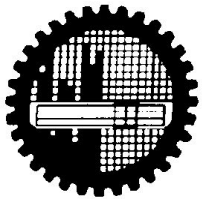
Bangladesh University of Engineering & Technology, Dhaka.

Department of Computer Science & Engineering.



NETWORK SIMULATOR - 2

COURSE NO : **CSE 322**

ASSIGNMENT NO : **02**

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Section: **B2**

Department: CSE

Level: 3; Term: 2

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Network Topologies under simulation:

1. Wireless 802.11 (mobile)
2. Wireless 802.15.4 (mobile)

Extra :

2. Wired
5. Wireless 802.16 (Wimax)
6. Mixed, wired and wireless topology

Parameters Under Variation

1. Number of mobile nodes
2. Number of flows
3. Number of packets per second
4. Packet Size
5. Speed of the mobile nodes
6. Hop distance

Metrics Measured:

1. Network Throughput
2. Average End-to-End Delay
3. Packet Delivery Ratio
4. Packet Drop Ratio
5. Total Energy Consumption
6. Avg_energy_per_packet
7. Total_retransmit
8. Energy Efficeincy
9. **Congestion Window variation over time.**
10. **Per Node Throughput**
11. **Normalised Routing Load**

Normalised Routing Load : It is defined as the total number of **routing** packet transmitted per **data** packet. It is calculated by dividing the total number of **routing** packets sent (includes forwarded **routing** packets as well) by the total number of data packets received

This requires the **-routerTrace ON** flag to be configured for mobile nodes.

Per Node throughput: Throughput of individual Nodes

Modifications Made In The Simulator:

1. Congestion Control Mechanism: (in file tcp/***tcp.cc***)

In the function `void TcpAgent::opencwnd()` when the value of **cwnd_** is below a certain threshold **ssthresh_** the cwnd_ size increases exponentially. Above the threshold, certain algorithms are used to avoid congestion. In **case 1** , instead of using the standard algorithm, some modifications were made according to the paper: ***[1]***

We need to minimize the value of *f* to avoiding packets losses. The control of this problem by divide the last value of *f* by the previous *cwnd_* value multiplied by the exponent *cwnd_* to the *k* parameter in binomial control as shown below:

```
f = f / (cwnd * pow (cwnd, k_parameter))
```

Previously :

```
increment = increase_num_ / cwnd_;
if ((last_cwnd_action_ == 0 || last_cwnd_action_ ==
CWND_ACTION_TIMEOUT)
            && max_ssthresh_ > 0) {
     increment = limited_slow_start(cwnd_,max_ssthresh_,
increment);
}
cwnd_ += increment;
```

Modification :

```
double f;
f = wnd_const_ * ssthresh_ / cwnd_ * pow(cwnd_, k_parameter_);
            cwnd_ = cwnd_ + ( f / cwnd_);
```

The results of cwnd_ against time is plotted for before and after modification for each topology.

2. The gain of the omni-antennae (both transmitter and receiver) has been increased from 1.0 to 5.0 (in file mobile/omni-antenna.cc). The affected variable in the TCL files is **ant**.

3. Changes in **RTT** calculation:

One of the major problems in congestion control is related to the ability to estimate the average value of the round trip time (RTT) as close to the correct value as possible. This is particularly true when the measure of the congestion is obtained from the estimate of RTT and when the average value of RTT actually changes considerably.

we have proposed mechanisms for estimating the average value of the RTT based on change detection algorithms and principles from the practice of statistical process control (SPC).

The principle used in our approach is that when there is a statistical change or a shift in the mean, the next estimate of RTT should not be tightly linked to the past data.

A new variable:

```
double t_rtxtimeout_;
```

(In file tcp/***tcp.h***) is added inside

```
class TcpAgent : public Agent {}
```

Modification in (tcp/***tcp.cc*** file) :

```
double diff = t_rtt_*tcp_tick_ - (t_srtt_ >> T_SRTT_BITS)*tcp_tick_;
if (diff < 0)
    diff = -diff;
if (diff > 3*(t_rttvar_*tcp_tick_/4)) {
    t_srtt_ = t_rtt_ << T_SRTT_BITS;
```

```
        t_rttvar_ = t_rtt_ << (T_RTTVAR_BITS -1);
}

t_rtxtimeout_ = t_rtxcur_;
```

4. Changes in AODV routing protocol: (aodv/***aodv.h***)

ACTIVE_ROUTE_TIMEOUT has been increased from 10 to 30. TTL_START decreased from 5 to 3 and TTL_THRESHOLD increased from 7 to 10

Original values:

```
#define ACTIVE_ROUTE_TIMEOUT 10

#define TTL_START     5
#define TTL_THRESHOLD 7
#define TTL_INCREMENT 2
```

Modified values:

```
#define ACTIVE_ROUTE_TIMEOUT    30

#define TTL_START     3
#define TTL_THRESHOLD 10
#define TTL_INCREMENT 2
```

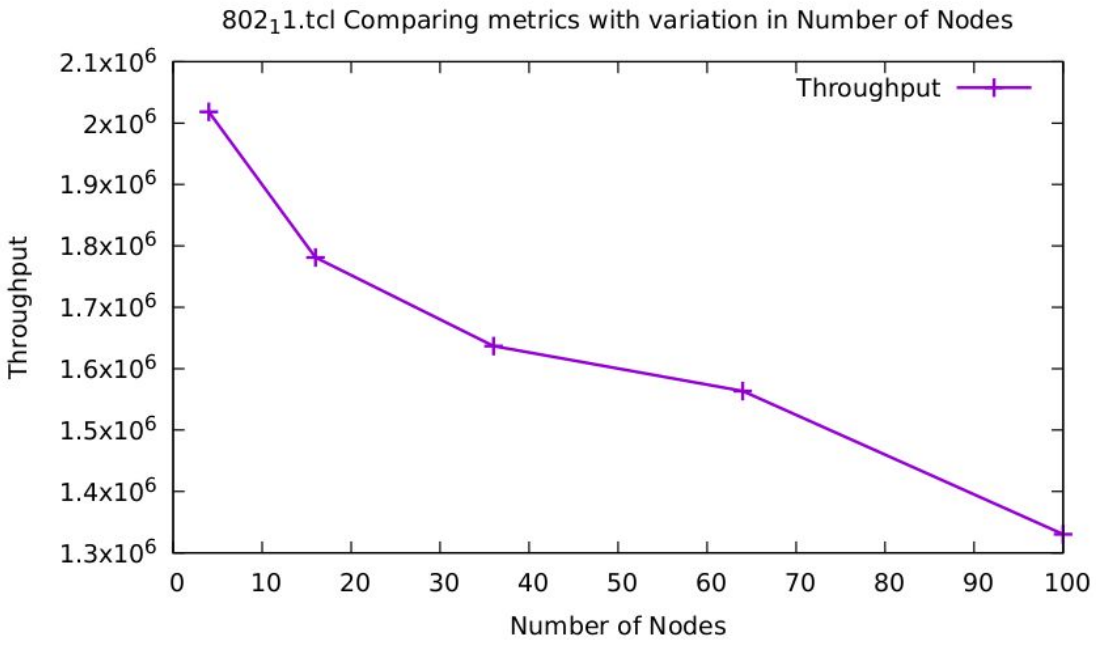
Simulation results with graphs

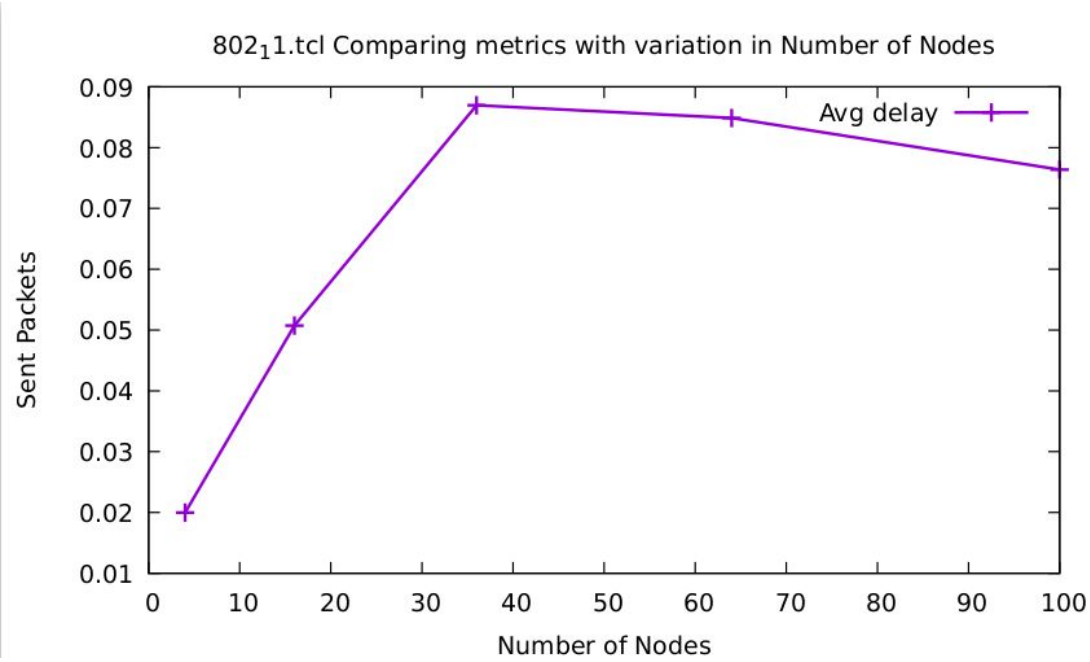
In this simulation, we varied different parameters as mentioned above, and plotted graphs for both the modified and unmodified simulator

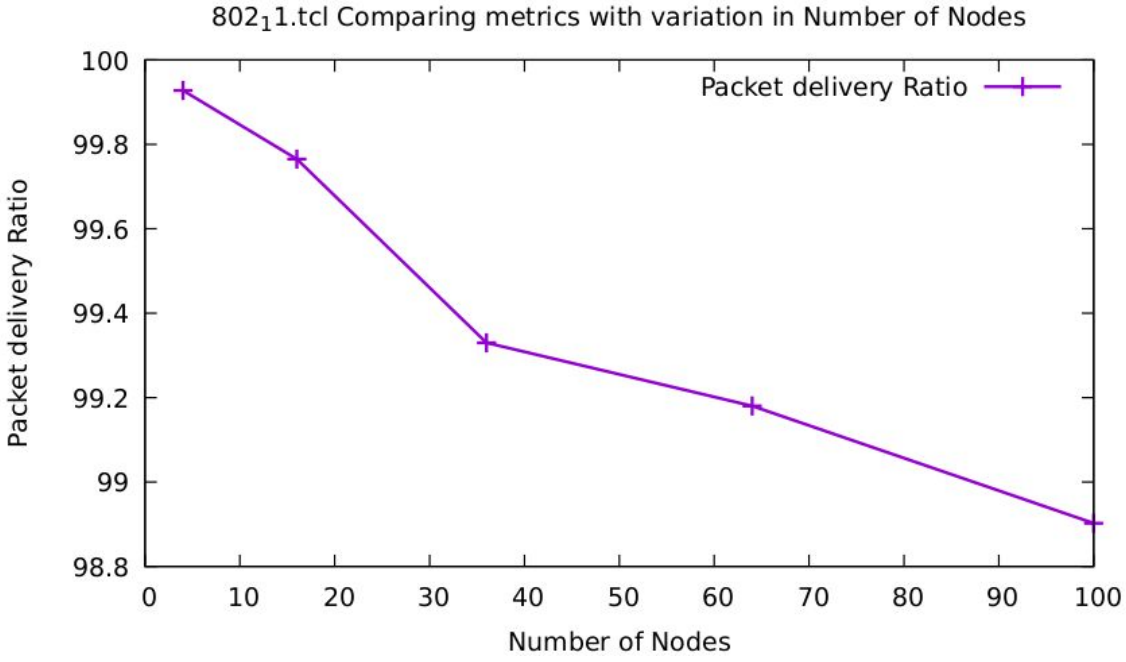
1. 802.11 : **IEEE 802.11** is part of the **IEEE** 802 set of LAN protocols, and specifies the set of media access control (MAC) and physical layer (PHY) protocols for implementing wireless local area network (WLAN) Wi-Fi computer communication in various frequencies, including but not limited to 2.4, 5, and 60 GHz frequency bands.

