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Routing Load Assessment for DSR and AODV Protocols

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Abstract: Mobile Adhoc Network is an autonomous system of mobile hosts which are free to move around randomly and organize themselves arbitrarily. They form a temporary network without any pre-existing network infrastructure. In this paper, performance evaluation of two on-demand routing protocols have been carried out which makes use of Dynamic Source Routing (DSR) and Adhoc On-Demand Distance Vector Routing (AODV). The performance has been studied by writing a network scenario and then analyzing Normalized Routing Load (NRL). The simulator used is NS 2.34. Based on the findings, the significance of both protocols under various situations is suggested.

Keywords: Adhoc, Mobile, Network, NRL, Protocol

1. Introduction

Mobile Adhoc Network (MANET) is a collection of wireless mobile nodes forming a temporary network without any fixed infrastructure where all nodes are free to move about arbitrarily and where all the nodes configure themselves. Each node acts both as a router and as a host & even the topology of network may also change rapidly. A routing protocol is needed whenever a packet needs to be transmitted to a destination via number of nodes and numerous routing protocols have been proposed for adhoc networking environment. These routing protocols find a route for packet delivery and deliver the packet to the correct destination. In this paper, performance evaluation of two prominent on-demand routing protocols [2] viz. DSR and AODV has been done by carrying out simulation over network simulator and using a self created network scenario.

2. Dynamic Source Routing

DSR [5] is an Adhoc routing protocol which is based on the theory of source-based routing rather than table-based. This protocol is source-initiated rather than hop-by-hop. It is a simple and efficient routing protocol designed specifically for use in multi-hop wireless ad hoc networks of mobile nodes. DSR allows the network to be completely self-organizing and self-configuring, without the need for any existing network infrastructure or administration. Dynamic Source Routing, DSR, is a reactive routing protocol that uses source routing to send packets. It uses source routing which means that the source must know the complete hop sequence to the destination. Each node maintains a route cache, where all routes it knows are stored. The route discovery process is initiated only if the desired route cannot be found in the route cache. To limit the number of route requests propagated, a node processes the route request message only if it has not already received the message and its address is not present in the route record of the message. As mentioned before, DSR uses source routing, i.e. the source determines the complete sequence of hops that each packet should traverse. This requires that the sequence of hops is included in each packet's header. A negative consequence of this is the routing overhead every packet has to carry. However, one big advantage is that intermediate nodes can learn routes from the source routes in the packets they receive. Since finding a route is generally a costly operation in terms of time, bandwidth and energy, this is a strong argument for using source routing. Another advantage of source routing is that it avoids the need for up-to-date routing information in the intermediate nodes through which the packets are forwarded since all necessary routing information is included in the packets. Finally, it avoids routing loops easily because the complete route is determined by a single node instead of making the decision hop-by-hop. The protocol is composed of the two main mechanisms of "Route Discovery" and "Route Maintenance", which work together to allow nodes to discover and maintain routes to arbitrary destinations in the ad hoc network. All aspects of the protocol operate entirely on demand, allowing the routing packet overhead of DSR to scale automatically to only what is needed to react to changes in the routes currently in use. The protocol allows multiple routes to any destination and allows each sender to select and control the routes used in routing its packets, for example, for use in load balancing or for increased robustness.

2.1 Route Discovery

Route Discovery is used whenever a source node desires a route to a destination node. First, the source node looks up its route cache to determine if it already contains a route to the destination. If the source finds a valid route to the destination, it uses this route to send its data packets. If the node does not have a valid route to the destination, it initiates the route discovery process by broadcasting a route request message. The route request message contains the address of the source and the destination, and a unique identification number. An intermediate node that receives a route request message searches its route cache for a route to the destination. If no route is found, it appends its address to the route record of the message and forwards the message to its neighbors. The message propagates through the network until it reaches either the destination or an intermediate node with a route to the destination. Then a route reply message, containing the proper hop sequence for reaching the destination, is generated and unicast back to the source node.

