Wireless Electric Meter Reading Based On Zigbee Technology

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***Abstract* – This paper describe about Implementation of Wireless Electric Meter Network, implementing of network is based on Zigbee technology. Wireless Electric Meter is used for remote collection of unit count and sending bill on consumer's meter screen . It is evolved from traditional meter reading scheme and power theft from transmission line. Wireless automatic meter reading technology not only saves human resources but improves the accuracy and remote access of a meter. Meter reading is wirelessly transmitted to base station. Consumer node is composed of electric meter, ARM processor, Liquid Crystal Display (LCD), and a Zigbee module operated at 2.4 GHz ISM band. Base Station is composed of a Computer with Zigbee module. It will take readings of Consumer node wirelessly and send bill on Consumer node display.**

Keywords-Wireless Electric Meter (WEM), Zigbee module

I. INTRODUCTION

Billing system for electricity consumption is manually done by human operator. Readings collected by human operator are used for bill calculation. Manual processing of billing system is very time consuming and can cause human error as it is a very tiresome job. Thus billing system becomes inaccurate and inefficient. With development of digital technology, analog electro-mechanical meter is replaced by digital electronic meter. It is convenient to implement wireless electric meter by interfacing Zigbee module with the digital electronic meter. All digital electronic meter along with Zigbee module can form a network.

The use of Wireless Personal Area Networks has been steadily increasing in recent years. The inconvenience and logistical concerns of laying wires for a communication network lay the ground for a much more appealing technologies incorporating wireless transmission. Removing the constraints of the physical installation of wires, wireless solutions provide diversity and in many applications can reduce cost.

Data from electric meter such as meter reading can be transmitted to the Base Station from consumer node by forming a path using network topologies. Zigbee module support Star, Tree, and Mesh topology. Zigbee networks facilitate many applications, such as Commercial Building and Home Automation, Security, Healthcare Medical Monitoring, Vehicle Monitoring, Agriculture and Environmental Monitoring and so on.

The Zigbee protocol stack based on IEEE 802.15.4 offers a practical, cost-effective solution for low-cost and low power consumption WPANs. These characteristics make Zigbee networks the ideal candidate for Wireless Sensor Networks in many applications such as Commercial Building and Home Automation, Medical equipment monitoring and Industrial control. Latency and reliability are significant performance measurements in sensor networks; this project focuses on simulating and assessing a Wireless Sensor Network implementing the Zigbee protocol using the OPNET network simulation tool.

Zigbee is based on the IEEE 802.15.4 standard along with other protocols like Wi-Fi and Bluetooth. Zigbee operates in the industrial, scientific and medical (ISM) radio band, specifically at 2.4 GHz internationally and 868 MHz or 915 MHz in specific parts of the world. Zigbee differs from Wi-Fi and Bluetooth technologies; in that is was mainly developed for low-rate WPAN's (LR-WPAN). Technology defined by the Zigbee specification is intended to be much simpler and less expensive than that of other WPANs. The simplicity and cost of Zigbee networks makes them a great candidate for wireless control and monitoring applications.

The Zigbee protocol can support over 64,000 nodes and can operate in three network topologies: Star, Tree and Mesh. The large amount of supported nodes is another appealing characteristic, specifically in industrial applications.

II. ZIGBEE SPECIFICATION

A. Addressing

IEEE 802.15.4 uses two methods of addressing:
• 16-bit short addressing
• 64-bit extended addressing

A network can choose to use either 16-bit or 64-bit addressing. Using the short addressing mechanism reduces the packet length and thereafter the space to store the addresses. This mechanism allows addressing within a single network; however, the combination of a unique PAN ID (personal area network identifier) and 16-bit addressing can be used to address independent networks. Alternatively, 64-bit addressing in IEEE 802.15.4 has not limitation on the number of devices in a single network.

The network layer (NWK) of Zigbee protocol uses a 16-bit address in addition to the IEEE address. The network layer data transactions require an NWK address. A lookup table is used to map each IEEE 802.15.4 64-bit address to a unique network layer address.

