RESEARCH ARTICLE OPEN ACCESS

Investigating The Impact of Back off Exponent Value of ZIGBEE MAC Protocols in Tree, Mesh Routing Protocols for ZIGBEE Personal Area Networks

Ratna kumari Jogi [1], Mohan Krishna. K [2]
Department of computer science and Engineering
VVIT, Guntur
India

ABSTRACT
zigbee networks are very popular in present days due to the rapid development of communication technology even for micro electrical mechanical systems (MEMS). The small size and self configurable nature of sensors makes them applicable for the zigbee networks. ZigBee sensor networks support small power consumption and node expansion compared to other network standards for WSN. Body sensor networks (BSN) require a number of sensors for sensing medical information from human body, and low power consumption to monitor a patient's status for a long time. Sensor nodes will capture the physical parameters of monitoring area and transmit to router and from router to zigbee coordinator. During this process in Mac layer there is possibility of collision between two or more sensor nodes while transmitting data. For transferring the data in the networks need routing protocols. Construction of routing is also consumes more energy. Hence construction of routing is also an important thing in small communication device networks like Zibee networks. Here, authors, authors proposed tree routing, mesh routing protocols for maximizing the network life time. ZigBee sensor network has become one of the most useful communication standards used in the healthcare monitoring system. Channel usage of Zigbee network is based on carrier sense multiple accesses with collision avoidance (CSMA/CA) due to its wireless nature. A ZigBee node competes with all other nodes in its network range for access to the channel for transmission. Thus the network performance depends on their data packet rate and the number of nodes. The channel utilization is significantly affected by back-off time and packet collision. Successful channel access probability is an important factor for reliable data transmission and low packet latency. If a node cannot access the channel after several back-off attempts, it wastes transmission time and loses the data packet.in this paper, investigated,impact of backoff exponential constant time on the zigbee sensor node for channel usage without collision with other nodes in the networks and how the Quality of service metrics will effect during this time and among all combinations of optimized backoff exponential values. From the simulation of different scenarios using OPNET simulator, analyzed QoS parameters such as effective data rate, average end to end delay by different network parameters including the size of payloads, node count and data rate with different Mac parameters. In this paper, authors concluded that minimum 2 and maximum 4 Backoff exponential constants are optimal in CSMA/CA technique for zigbee MAC Layer in tree routing as well as mesh routing protocols for better QoS metrics.

Keywords:- Wireless Networks, Zigbee Networks, Tree Routing Protocol, Mesh Routing Protocol, Qos Metrics, Opnetsimulator.

I. INTRODUCTION

Rapid growth in the communication technology attracts the researchers to do their research in the communication technology even for the small area monitoring purpose also. Now a days, every physical device becoming the part of communication network group by enabling the device with sensor. Due to the small size and self configurable nature of sensor, apply for monitoring the home, city, military applications, traffic monitoring, agriculture monitoring and even for health monitoring of the human body applications. Health monitoring applications are enabled with zigbee based sensor nodes. Hence, Zigeee enabled sensor networks are also called as personal area networks (PAN). Zigbee enabled sensors are used for short range communication like patient monitoring to identify the health conditions of human being using this technology for long time.

Now a day's , pollution in the environment causes for new diseases in human body. It is difficult to identify the disease at the earlier stage even for the expert doctors. Hence health monitoring of the human being becomes new business market. For that, researchers take one step forward and apply the communication for monitoring the health of the patient as well as normal human being for predicting his health conditions using personal area network technology.

Personal area networks are configured using battery enabled zigbee sensor nodes within shortest distance. Sensor nodes are placed very low communication range frequency. Due to the self configurable nature and small size of the sensor causes to creating the network for different applications monitoring purpose.

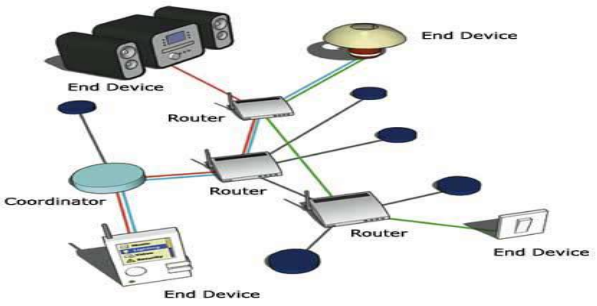

Figure 1.1 : Zigbee Network

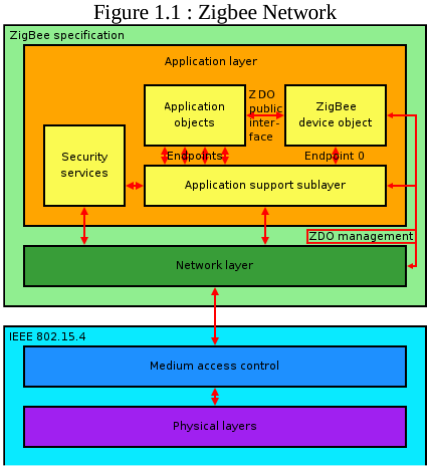

Figure1.2 : Zigbee protocol layer in wireless personal area networks.

