Queuing Approach to Model the MANETs Performance

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Abstract

Mobile Ad-hoc Network (MANET) was defined as a set of mobile nodes that moved freely and connected among each other without any infrastructure. Simulation represents a tool that evaluates the performance of an existing or proposed queuing system, under different configurations of interest and over long periods of real time.

In this paper each node of the MANET was modeled as a queuing system to serve the customers (packets) that reaching according to certain arrival rate. The network simulator NS-2 was used as a tool to study and evaluate the effects of two queuing mechanisms (DropTail and REM) on the performance of certain MANET. Many performance metrics such as throughput, packets loss, packet delivery fraction, and average end-to-end delay were used as comparison indications. The simulation environment was implemented with different number of nodes, different speeds, different simulation area, and varying pause times. The recorded results indicated different MANET behaviors with each queuing mechanism and certain parameters values.

Keywords: MANET, Queuing process, Queuing mechanisms, simulation

1. Introduction

MANET is a collection of nodes that correctly connected among each other in wireless manner without any infrastructure. Based on the location of nodes the data packets can be received by the destination directly or in many hops [Christos Tachtatzis, et. al., 2008]. The topology of this type of network is changing dynamically . The nodes are moving frequently from one location to another and the energy of each node is limited [Yangcheng Huang, et. al., 2007].

Many real systems can be modeled as a network of queues, such as the waiting line in a bank, a bus stop, waiting line in airport, material flow in factory, signal flow in network. So, each of these simple systems consists of three major components [Christopher A. Chung , 2004]. Each router must implement some queuing discipline. Queuing allocates both bandwidth and buffer space.

Simulation is a tool that evaluates the performance of an existing or proposed system, under different configurations of interests over long periods of real time [Anu Maria, 1997]. The term Computer Simulation means design a model of an actual or theoretical physical system, execute the model on a digital computer, and analyze the execution output [Paul A. Fishwick, 1996] .

A major feature of discrete event simulation is its ability to model random events based on standard and non-standard distribution and to predicate the complex interactions between these events. Simulation tools also include the element of time, which is missing from other design methods. A simulation model contains a clock that progresses through time, handling events as they occur. A simulation model built on computer and experiment are then performed changing the input parameters and predicating the response. Experiment is normally carried out by asking ' what if ' questions and using the model to estimate the outcome or to evaluate the existing process [Juhani Heilala, 1999]. Here are several concepts underlying simulation. These concepts include system and model.

2. Queuing process

Queuing theory constitutes a powerful tool in modeling and performance analysis of many complex systems, such as computer networks, telecommunication systems, call centers, manufacturing systems and service systems. In recent years, queuing theory including queuing systems and networks motivates being the attention of mathematicians, engineers, designers and economics [B. Filipowicz et al., 2008].

Queuing models are constructed to help the scientists and the engineers to analyze the performance of complex dynamic systems. These models are dealing with the waiting and the sequence that occurs with their activities. The purpose of building a queuing model is to obtain reliable statistics that can be used to analyze, evaluate and improve the performance and the behavior of the current or the new complex networks. Simulation is the unique technique that can be used and applied to evaluate and analyze any current or new designed queuing systems. Simulation techniques represents an economical manner to implement and operate any expensive complex systems.

3. Queuing mechanisms

queuing strategy determines the discipline for ordering entities in a queue . It defines the order in which they are served and the way in which resources are divided between customers (packets). Each router must implements some queuing discipline to govern the packets buffers in which packets waiting to be transmitted. Various queuing mechanisms were applied to control the transmission process by indicating which packets must be transmitted (bandwidth allocation) and which packets must be dropped (buffer space). These mechanisms affects the packets latency experienced by determining how long a packet must waits before its transmission.

Examples of the common queuing disciplines are the first in first out (FIFO) which is called Drop Tail in networking, Last In First Out (LIFO), Priority Queuing (PQ), The shortest is served first , service in random order, Round Robin , Random Exponential marking (REM) and others [S. Athuraliya, et al , 2001].

