Analysis of the effect of application traffic load variation on the throughput performance of MANETs

G.K. Abraha, S. Musyoki, and S. Kimani

Abstract- The advancement of sophisticated mobile and computing devices has led to the emergence of Mobile Ad-hoc Networks (MANETs) in which autonomous mobile users (nodes) are connected through wireless links to build a live and on-the-fly network without any pre-existing network. The nodes involved in the MANETs act as both routers and hosts and the network topology varies dynamically due to mobility of the nodes. Therefore, the performance of MANETs is affected by different parameters such as mobility speed, bandwidth, application traffic load and the protocols used. In this paper, the effect of application traffic load variation on the throughput performance of MANET networks is studied based on DSR and AODV protocols using. OPNET 14.5 simulator was used to study how the throughput behaves in Low, Medium and High FTP traffic loads. Analysis of simulation results has shown that the throughput increases as the FTP traffic load is increased in both AODV and DSR based MANETs. A maximum increment, however, is observed in the DSR based MANET.

Keywords- MANET, Throughput, Traffic load, FTP, AODV, DSR

I. INTRODUCTION

Mobile Ad Hoc Network (MANET for short) is a set of mobile communication devices or nodes in which the mobile nodes communicate with each other through a wireless link without any pre-existing infrastructure. The communication devices (nodes) function as both hosts and routers to make a live and on-the-fly communication [1]. They are characterized by their dynamic topology due to mobility, self-configuration without a centralized administration, ease of deployment and ability of nodes to communicate with each other even in out-of-range conditions with intermediate nodes performing the routing functions [3-5]. The network is decentralized where all network activities, including delivering messages and discovering the topology must be executed by the nodes themselves. Therefore routing functionality, the act of moving information from source to a destination, will have to be incorporated into the mobile nodes [2]. Because of these unique characteristics, the conventional routing protocols cannot be applied to MANETs and therefore, different MANET routing protocols were developed.

The performance of mobile ad hoc networks is constrained to varieties of network parameters such as bandwidth, traffic load, mobility speed, and transmission power. The routing protocol selection also greatly affects the performance of the MANETs particularly the throughput. The performance of MANETs in terms of throughput on the basis of different FTP traffic loads (Low load, Medium load and High load) is studied and analyzed in this paper. Dynamic Source Routing (DSR) and Ad hoc On-demand Vector (AODV) are used as routing protocols.

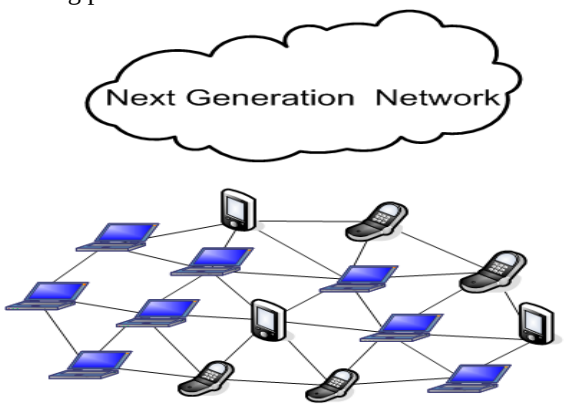

Figure 1 Mobile ad hoc network topology [12]

II. ROUTING PROTOCOLS IN MANETS

Different MANET routing protocols have been developed over the years. They are generally categorized as Proactive, reactive and hybrid routing protocols on the basis of their routing mechanisms. Proactive protocols are protocols that require nodes in mobile ad hoc networks to keep track of routes to all possible destinations so that when a packet needs to be forwarded, the route is already known and can be used immediately [8]. Example of proactive routing protocols is Optimized Link State Routing (OLSR). Reactive routing protocols are protocols which find path by exchanging the routing information (by flooding the network with Route Request packets) only when a node requires a path to communicate with the destination. Examples of reactive routing protocols are Ad hoc On-Demand Distance Vector (AODV) and Dynamic Source Routing (DSR) protocols. Hybrid routing protocols are protocols which have a combined character of the proactive and reactive protocols. A

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brief description of DSR and AODV, which are used in this research to study the performance of the MANET throughput, are presented below.

