Effect of Mobility and Traffic flow on DSR protocol in a pre-defined Mobile Ad Hoc Network

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Summary

The increased used of bandwidth restricted multimedia applications over Mobile Ad hoc Networks (MANETs) create new challenges to routing protocols in terms of Quality of Service (QoS) requirements. To meet these requirements, the existing routing protocols should provide data transfer with minimal delay, packet loss and jitter. In the present paper, a pre-defined topology was created using NS-2 with strategically placed nodes in order to test the performance of Dynamic Source Routing (DSR) protocol. The network was simulated with pre-defined mobility and workload and evaluated in terms of different performance metrics such as throughput, jitter, number of dropped packets, end-to-end delay and routing efficiency. The mobility of the nodes found to be more influencing than the workload. In a particular parameter combination of 20 seconds pause time, 5 CBR traffic flow and 200 PPS data rate, the network exhibited highest routing efficiency of 93.3%. At extended simulation time, congestion adversely affects the performance of the network.

Key words: *MANET; DSR, NS-2, mobility, workload, multimedia*

1. Introduction

Mobile Ad hoc Networks (MANETs) are self-organizing and self-configuring networks which work without any infrastructure or central control. All nodes within the network either act as routers or hosts which provide cooperative multi-hop communication. The nodes are also able to move, exit or can be connected arbitrarily. This leads to continuous change in network topology which makes the design of an ad hoc network a difficult task.

In recent years, many studies have been focused on MANETs due to the increased use of WLAN and the decline in the cost of wireless products [1, 2]. The infrastructureless and flexible nature of MANET have attracted numerous potential applications ranging from critical environments such as disaster recovery and battle fields to commercial applications such as voice and video communications [3-5]. In addition, the development of new multiplexing techniques, for example orthogonal frequency division multiplexing (OFDM), enhanced the available bandwidth for wireless channel. These advancements create new avenue for supporting bandwidth-restricted multimedia applications over wireless networks. However, video applications have stringent performance requirements in terms of bandwidth, delay, packet loss and jitter. To meet these critical requirements, a MANET inherently depends on the routing scheme employed. Many protocols have been proposed in the past to address these issues such as Dynamic Source Routing (DSR), Ad-hoc on-Demand Distance Vector (AODV), Zone Routing Protocol (ZRP) and Temporally Ordered Routing Algorithm (TORA) [6-9] and extensive performance analysis have been carried out with random mobility scenarios.

In the present paper, rather than using a random model, a pre-defined topology was created with the possibility for congestion to really assess the performance of a routing protocol (DSR) under streaming multimedia applications. DSR is being considered in the present case since of its wide use and on-demand nature of route discovery. Based on the simulation results, the performance of the network was evaluated in terms of throughput, jitter, number of dropped packets, end-to-end delay and routing efficiency.

2. Simulation Environment

2.1 Simulation Set-up

NS-2 simulator [10] was used with IEEE 802.11b. In order to transmit and receive data, carrier sense multiple access (CSMA) with collision avoidance (CA) was incorporated. A Two-Ray Ground radio model was considered in the present case to avoid random path loss component. Thus, the devices within a circular transmission range were able to communicate with each other. Simulations were performed with pre-defined network topology, node mobility and CBR traffic flows. Even though, in a real MANET environment, the changes in topology and nodal mobility are random and unpredictable in nature, an

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occurrence of congestion or failure of a node can easily be created in a pre-defined MANET situation which paves the way for more accurate and pointed analysis of the performance of the protocol. The simulation parameters used are listed in Table-1.

Table 1: Simulation Parameters

Parameter	***Value***
Toplogy Size	1200m x 1200m
Number of nodes	17
Mobility Speed	1000 m/s
Maximum queue size	50 packets
Number of sources	2
Number of destinations	5
Mobility Model	Random way-point
Traffic type	CBR
Packet Size	512 bytes
Mac Layer Protocol	IEEE 802.11b
Simulation time	100s
Routing protocol	DSR