TABLE 1: ZIGBEE SPECIFICATION

TRANSMISSION BAND	2.4GHZ
TRANSMISSION RANGE	100 METERS
NETWORK SIZE	65536 NODES (SHORT ADRESSING MODE)
	1.8X10^19 NODES(EXTENDED ADRESSING MODE)
DATA RATE	250 KBPS
CHANNELS	16

B. Zigbee Devices

The Zigbee standard defines three different types of devices: end-devices, characterized as reduced functional devices (RFDs), and routers and coordinators, characterized as fully functional devices (FFDs).

i. *Coordinator*

For every Zigbee network there must be one and only one coordinator. The coordinators responsibilities include initializing the network, selecting the transmission channel and permitting other Zigbee nodes to connect to its network. A Zigbee coordinator can also route traffic within a network.

ii. *Router*

A Zigbee router is responsible for message routing within a network. Not all networks require a router because traffic can travel directly from an end device to a coordinator or even from end device to another end device by using routing features of a coordinator. A routing device can also act as an end device; however, its routing capabilities would be inactive. A router can have child nodes connected to it depending on the network topology implemented.

iii. *End device*

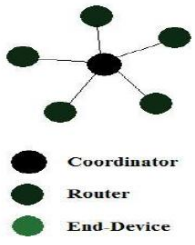
ZigBee end devices connect to routers or coordinators in a network but cannot have other devices connect to the ZigBee network by piggybacking of its connection. End devices are the end points of a ZigBee network and contain limited functionality to talk to parent nodes (coordinator or a router). Since they do not have routing responsibilities and can enter low-power sleep modes during periods of inactivity, ZigBee end devices have substantial battery lives. Due to its limited functionality, end devices impose limited memory footprints and can therefore be less expensive to manufacture than a router or a coordinator.

III. ZIGBEE CHARACTERISTICS

Zigbee networks support operating in Star, Tree, and Mesh topologies. Depending on the application of the Zigbee network, topology selection can drastically affect the behavior of the network. For this reason, proper topology selection is very important.

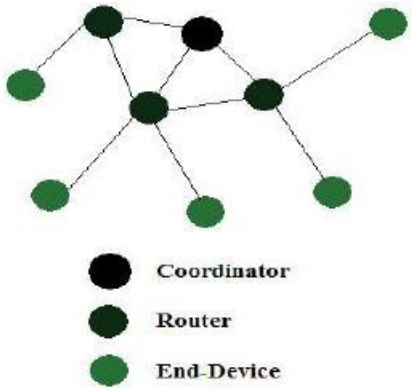
A. Star Topology

In Star topology, a coordinator is surrounded by a group of either end devices or routers. Routers are connected to the coordinator but their message relaying functions are not used. This topology is attractive because of its simplicity, but at the same time it is having some key disadvantages. In the event that the coordinator stops functioning, the entire network stops functioning because all traffic travels through the centre of the star. For the Same reason, the coordinator could easily be a bottleneck to traffic within the network.



B. Mesh Topology

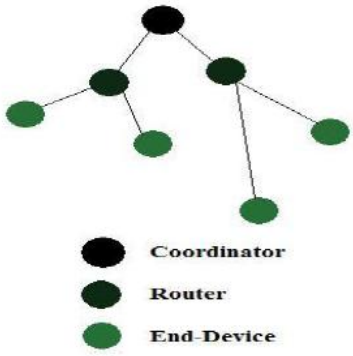
In Mesh topology, Coordinator and routers are interring connected forming a spider-net like structure. End-devices are connected to routers. Communication between end-device is possible if a router is present in between them for data routing. Coordinator is solely responsible for network formation. End-device neither add external device in the network nor communicate with external device or end-device in the network.



C. Tree Topology

In a tree network, the coordinator is at the top (root) of the tree. End devices can connect to this root via a direct point to point connection or through a child router of the coordinator. For every child router connected, additional child routers can also be connected, creating different levels of nodes.

Message passing within the network works in a hierarchical manner, source nodes must transmit messages to their parents (the node one level higher than the source node) which then relay their messages higher up the tree until it reaches the coordinator or until it reaches a router that can redirect the message back down the tree to the intended destination.



IV. PROPERTY OF ZIGBEE

A. Self-healing Property

In Tree topology, Zigbee end-devices are connected to coordinator via Zigbee routers. If any Zigbee end-device is not in the range of Zigbee coordinator then it sends the data to Zigbee router and further, router forwarded that data to the end-device. Router only sends the data to maximum children nodes under its network. Extra nodes, other than children node is not connected to the router. That extra node will connect under another router if that router does not have maximum children nodes i.e. its maximum limit to connect to end-devices.

In the figure shown below, Coordinator sends data to end devices which is near to it and also to the routers. Router sends that data to end-devices. It only sends the data to the number of nodes equal to maximum number of children it handles. In this, all routers are performing their function.

Now, if any of the routers get fail due to battery discharge or communication error in between the nodes then self healing property of Zigbee sends that data from Zigbee coordinator to end-device via another routers.

