Mobile Ad hoc Networking (MANET): Routing Protocol Performance Issues and Evaluation Considerations

***Meenakshi Bansal, **Rachna Rajput , ***Gaurav Gupta**

*Yadvindra College Of Engg. Guru Kashi campus, Punjabi Univ., Talwandi Sabo *

* Guru Gobind Singh College Of Engg., Talwandi Sabo., ***RIMT-IET, Mandi Gobindgarh.

Abstract *Mobile Nodes in Wireless ad-hoc network need to operate as routers in order to maintain the information about network connectivity as there is no centralized infrastructure. Therefore, Routing Protocols are required which could adapt dynamically to the changing topologies and works at low data rates. As a result, there arises a need for the comprehensive performance evaluation of the ad-hoc routing protocols in same framework to understand their comparative merits and suitability for deployment in different scenarios. In this paper the protocols suite selected for comparison are AODV, DSR, TORA and OLSR ad-hoc routing protocols, as these were the most promising from all other protocols. The performance of these protocols is evaluated through exhaustive simulations using the OPNET Modeler network simulator under different parameters like routing overhead, delay, throughput and network load under varying the mobile nodes.*

Key Words : alphabetically sorted, excluding words used in title

1. Introduction

The word ad-hoc is derived from Latin, it means "for a particular purpose" or "in a way that is not planned in advance" [1]. The ad-hoc networks are designed to work autonomously, without any centralized infrastructure. In practice this means that network nodes should be able to communicate with each other even if there is no static infrastructure such as backbone network, base stations, and centralized network management functions or Internet Service Providers (ISPs) are available. In these situations, network nodes should cover the missing functions. 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 make 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. The need for mobility in wireless networks necessitated the formation of the MANET working group within The Internet Engineering Task Force (IETF) for developing consistent IP routing protocols for both static and dynamic topologies. After years of research, MANET protocols do not have a completed formed Internet standard. There is only been an identification of experimental Request for Comments (RFCs). At this stage, there is an indication that questions are unanswered concerning either implementation or deployment of the protocols but the proposed algorithms are identified as a trial technology and there is a high chance that they will develop into a standard. 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).

2. Review literature

Wireless networks emerged in the 1970's, since then they have become increasingly popular. The reason of their popularity is that they provide access to information regardless of the geographical location of the user. Wireless networks can be classified into two types [2] i.e. infrastructured and infrastructureless networks. In wired networks, in order to obtain the shortest path usually Distance Vector or Link state routing protocols are used. These protocols do not perform well in ad-hoc wireless networks because wireless ad-hoc networks have limited bandwidth and there is no central control. Ad-hoc wireless networks are different from other networks because of the characteristic like absence of centralized control, each node has wireless interface, nodes can move around freely which results in frequent changes in network topology, nodes have limited amount of resources and lack of symmetrical links i.e. transmission does not usually perform equally well in both directions. Therefore, modifications to these routing protocols or totally new routing protocols are required for the ad hoc wireless domain. Presently there are four ad-hoc routing protocols in demand for wireless ad-hoc networks i.e. AODV [3], DSR [4], TORA [5] [6] and OLSR [7]. From the various ad-hoc routing protocols proposed, the authors [8] founded TORA, DSR and AODV on-demand routing protocols as most promising and compared them