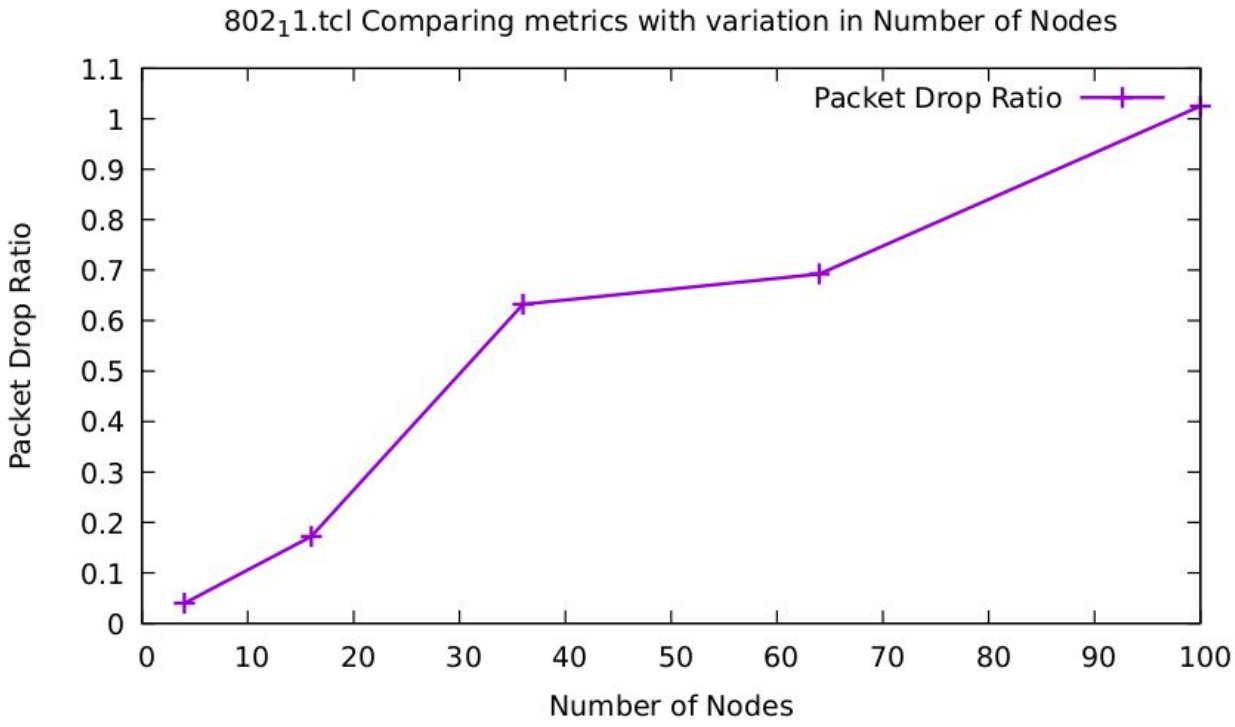
For each variation in parameter (No. of nodes etc), 4 iterations were executed, and the average value was taken. For even iterations, grid topology was used, and for odd iterations random topology was used. Three types of flow: parallel, cross and random flow was used. Respective code is attached in **802_11.tcl** file.
The graphs are also attached in separate pdf files for convenience (***802_11_*.pdf***)

