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Performance Evaluation of AODV, DSR, TORA and OLSR in with Respect to End-to-End Delay

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Abstract: ***Aggressive research in this area has continued since then, with prominent studies on routing protocols such as AODV, DSR, TORA and OLSR. In this paper, we evaluate the performance of AODV, OLSR, DSR and TORA ad hoc routing protocols in OPNET. In addition, the mobile nodes were randomly placed in the network to provide the possibility of multihop routes from a node to the server. The performance of these routing protocols is evaluated with respect to end-to-end delay. OLSR outperforms AODV, DSR and TORA in terms of end-to-end delay Varying traffic volumes or speeds in the network, leaves OLSR superior in terms of end-to-end delay. OLSR build and maintains consistent paths resulting in low delay. The results in this study also confirm TORA's inability to handle rapid increases in traffic volumes. TORA performs well in networks where the volume of traffic increases gradually.***

Keywords: MANET, TORA, AODV, DSR, OLSR**,** RREQ, RREP**,** Proactive, Reactive, Hybrid.

1. Introduction

MANET stands for Mobile Ad hoc Network. It is a robust infrastructure less wireless network. A MANET can be formed either by mobile nodes or by both fixed and mobile nodes. Nodes randomly associate with each other forming arbitrary topologies. They act as both routers and hosts. The ability of mobile routers to self-configure makes this technology suitable for provisioning communication to, for instance, disaster-hit areas where there is no communication infrastructure, conferences, or in emergency search and rescue operations where a network connection is urgently required. Aggressive research in this area has continued since then with prominent studies on Ad hoc On-demand Distance Vector (AODV), Dynamic Source Routing (DSR), Temporally Ordered Routing Algorithm (TORA) and Optimized Link State Routing (OLSR) [1]. In this paper, we address the modeled MANET scenarios with varying AODV, DSR, OLSR and TORA with respect to end-to-end delay.

In this paper we present the theoretical concepts of ad hoc routing protocols. We begin by describing proactive routing protocols under which OLSR is covered. We then describe reactive ad hoc routing protocols under which AODV, DSR and TORA are discussed.

2. Routing Protocol in MANETs

There are several routing protocols designed for wireless ad hoc networks. Routing protocols are classified either as reactive or proactive [8]. There are some ad hoc routing protocols with a combination of both reactive and proactive characteristics. These are referred to as hybrid.

2.1 Proactive Routing Protocols

Proactive routing protocols build and maintain routing information to all the nodes. This is independent of whether or not the route is needed [9]. In order to achieve this, control messages are periodically transmitted. Proactive routing protocols are not bandwidth efficient.

2.1.1 Optimized Link State Routing

OLSR is a proactive IP routing protocol for mobile ad hoc networks. It can also be implemented in any ad hoc network. OLSR is classified as proactive due to its nature. Nodes in the network use topology information derived from HELLO packets and Topology Control (TC) messages to discover their neighbors. Not all nodes in the network route broadcast packets. Only Multipoint Relay (MPR) nodes route broadcast packets. Routes from the source to the intended destination are built before use. Each node in the network keeps a routing table. This makes the routing overhead for OLSR higher than any other reactive routing protocol such as AODV or DSR. However, the routing overhead does not increase with the number of routes in use since there is no need to build a new route when needed. This reduces the route discovery delay. In OLSR, nodes send HELLO messages to their neighbors at a predetermined interval. These messages are periodically sent to determine the status of the links.

2.2 Reactive Routing Protocols

Reactive routing protocols are bandwidth efficient. Routes are built as and when they are needed. This is achieved by sending route requests across the network. There are disadvantages with this algorithm. One of them is that it offers high latency when finding routes. The other disadvantage is the possibility of network clog when flooding is excessive [10]. In this paper, we considered AODV, DSR and TORA.