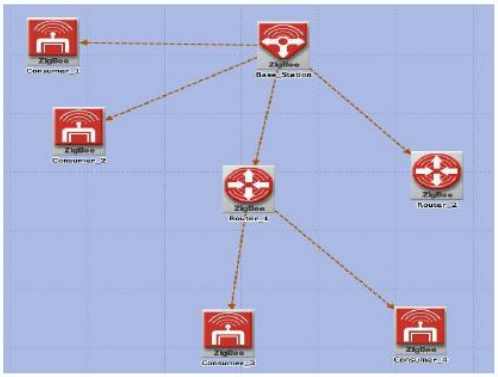


Fig.1: Normal Router Functioning

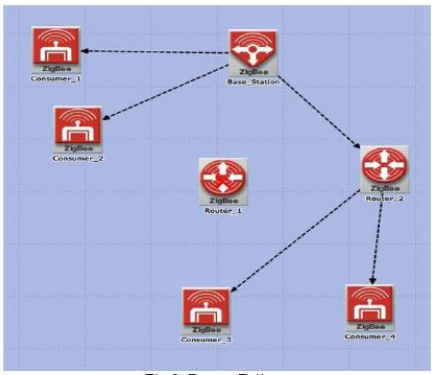


Fig.2: Router Failure

In the figure shown above, one router is failed and nodes connected to that router node are shifted to another router node. This shows the Self-healing property of Zigbee.

B. *Self-forming Property*

Zigbee coordinator establish network which allows other Zigbee nodes to join in the network for communication with another nodes. Zigbee coordinator is solely responsible for network formation. Zigbee network is also called as *Self-forming network.*

V. HARDWARE CONFIGURATION

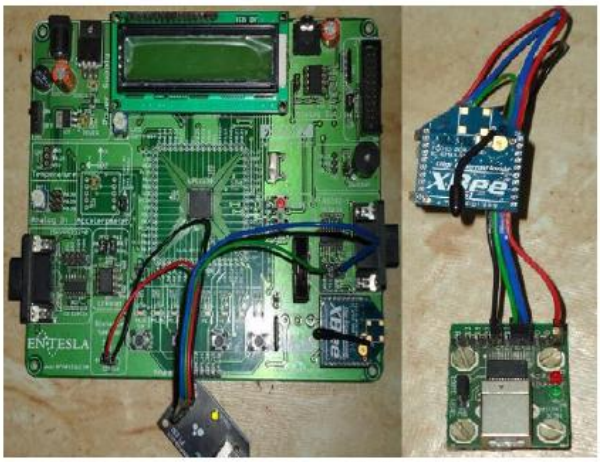


Fig.3: Consumer Unit and Base Station Unit System

Fig.4: Electric meter interfaces with Microcontroller showing Unit count and Bill amount

In the figure shown above, it is having electric meter interfaced with ARM7 Development board which is having facility for mounting of Zigbee module. This hardware will be available on consumer side and it will communicate with coordinator node present at Base Station of Electricity Board.

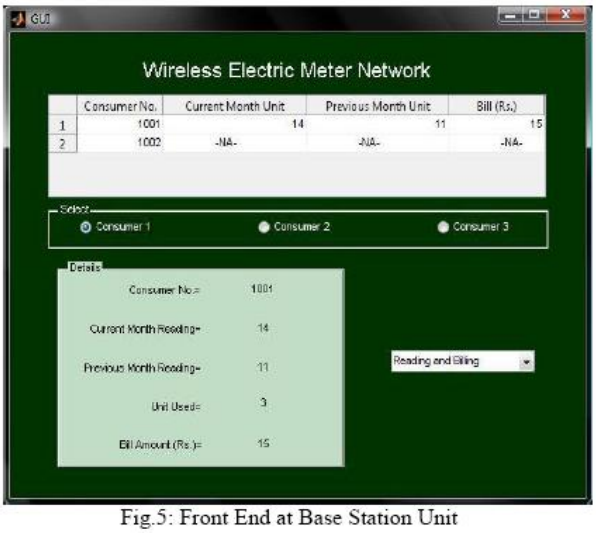


Fig.5: Front End at Base Station Unit

In the above figure, it is showing unit count of current month and previous month and also bill amount. Details of the consumer can be seen by selecting the consumer from the list.

VI. CONCLUSION

Through this design, electric meter will communicate with base station node and will send utility data such as unit count and receive bill for that unit count. In this way, it is convenient to get the data wirelessly from consumer side. This system consumes low power to set the network.

VII. REFERENCES

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