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Performance Analysis Of Ad-Hoc Mobile Network

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ABSTRACT

As a new generation of wireless communication systems ah-hoc mobile network has expanded significantly over the last ten years. With its high mobility, dynamic topology, self-organizing and other unique features it is widely used in emergency operations, disaster assistance and military networks. At the same time this new wireless network has many technical problems and its potential benefits should be discovered and developed. Undoubtedly, we will see the expansion of ad-hoc network in the nearest future. In this paper we analyze performance of the ad-hoc network with routing protocols on demand of AODV, DSR and TORA. The work of the network is emulated and compared in simulated small networks using the OPNET Modeler software to analyze the differences in their characteristics.

INTRODUCTION

The ad-hoc mobile network is a technology developed over the last 20 years mainly through research funded by the US government. There are several synonyms of this term - Mobile Packet Radio Networking (the term from early military research in the 70's and 80's), Mobile Mesh Networking (the term appeared in The Economist article on the structure of future military networks) and Mobile Multihop Wireless Networking (perhaps the most accurate term, albeit a little cumbersome). In the mid-1990's, within the framework of the Internet Engineering Task Force (IETF), a Mobile Ad-Hoc Networking working group was created to standardize routing protocols for special networks. The development of routing in the workgroup and in the larger community has led to the creation of reactive and proactive routing protocols. As a new technology for information collection the ad-hoc mobile network has a high research value and wide prospects for use. Due to its mobility, dynamic topology, equivalence, self-organization and other unique functions it has great advantages in emergency communication and military mobile communication (Mueller, S., *et al*., 2004; Humayun, B., 2005).

Routing is one of the main problems in the ad-hoc mobile network. An efficient routing mechanism will be useful for its successful deployment. Three existing proactive routing protocols (AODV, DSR, TORA) are considered, including their algorithms, terminology, message format and workflow (Anne, A. and W. Jie, 2001; Haitao, W. and Z. Shaoren, 2002). The main purpose of this article is an attempt to compare the performance of these three protocols in emulated small networks based on the OPNET Modeler software (Ming, C., 2004; Wenbo, W. and Z. Jinwen, 2003).

1 Emulation based on OPNET:

1.1 Estimate options:

The commonly used performance indicators in the ad-hoc network are as follows:

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Load:

represents all control packets sent by nodes on the network to detect and maintain a route during emulation. The load capability can be used to compare scalability, efficiency and competence in adapting network congestion in different networks. Routing protocols with a large load capability have a high probability of packet collisions and delays.

Average delay:

this indicator refers to the average delay time of the packet going from the source node to the target node. It includes a buffer delay in route detection, a send delay at the MAC level and a transmission time.

Route detection time:

it refers to the entire detection time after the node receives a response.

Bandwidth:

this is the total number of accumulated bits that all destination nodes received at the MANET station.

Number of jumps along the route:

this is the number of jumps of each source node for each destination node in the network.

Routing of send and receive traffic:

it refers to the total number of sent and received packets in the entire network.

FTP Time Response Time:

The response time at which the application layer receives a response after sending a request to the server at boot time.

FTP upload response time:

response time at which the application layer receives a response at boot time.

1.2 Analysis:

We chose different estimates according to different emulation models with the protocols AODV, TORA and DSR (Subir, K. and C.S. Das, 2002; Varun, G, *et al*., 2013).

1.2.1 DSR:

Two emulations of ad-hoc networks with 50 nodes and 100 nodes were created in accordance with the DSR routing protocol. These nodes were located in the area 10×10 km. Both networks performed an FTP service, the emulation time was one hour. As the parameters were used routing traffic sent and received, route discovery time, number of jumps in the route.

