WSN Performance Parameters of AODV, DYMO, OLSR and IERP in RWP Mobility Model through Qualnet

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ABSTRACT
Wireless Sensors are devices that monitor and record their surroundings physical and environmental parameters and transmit them continuously to one of the source sensors. A collection of such wireless sensors form a network called Wireless Sensor Networks. This technology is considered to be the best for the study of performance parameters. Routing is a technique which we use to select path to send traffic in the network, also called as Protocol. AODV, DYMO [6], OLSR and IERP[5] are adhoc routing protocols. In this paper we shall study different performance parameters in a Random Waypoint Mobility Model by varying the number of nodes and also changing the maximum speed of a node, such as Average Throughput, Average End to End Delay, Average Jitter, Average PDR (Packet Delivery Ratio) and Total Packets Received. Analysis and performance study is done using Qualnet 6.0 simulator.

General Terms
Wireless sensor networks, Routing Protocols, Simulation, Performance Metrics, Mobility.

Keywords
Mobility Models, AODV, DYMO, OLSR, IERP, Qualnet 6.0, Jitter, End to end delay, PDR, Throughput.

1. INTRODUCTION
Wireless sensor networks (WSN) is a special class of adhoc wireless network that are used to provide a wireless communication infrastructure, observe and respond to phenomena in the natural environment and in our physical and cyber infrastructure [1]. A routing protocol is such that it specifies how routers communicate with one another, broadcast information that allows them to select their path between any two given nodes on an adhoc network. Each router has a preceding knowledge only of networks attached to it directly. A routing protocol distribute this information first among to its neighbours, and then to the whole of the network. In this way, the routers achieve knowledge of the topology of the network. An ad hoc routing protocol is a principle, or standard, that manages how the nodes decide which way it has to send packets between the communicating devices in the network. Some examples of routing protocols available for Ad- hoc networks are AODV, CGSR, DSDV, DSR, OLSR, WRP, ZRP etc. [2]. AODV and DYMO are also known as Reactive Protocols, whereas OLSR is a Proactive Protocol and IERP is a Hybrid Protocol [6]. Mobility model represent the movement of nodes and how their location, velocity and acceleration change with respect to time. In the study of a new Mobile ad hoc network protocol, it is important to simulate the protocol and evaluate its protocol performance. Protocol simulation has several key parameters; including mobility model and communicating traffic pattern Mobility models characterize user-movement-patterns. Traffic models describe the condition of the mobile services [7].

2. RANDOM WAYPOINT MOBILITY MODEL
Random waypoint model is a random model for the movement of mobile users, and how their location, velocity and acceleration change over time. Mobility models are used for simulation purposes when new network protocols are evaluated. The Random waypoint model was first proposed by Johnson and Maltz [3]. It is one of the most popular mobility models and the "benchmark" mobility model to evaluate other Mobile ad hoc network (MANET) routing protocols, because of its simplicity and wide availability.

In random-based mobility simulation models, the mobile nodes move randomly and freely without restrictions. To be more specific, the destination, speed and direction are all chosen randomly and independently of other nodes. This kind of model has been used in many simulation studies. In random waypoint mobility model, the nodes randomly selects a position, moves towards it in a straight line at a constant speed that is randomly selected from a range, and pauses at that destination. The node repeats this, throughout the simulation [4].

3. ROUTING PROTOCOLS
A lot of protocols have been designed for Ad-hoc networks since last few years. Routing protocols are a set of rules that a network adopts for movement of data packets in a timely and secured fashion [8].The nodes within the network are interconnected to each other forming a cluster among themselves, and the data packets move and finds the shortest, that is least time taking path and also at the same time the most secured path to avoid and data loss and to avoid any unnecessary delays. Broadly routing protocols are classified into three categories: Reactive, Proactive and Hybrid. Proactive routing protocols are table driven protocols, when there is a need of data transfer the source node reached the path immediately which in turn helps in minimizing the bandwidth overhead and less time for the data packet movement. Proactive routing protocol used in our scenario is OLSR. Reactive protocols are on demand protocols, it finds a path within a network only when it is necessary [11]. Reactive protocols used in our scenario are AODV and DYMO. Hybrid protocol includes combination of Reactive and Proactive Routing Protocols. Hybrid protocol used in our scenario is IERP.

