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Performance Comparison of Distributed Routing Algorithms in Ad Hoc Mobile Networks

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Abstract: - Wireless networks can be classified in two types: infrastructured wireless networks and infrastructureless (ad hoc) wireless networks. Ad hoc networks are characterized by the need for efficient routing protocols. According to previous research, the Destination-Sequenced Distance-Vector (DSDV) routing protocol and the Ad Hoc On-Demand Distance Vector (AODV) routing protocol are two good representatives for each routing protocol category, Table-Driven category and On Demand category respectively. We compare via simulation their performance with respect to the pause time of nodes movement. We find which routing protocol is appropriate for certain network conditions. When the nodes move continually then AODV seems to be better than DSDV. When nodes stay unmoving for a long time then DSDV is preferable.

Key-words: **-**Ad Hoc, Mobile Networks, Network Management, Performance Evaluation, Routing**.**

1 Introduction

Since their appearance in the '70's, the wireless networks have increasingly become more and more popular. This became quite noticeable in the course of the previous decade when the wireless networks managed to support the mobility of nodes. There are two categories of mobile wireless networks. The first category is known as infrastructured network and it maintains constant connections with the gates via cables. The access of terminals in these networks is made possible via concrete points of access, which are known as base stations. Wireless local area networks (WLANs) belong to this category.

The second category of mobile wireless networks is the infrastructureless (not structured) wireless network, also known as wireless mobile ad hoc network – **MANET** [1, 2]. The infrastructureless networks have no fixed router, so all nodes are capable of moving and are dynamically connected in an arbitrary way. Nodes of these networks function as routers themselves discovering and maintaining the paths to other nodes in the network. Such networks are particularly useful in cases where there is not fixed network structure. The nodes of a wireless mobile ad hoc network are equipped with wireless devices for sending and receiving signals and use aerials for broadcasting, multicasting, or a combination of the above.

2 Classification Of Ad Hoc Routing Protocols

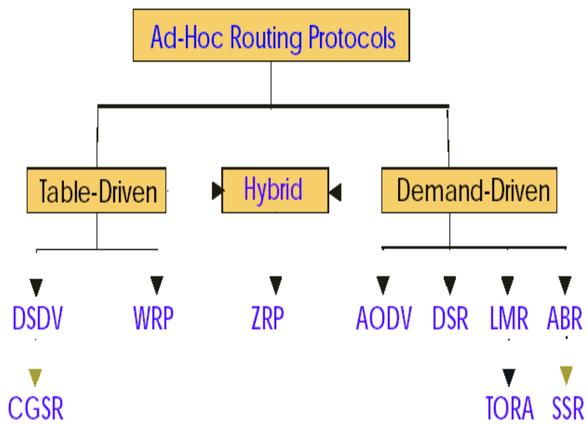

Fig. 1 Classification of Ad hoc Routing Protocols [12]

The routing protocols for ad hoc networks have been classified into two categories: table-driven protocols and on-demand protocols. They differ from each other on the way they obtain the routing information. The table driven protocols usually maintain the routing table of the whole network whereas the on-demand protocols only try to keep routes on need to know bases.

The DSDV (Destination-Sequenced Distance-Vector) routing protocol is an algorithm that is based on routing tables and on the classic routing mechanism of Bellman-Ford [8]. We select DSDV algorithm as the "representative" of the Table-Driven protocols because it maintains a loop-free, fewest-hop (resulting to the creation of fewer forwarded packets) path to every destination in the network. DSDV prevents loops because of the sequence number, which gives the ability to the network to distinguish stale routes from new ones. So this protocol achieves low routing overhead and low packet delay. Routing information is exchanged when significant new information is available, for instance, when the neighbourhood of a node changes.

We select AODV algorithm because on the contrary to other On-Demand protocols, it supports unicast and multicast (support multi-party wireless communications) packet transmissions. None of the other On-Demand algorithms incorporate multicast communication. It also appears to achieve the lowest Routing Overhead from all other protocols in its category in accordance with other papers. AODV also contains mechanisms that help to select the least congested route. Its main advantage that counted in our choice is that the overhead of DSR [3] and TORA (temporally Ordered Routing Algorithm) is potentially larger than that of AODV since each DSR and TORA packet must carry full routing information, whereas in AODV packets only the destination address is contained.

3 Previous Work

Most previous work on routing protocols for ad hoc networks analyses the performance of only a single algorithm. The performance of the DSDV routing protocol, which is one the most famous routing protocols for multi-hop ad hoc networks, is analysed in [11]. Its Packet Delivery Fraction (PDF) and Routing Overhead are evaluated. No comparison is made to other routing protocols. ZRP (Zone Routing Protocol) is described and demonstrated in [10]. This protocol is suitable for highly versatile networks, characterized by a large range of nodal mobility and large network diameters according to the related paper. AODV-UU [12] differs from others since it is exclusively for Linux. DSDV and AODV appear to be the most appropriate routing algorithms for small networks with few nodes. They achieve high PDF (Packet Delivery Fraction), low Routing Overhead and low Average Delay. They are efficient algorithms because they can easily find routes that approach the optimal routes.

