Performance Analysis of MANET Routing Protocols over Different Mobility Models

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ABSTRACT:

This work is a simulation based comparison of three Mobile Ad Hoc Networks (MANETs) routing protocols – Destination Sequenced Distance Vector (DSDV), Ad hoc on demand Distance Vector (AODV) and Dynamic Source Routing (DSR). The comparison is based on their performance in some existing mobility models used in the simulation of MANETs. The mobility models used in this work are Random Waypoint, Manhattan Grid, Gauss-Markov, Reference Point Group and Heterogeneous Mobility Models. With detailed simulations of the protocols across these models, comparisons are made based on results obtained using known metrics for evaluating the protocols. Also, the protocols are compared under varied categories of disaster area scenarios modelled by a Heterogeneous mobility model. Across the models with respect to considered metrics for comparison, DSR outperformed others followed by AODV and then DSDV.

Keywords: Simulation based comparisons, MANET protocols, Protocols performance.

1. INTRODUCTION

Though the original motivation for research in the area of MANETs was geared towards military needs[1] its application today has evolved cutting across areas such as Emergency services (Search and Rescue, Disaster Recovery) and Educational applications (Conference rooms, meetings)[2]. According to [3], a MANET is defined as a collection of mobile platforms or nodes where each node is free to move about arbitrarily. In a broad sense a MANET consists of nodes in an *infrastructure-less* environment where every node can be seen as logically consisting of a router which could have multiple hosts possessing multiple wireless communication devices [1].

Extensive research with simulations has been carried out on the performance of MANET routing protocols using a mobility model. The most popular model has been the Random Waypoint mobility model [4, 5, 6, 7]. However this work seeks to provide an evaluation of existing MANET protocols over a number of mobility models providing a critical evaluation of their respective performances in these models. Part of our simulation considers different categories of disaster scenarios in terms of high/low mobility (movement), high/low traffic (packet rate) and the combination of both. Emphasis here is on comparing these selected routing protocols with respect to the mentioned categories of disaster scenarios. In Section 2 we provide brief explanations of related research works in this area highlighting the unique approach taken by us to evaluate these protocols. Section 3 provides explanations of the Ad Hoc routing protocols evaluated here while Section 4 gives an insight into the Mobility models used in this evaluation. In Section 5 we discuss details of the simulation with obtained results and Section 6 provides our conclusions drawn from the obtained results.

2. RELATED WORKS

Various research methodologies employed in this area involve the performance comparison of existing MANET protocols which are Distance-Sequenced Distance-Vector (DSDV) [11], Temporally-Ordered Routing Algorithm (TORA) [14], Dynamic Source Routing (DSR) [13] and Ad-hoc On-Demand Distance Vector (AODV) [12]. These methodologies have utilized the Random Waypoint Model as the underlying mobility model except in [5] where other models were taken into consideration. The comparative analysis of two on-demand routing protocols, AODV and DSR based on Packet Delivery Ratio (PDR), normalized routing overhead and end-to-end delay while varying the number of sources and pause time has been performed [8]. They observed that DSR performs better in terms of overhead and in terms of PDR when compared with AODV. A similar methodology with parameters involving models at the physical and data link layers has also been done [9]. The same conclusion was made. [5] evaluated the performance of DSR, AODV and DSDV using a proposed framework not limited to the Random Waypoint Model stating that the model can only be applicable to some scenarios. They observed that the protocol performance may vary drastically across mobility and that performance rankings of protocols may vary with the mobility models used. [7] presented comparisons of the performance of Multi-Hop Wireless Ad Hoc Routing protocols, DSDV, TORA, DSR and AODV with parameters adapted to accurately model the MAC and Physical-layer behaviour of the IEEE802.11 wireless LAN standard and realistic wireless transmission channel model. They observed that DSR performed best at all mobility rates and movement speeds, although its use of source routing increases the number of routing overhead bytes required by the protocol. [10] compared DSDV, AODV and DSR using the Random Waypoint model in scenarios where nodes move randomly and also in three realistic scenarios (Conference, Event Coverage and Disaster scenarios) providing a more specialized context. They observed that in most simulations the reactive protocols performed significantly better than DSDV a proactive protocol. However our work provides results of comparisons between DSDV, AODV and DSR with respect to their performance across four different mobility models and over different categories of disaster area scenarios hence providing a broad base over which these protocols can be compared.

