Impact of Network Size on Performance of Wireless Network Topology

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Abstract: The goal of this work is to investigate the impact of network size on the performance of the IEEE 802.11 MAC protocol. The performance of any network needs to be evaluated on certain criteria, these criteria then decide the basis of performance of any system. Study on wireless networks' simulation and measuring performance metrics, mainly throughput and Packet Delivery Ratio has been done using NS-2 and AWK scripts. The effect of variations in number of nodes on the network performance is analyzed over a wide range of their values. Results are shown in terms of graph and table.

Keywords: Wireless, NS-2, AWK, Performance Metrics, Throughput, PDR Packet Delivery Ratio and Simulation.

I. INTRODUCTION TO WIRELESS NETWORK

Wireless networks are computer networks that use radio frequency channels as their physical medium for their communication. Wireless networks can be broadly classified into Cellular wireless networks and Ad hoc wireless networks[1].

An ad hoc wireless network consists of a set of mobile nodes that are connected by wireless links. An Ad hoc wireless networks are defined as the category of wireless networks that utilize multi-hop radio relaying and are capable of operating without the support of any fixed infrastructure, hence they are also called infrastructure less networks. In an ad hoc wireless networks, the routing and resource management are done in a distributed manner with more information about the destination node. This requires each node to be more intelligent so that it can function both as a network host for transmitting and receiving data and as a network router for routing packets from other nodes. Hence the mobile nodes in ad hoc wireless networks are more complex than in cellular networks.

The IEEE 802.11 standard is one of the most popular standards for wireless LANs. This standard specifies the physical layer and MAC layer adapted to the specific requirements. It also aids the regularity bodies in standardizing access to one or more radio frequency bands for the purpose of local area communications.

II. MATERIAL AND METHODOLOGY

Performance evaluation helps to determine the suitable network configuration that serves the best. The network performance can be measured with many metrics. Following sections give brief about few of those metrics and simulation setup of the experiment done in this paper.

A. Performance Metrics

One should have a well configured network with proper load balancing capabilities. Such parameters are known as performance metrics [1], [2], [3]. Some of the metrics are throughput, effective capacity, delay, round trip time, queue size, channel utilization, packet loss rate, queue overflow.

The different types of performance metrics used to evaluate performance of any networks are described below:

- *Throughput*

The throughput is the measure of how fast we can actually send data through the network. It is the measurement of number of packets that are transmitted through the network in a unit of time. It is desirable to have a network with high throughput.

$$\text{Throughput} = \Sigma PR / (\Sigma t_{sp} - \Sigma t_{st})$$

PR – Received Packet Size,

t_{st} – Start Time,

t_{sp} – Stop Time.

- *Link Throughput*

In computer technology, throughput is the amount of work that a computer can do in a given time period. In communication networks, such as Ethernet or packet radio, network throughput is the average of successful message delivery over a communication channel.

Transmission Time = File Size / Bandwidth (sec).

Throughput = File Size / Transmission Time (bps).

Link throughput say from node S to D is given by the following formula:

$$\sqrt{} = \Sigma N_b / t$$

N_b- Number of bits transmitted from node S to D

t - Observation duration.

- *Packet Delivery Ratio (PDR)*

It is the ratio of number of packets received at the destination to the number of packets generated at the source. A network should work to attain high PDR in order to have a better performance. PDR shows the amount of reliability offered by the network. The greater value of packet delivery ratio means the better performance of the protocol.

$$PDR = (\Sigma N_R / \Sigma N_G) * 100$$

N_R – Number of Received Packets,

N_G – Number of Generated Packets,

Unit – Percentage ratio (%).

- *Average End – to – End Delay (AED)*

This is the average time delay consumed by data packets to propagate from source to destination. This delay includes the total time of transmission i.e. propagation time, queuing time, route establishment time etc. A network with minimum AED offers better speed of communication.

$$AED = \Sigma t_{PR} - \Sigma t_{PS}$$

t_{PR} – Packet Receive Time,

t_{PS} – Packet Send Time,

Unit – milliseconds (ms).

B.   Simulation

Simulation of wired as well as wireless network functions and protocols (e.g., routing algorithms, TCP, UDP) can be done using NS2. AWK scripts are useful to extract required data from trace files.

1)   About NS2

All the implementations will be done in NS simulator, which is well-known discrete event network simulation tool and it uses an architecture which is organized according to the OSI reference model. The other discrete-event network simulators for performance analysis include GloMoSim, QualNet and OPNET [4].

NS2 works well for almost all real time applications. This approach is cheap, it does not require costly equipment, complex scenarios can be easily tested, results can be quickly obtained and more ideas can be tested in a smaller time-frame. NS provides substantial support for simulation of TCP, routing, and multicast protocols over wired and wireless (local and satellite) networks [5].   The NS instructions can be used to define the topology structure of the network and the motion mode of the nodes, to configure the service source and the receiver, to create the statistical data track file and so on.

After executing tcl files, we get trace files. Events in Queues can be recorded in these trace files. Statistical information such as throughput on a link/queue can be computed using the trace data. Packet tracing proceeds in two steps. First step is to write all information at the network checkpoints into a trace file using an OTcl statement as follows:

"$ns trace-all $fch."

The second step is to filter out unnecessary information and compute performance measures of interest. In this step, a scripting language such as AWK can be used For text processing, The AWK utilities allows users to do operation on data files i.e. Filtering data column by column, averaging the value, summation, and data reformatting tasks.

2)   About AWK Programming structure

AWK programming consists of 3 main parts as follows [6].