Comparisons among the routing algorithms in ad hoc mobile networks are very difficult to be done because the advantages for one protocol constitute disadvantages for others. [7] considers Packet Delivery Fraction (PDF) and Routing Overhead, as the main performance metrics for DSDV, AODV and DSR without measuring the Average Delay Time. However, they do not suggest the most appropriate routing algorithms for different network conditions. In this paper, we provide an extensive comparison of DSDV and AODV under various network situations.

4 Simulation Model And Performance Results

4.1 Movement and Communication Scenario

Most simulations use a file that describes the movement scenario of nodes. We carefully edit scenario files so that all the different network situations would be extensively simulated. The drawing of a movement scenario file's name is as follows:

scen-LengthxWidth-Nodes-PauseTime-MaxSpeed

where Length and Width are the size of the simulation area, where the mobile nodes are allowed to move to all directions. Nodes are the number of mobile nodes in the simulation, PauseTime is the pause time between successive movements of nodes and it is measured in seconds and MaxSpeed is the maximum speed of the nodes' movement. The change of any of the parameters of the simulations will influence the delivery of packets from a mobile node to a destination node, using routing protocols. All these parameters are supplied in the simulations by movement scenario files. For example, the file **scen-670x670-30-20-20**, is a movement scenario file with the following parameters: **Length** = 670m, **Width** = 670m, **Nodes** = 30, **PauseTime** = 20sec. and **MaxSpeed** = 20m/sec.

In order to make the treatment of extensive simulations easier, we create a file that describes the communication scenario of a particular simulation. The name of this file is as the following:

cbr-Nodes-Seed-MaxConnection-TransmissionRate

where Nodes is the number of mobile nodes in simulation, Seed is the accidental number that it produces seed, MaxConnection is the maximum number of connections are realised in simulation time and TransmissionRate is the rate of packets' transmission. This rate is the number of packets that are transmitted by the mobile nodes (senders) in each second. For example, file **30cbr--1-8-4**, is a communication scenario file with the following parameters: **Nodes** = 30, **Seed** = 1, **MaxConnection** = 8 and **TransmissionRate** = 4.

Below we see in NAM (Network Animator), which is the graphical representation of NS-2 for simulations, an example with a movement and a communication scenario with the following configuration:

***Movement scenario**: Nodes: 30, pause time: 10.00 sec, max speed: 20.00 m/sec simulation time: 200 sec. max x = 670.00m, max y: 670.00m*
***Communication Scenario** : Nodes: 30, max conn: 8, send rate: 4.0, seed: 1*

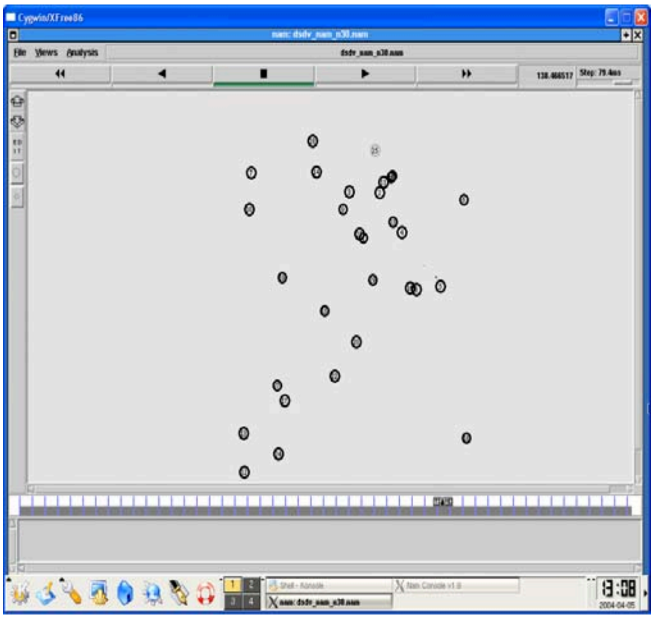

Fig. 2 The Network Animator that shows the above Movement and Communication Scenarios

4.1 Performance Metrics

In this paper, we compare via simulation the performance of the DSDV and AODV routing protocols under certain network conditions [9]. We use the NS-2 simulator. We evaluate these routing protocols according to the following performance measurements:

a) **Packet Delivery Fraction (PDF)**: This measurement shows the percentage of successfully delivered packets. The larger this percentage the more efficient the ad hoc routing will be. It is the fraction between the number of packets sent by CBR and TCP sources and the number of received packets by the CBR or TCP sink at destination [4,5].

b) **Rate of Forwarded/Sent packets (Routing Overhead):** Routing Overhead is actually the percentage of sent packets that are required to reach the destination mobile node. Since a forwarded packet incurs big costs in ad hoc networks, our objective is to minimize the above percentage as much as possible [6].

c) **Average Delay time:** It is the average delay between the time when a data packet is given to the source node and the time when the packet arrives at the destination node. It is associated with Routing Overhead. Reducing the routing overhead, it naturally would lead to better packet delivery times [4].