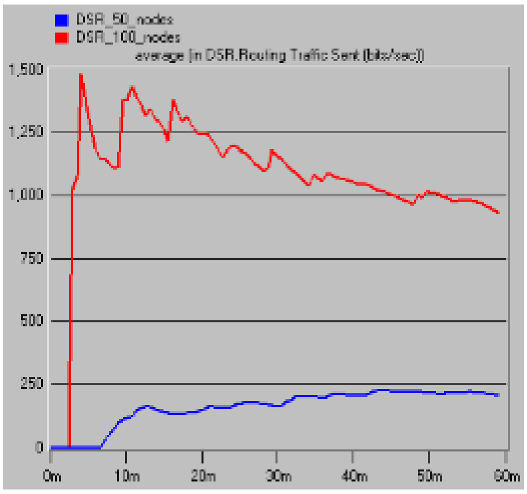

Fig. 1:

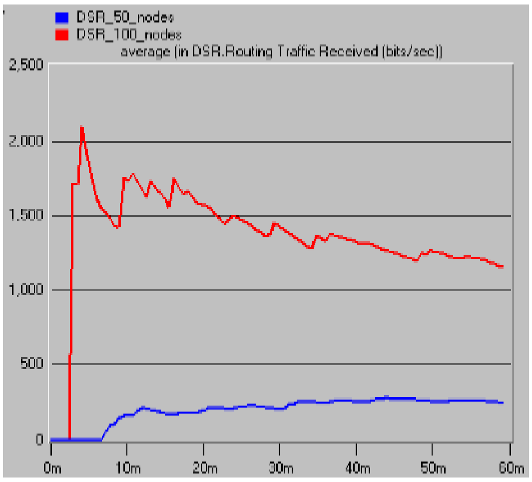

Fig. 2:

Fig. 1 and 2 shows that with increasing number of nodes, the number of packets sent and received increases as well. This is due to the fact that in a network that has 100 nodes the number of its neighboring nodes for each node is greater than in a network with 50 nodes. Therefore, when sending routing information, each node must send more packets to its neighboring nodes on the previous network. The same happens with the received packets.

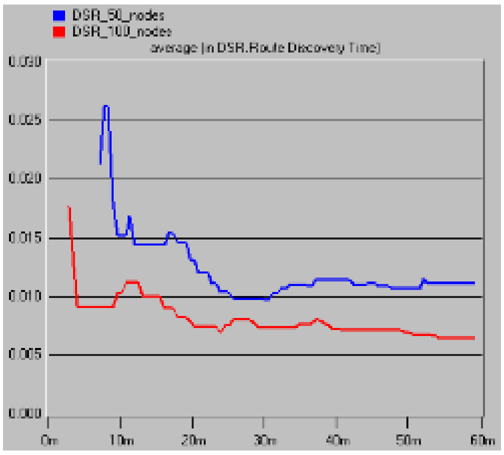

Fig. 3:

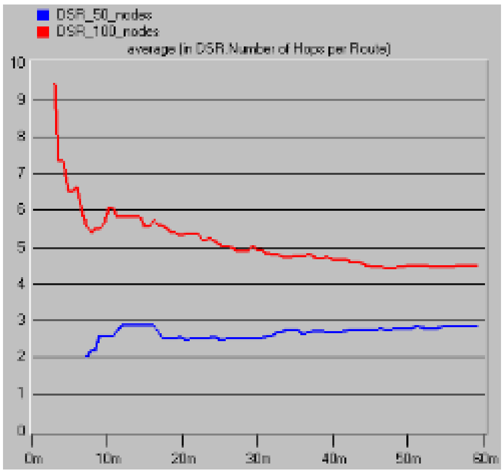

Fig. 4:

Fig. 3 shows that regardless of the number of nodes the route discovery time is relatively long at the beginning of the emulation, since there is no route information in the cache. After a lapse of time the detection time gradually decreases and then becomes equalized. The reason for this is that the DSR uses caching mechanisms that can store known node routing information to shorten the detection time.

Fig. 4 shows the number of transitions per route reaches 9 times in a network with 100 nodes in the first 5 minutes. When the emulation is just beginning the best route has not yet been found, so the number of transitions is quite large. As the working time increases, the number of transitions slowly becomes stable by approx. 4-5 times. However, due to the smaller number of nodes, in the network with 50 nodes the average range of transitions is from 2 to 3 transitions.

