Performance Comparison of Two Reactive Routing Protocols for Ad Hoc Network

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Abstract: *Ad hoc networks are characterized by wireless connectivity, continuous changing topology, distributed operations and ease of deployment. Routing in Ad hoc networks is a challenge due to mobility and thus is a current area of research. Considering the importance of reactive routing potocols, we have compared the multiple performance metrics of DSR and AODV protocols. Both protocols share similar on-demand behaviour, but their internal mechanisms lead to significant differences in their performance. We have analyzed the performance of the protocols by various network load and mobility by using detailed simulation model. We have considered packet delivery fraction, normalized routing load, average delay, routing overheads, average hop-count and packet-loss as matrices for performance analysis of these protocols. The results reveal that in adverse situations like high mobility and load, AODV outperforms significantly over DSR, whereas in moderate situations DSR has an advantage.*

Keywords: *AODV, DSR, Performance, Mobility, Routing*

Introduction

Wireless network systems have gained importance in recent years by combining the potentiality of large number of computers situated at different places. An Ad hoc network is a collection of wireless mobile hosts, which are capable to communicate with each other without any pre-existing infrastructure. All nodes of these networks behave as routers and take part in discovery and maintenance of routes to the other nodes in the network. Ad hoc networks have to deal with many challenges and the one that is most important is route selection. So the routing algorithm must be dynamic and must be adaptive to the frequent topology changes due to node mobility. Many algorithms have been proposed in the literature that can be used in ad hoc networks for finding routes [1][2][3]. Availability of low cost wireless devices and vast application areas of ad hoc networks, has encouraged researchers to develop new and efficient routing protocols. In this paper we present performance comparison of two reactive routing protocols DSR [1] and AODV [2] to bring out their relative merits. Both are on demand and initiate their routing activities only when required. The motivation behind this comparison is to understand their internal working mechanism and bring out situations where one is preferred than the other.

2. Routing Protocols

Routing is defined as the process of finding a path from a source to some arbitrary destination on the network. Mobile ad hoc networks, or MANET, are fundamentally different from traditional wired networks as wired networks are assumed to be stationary and static. So the routing protocols designed for wired networks can't work efficiently in Ad hoc networks. This imposes different design requirements and constraints on routing protocols for MANET. There are two categories of routing protocols: table-driven and on-demand routing. In table-driven routing protocols, routing information is periodically advertised to all nodes so that all nodes have an up to date view of the network. Alternatively, on-demand routing protocols only discover a new route when it is required.

(i) DSR: The dynamic Source Routing (DSR) protocol is a source-routed on-demand protocol. There are two major phases for the protocol: route discovery and route maintenance. The key difference between DSR and other protocols is the complete routing information is contained in the packet header. Since the routing information is contained in the packet header, the intermediate nodes do not need to maintain routing information. An intermediate node may wish to record the routing information in its tables to improve performance, but this is not mandatory. DSR is suited for small to medium sized networks as its packet overhead (not packet data overhead) can scale all the way down to zero when all nodes are relatively stationary. The packet data overhead will increase significantly for networks with larger hop diameters, as more routing information will need to be contained in the packet headers. It is based on the concept of source routing. For this protocol, mobile nodes are required to maintain route caches that contain the source routes of which the mobile is aware. Entries in the route cache are continually updated as new routes are learned. There are two major phases of the protocol: route discovery and route maintenance. Route discovery uses *route request* and *route reply* packets. Route maintenance uses *route error* packets and acknowledgements.

(ii) AODV: This routing algorithm builds on the DSDV algorithm and the improvement is on minimizing the number of required broadcasts by creating routes on an on-demand basis, as opposed to maintaining a complete list of routes as in DSDV algorithm. A path discovery is initiated when a route to a destination does not exist. Broadcast is used for route request. Link failure notification is sent to the upstream neighbors and this algorithm requires symmetric links. To find a route to the destination, the source broadcasts a route request packet. This broadcast message propagates through the network until it reaches an intermediate node that has recent route information about the destination or until it reaches the destination. When intermediate nodes forward the route request packet, it records in its own tables which node the route-request came from. This information is used to form the reply path for the route-reply packet as AODV uses only symmetric links. As the route reply packet traverses back to the source, the nodes along the reverse path enter the routing information into their tables. Whenever a link failure occurs, the source is notified and a route discovery can be requested again if needed.

3. Performance Issues in Routing Protocols

MANET working group has defined some unique characteristics of ad hoc networks in RFC 2501 [4]. These properties do not directly relate to performance, but they describe very nature of ad hoc networks and formulate boundary conditions of ad hoc networks. To measure external performance of a protocol, we consider throughput and end-to-end delay as metrics and to measure internal effectiveness of a protocol; we consider routing overhead, normalized routing load, packet delivery ratio and average hop count as the metrics.

Throughput: It gives the fraction of the channel capacity used for useful transmission (Data packets correctly delivered to the destination). It is defined as the total number of packets received by the destination. It is a measure of the effectiveness of a routing protocol.

