ZigBee Network Based System For Power Monitoring and Data Logging

Aruna Prabha V.S[1], D.Sam Devid Jero[2]
[1] *ME Communication system engineering,*
Department of Electronics and Communication engineering
RVS College of Engineering and Technology
Coimbatore, India.
[2]*Assistant Professor,*
Department of Electronics and Communication engineering
RVS College of Engineering and Technology
Coimbatore, India.
[1]arunaprabha88@gmail.com
[2] meetjero@hotmail.com

Abstract—**The power systems in this present day combine different modes of generation, transmission and conversion of the energy. There is no unique system of monitoring the power distribution and for the power failure detecting mechanism. The major issue facing is the continuous isolation required for the measuring equipments. A controlled power supply can be obtained by continuously monitoring the power supply by which to reduce the unwanted power consumption and detection of failure of electronic equipments. An optimal solution for this problem is proposed by designing a wireless system, which continuously monitors the power supply and the power usage. A low data rate ZigBee based wireless transceiver is used for the wireless communication. The suitability of ZigBee for the required communication link is that, ZigBee has major role in monitoring and direct load controlling for efficient power utilization. It covers enough area needed for communication and it works on low data rate with minimum power consumption. Transmission distances range from 10 to 100 meters line-of-sight, depending on power output and environmental characteristics. The proposed technique uses ZigBee network for monitoring the power supply and the data is stored on the server. Based on the data captured through the ZigBee network, a technique will be proposed as a protocol for the effective and efficient usage of power as per the requirement.**

Keywords—**ZigBee, Wireless network, Repeaters, Throughput, End device, Router, ZigBee network**

I. INTRODUCTION

The world is facing the biggest problem of power management. Production of power is less than the demand. A ZigBee wireless sensor network with number of nodes, which communicate with each other in full duplex mode, can use for the effective power monitoring and management. Wireless networking has been mainly focusing on high-speed communications and relatively long-range applications. For such wireless applications, IEEE has developed a new standard called IEEE 802.15.4. called ZigBee, specifically designed to use in low cost and low power wireless sensor and control networks which make use of 2.4GHz frequency band. ZigBee has a defined rate of 250 Kbit/s best suited for periodic or irregular data or a single signal transmission from a sensor or input device.

Sensors and controls do not need high bandwidth but they do need low latency and very low energy consumption for long battery lives and for large device arrays. Low cost allows ZigBee technology to be widely used in wireless control and monitoring applications and the low power usage allows longer life with smaller batteries. It also yields high throughput and low latency for low duty cycle devices like sensors and controls. . The addressing space of ZigBee is up to18, 450,000,000,000,000,000 devices, which means 64 bit IEEE address and 65,535 networks. ZigBee architecture has four layers namely Application layer (APL), Network layer (NWK), Medium access control layer (MAC) and Physical layer (PHY). The top layer is called the APL gives the device its functionality. It converts the input in to digital data and converts digital data into output. The application layer is on top of the NWK which provides ZigBee functionality and acts as a buffer between APL and DLL. It is responsible for network structure, routing, and security such as encryption, key management, and authentication. The data link layer is provided by IEEE 802.15.4 standard. It consists of two sub-layers such as MAC and the PHY.

A ZigBee transceiver can operate as three different types of ZigBee devices such as ZigBee Coordinator, ZigBee Router and ZigBee End Device. In every ZigBee network each ZigBee module has to be configured as any of these device types depending up on the requirement of the network for the proper configuration and the data

transmission. The ZigBee coordinator in a ZigBee network forms the root of the network and also it is capable to bridge to other networks. Exactly one coordinator is needed as it is the device that starts the network. It initializes the network, store information about the network and also select appropriate channels and there by granting access for other devices to connect in to the network. ZigBee routers transmit data from other ZigBee nodes which are commonly called as child nodes to the required node attached. It passes data from one node to other so as to create a data flow through the network. Routers need very less memory space when compared to ZigBee coordinator. The ZigBee End device communicate with the coordinator or to the router, it cannot relay data from other end device directly. This node requires the least amount of memory space and gives very long battery life.

II. LITERATURE SURVEY

A study of the relevant literature materials and its review which is a survey of related topics and its discussion with concise overview of appropriate topic has been done. Here it discusses about various applications of ZigBee and the different types of data transmissions.

