of received packets per node in order to measure the performance of the deployed system. Communication gaps and bottlenecks are measured by the success rate of received packets per node.

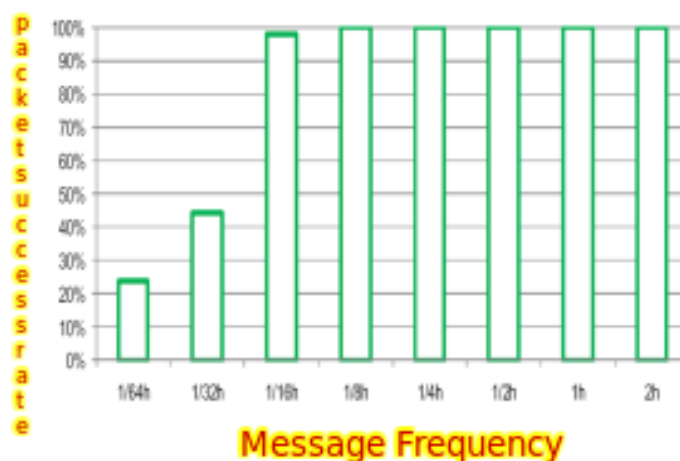


Fig .2 Packet Success Rate Vs Message Frequency

The system performs with 100% success rate (i.e. received packet ratio) for the small-scale area, given a message frequency of 1 message per 4hrs. In order to identify bottlenecks in the network topology, the message frequency was increased to 1h, 15min, 7.5min and 4min which led to more than 98% success rate for a message frequency below 7.5min (see Figure 2). Above this frequency a drastically reduced success rate was noticed due to collisions in some central nodes.

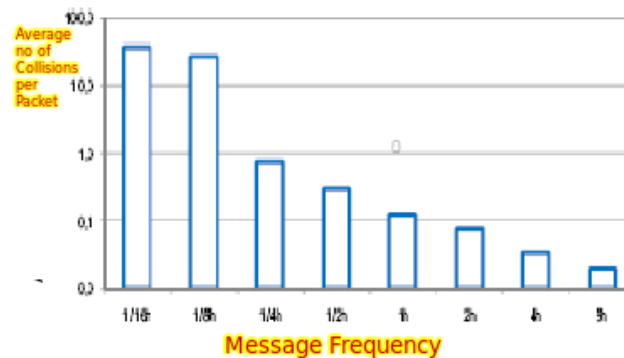


Fig.3 No Of Collisions Vs Message Frequencies

The number of average collisions per packet is shown in Figure 3. Within the large-scale scenario, an overall success rate of the system was observed with 99.99% for a message frequency of 1 message per 4h.

## VI. SIMULATION RESULTS

Network simulator 2 is used to visualize the network and the data packets. When the code is executed the nodes get appeared. The power provider first prioritizes the electrical appliances at each node. Initially all the nodes are given equal priority when the power level is high and all nodes receives power. (See fig .4)

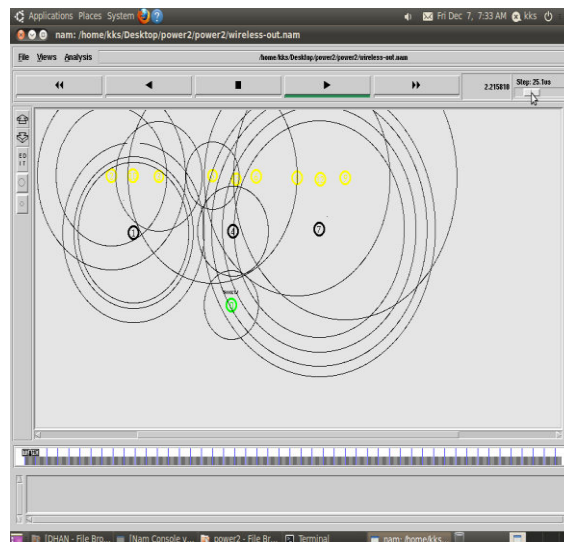


Fig .4 Snapshot of power provided to all nodes

As power at the provider decreases below the first threshold, the lowest priority appliances will get automatically disconnected. (See fig .5)

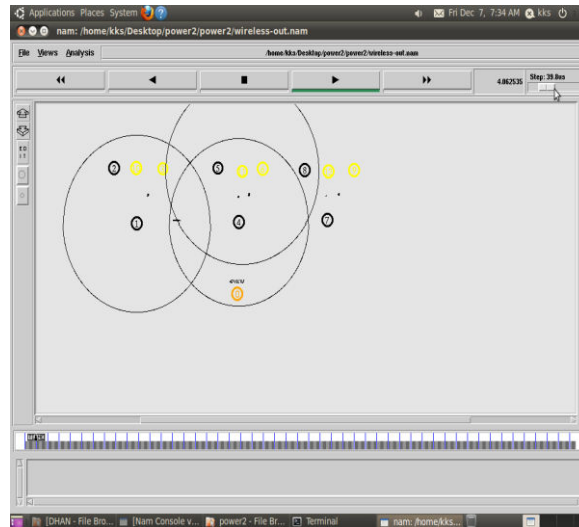


Fig .5Snapshot Of Power given to most prioritized nodes

When the power at the provider decreases below the second threshold, the intermediate priority appliances will get disconnected automatically. (See fig .6). And only the lower priority appliances will be provided with power.

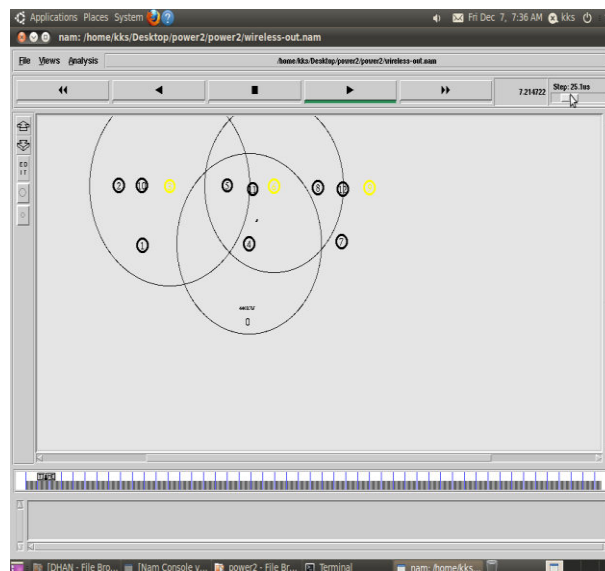


Fig. 6 Snapshot of Power given Only to Higher Priority Nodes

## VII. CONCLUSION

In order to overcome the manual errors made during meter reading and to effectively manage long duration of power cuts this method has been proposed. This method makes sure that power is equally distributed to all providers irrespective of the amount of power needed. The execution involves both by the consumer side controller in collecting the meter reading and by the administration controller in issuing interrupts to the user's section. The controller at the user's side has to also take of the priority based issue. The priority can be of two types, either the customer can make a choice of priority during installation or the electricity board can make a general assumption for the given area. The method is very much useful for the regions where lack of human reach and uneven distribution of energy is present.

In future the controllers can be also used to monitor the excess energy usage of each customer and send a note to customer indicating the issue. This way the wastage of power can be avoided in each individual houses.

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