TORA is a distributed routing protocol for ad-hoc networks, which uses a link reversal algorithm. TORA performs the routing portion of the protocol but depends for other functions on the internet MANET encapsulation protocol (IMEP). DSR allows nodes to find out a route over a network dynamically. The AODV algorithm is a confluence of both DSR and destination sequenced distance vector (DSDV) protocols. It shares on-demand characteristics of DSR, and adds the hop-by-hop routing, sequence numbers and periodic beacons from DSDV. The protocols were compared over varying loads using OPNET Modeler 10.5 network simulator using packet level simulations. The simulation characteristics used for performance evaluation were the control traffic received and sent, data traffic received, throughput, retransmission attempts, utilization, average power, route discovery time and ULP traffic received. For comparative performance analysis, each protocol for ad-hoc networks was simulated for three different scenarios with varying network sizes of 40, 80 and 100 nodes. In case of network of 40 nodes, TORA shows good performance for the control traffic received and sent, data traffic sent and for successful transmission of packets. AODV shows better performance for data traffic received, throughput and channel utilization. DSR shows an average level of performance in both power and channel utilization over time. However, when the network size was increased to 80 and 100 nodes, for DSR, the number of packets in routing traffic received and sent, as well as the number of packets in total traffic received and sent, increase with increasing load. However, for route discovery time and the number of hops per route, the performance depends primarily on the algorithm rather than on the load. For TORA, the number of packets in control traffic received and sent, as well as in ULP traffic received and sent, increases with the increment of loads. In the case of AODV, varying the number of nodes has no effect on the number of hops per route or route discovery time. Therefore, it was concluded that for specific differentials, TORA shows better performance over the two on-demand protocols, that is DSR and AODV.

3. Performance Matrics

3.1 Routing Overhead

Ad hoc networks are designed to be scalable. As the network grows, various routing protocols perform differently. The amount of routing traffic increases as the network grows. An important measure of the scalability of the protocol, and thus the network, is its routing overhead. It is defined as the total number of routing packets transmitted over the network, expressed in bits per second or packets per second.

Some sources of routing overhead in a network are cited in [7] as the number of neighbours to the node and the number of hops from the source to the destination. Other causes of routing overhead are network congestion and route error packets.

Mobile nodes are faced with power constraints and as such, power saving is a major factor to consider in implementation of MANET. Furthermore, radio power limitations, channel utilization and network size are considered. These factors limit the ability of nodes in a MANET to communicate directly between the source and destination. As the number of nodes increases in the network, communication between the source and destination increasingly relies on intermediate nodes. Most routing protocols rely on their neighbours to route traffic and the increase in the number of neighbours causes even more traffic in the network due to multiplication of broadcast traffic.

3.2 Packet End-to-End Delay

The packet end-to-end delay is the average time that packets take to traverse the network. This is the time from the generation of the packet by the sender up to their reception at the destination's application layer and is expressed in seconds. It therefore includes all the delays in the network such as buffer queues, transmission time and delays induced by routing activities and MAC control exchanges.

The delay is also affected by high rate of CBR packets. The buffers become full much quicker, so the packets have to stay in the buffers a much longer period of time before they are sent. This can clear be seen at the highest rate 20 packets/s. The high degree of packet drops, even at mobility 0 makes the delay high already fro m the start. DSR has a much lower delay compared to AODV. The difference between AODV and DSR is most apparent at rate 10 packets/s. DSDV has the lowest delay of them all. This is however an effect from the large fraction of packet drops that DSDV has, compared to DSR and AODV. The increase in delay for DSDV also comes from the increased time that the packets must stay in the buffers. The high delay at a mobility factor of 0-1 and a data rate of 20 packets/ s that can be seen for all protocols is a result of the extremely high data rate and the low mobility. The high data rate will fill up the buffers very quickly. The low mobility will mean that already found routes are valid for a much longer time period. This means that found routes can be used for more packets. Even the packets that have stayed in the buffer for a long time have a chance to get through. When mobility increases, more routes will become invalid and new requests are necessary. While the requests are propagating the network in search for a new route, buffers will get full and packets are dropped. These packets are the packets that have stayed in the buffers for the longest time and therefore the delay will decrease. The increase in mobility actually results in a load balancing of the traffic between the nodes; hot spots are "removed" due to mobility. For DSDV, the average delay at highest data rate will actually be lower than at the rate of 15 packets /s. This is a little strange but has probably something to do with the fact that DSDV only uses a buffer that only has room for 5 packets per flow. At the rate of 15 packets/s and 20 packets/s, when mobility starts to get so high that the topology changes frequently, only 40-60 % of the packets gets through the network. These topology changes means that the protocol needs more time to converge before the packets can be sent. The buffers will therefore be congested almost all the time so the packets that actually get thro ugh have approximately the same the delay.