3.1 AODV (Adhoc On demand Distance Vector)

Ad hoc On-demand Distance Vector Routing (AODV) [9] protocol is an on demand routing protocol [12] as it determines a route to the destination only when a node wants to send data to that destination. The source node broadcasts a route request (RREQ) packet when it wants to find path to the destination. The neighbors in turn broadcast the packet to their neighbors until it reaches a transitional node that has recent route information about the destination or until it reaches the destination. An already received route request packet is redundant by the nodes. The route request packet uses sequence numbers to ensure that the routes are loop free and that the intermediate node replies to route requests are the most recent. A node records the node from which request packet received first to erect the reverse path for route reply to source node [13]. As the route reply packet traverses back to the source, the nodes along the path enter the forward route into their tables. Due to the mobile nature of nodes, route maintenance is required. If the source moves then it can reinitiate route discovery to the destination. If one of the intermediate nodes move then moved nodes neighbor realizes the link failure and sends a link failure notification to its upstream neighbors and so on until it reaches the source upon which the source can reinitiate route discovery if needed. AODV [10] has greatly reduced the number of routing messages in the network. AODV only supports one route for each destination. This causes a node to reinitiate a route request query when it's only route breaks. But if mobility increases route requests also increases.

3.2 DYMO (Dynamic MANNET On demand)

Dynamic MANET On-demand (DYMO) routing protocol enables reactive, multi-hop unicast routing between participating DYMO routers. DYMO is an enhanced version of AODV. DYMO operation is split into route discovery and route maintenance. Routes are discovered on-demand when the originator initiates hop-by-hop distribution of a RREQ (rout request) message throughout the network to find a route to the target, currently not in its routing table. This RREQ message is swamped in the network using broadcast and the packet reaches its destination. The target then sends a RREP (route reply) to the source. Upon receiving the RREP message by the source, routes have been established between the two nodes. For maintenance of routes which are in use, routers elongate route lifetimes upon successfully forwarding a packet. In order to react to changes in the network topology, routers monitor links over which traffic is flowing [8]. When a data packet is received for forwarding and a route for the destination route is broken, missing or unknown, then the source of the packet is notified by sending a RERR (route error) massage. Upon receiving the RERR message, the source deletes that route. In future, it will need to perform route discovery again, if it receives a packet for forwarding to the same destination. DYMO uses sequence numbers to ensure loop freedom and enable them to determine the order of DYMO route discovery messages, thus avoiding use of outdated routing information (Chakeres and Perkins 2006).

3.3 OLSR (Optimized Link State Routing)

Optimized Link State Routing (OLSR) is a proactive MANET routing protocol. Unlike DSDV and AODV, OLSR reduces the number of retransmissions by providing optimal routes in terms of number of hops. For this purpose, the protocol uses MPRs (Multipoint Relays) to efficiently flood its control messages by declaring the links of neighbors within its MPRs instead of all links. Only the MPRs of a node retransmit its broadcast messages, hence no extra control traffic is generated in response to link failures. OLSR is particularly suitable for large and dense networks. The path from source to destination consists of a sequence of hops through the MPRs. In OLSR, a HELLO message is broadcasted to all of its neighbors containing information about its neighbors and their link status and received by the nodes which are one hop away but they are not passed on to further nodes [8]. In response of HELLO messages, each node would construct its MPR Selector table. MPRs of a given node are declared in the subsequent HELLO messages transmitted by this node. OLSR is designed to work in a completely distributed manner and does not require reliable transmission of control messages. Control messages contain a sequence number which is incremented for each message. Thus the recipient of a control message can easily identify which information is up-to-date - even if the received messages are not in order (Clausen and Jacquet 2003).

3.4 IERP (Interzone Routing Protocol)

Interzone Routing Protocol (IERP), the reactive routing component of the Zone Routing Protocol (ZRP). IERP adapts existing reactive routing protocol implementations to take advantage of the known topology of each node's surrounding r-hop neighborhood (routing zone), provided by the Intrazone Routing Protocol (IARP). The availability of routing zone routes allows IERP to suppress route queries for local destinations. When a global route discovery is required, the routing zone based bordercast service can be used to efficiently guide route queries outward, rather than blindly relaying queries from neighbor to neighbor. Once a route has been discovered, IERP can use routing zones to automatically redirect data around failed links. Similarly, suboptimal route segments can be identified and traffic re-routed along shorter paths [14].

