

ZIGBEE AND GSM BASED WIRELESS METER WITH TAMPER DETECTION AND CONTROL SYSTEM

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ABSTRACT

An electric meters are used everywhere to calculate the consumption of power. Wireless meter reading technology can save human resources and another feature of this kind of meter is, it improve the accuracy since it works on real time application, enabling management sector to access to data messages within a short period of time and accurately. Due to its wireless communication network, it just not save human and material resources but this property leads to most economical meter in terms of investment. In this paper, power consumed by the consumer is monitored by base stations through wireless network. It aims to reduce the man power for billing since the meter reading is transmitted through ZigBee and at base stations we calculate bill, save records of consumers. The most important part of this project is that we can monitor any fault in meter as well as any tempering which is used to steal the electricity.

Keywords – ZigBee, WMR, Tamper detector, Auto load system.

I. Introduction

Our traditional meters, in which the pendulum rotates for a predefined times and it calculates the consumption of unit power in terms of Watts. Those meters are economical ones and installed at home and as well as in industries. Our traditional meters are non real time ones so calculation of bills is slow in process. Now a day's a computer operated meter are used but they are also non real time system operated device. In this process we require more time and human resources. And if any fault occurs then to detect it and resolve the problem is the big task.

After emerging a rapid increase in digital technology and computer communication system we had seen a plenty of revolutions to replace old systems by newer ones. Our traditional electric meters are on the verge of replacement by new smart meters and wireless meter. Whereas wireless meter are more preferred over smart meter. Smart meters are prepaid service meter so after its predefined limit power goes down. This disadvantage has been replaced by the wireless meters.

In India, a standard meters are implemented from the arrivals of electric meter in our country. as population is increasing the number of electric meter

installation is increased for their homes. To collect data from a large number of houses it requires more time and man power. Wireless meter reading is a proposed model for reading and processing of meter reading digitally with the help of computer communication in a very efficient way. Basic idea behind this model is to reduce the error made by human while collecting data visiting at consumer homes and to minimize the time which requires collecting the data from each area. It increases the speed of operation since it requires less human efforts and especially the power consumption is very low due to good installed low power consuming devices. The main part of this model is ZigBee since it has main feature of low data rate so it consumes less power to operate and it is highly reliable. It eliminates the error of any kind of data loss during the transmission and reception of digital data. We all know that a human operator visit to all houses and manually note down the reading and then submit all data to base stations. On those bases a bill is generated again which is manually distributed by visiting each and every consumers homes. Before the bills are generated meter readings are stored manually at base stations. This process is more time consuming and full of human errors. Consumers always complain about their bills. This entire

network is full of loop holes at different stages and cannot be eliminated or detected. This model is an experiment to remove all these errors.

If any fault occurs in wireless meter reading there is another provision to cut down the power supply of any house or of any area. Similarly we can also connect the main line between the service provider and users. This property is known as auto load control.

II. ZigBee Technology

2.1. ZigBee?

ZigBee is a new emerging technology used now days for short range communication network which works on a unique identification code. This unique ID makes this device highly reliable in terms of security. It is a wireless communication device which is comprised of a trans-receiver just like a blue tooth device or a Wi-Fi network but data rate is low.

It has 16 bits address so it creates 65536 nodes in a network or in other words it has 16 Channels for communication. It is a monitoring and controlling device in communication networks. The only difference in ZigBee is it uses unique identity method means if one ZigBee device transmits data then it is received by only that ZigBee device which is having its decoding address. While in Bluetooth or in Wi-Fi anybody can transmit or receive data. So data is prevented in ZigBee device, nobody can manipulate the data. Only authorized person or device can read data. Main features of ZigBee are low data rate & low power consumption.

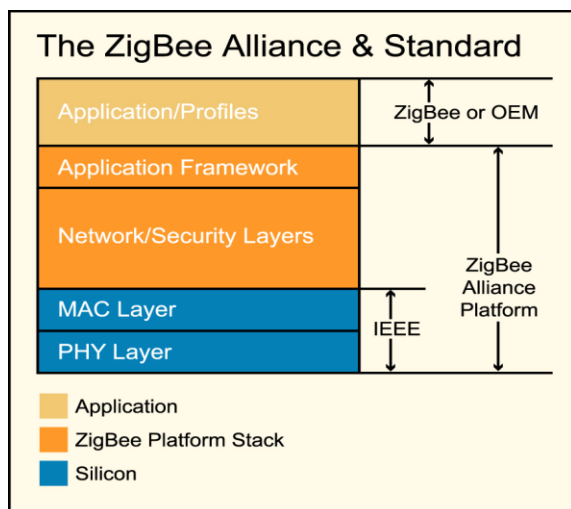


Fig. 1. Representation of ZigBee layers

The main layers which are used in communication are PHY layer and MAC layers of ZigBee. These layers form a network which is used for transmitting data, addressing, routing of data within network.