Six different simulation iterations were carried out in sets of three. In the first set, the pause time was varied at 4, 10 and 20 seconds, by keeping the workload and data rate constant at 5 CBR and 200 PPS, respectively. This will create high, medium and low mobility scenarios. In the second set, the workload was varied at 10, 15 and 20 CBR traffic flows by keeping the pause time and data rate constant at 4 seconds and 200 PPS, respectively. This will result in low, medium and high workload scenarios. In a 10 CBR workload scenario, one source node transmit two CBR traffic to three destinations and the another source node transmit two CBR traffic to other two destinations. In case of 15 and 20 CBR workload, the number of traffic flows from the source node proportionally increased to 3 and 4 CBR, respectively. The five destination nodes were placed close to the border of the topology in a circular manner and the two source nodes located at the center. The destination nodes were static throughout the simulation and the source nodes moved in a pre-defined manner. The data transmission from the source defined to be transmitted during pause times through a pre-defined path and by using a hop of another stationary node. During transmission, few other intermediate nodes are moved inside the transmission range to provide alternate path to destination. In addition to that, the workload was intentionally increased in certain instance to cause congestion in the primary path. The trace files generated at the end of the simulation was used to calculate the performance metrics.

2.2 Performance Metrics

The performance of the network was evaluated under different mobility and workload using the following performance metrics.

Average Throughput (AT): The average throughput is calculated using the ratio of total number of processed data packets to the total simulation time.

Average Jitter (AJ): Jitter is a measure of variation in delay across multiple packets associated with a given traffic flow. In streaming multimedia applications, only a small and limited amount of jitter is tolerable.

Average End-to-End Delay (AED): The average end-to-end delay is a measure of average time taken to transmit each packet of data from the source to the destination. Network congestion is indicated by higher end-to-end delays.

Number of dropped packets (NDP): It is the number of data packets unsuccessful reaching their destination.

Routing Efficiency (RE): It is the ratio of number of sent packets to the number of routing packets generated.

3. Performance Analysis

3.1 Influence of Mobility

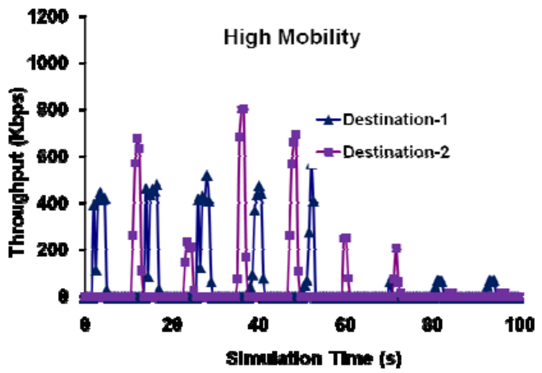
The performance of the network was analyzed under different mobility scenarios by varying the pause time. The throughput, jitter, number of dropped packets, end-to-end delay and routing efficiency was observed at all the five destinations. The measured values are listed in Table-2.

Table 2: Performance metrics in different mobility scenarios

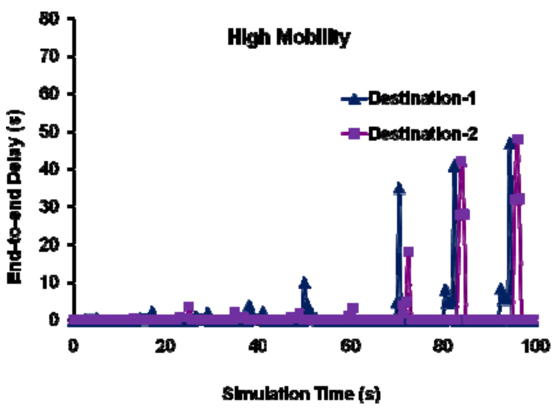
Scenario	*AT (Kbps)*	*AJ (ms)*	*NDP*	*AED (s)*	*RE*
High mobility	71.2	43.5	1172	0.62	36.7
Medium mobility	75.4	33.9	249	1.2	57.8
Low mobility	94.1	28.2	219	0.05	93.3

An in increase in average throughput was observed as the mobility decreased. The nodes in high mobility scenarios are static for less amount of time and then moves to the next pre-defined location. This has led to the frequent route failures and the protocol needs to search for next alternate route to the destination. This might have resulted in low throughput. The higher values of average jitter, average number of dropped packets and average end-to-end delay also supports this fact. In a medium mobility scenario, a slight increase in throughput was achieved with considerable reduction in average jitter and average number of dropped packets. However, the average end-to-end delay was higher due to the higher peaks at few simulation instances. As the mobility is further reduced, a significant increase in throughput was observed with further reduction in average jitter and average number of dropped packets. Moreover, the average end-to-end delay is reduced drastically to 0.05 seconds. This was mainly due to the fact that, a higher pause time of 20 seconds resulted in more stable routes. In addition, the network can use already cached routes to destination rather than searching for fresh routes which reduced the delay.

