Network Simulator-2

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1 Introduction

NS2 is an open-source event-driven simulator designed specifically for research in computer communication networks. In this experiment we have to vary different parameters such as number of nodes, number of flows, number of packets per second, speed of nodes and measure some metrics and plot them in some graphs. We also had to modify some mechanisms of tcp and/or routing, mac layer protocol, queue control mechanism etc and compare our modified version of the ns2 with the original version through the metrics and generated graph.

2 Simulated Networks

- Wired network using TCP in Ring topology
- Wireless 802.11 (Mobile) network using TCP in Random Topology
- Wired-Cum-Wireless Network
- LTE (4G)
- WiMax

3 Parameters and Metrics

3.1 Parameters

1. Number of nodes (20, 40, 60, 80, and 100)
2. Number of flows (10, 20, 30, 40, and 50)
3. Number of packets per second (100, 200, 300, 400, and 500)
4. Speed of nodes (5 m/s, 10 m/s, 15 m/s, 20 m/s, and 25 m/s) [for 802.11 mobile nodes]

3.2 Metrics

1. Network Throughput
2. End-to-End Delay
3. Packet Delivery Ratio
4. Packet Drop Ratio
5. Energy Consumption [for 802.11 mobile nodes]
6. Average Congestion Window
7. Per-Node Throughput

4 Bonus Tasks

We have attempted 3 bonus tasks as instructed in the assignment. They are:

1. Cross transmission of packets [Simulation and Statistics Building]
2. Simulating LTE(4G) [Simulation Only] and WiMax network [Simulation and Statistics Building]
3. Measuring 2 extra metrics
   - Average Congestion Window
   - Per-node Throughput

5 Modifications

We have done several modifications in the simulator and run our code in the modified version. The modifications are listed below.

1. Congestion Control: TCP uses slow-start algorithm for congestion control. In congestion avoidance phase after the congestion window has crossed threshold value, it increases window by $1/cwnd\_$. In our case we have formulated a new mechanism of increasing the congestion window in congestion avoidance phase. We have increased the congestion window when the expression $awnd\_ \times wnd\_const\_ \times srtt$ is greater than the current congestion window. where $awnd\_$ is averaged congestion window $wnd\_const\_$ is packets per RTT $srtt$ is smoothed round trip time

2. RTT Mechanism: The current unbounded retransmit timeout calculation uses smoothed round trip time and rtt variation variables $srtt\_$ and $rttvar\_$. the formula for the calculation of srtt and rttvar is given below:

$$srtt(k+1) = \frac{7}{8}srtt(k) + \frac{1}{8}rtt(k+1)$$

and

$$rttvar(k+1) = \frac{3}{4}rttvar(k) + \frac{1}{4}|\delta|$$

where $rtt(k+1)$ = new rtt sample
and $\delta = rtt(k+1) - srtt(k)$

It is changed as below:

$$srtt(k+1) = \frac{15}{16}srtt(k) + \frac{1}{16}rtt(k+1)$$

and

$$rttvar(k+1) = \frac{7}{8}rttvar(k) + \frac{1}{8}|\delta|$$

We have changed the value of T_SRTT_BITS and T_RTTVAR_BITS to get this effect

3. **RTO Timeout change:** The function rtt_timeout is changed to enforce the value of rtt_update to be taken for calculating timeout value as

$$timeout = t\_rtxcur\_ \times t\_backoff\_$$

4. **Changing the gain of Omni-antenna:** We have changed the Transmission and Receiving gain Gt_ and Gr_ from 1.0 to 2.0 for wireless 802.11 protocol simulation

5. **AODV Change:** The changes done in AODV.h file are given below:

   1. $ACTIVE\_ROUTE\_TIMEOUT$ is changed from 10 to 8. As AODV is generally used for wireless nodes, this change will prune inaccessible routes faster in case of link failures.
   2. $RREQ\_RETRIES$ is changed from 3 to 5 and $MAX\_RREQ\_TIMEOUT$ is changed from 10.0 to 6.0. This change will make the nodes to try to retry more times in Route Discovery phase. This helps to find mobile nodes better.
   3. TTL_START, $TTL\_THRESHOLD$ and $TTL\_INCREMENT$ is changed from 5, 7, 2 to 3, 9, 3 respectively. AODV implements ring search in Route Discovery Phase. To limit the flooding in the network, at first we are searching with small TTL values and then gradually expanding our search. This should find routes to nodes which are close faster than before.

6. **SFQ Change:** We have used Stochastic Fair Queue i.e. SFQ instead of Droptail queue in wired network simulation and we have changed the number of buckets for the hash mechanism which have effected the variable **fairshare**. The buckets_ variable have been changed from 16 to 25 in this case.