Anmol N.Chaure and et al[1] proposed an automatic meter reading system designed to automatically collect consumption, diagnostic and status data from utility meters and transferring the retrieved data to a central database for billing and troubleshooting. The system is designed for measurement of electrical parameters of household appliances. The measurement of electrical parameters of home appliances is done by interfacing with fabricated sensing modules. The output signals from the sensors are integrated together and it is connected to ZigBee module for transmitting electrical parameters data wirelessly. The ZigBee nodes are interfaced with various sensing devices and are interconnected to form a network having reliable data reception at a centralized node as the coordinator.

Mahesh Chahare and et al[2] proposed a wireless electric meter reading system consists of small, low-power radio transmitters connected to individual water meters that send daily readings to a network of rooftop receivers throughout the city. Analog electromechanical meter is replaced by digital electronic meter and interfaced ZigBee module to make it wireless meter. Electric meter will communicate with base station node and will send utility data such as unit count and receive bill for that unit count. Prof.Vishal Pande, et al[3] proposed a new network communication system for energy meter reading by integrating communication technology and software system along with the existing meters. It collects the power consumption data and transmits to control room via ZigBee and sends bill details to consumer via GSM. Reading is feed to a central database and the bill is generated.

Shriram K.Vasudevan,et al[4] proposed a system by which human body parameters are monitored and is transferred to host pc via ZigBee. ZigBee provides great flexible, low cost, low power consumption system enables viewing of all sensed parameters on the computer. It can monitor only one patient at a time. Practical implementation is limited due to line of sight issue of ZigBee transceiver. Dr.N.S.Murthy,et al[5] proposed a system which is monitoring environmental data& parameters in laboratory by sensors and transfer via ZigBee to monitoring centre and then upload to web server. Sensor controlling board collects the data to web-server via ZigBee networks. The system is safe and convenient for environmental data management in lab. The connection between sensors and controlling board is wired. Simultaneous monitoring of different experiments is not possible. It has ensured safety and it can control the equipments in laboratory through a web browser. P.A.Abraham,et al[8] proposed a Wireless embedded system continuously monitoring RMS current through power line & transfer to microcontroller unit via ZigBee. System can easily mount on the power line without interrupting the power flow and equipment is isolated using ZigBee. Microcontroller unit should be placed near the power line due to limited range of ZigBee. Real-time implementation is difficult. Jinsoo Han,et al[10] proposed a system in which different electronic home appliances are connected to the home server which further connects to internet through ZigBee transceivers. Power usage is reduced by turning off devices when user moves out and can be controlled and accessed via internet. Line of sight transmission makes limitation to proper real time working of ZigBee transceivers.

III. FORMING A ZIGBEE NETWORK

The Coordinator is responsible for starting a ZigBee network. Network initialization involves different steps such as search for a radio channel. The coordinators first searches for a suitable radio channel, usually the one that has least activity. This search can be limited to those channels that are known to be usable by avoiding frequencies in which it is known that a wireless LAN is operating. Then the coordinator starts the network, assigning a PAN ID to the network. The PAN ID can be pre-determined, or it can be obtained dynamically by detecting other networks operating in the same frequency channel and choosing a PAN ID that does not conflict with theirs. At this stage, the coordinator also assigns a

network address to itself. Usually, this is the address 0x0000.

The Coordinator then finishes configuring itself and starts itself in Coordinator mode. It is then ready to respond to queries from other devices that wish to join the network. For the simulation of the ZigBee network OPNET 14.5 is used. It can simulate the ZigBee protocol more accurately without unnecessary overheads. It has device models for ZigBee coordinators, routers and end devices. The main focus is to analyze ZigBee network performance in the context of a wireless sensor network with repeaters and without repeaters which can range in size from a few meters to thousands of meters. In OPNET software, the two layers such as ZigBee application layer and network layer were intentionally provided without any source code. The network components include the server node which acts as the central node of the whole network. It will receive all the data from the end nodes and repeaters. The end devices, which are the end node, will collect the required data that has to be transmitted from the network environment and then will pass in to the network for further transmission.