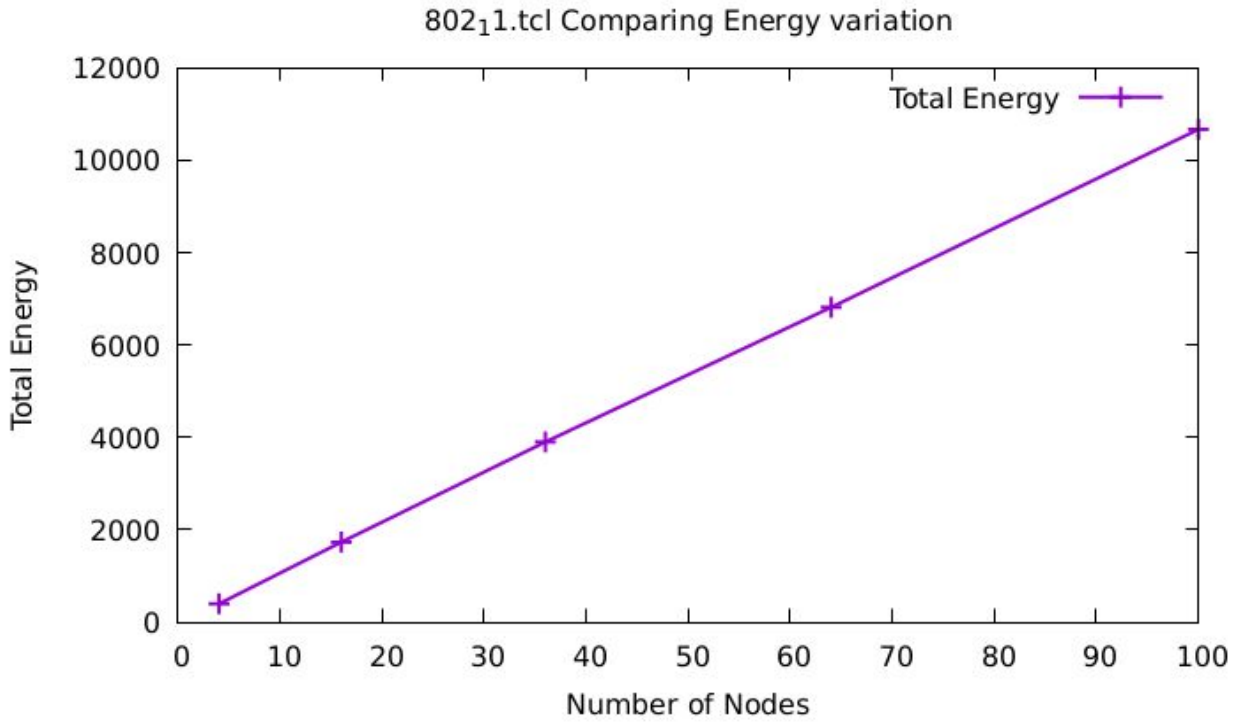
Unmodified

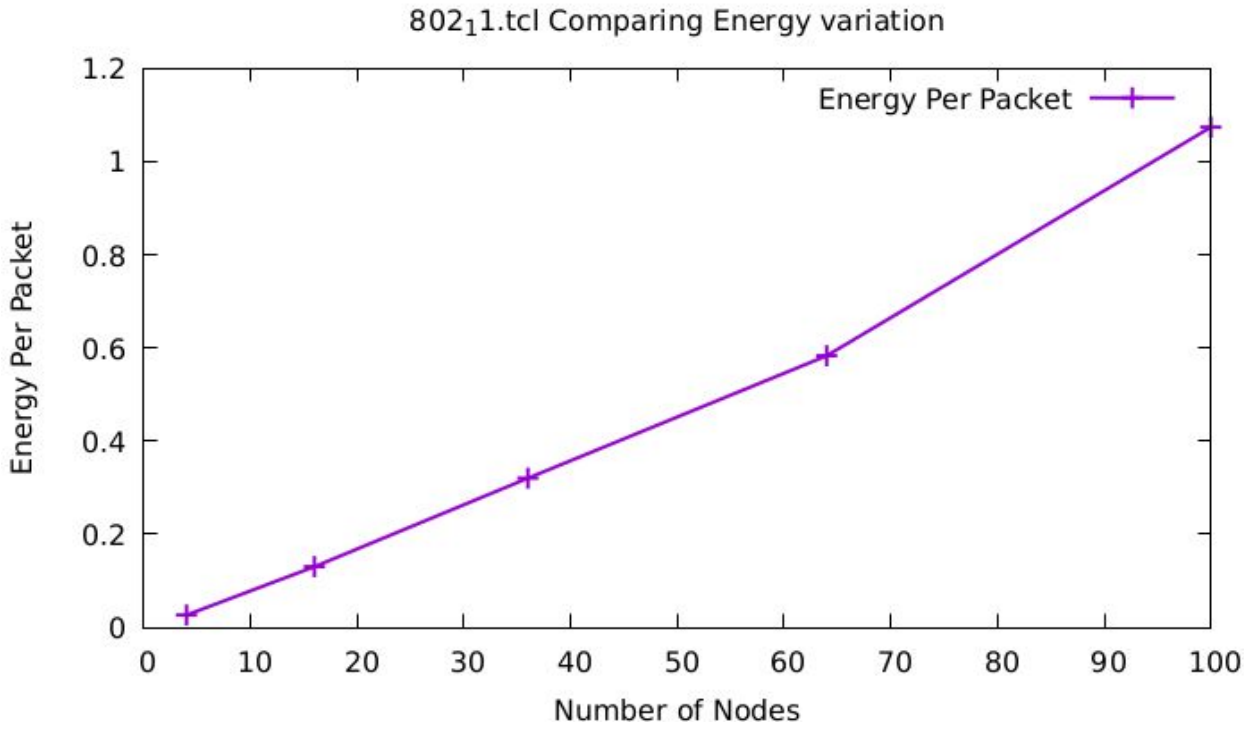


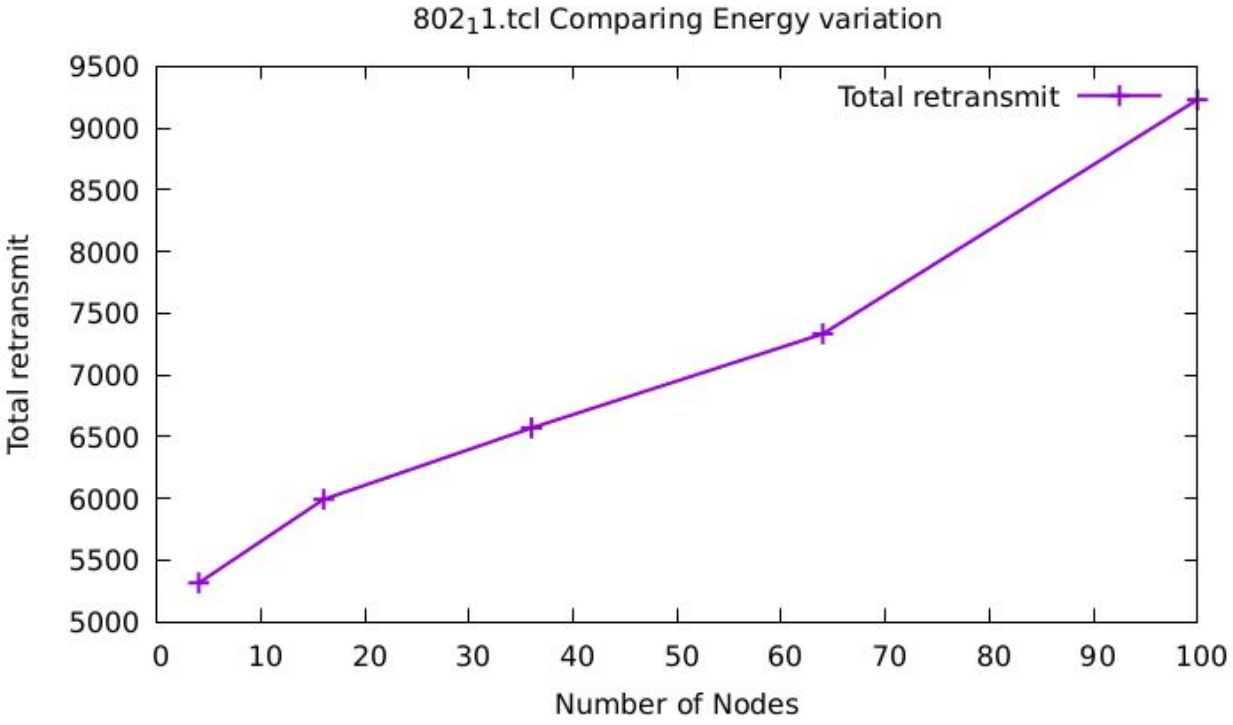


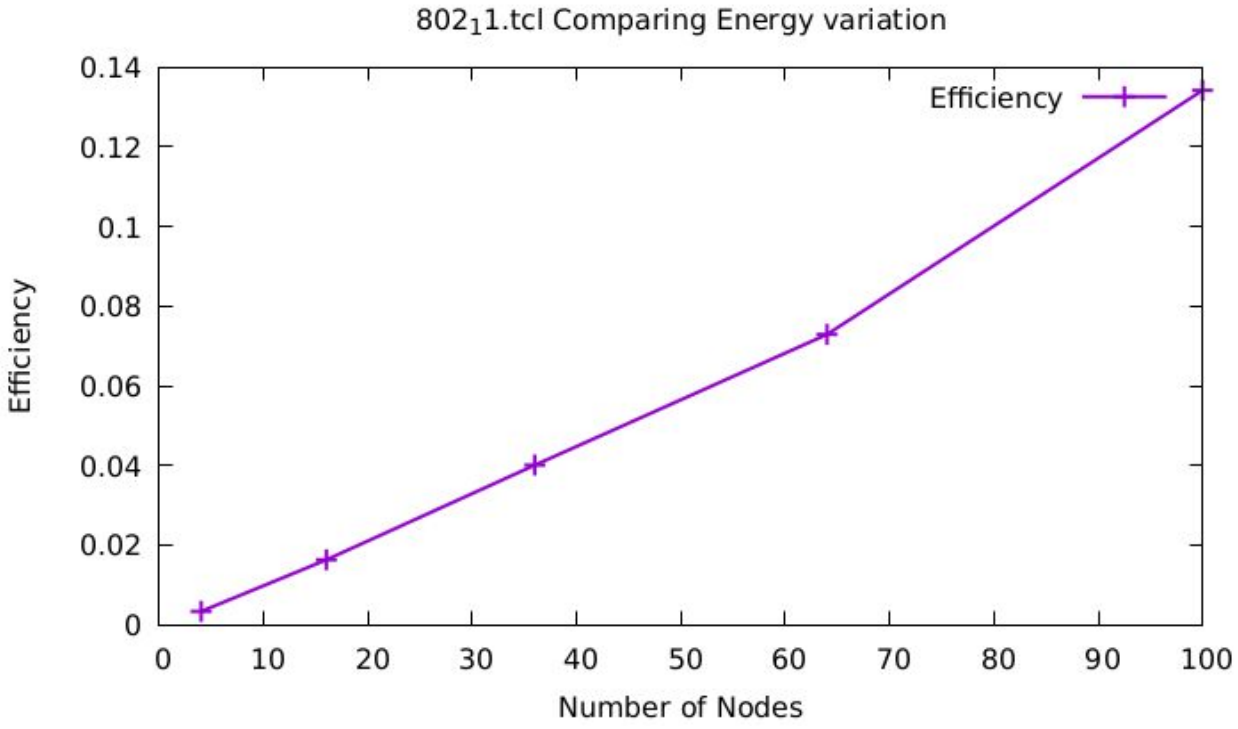

802_11.tcl Comparing metrics with variation in Number of Nodes
Packet delivery Ratio
Packet delivery Ratio
Number of Nodes
100
99.8
99.6
99.4
99.2
99
98.8
0
10
20
30
40
50
60
70
80
90
100

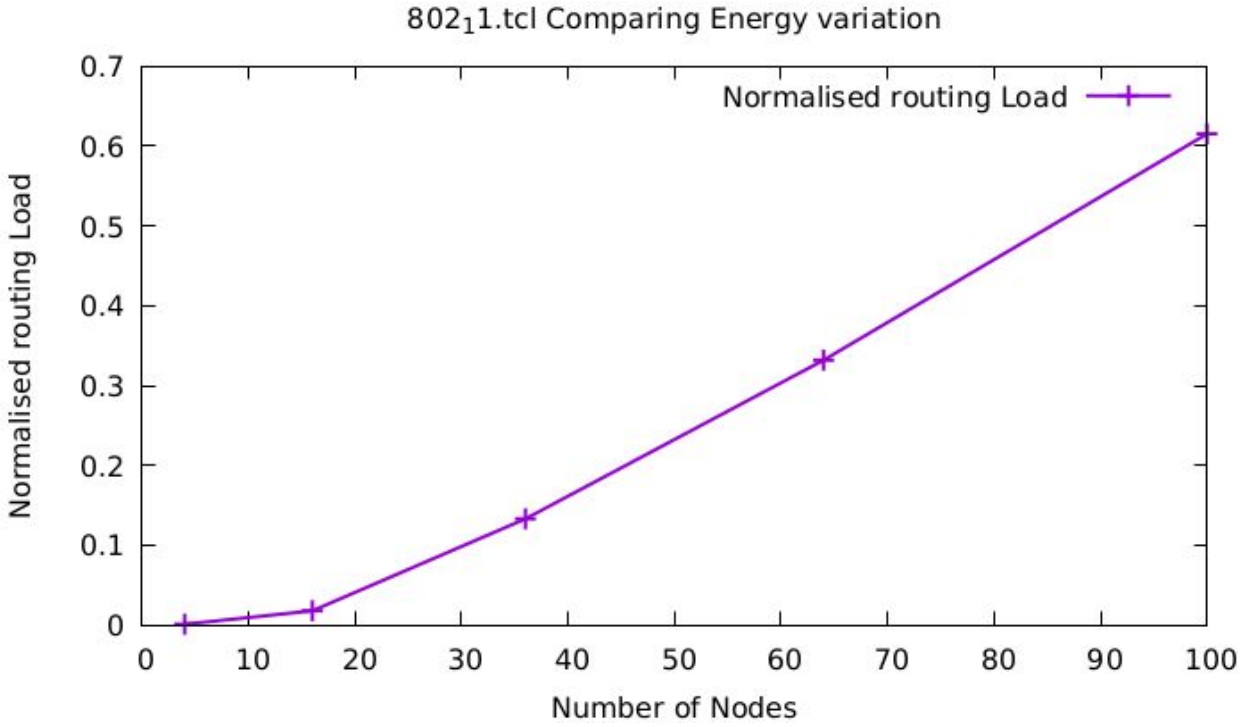

802_11.tcl Comparing metrics with variation in Number of Nodes
Packet Drop Ratio
Packet Drop Ratio
Number of Nodes
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100

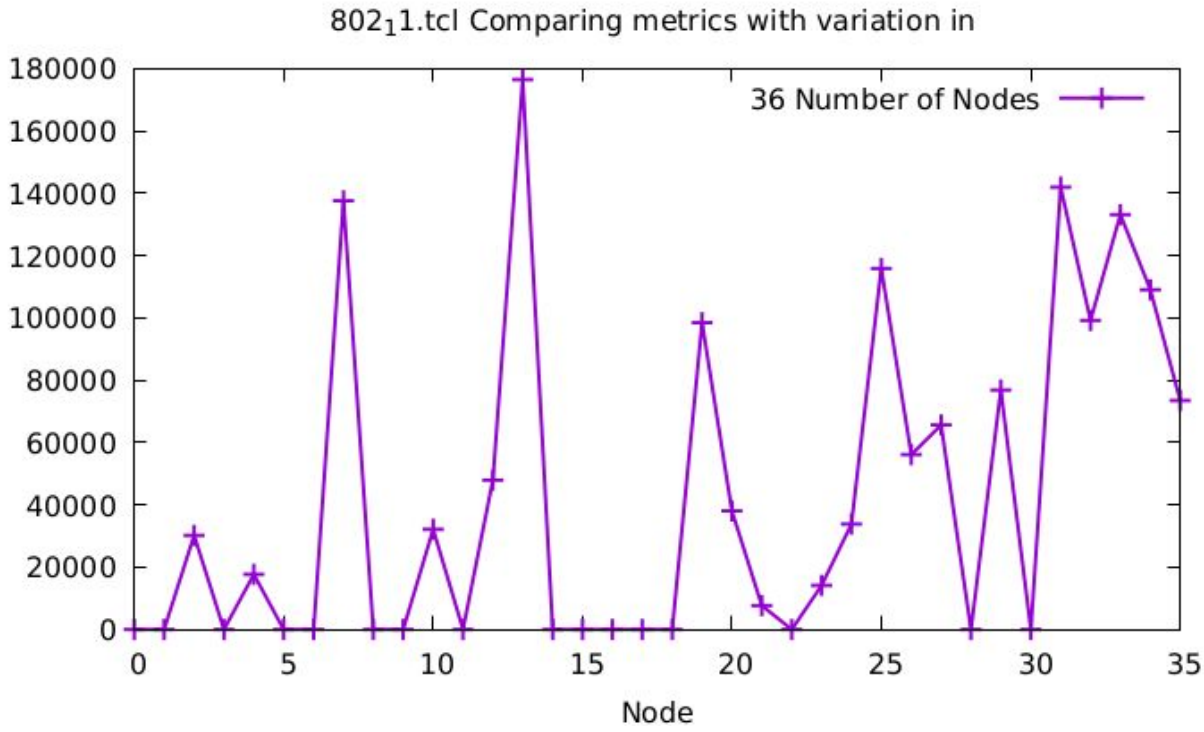

802_11.tcl Comparing Energy variation
Total Energy
Total Energy
Number of Nodes
0
2000
4000
6000
8000
10000
12000
0
10
20
30
40
50
60
70
80
90
100

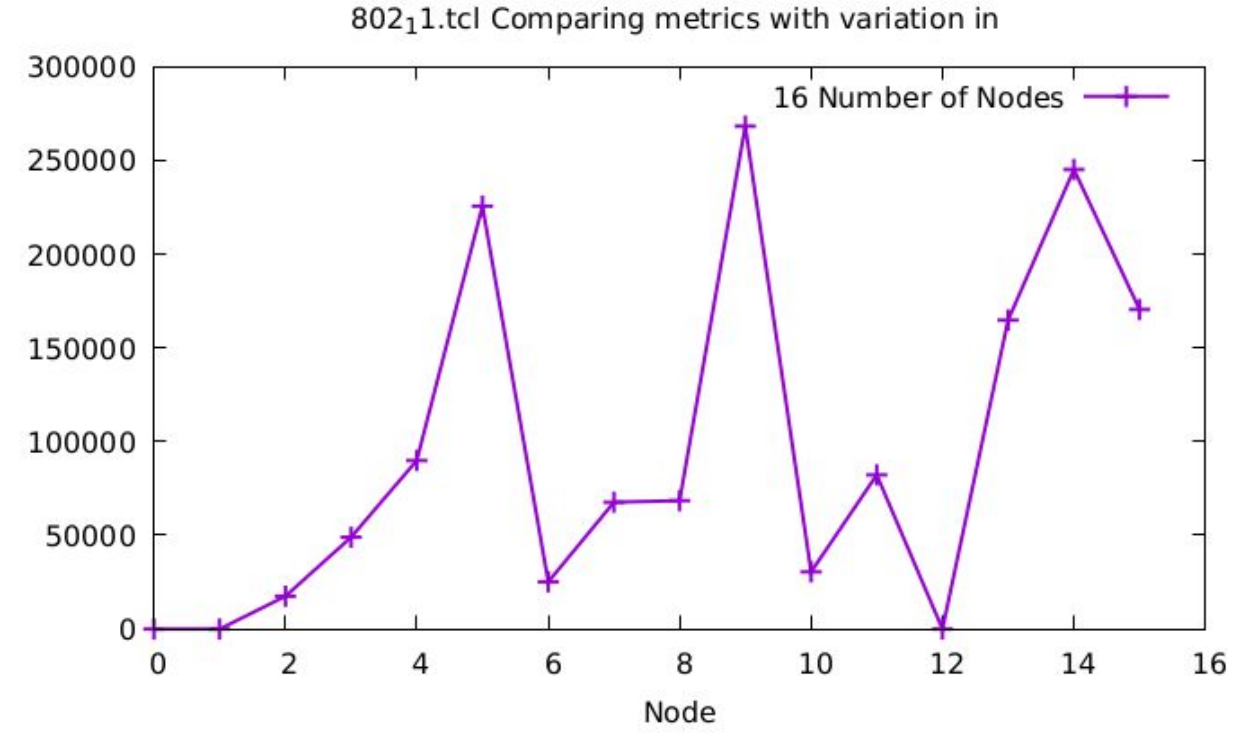

802_11.tcl Comparing Energy variation
Energy Per Packet
Energy Per Packet
Number of Nodes
0
0.2
0.4
0.6
0.8
1
1.2
0
10
20
30
40
50
60
70
80
90
100