2.2.1 Ad hoc On-demand Distance Vector

AODV is an on-demand routing protocol used in ad hoc networks. This algorithm, like any other on-demand routing protocol, facilitates a smooth adaptation to changes in the link conditions. In the case a link fails, notifications are sent only to the affected nodes. This information enables the affected nodes invalidate all the routes through the failed link. It has low memory overhead, builds unicast routes from source to the destination and network utilization is minimal. There is minimal routing traffic in the network since routes are built on demand. It does not allow nodes to keep routes that are not in use. When two nodes in an ad hoc network wish to establish a connection between each other, AODV will enable them build multihop routes between the mobile nodes involved. AODV is loop free. It uses Destination Sequence Numbers (DSN) to avoid counting to infinity. This is one of the distinguishing features of this algorithm. Requesting nodes in a network send DSNs together with all routing information to the destination. It also selects the optimal route based on the sequence number.

AODV defines three messages: Route Requests (RREQs), Route Errors (RERRs) and Route Replies (RREPs) [1]. These messages are used to discover and maintain routes across the network from source to destination by using UDP packets. When a node is requesting for a route, it uses its IP address as the source address in the message IP header and 255.255.255.255 for broadcast. The Time-To-Live (TTL) in the IP header determines the number of hops a particular routing message propagates in the ad hoc network. Whenever there is need to create a new route to the destination, the requesting node broadcasts an RREQ. A route is determined when this message reaches the next hop node (intermediate node with routing information to the destination) or the destination itself and the RREP has reached the originator of the request [10]. Routes from the originator of the RREQ to all the nodes that receive this message are cached in these nodes. Whenever there is a link failure, an RERR message is generated. This message contains information about the nodes that are not reachable because of this failure. It also contains IP addresses of all the nodes that were using it as their next hop to the destination.

AODV is table-driven; routing information for routes in the network is stored in tables. These routing tables have the following route entries: destination IP address, DSN, flag, state, network interface, hop count, next hop, the list of precursors and lifetime.

2.2.2 Dynamic Source Routing

DSR is a reactive routing protocol for ad hoc wireless networks. It also has on-demand characteristics like AODV but it's not table-driven. It is based on source routing. The node wishing to send a packet specifies the route for that packet. The whole path information for the packet traversing the network from its source to the destination is set in the packet by the sender [1]. This type of routing is different from table-driven and link-state routing by the way routing decisions are made. In source routing, routing decisions are made by the source node.

The source node collects the addresses of all the intermediate nodes between itself and the intended destination when discovering routes. During the process of route discovery the path information collected by the source node is cached by all the nodes involved in this process. The intermediate nodes use this information to relay packets. The information in the packet traversing the network includes the IP addresses of all the nodes it will use to reach its destination. DSR uses a flow *id* to facilitate hop-by-hop forwarding of packets.

In DSR, only the destination node sends the RREP. It is only sent when the RREQ message reaches the intended destination node. The destination uses the cached routing information to traverse the RREP message to the sender. If the cached information is not sufficient, the destination node will use the information in the RREP message header. Route maintenance starts when a fatal transmission occurs. The node causing the fatal transmission is removed from the route information cached by nodes in the network. Then route discovery begins again to establish the most reliable route.

The absence of periodic table-update messages in DSR makes it bandwidth efficient. DSR does not use periodic HELLO messages. Instead it floods the network with RREQ packets when establishing a route. When a destination node receives the RREQ packet it responds with a RREP packet. It carries the same information as in the RREQ packet about the route it traversed. When an intermediate node receives a RREQ packet, as long as it's not a duplicate RREQ packet and its TTL counter is not exceeded, it rebroadcasts it to all its neighbors. And the sequence number in the RREQ packet helps to avoid packets from looping. All duplicate RREQ packets are dropped.

2.2.3 Temporally-Ordered Routing Algorithm

TORA as its name suggest, is a routing algorithm. It is mainly used in MANETs to enhance scalability. TORA is an adaptive routing protocol. It is therefore used in multi-hop networks. A destination node and a source node are set. TORA establishes scaled routes between the source and the destination using the Directed Acyclic Graph (DAG) built in the destination node [12]. This algorithm does not use 'shortest path' theory, it is considered secondary. TORA builds optimized routes using four messages [12]. Its starts with a Query message followed by an Update message then clear message and finally Optimization message. This operation is performed by each node to send various parameters between the source and destination node. The parameters include time to break the link (t), the originator id (oid), Reflection indication bit (r), frequency sequence (d) and the nodes id (i). The first three parameters are called the reference level and last two are offset for the respective reference level. Links built in TORA are referred to as 'heights', and the flow is from high to low. At the beginning, the height of all the nodes is set to NULL i.e. (-,-,-,-,i) and that of the destination is set to (0,0,0,0,dest). The heights are adjusted whenever there is a change in the topology. A node that needs a route to a destination sends a query message with its route-required flag. A query packet has a node id of the intended destination. When a query packet reaches a node with information about the destination node, a response known as an Update is sent on the reverse path [12]. The update message sets the height value of the neighboring nodes to the node sending the update. It also contains a destination field that shows the intended destination.