The repeater nodes can be added so that these nodes will retransmit the data from each end devices to another repeater or to the server depending on the distance and range of the ZigBee nodes. The server node will be connected to the server system which will be normally a personal computer. It analysis all the received data and will also store the data as a database for further use. The personal area network is the network, which is being used for the data transmission using different ZigBee nodes. The network coordinator identifies its PAN and will connect to other nodes. In OPNET simulator, a ZigBee network can be created using inbuilt ZigBee nodes. The network parameters can be varied by changing the parameters in Edit Attributes. Then set parameters such as transmission band, network parameters, transmission power, packet inter arrival time, packet size, destination, data rate, enable or disable Acknowledgment (ACK) mechanism, setting CSMA/CA parameters of coordinator and end devices using edit attributes menu. In Wireless ZigBee network without repeaters, a server node is surrounded by a group of either end devices or routers. This topology is attractive because of its simplicity, but at the same time it is having some key disadvantages. The server node could easily be a bottleneck to traffic within the network, especially since a ZigBee network can have more than 60000 nodes.

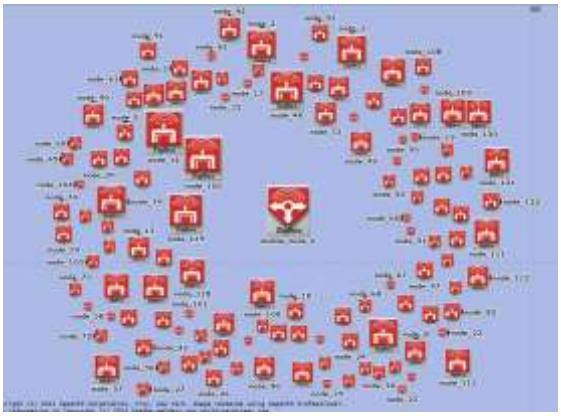

Fig: 1 ZigBee network without Repeaters

In the ZigBee network with repeaters the repeater nodes are added to the network as intermediate nodes between end nodes and the server node, which is being connected to the server system. The main function of ZigBee repeater is to receive the data which is being transmitted in the network from the different end devices. And then it will be retransmitting these data to another repeater node or to the server node depending on the range of the ZigBee nodes and the distance between the server and the end devices. When these repeater nodes are added to the network it is observed from the analysis that the efficiency of whole network is increased.

Fig: 2. ZigBee Network with Repeaters

IV. SIMULATION OF ZIGBEE NETWORK

There are two scenarios studied such as a wireless ZigBee network with repeaters and a wireless ZigBee network without repeaters. The method of gathering the global statistics in OPNET is that the global statistics provide information that relates to the overall system. Many separate objects may contribute to one global statistic during a simulation. In ZigBee networks, one of the most common scenarios for transmission is that ZigBee network without repeaters where all devices send packets the server device. The overhead may have to be the critical issue on performance analysis. Interference and collision could obviously decrease the packet delivery ratio and throughput of the global network. Instead of transmitting the packets directly to the end devices, packets may be transferred to the repeater first and then the repeater integrates the received packets and then sends to the server device. Thus, the overall packet delivery ratio can be improved with less overhead at the server. The server should be capable to handle large amounts of data than the ordinary end nodes.

In order to provide a general performance evaluation of OPNET 14.5 Modeler for ZigBee WSNs, the performance criteria such as end-to-end delay, throughput, packets dropped and simulation time are considered. In general these parameters give a clear prospective of the quality of service parameters in WSNs. Quality of service includes different statistics such as Delay, Throughput, Packets dropped, Simulation time, Traffic sent, Traffic received, Simulation time. By setting such statistics for IEEE 802.15.4 MAC Layer, ZigBee Network Layer, Application layer simulation can be done. The global throughput is a global statistics and any object could contribute to its value. It gives a general idea of the overall throughput of the system. The throughput is the number bits per second a node can deliver. In this simulation, the ZigBee wireless network with repeaters has the highest global throughput and without repeaters has the lowest global throughput.