6 Comparison

6.1 Wired

6.1.1 Network Throughput

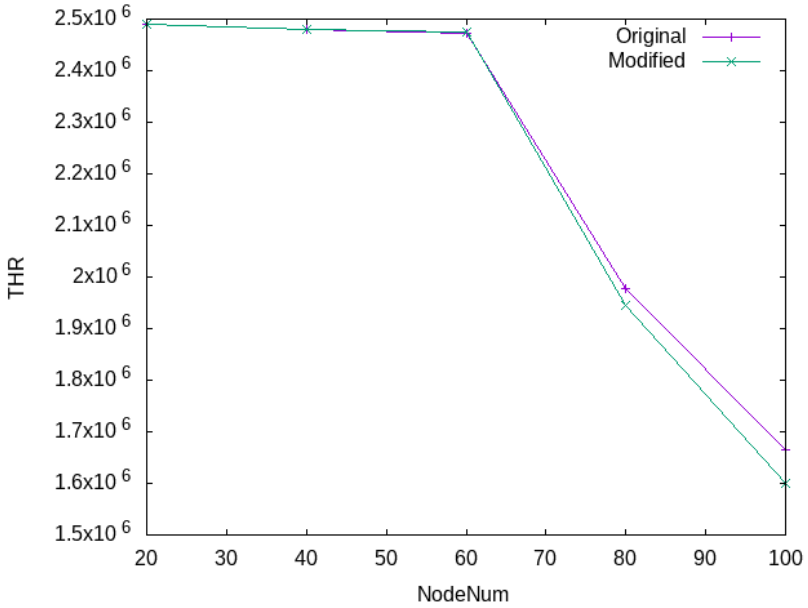


Figure 1: Wired : Network Throughput VS Number of Nodes

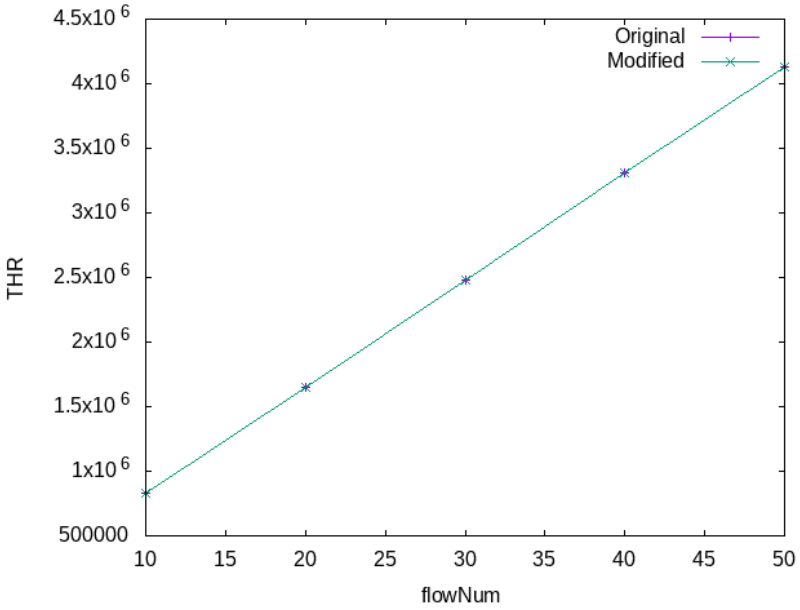


Figure 2: Wired : Network Throughput VS Number of Flows

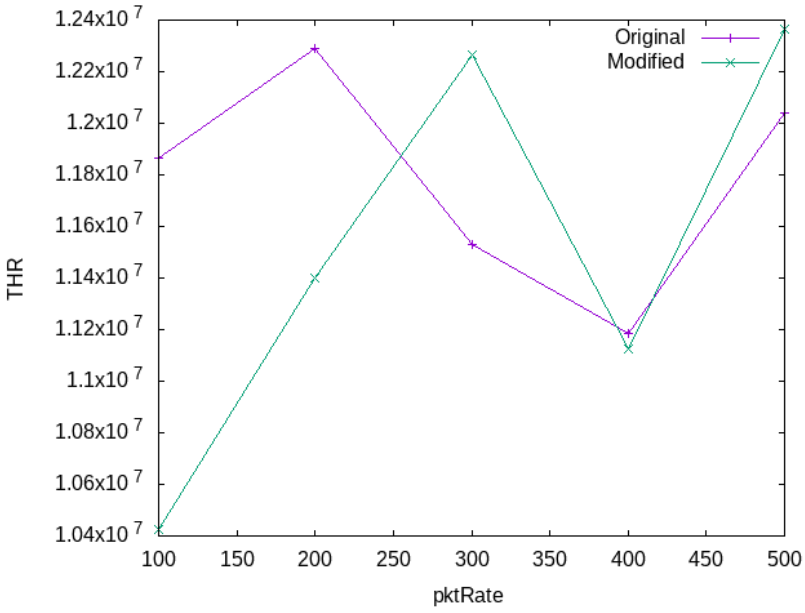


Figure 3: Wired : Network Throughput VS Packets Per Second

6.1.2 End-to-End Delay

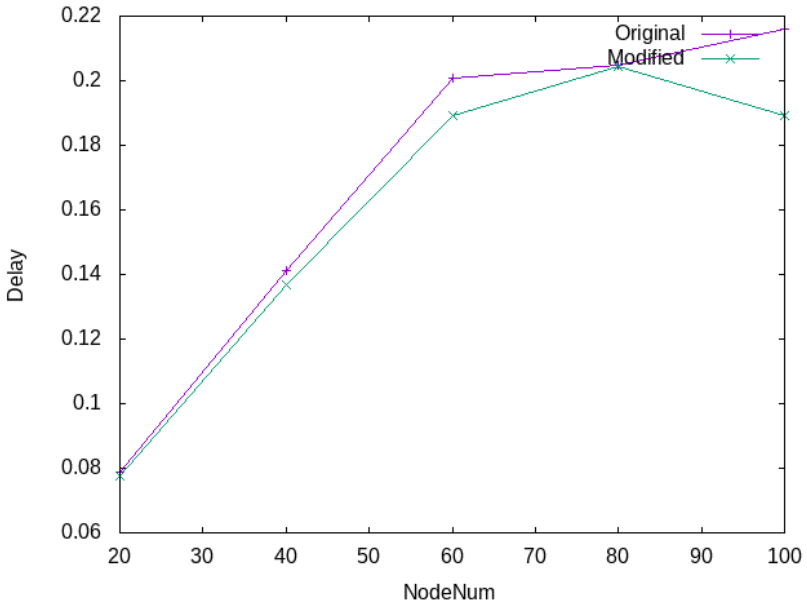


Figure 4: Wired : Delay VS Number of Nodes

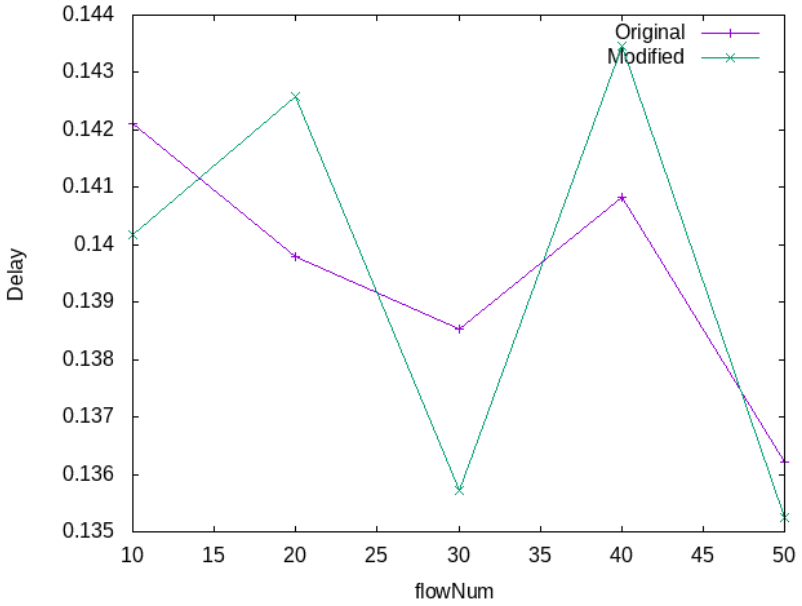


Figure 5: Wired : Delay VS Number of Flows

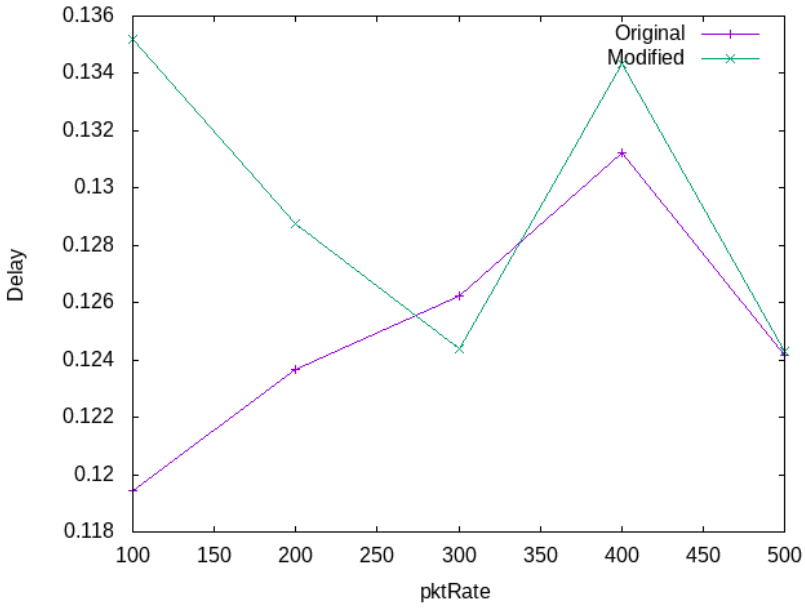


Figure 6: Wired : Delay VS Packets Per Second

6.1.3 Packet Delivery Ratio

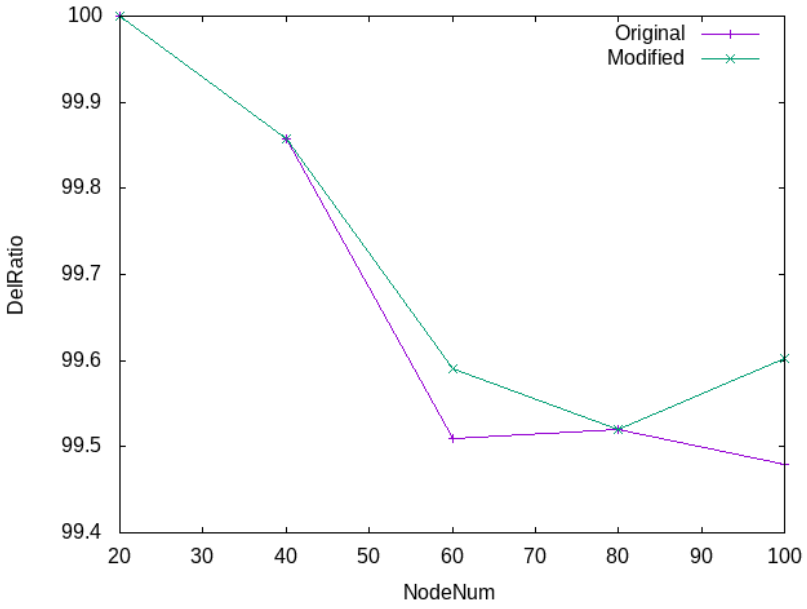


Figure 7: Wired : Delivery Ratio VS Number of Nodes

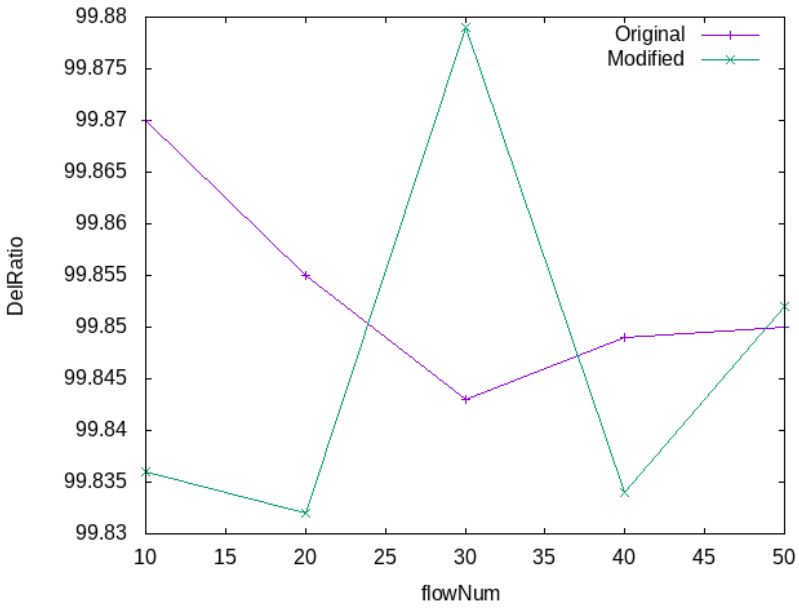


Figure 8: Wired : Delivery Ratio VS Number of Flows

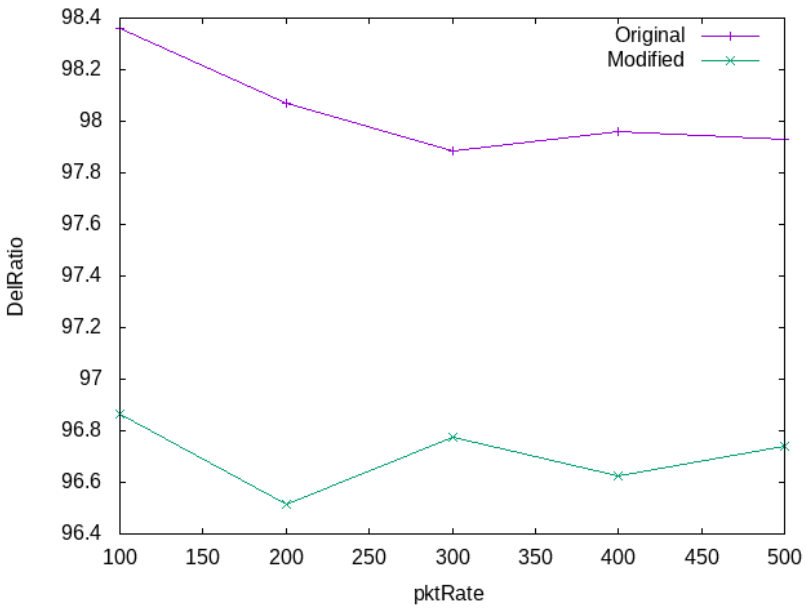


Figure 9: Wired : Delivery Ratio VS Packets Per Second

6.1.4 Packet Drop Ratio

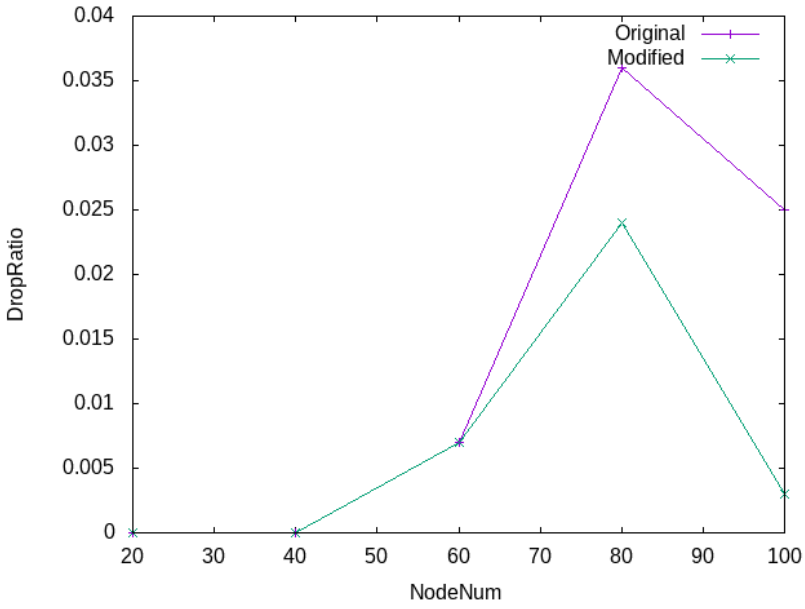


Figure 10: Wired : Drop Ratio VS Number of Nodes

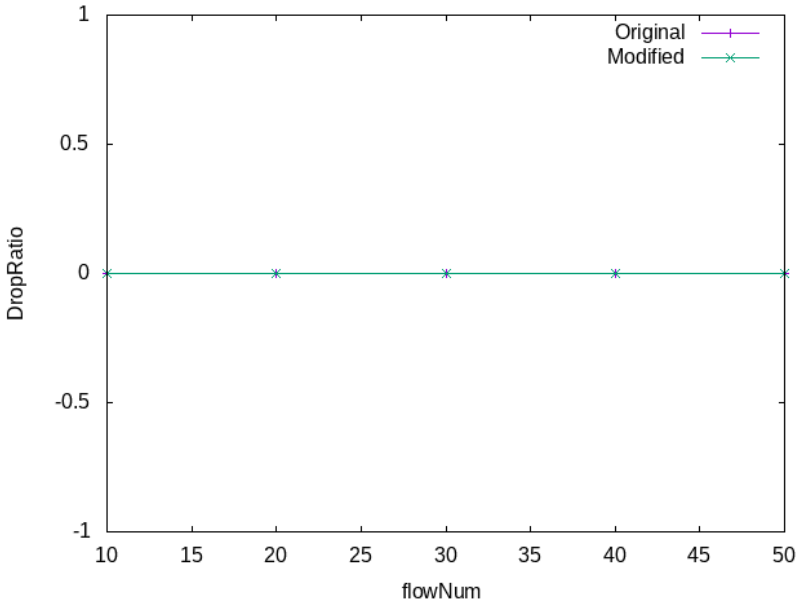


Figure 11: Wired : Drop Ratio VS Number of Flows

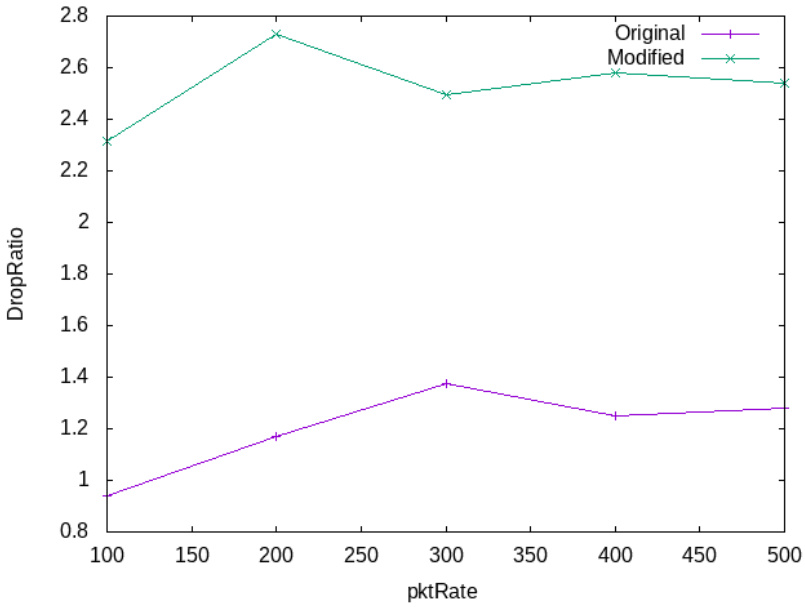
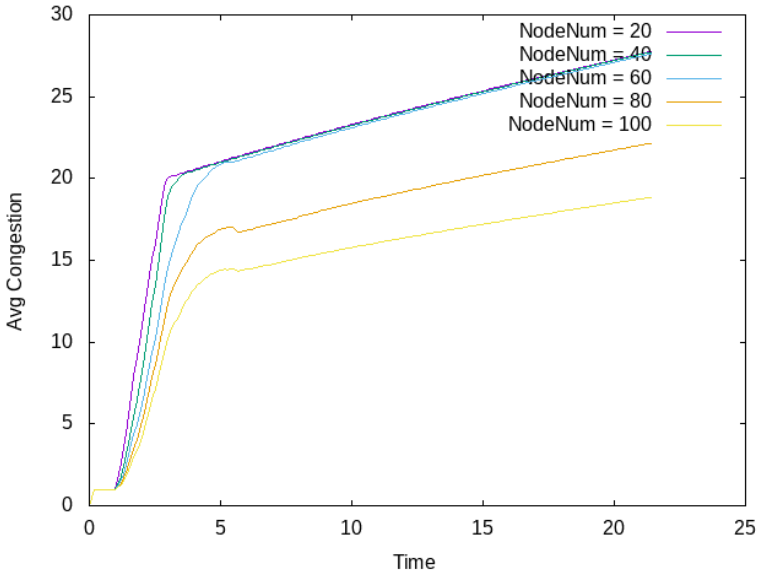


