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A study on routing protocols behaviour in MANETs

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Abstract- An issue of prime importance in MANET research is efficient routing. MANET performance is sensitive to mobility, traffic load and scalability. An important aspect is whether varying the topology, network size, node speed and traffic load will improve the performance of the protocols. This research aims to identify the effect that the choice of different network topology models has on the performance of MANET routing protocols, based on certain selected parameters.

Index terms- MANET, routing protocols, mobility models, access delay, retransmission attempts, data drop.

1. INTRODUCTION

A temporary network formed by a collection of wireless mobile nodes, without the aid of base stations or any other pre-existing network infrastructure, is termed as a Mobile Ad hoc Network (MANET)., Each constituent node acts both as a router and node, thus eliminating the need for access points. The nodes forming the network may rarely be in a stationary state which causes constant change in network topology. This brings up the problem of link instability, which thus becomes an important consideration for ensuring proper data transfer.

Routing protocols are the algorithms responsible for establishing and maintaining communication among network nodes. For mobile ad-hoc networks, various types of routing protocols that have been designed, differ in terms of the approach they adopt to establish routes for communication. The method by which the topology change information is distributed across the network and the number of necessary routing-related tables is different for each type of protocol. The protocols are divided among these main categories: table-driven, on-demand and hybrid.

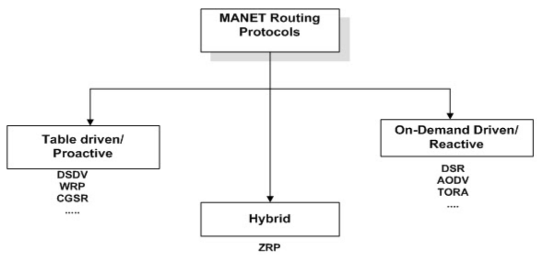

Fig 1. MANET Routing Protocols

In table-driven routing protocols, each node maintains one or more tables containing routing information to every other node in the network. All nodes update these tables so as to maintain a consistent and up-to-date view of the network. When the network topology changes the nodes propagate update messages throughout the network in order to maintain consistent and up-to-date routing information about the whole network.

The on-demand routing protocols take a lazy approach to routing. In contrast to table-driven routing protocols all up-to-date routes are not maintained at every node, instead the routes are created as and when required. When a source wants to send to a destination, it invokes the route discovery mechanisms to find the path to the destination. The route remains valid till the destination is reachable or until the route is no longer needed.

In hybrid routing protocols, every node acts reactively in the region close to its proximity and proactively outside of that region. Initially, the route is established with some previously setup routes, then as and how the demand arises, additional activated nodes are activated through reactive flooding.

The design of these protocols is subject to various requirements such as: need for constant maintenance of routing information acquired, limited availability of power, lack of a central governing authority, type of network topology present at a point. This last requirement has been met by the different mobility models that have been proposed. Mobility models serve to define the motion of mobile nodes, based on the variation in speed and direction which occurs in definite time intervals, which is otherwise hard to describe in accordance with the real-time user mobility pattern.

The task performed in this work, of evaluation of the behaviour of routing protocols based on three specific criteria, revolves around two types of mobility models created for MANETs, namely vector mobility model and random waypoint mobility model.

The Random waypoint model assumes the position of each node randomly chosen within an area. The node moves to a definite position linearly with any random velocity, valued as a uniformly distributed variable between the maximum and minimum values, up until pause time before starting to move again. The pause time measure is set at model initialization. These steps execute continually as long as simulation is made to take place. On the other hand, the Vector mobility model makes use of the values of present mobility parameters to determine the state of nodes at successive instants of time. Small variations are made to the existing conditions defining the mobility state, to obtain the subsequent positions of mobile nodes. This results in production of motion patterns closely approximating real-life scenarios.

Theoretically, vector mobility model has several advantages over random waypoint model in that it is more conveniently implemented and makes the generation of position information less complicated than the latter. Other than that, the random waypoint mobility model fails to account for some basic anomalies in the representation of communication in the ad-hoc network, such that the motion of nodes as described by the model does not resemble their actual behaviour. While in reality, the nodes move about with gradually changing velocities and under effect of the positions of the neighbouring nodes, the model denotes that the velocities and positions of nodes are independent of the previous states of nodes.

A routing protocol is chosen from each of the three categories mentioned earlier, to find out the behaviour that each type of protocol exhibits under specific criteria. The protocols studied here are the optimized link-state routing protocol (OLSR), ad-hoc on-demand distance vector protocol (AODV) and gathering-based routing protocol (GRP).