4. SCENARIO

The simulator used to record the performance parameters is Qualnet 5.0.2 developed by SCALABLE Network Technologies. In the Architecture mode of the simulator the scenario is designed in an area of 360000 square meters. Initially if no changes are made to the area then automatically the simulator takes an area of 1500 X 1500 square meters. Number of Nodes are increased from 5 to 20 in multiples of 5.Network traffic type is chosen as CBR (Constant Bit Rate) type, we have used 2 CBRs, where 1 CBR connects 2 nodes. The time for which the simulation is performed is 600 seconds. The node mobility model is set up as Random Waypoint Mobility, and further the minimum speed of the nodes at which they move randomly is set as 1m/s and maximum speed of the nodes are varied from 5m/s to 20m/s, this also is increased in multiples of 5, and the pause time is set as 30ms. A total of 100 data packets are sent over the 2 CBR traffic with an individual payload of 512 bytes. Initially the routing protocol is set as AODV and the option of add to batch is used to compare this simulation data with other routing protocols, DYMO, OLSR and IERP. After running the test, we study the graphs in the Analyser mode of the simulator. Hence we get the required performance parameters: Average end to end delay, Average throughput, average jitter, average PDR (packet delivery ratio) and total number of packets received.

Parameters	Values
Simulator	QualNet
Protocols studied	AODV,DYMO,OLSR & IERP
Number of nodes	20 nodes
Simulation time	600 s
Simulation area	600*600 sq m
Node movement model	Random waypoint mobility
Traffic types	2 CBR sources
Mobility of nodes	Min speed=1m/s ,Max speed=5m/s,10m/s,15m/s & 20m/s

Table 1: Scenario Description

Below are the screenshots from the Qualnet simulator when the above mentioned scenario is designed in the architect mode and before the results are analysed through the analyser, the Qualnet software runs the experiment. Several stages are shown below while the simulation takes place, in 3 dimensional and X-Y axis view. Each stage shows the performance and movement of nodes randomly, due to random waypoint mobility, broadcasting, data traffic through CBR, forming an adhoc network and choosing the paths as per the protocols used.

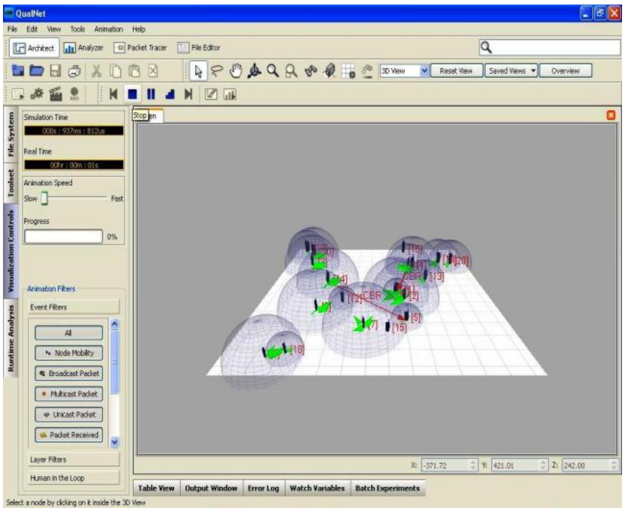

Fig. 1: 3D view of scenario simulation in Qualnet.

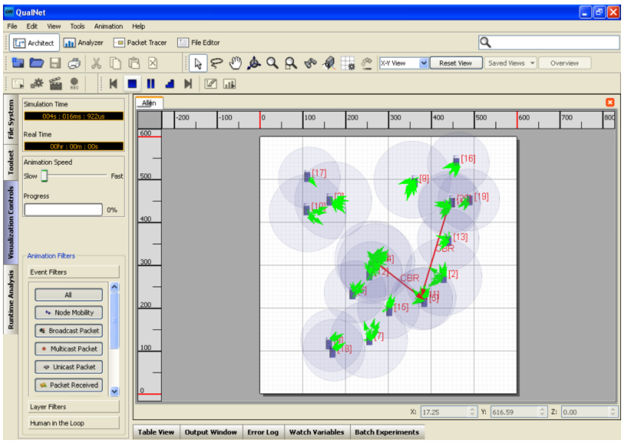

Fig. 2: X-Y view of simulation setup.

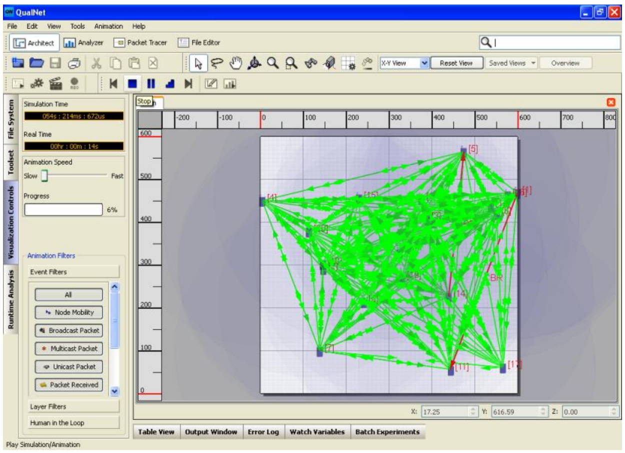

Fig: 3: Broadcasting and Network setup of Protocols.