Personal area networks consists two different types of devices

1. Full functional device (FFD)
2. Reduced functional device (RFD)

FFD have all the features of Zigbee technology.FFD Sensor monitoring the entire network and collect the data from the remaning nodes in the network. This device co ordinate the remainng nodes presented in the netwok based on their position and full communication capability in the network and also aggregate the collect data and forwards the data to outside of the network through the gateway with low energy consumption of battery power. Zigbee co-ordinators ats like as end device as well as co ordinator in the PAN.

Ex: Zigbee co-ordinator

Whereas RFD devices have only forwards the observed data from the monitoring network area to the Zigbee co-ordinator with modest resources and commmunication constraints like simple communication devices. RFDs are never acts like as co-ordinators of the network. RFD devices always acts like as end devices in the PAN.

EX: Zigbee end device.

PAN contains three types of zigbee sensors like

-Zigbee co-ordinator

-Zigbee router

-Zigbee end device

Zigbee co-ordinator contains full communication features of zigbee technology and zigbee router acts as intermediate device between the end device and zigbee co-ordinator for forwarding the data through shortest path in the network. The end device captured the data from the monitoring environment in the network area.

In PAN, devices are communicated using IEEE 802.15.4 radio specification with unlicensed bands of communication with the following frequencies: 2.400-2.484GHz, 902-928MHz an 868.0-868.6MHz.The ZigBee protocol carries all the benefits of the 802.15.4 protocol with added networking functionality.

IEEE 802.15.4 contains physical as well as mac layer specifications to configure the network with small communication range. It gives the basis for the Zigbee technology which applied for getting the solution for network by offering to the upper layers of the network.

Hence, IEEE 802.15.4 technology works low communication networks due to the constraints of this standard, incorporate this technology for the resource constrain sensor nodes. Low rate data transmission, low cost and self configurable nature are the main features of the 802.15.4 technology.

ZigBee technology is a low data rate, low power consumption and low cost wireless networking protocol targeted towards automation and remote control applications from the IEEE 802.15.4 technology. ZigBee Alliance and the IEEE decided to join forces and ZigBee is the commercial name for this technology. ZigBee is expected to provide low cost and low power connectivity for equipment that needs battery life as long as several months to several years but does not require data transfer in high rate

In this technology, power consumption is main constraint of the sensor network. Establishing the route in the network for forward the data between the nodes consumes more power of the Zigbee sensor node as well as collision between the packets in a channel also consumes more power for retransferring the data once again.

Hence in this paper, analyzed the performance of the Zigbee networks with optimal routing protocol along with Backoff exponential constant in CSMA/CA algorithm for channel utilization of the medium allocated with radio frequency of the physical layer.

The remaining part of this paper divided as section 2 related work, section 3 for for zigbee routing protocol and Back off exponential value definition in CSMA/CA algorithm section 4 for simulation setup in the OPNET Simulator section 5 for analysis of the obtained results section 6 for conclusion.

II. RELATED WORK

Routing and channel utilization are main power wastage computing techniques in the zigbee wireless technology. computation of shortest path routing protocol different routing protocols are implemented with minimum energy consumption. zigbee network layer defines different routing protocols like aodv, aodvjr, cluster tree, ehrp, multipath and so on which will be discussed in detail in this part. the aodv (ad-hoc on demand distance vector) routing is a pure on demand

route acquisition algorithm. the node which needs the connection broadcasts a route request rreq to its neighbours who re-route the message and safeguard the node from which they received the message. along with its own sequence number and the route request id, the source node includes in the rreq the most recent sequence number it has for the destination. the path cost comparison of packets with the same rreq allows choosing best path at the moment and discarding anything worse. when a node receives a message and it has an entry corresponding to the destination in its routing table, it returns a rrep through the reverse path to the requesting node. so, the source sends its data through this path to the destination with the minimum number of hops [4,5]. in the zfa protocol, if one node has no route to one destination node, it broadcasts the data of transport layer through the way of flooding. the zfa protocol combines routing discovery with data transmission. the destination node sends the packet of route layer along the reverse direction after receiving packet, and then the routing is established [6]. aodvjr removes form the aodv specification the sequence numbers, gratuitous rrep, hop count, hello message, rrep, precursor lists. in aodvjr, if communications are unidirectional, the destination sends connect messages to the source. if data traffic is bidirectional, no additional messages are used. in any case, a source detects a link break in a route when it receives no messages from the destination [1].an aodvjr routing protocol with multiple feedback policy [7] by means of processing main message during route discovery. the source node starts the route discovery, the destination node processes every route request (rreq) and sends every route reply (rrep) as feedback information to the source node, and the source node processes multiple rrep messages for routing decision. the improved aodvjr changes the routing decision commander from destination to source and make a proactive routing decision on the basis of multiple feedback information.