A. DYNAMIC Source Routing (DSR) Protocol

The Dynamic Source Routing (DSR) protocol, as its name indicates, is a source routed reactive protocol, in which a node in the network maintains route caches containing the source routes that it has learnt. That is, the entire path from the source to the destination is provided by the source in a packet header. The address of each node between the source and destination are required to be accumulated during the route discovery process to determine source routes. The accumulated route information is cached by each node involved in processing the route discovery packets and then the packets are routed through the learned paths [8]. The addresses of each device that the packet will traverse are contained in the routed packets so as to accomplish the source routing. The routing philosophy of Dynamic Source Routing protocol has Route Discovery and Route maintenance phases. When a source node intends to send a packet to a destination, it checks its route cache to determine whether it already has a route to the destination. If it finds that an unexpired route to the destination exists, then it uses this route to send the packet. But if the node does not have such a route, then it initiates the route discovery process by broadcasting a route request packet [8].

A node that receives a route request checks whether the destination address of the request matches with its own address or not. If it matches, it is the destination and sends a route reply back to the source. If any link of a source route is detected (detected by the MAC layer of the transmitting node) to be broken, the Dynamic Source Routing protocol uses two types of packets called Route Error packet and Acknowledgements to maintain the error. A node generates a Route Error packet if it encounters a fatal transmission problem at its data link layer. The route error is unicasted back to the source using the part of the route traversed so far, erasing all entries of the link in error from the route caches along the way.

B. Ad hoc On-demand Distance Vector (AODV) Protocol

Ad-hoc On-demand Distance vector (AODV) [6] protocol is a reactive routing protocol that builds routes using a route request (RREQ) and route reply (RREP) query cycle[11]. It is developed based on the DSDV and DSR routing algorithms. It uses periodic beaconing of “Hello Messages” and sequence numbering procedure like that of DSDV and a routing discovery procedure similar to that of DSR [6]. The major differences between AODV and DSR are that in DSR the full routing information is carried by each packet, where as in AODV packets carry the destination address [6]. This implies that AODV has a relatively less routing overhead than DSR. Another difference is that route replies in AODV carry only the destination IP address and sequence numbers while route replies in DSR carry the addresses of all nodes along the path. AODV is adaptable in very dynamic networks but there may be larger delays during route construction and while initiating another route discovery during link failures.

III. RELATED WORK

Kaur et al [10] studied the performance comparison of OLSR, GRP and TORA using OPNET modeler by varying the number of nodes (15, 50, 100, and 150) with the performance metrics of delay, throughput, routing overhead and network load using an FTP traffic type. According to this study, it was found that OLSR has a best performance in terms of load and throughput and GRP has best performance in terms of delay and routing overhead in all the scenarios. TORA was found to have the worst performance with regard to the four performance metrics considered. In conclusion, it was found that OLSR is best in terms of throughput (it has the highest throughput) as compared to GRP and TORA in all the network sizes or traffic volumes [10].

Jain et al [6] analyzed and compared DSR and AODV under free space and two ray ground propagation models. Simulation was done using QualNet and performance metrics packet delivery ratio, throughput, average jitter and average end to end delay were used to illustrate the overall performance. Constant Bit Rate (CBR) traffic type was used. DSR was found to have a better overall performance in both models in terms of packet delivery ratio and throughput. AODV performs better in the both models with respect to average jitter. In terms of end to end delay, DSR was found to be better in free space model and AODV performs better with a relatively less delay in Two Ray Ground models. The overall performance of DSR was, therefore, indicated to be better in both models except in the average jitter and end-to-end delay in which AODV is better or it takes less time to successfully deliver the packets in the Two Ray Ground model.

Ramesh et al [7] did performance analysis and comparison of DSDV and AODV with the help of simulations using NS-2 under different pause times, number of nodes and mobility speeds. Packet delivery ratio and average delay were used as performance measurement metrics. A UDP based traffic type, constant bit rate (CBR), was employed. Both protocols were found to have greater performance in packet delivery ratio under little motilities. AODV performs best in terms of packet delivery ratio in all the scenarios. It was also indicated in the simulation results that AODV suffers from a longer end to end

delay relative to DSDV while DSDV has a very low packet delivery ratio as compared to that of AODV's in high mobility scenarios. The authors asserted that for communications under UDP based traffic type, AODV is an ideal choice.

