Performance Comparison of Routing Protocol by Deploying ZIBGEE as Wireless Sensor Network

Rehan Baber, Muhammad Abrar and Roha Masroor

***Abstract* – In the last few decades,Wireless Sensor Networks (WSN) have led to new aspects of research in the communication field. WSN's are widely available and economic wireless networks, consisted of simple devices resulted in an advanced expansion in mobile computing. A Mobile Ad-hoc network (MANET) is itself a self-configuring network consisting of multiple nodes connected by wireless connections.Unlike previous mobile wireless networks, Ad-hoc network's host keeps their network alive by relying on each other, and do not carry any infrastructure. This paper attempts to present a comprehensive performance of Mobile Ad-hoc network with two non-identical routing protocols. Ad-hoc On-demand Distance Vector (AODV) and the other Dynamic Source Routing (DSR) is primarily focused. The successful performance of the above two routing protocols is presented comprehensively using their End to End delay, network load and throughput. ZIGBEE will be used to increase the lifespan of the required Wireless network. All the characteristics of the network will be defined in terms of ZIGBEE. A comparison between the ZIGBEE and a simple wireless network is given in paper.**

***Index Terms* – Wireless Sensor Networks, MANET, Routing Protocols, DSR, ZIGBEE, AODV.**

I. INTRODUCTION

The Wireless Sensor Network is important and focused area in vast field of communication. The Wireless Sensor Network (WSN) uses the radio communication system and user information. It is transmitted to the desired base station by the station nodes. The network basically consists of sensors, sensor nodes, memory, and communication device energized by a power supply [1].

There are multiple factors which affect the design of the WSN network. They mainly include communication and band frequencies,fault tolerance range, scalability, hardware limitations and demand of power supply for communication and processing of data. Depending upon system requirements the WSN network is classified on the basis of architectural and communication specificity. However, the radio propagation conditions are also important. It mainly includes the network node mobility, different configurations, environmental conditions, single-hop and multi-hop network algorithms. WSN have military applications which include enemy tracking and battlefield surveillance [2], [3]. The environmental application mostly includes the monitoring and emergency services. Moreover, it also includes monitoring of temperature, air streams, air pollution, sensing light. Earthquake and smoke detection in the building can also implemented using WSN. The list further includes [4] acoustic detection, disaster relief operations, biodiversity mapping, agricultural processing, [5] health applications, process monitoring, ground and underwater coverage, indoo and outdoor coverage.Specific applications of WSN require individual solutions to different complex systems.

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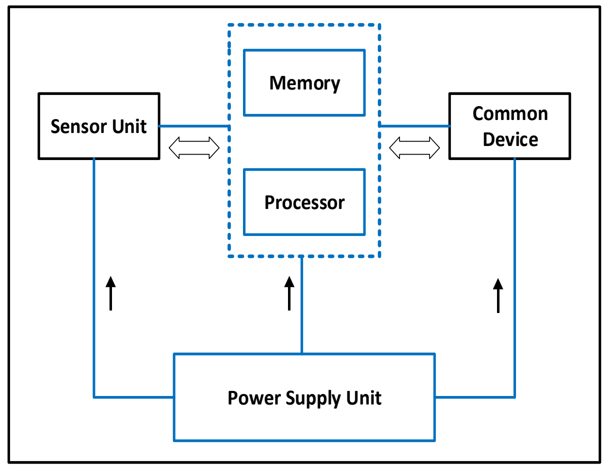

Fig. 1 Components of Wireless Sensor Network

Contrary to other infrastructural networks, the mobile ad-hoc network does not obey any basic infrastructure during the operation. During operation, the mobile nodes successfully communicate with each other within their accessible range in an autonomous manner. They result in random and unpredictable topology changes because of being free to join or leave the target. It is a multi-hop system, thus each node acting as an intelligent node without any mediator network device [6]. MANET has applications in military communication, automated battlefields, detecting earth activities and location-aware services which include Location-dependent travel guide, automatic call forwarding and advertise location-specific services.

