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Research Article

DESIGN OF MULTI FUNCTIONAL ELECTRONIC ENERGY METER ENABLED WITH ZIGBEE PROTOCOL INTENDED FOR INDUSTRIAL APPLICATIONS

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A B S T R A C T

In the present scenario, electronic metering technology has gone through rapid technological advancements and there is an increased demand for a reliable and efficient automatic meter reading system. The objective of this research article is to design a simple low cost wireless Zigbee energy meter and its associated user interface for managing the collected data globally. The proposed system replaces traditional meter reading methods and enables remote access of existing energy meter by the energy provider. Also the meter readings can be monitored regularly without the person visiting each industrial unit area. A Zigbee based wireless communication module is integrated with electronic energy meter of each entity to have remote access over the usage of electricity. Live meter reading from the Zigbee enabled energy meter is sent back to this reading periodically and these details are updated in a central database. It is concluded that, our proposed system helped in saving cost and time as compared to the conventional method of getting the meter reading.

INTRODUCTION

Now a day's electrical power has become indispensable to human survival and progress. Apart from efforts to meet growing demand, automation in the energy distribution is also necessary to enhance people's life standard [1, 4, 7, 17]. Traditional meter reading by human operator is inefficient to meet the future residential development needs. So there is increased demand for automatic meter reading (AMR) systems which collects meter readings electronically, and its application is expanding over industrial, commercial and utility environment. Electronic utility meters are an important step towards automating the utility metering process [2, 5, 8, 10]. Traditional electro-mechanical meters, still widely used today, are prone to drift over temperature and time as a result of the analogue and mechanical nature of the components in these meters [3, 9, 11, 12]. Collection of meter readings is also inefficient, because a meter reader has to physically be onsite to take the readings. This method of collecting of meter readings becomes more problematic and costly when readings have to be collected from vast, and often scattered rural areas [13, 14, 15]. Meter readers are reluctant to make the effort to travel to such areas and will often submit inaccurate estimations of the amount of electricity consumed. There exists chance for missing reading, absence of consumer etc. Even though these conventional meters were replaced with more efficient electronic energy meters these problems still persists [6, 16, 18]. So a system which will provide the meter reading details in users mobile or personal computer will be more suitable in the current scenario.

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Existing System

Conventional reading is suitable for a yearly reporting. Service technicians arrange target dates with the inhabitants in the flats, read out the displayed values on the different meters and register them in paper form. These values will be then sent to the centre after a time period in order to generate the rate of energy consumed by the industry. The manual meter reading is in general associated with many disadvantages. In this context we can mention high operational costs, since a service technician has to go to the premises and read out all the values of the meters. The inhabitant should be also present to allow the service technician to read out the meter values, which is non-convenient. The manual reading out leads also to errors, since the service technician is always under stress and has to read out the values in a short time.

Proposed System

Automatic meter reading is a technology which automatically gathers data from energy metering devices and transfers it to the central office in order to analyse it for billing purposes. Data are read remotely, without the need to physically access the meter. The structure of AMR system is shown in Figure 1, which consists of measure meters, sensor nodes, data collector (gateway), management centre (server) and wireless communication networks. The data transmit from the sensor nodes to the data collector using the Zigbee communication

network. The data transmit from the data collector to the server, system uses ethernet. The data collector in this system act as gateway, it is the protocol conversion used to transform a data package in Zigbee protocol to transmission control protocol/internet protocol (TCP/IP) before transmitting and a data package in TCP/IP protocol to Zigbee protocol.