2.2 Route Maintenance

Route Maintenance is used to handle route breaks. When a node encounters a fatal transmission problem at its data link layer, it removes the route from its route cache and generates a route error message. The route error message is sent to each node that has sent a packet routed over the broken link. When a node receives a route error message, it removes the hop in error from its route cache. Acknowledgment messages are used to verify the correct operation of the route links. In wireless networks acknowledgments are often provided as e.g. an existing standard part of the MAC protocol in use, such as the link-layer acknowledgment frame defined by IEEE 802.11. If a built-in acknowledgment mechanism is not available, the node transmitting the message can explicitly request a DSR-specific software acknowledgment to be returned by the next node along the route.

3. Adhoc On-demand Distance Vector Routing

AODV [4] is a variation of Destination-Sequenced Distance-Vector (DSDV) routing protocol which is collectively based on DSDV and DSR. It aims to minimize the requirement of system-wide broadcasts to its extreme. It does not maintain routes from every node to every other node in the network rather they are discovered as and when needed & are maintained only as long as they are required. The establishment of unicast routes by AODV is explained as under:

3.1 Route Discovery

When a node wants to send a data packet to a destination node, the entries in route table are checked to ensure whether there is a current route to that destination node or not. If it is there, the data packet is forwarded to the appropriate next hop toward the destination. If it is not there, the route discovery process is initiated. AODV initiates a route discovery process using Route Request (RREQ) and Route Reply (RREP). The source node will create a RREQ packet containing its IP address, its current sequence number, the destination's IP address, the destination's last sequence number and broadcast ID. The broadcast ID is incremented each time the source node initiates RREQ. Basically, the sequence numbers are used to determine the timeliness of each data packet and the broadcast ID & the IP address together form a unique identifier for RREQ so as to uniquely identify each request. The requests are sent using RREQ message and the information in connection with creation of a route is sent back in RREP message. The source node broadcasts the RREQ packet to its neighbours and then sets a timer to wait for a reply. To process the RREQ, the node sets up a reverse route entry for the source node in its route table. This helps to know how to forward a RREP to the source. Basically a lifetime is associated with the reverse route entry and if this entry is not used within this lifetime, the route information is deleted. If the RREQ is lost during transmission, the source node is allowed to broadcast again using route discovery mechanism.

3.2 Expanding Ring Search Technique

The source node broadcasts the RREQ packet to its neighbours which in turn forwards the same to their neighbours and so forth. Especially, in case of large network, there is a need to control network-wide broadcasts of RREQ and to control the same; the source node uses an expanding ring search technique. In this technique, the source node sets the Time to Live (TTL) value of the RREQ to an initial start value. If there is no reply within the discovery period, the next RREQ is broadcasted with a TTL value increased by an increment value. The process of incrementing TTL value continues until a threshold value is reached, after which the RREQ is broadcasted across the entire network.

3.3. Setting up of Forward Path

When the destination node or an intermediate node with a route to the destination receives the RREQ, it creates the RREP and unicast the same towards the source node using the node from which it received the RREQ as the next hop. When RREP is routed back along the reverse path and received by an intermediate node, it sets up a forward path entry to the destination in its routing table. When the RREP reaches the source node, it means a route from source to the destination has been established and the source node can begin the data transmission.

3.4. Route Maintenance

A route discovered between a source node and destination node is maintained as long as needed by the source node. Since there is movement of nodes in mobile adhoc network and if the source node moves during an active session, it can reinitiate route discovery mechanism to establish a new route to destination. Conversely, if the destination node or some intermediate node moves, the node upstream of the break initiates Route Error (RERR) message to the affected active upstream neighbors/nodes. Consequently, these nodes propagate the RERR to their predecessor nodes. This process continues until the source node is reached. When RERR is received by the source node, it can either stop sending the data or reinitiate the route discovery mechanism by sending a new RREQ message if the route is still required.