3. AD HOC ROUTING PROTOCOLS

A number of routing protocols for Ad Hoc networks exist and generally they can be classified as *proactive* and *reactive* protocols [15]. This work focuses on DSDV (proactive), AODV and DSR (reactive) protocols.

Destination-Sequenced Distance-Vector (DSDV): DSDV as explained in [11] is a distance vector protocol also known as a proactive protocol and a table-driven routing protocol[15] which is derived from the Bellman-Ford routing mechanisms with modifications to address the poor looping properties and time dependent nature of the interconnection topology describing links between mobile hosts. According to [11] the protocol requires that each mobile host maintains a routing table which lists all available destinations with the number of hops to these destinations and each forming the network is required to advertise to its "current" neighbours its own routing table.

Ad Hoc On Demand Distance Vector (AODV): AODV as presented in [12] is a reactive or Source-initiated On-demand [15] protocol which requires that all mobile hosts obtain routes as needed with little or no reliance on periodic advertisements. It has been described as a *pure on-demand route acquisition system* [12] because when connectivity is required each host becomes aware of its neighbours by the use of *hello* messages and a path discovery process is initiated to locate the destination host.

Dynamic Source Routing (DSR): DSR [16] is another reactive protocol which operates on an entirely *on-demand* basis and allows mobile hosts to dynamically discover a source route across multiple network hops to any destination within the ad hoc network. According to [16] each data packet sent carries a complete ordered list of nodes including the source node in its header which helps to remove loops and also the need for up-to-date routing information in the intermediate mobile host through which the packet is forwarded. With this all nodes involved in the transmission of this packet can cache this routing information for use later.

4. MOBILITY MODELS

Various mobility models [4] exist which are used in wireless simulations and have been designed to depict real-life scenarios. This work is based on four of these existing models and a novel model specifically created for this work based on a combination of the previously stated models. They are:

Random Waypoint Mobility Model (RWP): According to [4] the Random Waypoint Mobility Model depicts a mobile host as remaining in a location for a certain period of time after which a random point within the simulation space is chosen and it travels to that point with a selected speed. The use of this model is really popular in MANET research [4, 6].

Gauss-Markov Mobility Model (GMM): This model has been used for simulation of MANET protocols [4] and it was designed to adapt to different levels of randomness through a tuning parameter.

Reference Point Group Mobility Model (RPGM): The Reference Point Group Mobility Model depicts the random motion of a group of mobile hosts and also the random motion of each individual host in the group [4]. The movement of the group is based on the path travelled by a logical centre for the group.

Manhattan Mobility Model (MM): The introduction of the Manhattan model to emulate the movement pattern of mobile nodes on streets defined by maps was made by [5]. The velocity of a host at a time slot is dependent on its velocity at the previous time slot and also a mobile host's velocity is restricted by the velocity of the node preceding it on the same lane of the street.

Heterogeneous Mobility Model: This is a hybrid of entity and group mobility models (depicting varied movement patterns) by pulling other mobility models together into one. Heterogeneous mobility can be achieved in two ways as considered below:

– Heterogeneous Mobility Model 1 (Het1): This is based on the BonnMotion ChainScenario model [17]. In this model each mobile node observes movement patterns defined in all constituent models. Het1 comprises of RWP, GMM and MM and each node in the model moves in patterns defined by all three models such that nodes final position of the $(n-i)^{the}$ scenario is linked to the initial position of the nth scenario, and so on. RPGM is not included in Het1 because the BonnMotion ChainScenario model does not support the implementation of RPGM.

– Heterogeneous Mobility Model 2 (Het2): Het2 defines a situation where each constituent model depicts movement for one-third of the overall considered number of nodes. RWP depicts movements for nodes 0 – 9, GMM 10 – 19 and RPGM 20 – 29. This model does not generate a scenario file but in this implementation, each scenario file making up the model is defined separately and linked from the Tcl file to run the simulations.