1.2.2 TORA:

Similarly, we created two emulations of ad-hoc networks with 50 nodes and 100 nodes respectively with the TORA routing protocol. These nodes were located in the area 10×10 km. Both networks performed an FTP service and the emulation time was one hour. In this case we used the wireless LAN load and the IMEP traffic sent and received as indicators.

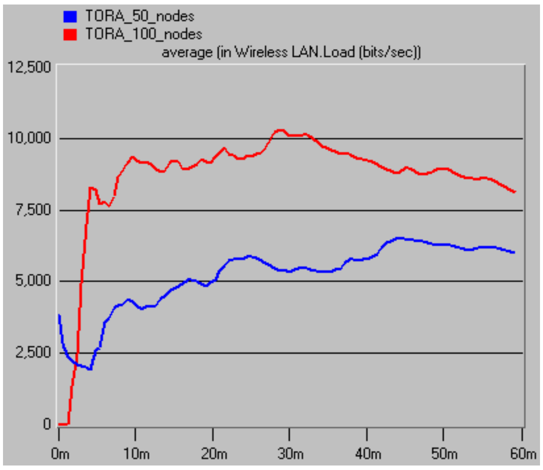

Fig. 5:

Fig. 5 shows that at first the capacity of the load in both networks is small. As time passes, linear patterns grow explicitly at the same speed. The more nodes, the more network routing can be loaded. As a result, in a network with 100 nodes it is almost twice as large as in a 50-nodes network.

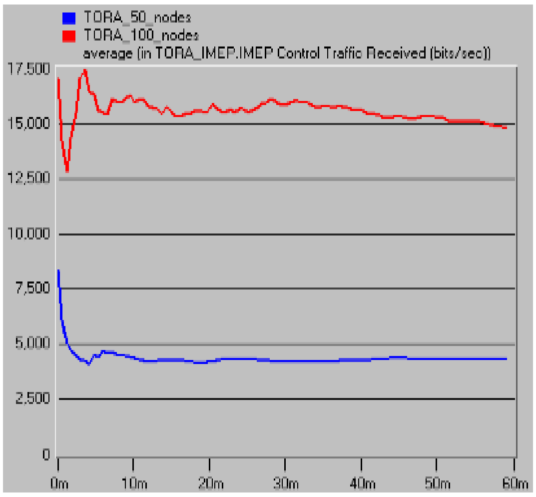

Fig. 6:

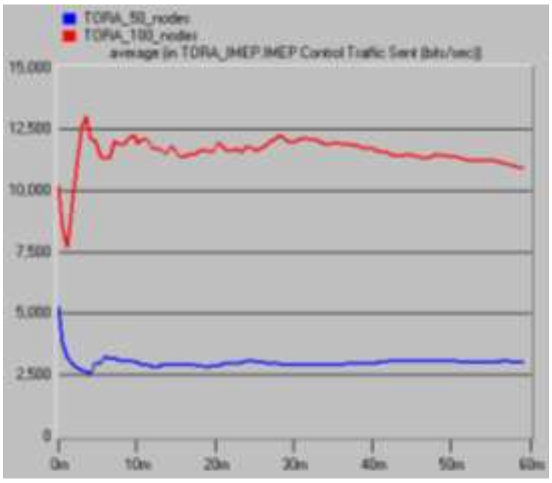

Fig. 7:

Fig. 6 and 7 show that IMEP traffic on a 100-node network is more than twice higher, than the IMEP traffic in a 50-node network. Likewise, having more nodes on the network means that each node has more recipients for sending packets and also gets more information about routing from its neighboring nodes.

1.2.3 AODV:

In this section, we made three different scenarios with the AODV routing protocol. Each of them consists of 50 nodes distributed in the area of 10×10 km.