In this paper, the throughput performance analysis and comparison of DSR and AODV based MANETs is studied with different scenarios by varying FTP traffic loads as low load, Medium load, and High load in which the effect of each traffic load level on the throughput performance of each protocol is analyzed.

IV. SIMULATION ENVIRONMENT AND PERFORMANCE ANALYSIS

A. *Simulation Set up*

There are different simulation platforms for MANETs such as NS-2, NS-3, GloMoSim, QualNet and OPNET. In this research OPNET 14.5 (Optimized Network Engineering Tool version 14.5) was used to perform the modeling, simulation and performance analysis of MANET. OPNET Modeler is the industry's leading high level event based network simulation and development tool. It provides a very attractive virtual network environment that is prominent for the research studies, network modeling and R&D operations and performance analysis of routing [9]. A WLAN (Ad-hoc) network was modeled and deployed in an area of 1500x1500 square meters. The network setup and simulation parameters used in designing the model and configuring the applications, profiles and statistics collection modes are listed in the table below.

Table1: Summary of Model design and simulation parameters

Environment Area (m^2)	1500x1500
Mobility Model	Random waypoint
Routing Protocol	AODV, DSR
Data rate	11 Mbps
Traffic source	FTP [Low load, Medium load, High load]
Number of nodes (m/s)	30
Mobility speed	10
Simulation time (seconds)	1800
MAC protocol	802.11b
Transmission power (W)	0.005
Node placement	Random
Pause time	150
Stations	Wlan_wkstn
Server	Wlan_server

B. *Performance Metric*

The performance of the mobile ad hoc network was simulated using OPNET Modeler 14.5 and analyzed in terms of throughout with different FTP traffic loads. Throughput is defined as the ratio of the amount of data that arrives at a receiver from a sender to the time it takes for the receiver to get the last packet [10]. It is expressed in terms of bits or bytes per second (bits/second or Bytes/second) or packets per second (Packets/second). In MANETs, throughput is highly affected by the dynamic nature of the topology due to mobility of nodes, power constraints, limited bandwidth and traffic load. It is also affected by the choice the protocols used. The higher the throughput of a network, the more effective the protocol is. Mathematically, it is expressed as:

$$\text{Throughput}\left(\frac{bits}{second}\right) = \frac{Number\ of\ delivered\ Packets * Packet\ size * 8}{Total\ duration\ of\ simulatio}$$