The throughput and end-to-end delay at different instance of simulation is represented in Figures 1, 2 and 3, selectively for two destinations, in order to identify the variations. In high mobility scenario, the throughput increased linearly with simulation time and reached a maximum value of 802 Kbps and then decreased gradually as shown in Figure- 1(a). During initial stages, the route discovery process has led to additional overhead which may influence the throughput. As the requirement of route discovery reduced with increase in simulation time, the throughput increased. However, the intermediate nodes become congested with further increase in simulation time which results in decrease in throughput. This is quite clear as, towards the end of simulation the throughput is very low. The Figure-1(b) further supports this observation of influence of congestion. The end-to-end delay almost non-existence during the start of the simulation. However, it notably increased between 70-100 seconds of simulation time. In medium mobility scenario, the frequency of peak values is reduced compared to high mobility scenario. This was evident in all destinations apart from the two destinations shown in Figure-2(a).

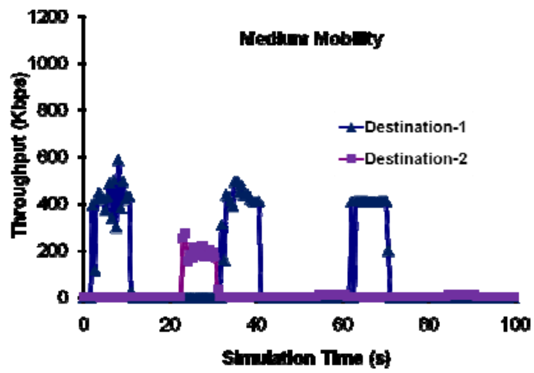


(a) Throughput

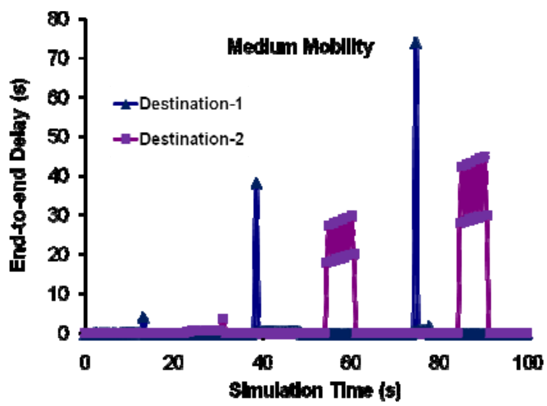


(b) End-to-end Delay.

Fig. 1 High Mobility Scenario.



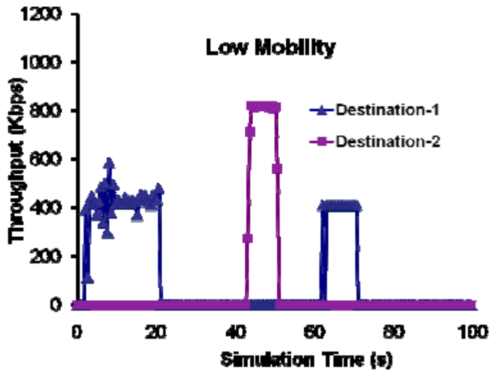
(a) Throughput



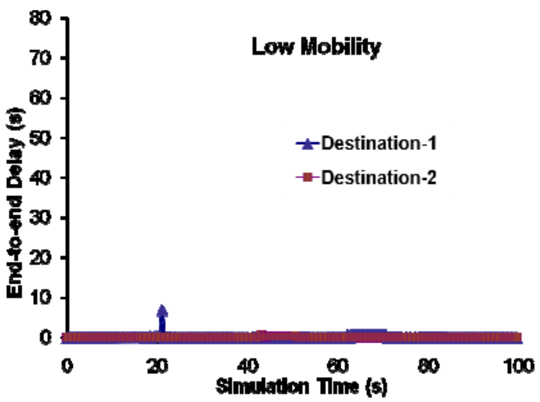
(b) End-to-end Delay.

