Simulation based Performance Evaluation and Comparison of Reactive, Proactive and Hybrid Routing Protocols based on Random Waypoint Mobility Model

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ABSTRACT
Ad hoc network is a collection of wireless mobile nodes dynamically forming a temporary network without the aid of any established infrastructure or centralized administration. Routing protocols in mobile ad hoc network helps node to send and receive packets. In this paper our focus is to study Reactive (AODV), Pro active (OLSR), and Hybrid (ZRP) protocols based on random waypoint mobility model. In this paper we evaluate performance of three types of routing protocols (AODV, OLSR, and ZRP) based on packet delivery ration, average end to end to end delay, and packet delivery ratio. In this paper we will analyze and compare the performance of protocols using Qualnet 4.5[1] from scalable network.

Keywords
MANETs, AODV, OLSR, and ZRP

1. INTRODUCTION
Mobile Ad Hoc networks are collection of mobile nodes with a wireless network interfaces forms a temporary network without the aid of any fixed infrastructure or centralized administration. Nodes within each other transmission ranges can communicate directly; however nodes outside each other's range have to rely on other nodes to transmit the message [2]. Each node functions as a router. The network topology may change with time as the nodes move or adjust their transmission and reception parameters. Thus, a MANET has several salient characteristics: dynamic topology, resource constraints, no infrastructure, and limited physical security [3]. In 1996, the Internet Engineering Task Force (IETF) created a MANET working group with the goal to standardize IP routing functionality suitable for wireless routing applications within both static and dynamic topologies. Possible applications of MANETs are personal area networks, disaster relief, casual conference, military communication etc. Main problem is how to deliver packets efficiently to mobile nodes, which is main objective of routing protocol. So routing in mobile ad hoc network is a challenging task due to node mobility. Moreover bandwidth, energy and physical security are limited.

2. ROUTING PROTOCOLS
All Routing in ad-hoc networks involves finding a path from the source to destination, and delivering packets to the destination nodes while nodes in the network move freely. Due to node mobility, a path established by source may not exist after some time. To deal with node mobility, nodes need to maintain routes in the network. Depending upon how nodes establish and maintain path, routing protocols are divided in to four categories: Proactive [4], Reactive [5, 6], Hybrid [7], and Location Based [8, 9, and 10].

Proactive Routing Protocols are also called table driven protocols. It maintains routing table using the routing information learnt from neighbors on periodic basis. Main characteristics of these protocols include: distributed, shortest-path protocols, maintain routes between every host pair at all times, based on Periodic updates of routing table and high routing overhead and consumes more bandwidth

Reactive Routing Protocols are also called demand driven protocols that find path as and when required. They maintain information about the active routes only. They performs route discovery phase before data transmission by flooding route request packet and destination node reply with route reply packet. A separate route maintenance procedure is required in case of route failure. Main Characteristics of these routing protocols are: determine routes as and when required, less routing overhead, source initiated route discovery and more route discovery delay

Hybrid Routing Protocols**:** In this various approaches of routing protocols are combined to form a single protocol. ZRP (Zone Routing Protocol), is one such protocol that combines the proactive and reactive approach. Main characteristics include: Combination of selected features of proactive and reactive protocols, Adaptive to network condition.

2.1 Ad Hoc on Demand Routing Protocol
AODV also called source initiated routing protocol. Messages in network are of two types, routing messages and data messages. Routing messages are further divided into two types, path discovery message and path maintenance message. Path discovery includes RREQ (Route Request) and RREP (Route reply). Path maintenance includes RERR (Route error) and HELLO messages. Its basic principal contains two components: (i) Route discovery (ii) Route maintenance.
When a source wants to find a route it broadcast a RREQ (route request message) to all the nodes in the network. Upon receiving of RREQ message node checks whether it is the originator or if such an RREQ is repeated. If it is repeated then it will be dropped otherwise it will be broadcasted to all the neighbor nodes again. Each node maintains a routing table and updates it after receiving a routing message. In processing of RREQ, an

intermediate node checks whether if corresponding reverse route exists in the routing table, if not then it creates an entry for the reverse route. Destination sequence number is used for checking the freshness of routing message. If route already exists then it checks entry whether it contains fresh message or not. Larger sequence number means fresh message. If message in the routing table is not fresh then it is replaced with the newer one and it also check hop count if the sequence number are same but hop count is different than message with lesser hop count will be placed in the routing table. Then, it checks whether it contains route to the destination and route is not expired then it sends RREP packet back to the source through reverse route, otherwise it broadcast the route request (RREQ). In AODV, each mobile node would periodically broadcast Hello messages thus, each node knows which nodes are in its neighboring nodes within one hop. If one node has not received any Hello message from a neighboring node within a certain time, the node would send an error message (RERR) to the nodes that are recorded in the corresponding precursor list in the routing table. The node receiving an RERR would remove the compromised route from their routing table.