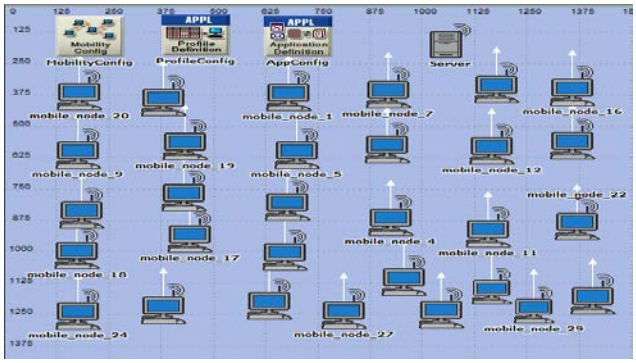

Figure 2 Mobile Ad hoc Network Model with 30 mobile nodes

C. *Simulation Results*

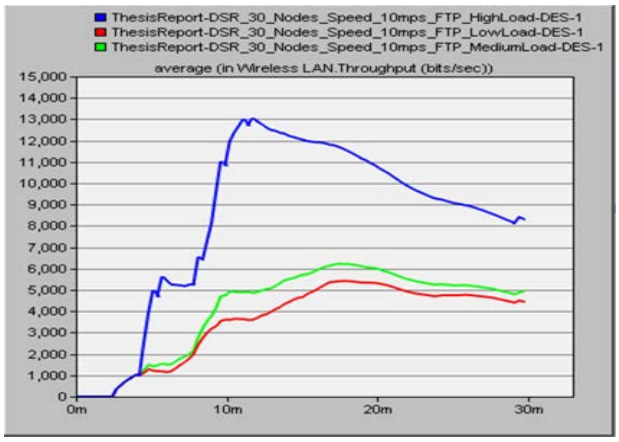

Figure 3 Throughput (bits/sec) of DSR for 30 mobile nodes

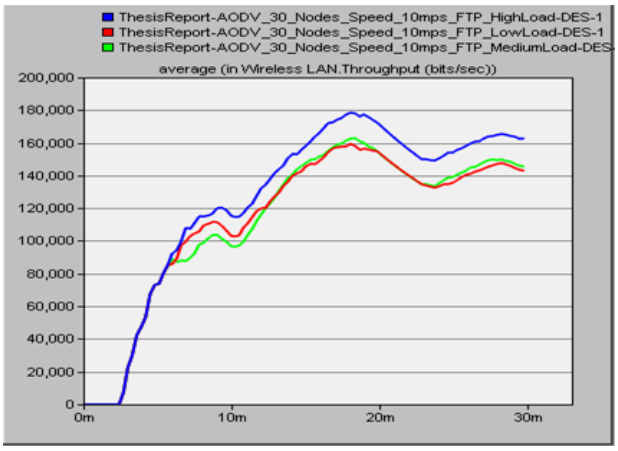

Figure 4 Throughput (bits/sec) of AODV for 30 mobile nodes

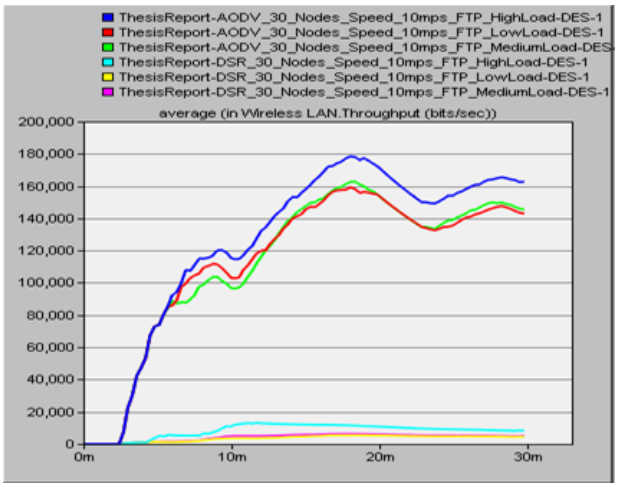

Figure 5 Throughput (bits/sec) performance comparison of AODV and DSR for 30 nodes and different FTP Traffic loads

D. Performance Analysis

i. Result Analysis for DSR

As it can be seen from the graphs in figure 3 the throughput of DSR increases as the FTP traffic increases from low load to medium load and then to high load. Therefore, the throughput performance increases as the traffic load increases in DSR protocol based MANETs.

ii. Result Analysis for AODV

The simulation results of AODV with respect to different FTP traffic loads indicate that the throughput performance increases as the traffic load increases from low load to medium and then to high load. However, there is no significant increment in the throughput performance between the low and medium loads.

iii. Performance comparison of AODV and DSR

The simulation results, as shown in the graphs in figures 3, 4 and 5 above, indicate that AODV outperforms DSR in terms of throughput in all the traffic load levels. The performance increment rate when the traffic load level is varied, however, is greater in DSR than in AODV. The maximum throughput increment rate when the traffic is changed from low load to high load in DSR is approximately 61.54% whereas it is approximately 11.1% in AODV. This indicates that the effect of FTP traffic load variation on the throughput performance is higher in DSR than in AODV.

V. CONCLUSIONS AND RECOMMENDATION

In this paper the effect of application traffic load variation on the throughput performance of MANETs was analyzed based on AODV and DSR protocols. The throughput performance generally increases with increasing the traffic load from low to high in both the protocols. The throughput, small in the beginning, increases up to a certain value above which it starts to decrease or remains constant. The decrement in throughput after a certain maximum value is due to the increase in network load that in turn causes network congestion. The performance analysis in all the scenarios was made with a fixed number of 30 nodes and 10m/s constant mobility speed of nodes. And also, only two protocols were used to analyze the throughput performances. Therefore, in future works the research can be done by using different number of nodes with different mobility speeds and different protocols to further investigate how the throughput behaves when the traffic load varies in such situations.

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