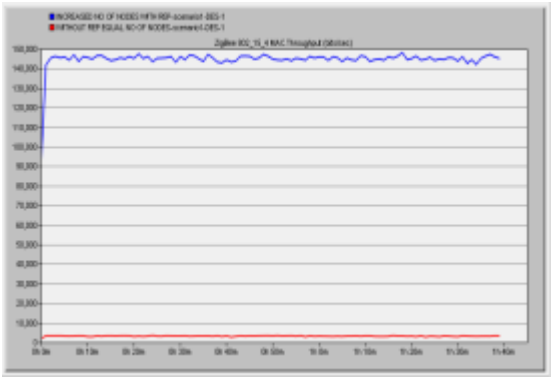

Fig: 3 Global Statistics Throughput.

The packets dropped represent the estimate of the number of packets that are dropped in the network layer during the data transmission. In a wireless network, the number of packets dropped will increase with increase in number of nodes which result collision. It also increases with increase in traffic in the network.

Fig: 4. Packets Dropped

The traffic transmitted by all the 802.15.4 MACs in the ZigBee network in bits/sec is termed as management traffic send. While computing the size of the transmitted packets for this statistic, the physical layer and MAC headers of the packet are also included. This statistics include all the traffic that is sent by the MAC via CSMA CA. It does not include any of the management or the control traffic, nor does it include ACKs. Figure.15 represents traffic sent by 802.15.4 layer for both ZigBee network with repeaters and without repeaters.

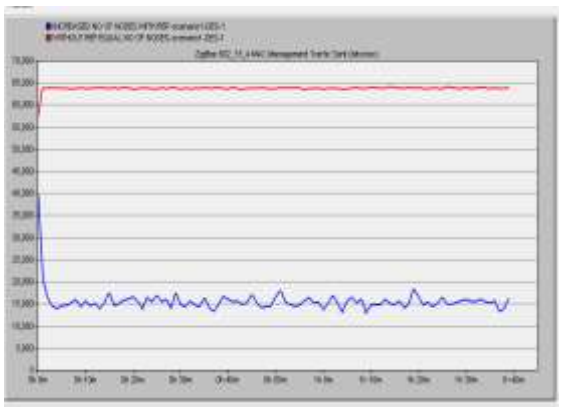

Fig: 5 Management traffic sent by 802.15.4 layer

The traffic received by all the 802.15.4 MACs in the ZigBee network in bits/sec is termed as management traffic received. It represents the total traffic successfully received by the MAC from the physical layer in bits/sec. This includes retransmissions of packets also.

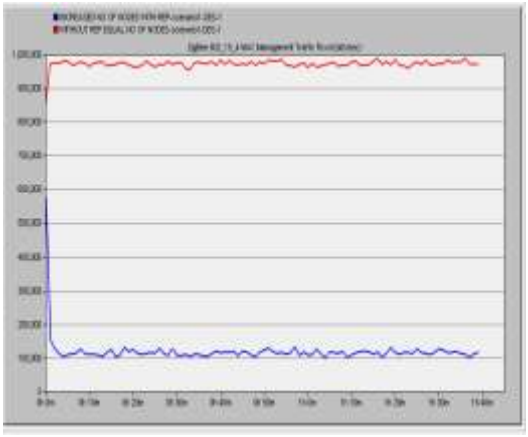

Fig: 6. Management Traffic Received

V. CONCLUSION AND FUTURE WORK

A wireless network is designed using ZigBee modules for the transmission of data to a server system. By creating a network using ZigBee, the limitations of ZigBee such as line of sight transmission problem, limited range etc are overcomed and an effective low coast data transmission is achieved. The data being transmitted is the estimated power usage values from the power monitoring systems. The data are then analyzed and stored in the server system. Here each ZigBee module is configured as end device, repeater, server node and coordinator. Two scenarios are simulated such as wireless ZigBee network without repeaters and wireless ZigBee network with repeaters. From the simulation and analysis it has been proved that when repeaters are used in ZigBee network then the throughput, data traffic etc are improved and thus a more effective and efficient data transmission is achieved. As a future work, this project can be enhance by establishing the wireless ZigBee network on hardware level for the real time monitoring of the power consumption of different labs in the college. The digital energy meters can be made wireless by interfacing it to ZigBee module. The sensed datas can be transmitted through the ZigBee network to the server system and is stored for further analysis.

REFERENCES

[1]. Anmol N.Chaure, et al (2014, March),"Fault Detection System using ZigBee and Embedded base Meter Reading",IORD Journal of Science and Technology,E-ISSN:2348-0831 Volume 1, Issue III PP34-37.

