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Impact of Node Convergence and Divergence in AODV and OLSR Routing Protocols

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***Abstract*— Wireless ad hoc networks must be capable self-organizing and self-configuring to handle the dynamic nature of the network. Routing protocols should be able to handle the dynamic nature, and the limited resources of the nodes while maintaining Quality of service. Routing protocols try to find the shortest path to the destination. Depending on how and when the routes are discovered, the protocols are classified as proactive and reactive routing protocols. This paper investigates the performance of a reactive routing protocol, Ad hoc On Demand Distance Vector (AODV) and a proactive routing protocol Optimized Link State Routing (OLSR) under different speed with nodes converging and diverging.**

***Index Terms*— Mobile Ad-Hoc Network, Routing Protocol, AODV, OLSR and Performance**

I. Introduction

A mobile ad-hoc network (MANET) is a made up of only wireless mobile nodes, communicating with each other without any centralized control. Nodes within the radio range, communicate directly else communicate through multi-hop. Thus, each node acts as either host or router in the network. Routing protocols try to find the shortest path to the destination. Routing protocols should be able to handle the dynamic nature, and the limited resources of the nodes while maintaining Quality of service. It should also be distributed in nature and loop free for efficient communication [1]. The routing protocol is responsible for the route discovery to find the shortest possible route to the destination and maintenance of routes in the network. Depending upon how and when the routes are discovered, the routing protocols are classified as reactive protocols and proactive protocols. In reactive routing protocols, the routes are discovered only when necessary i.e., on demand, from the source to the destination, and these routes are maintained as long as it is required. Reactive protocols are based on distance-vector routing algorithms; routing information consists of the cost and the path to the destination.

Ad-hoc On Demand Vector (AODV) is the most popular reactive routing protocol. Proactive routing protocols maintain up-to-date routing information in its tables and this information are periodically updated using control messages. The proactive routing protocols are based on the link-state routing algorithm. Optimized Link state routing (OLSR) is commonly used proactive routing protocol.

The advantages of AODV algorithm [2] include dynamic, self-starting, multi-hop routing between participating mobile nodes wanting establishment and maintenance of ad hoc networks. It also ensures that mobile nodes get routes for new destinations but at the same time does not require that they maintain routes to destinations not in communication. It also allows mobile nodes to respond to link breaks and changes in network topology as and when necessary. When link breaks occur the algorithm ensures that affected set nodes are informed so that routes using the lost link are invalidated. It has a loop free operation and allows expeditious convergence as it avoids the Bellman Ford "counting to infinity" problem when ad hoc network topology changes.

A remarkable feature of AODV is the use of destination sequence number for every route entry. This is generated by the destination and is included along with any route information which nodes request. This in turn ensures loop freedom and moreover is easy to program. When there is a choice of routes to a destination the requesting node has to select one with the biggest sequence number. The AODV routing protocol is meant for MANETs with populations ranging from ten to thousands of mobile nodes. AODV can handle low, moderate, and relatively high mobility rates in addition to various traffic data levels also. AODV is also meant for networks where all nodes trust each other, either through use of preconfigured keys, or because there are no malicious intruder nodes. It is also meant to reduce the control traffic dissemination and rid itself of data traffic overhead so that scalability and performance are improved.

Route Requests (RREQs), Route Replies (RREPs), and Route Errors (RERRs) are AODV defined message types which are received via UDP. Normal IP header processing applies. If for example, a requesting node expects use of its IP address as Originator IP address for messages, the IP limited broadcast address is used for to broadcast messages. This ensures that messages are not forwarded blindly. But an AODV operation does needs certain messages (e.g., RREQ) to be publicized far and wide throughout the network. The

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dissemination range of such RREQs is revealed by the TTL in the IP header. So long as endpoints of communication connections have valid routes to each other, AODV is silent without any role. When routes to new destinations are required the node broadcasts a RREQ to locate a route. A route is determined when either the RREQ reaches the destination by itself or an intermediate node with a 'fresh enough' route to the destination. A 'fresh enough' route is a valid route entry to the destination where its associated sequence number is as great as that contained in the RREQ. The route becomes available when a RREP is unicst ack to the genesis of the RREQ. Each node which receives the request caches a route back to the request generator, so that RREP can be unicast from the destination along a path to that originator, or from any intermediate node that satisfies the request.