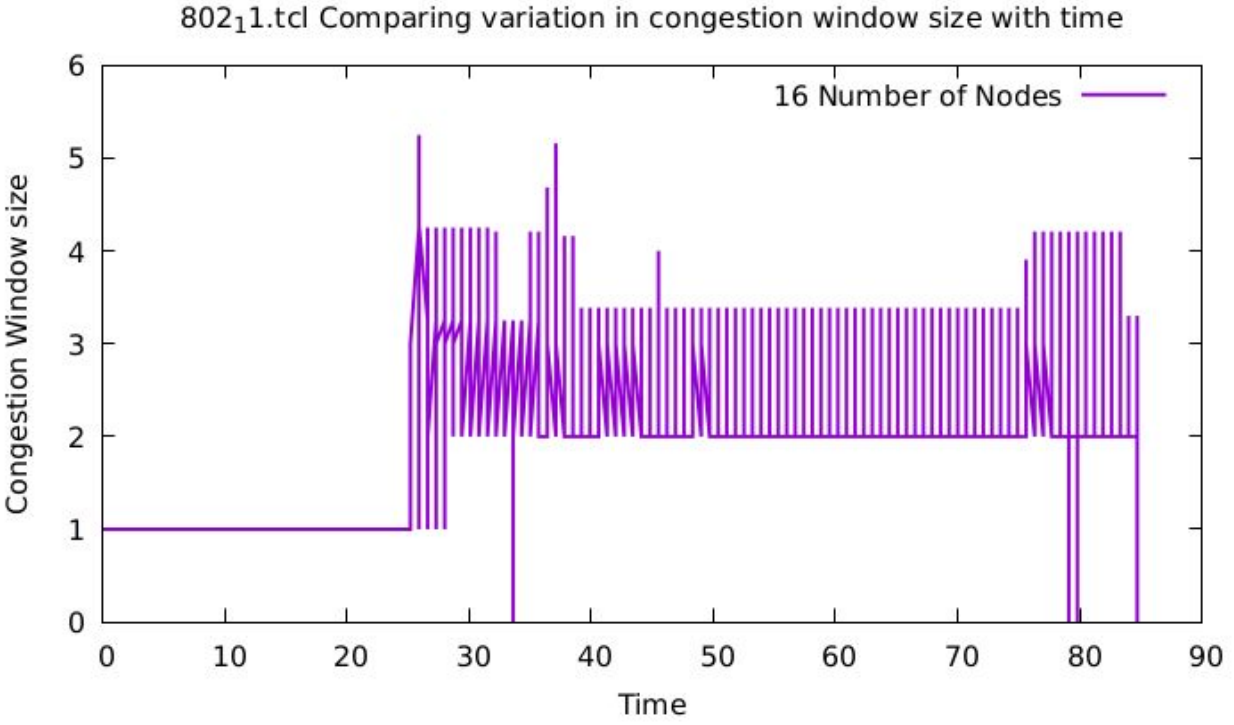

802_11.tcl Comparing Energy variation
Total retransmit
Total retransmit
Number of Nodes
9500
9000
8500
8000
7500
7000
6500
6000
5500
5000
0
10
20
30
40
50
60
70
80
90
100


802_11.tcl Comparing Energy variation
Efficiency
Efficiency
Number of Nodes
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
70
80
90
100

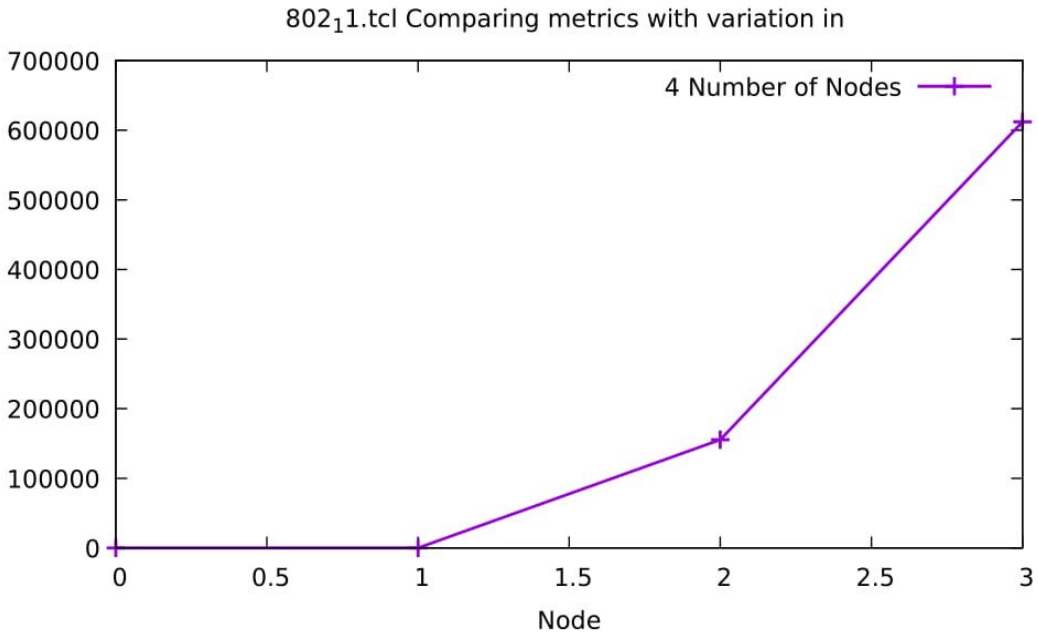

802_11.tcl Comparing Energy variation
Normalised routing Load
Normalised routing Load
Number of Nodes
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
10
20
30
40
50
60
70
80
90
100

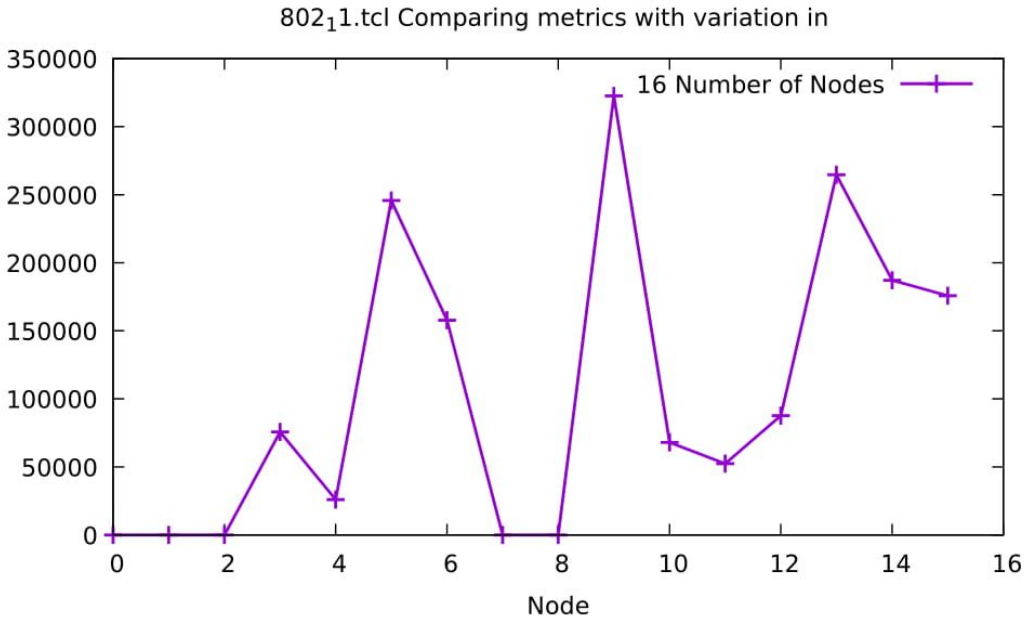

802_11.tcl Comparing metrics with variation in
36 Number of Nodes
Node
0
20000
40000
60000
80000
100000
120000
140000
160000
180000
0
5
10
15
20
25
30
35

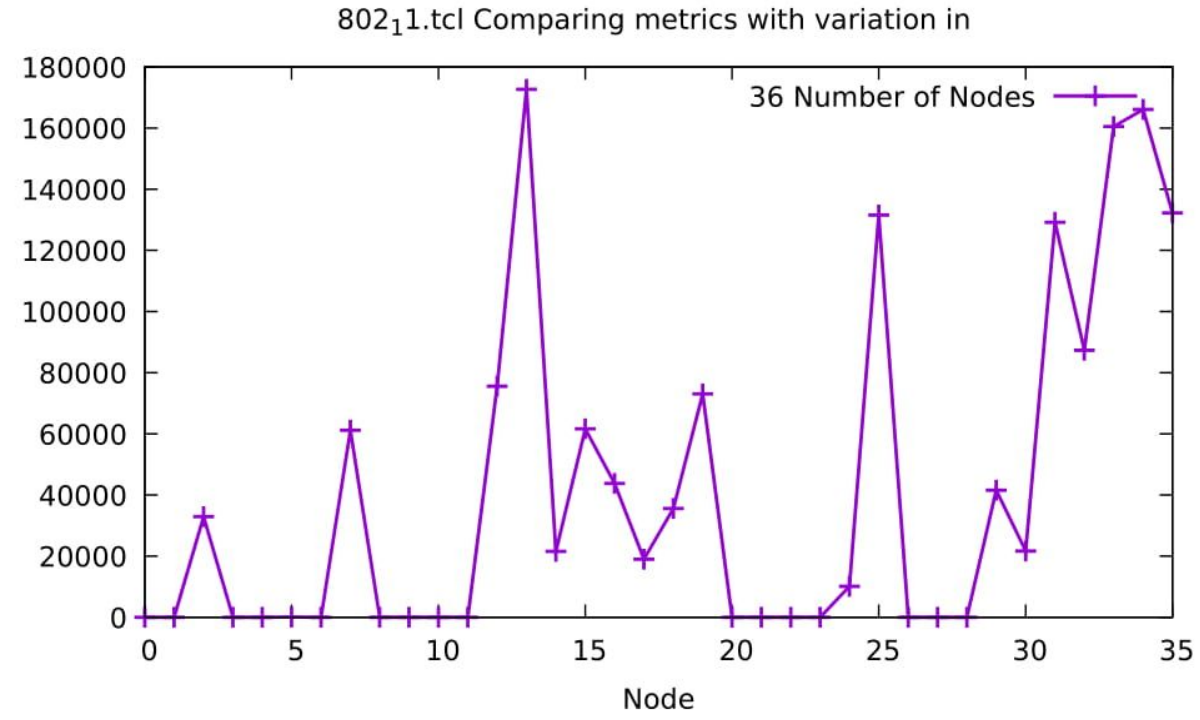

802_11.tcl Comparing metrics with variation in
16 Number of Nodes
300000
250000
200000
150000
100000
50000
0
0
2
4
6
8
10
12
14
16
Node

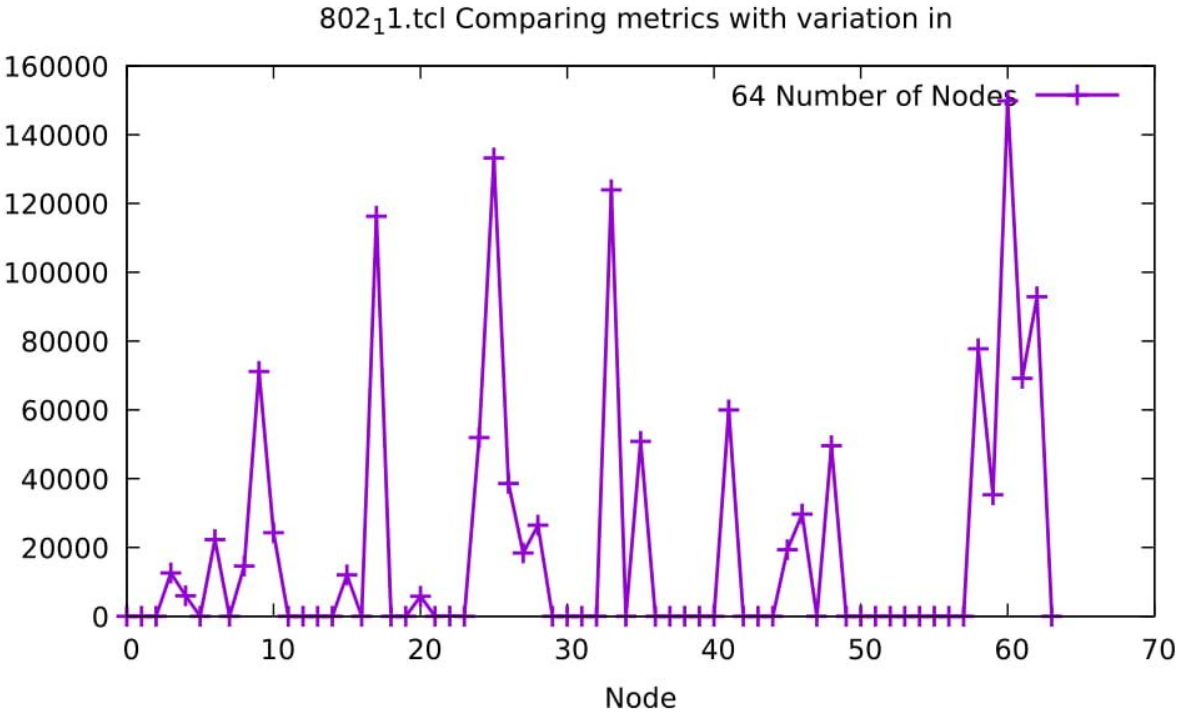

802_11.tcl Comparing variation in congestion window size with time
16 Number of Nodes
Congestion Window size
6
5
4
3
2
1
0
0
10
20
30
40
50
60
70
80
90
Time