Table 1: Settings in different scenarios

Settings	Scenario I	Scenario II	Scenario III
Excess route response	OFF	ON	OFF
Active route time	3 sec.	30 sec.	30sec.
Hello interval	Uniform (1,1,1)	Uniform (10,10,1)	Uniform (10,10,1)
Allowed Hello Loss	2	10	10
TTL-parameter: TTL start	1	2	2

TTL is the real-time value in an IP protocol packet that tells the network router whether the packet was too long and whether it should be discarded. For a number of reasons packets may not be delivered to their destination within a reasonable amount of time. For example, a combination of incorrect routing tables can lead to an infinite loop of the packet. The solution is to drop the packet after a certain time and send a message to the sender that can decide whether to resend the packet.

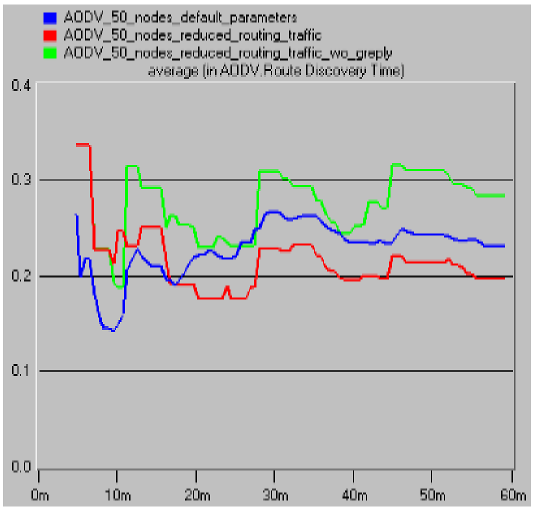

Fig. 8:

Fig. 8, shows, that regardless of the scenario, it took a relatively long time to discover the route. Due to the on-demand property, it is difficult to find a suitable route to the destination node. In addition, the creation of a

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routing table also requires time for the AODV routing protocol. Once the routing table is established, the route discovery time, therefore, decreases. In comparison with the first scenario, the allowed redundant route is the reason why the second scenario has the shortest detection time. In contrast, although the third scenario disabled the redundant re-routing as the first in the first scenario, its longer timeout, large losses of Hello Packet and a larger TTL value resulted in the longest average route discovery time in the three scenarios.

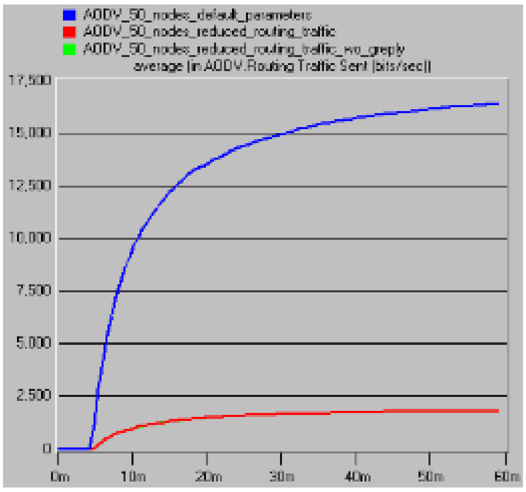

Fig. 9:

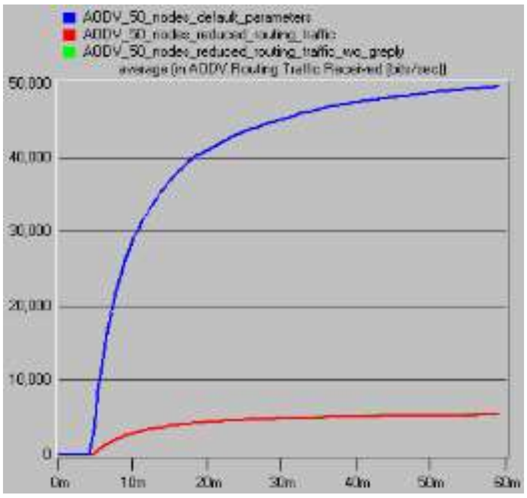

Fig. 10:

Figures 9 and 10 show the routing traffic of three scenarios. The same number of bits was sent and received in scenarios II and III on the graph as the two lines coincide. This is due to the fact that they have the same unit for the hello interval and the TTL value. The reason the network in scenario I has greater traffic is because it has a much shorter packet interval and packet waiting time.