4. RESULT AND DISCUSSION

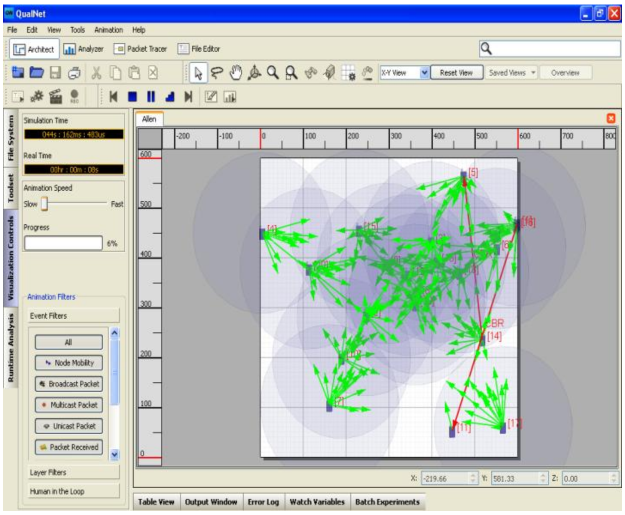

Fig: 4: Random Waypoint Mobility and CBR connections

4.1 THROUGHPUT

In a mobile or data communication network throughput is the average rate of successful message delivery in a communication channel. This data may be delivered over a physical or logical link, or pass through a certain network node. The throughput is usually measured in bits per second (bit/s or bps), and sometimes in data packets per second or data packets per time slot.[3][7]. Better the throughput better will be the communication system. Here the graph shows that we have a better throughput in DYMO and AODV in comparison to OLSR and IERP.

In routing protocols DYMO and AODV, the performance parameter: throughput exhibits better results due to its path finding techniques, which uses the least and secure path in its network as compared to the other routing protocols OLSR and IERP.

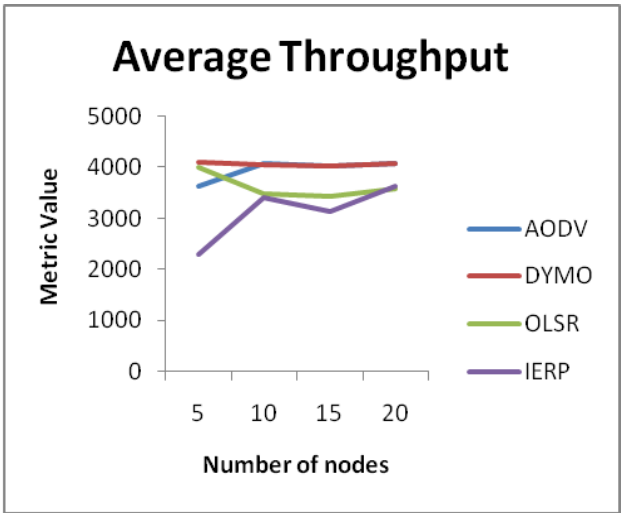

Fig 5: Average Throughput

4.2 END TO END DELAY

End to end delay refers to the time taken for a packet to be transmitted across a network from source to destination. Usually a data packet may take few extra second to reach the client or the server's end, which happens due to congestion in the communication network in the situation of a queue or when different routing paths are chosen by the routing protocol [5]. The graph below shows the end to end delay is greatest in IERP as compared to the others which are very small.

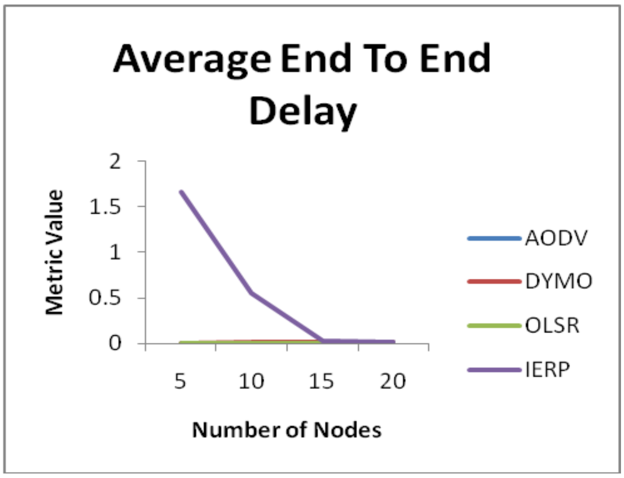

Fig 6: Average End to End delay

4.3 JITTER

Jitter is the variation in delay by different data packets that reached the destination and can seriously affect the quality of audio/video and thus an unwanted parameter [3]. Here we can see that the average jitter is fairly high in the case of IERP, then, it is DYMO, AODV [7] and least is in the case of OLSR.