wireless resources need to be allocated properly so as to avoid collisions or interferences. there are three main approaches for channel allocation in terms of granularity, i.e., packet-, link-, and flow-based approaches. by granularity, we refer to the scope of a channel allocation decision in terms of the number of different entities the decision impacts and apply to. the packet based approaches allocate channels on a per-packet basis at a given node and the decision does not apply to subsequent packets or other entities [12]. channel allocation using by the link-based approaches is performed for a link between two given nodes, and all packets between the two nodes will be transmitted on the same channel for the duration the decision is valid for [1, 10]. for the flow-based approaches, all packets belonging to a flow are sent on the same channel [9].

on the other hand, two main approaches exist in time allocation: time division multiple access (tdma) and carrier sense multiple access (csma). tdma is a conventional proposal that assigns shared physical medium to each node individually. csma is a probabilistic media access control (mac) protocol in which a node verifies the absence of other traffic before transmitting on a shared physical medium such as an electrical bus, or a band of electromagnetic spectrum. csma can further be divided into two main categories: synchronous and asynchronous schemes. nodes in a synchronous scheme such as s-mac [13, 14] and t-mac [11] negotiate a schedule, i.e., when nodes are awake and asleep within a frame. on the other hand, bmac [8] and x-mac [3] use asynchronous scheme where a sender use preamble sampling to discover a receiver. the preamble period must be at least as long as the sleep period of the receiver so as to ensure that a sender discovers any receivers. the above surveys encourage to do the work for designing the optimal routing protocols as well as channel allocation using enhanced parameter values in the network with time division with csma/ca technique based on the optimal back off exponential constant values for different routing protocols with qos metrics analysis.

III. WPAN WITH MESH ROUTING AND TREE ROUTING PROTOCOLS FOR CSMA/CA ALGORITHM ANALYSIS.

All A personal area network (PAN) is a computer network used for data transmission amongst devices such as computers, telephones, tablets and personal digital assistants. PANs can be used for communication amongst the personal devices themselves (interpersonal communication), or for connecting to a higher level network and the Internet (an uplink) where one "master" device takes up the role as internet router. A wireless personal area network (WPAN) is a personal area network—a network for interconnecting devices centred on an individual person's workspace—in which the connections are wireless. Wireless PAN is based on the standard IEEE 802.15. The two kinds of wireless technologies used for WPAN are Bluetooth and Infrared Data Association.

Zigbee Networks

A wireless personal area network (WPAN) is a low-powered PAN carried over a short-distance wireless network technology such as: INSTEON, IrDA, Wireless USB, Bluetooth, Z-Wave, ZigBee, Body Area Network (BAN).

Out of all specifications, Zigbee technology is more helpful for small area networks. In this project, explained zigbee networks implementation with different routing protocols in wireless personal area networks along with QoS metrics

The ZigBee was built on top of IEEE 802.15.4 standard. The IEEE 802.15.4 standard defines the characteristics of the physical and Medium Access Control (MAC) layers for Wireless Personal Area Network (WPAN)(1). The name refers to the waggle dance of honey bees after their return to the beehive. ZigBee is named for erratic zigzagging patterns of bees between flowers which symbolizes communication between nodes in a mesh network. Network components of ZigBee are analogous to queen bee, drones and worker bees. This communication dance (The ZigBee Principle) is what engineers are trying to emulate with this protocol a bunch of

separate and simple organisms that join together to tackle complex tasks. [8] ZigBee is a lowcost, low-power, wireless mesh network standard. The low cost allows the technology to be widely deployed in wireless control and monitoring applications. Low power-usage allows longer life with smaller batteries. Mesh networking provides high reliability and more extensive range. ZigBee chip vendors typically sell integrated radios and microcontrollers with between 60 KB and 256 KB flash memory(3). ZigBee provides specifications for devices that have low data rates, consume very low power and are thus characterized by long battery life. ZigBee makes possible completely networked homes where all devices are able to communicate and be controlled by a single unit.

Advantages of Zigbee :

1. Low power consumption
2. Low cost
3. High quality of voice data
4. High density of nodes per network
5. Easy installation
6. Reliable data transfer
7. Short range operation
8. Global implementation and Simple protocol

Zigbee networks are designed mainly in three types of topologies out of all available topologies. they are

-Star topology
- Mesh topology
- Tree topology.

In the star topology, the communication is established between devices and a single central controller, called the PAN coordinator. The PAN coordinator may be mains powered while the devices will most likely be battery powered. The star topology is not preferred in sophisticated wireless sensor networks. The star topology of ZigBee is mainly designed for the simple communication from one node to several nodes.