The link status of the next hops in active routes is monitored by nodes and when a break in link is located RERR message informs nodes about the break. This RERR message finds destinations (possibly subnets) no longer reachable by the broken link. To ensure this reporting mechanism, every node has a "precursor list", with IP addresses of neighbors likely to use it as a next hop towards a destination. The precursor list information is got during generation of a RREP message, which has to be sent to a node in a precursor list.

The OLSR [3] is a table driven, proactive protocol, i.e., regularly exchanging topology information with other network nodes. It inherits the stability of a link state algorithm and with the additional advantage of having routes available immediately as and when needed due to its proactive nature. OLSR is an optimization over the classical link state protocol, tailored for MANETs and minimizes the overhead from control traffic flooding through use of selected nodes, called MPRs which in turn retransmit control messages. This greatly reduces the number of retransmissions needed to flood a message to all network nodes. Secondly, OLSR needs only a partial link state to be flooded to ensure shortest path routes. The minimal link state information required is that all nodes, selected as MPRs, should declare links to their MPR selectors. Additional topological information is used for redundancy purposes.

A node selects neighbor nodes as "multipoint relays" (MPR). In OLSR, only nodes, selected as such MPRs, can forward control traffic, meant to be diffused into the entire network. MPRs provide an efficient mechanism to flood control traffic through reduction of the required transmission number. Nodes, selected as MPRs, are responsible when declaring link state information in the network. In fact the only requirement for a OSLR providing short routes to destinations is that MPRs declare link state information to their MPR selectors. Additional link-state information available can be used for redundancy. Nodes selected as MPRs by neighbor node(s) reveal this information at regular intervals in their control messages. Thus a node reveals to the network that it has reachability that has chosen it as an MPR. In route calculation, MPRs are used to form routes from nodes to destinations in the network. The protocol also utilizes MPRs to facilitate efficient control message flooding in the network. A node selects MPRs from one hop neighbors with "symmetric", i.e., bi-directional, linkages. Hence selecting routes through MPRs automatically avoids data packet transfer associated problems over uni-directional links.

OLSR may optimize the reactivity to topological changes through reducing maximum time intervals for periodic control message transmissions. Also, as OLSR continuously maintains routes to network destinations it helps traffic patterns where large node subsets communicate with each other and where source/destination pairs change over time. The protocol also suits large and dense networks, as MPRs optimization works well here. The larger/denser a network, the more optimization is possible unlike the classic link state algorithm.

Because of its proactive nature, the OLSR protocol has a natural control over control traffic flow. Nodes transmit control message at predetermined rates regulated by predefined refresh intervals. Also, MPR optimization saves on control overhead on two sides. First, the packets advertising topology are shorter as only MPR selectors may be advertised. Second, the flooding cost of information is highly reduced as only MPR nodes forward broadcast packets. In dense networks, control traffic reduction can be several orders of magnitude compared to routing protocols which use classical flooding (such as OSPF) [4]. This provides more bandwidth for useful data traffic and pushes congestion frontier further. Since control traffic is continuous and periodic, used link quality is kept stable. But in some OLSR options, control messages may be wantonly forwarded in advance of their deadline (TC or Hello messages) to increase the protocol reaction against topology changes. This can lead to small, temporary and local control traffic increase.

In this paper, it is proposed to compare Ad hoc On Demand Distance Vector (AODV) and Optimized Link State Routing (OLSR) protocols under converging and diverging nodes with different speeds. Section II reviews some the research related to the current work. Section III describes the experimental setup for the performance evaluation and section IV concludes the paper.

II. Literature Review

Huhtonen [5] investigated the performance of the AODV and OLSR. The AODV protocol performs better with static traffic and limited number of source and destination pairs for each host. It requires fewer resources than OLSR as the control messages size and the route table is small reducing the computational power. In high density networks with highly sporadic traffic, OLSR performs better. But the best situation is when the between a large number of hosts. The quality metrics are easy to incorporate into current protocol. OLSR requires continuous bandwidth to receive the topology updates messages. In both protocols scalability is restricted due to their proactive or reactive characteristic. In the AODV protocol it is due to flooding overhead and in OLSR it is the size of the routing table and topological updates messages.

Chen, et al., [6] presented a simulation study on the performance of AODV and OFLSR. Study shows that both on-demand and table-driven routing protocols work well in networks with small traffic load. Scalability becomes a problem when the traffic load and the mobility increase in AODV. The proposed table-driven routing protocol OFLSR, achieves better performance in terms of data packet delivery ratio, throughput, packet latency and routing overhead, under different traffic and mobility instances.