2.2 Zone Routing Protocol

ZRP combines both proactive and reactive approach of routing. It takes advantage from proactive and reactive approaches and removes the disadvantage. ZRP limits the scope of the proactive procedure to the node's local neighborhood. The on-demand search for nodes outside the zone, albeit global, is done by querying only a subset of the nodes in the network. Each node individually creates its own neighborhood which it calls a routing zone. The zone is defined as a collection of nodes whose minimum distance (in hops) from the node in question is no greater than a value that is called the "zone radius" and peripheral nodes are those nodes whose minimum distance from the node in question is equal to the zone radius. It includes IARP (Intrazone Routing Protocol) which is used to communicate within zone radius of a node using proactive approach, IERP (Interzone Routing Protocol) which is used to communicate between zones using reactive approach and BRP (Border Resolution Protocol) is used to direct route request generated by global reactive IERP to the peripheral nodes.

2.3 Optimized Link State Routing

Optimized Link State Routing protocol (OLSR), is a proactive link state routing protocol. OLSR consists of two types of messages, HELLO and TC ("Topology Control"). HELLO messages emitted periodically by the node including its own address and three lists: a list of neighbor nodes from which control traffic has been heard but bidirectional links are not confirmed, a list of neighbor nodes which are selected as MPR (Multipoint Relay) and a list of neighbor nodes with which bidirectional communication has been established. Upon receiving HELLO message, a node examines list of addresses, if its own address is inside it, it is confirmed that bidirectional communication has been established with the originator of HELLO message. When a link is confirmed as bidirectional, it is advertised periodically by the node with the corresponding link status symmetric. HELLO messages also allow each node to maintain information describing link between neighbor node and nodes which are 2-hop away. TC (Transmission Control) contains a set of bidirectional links between a node and subset of its neighbor nodes and is used to diffuse topological information to the entire network and emitted periodically. Each node must select MPR(Multipoint Relay) among its neighbor nodes such that message emitted by node and repeated by MPR nodes will be received by nodes which are 2-hop away.MPR selection is based upon the 2-hop neighbor list received through exchange of HELLO messages. Thus each node maintains a MPR selector set (neighbor nodes which are selected as MPR). Upon receiving OLSR control packets, node consults with its MPR selector set to make decision about the packet: if the last hop of the message is inside the MPR set, it is to be retransmitted, otherwise not. Each node maintains a routing table which contains the destination address, next hop address and number of hops to the destination and local interface information and this information is got from topological set(from TC messages) and HELLO message. So, if there is some change like neighbor node link appear or disappear, 2-hop neighbor is created or removed, topological link is appeared or lost etc. routing table is updated.

3. SIMULATION AND PERFORMANCE ANALYSIS

In this paper, we have taken two different scenarios. In the first scenario, traffic pattern is taken as CBR and no. of nodes have been varied and performance comparisons have been made between AODV, OLSR, and ZRP protocol. In the second scenario, traffic pattern is taken as CBR and pause time have been varied and performance comparisons have been made between AODV, OLSR and ZRP protocols. Identical mobility pattern are used across protocols to gather fair results.

3.1 Test Scenario 1

In first scenario we have taken CBR as traffic pattern. Parameters are specified in table 3.1

Table 3.1: Parameters for Scenario 1

Parameter	Value
Number of nodes	25,50,75, 100
Maximum Speed	20 m/s
Minimum Speed	0 m/s
Simulation time	50s
Packet Size	512
Traffic Type	CBR
Packet Rate	4 Packets/sec
Dimension of Space	1000x1000 m
Mobility Model	Random Waypoint
Pause Time	20s

3.2 Test Scenario 2

In this scenario numbers of nodes are fixed and pause time is varied. Parameters are specified in table 3.2

Table 3.2: Parameters for Scenario 2

Parameter	Value
Number of nodes	50
Maximum Speed	20 m/s
Minimum Speed	0 m/s
Simulation time	50s
Packet Size	512
Traffic Type	CBR
Packet Rate	4 Packets/sec
Dimension of Space	1000x1000 m
Pause Time	10s,20s, 40s,100s

4. PERFORMANCE METRICS [12][13]

4.1 Packet Delivery Ratio

It 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. It specifies the packet loss rate, which limits the maximum throughput of the network. The better the delivery ratio, the more complete and correct is the routing protocol.