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3. Results and Analysis

We discuss and analyze the results of our simulations. We analyze the packet end-to-end delay of the network.

3.1 Packet End-to-End Delay

In a figure show the average packet end-to-end delay characteristics of the protocols. In all scenarios considered, we observe that OLSR has the lowest delay. OLSR is a proactive routing protocol, which means that routes in the network are always ready whenever the application layer has traffic to transmit. Periodic routing updates keep fresh routes available for use. The absence of high latency induced by the route discovery processes in OLSR explains its relatively low delay. With higher number of mobile nodes, the performance of OLSR competes with that of AODV. In the networks considered, OLSR had a consistent end-to-end delay due to its proactive characteristics.

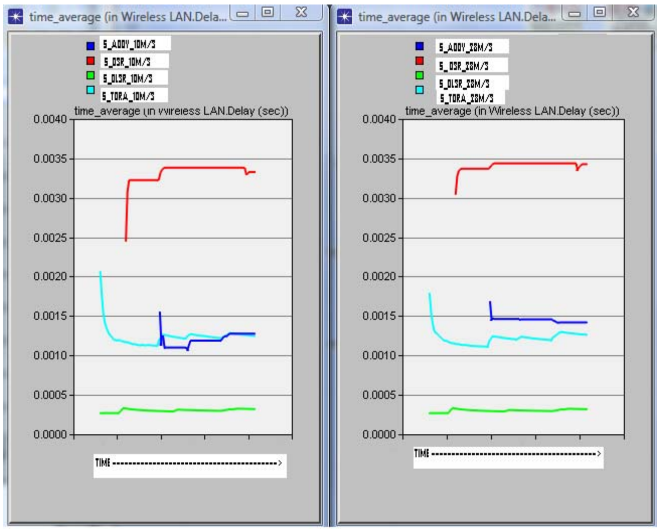

Figure 1: End-to-end delay 5 sources at 10m/s and 28m/s

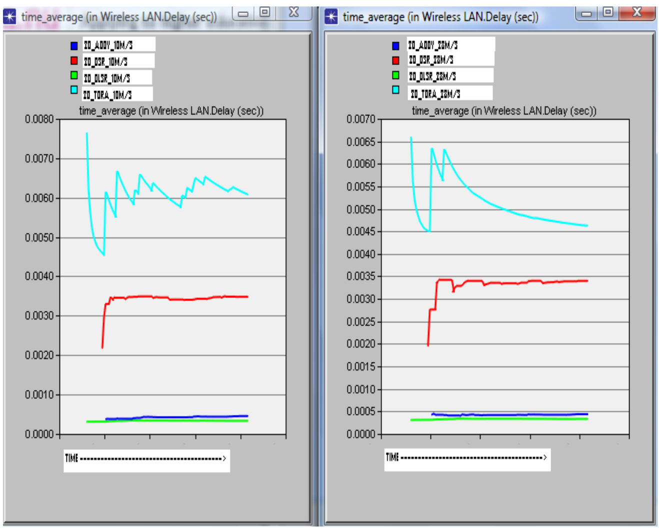

Figure 2: End-to-end delay 20 sources at 10m/s and 28m/s

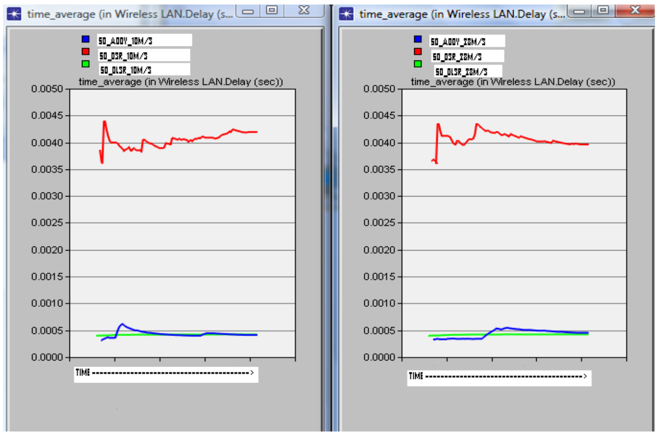

Figure 3: End-to-end delay 50 sources at 10m/s and 28m/s

In smaller networks with five traffic sources, we observe that TORA outperforms DSR by ratios of 1:3 at both low and high speeds. On the other hand, TORA competes with AODV at low speeds and is superior at high speeds. It has a consistent delay and outperforms AODV at higher speeds due to the performance degradation in AODV. When the number of nodes increased to 20. TORA suffers a significant degradation in its end-to-end delay. One reason for the degradation in the end-to-end delay of TORA at higher number of nodes is attributed to its route discovery process.

AODV also has a very low end-to-end delay and comes second to OLSR. This is observed in all the scenarios considered except in the case of lower number of nodes and high speed where TORA outperforms it. However, we observe that the performance of AODV improves with the increase in the number of sources. The hop-by-hop initiation in AODV helps reduce the end-to-end delay.

DSR shows a more consistent end-to-end delay both at low and high speeds in networks with five and twenty nodes. With the network comprising fifty traffic sources, the end-to-end delay of DSR increases both at low and high speeds. DSR uses cached routes and more often, it sends traffic onto stale routes, which may cause retransmissions and leads to excessive delays. Thus, in networks with high traffic sources, the increase in the number of cached routes worsens the delay. On the other hand, DSR tries to minimize the effect of stale routes by use of multiple paths.