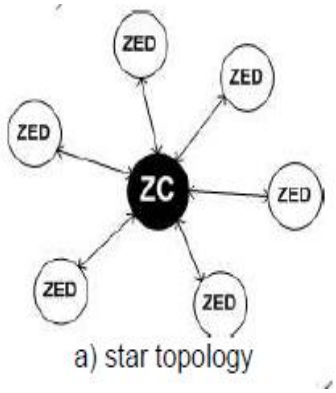

Figure 3.1:Star topology in personal area networks

In the case of mesh topology, network contains PAN coordinator, intermediate routers and end devices. Any device can communicate with any other device as long as they are in range of one another. A mesh network can be ad hoc, self organizing and self-healing. Applications such as industrial control and monitoring, wireless sensor networks, asset and inventory tracking use this topology. It also allows multiple hops to route messages from one device to other in the network. It can provide reliability by multipath routing.

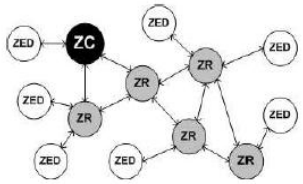

Figure 3.2 : Mesh topology in personal area networks

There is a special kind of mesh topology is presented in the wireless personal area network s for minimizing the energy consumption of the zigbee sensor nodes in the network is called as tree topology.

The tree network topology is a special case of a mesh network where there is a single routing path between any pair of nodes and there is a distributed synchronization mechanism (IEEE 802.15.4 beacon-enabled mode). There is only one ZC which identifies the entire network and one ZR per cluster. Any of the FFD can act as a ZR providing synchronization services to other devices and ZRs.

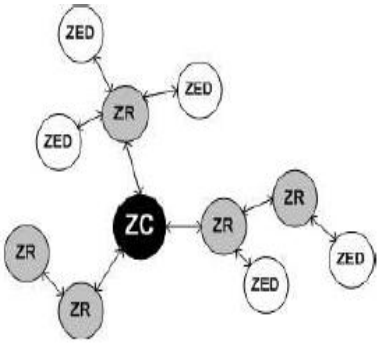

Figure 3.3: Tree topology for wireless personal area networks

	Star	Mesh	Tree
Scalability	No	Yes	Yes
Synchronization	Yes (no)	No	Yes
Inactive Periods	All nodes	ZEDs	All nodes
Guaranteed bandwidth	Yes (GTS)	No	Yes (GTS)
Redundant Paths	N/A	Yes	No
Routing Protocol Overhead	N/A	Yes	No
Commercially Available	Yes	Yes	No

Table 3.1: Zigbee technology with star, mesh and tree topology features

Routing Protocols, Backoff Exponential Values In WPANs

Routing:

Routing is the process of choosing shortest paths through which network traffic flows. Routing is implemented in different sort of networks, for instance telephone network, electronic data networks and internet network. In electronic data networks routing uses packet switching technology. In packet switching networks, routing makes the path for packet forwarding, and also supports for the transportation of addressed packets from source to destination through intermediate nodes by using hardware devices like routers, bridges, gateways, firewalls or switches. Ordinary computers with multiple network cards may forward packets and activate routing, regardless of limited performance. The routing process usually adopts forwarding in terms of routing tables. Therefore for the manufacturing of routing tables memory is necessary for precise routing.

Routing Protocols In Wireless Personal Area Networks

There are two important routing protocols are implemented for Zigbee based personal real networks based on the topology of network for transferring the data between the nodes.

They are

i. Tree routing protocol
ii. Mesh routing protocol

Tree routing protocol:

Tree routing is used together with a special method of network nodes addressing. In Tree Routing (TR) protocol, coordinator is responsible to initiate the network by choosing certain key of network parameters and thus becomes the parent node. Other nodes can join the network by becoming the children of the existing node [10]. In TR protocol, the network addresses are distributed in tree structure in which coordinator uses zero network address while other nodes have the non-zero address. The addresses are computed by the parent node based on its own network address and the network address of its children. When the tree address allocation is enabled, the network addresses are assigned using a distributed address allocation scheme. This is a scheme which is designed to provide potential parents with a finite sub-block of network addresses to be distributed to its children. The size of the sub-block depends on the following parameters: Cm: Maximum number of children per parent. Rm: Maximum number of router children a parent can have. Lm: Maximum depth of the network. Depending on these parameters (Cm, Rm, and Lm) and the depth of the node, d, if node wants to join the network, router node computes Cskip (d)[30]which is the address block size for each of its router child. For ZigBee routing nodes whose address of A, depth of d, if met the following inequality, then the destination node whose address of D is one of its children:

$A < D < A + Cskip\ (d-1)$ ---------- (1)

If it is determined the packet destination node is the descendant of the accept node, the node will send packets to a sub-node. This time, if satisfied:

$D > A + Rm \times Cskip\ (d)$ ---------- (2)

It means that the destination node is its terminal child node, then the next node address N as follows:

$N = D$ ---------- (3)

Otherwise, if the destination node is not an offspring of receiving node, it will send the packet to its parent node.