Fig. 2 Medium Mobility Scenario.

Even though, the peak values are lower compared to high mobility scenario, a reduction in route discovery overhead leads to increase in average throughput value. The high average end-to-end delay of 1.2 seconds may be attributed to the few peaks between 40-92 seconds of simulation time as shown in Figure- 2 (b). In low mobility scenario, the occurrence of peaks further reduced, however with the increase in the spread of the curve as shown in Figure-3(a). An increase in pause time leads to an increase in the longevity of routes. This leads to extended data transfer for longer duration that resulted in higher average throughput. The end-to-end delay shown in Figure-3(b) indicates the lowest delay observed in the selected destinations. The routing efficiency shown in Table-2 exhibits an increasing trend as the mobility is reduced. The amount of routing packets needed for route discovery was minimal as mobility decreases.



(a) Throughput



(b) End-to-end Delay.

Fig. 3 Low Mobility Scenario.

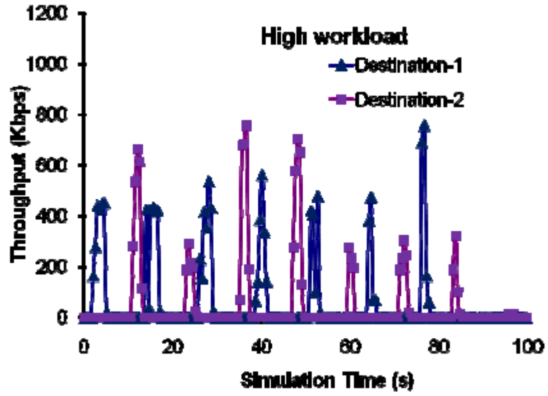
3.1 Influence of Workload

The performance metrics were measured at different workloads by keeping a constant pause time. The simulated values of the metrics are listed in Table-3.

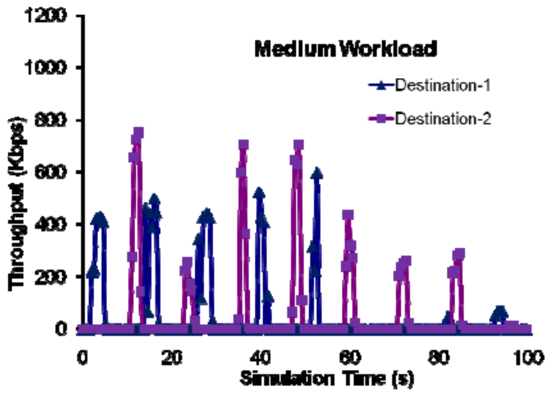
Table 3: Performance metrics at different workloads

Scenario	*AT (Kbps)*	*AJ (ms)*	*NDP*	*AED (s)*	*RE*
High Workload	84.3	43.6	1379	0.81	38.1
Medium Workload	75.3	42.1	1559	0.67	52.7
Low Workload	80.6	43.3	1624	0.4	52.7

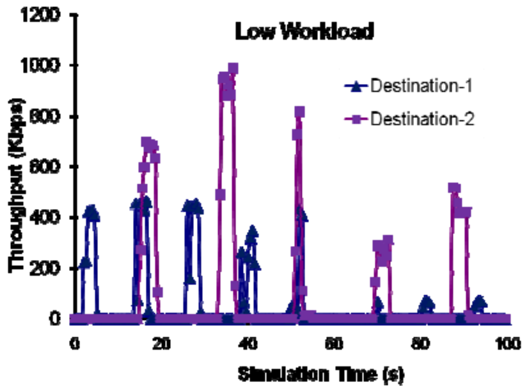
It is quite evident from Table-3 that the influence of workload is very minimum compared to the mobility.



(a) Throughput at high workload.



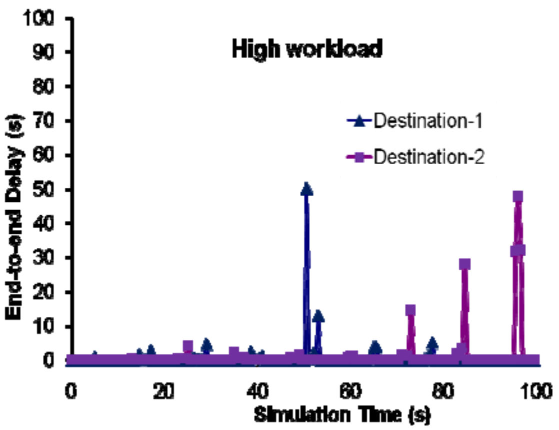
(b) Throughput at medium workload.