5. SIMULATION

The simulation study was done using *ns-2*[18]. The mobility models were generated using *BonnMotion-1.4*[17] scenario generation tool. Comparison of protocol performance was made using the individual scenarios and a final scenario of heterogeneous mobility model (All individual models combined within a scenario). Parameters utilized were routing overhead, normalized routing load, packet delivery fraction, and average end-to-end delay (Heterogeneous model) as metrics.

5.1 Simulation set up

The individual scenarios were generated with the following configurations:

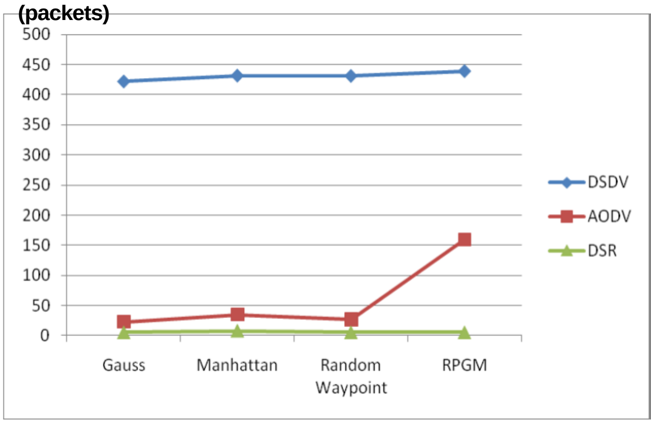
Nodes	Duration (s)	Initial phase (s)	X(m)	Y(m)	Packet size (bytes)
5	900	3600	200	200	512

Table 4.1: General Simulation Parameters

The Final scenario used to investigate the end-to-end delay was carried out using 30 nodes, packet size of 192 bytes and a longer duration of 1000sec compared with the previous scenarios. Four different scenarios, in terms of category (volume of traffic and mobility), are run. The four scenarios are high mobility high traffic (hmht), high mobility low traffic (hmlt), low mobility high traffic (lmht) and low mobility low traffic (lmlt). These are implemented by varying the maximum speed and packet rate parameters. In specifying the grid for the Manhattan model, a 4x4 grid was chosen for simplicity. Also additional values were specified for RPGM, a (group size) = 10 and c (probability of a node joining a group) = 0.25. Traffic was generated using the Continuous Bit Rate (CBR) generator.

5.2 Simulation Results

Figures 1 & 2 present a clear representation of the protocols over the four models with respect to routing overhead and Normalized Routing Load. While DSDV generates a huge amount of routing overhead due to periodic advertisements transmitted to all mobile nodes compared to AODV and DSR, DSR on the other hand generates the least amount of outing overhead. The case is the same for normalized routing load which also reflects this.



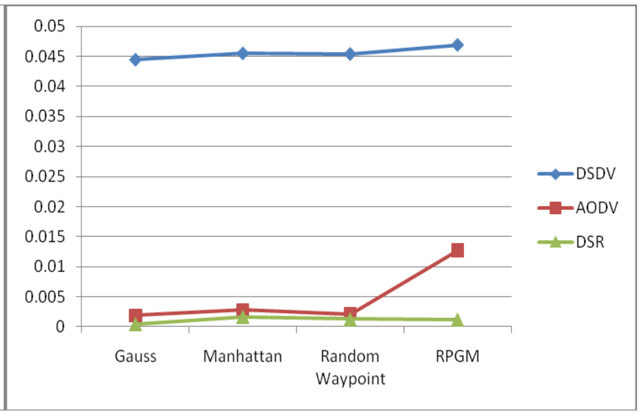


Figure 1: Routing Overhead

Figure 2: Normalized Routing Load

In Figure 3 the performance of the protocols in terms of packet delivery fraction can also be observed. DSRs performance in comparison with the others is best delivering the most packets across all models with less packet drops compared to the others. In Figure 4 all three protocols agree for hmlt and lmlt scenarios. We observe that DSR can be used with Het2 for all categories of scenarios. Het1 and Het2 performed similarly with slight improvement in Het2. The scenarios of high mobility low traffic (hmlt) and low mobility low traffic (lmlt) shows that the routing overhead condition in the proactive approach is tolerable. But generally speaking end-to-end delay is minimal with DSR due to source routing compared to AODV and DSDV.