In the present study, different setups of wireless sensor networks are developed. The network is scaled and its impact on the characteristics of the network will be checked. The qualitative factors related to MANET are adaptability, flexibility, heterogeneity, reliability, scalability, security and stability [7]. Power consumption is also an important feature of WSN application. In the need of simple setup and less data rate, ZIGBEE is implemented. WSN consist of its own routing protocol [8]. The less power and smaller sizes of the Wireless Sensor Network limit the applications of routing protocols. In this research paper, Ad-hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) the comprehensive analysis of Wireless Sensor Network is implemented. It will help to find the best routing protocol on the basis of scalability factors, varying scenarios, and variation in applications.

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II. ZIGBEE TECHNOLOGY

ZIGBEE Technology is the widely used Wireless Sensor Network. It carries lower dissipation of power; lower data rate for communication, characteristics of short time delay, low cost is easily deployed with robust security. "ZIGBEE" is derived from the pattern of honey bees moving within the flowers. It represents a complete mesh network between nodes in a system. ZIGBEE has been the communication protocol of advanced level that is successfully used in Personal Area Network (PAN) i.e. specifically digital radio connections between the computers and other related devices in the system [9]. The power used by ZIGBEE is as small as 1mW and provides a 150-meter range by using direct sequence spread spectrum(DSSS) [10]. It leads to a very big network by connecting more than 65,000 nodes in a big network. The ZIGBEE application profiles include home automation, telecommunication applications, ZIGBEE smart energy and personal home.

ZIGBEE devices can be classified as logical and physical. The former consists of a coordinator router and the end device, whereas later contains the full function device and the reduced function device. ZIGBEE is based on IEEE standard 802.15.4, easy to be connected as it is an open system connection (OSI). Fig. 2 represents the ZIGBEE protocol Stack. Physical layer controls and communicates directly to the radio transceiver, being closest to the hardware. MAC layer provides two services to be performed. First is the MAC managed service and secondly, MAC data service. The network layer is responsible for the formation of network and routing. Application layer hosts the application objects being higher protocol layer [11].

ZIGBEE network can be connected in different topologies: Star topology consisting one coordinator and multiple or single end devices. Cluster tree topology is same as that of Star topology except that other nodes can also connect with each other. In a Mesh topology, all the nodes can connect with each other in their ranges ZIGEE networks use three different types of devices.

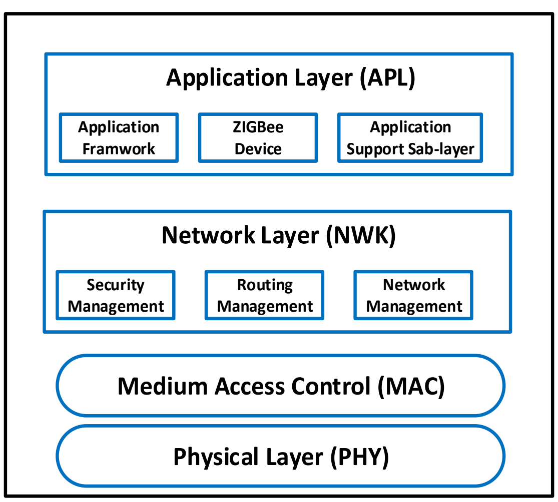

Fig. 2 ZIGBEE Wireless Network Layers

The network coordinator, Full Function Device (FFD) and the Reduced Function Device (RFD).The first maintains the overall knowledge of the network. It requires the most memory. It is the most sophisticated of all requiring the maximum computing power. FFD supports all the features and functions of 802.15.4. The RFD performs limited functionalities as specified by the standard. It is generally used in the network-edge devices. All these devices carry 64-bit IEEE addresses. Shorter addresses can be enabled to reduce the work or size in two address modes- Per-to-peer and star [12].

A comparative study of wireless protocols with ZIGBEE [13] is represented in Table I.