While the network may have a star, bus, mesh topology or hierarchical tree structure for routing of data between two stations. The main advantage of ZigBee is that it can create network automatically in which it can add or leave any device of a network.

Now a day's power sector companies are looking for improved technologies to reduce their cost and to boost their profits, which include flexible billing dates for their customer, forecasting their bills in advance, to remind bill dates and amount of money, to inform their load shedding schedule in advance. An important feature is to detect theft.

2.2. IEEE 802.15.4 ZigBee Parameters

The following parameters defined in the IEEE 802.15.4 standard are used

- Transmission maximum output power is -3dBm at the lower limit and is not specified for the upper limit.
- Carrier accuracy and modulation accuracy are not to exceed +/-40ppm.
- EVM cannot exceed 35%.
- Transmission spectral density has to be less than -20dBc relative to carrier and less than -30dBm absolute power, both at +/-3.5MHz offset from highest average spectral power measured within +/-1MHz of carrier.

Transmission power control range and transmission power step size are not explicitly set by the 802.15.4 standard. However, devices should transmit lower power when possible in order to reduce interference to other devices and systems.

2.3. Why ZigBee?

Performance	ZigBee	Bluetooth	Wi-Fi
Working frequency	2.4GHz, 868/915 MHz	2.4GHz	2.4GHz
System resource	50Kbyte-60Kbyte	250Kbyte	>1Mbyte
Comm. range	0.1-1.5km	0.1km	0.1km
Data rate	250 Kbps	1Mbps	11Mbps

Max. network nodes	65536	8	32
Wake-up time	30ms	10s	3s
Low power consumption	Support	No Support	No Support
Standard	802.15.4	802.11 a,b,g	802.15.1
Application	Monitoring & control	Cable replacement	Web, email, video
Battery life(days)	100 to > 1000	1 to 5	1 to 7
Bandwidth	20 to 250	720	11,000
Success Metrics	Reliability, power, cost	Cost convenience	Speed, flexibility

III. Design of wireless meter reading using ZigBee

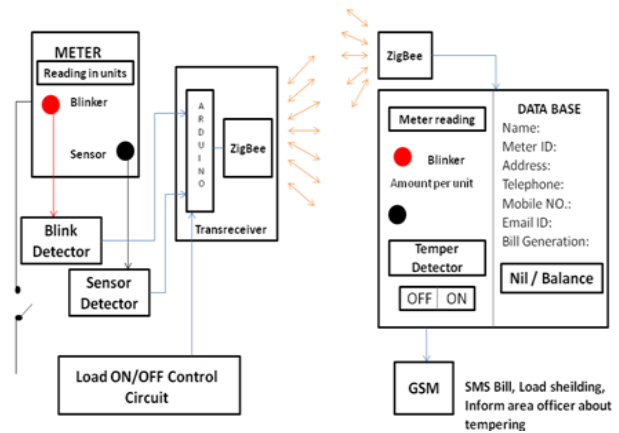


Fig. 2. Block representation of WMR

In wireless meter model, there are two main components of system one is an interface circuit and second is digital trans-receiver circuit.

a) Interface circuit: An Arduino kit or any microcontroller acts as interface circuit. It is a link between the electric meter, power line and ZigBee. The basic part of interface circuit is to observe the blinks of electric meter and counts every blink. After 3200 blinks it calculates power as 1 Watt and transmits those digital counts to base stations. Interface circuit can make or break a circuit by connecting or disconnecting power cable to the energy meter.

b) ZigBee Device: It collects the blinks and updates every count of blink which is coming from the electric meter through interface circuit. After processing the blinks it transmits that low rate digital data into network of ZigBee concentrator. Since it is short range device the setup of ZigBee network is connected as end to end device which transfers the data from single home to base stations. A meter and base station may have long distance so it sends data from home to base stations via different kinds of communication network such as mesh, star, etc.

c) ZigBee Router: The entire network is full of ZigBee devices to pass the data from one device and acts as communication link between utility provider and service provider.