Average end-to-end delay of data packets: This includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, and propagation and transfer times.

Routing overhead: The total number of routing packets transmitted during the simulation. For packets sent over multiple hops each transmission (per hop) is considered as one transmisission. All the packets sent or forwarded at network layer is considered as routing overhead.

Normalized routing load (NRL): NRL is the number of routing packets transmitted per data packet delivered at the destination. Each hop-wise transmission of a routing packet (forwarded) is counted as one transmission. This metric is highly correlated with number of route changes occurred in the simulation.

Packet delivery fraction: The ratio of the data packets delivered to the destinations to those generated by the CBR sources.

Average hop count: Average hop count is the ratio of the number of packets transmitted at MAC layer to the total number of packets transmitted at CBR source.

Packets loss: Packet loss is a measure of the number of packets dropped by the routers due to various reasons.

All these metrics are most widely used for representing performance of routing protocols because higher data delivery, lower control overhead and lower delay are always desirable. The essential parameters, which we have varied in our simulations, are mobility, network size and number of nodes.

4. Simulation Model

We have used NS-2[5] in our evalua[illegible] Monarch research group in CMU [7] develope[illegible]pport for simulating multi hop wireless networks [illegible]S-2. The protocols maintain a send buffer of [illegible]ckets. It contains all data packets waiting for a [illegible], such as packets for which route discovery has [illegible]d, but no reply has arrived yet. To prevent bufferi[illegible]f packets indefinitely, packets are dropped if they w[illegible]n the send buffer for more than 30s. All packets ([illegible] data and routing) sent by the routing layer are q[illegible]ed at the interface queue until the MAC layer can tra[illegible]mit them. The interface queue has a maximum size of 50 packets and is maintained as a priority queue with two priorities each served in FIFO order. Routing packets get higher priority than data packets.

4.1 The Traffic and Mobility Models

We have done simulation of the scenario for 900 simulated seconds in a rectangular field of 1500x300

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with 50 nodes and varying the degree of connectivity among nodes. Continuous bit rate (CBR) traffic sources are used. The source-destination pairs were spread randomly over the network. The size fo data packets is 512 bytes. Changing the number of sources and data rate varies the offered load in the network. The mobility model used is the random waypoint [6]. Here, each node starts its journey from a random location to a random destination with a randomly chosen speed (uniformly distributed between 0-20 m/s). Once the destination is reached, another random destination is targeted after a pause. The pause time, which affects the relative speeds of the mobiles, is varied from 0 to 900s (0 means continuously moving and 100 means stable). Identical mobility and traffic scenarios are used across all the protocols to gather the results.

5. Experimental Results and Performance Comparison of the Protocols

The goal of our simulation is to find the performance difference based on the internal effectiveness of these protocols. We have varied mobility and the number of sources to measure their performance difference. Simulations were carried out with the number of traffic sources as 10, 20, 30 and 40. The pause time was varied as 0 (high mobility), 100, 200, 300, 400, 500, 600, 700, 800, 900 (no mobility) and the packets were sent at a rate of 4 packets/sec. The simulation results bring out some important characteristic differences between the routing protocols. The presence of high mobility implies frequent link failures and each routing protocol reacts differently during link failures. The different basic working mechanisms of these protocols lead to the differences in the performance.

5.1 Packet Delivery: Both of the protocols deliver almost all the originated data packets when node mobility is low (i.e., at large pause time) and the number of sources is kept small (say at 10), converging to 100% delivery when there is no node motion (Fig. 5.1). But the delivery rate starts decreasing when there is increase in the number of sources and goes down up to 30% when the number of sources is large (say at 40).

5.2 Normalized Routing Load: In all cases, DSR demonstrates significantly lower routing load than AODV (Fig. 5.2), with the factor increasing with a growing number of sources. We observe that when the number of sources is small, the performance of DSR and AODV is similar regardless of mobility. With large numbers of sources, DSR outperforms AODV for high-mobility scenarios. Further, DSR always demonstrates a lower routing load than AODV. The trace files of NS-2 indicate that the major contribution to AODV routing-overheads is from route requests, whereas in DSR route replies constitute a large fraction of routing-overheads.