3.1 Drop Tail and REM

The idea of Drop Tail queuing is that the first packet that arrives at a router is the first packet to be transmitted. If a packet arrives and the buffer space is full, then the router will discards (drops) this packet. It represents one of the simplest network routers algorithms and it has been implemented widely [T. Reddy, et. al.,2009].

When the queue is overflows in a Drop Tail mechanism the packets will be dropped. This means that the packets of many connection sources will be dropped when the network is being under heavy load circumstances. Drop Tail routers may cause global synchronization of occurrences in which transmitters that belongs to a same bottleneck router will retrieve from sending any more packets all at almost the same time [K. Zhou, 2006].

The Random Exponential marking (REM) is aimed to stabilize both the input rate around link capacity and the queue around a small target. There is a variable (represents the key insight) called "price" in each queuing system that implements REM to be a congestion measure. This variable indicates the marking probability. Price represents an indication of the difference between input rate and link capacity with the difference between queue length and target. The "price" is decoupled form performance measures such as packet loss and queue length. The REM Congestion measure can be computed depending on the difference between input rate (arrival or reception rate) , output rate (sending or transmission rate) and current buffer occupancy at router. The end-to-end marking (or dropping) probability observed by a user depends in a simple and precise manner on the sum of link prices (congestion measures), summed over all the routers in the path of the user. The output queue are tend to mark each arrival packet that is not already marked at an upstream queue, with a probability that is exponentially increasing in its current price [Abdullah Al Masud, et. al.2011].

4. Performance metrics

One approach to the performance measurement is to obtain the data by observing the events and activities on an existing system. Performance modeling means representing the system by a model and manipulate the model to obtain information about its behavior and its performance. The performance of the system can be estimated either directly or by characterizing the system workload mean response time, the total service time, the workflow, the numbers of completed or aborted service requests, the total waiting time, the queue length, the number of transactions completed per unit time, the ratio of blocked connection requests**.** To evaluate the MANET as a queuing system, there are many other performance metrics that can be used. The most related important to this study are:

a. Throughput

Which represents the mount of data received by the destination nodes through certain period of time [Ravi Kumar Bansal et al. 2006].

Throughput=receive packets/simulation time

B. Average end-to-end delay (average E2E delay):

It represents the time required to move the packet from the source node to the destination node.

E-2-E delay [packet_ id] = received time [packet_ id] – sent time [packet_ id]

The average end-to-end delay can be calculated by summing the times taken by all received packets divided by its total numbers [Aliff Umair Salleh et al. 2006]

c. Dropped Packets:

It represents the number of packets that sent by the source node and fail to reach to the destination node [Aliff Umair Salleh et al. 2006].

Dropped packets = sent packets– received packets.

d. Packets delivery fraction (PDF):

It can be measured as the ratio of the received packets by the destination nodes to the packets sent by the source node [Imran Khan et al. 2009].

PDF = (number of received packets / number of sent packets) * 100

5. Simulation Environment

The following suggested simulation environment was used in building the suitable MANET's using NS-2 in this study. The DSDV routing protocol was suggested to be the main operating protocol in all of the suggested tested simulation scenarios. Table (1) shows the important proposed parameters and their values.

Table (1) simulation environment

Parameter	Value
The simulator	NS-2.34
MAC	802.11
Routing protocol	DSDV
Simulation time	90 second
Propagation model	Two ray ground
Transmission rate	4 packets/second
Mobility model	Random way point model
Traffic generation	CBR
Antenna	Omni Antenna
Packets size	512 bytes

6. Simulation Results

In this study, the performance of the MANET was evaluated by applying two types of queuing disciplines (DropTail and REM). Different MANET's parameters were tested and experimented to show the effects of each of the two queuing mechanisms on the MANET performance. The suggested varying MANET's parameters are: number of nodes, nodes speed, pause times, and simulation areas. Table (2) shows these suggested varying MANET's parameters values.

Table (2): suggested MANET's parameters.