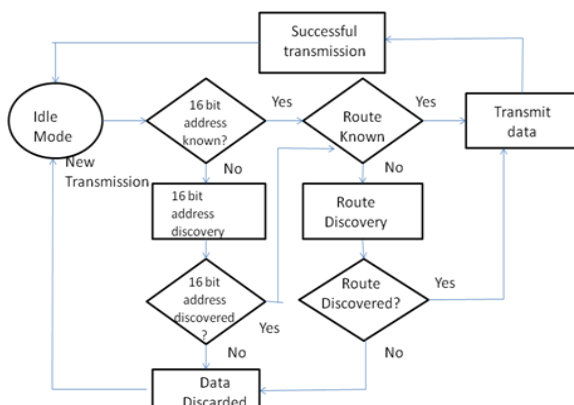
d) GSM Modem: This module is installed at base station. The basic idea behind this part is, it is a simple communication setup between two people which service provider and meter owner. It passes the information about electric bill, load shedding time and gives a call to authorized people during occurrence of any fault.

e) Range Extender: To cover long distance in a network a group of ZigBee is installed which is an intermediate terminal of a network. Data is passed

2.4. Key features of ZigBee

- Retries and Acknowledgements
- DSSS (Direct Sequence Spread Spectrum)
- Each direct sequence channel has over 65,000 unique network addresses available
- Point-to-point, point-to-multipoint and peer-to-peer topologies supported
- Self-routing, self-healing and fault-tolerant & mesh networking

2.5. Transmission Mode Sequence of ZigBee



from one point to point before delivered to base stations. In other words we can say it as a standalone device with ZigBee routing functionality

f) Concentrator: Is able to collect, store and forward meter data from other meters. Concentrators are mainly thought to manage metering data from meters that are not always online.

Zigbee has major role in monitoring and for efficient power utilization. It covers enough area needed for wireless communication and it works on low data rate of 20Kbps to 250Kbps with minimum power consumption. It is a low data rate communication device.

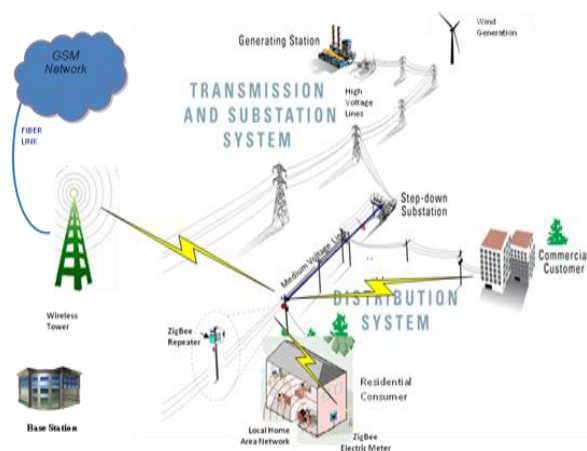


Fig. 3. Modelling of WMR

Each Zigbee module is like a telecommunication station since it's a trans-receiver, and the modules can communicate with each other within the entire network due to its unique ID coding technique. The communication distance between the nodes can range from several meters up to kilometers such as the standard 75 meters to hundreds of meters and even several kilometers, generally considered as 1.5 km of range. The Zigbee network can also be connected to other networks depends on its applications and network. Each meter contains an Interface Circuit (IC), here in this paper we are dealing with arduino kit as IC and a ZigBee module according to the connection type. Practically we can implement ZigBee network into two ways, first a group-meters-connection when various meters are connected to a module this kind of installation is seen at a single building or in a office or at any industry. And second one, a single-meter-connection when a meter is connected to module examples of such modules is a single meter at individual home. By using group-meters-connection reduces various ZigBee modules; since it install group of meters by using single ZigBee. As a consequence it reduces the total cost of modules of an entire network and reduces network

traffic or load. An wireless meter network comprised of, interconnected via mesh, star, point to point, etc. involves ZigBee device, ZigBee routers, concentrators, range extender and ZigBee-GSM coordinator according to the ZigBee standard to set up a end to end wireless communication network between consumer and base station. If a service provider wants to break the power connection for maintenance or after detecting a theft or tamper at any stage, it can switch-off the power line by a simple command from base station. As soon as the power line is disconnected a message is forwarded to the consumer with a valid reason via GSM network. To establish a connection again a command is given via ZigBee network to switch-on the line that enters into meter. Relays are basic component acts here as a switch for power for meters at consumers home. Relay make or break circuit for a main power line at consumers home. ZigBee is connected at base stations by using serial port with computer network for recording of data on real time bases.