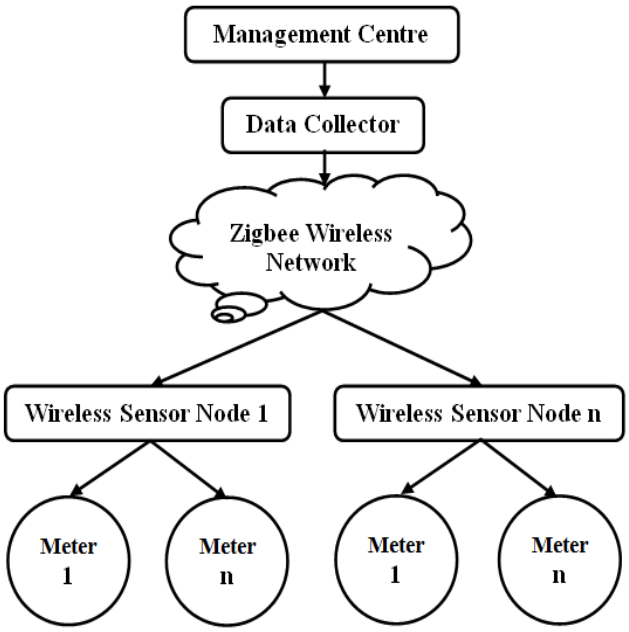


Fig 1 Structure of AMR System

AMR system mainly consists of three primary components, namely meter interface module, communication system as well as the central control unit or data concentrator used to store the transmitted meter readings data is shown in Figure 2. In this scheme, we may use the Zigbee network for automatic meter reading and we can send the instantaneous voltage and current to server/service provider side and then further process will be carried out. The data concentrator is a compact computer type electronic unit, located at an easy accessible point for processing the data received from the end units. The AMR approach leads to many advantages such as more convenience for worker head, since the presence is no more necessary, minimization of errors from human factors, improvement of the meter reading accuracy, reduction of operational costs for data collection and frequent reporting.

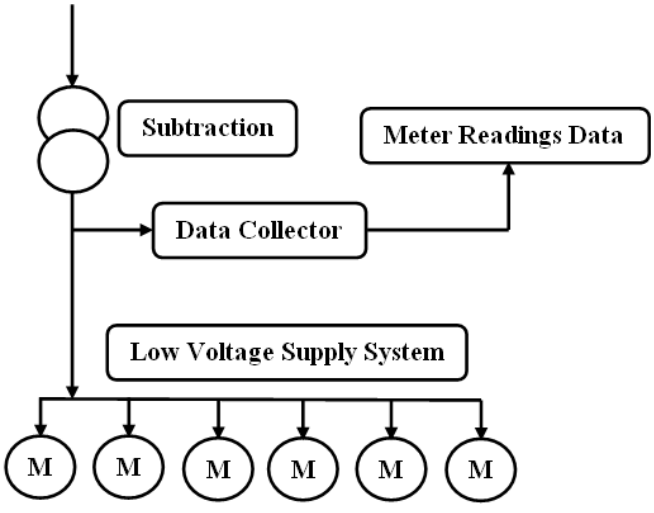


Fig 2 Access in AMR System

Electrical Meter: An electronic device that measures the amount of electrical energy supplied to a residence or business. It is electrically fed and composed of electronic controllers. It has an interface which allows data to be transmitted from the remote terminal to the central device.

Central Office: Equipped with a system which includes receivers, data concentrators, modems, and computers that are able to store and to process received information

Communication System: A communication system needs to be implemented in order to transmit data and to control the different signals between the remote device and the central office. AMR includes mobile technologies, based on transmission over the electric cables (power line), or telephonic platforms (wired or wireless). AMR is performed with fixed networks in order to provide information without the intervention of human factor or the deployment of handhelds. AMR is generally appropriate to provide information daily and in special cases hourly. Therefore this is the only way to realize the smart metering approach.

Zigbee Modem

ZigBee is a home area network device designed specifically to replace the proliferation of individual remote controls the main motive behind the creation of Zigbee is to satisfy markets need for a cost effective, standard based wireless network that supports low data rates, low power consumption, security and reliability. A smart home and a smart office with flexibility and seamless mobility, all without wires, are some of the promises of the ZigBee wireless solution. The structure of the scheme using Zigbee communication network is shown in Figure 3.

Central Office Side: Primarily the global system for mobile (GSM) modem and also the ZigBee modem should be initialized. Data are received from channel 0 and channel 1. Remove the extra information on channel I0 and I1. The data will be in the form of a string, then it should be converted from string to decimal number and calculate the real voltage and current. And also calculate the power and energy with system time and also the total amount corresponding to the energy utilized. This amount is sent to the user mobile via GSM network as a message. As soon as the message is sent for the total energy consumed for the particular month, amount will be made zero. In case if the payment is not made then signal will be given such that the relay at the energy meter side trips to disconnect the supply automatically.

Conceptual Design

In this research we have developed three different topologies for demonstrating how the simulation works as shown in Figure 4. Every single topology consists of ten ZigBee devices which are all connected to single control centre. These topologies can be interpreted as buildings in a little town or street. Next step is defining the analyses by working through the simulator and present the results for two analyses such as average battery life and loss of connectivity which are defined as follows.

Average Battery Life: In this analysis, the remaining battery life is calculated via simulator for a constant moment. And for the rest of devices in the network, this calculation is being used. This value provides important data about network architecture success and battery life.