Mesh routing protocol:

It has been discussed that ZigBee supports mesh topology along with mesh routing protocol, so using this topology mesh wireless sensor network can be created and created mesh routing protocol. In the mesh routing protocol, each node is attached to every other node in the network with some wireless medium. Different algorithms are used to carry out the communication between different nodes. For a mesh networking, a multi-hop network will be a good strategy. The mesh wireless network architecture can be built considering the scenario of this paper. The mesh network nodes are connected in a point-to-point fashion by the use of directional antennas and have wireless link between them. To create the wireless link, different modulation techniques can be used like Quadratic Phase Shift Keying and others. The modulation technique contributes to physical capacity of the wireless link between the nodes. In the case of mesh network, the failure of one link will not lead to the failure of the whole network. In our case, we can build a mesh network within the container according to its size. Each pallet is equipped with the ZigBee sensor node. These sensor nodes develop a mesh network between them in which every node is connected to all other nodes. Figure 16 shows that ZigBee sensor nodes are making a Wireless mesh network in which different ZigBee sensor nodes are behaving differently; some acting as RFDs, some as FFDs and one of these FFDs will behave as a network coordinator of this created network.

The characteristics of mesh routing protocol are

• In mesh routing protocol, the configuration of the network can be done by the network itself.
• It is also scalable means it can grow from a smaller to a larger network by adding more nodes as per requirement.
• More reliable than others in these wireless sensor networks, as if one sensor node in the network fails to work, it will not stop the overall operation of the whole wireless sensor network.
• Another advantage is that it supports multi-hop communication in the WSN to reach far distances conserving energy in case single hop does not work properly.
• ZigBee mesh network is cost effective and the batteries used to make this network are quite efficient because they can last for months even for years with simple size batteries.

Media access control layer (MAC)

Mac layer of a network maintains the channel allocation of a medium for the networks to transfer the data between the nodes and monitoring whether allocated channel is free or not to transfer the data in the network. Monitoring of the channel also consumes more energy of the battery based zigbee sensor node in the network. hence ,for monitoring the channel of the network need time divisional algorithms like TDMA as well as CSMA. PAN is a wireless network and TDMA will take more waiting time than CSMA causes to apply CSMA /CA algorithm for Zigbee networks to minimize the wastage of the power of the Zigbee sensor node.

Here, in this paper, CSMA/CA algorithm consider for monitoring the channel whether it is freely available for the node to transfer the data in the network

Mac protocol operates in two modes they are

- Non beacon mode
- Beacon mode

- The non beacon-enabled mode. When the ZC selects the non-beacon enabled mode, there are neither beacons nor super frames. Medium access is ruled by an unslotted CSMA/CA mechanism

- The beacon-enabled mode. In this mode, beacons are periodically sent by the ZC or ZR to synchronize nodes that are associated with it, and to identify the PAN. A beacon frame delimits the beginning of a super frame defining a time interval during which frames are exchanged between different nodes in the PAN. Medium access is basically ruled by Slotted CSMA/CA. However, the beacon-enabled mode also enables the allocation of contention free time slots, called Guaranteed Time Slots (GTSs) for nodes requiring guaranteed bandwidth.

Out of all types of MAC layer characteristics, CSMA/CA mechanism is useful for avoiding the collisions between the nodes to transfer the data in a channel and enhancing the performance of the network in the form of better QoS.

CSMA/CA Mechanism:

In IEEE 802.15.4, contention-based MAC (Medium Access Control) can be either slotted or unslotted CSMA/CA, depending on the network operation behaviour: beacon enabled or non beacon-enabled modes, respectively.

The CSMA/CA mechanism is based on backoff periods (with the duration of 20 symbols). Three variables are used to schedule medium access:

- *Number of Backoffs* (*NB*), representing the number of failed attempts to access the medium
- *Contention Window* (*CW*), representing the number of backoff periods that must be clear before starting transmission;
- *Backoff Exponent* (*BE*), enabling the computation of the number of wait backoffs before attempting to access the medium again.

IV. SIMULATION SETUP, RESULTS AND ANALYSIS

OPNET (Optimized Network Engineering Tool) Modeler17.5 is used for the design and implementation of this work by taking the all necessaries in the network environment.After running different scenarios in Zigbee network with different bakcoff exponential values in mac layer for tree routing protocol with simulation time 1200 seconds.

From the simulation results, analyze the QoS metric values like throughput, delay, load ..etc.

Figure given below shows MAC_Delay parameter values according to the backoff exponential values in tree routing protocol.