4.2 Average end to end delay

It is the average time it takes a data packet to reach the destination. This metric is calculated by subtracting time at which first packet was transmitted by source from time at which first data packet arrived to destination. This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation and transfer times. This metric is significant in understanding the delay introduced by path discovery.

4.3 Throughput

The throughput of the protocols can be defined as percentage of the packets received by the destination among the packets sent by the source. It is the amount of data per time unit that is delivered from one node to another via a communication link. The throughput is measured in bits per second (bit/s or bps).

5. RESULTS AND PERFORMANCE COMPARISON

The Performance of AODV, OLSR and ZRP are evaluated and simulation is carried out on Qualnet 4.5[1] by scalable-networks.

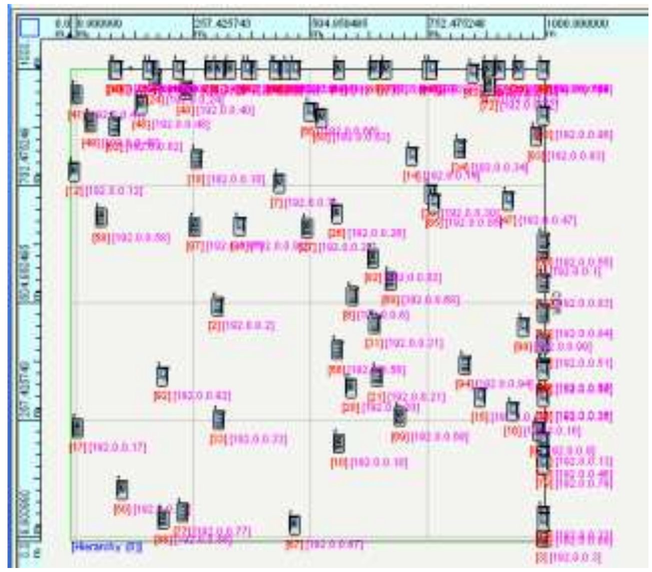

Figure 5.1: Snapshot of the network in simulator

5.1 Packet Delivery Ratio

In case of variable pause time reactive routing protocol (AODV) delivers almost all the originated data packets and proactive routing protocol (OLSR) and hybrid routing protocol (ZRP) delivers only 20-40% data packets(figure 5.2). In case of variable number of nodes packet delivery ratio of reactive routing protocol (AODV) is approximate 90% for 25, 50, and 75 nodes but decreases as number of nodes increased to 100, packet delivery ratio of proactive routing protocol (OLSR) decreases as we increase the number of nodes, and packet delivery ratio of hybrid routing protocol (ZRP) decreases as number of nodes are increased from 25 to 50 and increases as the number of nodes are increased from 50 to 75 and 75 to 100(Figure 5.3)

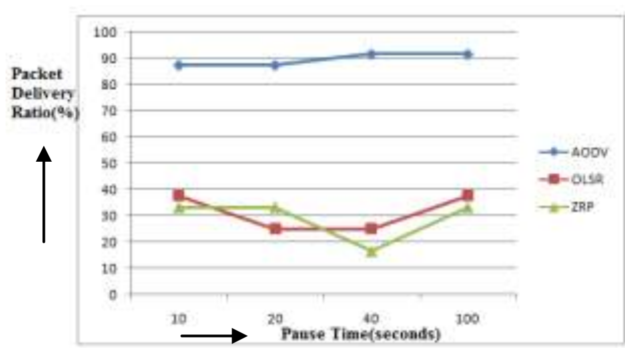

Figure 5.2 Packet Delivery Ratio based on variable Pause Time

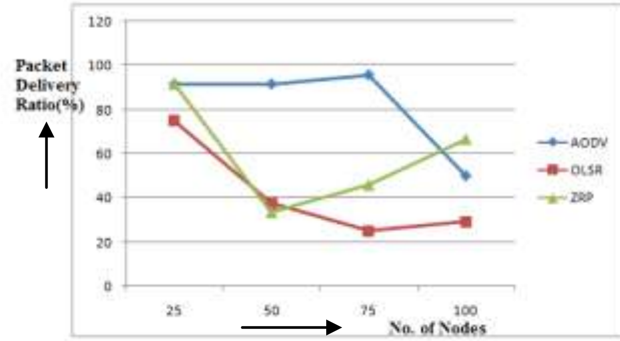

Figure 5.3: Packet Delivery Ratio based on variable no. of nodes

5.2 Average End to End Delay

In case of variable pause time Average end to end delay of reactive routing protocol (AODV) is much higher than reactive routing protocol (OLSR) and hybrid routing protocol (ZRP). Reactive routing protocol (OLSR) has lowest average end to end delay compared to two other routing protocols (figure 5.4). In case of variable number of nodes average end to end delay of proactive routing protocol (OLSR), hybrid routing protocol (ZRP) increases with the increase in number of nodes and reactive routing protocol (AODV) varies with respect to number of nodes.