4. Results

4.1 Routing Overhead

We evaluated that the highest amount of routing traffic is sent by the OLSR routing protocol then by TORA which is followed by AODV and lastly DSR. The reason for DSR, incurring less overhead is that, it sends the routing traffic only when it has data to transmit, which eliminate the need to send unnecessary routing traffic. AODV has routing overhead slightly higher than DSR because of multiple route replies to a single route request. The routing overhead for TORA is higher than AODV and DSR because of the periodic beacon and HELLO packets, which it sent on the network for route discovery.

As OLSR constantly floods the network with control and routing traffic to keep its routing tables updated it leads to highest amount of routing overhead as compared with other ad-hoc routing protocols.

4.2Delay

Delay refers to the time taken by packets to traverse the network and reach the destination. OLSR has the lowest delay as it is a proactive routing protocol which means that routes in the network are always available whenever the application layer has traffic to transmit, periodic routing updates keep fresh routes available for the use. The absence of high latency induced by the route discovery process in OLSR explains its relatively low delay with higher number of mobile nodes. In AODV hop-by hop initiation helps to reduce the end-to-end delay. Although in case of 50 nodes, the delay for AODV is higher at start but it reduces in the next stages until end of the simulation. DSR uses cached routes and more often, it sends traffic to the stale routes which causes retransmission and leads to excessive delays. Delay for TORA is higher because of its route discovery process. It takes a lot of time discovering and deciding a route for data transfer.

4.3 Throughput

The amount of throughput in all cases is highest for OLSR as compared with other protocols as routing paths are readily available for the data to be sent from source to destination.The amount of throughput for TORA is higher at start from AODV and DSR in case of 10 and 30 nodes but it fall below AODV throughput curve as the nodes start moving. AODV performs better in network with relatively high number of traffic sources and higher mobility. The DSRs throughput is very low in the network in all the cases.

5. Conclusion

We evaluate the performance of AODV, DSR, TORA and OLSR ad-hoc routing protocols under varying load and number of users. The software used is OPNET Modeler 14.0 and simulations with varying traffic were run for 3600 sec.

6. References

List and number all bibliographical references in 9-point Times, single-spaced, at the end of your paper. When referenced in the text, enclose the citation number in square brackets, for example [1]. Where appropriate, include the name(s) of editors of referenced books.

[1]. Klaus Nieminen,”Introduction to Ad-Hoc Networking”, http://www.citeseerx.edu/ .

[2]. Humaira Ehsan and Zartash Afzal Uzmi “Performance Comparison of Ad Hoc Wireless Network Routing Protocols," Proceedings of **INMIC 8th International**, 24-26 Dec. 2004, pp-457- 465.

[3]. C. E Perkins and E. M. Royer ,”Ad-hoc On-Demand Distance Vector Routing,” Proceedings of the 2nd IEEE Workshop on Mobile Computing Systems and Applications, New Orleans, LA, pp-90-100, February 1999.

[4]. David B. Johson, David A. Maltz and Josh Broch, “DSR: The Dynamic Source Routing Protocol for Multihop Wireless Ad-Hoc networks“, in Ad-hoc Networking, Edited by Charles E. Perkins, Chapter-5, pp-139-172, Addison-Wesley, 2001.

[5]. Vincent D. Park and M. Scott Corson, “A performance comparison of the Temporally-Ordered Routing Algorithm (TORA) and Ideal Link-State Routing”, Proceedings of IEEE symposium on Computer and Communication, June 1998.

[6]. Vincent D. Park and M. Scott Corson, “Temporally-Ordered Routing Algorithm (TORA) Version 1: Functional Specification”, Internet draft, draft-ietf-manet-tora-spec-01.txt, August 1998.

[7]. P. Jacquet, P. Muhlethaler, T. Clausen, A. Laouiti, A. Qayyum and L. Viennot, “ Optimized Link State Routing Protocol for Ad-Hoc Networks”, Proceedings of 5th IEEE Multi Topic conference (INMIC 2001), 2001.

[8]. S. Ahmed and M. S. Alam, **“Performance Evaluation of Important** Ad-hoc N**network Protocols**", Proceedings of EURASIP Journal on Wireless Communications and Networking Volume 2006, Issue 2 (April 2006), pp- 42 – 42.