Results of Tree routing protocol:

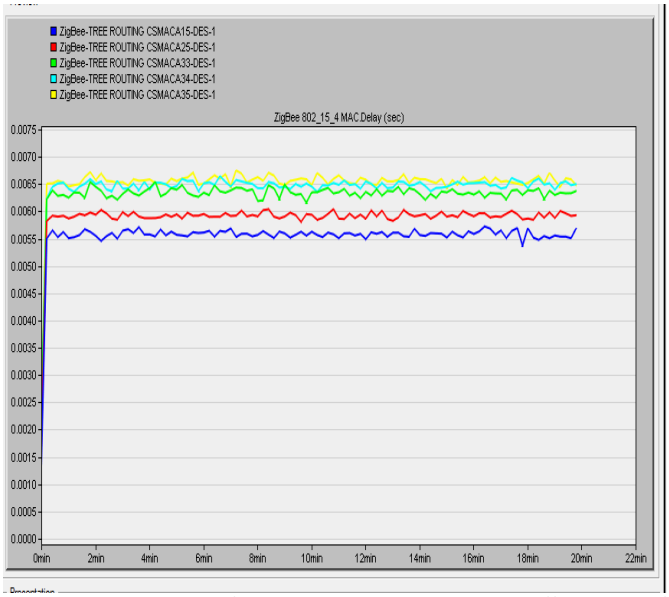

Figure 4.1: :mac delay for tree routing protocol under different backoff exponent values in Zigbee mac protocol.

From the observation of graph values shows that in tree routing protocol, MAC_Delay is very low for Backoff exponent values min 1 and max 5 in CSMA/CA algorithm . and Min 2 and max 4 iterations of backoff exponential constant values in CSMA/CA algorithm gives the average MAC_Delay value . they are identifying the channel in tree routing with min number of iterations in tree routing protocol due to less number no nodes are waiting for the channel.

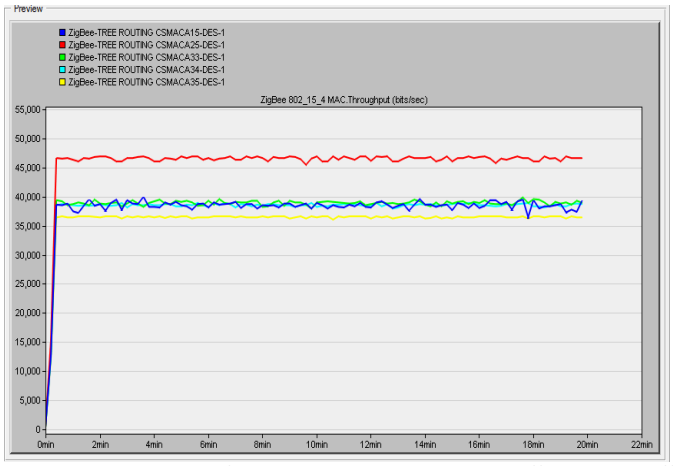

Figure 4.2: Throughput for tree routing protocol under different Back off exponents values in zigbee mac protocol.

From the above figure , in Zigbee tree routing protocol, min 2 and max 5 iterations of Backoff exponential constant in CSMA/CA gives maximum throughput due to less amount of waiting time along with effieicient channel utilization than min 1 and max 5 iterations of backoff exponential constants in CSMA/CA algorithm.

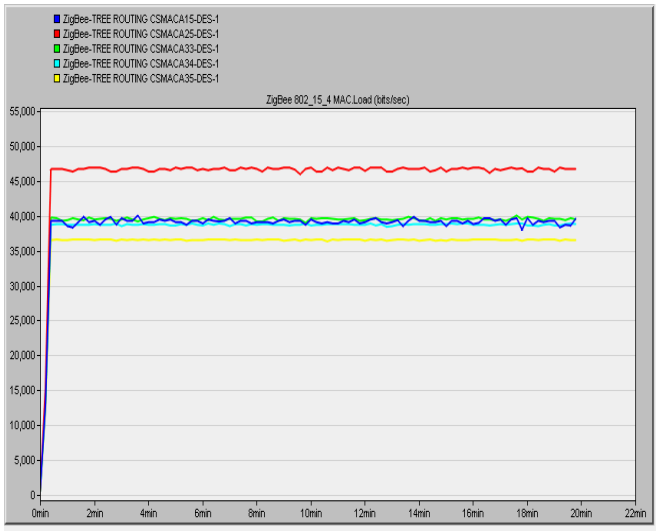

Figure 4.3 : Load in Zigbee mac for tree routing protocol using backoff exponential values under zigbee mac protocol.

From the above graph, in Zigbee tree routing protocol more load placed in channel when min 2 and max 5 backoff exponential constants due to its efficient utilization of channel within min exponential value as 2. But in remaining scenarios, the channel hit by the nodes min as high hence it causes to increase the delay for utilization of the given channel causes to very low traffic carried by the channel.