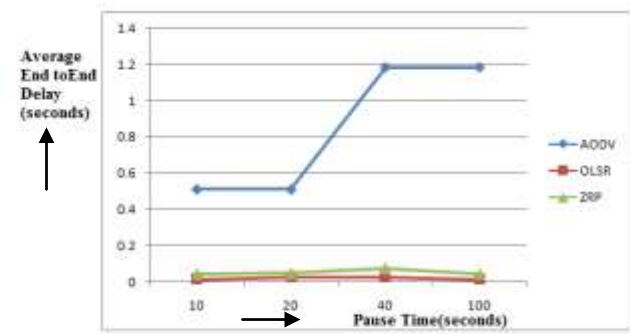

Figure 5.4: Average End to End delay based on variable pause time

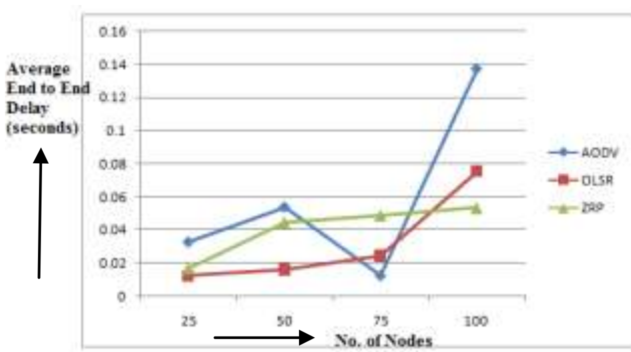

Figure 5.5: Average End to End delay based on variable no. of nodes

5.3 Throughput

In case of variable pause time Throughput of hybrid routing protocol (ZRP) is very low as compared to other two routing protocols (AODV and OLSR)(figure 5.6). In case of variable pause time reactive routing protocol(AODV) performs better than other two routing protocols(OLSR and ZRP)(figure 5.7).

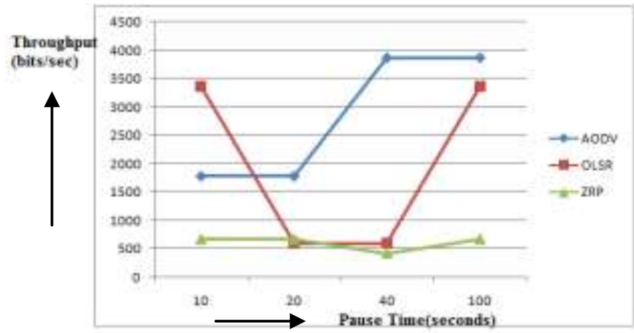

Figure 5.6: Throughput based on variable Pause Time

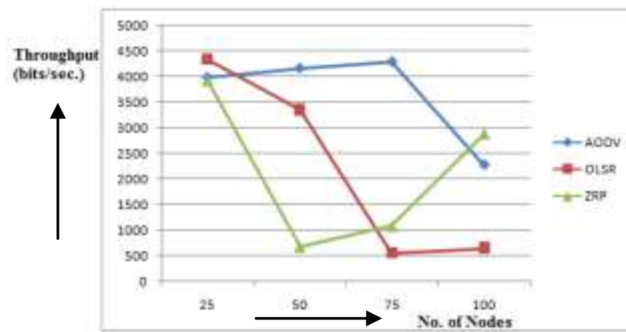

Figure 5.7: Throughput based on variable no. of nodes

6. CONCLUSIONS & FUTURE WORK

This study was conducted to evaluate the performance Reactive (AODV), hybrid protocols (ZRP) and Proactive protocol (OLSR) of MANET. These routing protocols were compared in terms of Packet delivery ratio, Average end-to end delay and Throughput when subjected to change in no. of nodes and pause time. Simulation results show that Reactive protocols better in terms of packet delivery ratio and throughput.

Future work will be to evaluate the performance of these protocols by varying the speed, pause time. Performance can also be analyzed for other parameters like Jitter, Routing Overhead. By evaluating the performance of these protocols new protocols can be implemented or changes can be suggested in the earlier protocols to improve the performance.

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