IV. Concept of Auto load control

Auto load is a new feature which has been added in this model. It is used to make or break a circuit. When the communication network is of error free in this case a power line is connected to meter and energy is consumed by appliances. But if someone fails to pay the bills as per meter reading before due date then base system generates a signal to turn off the meter and shut down the power system of that particular ID. There is another situation in which any house holder tries to manipulate the meter reading or to steal the electricity then tamper sensor generates a signal to base station and after receiving a tamper signal an authorized person again shuts down the meter or power cable.

When a meter holder pays a bills then at base station a automatic signal is generated by data software all due are cleared and start the power. In case of tempering a inspection team complete it all necessary formalities and then power line is connected to meter via base station.

V. GSM Modem

GSM Modem can accept any GSM network operator SIM card and act just like a mobile phone with its own unique phone number. Advantage of using this modem will be that you can use its RS232 port to communicate and develop embedded applications. Applications like SMS Control, data transfer, remote control and logging can be developed easily.

The modem can either be connected to PC serial port directly or to any microcontroller. It can be used to send and receive SMS or make/receive voice calls.

It can also be used in GPRS mode to connect to internet and do many applications for data logging and control. In GPRS mode you can also connect to any remote FTP server and upload files for data logging.

This GSM modem is a highly flexible plug and play quad band GSM modem for direct and easy integration to RS232 applications. Supports features like Voice, SMS, Data/Fax, GPRS and integrated TCP/IP stack.

VI. Network Structure

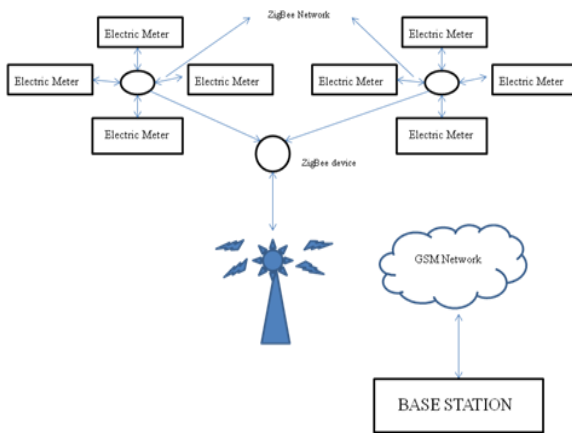


Fig. 4. Communication network using ZigBee

Network may be comprised of any hierarchical structure, tree, star or ring network. A single or group of electric meters are connected to a ZigBee range extender device which is simply a another ZigBee device to make a path for communication link between base station and users. A GSM network is installed at base station for messaging all meter owners and service provider employees.