Results of Mesh routing protocol:

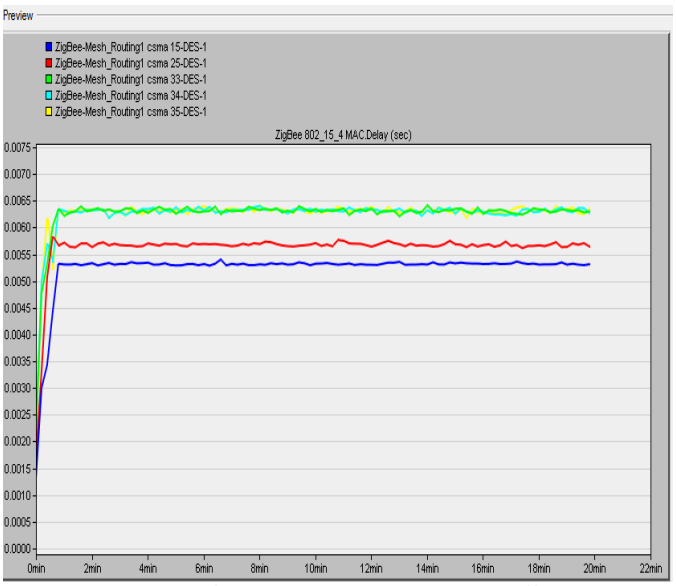

Figure 4.4: mac delay for mesh routing protocol under different exponents using Zigbee mac protocol.

From the observation of above graph values shows that in mesh routing protocol, MAC delay is very low for Backoff exponent values min 1 and max 5 in CSMA/CA algorithm in MAC layer . and Min 3 and max 4 iterations of backoff exponential constant values in CSMA/CA algorithm gives the average MAC delay value in MAC layer due to its identification ofefficient channel free for data transmission without collision within in small backoff exponential constant values for Zigbee mac layer.

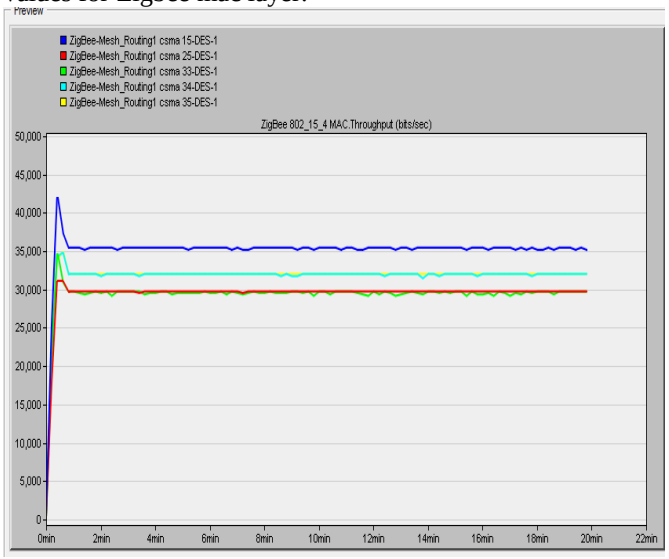

Figure 4.5: Throughput for mesh routing protocol under different backoff exponents values in zigbee mac protocol.

From the observation of above graph values shows that in mesh routing protocol, MAC_Throughput is high for Backoff exponent values min 1 and max 5 in CSMA/CA algorithm in MAC layer . and Min 2 and max 4 iterations of backoff exponential constant values in CSMA/CA algorithm gives the average MAC_throughput value in MAC layer due to its identification ofefficient channel free for data transmission without collision within in

small backoff exponential constant values for Zigbee mac layer.

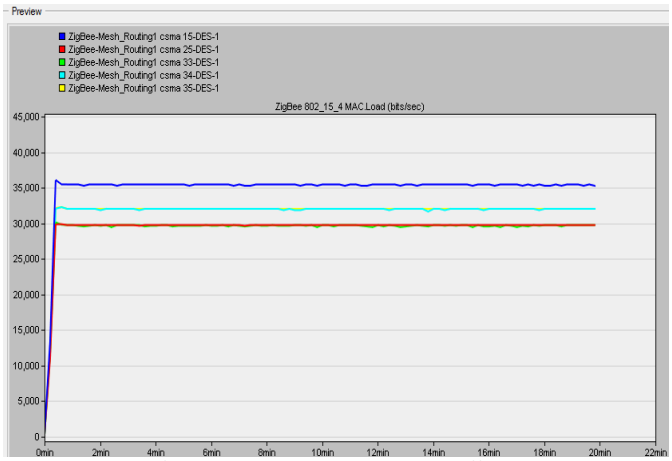

Figure 4.6: Load for mesh routing protocol under different exponents using Zigbee mac protocol

From the observation of above graph values shows that in mesh routing protocol, MAC load is very high for Backoff exponent values min 1 and max 5 in CSMA/CA algorithm in MAC layer . and Min 3 and max 4 iterations of backoff exponential constant values in CSMA/CA algorithm gives the average MAC load value in MAC layer due to its identification of efficient channel free for data transmission without collision within in small backoff exponential constant values for Zigbee mac layer.