III. REACTIVE ROUTING PROTOCOLS

In the case of reactive routing protocols, the protocol searches the route on-demand. During the communication dismal the reactive protocols lack the routing activities in the networks. Les overhead is normally used to maintain the unused route. It makes the connection when the node wants to send or receive the data packets. Initially, it will result in more time delay. There are two defined types of Reactive protocols: hop-by-hop routing and source routing. They mainly include Routing discovery and Route Maintenance. Source rote on-demand protocols carry the complete source to the designated address while forwarding the data packets; every intermediate node evaluates the complete information present in the header. To maintain the evaluated routing data the intermediate nodes are not essentially required for each active rote These routers are easily adaptable to changing environment as fresher topology information is there to update the routing table of each node. The data packets are transmitted over better routes dynamically in the MANET's.[14]. Dynamic Source Routing (DSR) and Ad-hoc On-Demand Distance Vector (AODV) have been discussed under this category.

TABLE I COMPARISON OF THE WIFI, BLUETOOTH AND ZIGBEE PROTOCOLS

Standard	Band-width	Nominal range	Nominal TX Power	Proto-col Size
Wi-Fi	54Mbps	100 m	15-20 dBm	100+ Kbps
Bluetooth	1Mbps	10m	0 - 10 dBm	~100+ Kbps
ZigBee	250kbps	10-100m	(-25)-0 dBm	4^{32}Kbps

AODV protocol can adapt rapidly in the dynamic network with the smallest management and minimum overhead. It is known to be a unicast reactive protocol. It shows that routes will only be established when required. Ad-hoc On-Demand Distance Vector implies a broadcast discovery mechanism. It depends upon dynamically developed routing table entries. In AODV, the information regarding active routes are stored by all the nodes

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maintaining a routing table. The stored information contains the destination, number of hops, next hop, the sequence number of destinations, the expiration time for a route table entry and neighbors for a route. It performs local connectivity management, path maintenance, route table management and route discovery. Local connectivity is managed as follows: Nodes send or receive broadcast packets to or from their neighbors. Receiving a broadcast packet from a new neighbor or not receiving a broadcast packet from the already existing node helps to sense the local connectivity. Path maintenance is performed by sending the special ERROR message in case of an unreachable node. In the case, the source node again starts the path discovery. Path discovery is initiated by the RREQ route request packet. On receiving RREQ, a node sends RREP in return carrying the information. A sequence number is attached with RREQ's and RREP's to prevent the existence of looping in the distance vector routing. The recently updated routing information and the highest sequence number will be utilized as the sequence number. If any of the two routes have the same sequence number, then the one with a shorter route will be utilized. [15], [16].

Dynamic Source Routing (DSR) is a source routing protocol in which Route Request is created by the first node and the data is sent to the desired destination. It generates Route Reply message back to the initial source node. In case of any error during the transmission of data, a Route Error (RERR) is generated at the instant and sent to the route. It is specially designed for mobile multi-hop wireless ad-hoc networks. In case of DSR, the network does not require any particular network administration or infrastructure. It is completely self-configuring and self-establishing. Communication over multiple hops is allowed by the network nodes to forward the data packets for each other between the nodes and not only within the wireless transmission range. DSR automatically maintains and determines the DSR routing protocol in any case such as any node joins or leaves the network and in any wireless transmission cases such as if the source of the interference is changed. As a result, the network topology is rapid and rich in spite of the number of intermediate hops reaching any address can be changed at any instant. In case of DSR protocol, the nodes dynamically discover a source route across any network hop to any destination of the ad hoc network. Each data packet carries the complete periodic list of the nodes through which the data packets will pass. It allows the loop-free routing and there is no need for updated routing information between the intermediate nodes. This source route is present in each data packet's header. This routing information can be used by other nodes, overhearing or forwarding any of these packets in future. [17].

A technique introduced to evaluate the effect of ambient load noise and also the path loss for the received signal strength at the mobile node of ad hoc network has been calculated [18] by the given equations

$$A_n = RW * K \qquad (1)$$

Where, An is the ambient noise, RW represents the receiving bandwidth and K is the constant called ambient noise level, given as 1e-26. The path loss model was represented as

$$PL = \frac{\lambda^2}{\left(\frac{4}{\Omega D}\right)^2} \qquad (2)$$

Where PL is the path loss, Lambda is the wavelength and D represents the propagation distance.