Case	Number of Nodes	Nodes Speed	Pause time	MANET's area
1	5	10, 15, 20, 25, 30	3s	500m*500m
2	5, 8, 15, 20, 25	30m/s	4s	800m*800m
3	10	40m/s	5s	(500m*500m, 800m*800m, 900m*900m, 1000m *1000m, 1500m* 1500m)
4	10	30m/s	2, 3, 4, 5, 6s	1000m*1000m

Each simulation Scenario was executed (runs) 10 times and all of these ten values for each metric were recorded. The average was estimated to be the best possible value for each metric. These repetition was done due to the randomness effects used in generating the simulated values in each case. Four performance metrics values (the throughput, the loss packets, average end-to-end delay, and packet delivery fraction) were calculated for each of the Drop Tail and the REM queues. The following figures shows the behaviors of each performance metric in each MANET scenario (the red line is for the Drop Tail while the green line is for the REM).

Figure1 shows the packet delivery fraction with different nodes speeds with the Drop Tail and REM queues. Figure2 illustrates the average end-to-end delay with varying nodes speeds with the two types of queues.

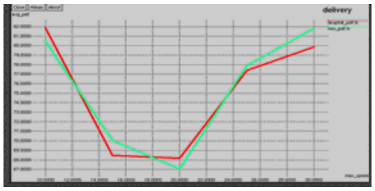

Fig1: the PDF of case1.

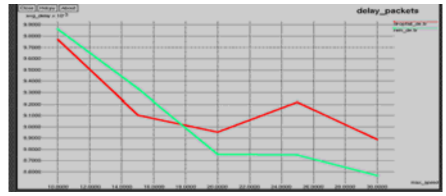

Fig2: the average end-to-end delay of case1.

From these graphs it is clear that REM is better than Drop Tail with high speed in average end to end delay.

Figure3; illustrates the number of the packets loss for different node speeds. While figure4; illustrates the throughput of the case1 where the speeds are different.

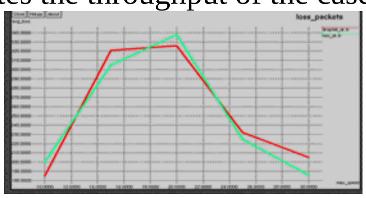

Fig3: the packets loss of case1.

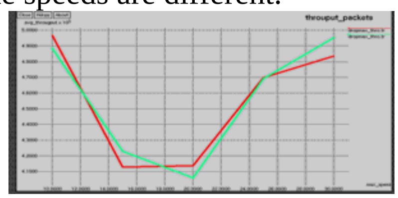

Fig4: the throughput of case1.

These figures indicate no significant difference between the MANET behavior for the packets loss and the throughput with both those queuing mechanisms.

Figure5; shows the packet delivery fraction with different nodes numbers and Figure6; illustrates the average end-to-end delay with many different nodes numbers in two types of queues.

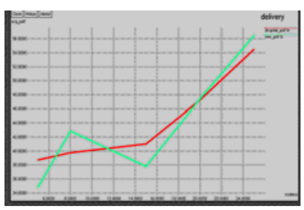

Fig5: The PDF of case2.

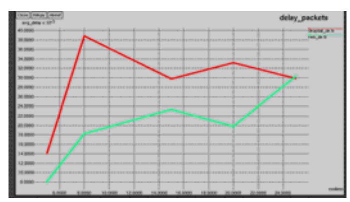

Fig6: The average end-to-end delay of case2.

In the two figures with different number of nodes with REM is seemed to be better than with DropTail in PDF and average delay measures.

Figure7; clarifies the number of the lost packets with varying nodes number for case 2. Figure8; illustrates the throughput of the case2 where the numbers of nodes are different.

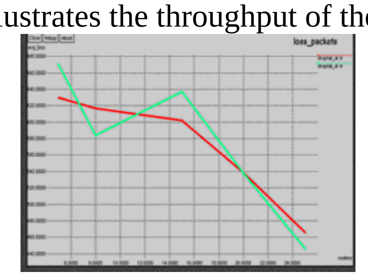

Fig7: The packets loss of case2.