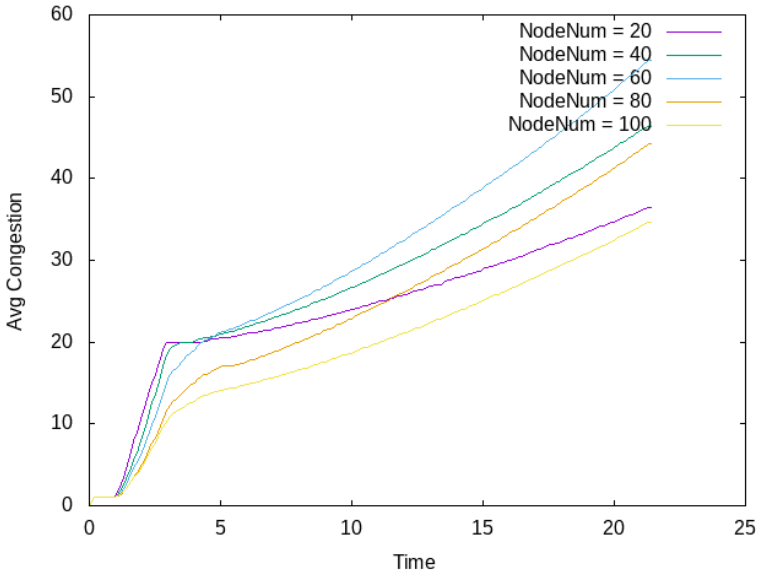
Figure 12: Wired : Drop Ratio VS Packets Per Second

6.1.5 Average Congestion Window



[!h]

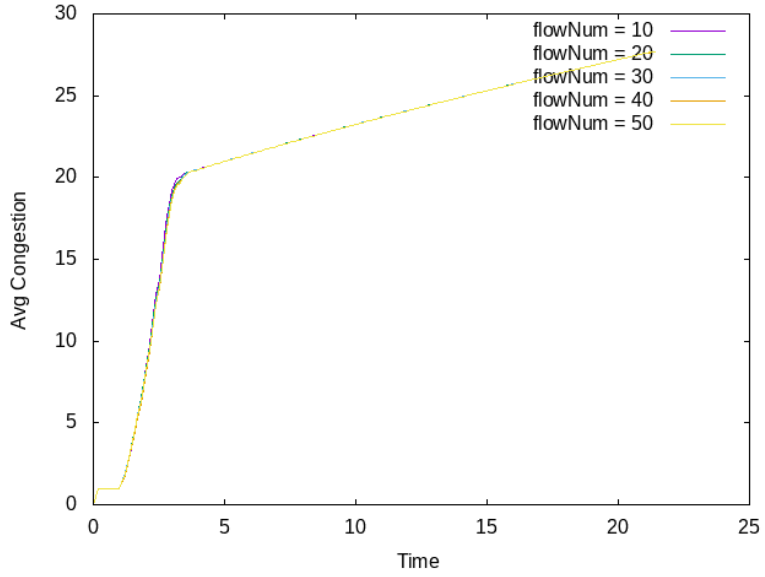
(a) Original



[!h]

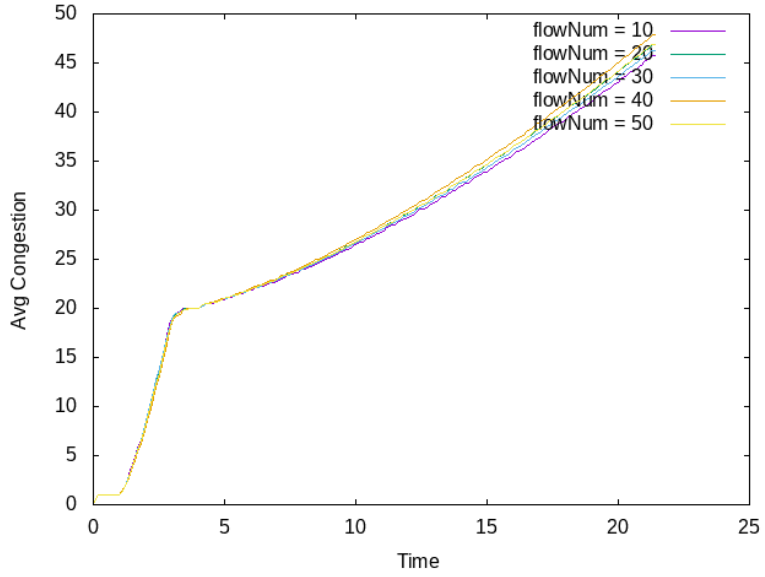
(b) Modified

Figure 13: Wired : Average Congestion Window VS Number of Nodes



[!h]

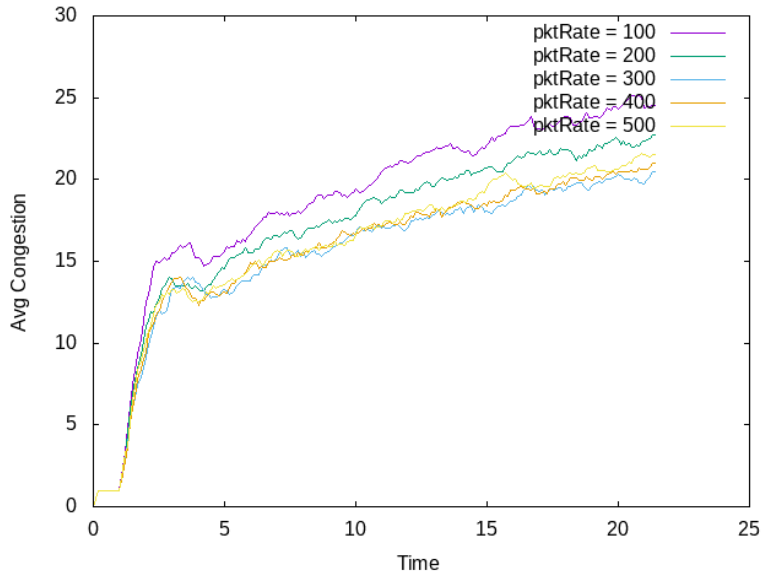
(a) Original



[!h]

(b) Modified

Figure 14: Wired : Average Congestion Window VS Number of Flows



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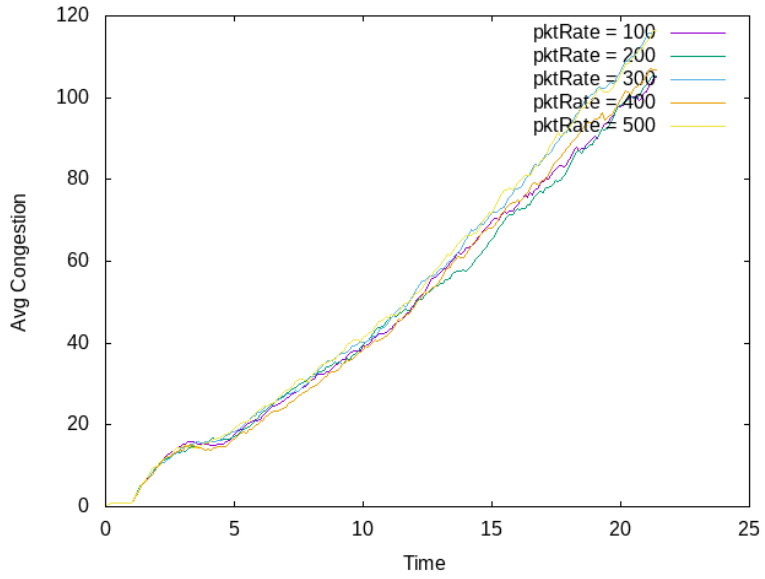
(a) Original

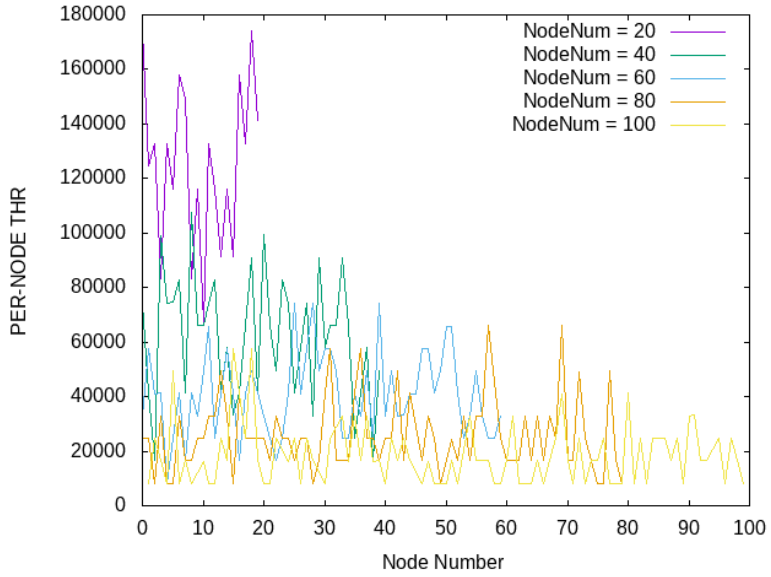


[!h]

(b) Modified

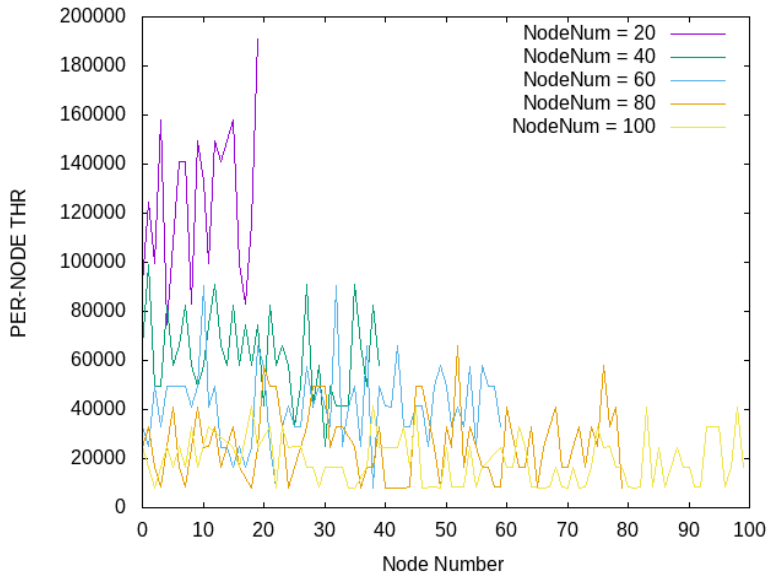
Figure 15: Wired : Average Congestion Window VS Packets Per Seconds

6.1.6 Per-Node Throughput



[!h]

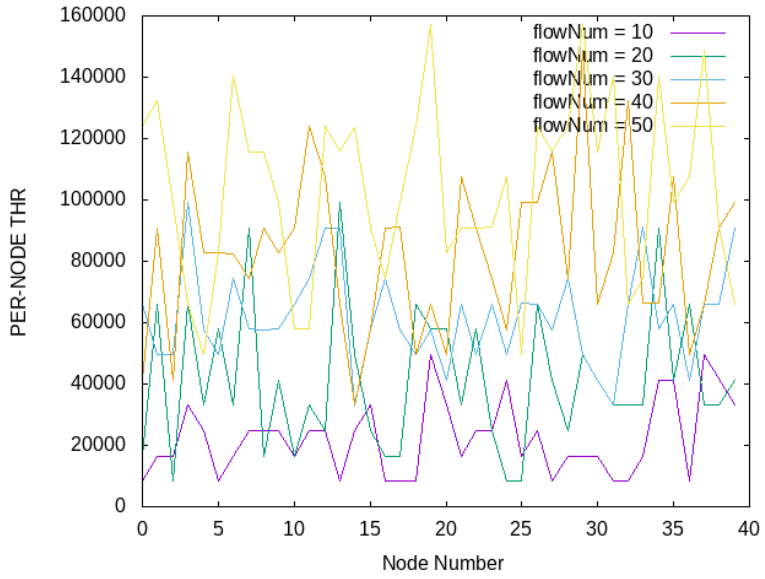
(a) Original



[!h]