It has compared the performance of AODV and DSR on the optimized simulator, OPNET. The results have shown that by changing the mobility model and power control mechanism the performance of both the routing protocols can be drastically changed.

IV. SIMULATIONS AND RESULTS

As simulation software, we used OPNET modeler simulation. It is so far the best simulator designed for communication systems, simulating the protocols and new technology networks. It helped to completely analyze the desired performance management of the network. Network performance tells the quality of service of the network seen by the customer. Different ways are opted to measure the performance of the network depending upon the nature and design of the network. The proposed network is modeled and simulated to observe the characteristics at different conditions. Network simulations have been performed for variable node density with 10, 15 and 20 nodes. The End to End delay, throughput and the network load of the mentioned protocols have been analyzed for the 10, 15 and 20 nodes for 3700 seconds. Throughput and end to end delay are the two most important features to measure the performance of the wireless networks. Throughput represents the number of messages per unit of time represented as

$$\text{Throughput} = \frac{\text{Number of Packets Sent}}{\text{Time Taken}} \qquad (3)$$

Throughput highly depends on the bandwidth of the network, the signal to noise ratio and some of the hardware limitations. End to End delay also known as one-way delay represents the time of the delivery of the packet from source to destination across the network. The formula for evaluation is

$$\text{End to End Delay} = \frac{1}{N}\sum_{n=1}^{N}(R_n - S_n) \qquad (4)$$

Where,
S_n is the time at which nth data packet is sent, R_n is the time at which nth data packet is received and N is the num. of data packets received.

The End to End delay is mostly used as the average. It is represented as

$$\text{Average End to End Delay} = \frac{\text{Total E2ED}}{\text{Number of Packets Sent}} \qquad (5)$$

Where,
E2ED= End to End delay

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The desired high throughput and low end to end delay are mainly difficult to achieve in the network. It is also good to maintain the delay under a certain threshold to achieve the required application. Both the protocols AODV and DSR successfully applied to the networks. The outputs showing the throughput, end to end delay and network load are illustrated.

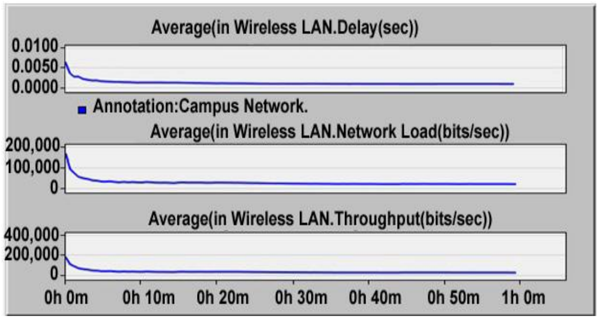

Fig. 3 Features of AODV deploying 10 Nodes.

It is observed in Fig. 3-5 that by increasing the number of successive nodes, an increase in the Throughput and End to End delay is observed in the response of AODV protocol. In this case the throughput is near 300 Kbps for 10 nodes and then increases to almost 250 Kbps and 350 Kbps for 15 and 20 nodes. The delay is 0.005sec for 10 nodes and then increases to almost 0.0025sec and 0.004sec for relative 15 and 20 nodes. It shows that by increasing the number of successive nodes in the network, the average data transmission increases between the source and destination per unit time. However, by increasing the number of successive nodes the delay also increases.

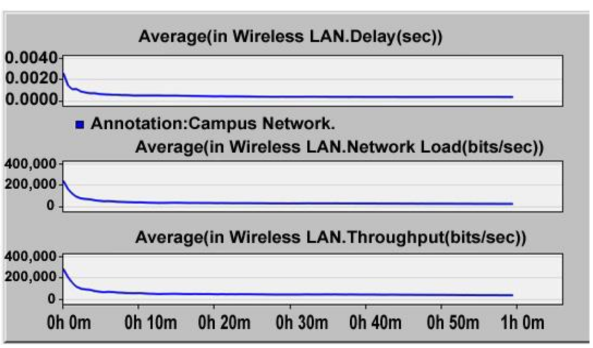

Fig. 4 Features of AODV Deploying 15 Nodes.