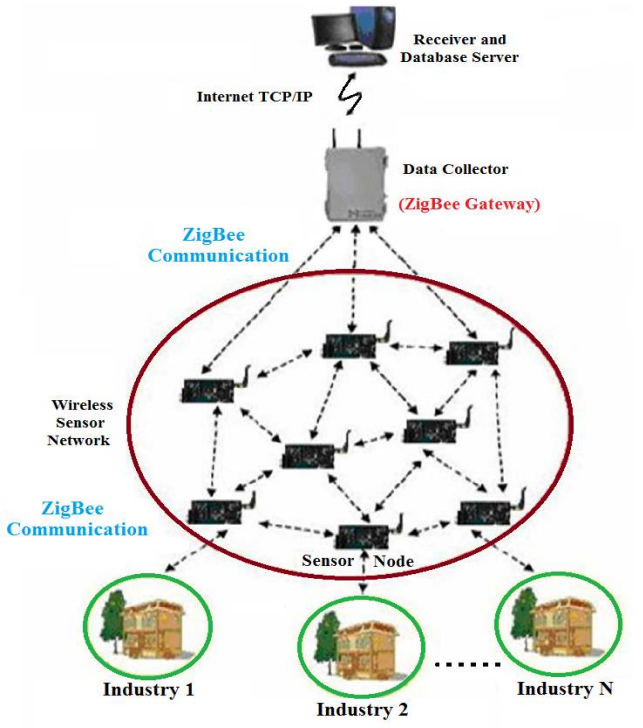
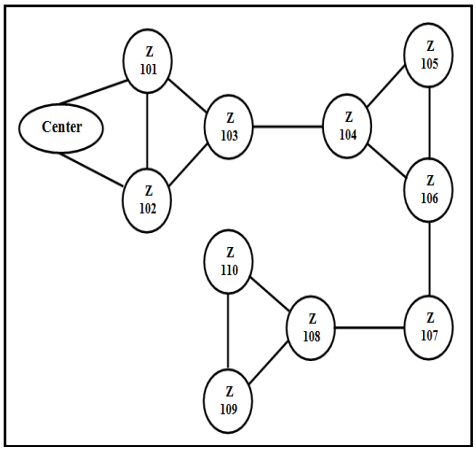
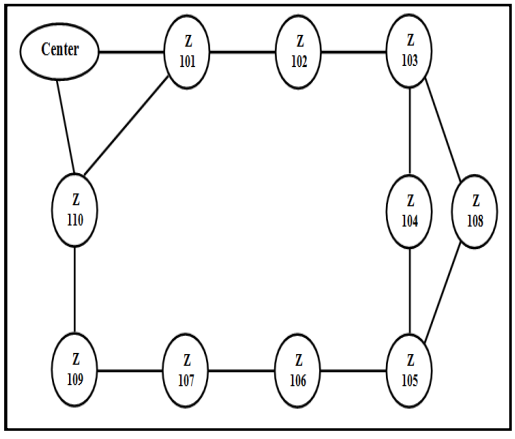


Fig 3 Proposed Structure Diagram

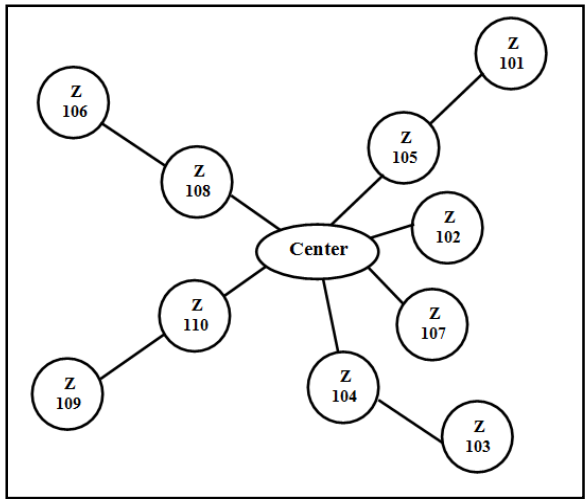
Loss of Connectivity: In this analysis, the connectivity between each device and the control centre will be investigated. Due to various reasons such as battery drain or device fault, a device can stop functioning and in this analysis we find out how much of the network will be negatively affected from such situations.



a Topology 1



b Topology 2



C Topology 3

Fig 4 Different Topologies for Simulation

RESULT AND DISCUSTION

In this section, we present the results of the simulation on average battery life and loss connectivity analyses.