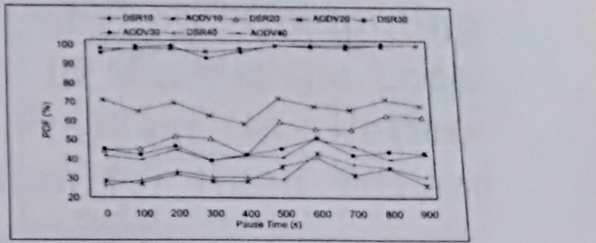

Fig. 5.1. Packet Delivery Fraction

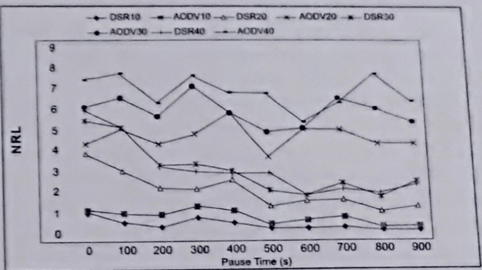

Fig. 5.2. Normalised Routing Load vs. Pause Time

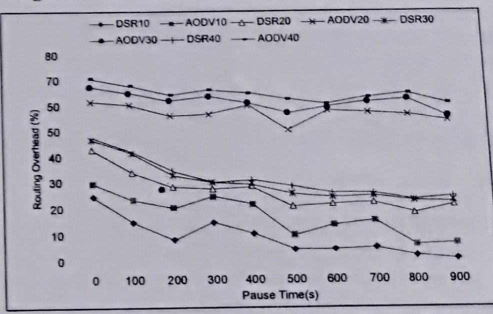

Fig. 5.3. Routine Overheads vs. Pause Time

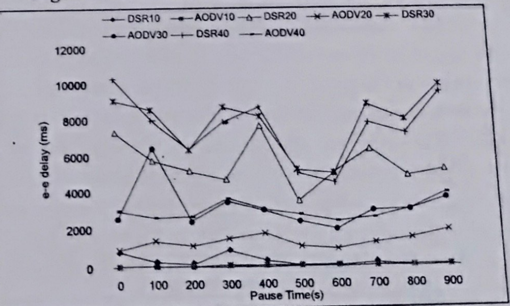

Fig. 5.4. Average End-End Delay vs. Pause Time

5.3 Average end-to-end Delay: Average delay in DSR is comparable to AODV when the number of sources is small. But with the increase in the network load (number of sources) the delay in DSR becomes at least double as the delay in AODV.

5.4 Packet Loss: When the number of sources is small, the packet-loss is comparable. But with the increase in the network load, the packet-loss in DSR is lower as compared to AODV. The reason appears to be that DSR always has more than one route for a destination. If one route fails, then route discovery is not started and the packet is sent using an alternate route.

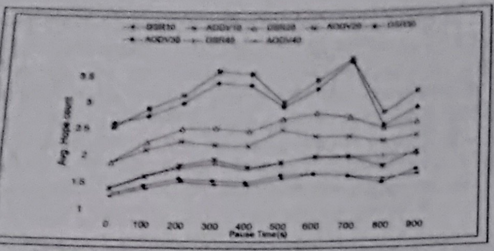

Fig. 5.5. Average Hope Count vs. Pause Time

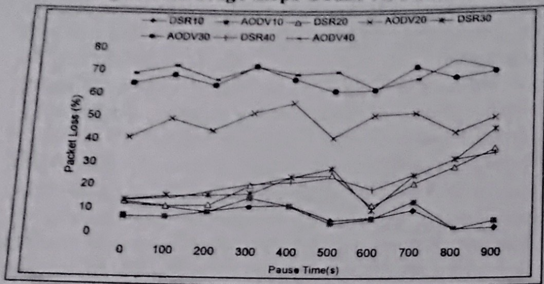

Fig. 5.6. Packet Loss vs. Pause Time

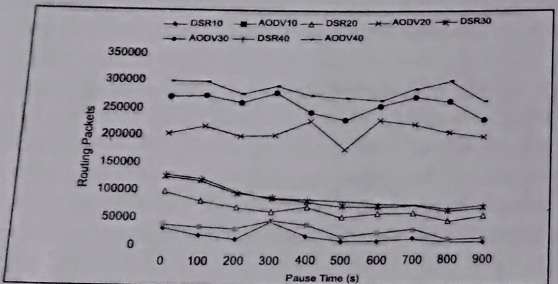

Fig. 5.7. Routing Packet at Mac Layer vs. Pause Time

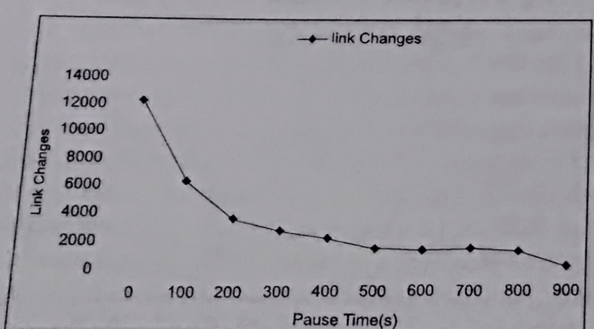

Fig. 5.8. Link Changes vs. Pause Time

6. Conclusions

DSR and AODV both use on-demand route discovery, but with different routing mechanism. The general observation from the simulation is that for application-oriented metrics such as packet delivery fraction and delay, AODV.outperforms DSR in stressful situations (high load and/or high mobility), with widening performance gaps with increasing stress (e.g., more load, higher mobility). DSR, however, consistently generates less routing load than AODV. In summary, it can be said that for robust scenario where mobility is high, area is large, the amount of traffic is more and network is for longer period, AODV performs better. For the normal situations where a network is of general nature with moderate traffic and moderate mobility DSR would be the right choice as it delivers more packets at the destination with lowest routing overheads.

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