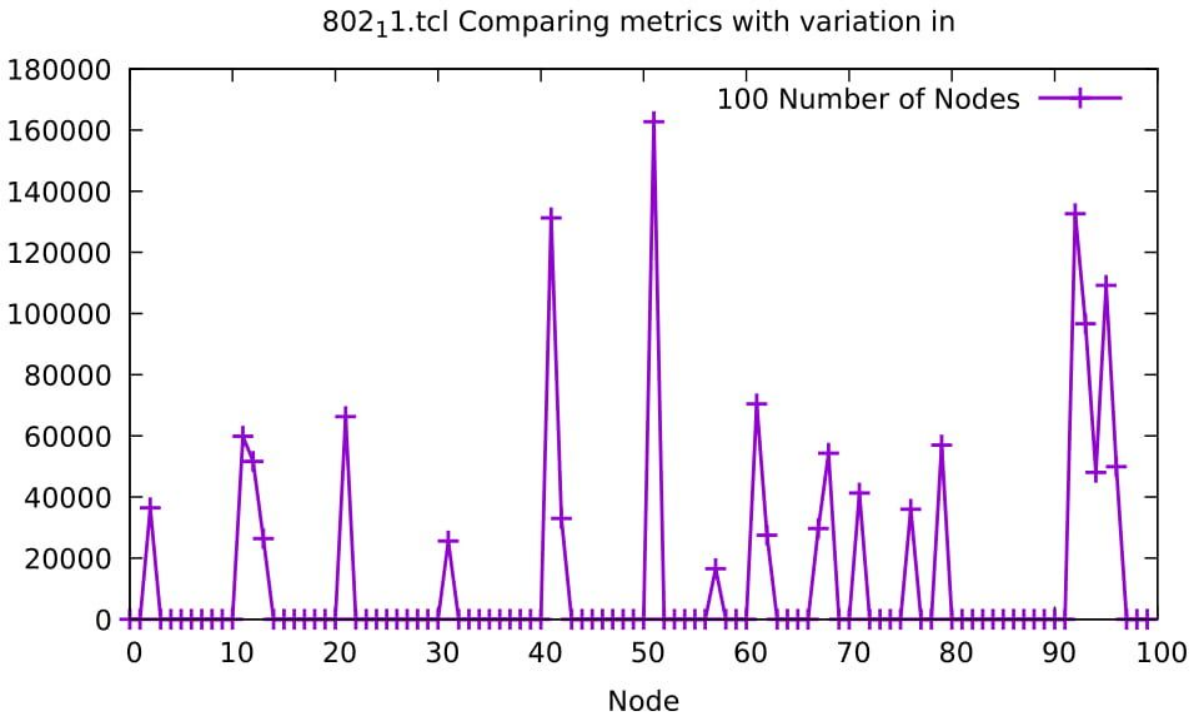
Modified

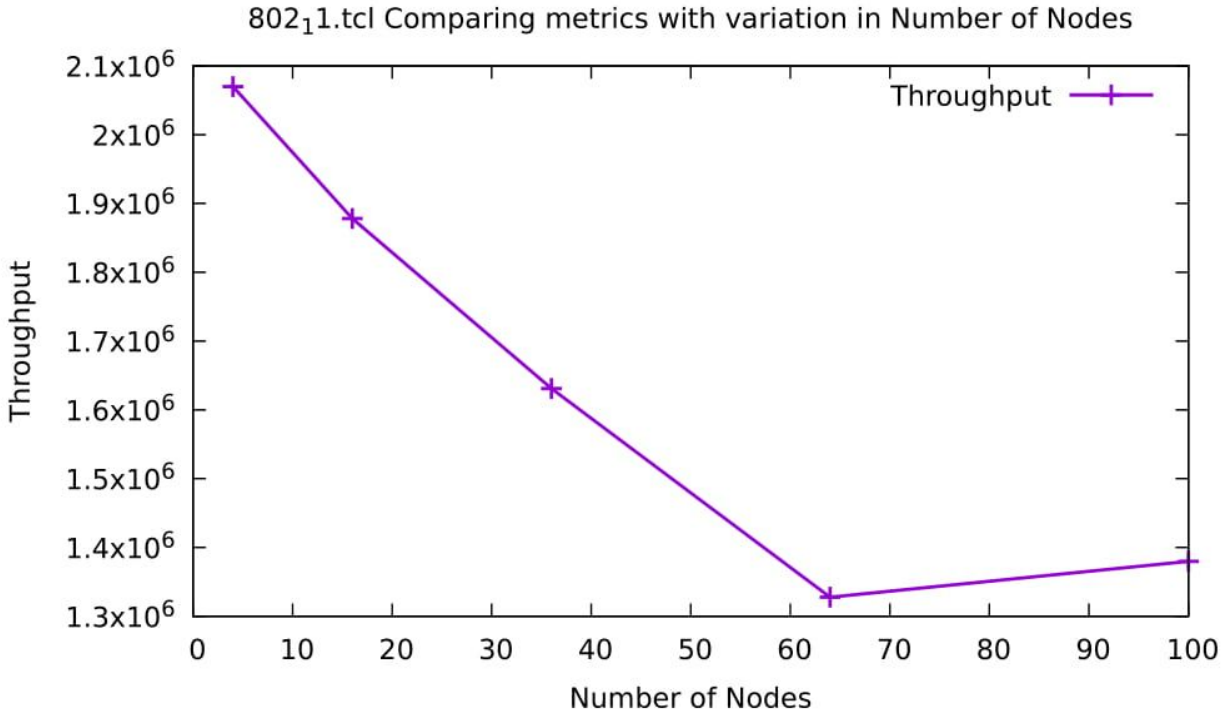

802$_1$1.tcl Comparing metrics with variation in
4 Number of Nodes
700000
600000
500000
400000
300000
200000
100000
0
0
0.5
1
1.5
2
2.5
3
Node

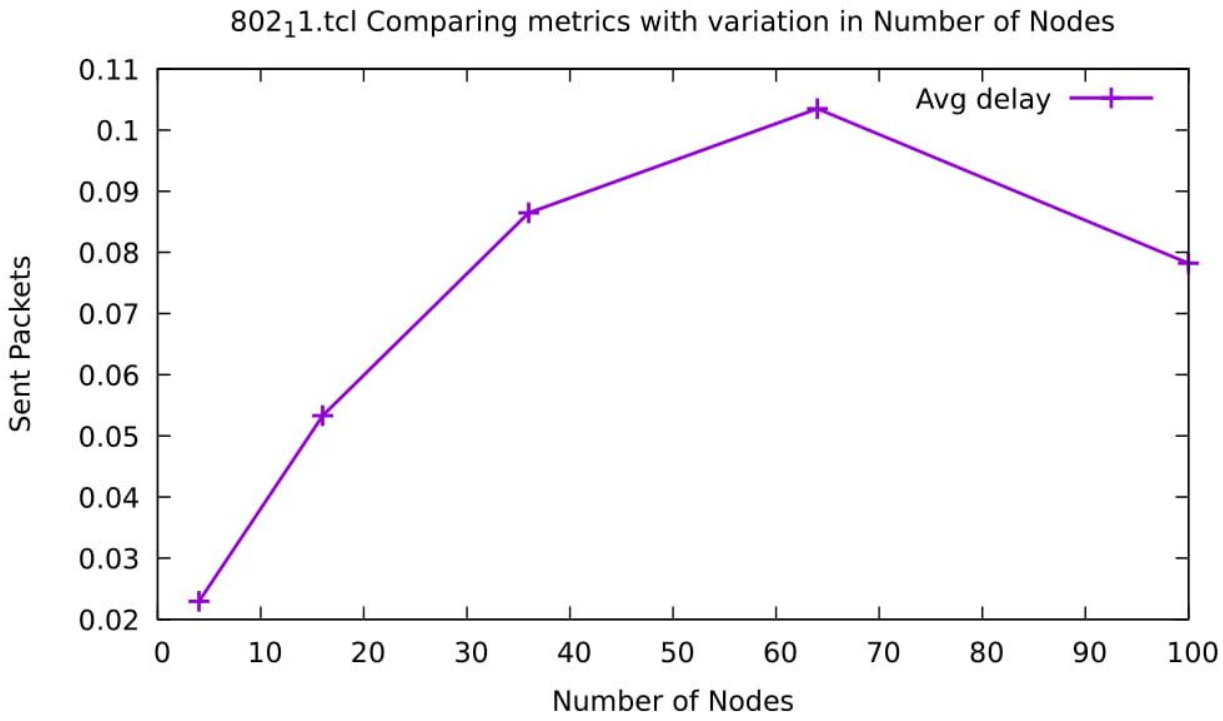

802$_1$1.tcl Comparing metrics with variation in
16 Number of Nodes
350000
300000
250000
200000
150000
100000
50000
0
0
2
4
6
8
10
12
14
16
Node

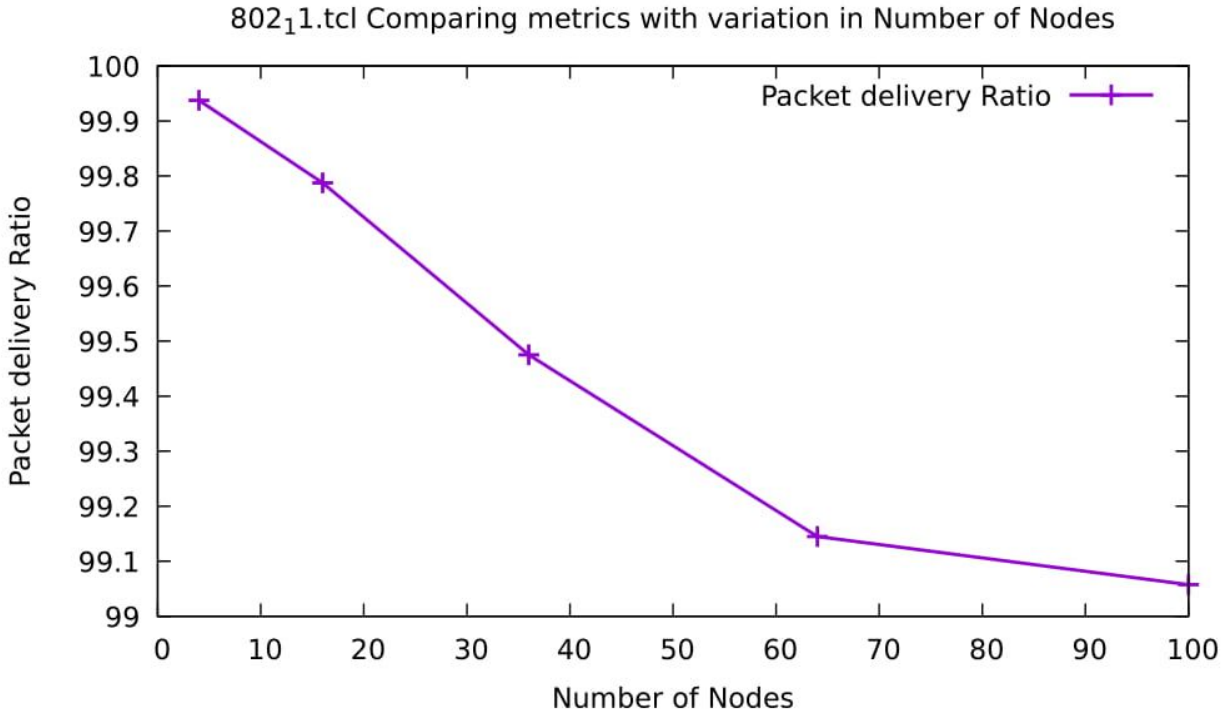

802_11.tcl Comparing metrics with variation in
36 Number of Nodes
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0
5
10
15
20
25
30
35
Node