[2]. Mahesh Chahare, et al (2013, June),"Wireless Electric Meter Reading Based On ZigBee Technology",ITSI Transactions on Electronics Engineering,ISSN:2320-8945,Volume-1,Issue-6.

[3]. Prof. Vishal Pande, et al (2013, April),"Energy Meter Automation using ZigBee Protocol", International Journal of Computer Technology and Electronics Engineering, Volume 3, ISSN: 2249-6343.

[4]. Shriram k. vasudevan, et al (2013, March),"Design and Development of an Embedded System for Monitoring the Health Status of a Patient" ,I.J.IntelligentSystems and Applications,DOI:10.5815/ijisa.64-71.

[5]. Dr. N.S Murthy Sharma, et al (2012, December),"Design and Implementation of ARM Intelligent Monitoring System Using ZigBee"International Journel of Research in Computer and Communication Technology,ISSN:2278-5841,Volume 1,Issue 7.

[6]. Prof.Pravin r.Lakhe, (2012,March),"Wireless Sensor Network Using ZigBee", International Journal of Engineering Research and Applications,ISSN:2248-9622.

[7]. P.Rohitha, et al (2012,July),"Wireless Networking Through ZigBee Technology",International Journal of Advanced Research in Computer Science and Software Engineering,ISSN:2277-128X,Vol-2,Issue 7.

[8]. P.Abraham, et al (2011,December),"Wireless Embedded System for Power Line Monitoring",International Journal of Power Systems and Integrated Circuits,ISSN:2250-1088,Volume 1,special issue.

[9]. K.Nirmal Kumar, et al (2011,June),"ZigBee Wireless Sensor Network Technology Study for Paddy Crop Field Monitoring", International Conference on VLSI,Communication and Instumentation.

[10]. Jinsoo Han, et al (2011, February),"More Efficient Home Energy Management System Based on ZigBee Communication and Infrared Remote Controls",IEEE Transaction on Consumer Electronics,Volume 57,no.1.

[11]. Guilin Zheng; Zhifu Zhang,"Intelligent wireless electric power management and control system based on ZigBee technology ", Transportation, Mechanical, and Electrical Engineering (TMEE),2011 International Conference on Digital Object Identifier.2011 Page(s): 1120 – 1124.

[12] Chong, C. and Kumar, P. "Sensor Networks: Evolution, Opportunities, and Challenges", Proceedings of the IEEE, vol.91, No.8, August 2003.

[13] Kumar, H., Sarma, D., Kar, A. and Mall, R. "Energy Efficient Communication Protocol for a Mobile Wireless Sensor Network System" in International Journal of Computer Science and Network Security, Volume.9, No.2, February 2009.

[14] Chong, C. and Kumar, S. P. "Sensor Networks: Evolution, Opportunities, and Challenges," in Proceedings of the IEEE, vol. 91, no. 8, pp. 1247–1256, Aug. 2003.

[15] Mahlknecht, S. "WSSN (Wireless Self-sustaining Sensor Network) Project," 2005, http://www.ict.tuwien.ac.at/wireless/, last accessed on 15 July 2011.

[16] Mahlknecht, S. and Bock, M. "CSMA-MPS: a minimum preamble sampling MAC protocol for low power wireless sensor networks," in Proceedings of the IEEE International Workshop

on Factory Communication Systems (IWFC), 22 24 Sept. 2004, Vienna, Austria, 2004, pp. 73–80.

[17] Akyildiz, I. F., Su, Sankarasubramaniam, W. Y. and Cayirci, E. "Wireless sensor networks: A survey,"Computer Networks (Elsevier), vol. 38, pp. 393-422, 2002.

[18] Pottie, G. J. and Kaiser, W. J. "Wireless Integrated Network Sensors," Communications of the ACM, vol. 43, no. 5, pp. 551–558, May 2000.

[19] Al-Karaki, J. N. and Kamal, A. E. "Routing techniques in Wireless Sensor Networks: A survey", Department of Electrical and Computer Engineering Iowa State University, Ames, Iowa 50011.

[20] IEEE 802.15 WPAN Task Group 4, "IEEE 802.15.4 Standard " 2003, http://standards.ieee.org/getieee802/download/ 802.15.4-2003.pdf, last accessed on 15 July 2011.