(b) Modified

Figure 16: Wired : Per-Node Throughput VS Number of Nodes



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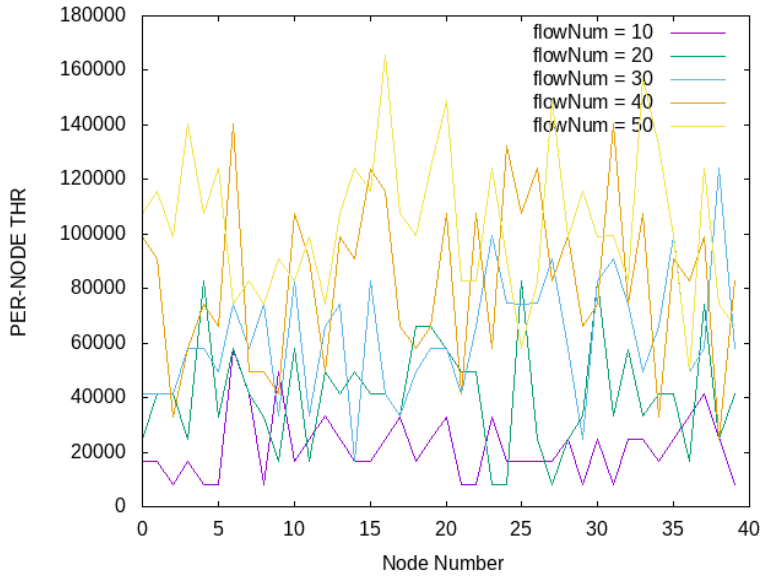
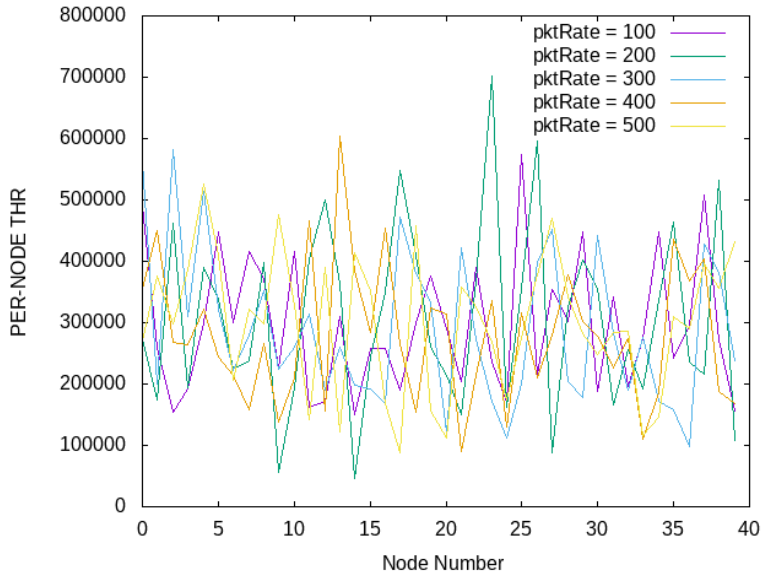
(a) Original



[!h]

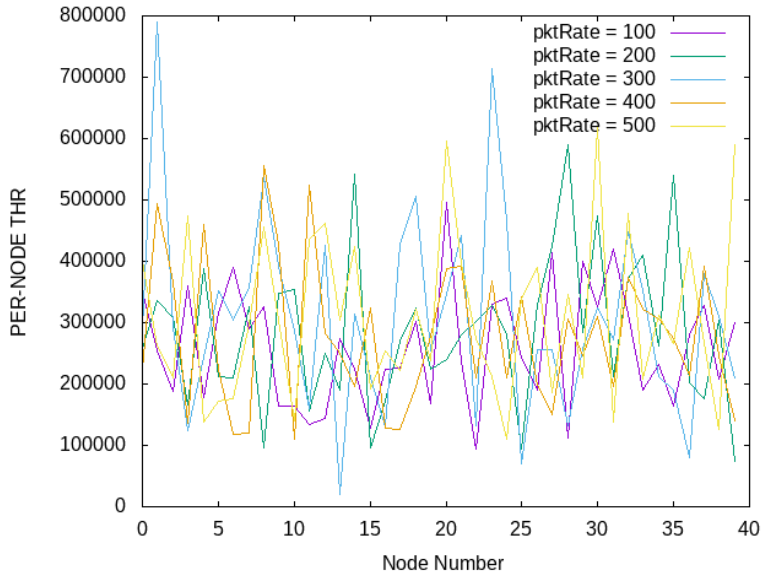
(b) Modified

Figure 17: Wired : Per-Node Throughput VS Number of Flows



[!h]

(a) Original



[!h]