Results in tabular form for Tree routing and Mesh routing protocol:

Back off Exponent	parameter	Mesh routing	Tree routing
Min 1 Max 5	Delay(sec)	0.005400	0.005634
	Network load (bits/sec)	36046	39849
	Throughput (bits/sec)	42124	39563
Min 1 Max 5	Delay(sec)	0.005832	0.005951
	Network load (bits/sec)	29857	46904
	Throughput (bits/sec)	31131	46618
Min 1 Max 5	Delay(sec)	0.006394	0.006618
	Network load (bits/sec)	32068	36608
	Throughput (bits/sec)	34806	36608
Min 1 Max 5	Delay(sec)	0.005721	0.006010
	Network load (bits/sec)	28840	46904
	Throughput (bits/sec)	31475	46713
Min 1 Max 5	Delay(sec)	0.006325	0.006613
	Network load (bits/sec)	32068	38800
	Throughput (bits/sec)	34804	38800
Min 1 Max 5	Delay(sec)	0.006416	0.006337
	Network load (bits/sec)	29857	40040
	Throughput (bits/sec)	34710	38991

Table 4.1 : simulation results of all scenarios

V. CONCLUSIONS

When the network size is same for all simulated scenarios with static deployment of the nodes in the network and Mac layer min back off exponential constant 1 and max back off exponential constant 5 in CSMA/CA algorithm of Zigbee mac layer shows better results than all different combinations of back off exponential constants in mesh routing protocol due to the reliability of the connection between the nodes in the network to efficient utilization of the channel for transmitting data between the nodes with minimum number of collisions.

Where as in the case of tree routing protocol, backoff exponential constant of min 2 and max as 5 gives better results than all other different combinations of back off constants in CSMA/CA algorithm for mac layer for efficient utilization of channel allocated for the network due to lack of awareness about the channel free or not causes more collisions between nodes for data transmission in the network.

Finally we conclude that mesh routing protocol gives better results in terms of delay and throughput due to its reliable connection between nodes in the network with shortest available path with minimum backoff exponential constant as 1 and maximum back off exponential constant as 5 and also tree routing protocol and mesh routing protocols give average QoS metrics with min back off exponential value as 2 and max back off exponential constant as 4 in CSMA/CA algorithm in zigbee MAC layer for tree routing protocol as well as mesh routing protocol.

ACKNOWLEDGMENT

The authors are grateful the department of Computer science and Engineering,Vasireddy Venkatadri Institute of Technology,for providing necessary facilities for successful completion of work.

REFERENCES

[1] Tony Larsson and Nicklas Hedman, “Routing Protocols in wireless Ad-hoc Networks-A simulation study”. Stockholm 1998.

[2] Jangeun Jun and Mihail L. Sichitiu, “MRP: Wireless Mesh Networks Routing Protocol”. Raleigh, NC 27695-7911.

[3] Sonia Waharte, Raouf Boutaba, Youssef Iraqi and Brent Ishibashi, “Routing Protocols in Wireless Mesh Networks: Challenges and Design Considerations”. School of Computer Science Waterloo, Canada.

[4] Rainer Baumann, Simon Heimlicher, Vincent Lenders and Martin May, “Routing Packets into Wireless Mesh Networks”

[5] http://en.wikipedia.org/wiki/Routing_protocol

[6] Krishna Gorantala, “Routing Protocols in Mobile Ad-Hoc Networks” June 15, 2006, Umeå University Sweden.

[7] Zhang Yan, Luo Jijun, Hu Honglin. "*Wireless Mesh Networking, Architectures Protocols and Standard*". USA: Auerbach Publications 2007.

[8] Zhang Yan, Zheng Jun, Hu Honglin. "*Security in Wireless Mesh Networks"*.

[9] Yuyan Xue, "Security issues in Wireless Mesh Networks", Department of computer science and engineering, University of Nebraska-Lincoln, July 2007.

[10] J.U. Lee, E.H. Choi, J.D. Huh, "Voice over ZigBee Networks with Environmental Monitoring," IEEE International Conference on Consumer Electronics(ICCE), 2011, pp 633-634, Jan. 9-12, 2011.

[11] Abbas El Gamal, James Mammen, Balaji Prabhakar and Devavrat Shah, "Throughput-Delay Trade-off in Wireless Networks", Department of EE and CS, Stanford University, IEEE 2004.

[12]. W.T.H Woon, T.C. Wan, "Performance Evaluation of IEEE 802.15.4 Ad Hoc Wireless Sensor Networks: Simulation Approach," in IEEE International Conference on Systems, Man and Cybernetics, vol. 2, october 2006, pp. 1443-1448.

[13]. Ye W. and Heidemann J. (2003). "Medium Access Control in Wireless Sensor Networks," USC/ISI Technical Report ISI-TR-580, October 2003.

[14] Burns, Robert B. "*Introduction to Research Methods"*. London: Sage Publications, 2000.

[15] Yi Pan, "Introduction to OPNET simulator".