Average Battery Life: The result of the average battery life analysis is shown in the following Figure 5. Since routing of the packets require more devices in Topology 1, more energy is consumed for data transmission. As an example for the difference between topologies, the farthermost device in Topology 2 connects to the control centre via 4 hops, whereas in Topology 1 this requires 6 hops. From the results it was observed that, the best results come from Topology 3 where most of the devices are in the control centre's signal field and do not need any hops in order to transmit data.

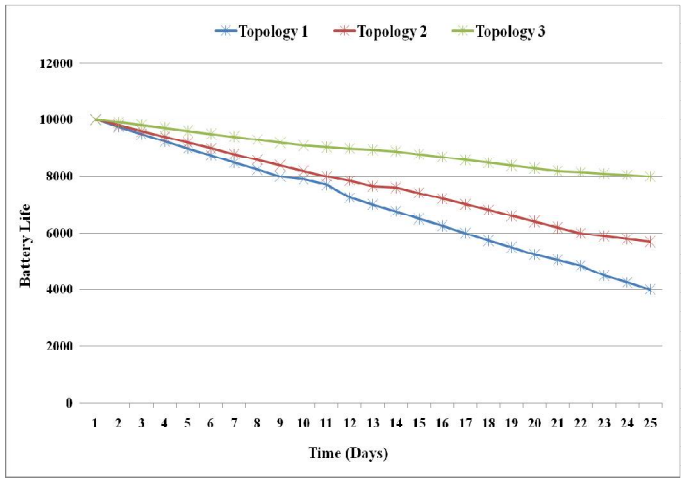


Fig 5 Result of Average Battery Life

Loss of Connectivity: The result of the loss of connectivity analysis is shown in Figure 6, where we present how a fault in the network affects the connection between control centre and other devices, in percentage. The best results came from Topology 2, where a device fault does not affect any other device. In Topology 2, a device fault in either of the devices 4, 5, 8, or 10 will cause 20% of the network stop functioning and the worst results come from the topology, where 80% of network is affected by a broken device in the worst case.

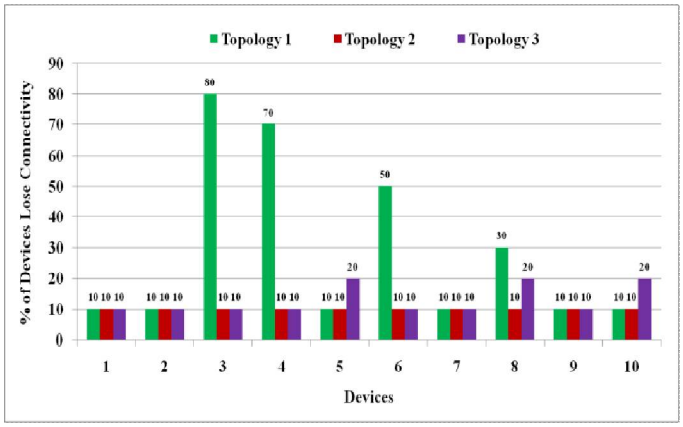


Fig 6 Result of Loss of Connectivity

CONCLUSIONS

Stand-alone meter readings are highly person dependant and human errors cannot be avoided. The manual reading of electromechanical meter for the purpose of reading is fraught with many social and management problems. Some of these problems are possible lock-out of a meter from easy accessibility, human error in reading, gross inaccurate estimated reading, lack of information on detailed breakdown of energy consumption over a period of time and possible misplaced paper of energy meter reading.

- To overcome from the issues, in this research a design of a wireless Zigbee enabled energy meter was developed which provides automatic meter reading.
- AMR is the technology of automatically collecting consumption, diagnostic and status data from energy metering devices, mainly electricity and transferring that data to a central database.
- To overcome misplace of reading, reading being erased we will be sending a message containing revenue register number, name of industry unit, units consumed is called billing.
- Two features, which can retrieve the meter reading with little human intervention, are proposed and implemented in the AMR system.
- It helped in saving cost and time as compared to the conventional method of getting the meter reading.

Future Scope

If there is any variation in the energy consumption occurs during every month then the entire module system should be changed otherwise it will show the previous reading only and it will affect the billing. More over the energy provider is not giving any information regarding over consumption of energy to the consumer. To overcome these issues the AMR through Bluetooth with MSP 430 microcontroller can be used in the future.

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