2. ORGANIZATION OF THE PAPER

The remainder of the paper consists of mention of the work which served as the background for the present research, followed by a detailed description of the experimentation carried out for the study. Afterwards, the results obtained are analysed and conclusions are provided as an end-result of the work, alongwith the scope for future work in this direction.

3. BACKGROUND

The performance of various MANET routing protocols has been studied earlier considering different network conditions such as traffic type, parameters, network size and by using different simulators. The study presented in this paper focuses on the impact of mobility models on the performance of routing protocols. Similar research has previously been done, taking into account parameters such as throughput, end-to-end delay and network load as performance metrics by Sohajdeep et al. It was observed that for the above mentioned metrics, the table-driven protocol OLSR gives the best performance for a network simulated according to the vector mobility model.

In this paper, the analysis is taken to a further stage by choosing the following criteria for study of the behaviour of protocols: media access delay, retransmission attempts and data drop rate.

4. EXPERIMENTATION

4.1 *Criteria for evaluation of performance*

The right choice of performance evaluation criteria for the characterization of wireless Ad-Hoc network is one of the key requirements for the effective design of high performance network. The chosen MANET Performance Evaluation Metrics are as follow:

4.1.1 Media Access Delay

This represents the global statistic for the total of queuing and contention delays of the data. We measure access delay as the time from when the data reaches the MAC layer until it is successfully transmitted out on the wireless medium. The reason for studying average access delay is that many real-time applications have a maximum tolerable delay, after which the data will be useless. Therefore, it is important to provide low delay for real-time flows. The efficient network can transmit data easily with low delay time. High delay affects the MANET routing packets and slows down the delivery of packets for reaching to the channel, and it results in increasing the collisions of these control packets. Thus, routing packets may encounter bottlenecks, increase dropped packets and thus lower the overall network performance.

4.1.2 Retransmission Attempts

It is defined as the number of times a source node tries to send the data over the network to meet the QOS levels. Retransmission means that precious bandwidth and other network resources are being used to try resending the data thus can cause delays for other nodes which contest to send out the data. Because these delays cause other stations that are sending to collide as well, there is a possibility that, on a busy network, hundreds of nodes may be caught in a single collision set. Because of this possibility, the process is aborted after a predetermined number of attempts at transmission. Due to the mobile nature of the network, such situations can actually have much more negative impact on the network performance as compared to a similar situation in fixed networks.

4.1.3 Data Drop Rate

When content arrives for a sustained period at a given router or network segment at a rate greater than it is possible to send through, then there is no other option than to drop packets. Most nodes can buffer, or store, data and give every device attempting to send data an equal chance to get to the destination. Packet loss can be caused by a number of other factors that can corrupt or lose packets in transit, such as radio signals that are too weak due to distance or multi-path fading (in radio transmission), faulty networking hardware, or faulty network drivers. Packets are also intentionally dropped by normal routing routines (such as Dynamic Source Routing in ad hoc networks) and through network dissuasion technique for operational management purposes. Recovering from dropped network packets results in large performance degradation. In addition to the time spent determining the data that was dropped, the retransmission uses network bandwidth that could otherwise be used for current transactions.

4.2 *Experimental Setup*

The network activity is simulated and studied under the following conditions and with the help of below-mentioned tools:

1. Simulation software – OPNET, version 14.5
2. Number of MANET nodes – 50
3. Type of data-traffic – HTTP
4. Wireless LAN – 802.11
5. Data rate – 11 Mbps
6. Simulation time per case – 5 minutes

4.3 *Implementation stage*

Corresponding to each of the criteria chosen for study of performance of protocols, three distinct cases exist. All three are realized for an ad-hoc network with a node density of 50.

4.3.1 Simulation and observations

The simulation of the above mentioned scenarios is conducted in two phases. In the first phase, the number of nodes is fixed to twenty-five. The results are obtained on the basis of three parameters: Throughput, Network Load and Delay. In the next phase, to investigate the performance of routing protocols by varying node mobility i.e. density and pause time in random waypoint and vector mobility models; the number of nodes is then increased to 50. Doing so would help in ascertaining the performance of the given protocols in both the mobility models (RWP and VMM). Also, this approach would clearly show the impact of variations in the node density and speed of nodes on the performance of MANET routing protocols.

<u>Media access delay</u>**:** It is the duration of time from when the data reaches the MAC layer until it is successfully transmitted out on the wireless medium.