<div align="center">

BEGIN {<initialization>}

<pattern1> {<actionSet1>}

<pattern2> {<actionSet2>}

END {<final finalActionSet>}

</div>

Begin: What to be executed prior to text file processing.

Content: Script which process the text file. In this part, AWK moves lines by lines (i.e., records by records) and executes the <actionSet> if the current line matches with the pattern. The actions repeat until AWK reaches the end of the file.

End: What to be executed after the text file processing.

III. IMPLEMENTATION

A mobile node consists of network components like Link Layer (LL), Interface Queue (IfQ), MAC layer, the wireless channel nodes transmit and receive signals from etc. Each of these parameters are set with following values.

Parameters	Values
Channel type	WirelessChannel
Radio-propagation model	TwoRayGround
Antenna type	OmniAntenna

Link layer type	LL
Interface queue type	Queue/DropTail/PriQueue
Maximum packet in ifq	50
Network interface type	Phy/WirelessPhy
MAC type	Mac/802_11
Ad hoc routing protocol	AODV
Number of mobile nodes	4/9/16/25/49

Table 1: Wireless Node Parameters

For this simulation, a single hop network is chosen where all nodes are in range of each other and all flows are of type CBR. At the end of the simulation run, trace output file is created. In general OTcl packet tracing objects are as follows:

Trace/ Enqueue("+"): Trace packet arrival , usually at a queue.

Trace/Dequeue("-"): Trace packet departure, at queue.

Trace/Drop("d"): Trace packet drop, delivered to a drop-target.

Trace/Recv("r"): trace packet reception at a certain node, and "c" : represents collision event at the MAC level.

"$ns use-newtrace" is added to script to enable new trace format. The program takes a single command-line argument "node_number" and creates a topology of node_number^2 nodes' topology. Command line is $ns sim.ns -rlen 2/3/4/5.

IV. RESULT

Data table2 is obtained from executing Tcl script and AWK program of work done on wireless network topology. Graph plotted from the above table details presented in figure 1 and 2. As the number of nodes are increasing, rate of received packets are becoming less. And also PDR ratio is decreasing.

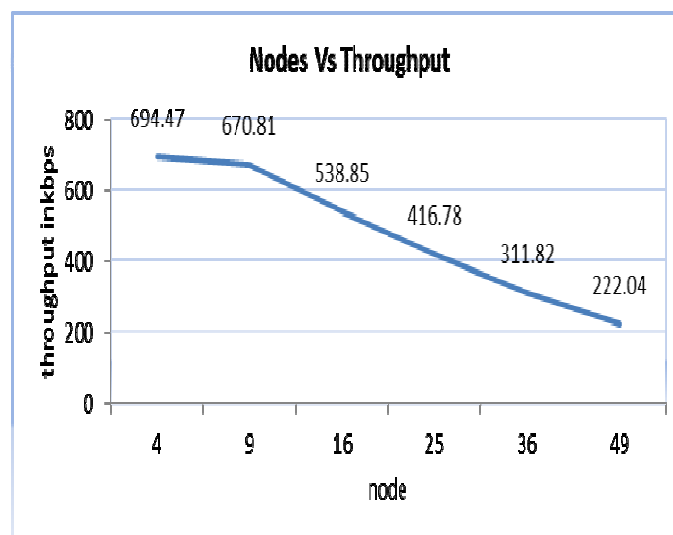| Nodes	Throughput (kbps)	PDR %
4	694.47	0.4242
9	670.81	0.1825
16	538.85	538.85
25	416.78	0.0409
36	311.82	0.0213
49	222.04	0.0112

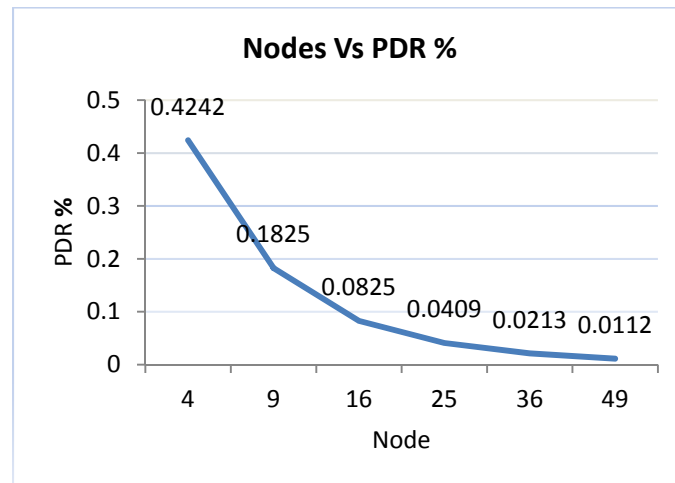Table 2: Throughput and PDR.

Figure1: Nodes Vs Throughput

Figure2. Nodes Vs Packet Delivery Ratio

V. Conclusion

We must choose the different metrics that would help us in making comparisons. The choice of metric would depend upon the purpose the network has been setup for. The metrics could be related to the different layers of the network stack. Once the metrics have been chosen, one goes for their quantitative evaluation by subjecting the network under diverse conditions. Thus, the optimum value of parameter, for example, bandwidth can be determined.

Obtaining optimum performance by balancing different factors is the real task. The trend may or may not be very clear due to factors like interference with increase in density etc. This work showed the impact of network density on performance factors of the network mainly on variation in throughput and packet loss rate.

This work can be continued to investigate the impact of contention window size on the performance of the IEEE 802.11 MAC protocol which may lead to correlate the CW size and network size/density. Next future task can be to see the effect of RTS/CTS, or virtual carrier sending.

Acknowledgement

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