(b) Modified

Figure 18: Wired : Per-Node Throughput VS Packets Per Seconds

6.2 Wireless 802.11 (Mobile)

6.2.1 Network Throughput

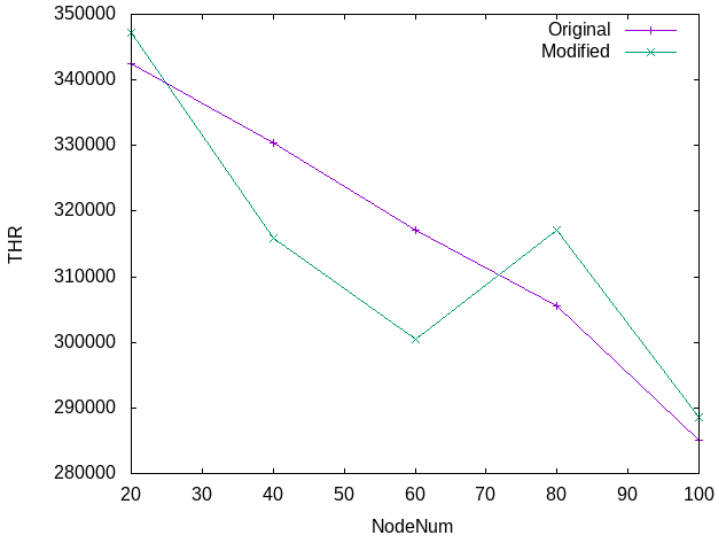


Figure 19: Wireless 802.11 : Network Throughput VS Number of Nodes

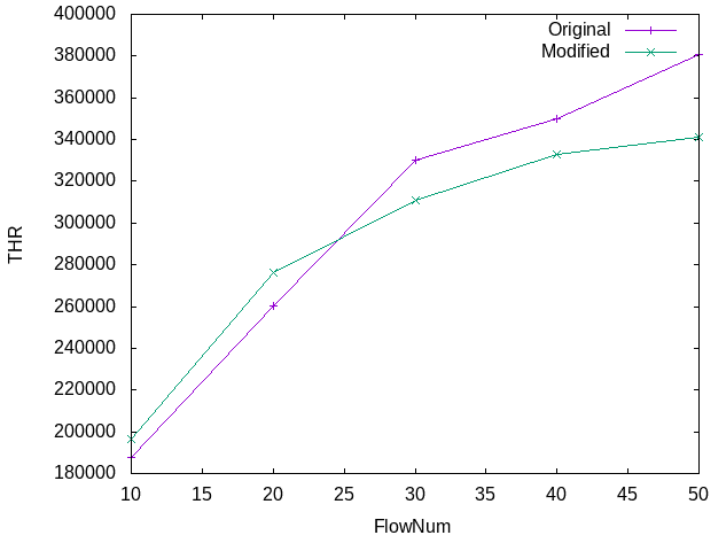


Figure 20: Wireless 802.11 : Network Throughput VS Number of Flows

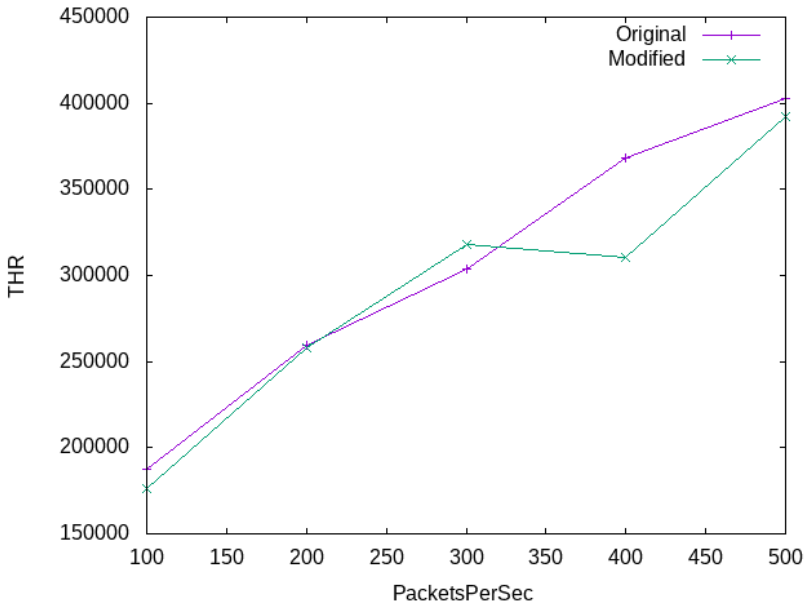


Figure 21: Wireless 802.11 : Network Throughput VS Packets Per Second

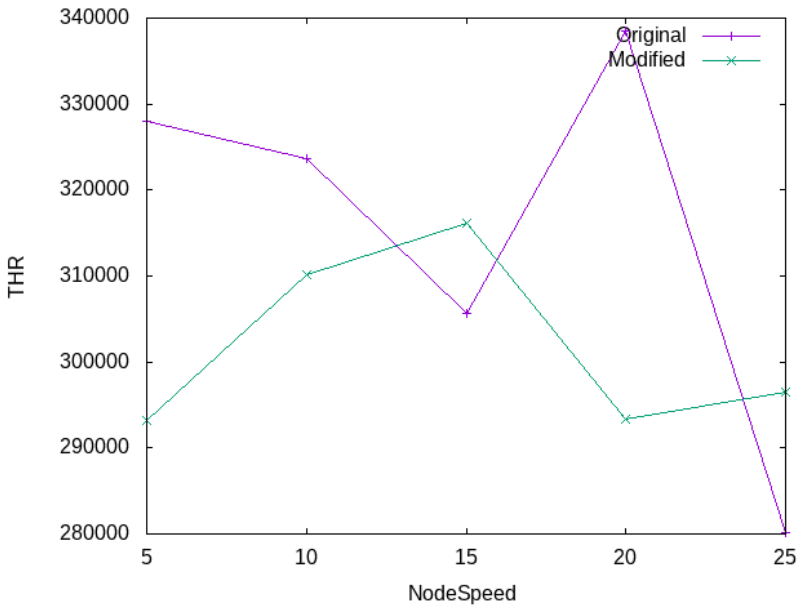


Figure 22: Wireless 802.11 : Network Throughput VS Node Speed

6.2.2 End-to-End Delay

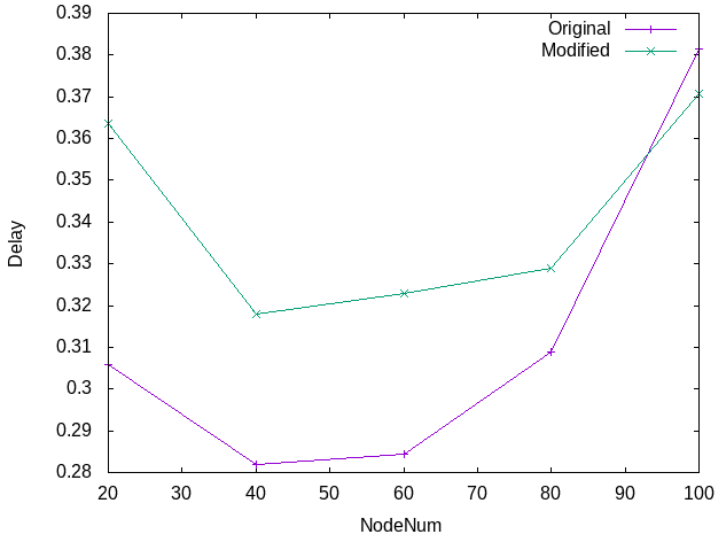


Figure 23: Wireless 802.11 : Delay VS Number of Nodes

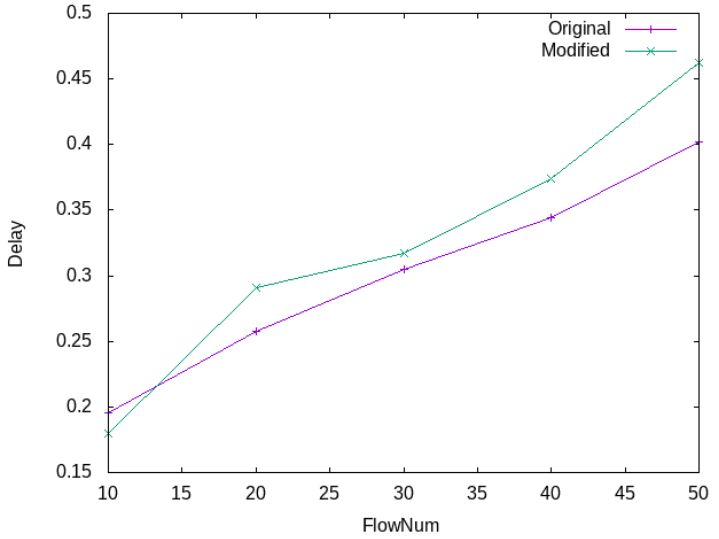


Figure 24: Wireless 802.11 : Delay VS Number of Flows

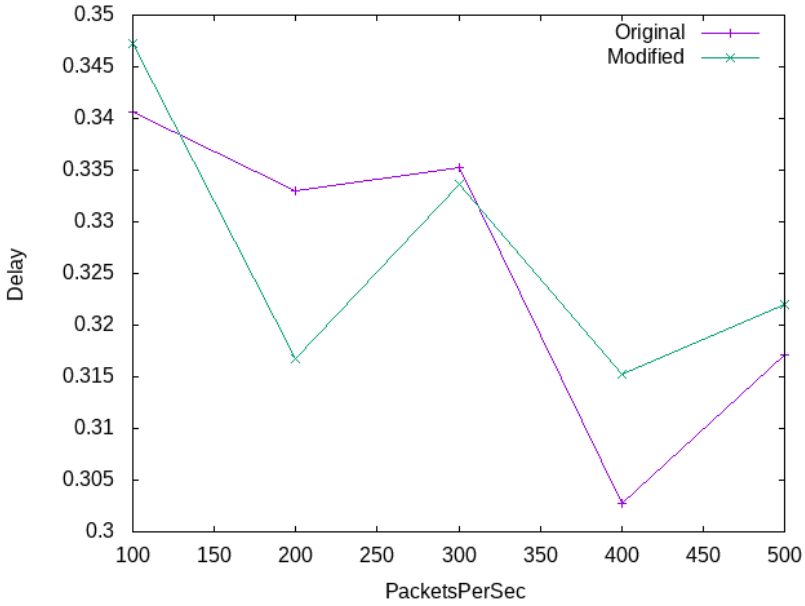


Figure 25: Wireless 802.11 : Delay VS Packets Per Second

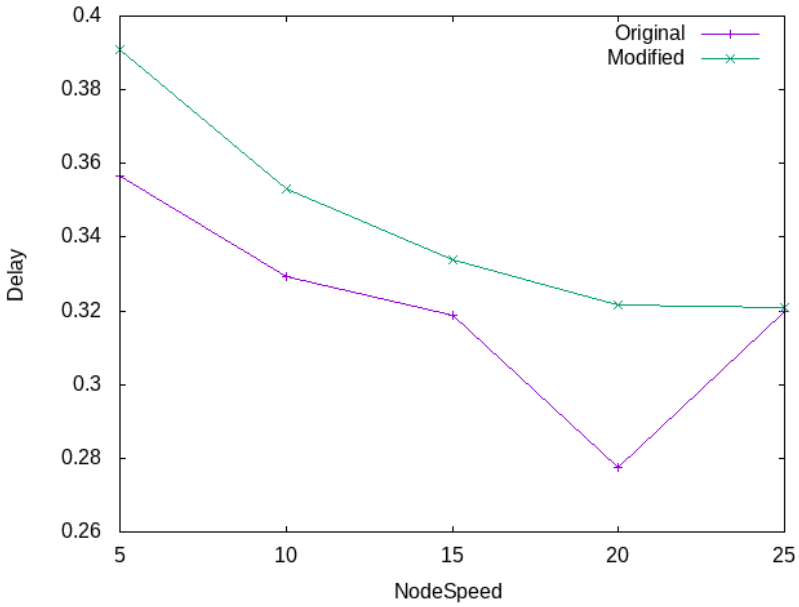


Figure 26: Wireless 802.11 : Delay VS Node Speed

6.2.3 Packet Delivery Ratio

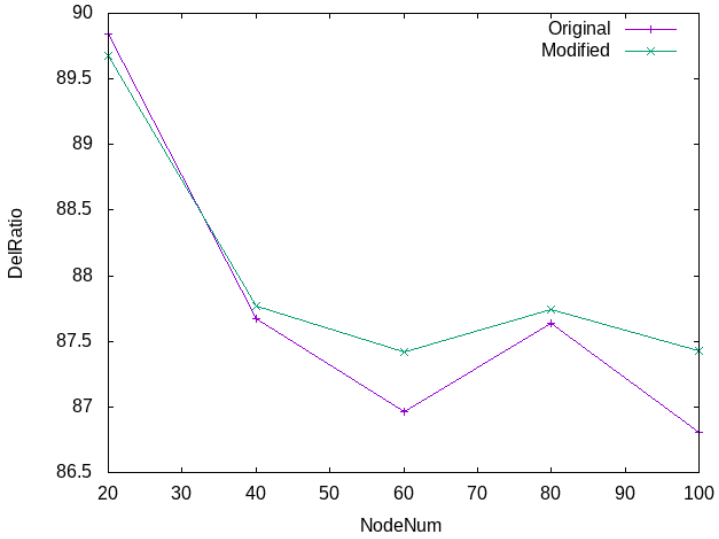


Figure 27: Wireless 802.11 : Delivery Ratio VS Number of Nodes

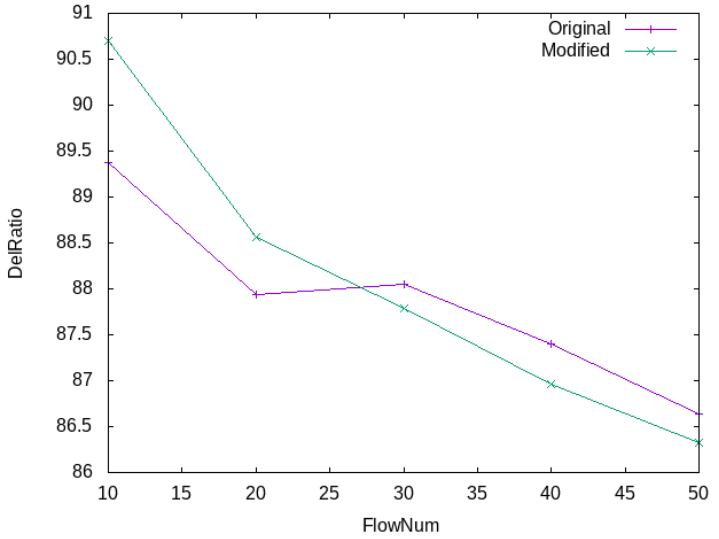