We also used different movement and communication scenarios in order to reach certain useful conclusions. These scenarios include different ways of wireless nodes' movement and different traffic load. The movement scenario files that were created are:

Mobile Networks with 4 mobile nodes, with different pause time of nodes' movement such as 0, 10, 20, 30 and 90 seconds, maximum speed: 20m/sec, topology limit: 670X670 meters and simulation time: 100 seconds. When the pause time is 0 seconds, the nodes move constantly. In contrast, when the pause time is 90 seconds the nodes move a little.

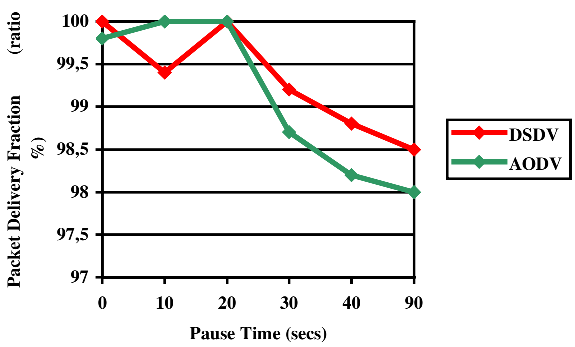

Fig. 3 Packet Delivery Fraction Metric for variable Pause Time

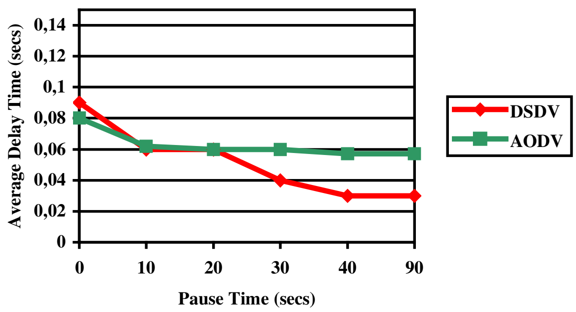

Fig. 4 Average Delay Time for variable Pause Time

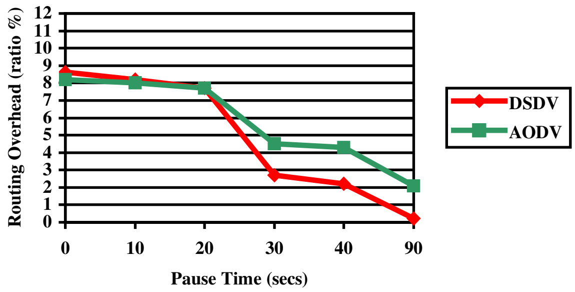

Fig. 5 Routing Overhead Metric for variable Pause Time

In the above figures, which are the results of our simulations, we can notice the performance metrics of the two routing algorithms when the pause time of nodes' movement is varying. First of all when the pause time is 0 sec, we observe that AODV algorithm causes the creation of more packets than DSDV. On the other hand, AODV achieves smaller average delay than DSDV. Finally, for the Routing Overhead we observe high values with AODV having the lowest. So we prefer AODV for this network because Routing Overhead and Average Delay Time are lower than those of DSDV. When the pause time increases (10, 20, 30, 40 and 90 secs), we notice that there is an important difference in performance between DSDV and AODV because DSDV produces larger PDF values, lower Routing Overhead and lower Average Delay Time. These metrics make DSDV more appropriate routing protocol than AODV. Finally we observe that there is a great difference in Routing Overhead. This is caused by the creation and the forwarding of many packets (forwarded packets) in order to reach the destination node. So AODV presents higher values of Routing Overhead because it creates forwarded packets and as a result we will possibly have congestion in our network. Deductively, AODV algorithm is a more efficient routing protocol than DSDV, when the pause time of nodes' movement is small. When the nodes stay unmoving for a long time, DSDV is preferable.

5 Conclusions

The above analysis makes obvious that routing is a very important but difficult problem in networks. Traditional routing algorithms cannot satisfy the requirements of an ad hoc network, because of the dynamic topology and the limited bandwidth that characterize these networks. For this reason there is a lot of research that deal with the extension of the existing routing algorithms or with the discovery of new and more efficient routing algorithms.

In this paper, we evaluate and compare two routing algorithms, AODV and DSDV, using the Network Simulator-2 (NS-2). We selected the DSDV routing as the "representative" of the Table-Driven protocols because it maintains a loop-free fewest-hop, which means the creation of fewer forwarded packets, path to every destination in the network. DSDV achieves a low Routing Overhead and low Average Delay. We selected AODV as the second algorithm for our comparisons because it supports unicast and multicast packet transmissions and it achieves the lowest Routing Overhead from other protocols in its category. AODV also contains mechanisms that help to select the least congested route instead of the shortest route.

While it is not clear that any particular algorithm or class of algorithm is the best for all network conditions, each protocol has definite advantages and disadvantages and has certain situations for which it is well suited. Deductively, AODV algorithm is a more efficient routing protocol than DSDV, when the pause time of nodes' movement is small. When the nodes stay unmoving for a long time, DSDV is preferable.

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