4. Literature Survey

The main researchers who have worked on the performance evaluation of routing protocols are Georgios Kioumourtzis [7], S.Shah, A.Khandre, M.Shirole and G. Bhole [11], J. Broch, D. A. Maltz, D. B. Johnson, Y. C. Hu, and J. Jetcheva [8], D. O. Jorg [6], K. U. Khan, R. U. Zaman, A. V. Reddy [9], A. Kumar B. R., Lokanatha C. Reddy and Prakash.S.Hiremath [1], N. Vetrivelan & A. V. Reddy [10]. Most of the researchers have carried out the performance comparison of routing protocols on the basis of packet delivery ratio and average end to end delay. Very few have worked on the NRL. Georgios Kioumourtzis [7] and S.Shah, A.Khandre, M.Shirole and G. Bhole [11] have worked on the entire key performance metrics viz. packet delivery ratio, average end to end delay and normalized routing load.

5. Metric Used

A number of quantitative metrics [7] can be used for evaluating the performance of a routing protocol for mobile adhoc networks. The performance metric used in this paper is NRL which is defined as the fraction of all routing control packets sent by all nodes over the number of received data packets at the destination nodes. In other words, it is the ratio between the total numbers of routing packets sent over the network to the total number of data packets received.

$$\text{Normalized Routing Load (NRL)} = \frac{\text{Total Routing Packets Sent}}{\text{Total Data Packets Received}}$$

In this paper, performance evaluation of DSR and AODV has been analyzed using normalized routing load as performance metric. This metric has been studied with respect to 25 and 60 mobile nodes by varying pause time and using UDP/TCP agents.

6. Simulation Model

The simulation experiments are carried over network simulator 2.34. The mobility model used is random waypoint model in a square area. The area configurations used are 800 meter x 800 meter for 25 nodes and 1200 meter x 1200 meter for 60 nodes. The packet size is 512 bytes. The packets start their journey from a random location to a random destination with a randomly chosen speed. The simulation run time is 500 seconds during analysis of 25 nodes and 650 seconds for 60 nodes. An extensive simulation model having scenario of 25 and 60 mobile nodes is used to study inter-layer interactions and their performance implications. Same scenario has been used for performance evaluation of both DSR and AODV protocols. It has been shown that even though DSR and AODV share a similar on-demand behavior, the differences in the protocol mechanics can lead to significant performance differentials. In figure 1, normalized routing load has been evaluated for DSR and AODV protocols using pause time as varying parameter with six UDP agents. Pause time has been varied from 100s to 500s. The normalized routing load values range from 0.13 to 0.50. In this scenario, the observation is that the DSR protocol presents low normalized routing load than AODV. Hence DSR protocol outperforms than AODV in terms of efficient routing. In figure 2, normalized routing load has been evaluated using pause time as a varying parameter on 25 mobile nodes having six TCP agents. Pause time varies 100s to 500s. The normalized routing load values range from 0.01 to 0.04. The observation is that on an average, the DSR protocol presents low normalized routing load than AODV in all situations and therefore DSR protocol outperforms than AODV in terms of efficient routing. In figure 3, normalized routing load has been evaluated for DSR and AODV protocols using pause time as varying parameter and ten UDP agents. Pause time has been varied from 100s to 650s. The normalized routing load values range from 0.7 to 0.25. In this scenario, again, the observation is than on an average, the DSR protocol presents low normalized routing load than AODV and therefore DSR protocol outperforms than AODV in terms of efficient routing. In figure 4, normalized routing load has been evaluated for DSR and AODV protocols using pause time as a varying parameter with ten TCP agents. Pause time varies 100s to 650s. The normalized routing load values range from 0.15 to 0.75. The observation is that the results have changed now in comparison to the results obtained in sub sections 4.1, 4.2 and 4.3. It has been found that the AODV protocol presents low normalized routing load than DSR in all situations and therefore AODV protocol has started outperforming than DSR in terms of efficient routing.