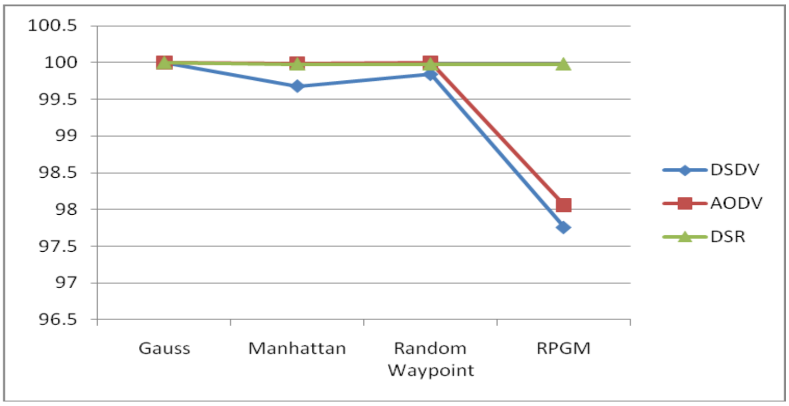


Figure 3: Packet Delivery Fraction

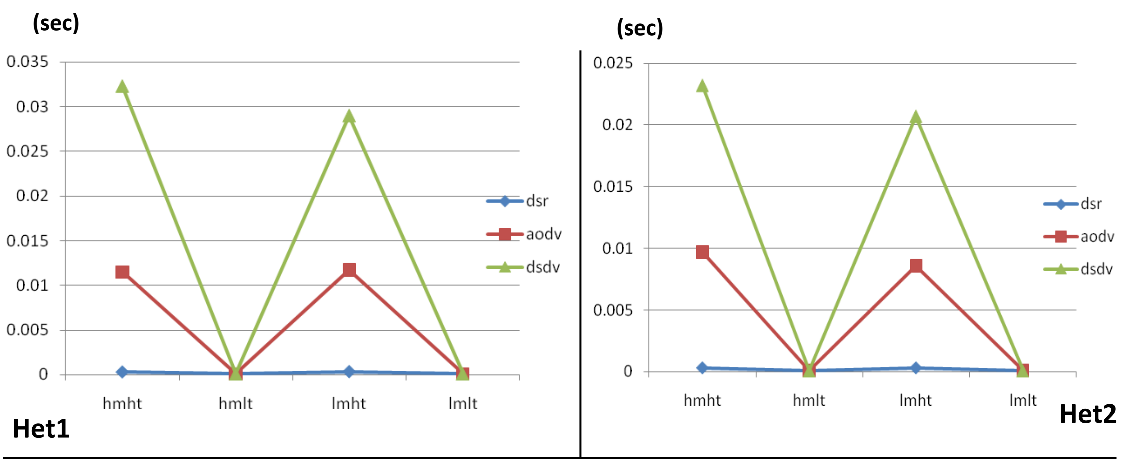


Figure 4: Average End-to-End delay

6. CONCLUSIONS

Having performed these extensive simulations and evaluated the results produced from the simulations in *ns-2*, a few conclusions can be drawn from the performance of the three protocols. While DSDV performs well in the routing of packets from one mobile host to the other, the on-demand protocols function efficiently to conserve bandwidth resources through reduced protocol overhead. It is worthy of note to state that in terms of the chosen metrics, DSR performs best making it efficient in the utilization of limited resources which includes bandwidth and power. The set of scenarios used with the Heterogeneous Mobility model reflects this same fact as can be observed from the figures under varying instances of mobility and traffic. DSDV on the other hand generates significantly larger traffic which in turn impacts much on the utilization of limited bandwidth and energy (battery power) and increase in delay when routes are to be discovered. DSDV is a table-driven protocol hence the need for periodical route advertisements hence more routing overhead. To ascertain our conclusion on the efficient performance of on-demand protocols it is necessary to make further evaluations taking into consideration other mobility models and the inclusion of other routing protocols. Another open area in the field of MANET security would be to evaluate the proposed MANET security protocols with regard to protocol performance which would help in the adoption of MANET security protocols that meet up routing demands as well as security requirements.

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