To conclude on this sub-section, we briefly recall our findings. We have observed that OLSR exhibited very low delay in all scenarios. TORA had high delay in the high traffic network, and mobility did not have an effect on the delay. AODV had an improved end-to-end delay as the network grew whereas the speed did not have a noticeable effect on delay, and lastly DSR had a consistent end-to-end delay and suffered more delay as the network grew larger but speed did not have profound effects on the performance. The three reactive protocols exhibited high delays at higher loads due to the increase in route discovery requests.

4. Conclusions

In this paper, we have evaluated four different ad hoc routing protocols with respect to the packet end-to-end delay. These performance metrics used in our evaluation represent end-to-end delay aspects of performance in a network. We have observed that OLSR exhibited very low delay in all scenarios. TORA had high delay in the high traffic network, and mobility did not have an effect on the delay. AODV had an improved end-to-end delay as the network grew whereas the speed did not have a noticeable effect on delay, and lastly DSR had a consistent end-to-end delay and suffered more delay as the network grew larger but speed did not have profound effects on the performance. The three reactive protocols exhibited high delays at higher loads due to the increase in route discovery requests

5. Future Work

The other alternative direction of this research will explore the feasibility of developing a new algorithm that will address the limitations that the ad hoc routing protocols evaluated in this research pose. For example, OLSR is superior to the other routing protocols in many aspects such as end-to-end latency but it has problems of flooding the network with routing traffic for discovery and maintenance even when a link is not in use. It is good in high bandwidth links. For instance, it outperforms DSR in high capacity links however, it is prone to network clogs in low capacity links. A new algorithm will strive to strike a balance between these discrepancies

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Kaushal Kishor is pursuing his Ph.D from UPTU Lucknow, M.Tech & B.Tech in Computer Science & Engineering from UPTU Lucknow. I am pursuing his Ph.D from UPTU LKO. in the domain of Mobile Ad hoc Network. I have more than 9.5 years of experience of teaching. I have Gate Qualified 2003 score 94.5 percentile. I have reviewed no. of books for publications and book published (1) Design and Analysis of Algorithm (2) Computer Networks (3) Compiler Design (4) Design and Analysis of Algorithms Techniques and Control Management (5) Computer Networks a system approach for various engineering field like B.Tech. and MCA student. He has published 10 papers in peer reviewed international/national journals and conferences. His research interest includes Computer Network, Algorithm, Compiler Design Wireless and Sensor networking.

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