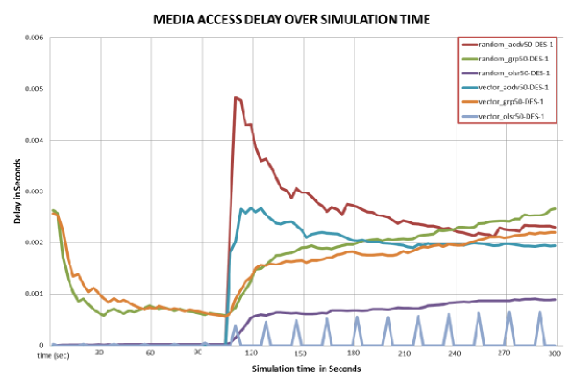

Fig 2. Comparative Media Access Delay for 50 nodes

With 50 nodes, OLSR protocol outperforms other protocols, since it presents the lowest media access delay. GRP and AODV have exhibit high delay values, with AODV leading the group with the highest access delay. The average value of Media Access delay shows that GRP protocol typically lies in–between the reactive and proactive protocol. As we dig deeper to understand the observed behaviour, we see that because of the highly dynamic nature of MANETs; there are frequent connection breakages. Hence, every time such a break occurs, new routes need to be found to transmit the data over the network. The proactive nature of OLSR implies that it would always have up-to-date routing information at hand, thus making route discovery quick whenever a path break is reported. Because AODV is a *reactive* protocol, a route discovery must be initiated. In situations where the network traffic is sporadic, OLSR offers less routing overhead due to having found the routes proactively. AODV and GRP on the other hand, will have to first discover a route before the actual information can be transmitted. Most control overhead in AODV and in GRP is related to route discovery, which is initiated when a path break occurs. In networks with low mobility, path breaks occurs less frequently, but in network with high mobility path breaks occurs most frequently making AODV and GRP perform worse. OLSR will perform best when the traffic is sporadic, that is, when the traffic can benefit from having found a route proactively. This follows from that the packet transmission delay is relatively small compared to running a route request protocol, as is done in AODV. Route maintenance is much better in OLSR as compared to AODV and GRP. The reduction in performance may be attributed to link breakage, which is more probable as the length of the route increases. In case of AODV and GRP re-establishment of new routes does not take place till there is a route table information packet coming from its neighbour nodes. But in case of OLSR, when route breakage takes place, packets are cached and route repair takes place. This improves the overall throughput of the system.

As goes the comparison between the mobility models, the media access delay is always higher in case of Random Waypoint mobility model as compared to Vector mobility model in all the three routing protocols. This is because of the randomness in motion and pause times in RWMM. Hence, we see that based on the Media Access delay parameter, the Vector mobility model is a better option.

<u>Retransmission attempts:</u> It is defined as the number of times a source node tries to send the data over the network to meet the QOS levels.

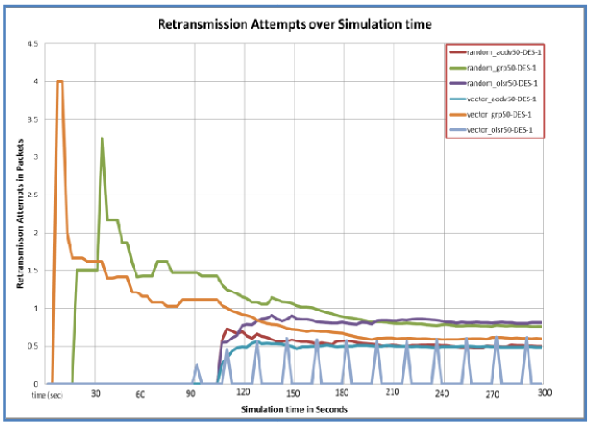

Fig 3. Comparative Retransmission attempts for 50 nodes.

Figure 3 shows the retransmission attempts index for a network of fifty nodes. The GRP protocol involves the greatest number of retransmission attempts in both types of mobility models. We see a peak in the number of retransmission attempts at the very beginning of simulation in GRP. This is explained by the tendency of GRP to transmit data to its immediate neighbours in a proactive manner and wait to see if the neighbours can transmit the data forward. As a node in GRP has only the routing information of its immediate neighbours, the nodes rely heavily on this initial interaction with their neighbours to ascertain if there is a chance to transmit particular sequence of bits before they can be dropped in order to allow other bits to flow. The performance of AODV and OLSR is almost similar. Both the reactive and proactive protocols have low allowance for retransmission and tend to drop data in favour of speedy transmission of data.