Hsu, et al., [7] presented a study on performance of AODV, DSR, OLSR, OSPFv2 and ZRP routing protocols under realistic network scenarios. The simulation evaluations of the protocols were based on an exercise of DARPA. GPS logs were used to simulate the mobility of the nodes. Qualnet simulations were used to model scenarios and were re-run on different parameters to study the network performance and optimization. Simulation results showed that the AODV performed the best with good overall throughput.

Azad, et al., [8] analyzed three routing protocols DSDV, OLSR and AODV using network simulator Ns-2. The routing protocols were compared based on the packet delivery ratio, average end-to-end delay, routing load and routing overhead. Simulation results show that none of the protocol is a winner. Each protocol works best in certain network. At low network load, AODV performs better whereas OLSR achieves better packet delivery ration in high network load. Similarly, in high mobility networks, OLSR performs better for some metrics.

III. Methodology

The simulation setup consisted of 25 nodes using random mobility as shown in figure 1. Four scenarios were considered.

Nodes converging at low speed (8 km/hr).

Nodes converging at medium speed (60 km/hr).

Nodes diverging at low speed (8 km/hr).

Nodes diverging at medium speed (60 km/hr).

Simulations were carried out using AODV and OLSR routing protocol. The analysis of AODV and OLSR protocols under converging and diverging traffic was done on delay, route discovery time and number of hops per route parameters.

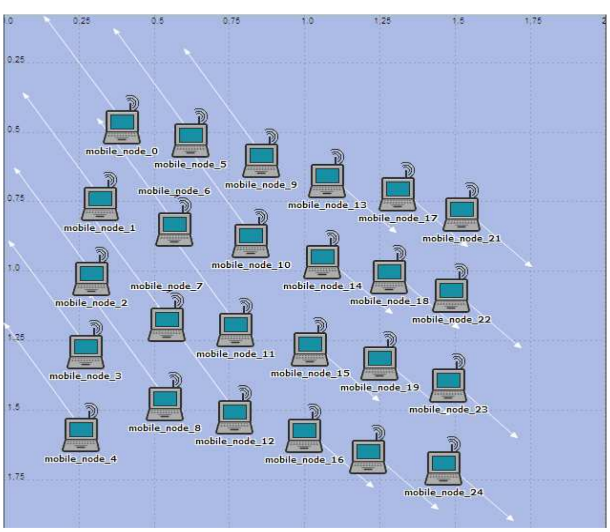

Fig. 1: The simulation setup used

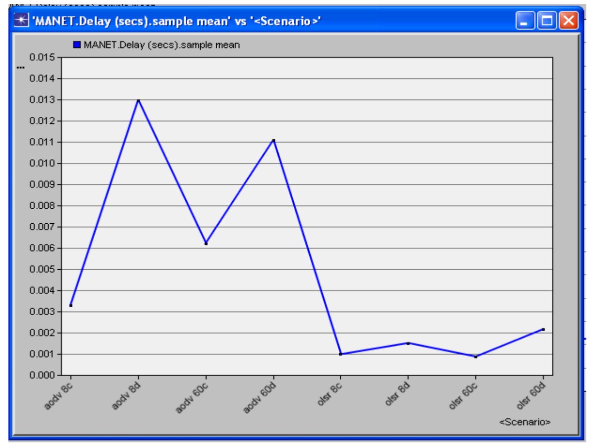

Fig. 2: The end to end delay for different scenarios

Fig. 2 shows combined end-to-end delay in all the 8 experiments. It can be seen that AODV performance comes down drastically with the end-to-end delay is very high for diverging condition (both at low and high speed). Similarly even during convergence the end-to-end delay for AODV is higher compared to OLSR routing protocol. The end-to-end delay of OLSR is almost 10 times lower when compared to AODV.

Fig. 3 shows the number of hops to reach the destination. The number of hops required to reach the destination using AODV is high in diverging traffic compared to converging traffic. The difference in number of hops is roughly 58% more for diverging traffic compared to converging traffic.