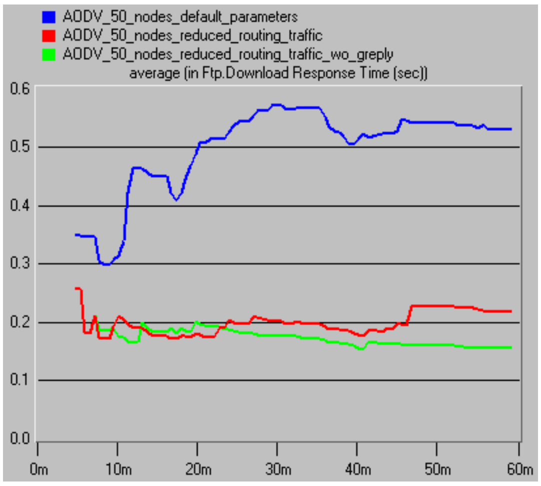

Fig. 11:

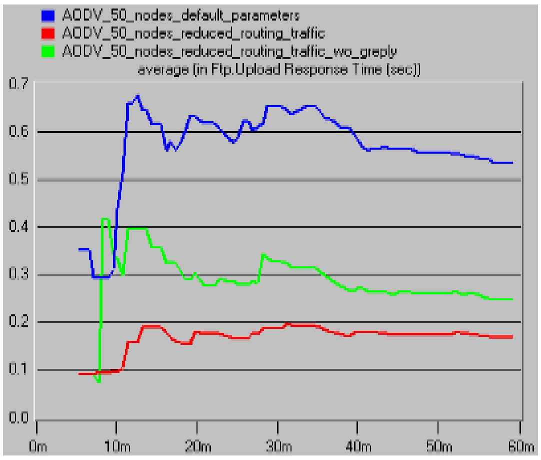

Fig. 12:

In Fig. 11 and 12 it is clearly seen that scenario II has a shorter load and load response time than the scenario I. We attribute this to the increased TTL starting value, the longer active route timeout and the activated redundant route recurrence. Also we see a similar model of load response time in scenarios II and III, but the load response time varies. Since redundant re-use of the route is disabled, the server needs to find an intermediate node response by running its own route.

1.2.4 Comparing the performance of the three protocols:

To compare the merits and demerits of each protocol, we create three scenarios with DSR, TORA and AODV, respectively. Each network has 50 nodes in the area of 10×10 km and the FTP service is on. In addition, we use the default settings and settings with each protocol in each network.

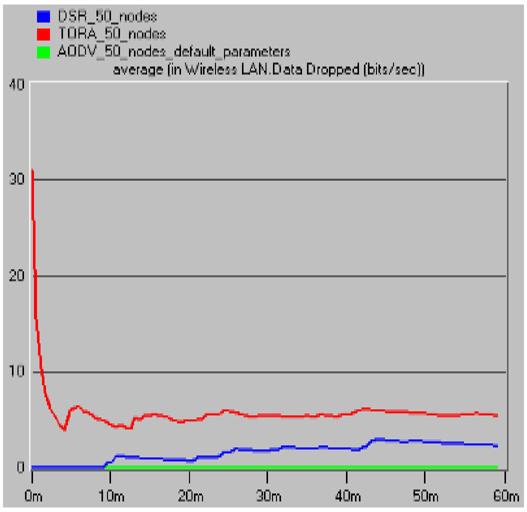

Fig. 13:

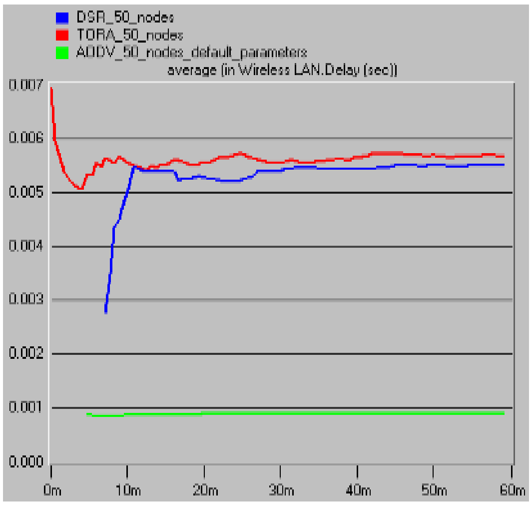

Fig. 14:

As can be seen from Fig. 13, in general, the amount of data loss is relatively small in the three networks. This is due to the fact that these three protocols are known as an on-demand routing protocol, so there will be no problems with additional transmission of routing information. Because TORA has issued a large number of traffic management messages that the network can not host, it loses more data than the other two protocols. From the point of view of the DSR network scenario, this protocol is excessively dependent on the route cache. When you encounter multi-hop routing, the DSR network selects the shortest route, and not the newest one, which may already be invalid. As a result, the wrong route will lead to incorrect information leading to data loss. Consequently, the DSR has a second level of data loss greater than AODV and less than TORA.

In Fig. 14 indicates that TORA has the longest delay and AODV has the smallest value. This is due to the fact that the TORA mechanism requires that each node send least one Hello Packet, as well as the routing and the IMEP packet, that is used to create or maintain the route and provide data retransmission. This is the way the large number of control messages causes a long delay.

There are two reasons why AODV has much less latency than DSR. First, the DSR uses the route cache and source routing mode, which stores several route data to the target node from one node, whereas each node in the AODV contains only one valid route to the target node. In addition, it refers to each node with a serial number to avoid a cycle and update the routing table. Secondly, AODV uses a shorter time to create a route than the DSR.

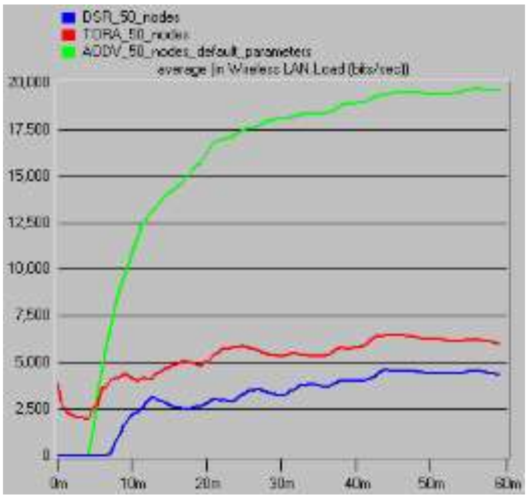

Fig. 15:

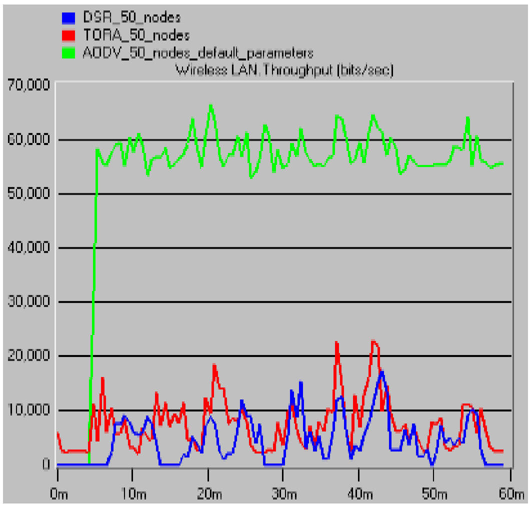

Fig. 16:

Fig. 15 shows the capacity of the three protocols. It seems that DSR has the lightest load. Source routing packets form part of the network load, so there is limited space for other packet transfers. However, TORA provides several routes and sends more control messages, therefore it has a greater load than DSR. It is believed that AODV has a much greater load than the other two, because it consumes less resources when picking up a channel.