Figure 28: Wireless 802.11 : Delivery Ratio VS Number of Flows

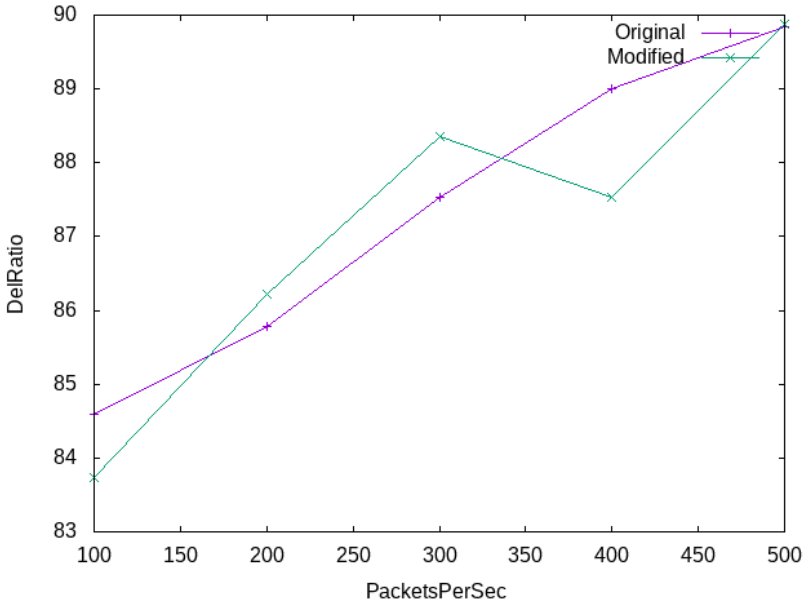


Figure 29: Wireless 802.11 : Delivery Ratio VS Packets Per Second

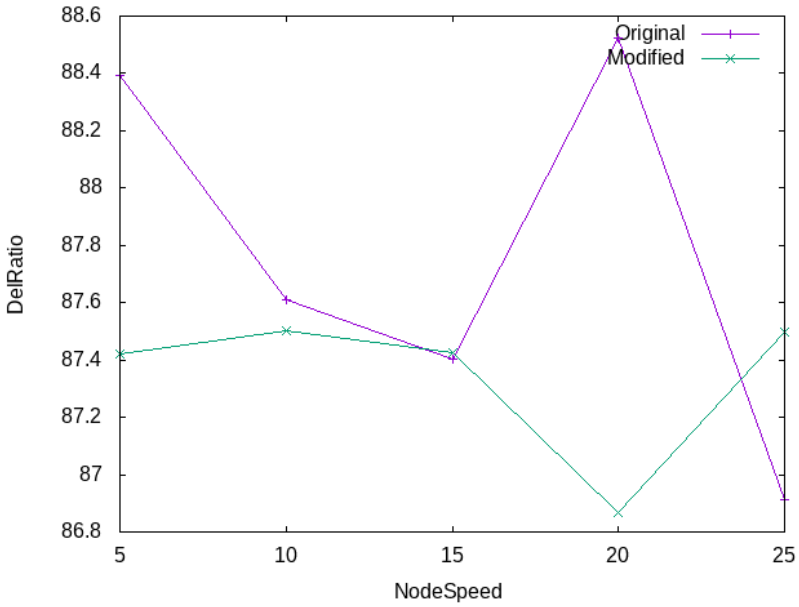


Figure 30: Wireless 802.11 : Delivery Ratio VS Node Speed

6.2.4 Packet Drop Ratio

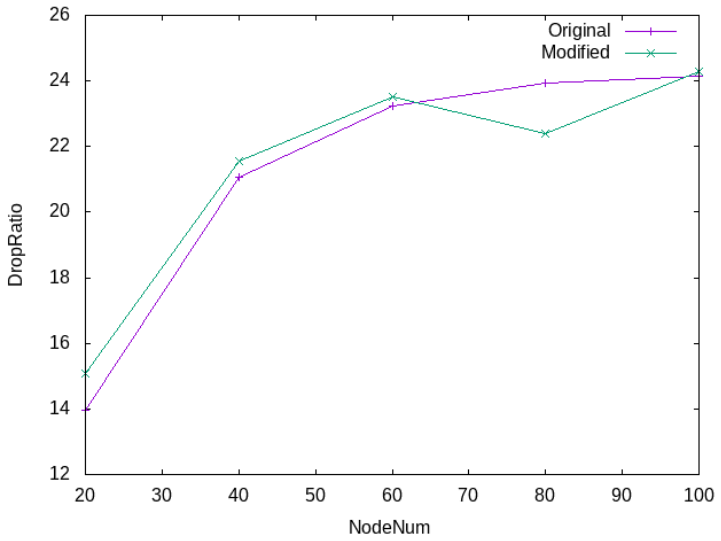


Figure 31: Wireless 802.11 : Drop Ratio VS Number of Nodes

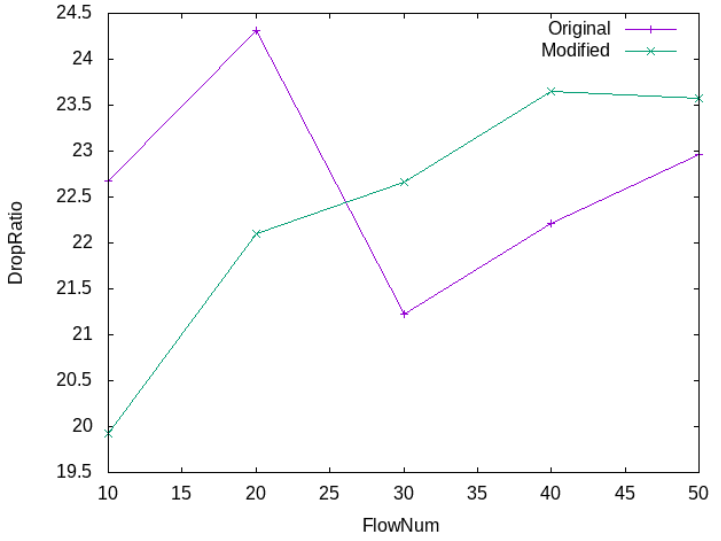


Figure 32: Wireless 802.11 : Drop Ratio VS Number of Flows

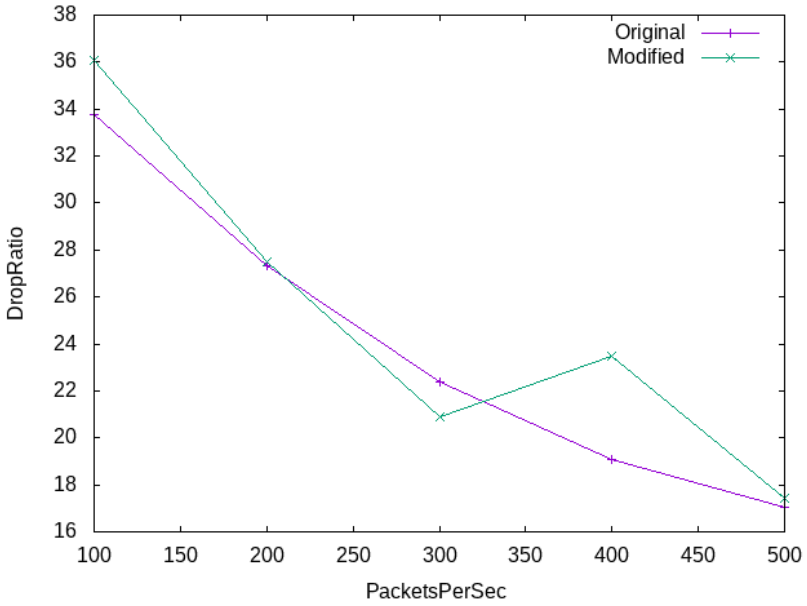


Figure 33: Wireless 802.11 : Drop Ratio VS Packets Per Second

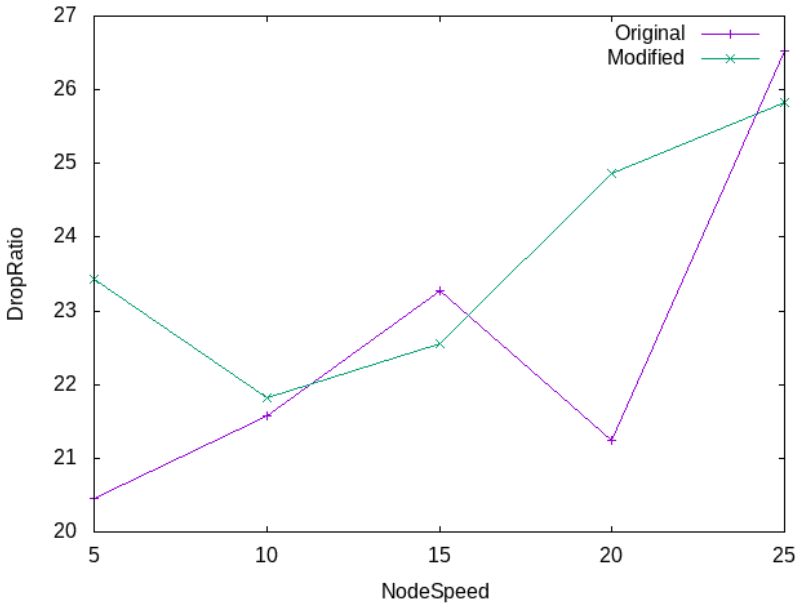


Figure 34: Wireless 802.11 : Drop Ratio VS Node Speed

6.2.5 Energy Consumption

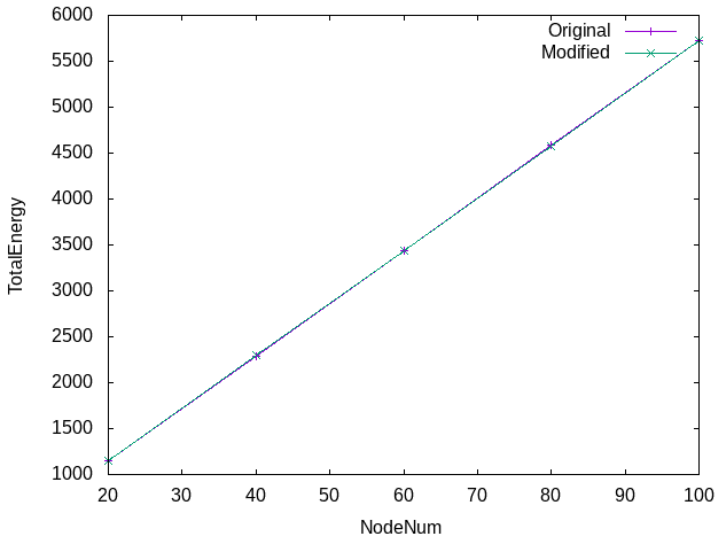


Figure 35: Wireless 802.11 : Energy Consumption VS Number of Nodes

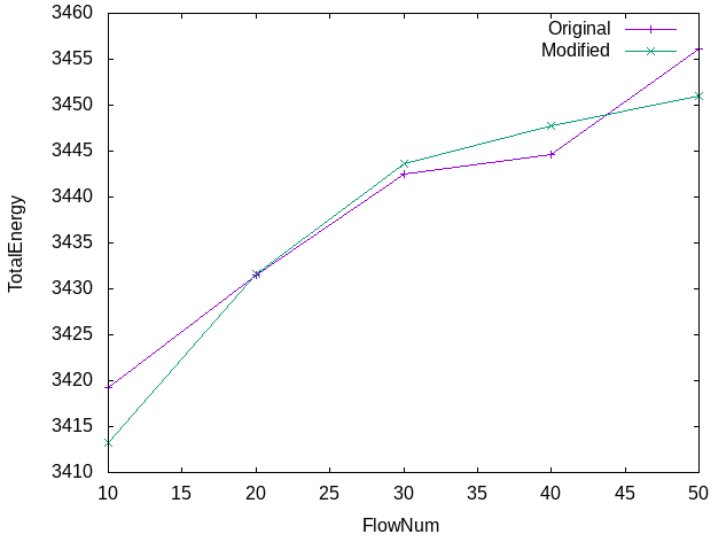


Figure 36: Wireless 802.11 : Energy Consumption VS Number of Flows

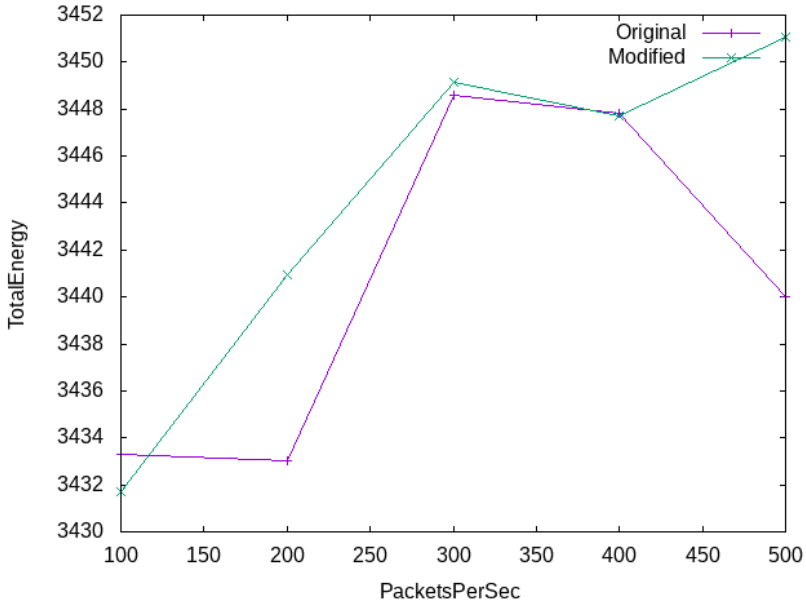


Figure 37: Wireless 802.11 : Energy Consumption VS Packets Per Second

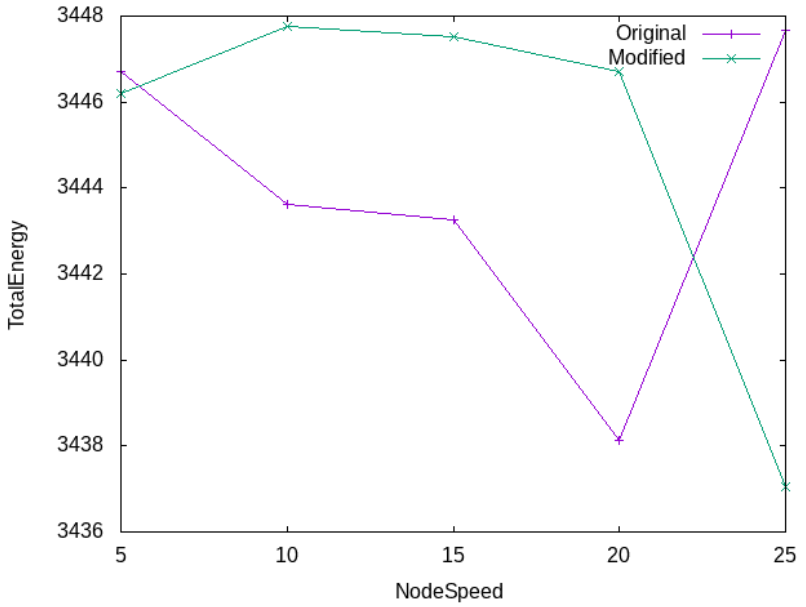
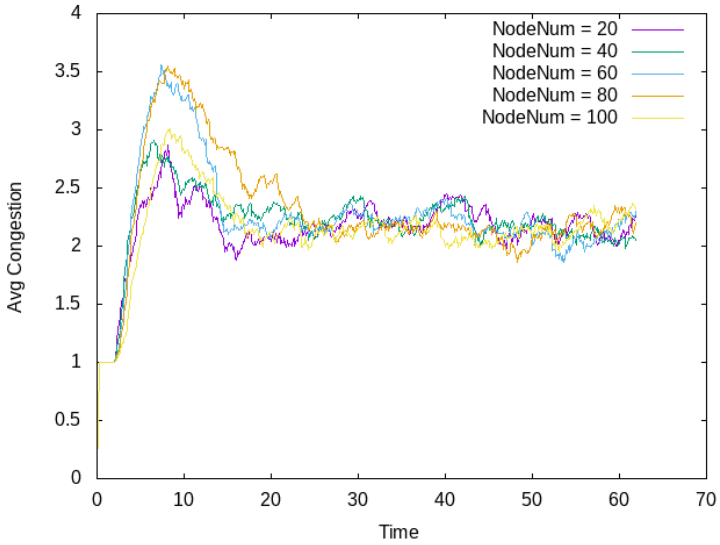
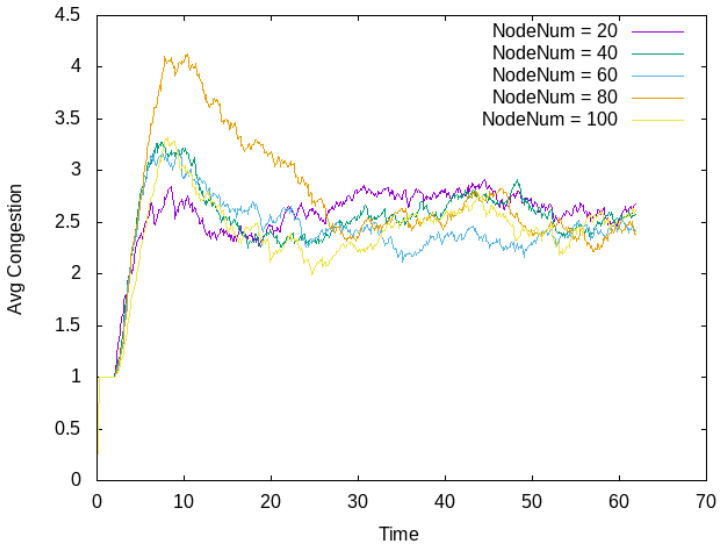