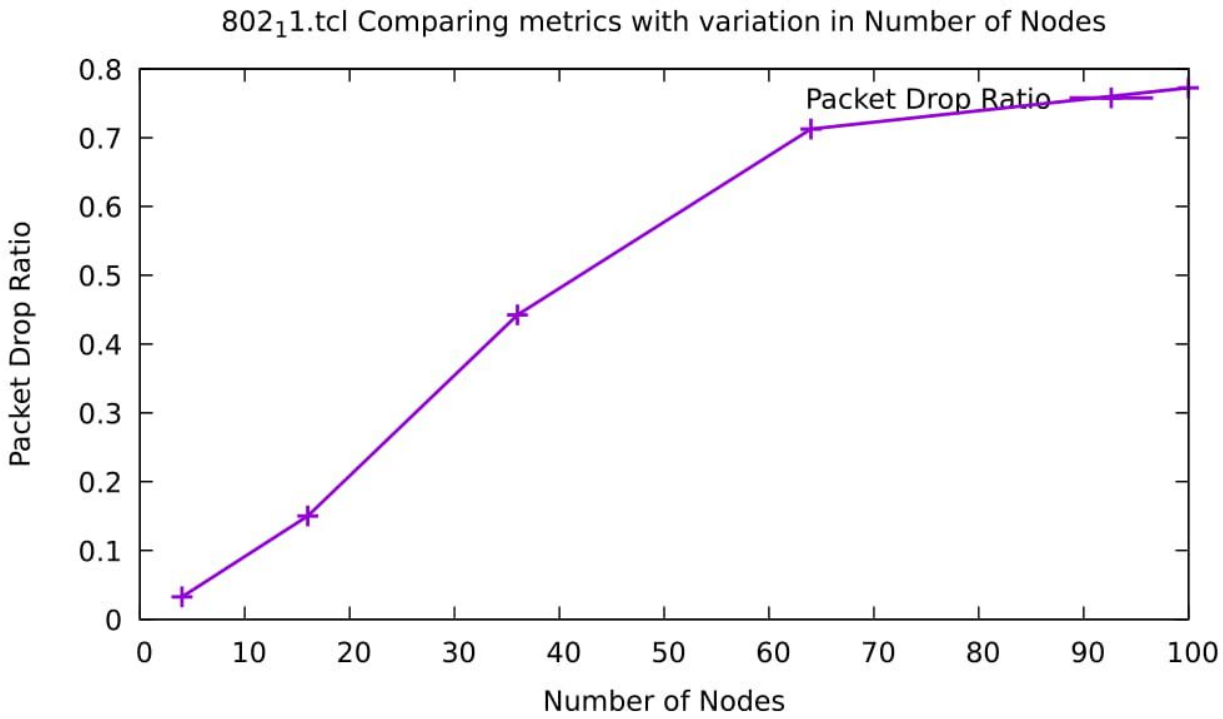

802_11.tcl Comparing metrics with variation in
64 Number of Nodes
160000
140000
120000
100000
80000
60000
40000
20000
0
0
10
20
30
40
50
60
70
Node

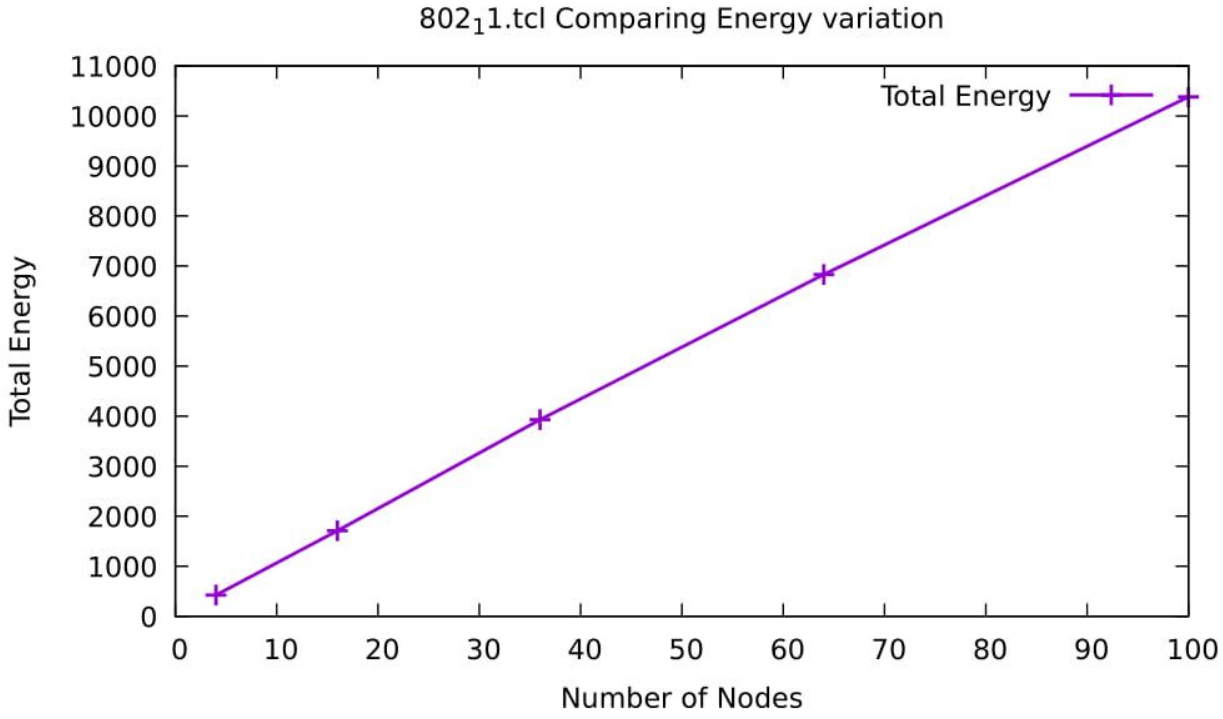

802_11.tcl Comparing metrics with variation in
100 Number of Nodes
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
0
10
20
30
40
50
60
70
80
90
100
Node

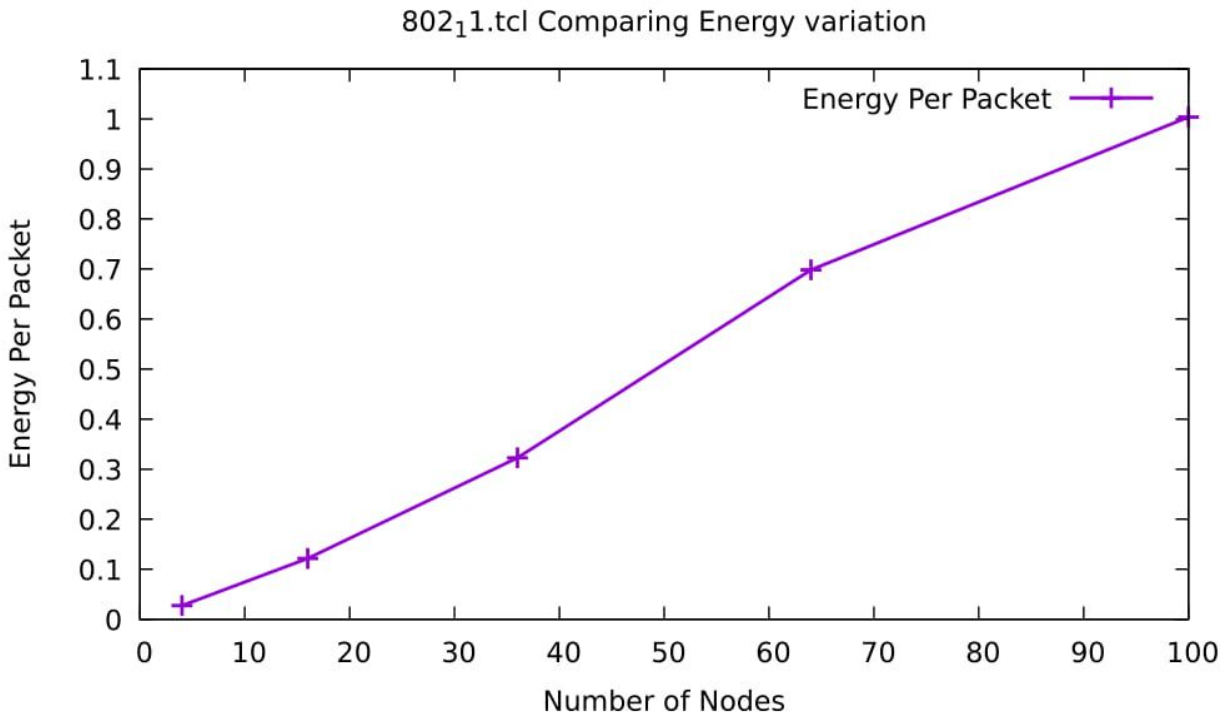

802_11.tcl Comparing metrics with variation in Number of Nodes
Throughput
2.1x10^6
2x10^6
1.9x10^6
1.8x10^6
1.7x10^6
1.6x10^6
1.5x10^6
1.4x10^6
1.3x10^6
0
10
20
30
40
50
60
70
80
90
100
Number of Nodes

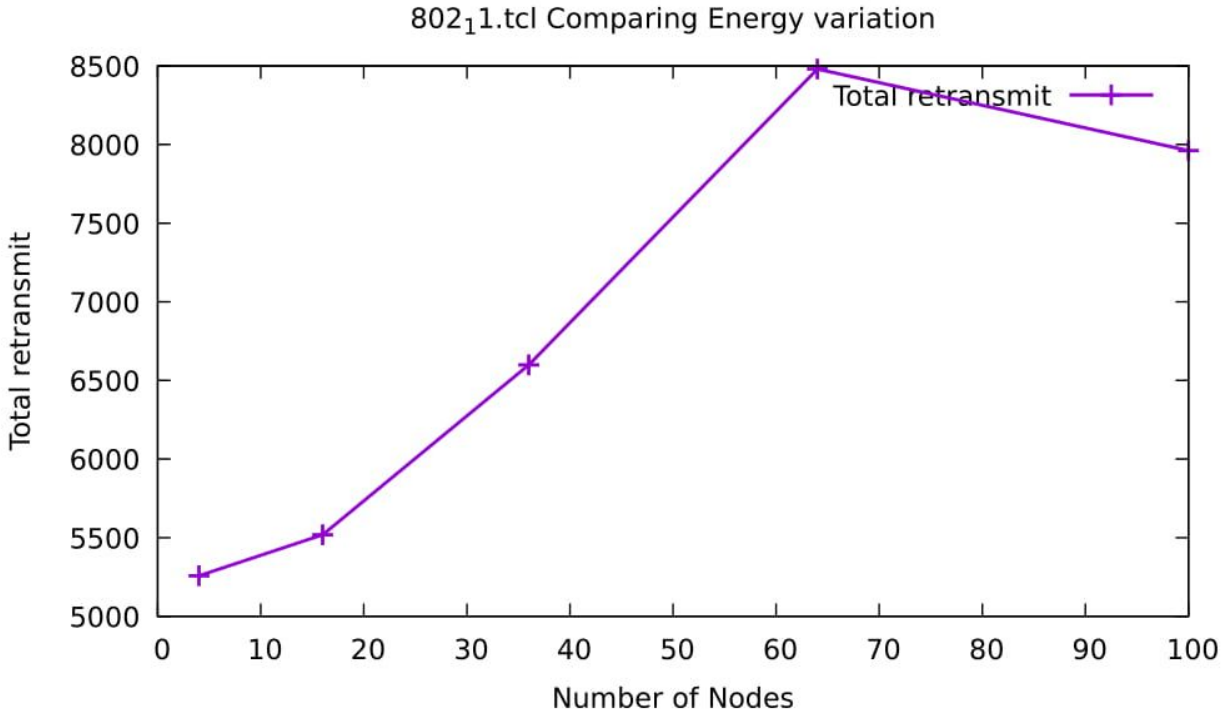

802_11.tcl Comparing metrics with variation in Number of Nodes
Avg delay
Sent Packets
Number of Nodes
0.11
0.1
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0
10
20
30
40
50
60
70
80
90
100