Similarly, due to the DSR routing cache and the source routing mechanism, route discovery and maintenance can be intermittent depending on the situation. Also there is no periodic broadcasting. If the message is not sent, the traffic on the network can be zero. Thus, the DSR has the lowest bandwidth. TORA provides several routes for data transmission, so it has better transfer speed and load. AODV uses a routing table and a serial number mechanism to prevent a cycle. This algorithm has the highest throughput due to its fast speed with the creation of a route and the restoration of a broken link.

2 Conclusion and prospects:

2.1 Assessment:

I.TORA

Benefits:

1) It supports multiple routes for any source or destination pair. A failure or removal of one node is quickly resolved without source intervention by switching to an alternative route (Xiaoyan, H., *et al*., 2002).

2) It has good distribution algorithms that make it highly adaptive in a dynamic network.

Disadvantages:

1) It uses synchronized clocks between nodes on the network. Although the external time sources are present (for example, GPS), this makes the hardware more expensive and introduces one point of failure if the time source becomes unavailable.

2) TORA also depends on the intermediate lower levels for certain functions. It involves such things as finding neighbors, determining the status of the channel, resolving the address and delivering the packets in order. As a result, you must run IMEP at a level below TORA. This makes it difficult to disable the overhead for this protocol from the imposed required lower level.

II. DSR:

Benefits:

1) Caching any eavesdropped or initiated routing information can significantly reduce the number of control messages sent, which will reduce the overhead.

2) Because the entire route is contained in the packet header, the routing tables should not be stored for routing of this packet. This saves electricity and bandwidth, because there are no communication costs in the network.

Disadvantages:

1) DSR does not scale for large networks, because Internet-Drafts in the IETF confirm, that the protocol assumes that the network diameter does not exceed 10 transitions.

2) Information on several routes in the cache will sometimes affect the accuracy of the choice of routing.

3) Much more processing resources are required than in the other protocols. To obtain information about routing, each node must spend much more time processing any control data that it receives, even if it is not the intended recipient.

III. AODV:

Advantages:

1) One of the advantages of AODV is that its use of destination numbers and responses to the first arriving RREQ implies that AODV prefers the least overloaded route instead of the shortest route.

2) The use of the hello protocol gives more knowledge about the network and can improve the route discovery process.

3) AODV is a modification of the distance vector algorithm in the sequence (DSDV). This idea is simple and clear to people.

4) Another advantage is that the developed standard supports both unicast and multicast packets.

Finally, although the three protocols have their advantages and disadvantages, it is evident from the comparison in the above figures that AODV is the more efficient protocol that is best suited for conventional ad-hoc mobile networks, since it consumes less bandwidth and reduces overhead compared with the other two protocols.

Due to the limited time and complexity of the network modeling process, only three protocols are presented in this article. Although it is not clear that any particular algorithm or algorithm class is best for all scenarios, each protocol has certain advantages and disadvantages and is well suited for certain situations.

Conclusions:

Unlike fixed wireless networks, the existing Internet protocols are insufficient to meet the operational requirements of ad-hoc networks. This new art of network formation has many potential benefits and can change the whole handiness of wireless communication. The field of special mobile networks is growing rapidly and changing. There are still many problems that need to be addressed and the lack of effective strategies for managing various network management elements is one of them. However, in the light of current efforts and growing interest in the ad-hoc mobile network, we are not far from such networks being widely used in the nearest future (Phone Lin, Wei-Ru, G. Chai-Hien, 2004).

In this article the performance indicators in the ad-hoc network with routing protocols on demand of AODV, DSR and TORA were considered. The network performance in simulated small networks using the OPNET Modeler software is emulated and compared.

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