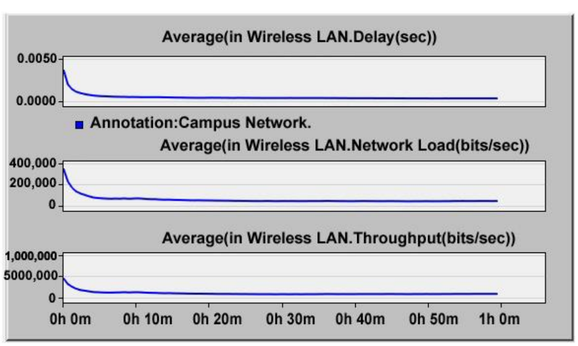

Fig. 5 Features of AODV deploying 20 Nodes.

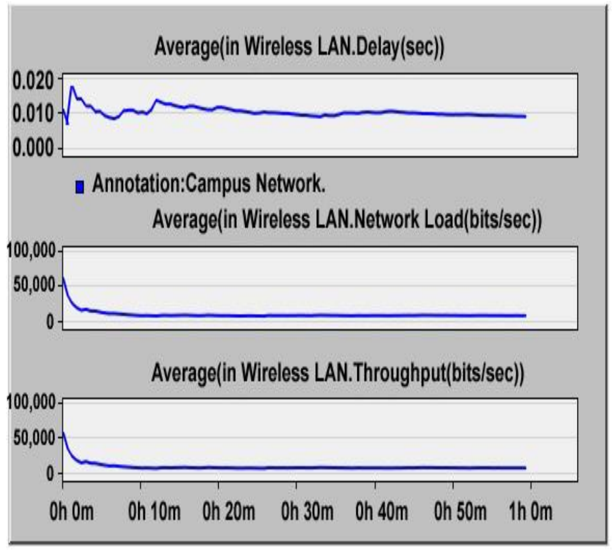

Fig. 6 Features of DSR Deploying with 10 Nodes.

The same networks have been shown for the DSR routing protocol. It is observed in Fig.6-8 that by increasing the number of successive nodes, similar to that of AODV, an increase in the End to End as well as Throughput delay is observed in the response of DSR protocol. In this case the throughput is near 60 Kbps for 10 nodes and then increases to almost 250 Kbps and 450 Kbps for 15 and 20 nodes. The delay is 0.001sec for 10 nodes and then increases to almost 0.005sec and 0.015sec for 15 and 20 nodes. Again, the successive data packet rate has been increased by the increased number of nodes, but the delay also tends to increase.

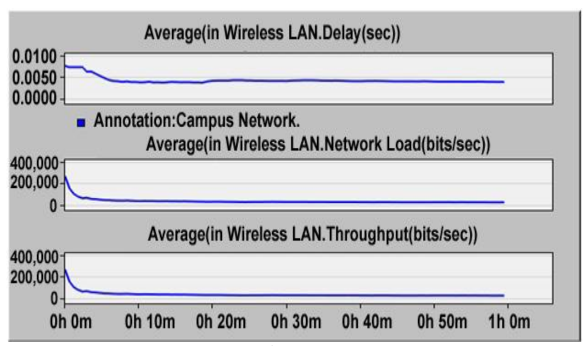

Fig. 7 Features of DSR Deploying 15 Nodes.

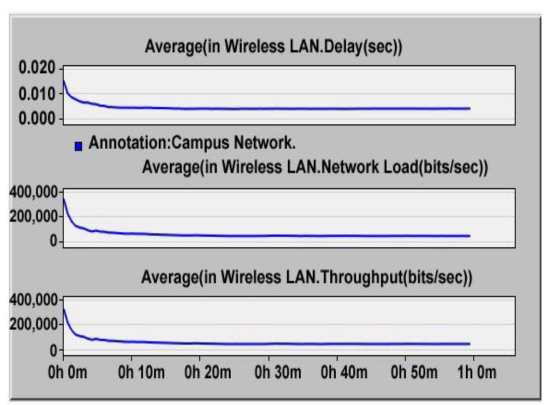

Fig. 8 Features of DSR Deploying 20 Nodes.