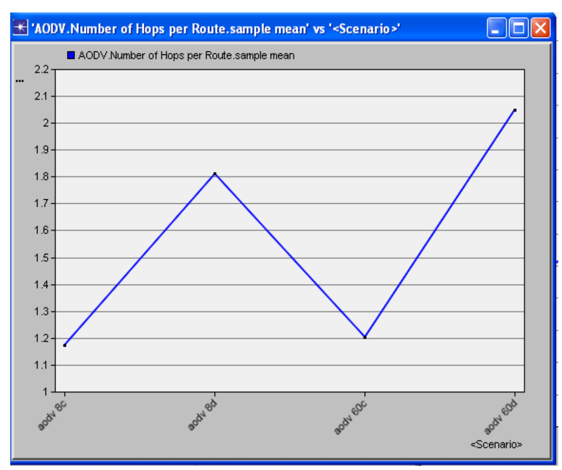

Fig. 3: The number of hops to reach the destination

The routing traffic received in AODV is shown in Fig. 4. The routing traffic is higher for converging traffic compared to diverging nodes.

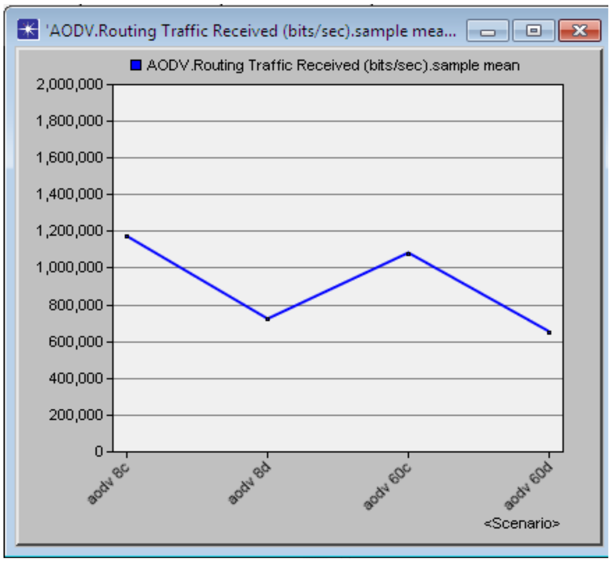

Fig. 4: Routing traffic received by nodes using AODV under different scenarios

The routing traffic received by nodes using OLSR protocol is shown in Fig. 5. The routing traffic received in AODV however is higher for converging traffic compared to diverging nodes. In OLSR the routing traffic received for node convergence is lowest at an average of 50000 bits/sec and for fast divergence increases by about 5.5 times, however in AODV the routing traffic is sent across the network is almost 14 times compared to OLSR.

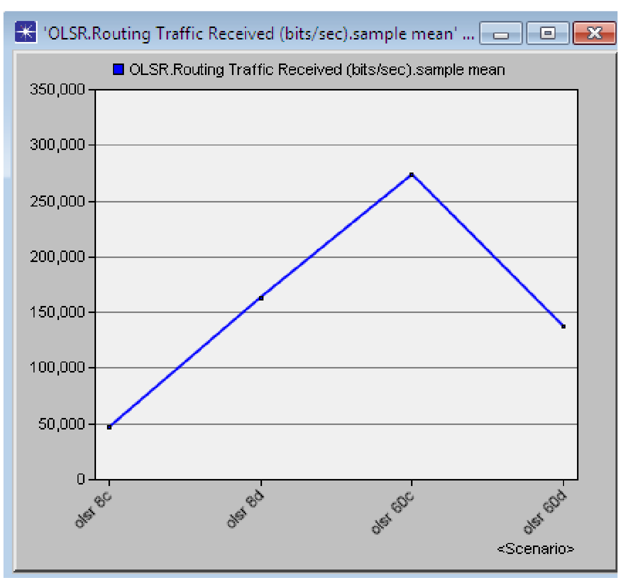

Fig. 5: The routing traffic received for various scenarios under OLSR protocol

IV. Conclusion

In this paper it was proposed to investigate the performance of AODV routing protocol and OLSR routing protocol under converging and diverging node movement condition. It is seen that OLSR has the lowest end-to-end delay in all the scenarios which is useful for bandwidth constraint environment using streaming data. It is observed that routing traffic received in OLSR has much more steady during diverging and converging conditions.

The study of these routing protocols shows that the OLSR is better in MANET according to our simulation results but it is not necessary that OLSR performs always better in all the networks, its performance may vary by varying the network. At the end we came to the point from our simulation and analytical study that the performance of routing protocols vary with network conditions and selection of accurate routing protocols according to the network, ultimately influence the efficiency of that network in magnificent way

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