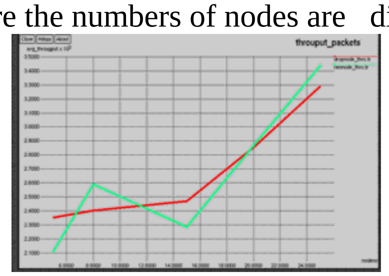

Fig8: The throughput of case2.

Figure9 shows the packet delivery fraction with different topologies of the simulation. Figure10 illustrates the average end-to-end delay with different topologies.

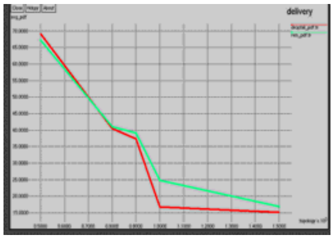

Fig9: The PDF of case3.

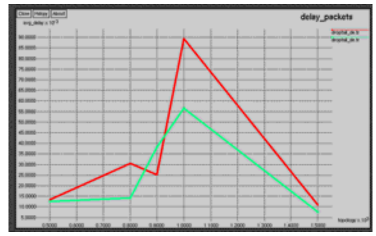

Fig10: The average end-to-end delay of case3.

Figure11; clarifies the number of the loss packets with different simulation topologies. Figure12; illustrates the throughput with varying simulation topologies.

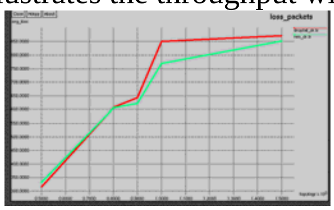

Fig11: The loss packets of case3.

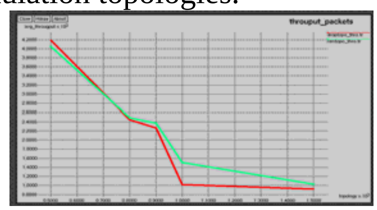

Fig12: The throughput of case3.

Figure13; shows the packet delivery fraction with different pause times for the mobile nodes. Figure14; illustrates the average end-to-end delay with different pause times.

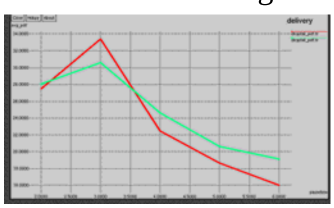

Fig13: The PDF of case4.

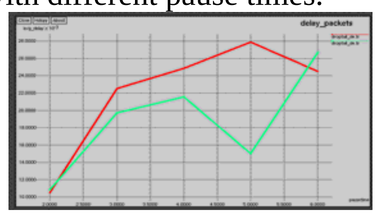

Fig14: The average end-to-end delay of case4.

Figure15; shows the number of the lost packets with different pause times for the mobile nodes. Figure16 illustrates the mount of the throughput with different pause times.

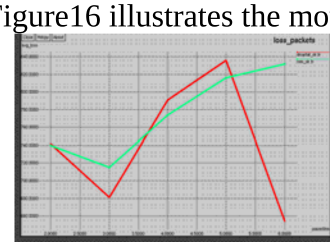

Fig15: The packets loss of case4.

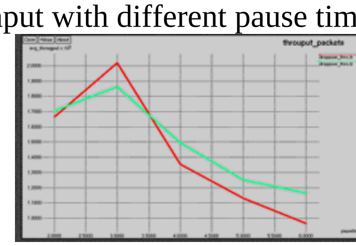

Fig16: The throughput of case4.

7. Conclusion

A stable and Reliable resulted simulation values of the performance metrics values for many MANET's Scenarios indicated that the MANET's behavior with REM queue management is best than Drop tail in throughput and pdf with high nodes speed. While delay and loss packets with high speeds decreases in both mechanisms. Network with small number of nodes behaves better with REM than with drop Tail. When simulation area increased (for 10 nodes) low throughput with REM and DropTail , with REM gives low delay better than with DropTail, in Packet loss and PDF. The effects of the pause time in both gives low throughput and high delay. With DropTail the packet loss is better than with REM. The network PDF in REM is better than with the DropTail. REM attempts to obtain high utilization, and low delay and low packets loss.

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