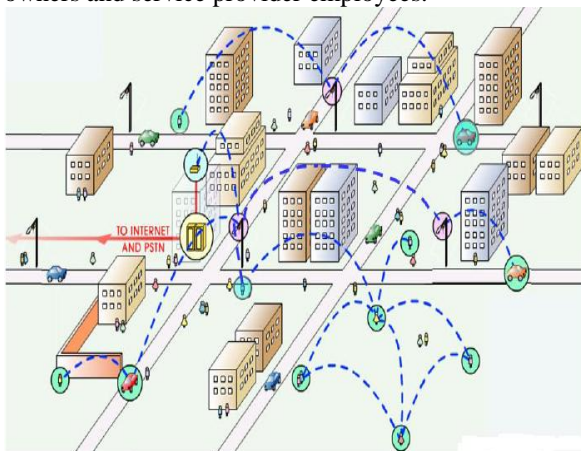


Fig. 5. GSM and ZigBee based communication model

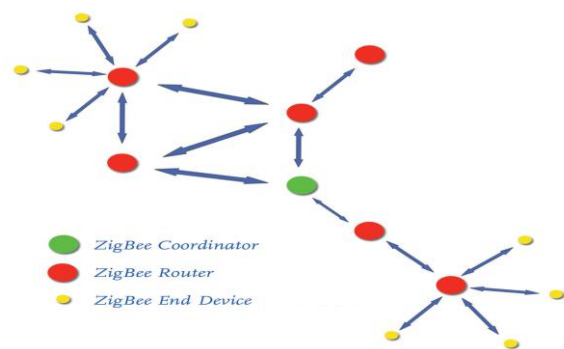
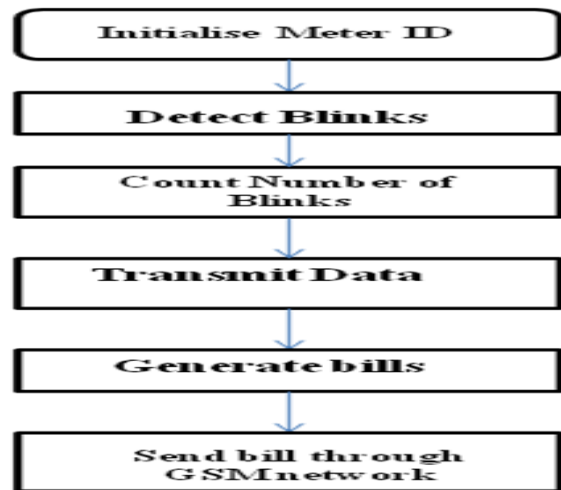


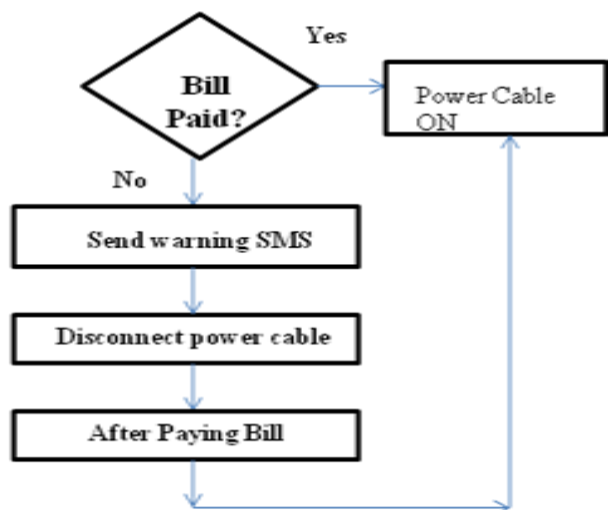
Fig. 6. ZigBee communication network model

VII. Software Implementation

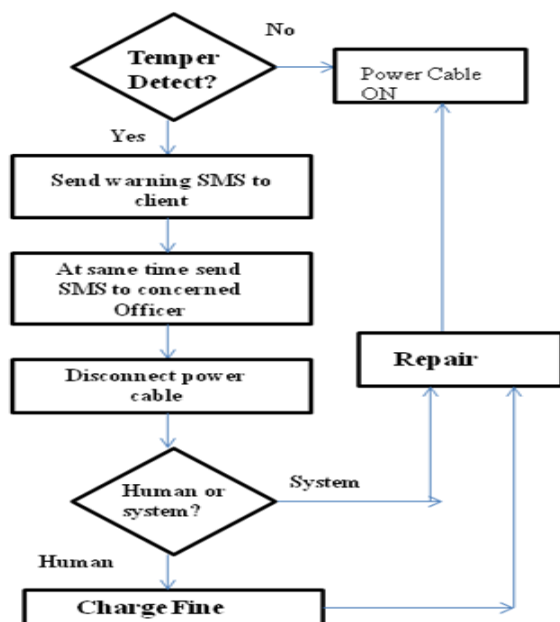
7.1. Basic operating mode



7.2. With autoload mode



7.3. With tamper detection mode



VIII. Aims and Objectives

- To collect data within short period of time.
- Power consumption should be low.
- To detect an error.
- Reduce the expenses while collecting data.
- Controlling and monitoring the entire network in real time application.
- Diagnosis the error in network.
- Reduce the losses due to unpaid bills by user.

IX. Conclusion

In this paper, ZigBee based wireless meter demonstrate how to replace old traditional meters. This new model eliminates the difficulties which are present in older system like saving of money and labor resources. The data is secured due to its unique ID technique. Wireless meter have additional feature which connects and disconnects the power line from meter. One of the advance technique used in this model is tamper detection and control system.

In addition to this model GSM modem is used to intimate consumer about power shut down schedule, about their monthly bills, or to inform area supervisor in case of emergency. This feature also helps to control power consumption limit monthly.

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