Figure 38: Wireless 802.11 : Energy Consumption VS Node Speed

6.2.6 Average Congestion Window

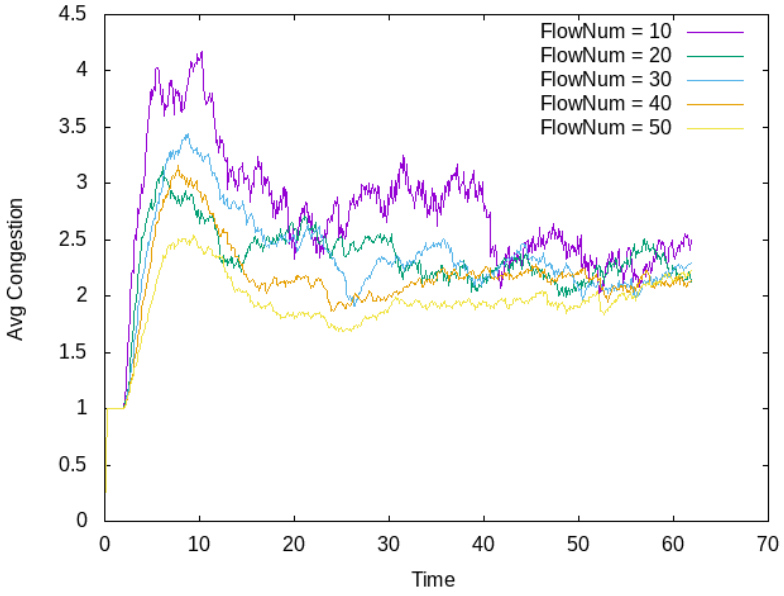


(a) Original

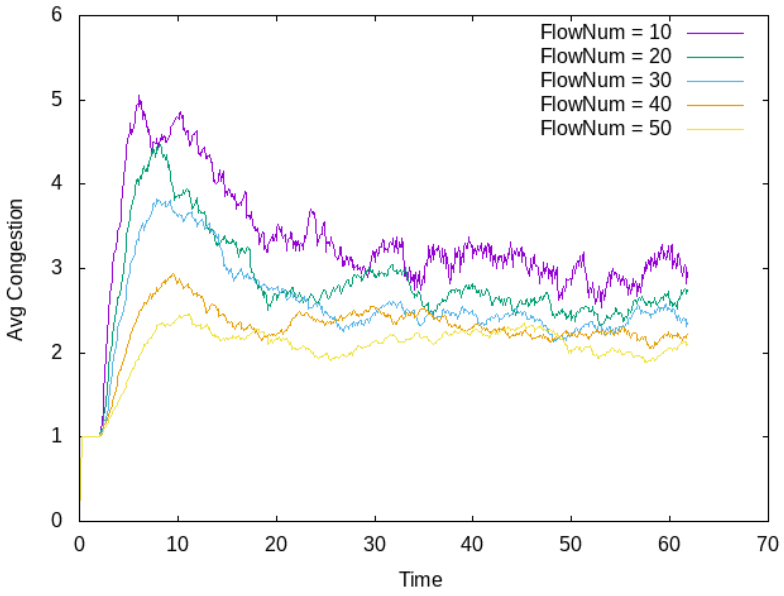


(b) Modified

Figure 39: Wireless 802.11 : Average Congestion Window VS Number of Nodes

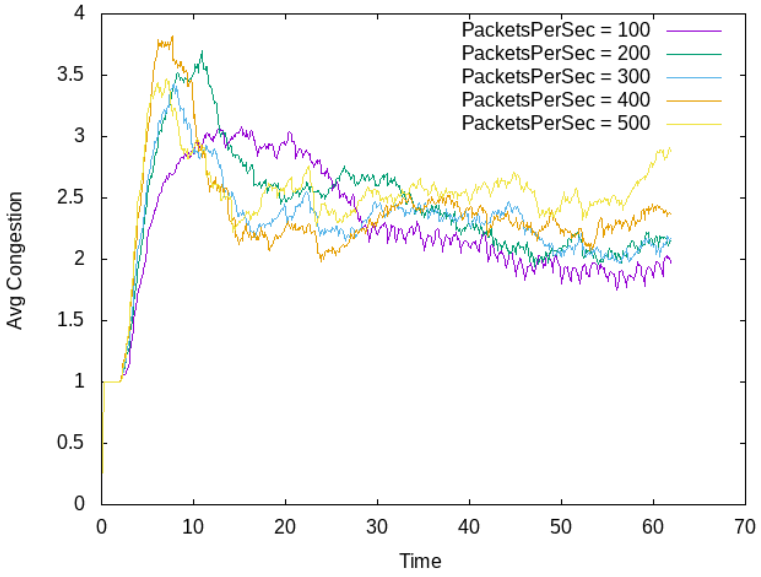


(a) Original

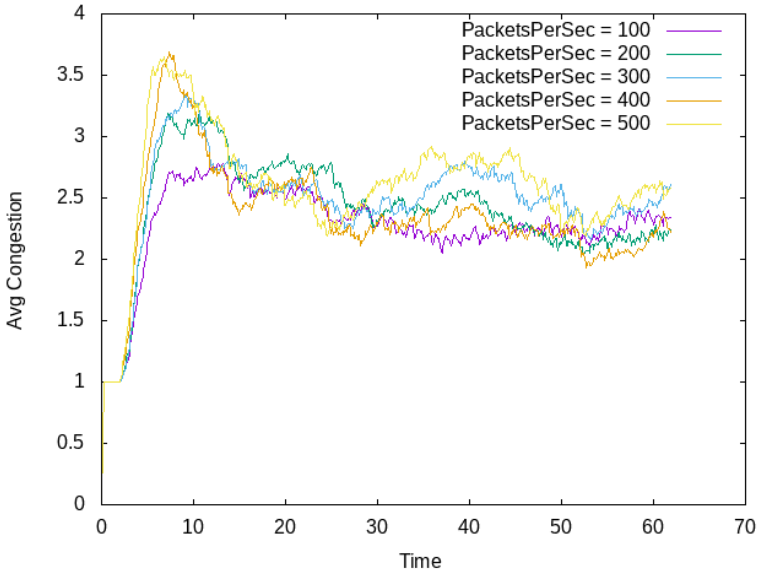


(b) Modified

Figure 40: Wireless 802.11 : Average Congestion Window VS Number of Flows

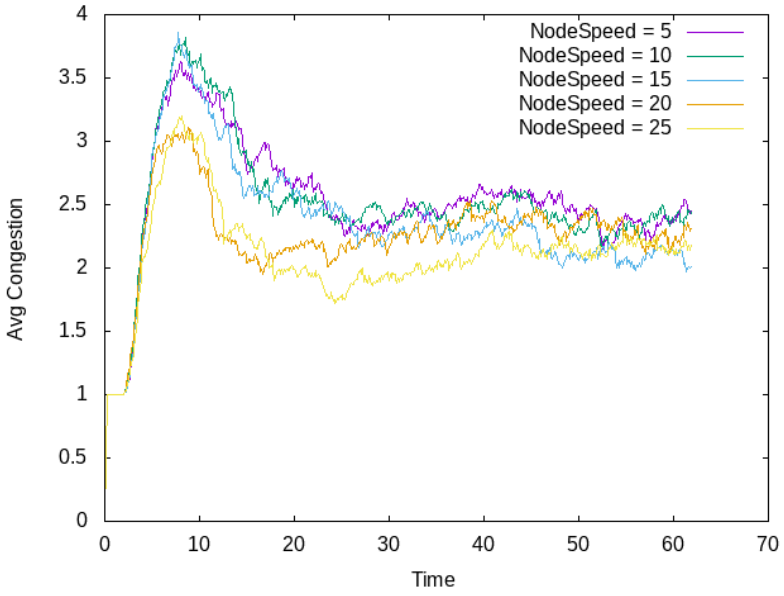


(a) Original

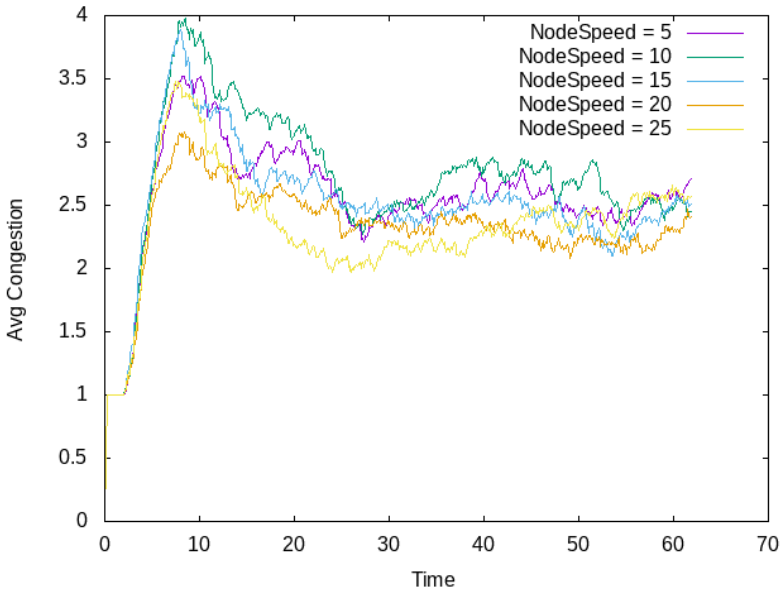


(b) Modified

Figure 41: Wireless 802.11 : Average Congestion Window VS Packets Per Seconds



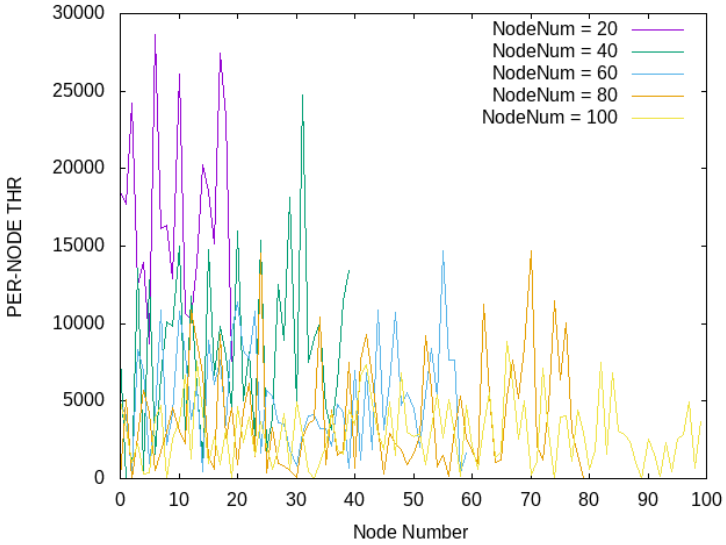
(a) Original



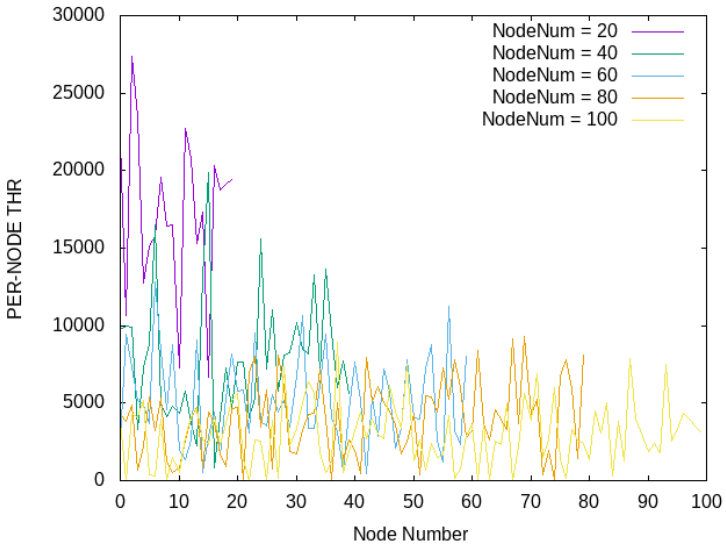
(b) Modified

Figure 42: Wireless 802.11 : Average Congestion Window VS Node Speed

6.2.7 Per-Node Throughput

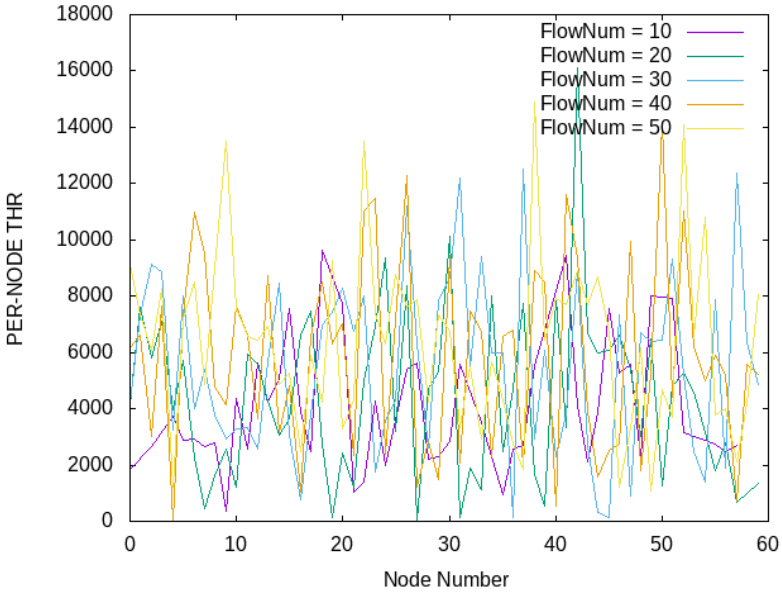


(a) Original

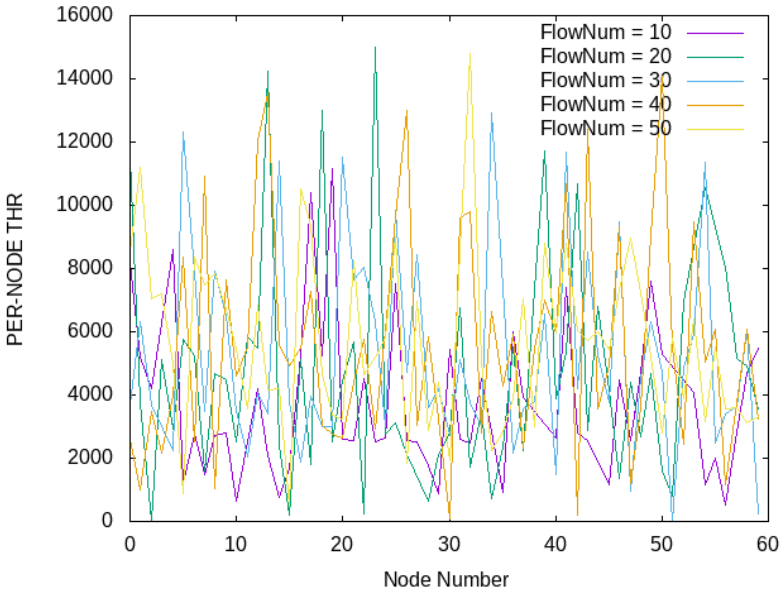


(b) Modified

Figure 43: Wireless 802.11 : Per-Node Throughput VS Number of Nodes

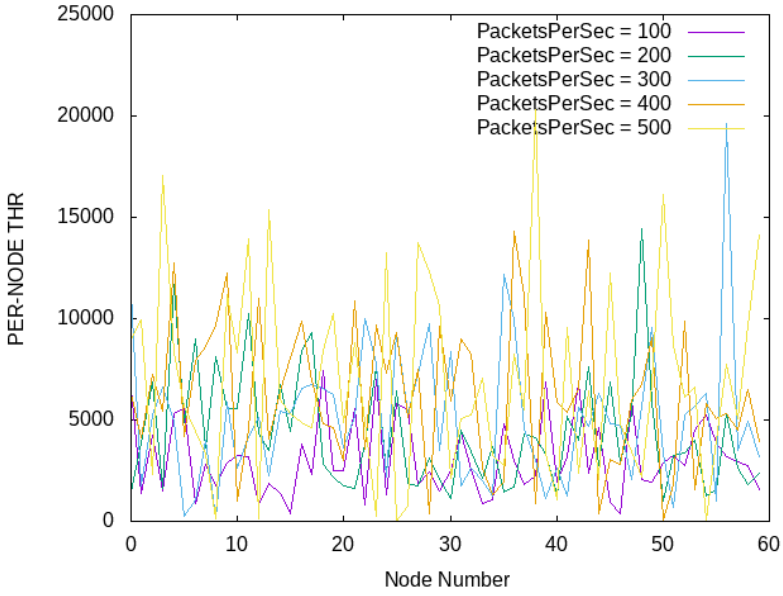


(a) Original

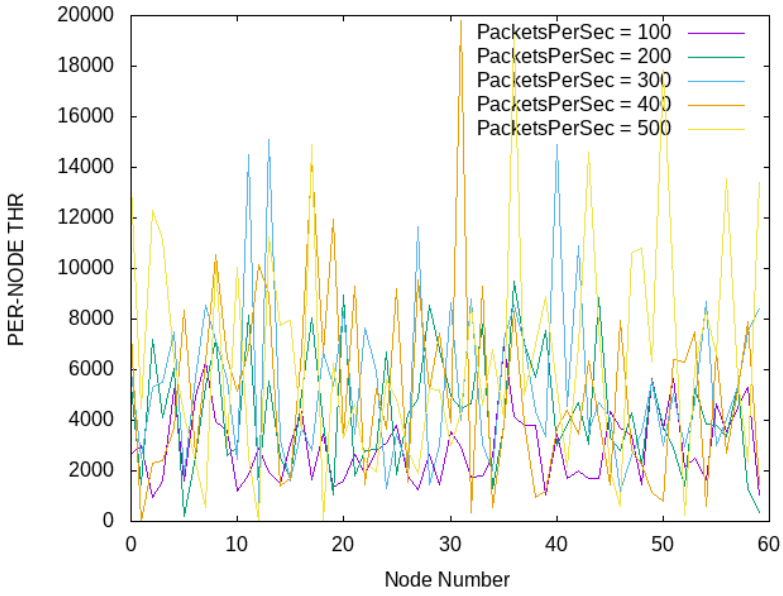


(b) Modified

Figure 44: Wireless 802.11 : Per-Node Throughput VS Number of Flows

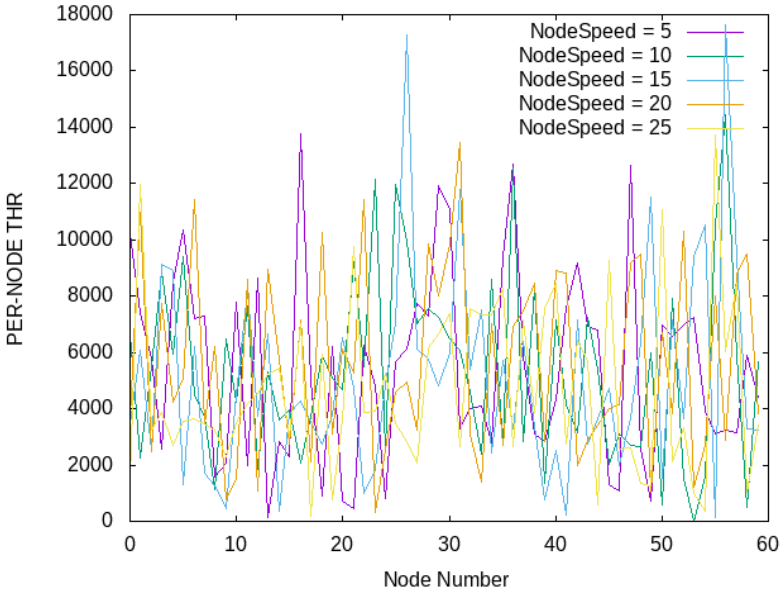


(a) Original

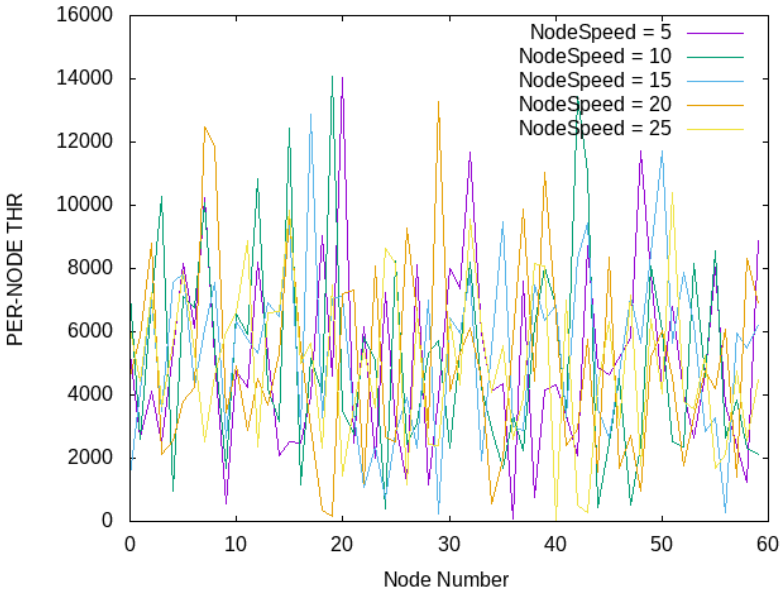


(b) Modified

Figure 45: Wireless 802.11 : Per-Node Throughput VS Packets Per Seconds



(a) Original



(b) Modified

Figure 46: Wireless 802.11 : Per-Node Throughput VS Node Speed

7 Bonus Simulation Data

7.1 Cross Transmission

The Average statistics found in 10 iterations of the wired-cum-wireless network simulation is shown in Table 1.