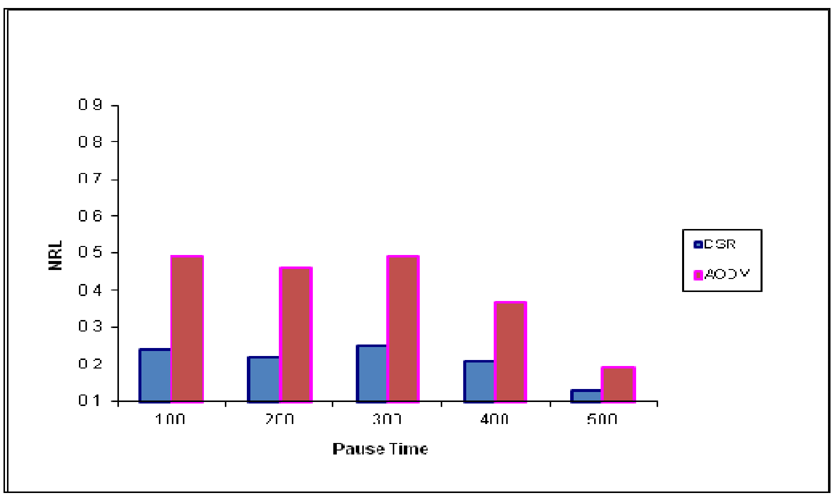

Figure 1. NRL for 25 Nodes with UDP Agents

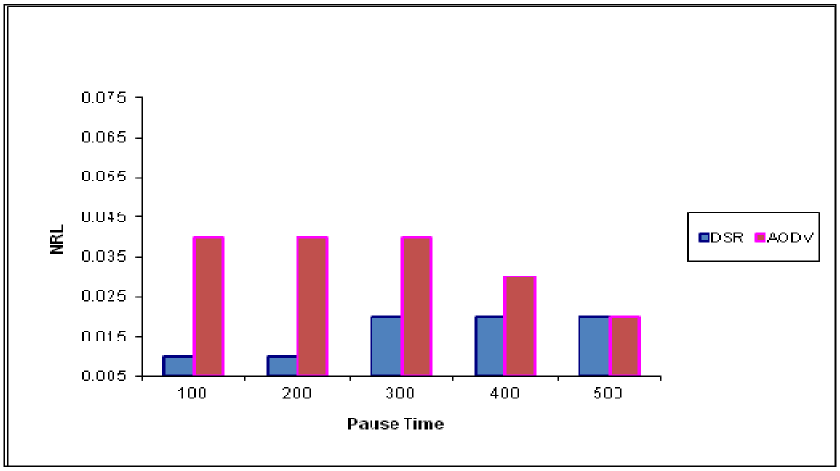

Figure 2. NRL for 25 Nodes with TCP Agents

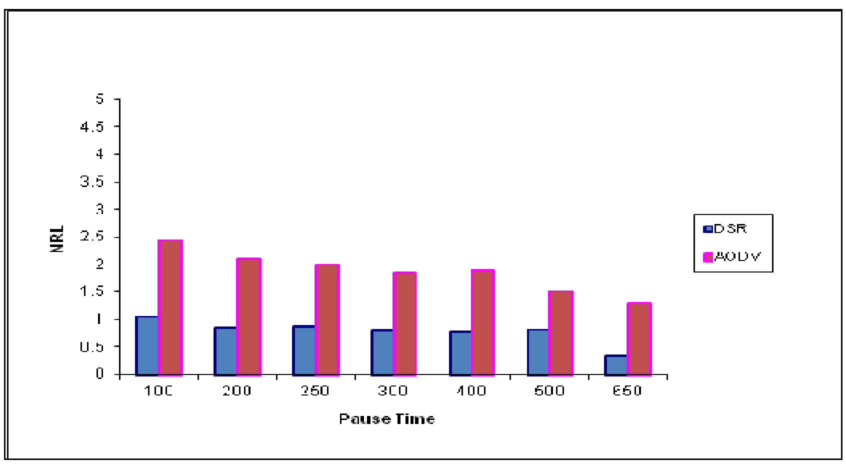

Figure 3. NRL for 60 Nodes with UDP Agents

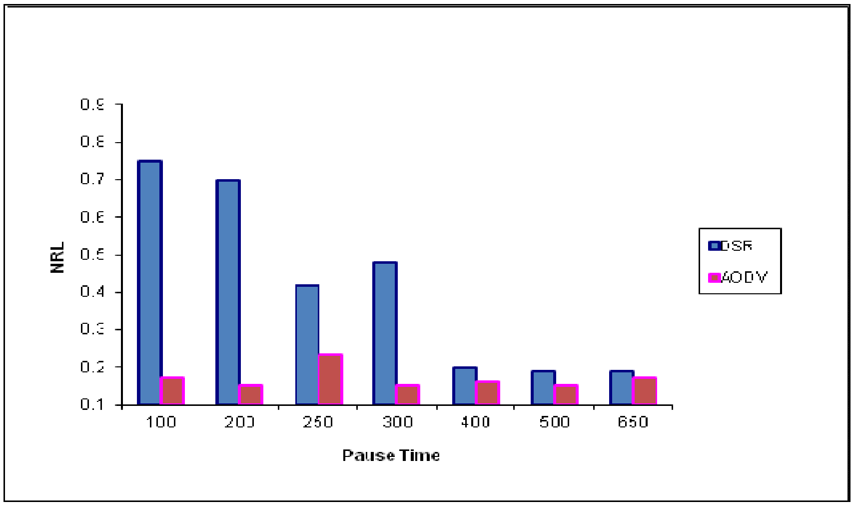

Figure 4. NRL for 60 Nodes with TCP Agents

It can be seen from the figure 1, 2, 3 that DSR presents the lower normalized routing load than AODV proving that source routing proves to be an efficient routing mechanism in networks because it utilizes the wireless medium for data traffic in a better way than the other tested protocols. The key point to note from these figures is that these results are for sparse medium i.e. small number of nodes. The low normalized routing load for DSR protocol can be attributed to the caching strategy used by DSR. By virtue of aggressive caching, DSR is more likely to find a route in the cache, and hence resorts to route discovery less frequently than AODV. It can be further analyzed from figure 4 that AODV presents low normalized routing load than DSR when TCP agents are used and number of nodes are high. If numbers of nodes are further increased to a large extent, AODV demonstrates low normalized routing load than DSR in all cases and hence it means that in denser medium, routing using AODV is more efficient than DSR. The DSR performance decreases in denser networks with higher mobility disclosing that source routing cannot efficiently adapt the network topology changes that are caused by the frequent movement of the nodes. Concluding, DSR demonstrates significantly lower routing load than AODV with the fact that it increases for DSR with growing number of nodes. When the number of nodes is less, the performance of DSR and AODV is similar regardless of mobility. With large numbers of nodes, AODV starts outperforming DSR. The major contribution to AODV's routing over-head is from route requests, while route replies constitute a large fraction of DSR's routing overhead. Furthermore, AODV has more route requests than DSR, and the converse is true for route replies.

7. Conclusion and Future Scope

In this paper, performance evaluation of DSR and AODV has been carried out on the basis of normalized routing load. The general observation from the simulation is that the AODV protocol performs better in denser mediums and the DSR protocol performs better in sparse medium. AODV is the proper protocol for any kind of application in networks with high mobility that consist of large number of nodes. In most cases, DSR presented the lower normalized routing load, proving that source routing proves to be an efficient routing mechanism in networks with a small number of nodes because it utilizes the wireless medium for data traffic in a better way than the other tested protocols. However, DSR performance decreases in denser networks with higher mobility disclosing that source routing cannot efficiently adapt the network topology changes that are caused by the frequent movement of the nodes. The general statement is that the use of AODV protocol is better choice over DSR protocol for efficient routing over mobile adhoc network. Efforts will also be made to evaluate the performance using remaining metrics. Work also needs to be done in the field of security and power management.

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