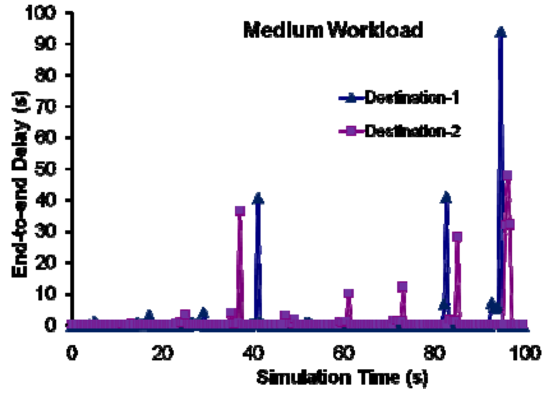
(c) Throughput at low workload.

Figure. 4 Variation in throughput at different workloads.

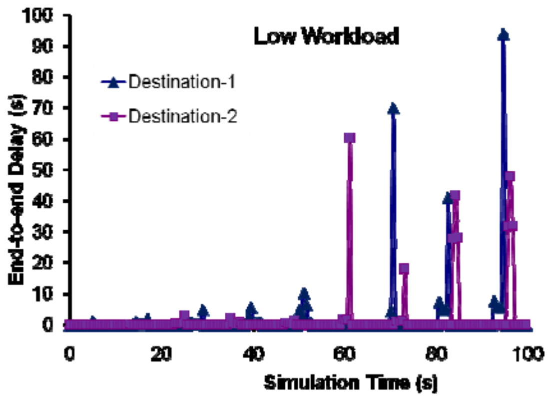
Previous studies on performance analysis either consider mobility as a primary parameter or analyses traffic flow variations under random mobility [11, 12]. The performance analysis using a pre-defined topology in a varying traffic flow is scarce in the open literature. The throughput measured at different workloads is given in Figure - 4 (a-c) for two destinations. For low and medium workloads, the highest peaks appear around 750 Kbps and for 20 CBR workload, it is between 800-100 Kbps. The jitter is almost constant in all workloads. The average number of dropped packets is lower at high workload and increases as the workload decreased. At low workload, the end-to-end delay is lower which increases linearly when workload increases. The congestion appears towards the end of the simulation and could be the only reason for higher end-to-end delay peaks as shown in Figure-5(a).



(a) End-to-end delay at high workload.



(b) End-to-end delay at medium workload.



(c) End-to-end delay at low workload.

Figure. 4 Variation in end-to-end delay at different workloads.

The peaks further increases to higher level, as an increase in workload leads to higher congestion levels as shown in Figure- 5 (b & c). The routing efficiency is same for both low and medium workloads. However, it reduced to 38.1 % as the workload increased to 20 CBR. Even though, a combination of higher throughput and reduced number of dropped packets are achieved at this scenario, the need for more routing packets to distribute the higher load may be attributed to the reduced routing efficiency.

4. Conclusion

A pre-defined MANET topology was created and the performance was evaluated under different mobility and workload scenarios using streaming multimedia CBR flow.

Based on the results of the simulation, the following conclusion was drawn.

In a pre-defined topology with pre-defined traffic flow and node movement, the performance of the network is more influenced by the mobility than the workload. Under different mobility scenarios, the low mobility scenario exhibited superior performance with higher average throughput, minimum number of dropped packets, lower average end-to-end delay and higher routing efficiency. An increase in mobility leads to frequent requirement of route discovery phase that might adversely affect the network performance due to the additional routing overhead. The performance of the network was quite stable irrespective of the workloads. However, a reduced routing efficiency and increased average end-to-end delay at higher workloads indicated a possible congestion and poor performance of the network. A MANET implemented with the DSR protocol is capable of transmitting streaming multimedia traffic in a moderate and low mobility cases with workloads up to 15 CBR flows.

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