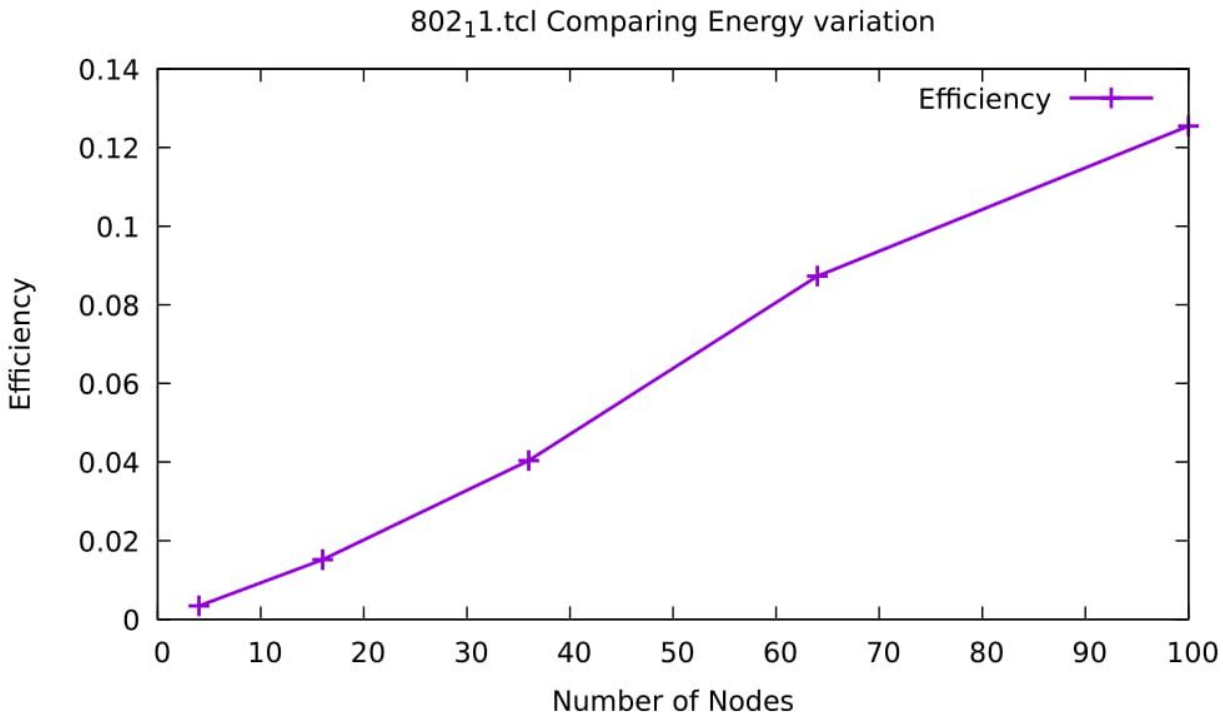

802_11.tcl Comparing metrics with variation in Number of Nodes
Packet delivery Ratio
Packet delivery Ratio
Number of Nodes
100
99.9
99.8
99.7
99.6
99.5
99.4
99.3
99.2
99.1
99
0
10
20
30
40
50
60
70
80
90
100

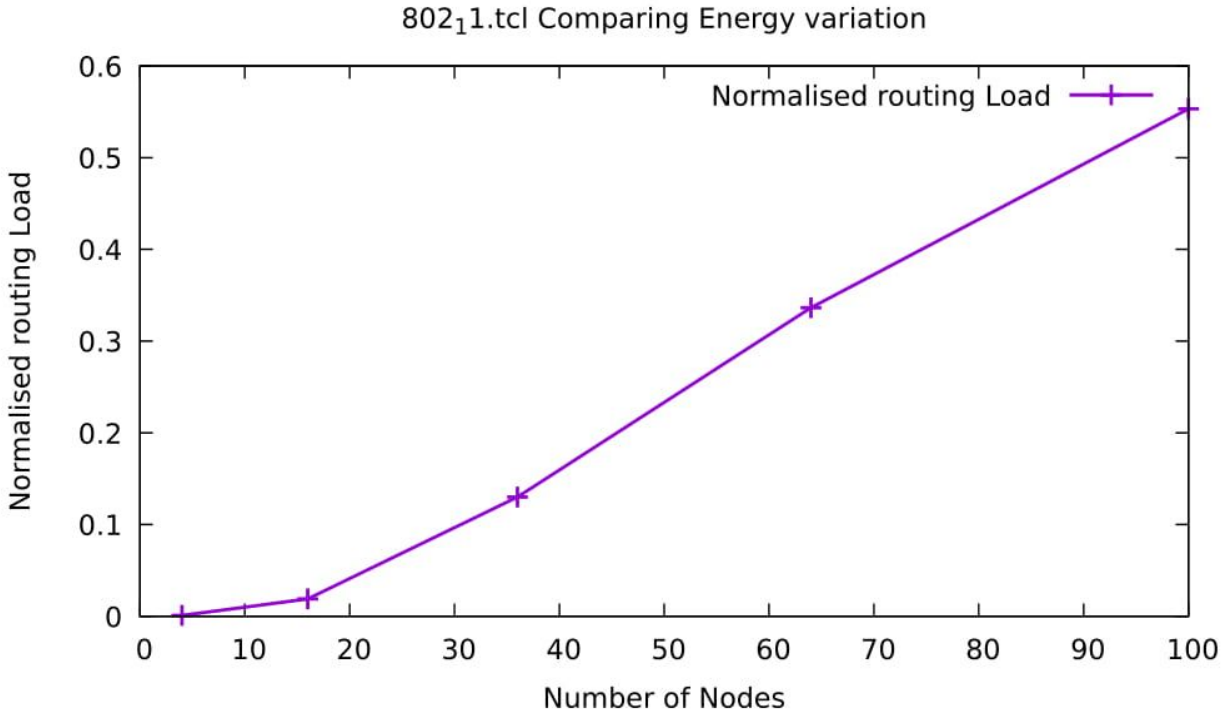

802_11.tcl Comparing metrics with variation in Number of Nodes
Packet Drop Ratio
Number of Nodes
Packet Drop Ratio
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0
10
20
30
40
50
60
70
80
90
100

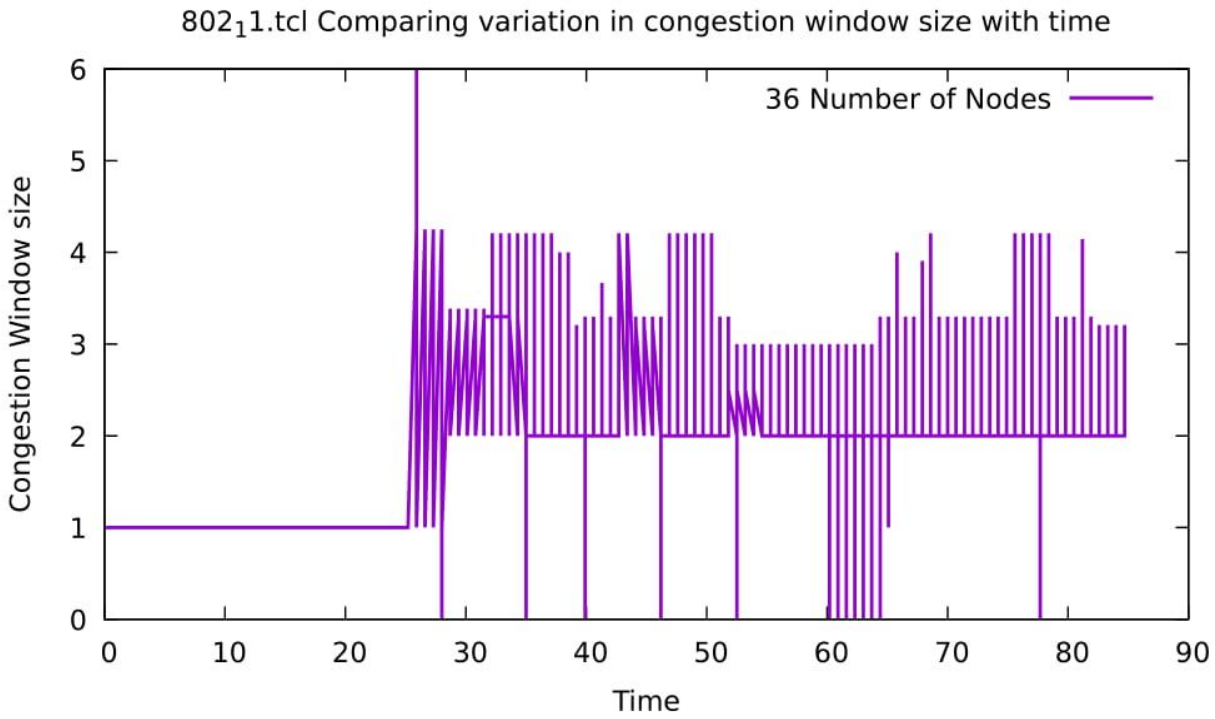

802_11.tcl Comparing Energy variation
Total Energy
Number of Nodes
Total Energy
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
11000
0
10
20
30
40
50
60
70
80
90
100

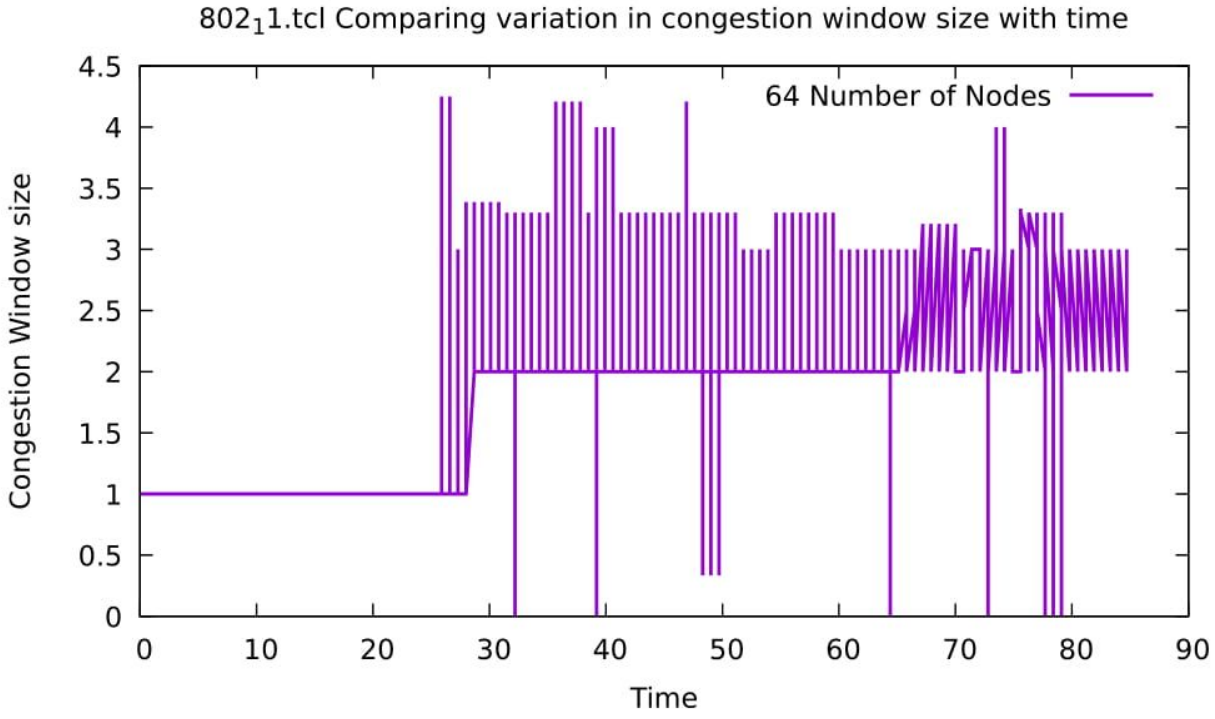

802_11.tcl Comparing Energy variation
Energy Per Packet
Energy Per Packet
Number of Nodes
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
1.1
0
10
20
30
40
50
60
70
80
90
100