Metric	Value
Throughput	323506.52000
Average Delay	16.24650
Sent Packets	1212.00000
Received Packets	1132.00000
Dropped Packets	0
Packet Delivery Ratio	93.40000
Packet Drop Ratio	0
Total Time	29.08820
Total Retransmit	1132.00000

(a) Statistics

Node Number	Throughput
6	323506.51880

(b) Per-Node Throughput

Table 1: Wired-Cum-Wireless Network

7.2 LTE

The simulation of LTE (4G) network was done and network animator view is attached of the simulation.

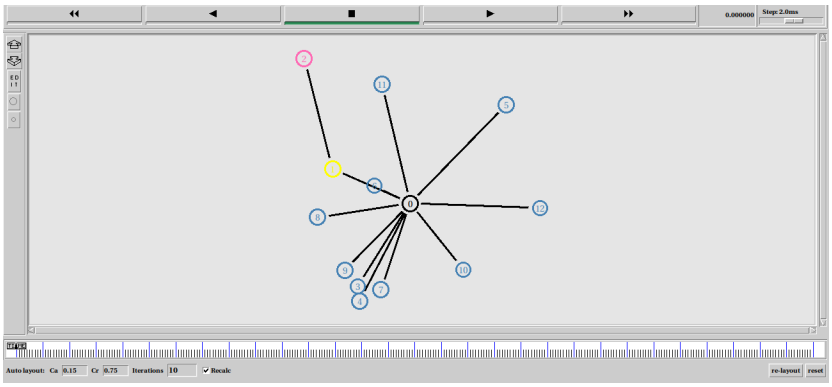


Figure 47: LTE Network

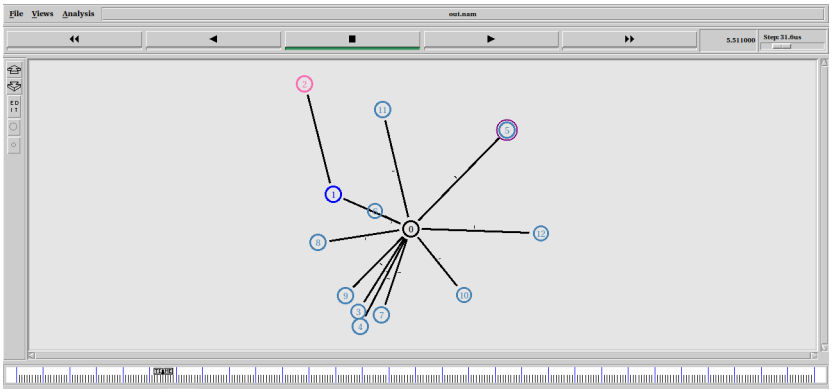


Figure 48: LTE Network Data Transfer

7.3 WiMax

The statistics found in simulation of WiMax network is shown in 2

Metric	Value
Throughput	38800.3376
Average Delay	0.0202
Sent Packets	101
Received Packets	97
Dropped Packets	33
Packet Delivery Ratio	96.0396
Packet Drop Ratio	32.673267
Total Routed Packets	16272

(a) Statistics

Node Number	Throughput
1	38800.3376

(b) Per-Node Throughput

Table 2: Wimax Network

8 Summary

We have performed the modifications mentioned in Section 5 with intuition to improve results of simulation and measured several metrics of network before and after the modifications. But in most of the cases, it is prominent from the graphs in Section 6 that the results of the measured metrics are degrading.
However, the average congestion window has increased after the modifications which can be identified as an improvement. Also in some cases of Wireless 802.11 network, Package Delivery Ratio has slightly increased within particular range.
Finally, simulations of Wired-Cum-Wireless network, WiMax network and LTE (4G) network are also done and statistics are built for the first two of those.