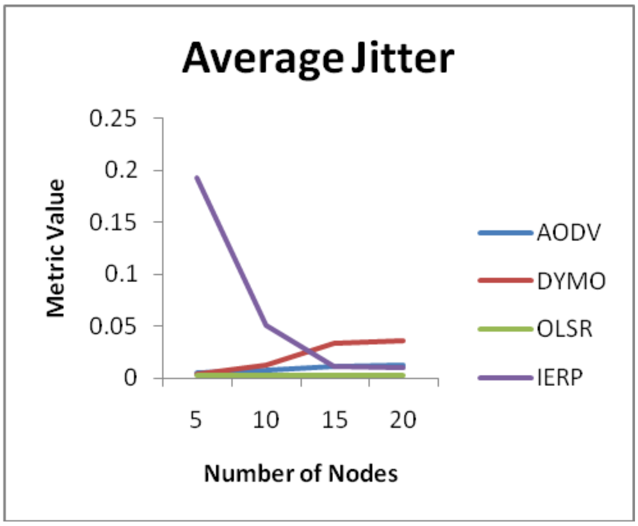

Fig 7: Average Jitter

4.4 PACKET DELIVERY RATIO

Packet delivery ratio is the fraction of packets sent by source that are received by the destination and is calculated by dividing the number of packets received by the destination through the number of packets originated by the application layer of the source [6]. Its higher value indicates good performance of the protocol. The graph below shows the best PDR is in the case of AODV and DYMO as compared to OLSR and IERP.

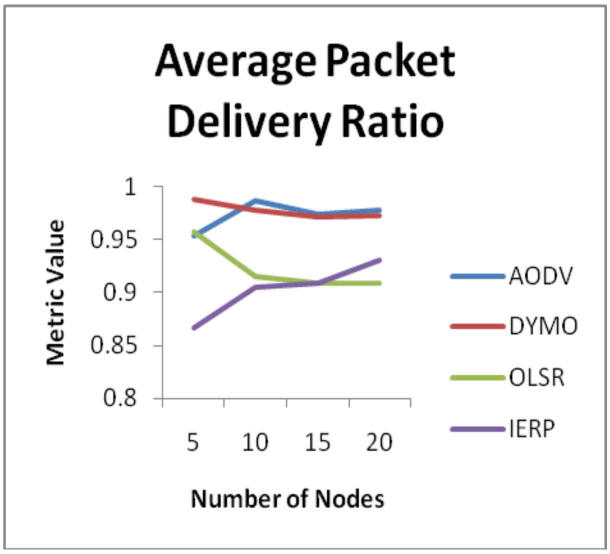

Fig 8: Average Packet Delivery Ratio

4.5 TOTAL NUMBER OF PACKETS RECEIVED

Total number of packets received at the destination. Its count tells us the total number of packets received out of total number of packets sent, in this case 100 data packets were sent. The graph shows the best protocol to deliver the data packets to the destination are AODV and DYMO in comparison to OLSR and IERP.

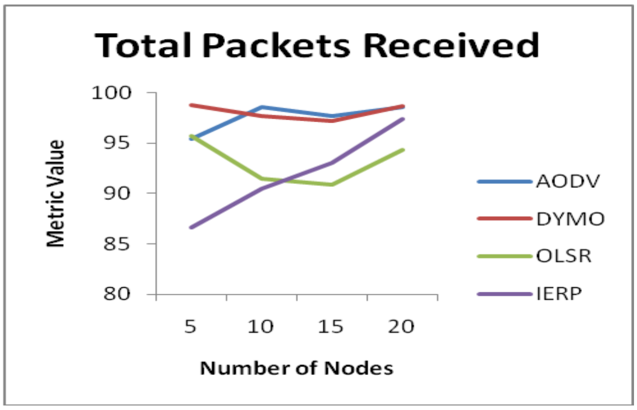

Fig 9: Total Packets Received

5. CONCLUSION

The above results give us a combine and comparative study of three types of protocols namely: Reactive, Proactive and Hybrid. Reactive protocols being: AODV and DYMO. OLSR being proactive protocol and IERP being the hybrid protocol. Here we can see that the reactive protocols are best in throughput, PDR and total packets received. While comparing the results of AODV and DYMO communication routing protocols individually, DYMO comes out to be the better one. Hybrid protocol IERP has high end to end delay and jitter values and the proactive protocol, OLSR stays second in the above mentioned performance parameters.

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