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In the present research study, 4 modules of ZIGBEE are simulated using OPNET.

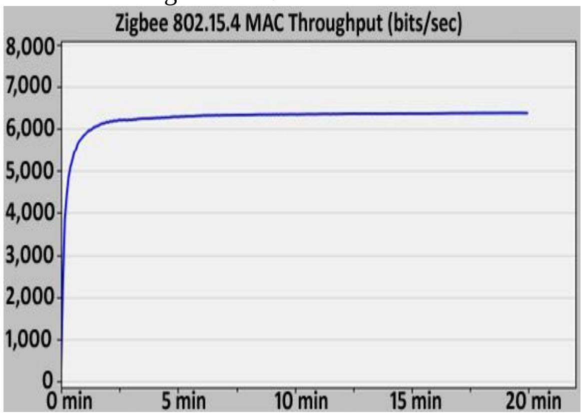

Fig. 9 Response Curve Network Throughput Of ZIGBEE

From the above Fig. 10, it is observed that the End to End is great for ZIGBEE nodes. The delay is started at 0.060 seconds and at 0.070 seconds it becomes saturated. However, in case of WSN nodes, the delay is not expected even before 0.200seconds. Thus, it can also be easily observed the throughput value of WSN network is higher than the ZIGBEE.

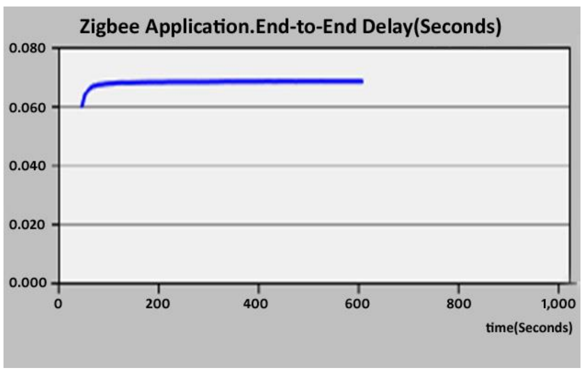

Fig.10 End To End Delay Curve for ZIGBEE network.

The results obtained above are represented in Table II showing the Throughput and End to End delay.

A. *Throughput:*

It can be clearly seen from the figures representing Throughput vs. a different number of nodes. AODV has a higher throughput during the time of simulation. It also shoots by increasing the number of the nodes from 10, 15 to 20.

B. *End to End Delay*:

It can also be seen that End to End delay also increases by increasing the number of the nodes. End to End delay for the DSR is observed to be larger than the AODV; which shows AODV have the lowest delay and performs better.

TABLE II. END TO END DELAY AND THROUGHPUT VALUES OF AODV AND DSR AT 10, 15 AND 20 NODES.

No. of Nodes	**Observed Parameters**	**AODV**	**DSR**
10	End-2-End Delay	0.005 Sec.	0.01Sec.
	Throughput	~300 Kbps.	~60 Kbps.
15	End-2-End Delay	0.0025 Sec.	0.005 Sec.
	Throughput	~320 Kbps.	~250Kbps
20	End-2-End Delay	0.004 Sec.	0.015 Sec.
	Throughput	~350 Kbps.	~450Kbps

V. CONCLUSIONS

In this research work, OPNET was used to make a desired network of nodes. This is known as a wireless sensor network. The application of WSN is used for area monitoring, relief operations, and healthcare monitoring. The two enlisted routing protocols AODV and DSR are compared. End to End delay and throughput values of both the routing protocols are considered. The increase in the size of the wireless network in case of AODV resulted in a decrease of an End to End delay and increase in throughput value. The throughput value in case of AODV is more consistent. However, in case of DSR End to End delay has more consistency. The performance evaluation of wireless sensor network will be exploreded by fire researchers. The routing protocols such as TORA and OSLR should also be evaluated. In this research work, a network with eight ZIGBEE nodes, consisting four routers, linked with one coordinator were successfully considered. The throughput values are greater and the data rate is less in case of ZIGBEE. For the best evaluation of ZIGBEE; different scenarios will be considered.

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