In almost all the cases, routing protocols in Random waypoint mobility model show more retransmission attempts as compared to Vector mobility model. The randomness in the behaviour of the nodes in the network makes it comparatively difficult to transmit data with reliability. the Vector mobility model is much more efficient in handling a larger amount of data and is more consistent of the two. Thus, Vector mobility model is more scalable and efficient than RWMM in time-crucial network setups (read real-time networks).

<u>Data drop rate</u>: After attempting a certain number of ties, the data needs to be dropped in favour of speed. This means a network with high data drop rate lays more importance on speediness and lesser importance on the consistency of data. It refers to the number of

packets of data that fail to reach the destination, for a specified time interval.

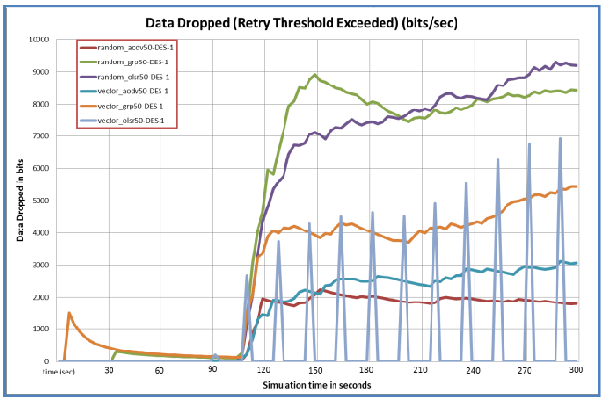

Fig 4. Comparative Data Drop Rate for 50 nodes

The AODV protocol shows the least data drop rates, with GRP and OLSR closely competing for the same. We observe that the OLSR eventually presents the highest data drop rate. This may be explained by the fact that OLSR, as a proactive protocol, has a faster processing at intermediate nodes. When a packet arrives at a node, it can immediately be forwarded or dropped because OLSR protocol proactively holds routes to all destinations in its table, regardless of topology changes. Hence we can say that in a highly mobile and consistently changing environment, the reliability of proactive protocols is questionable as there is a huge chance of data loss. On the other hand, in such environments, reactive protocols can provide a much more dependable communication. Given the fact that reactive protocols are cheaper to implement, in a network with large number of nodes and where consistency of data delivery is important, AODV presents itself as a viable alternative.

For all the routing protocols, data drop rates in random waypoint mobility are higher as compared to vector mobility because of unpredictable movement of the nodes in the network.

In reactive protocols, if there is no route to a destination, packets to that destination will be stored in a buffer while a route discovery is conducted (forwarded hop by hop). In other words, a route discovery process has to be activated, because AODV is a routing protocol that has no available route when needed. Because of inefficient route maintenance, delay is the largest for AODV. Accordingly as the network size is increased AODV shows more delay GRP, being a hybrid protocol, typically shows values of network load which lie in between the reactive and proactive protocols because of its initial on-demand nature.

5. CONCLUSIONS

The paper is a presentation of an analysis of the suitability of use of three types of routing protocols for mobile ad-hoc networks, under two different mobility models, to bring about efficient network performance. The conclusions derived from the experimental effort are summarized in the following points:

- The impact of mobility models is very evident on network performance as Vector Mobility model provides a more stable and efficient network performance as compared to Random waypoint mobility model in all the cases we explored in this paper.
- In terms of Media access delay, OLSR shows the best performance due to the routing tables it maintains. On a similar note, AODV shows ighest delays and thus has the lowest performance. Thus, if speediness of data transmission is the primary concern, the network should implement proactive protocols.
- In terms of Retransmission attempts, OLSR has the lowest number while the hybrid protocol GRP has the highest. Hence, if the purpose of the network is a more swift and speedy communication a table driven proactive protocol should be applied.
- Data drop rate is another aspect which needs to be considered for network performance. If reliable and secure communication is the primary purpose, the reactive protocol AODV should be used. On the other hand, if we can overlook data consistency and want to aim for speed of communication, the proactive protocol OLSR should be the choice.
- Hence we see that depending on what we aim to achieve from our network in terms of speed-reliability trade-off, a combination of different protocols as discussed above and vector mobility model should be applied.

6. SCOPE FOR FUTURE RESEARCH

Determination of suitable network arrangements, in terms of the routing protocols used and the mobility model implemented, can be further carried out by considering other parameters affecting network performance such as jitter, fault-tolerance, count of hops and power efficiency. Experimentation can be done on the same lines as those followed in this work, to come to a result pointing to the appropriate network configuration for the most efficient response.

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