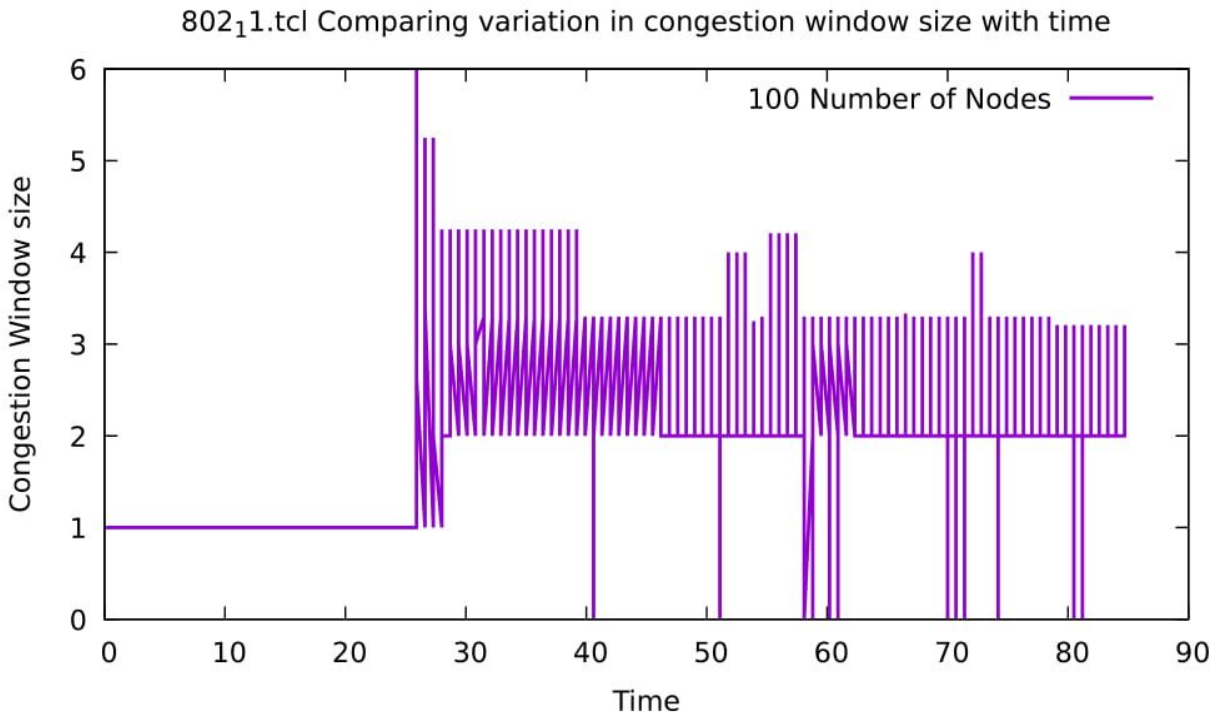

802_11.tcl Comparing Energy variation
Total retransmit
Total retransmit
Number of Nodes
5000
5500
6000
6500
7000
7500
8000
8500
0
10
20
30
40
50
60
70
80
90
100

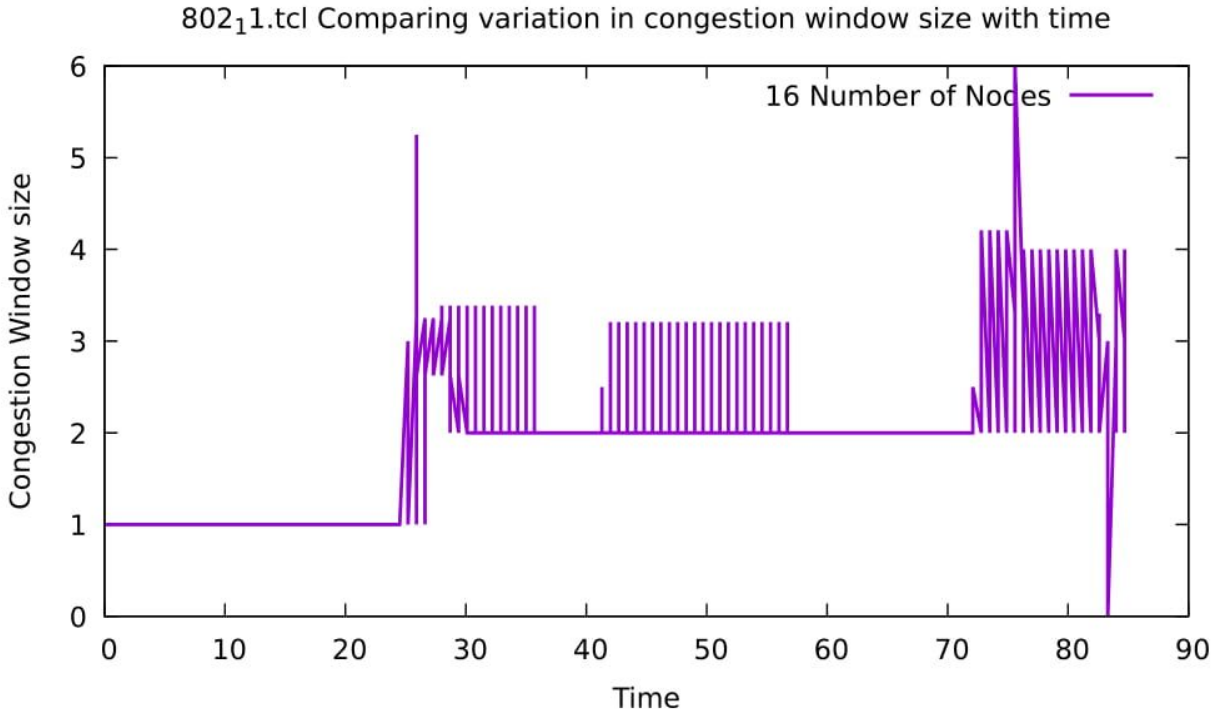

802_11.tcl Comparing Energy variation
Efficiency
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
70
80
90
100
Number of Nodes

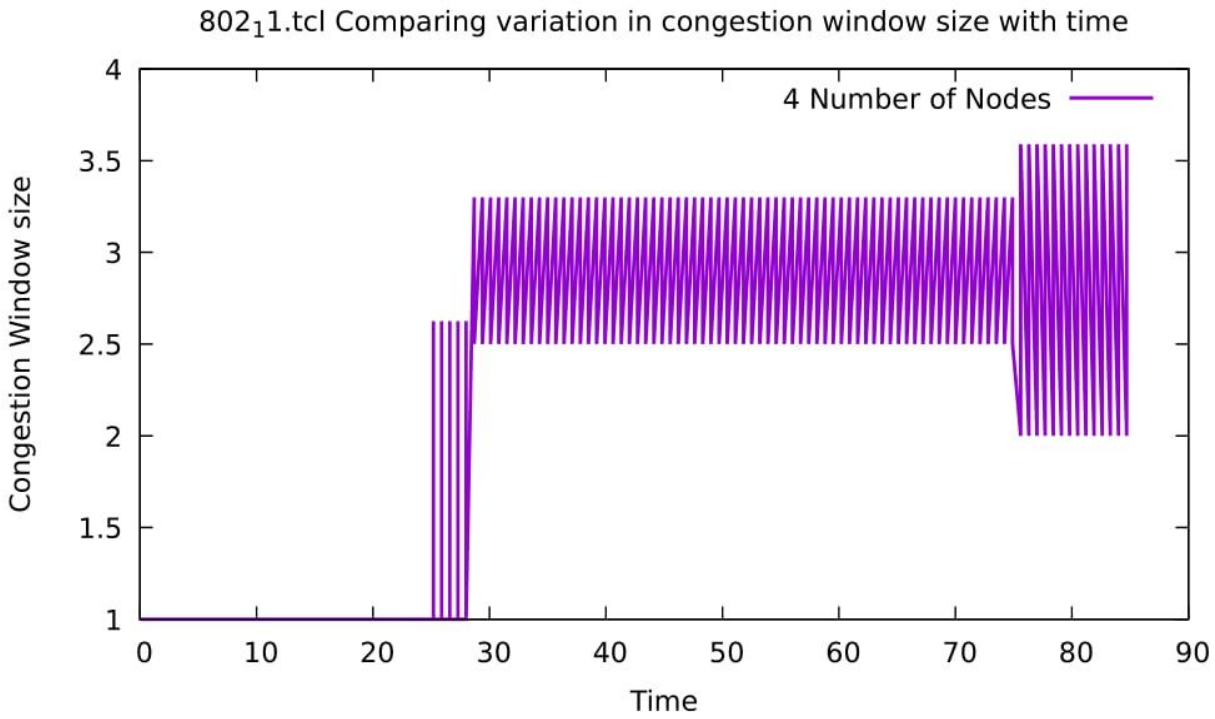

802_11.tcl Comparing Energy variation
Normalised routing Load
0.6
0.5
0.4
0.3
0.2
0.1
0
0
10
20
30
40
50
60
70
80
90
100
Number of Nodes

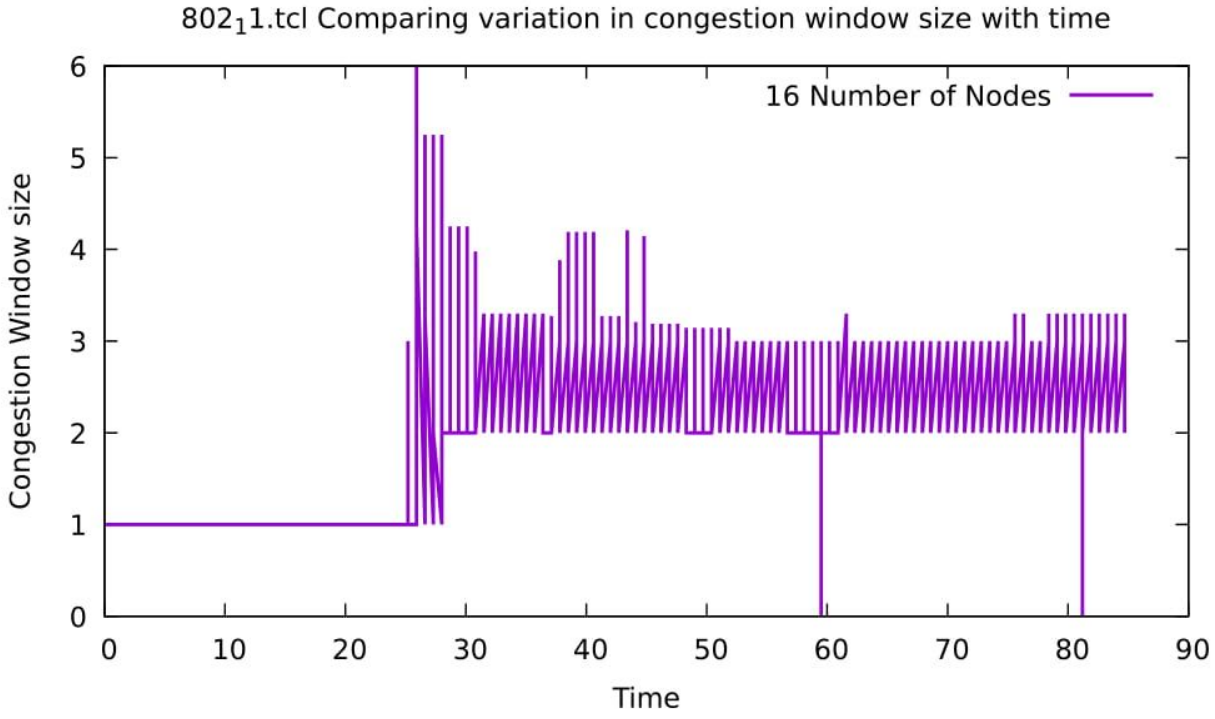

802_11.tcl Comparing variation in congestion window size with time
36 Number of Nodes
Congestion Window size
Time
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90


802_11.tcl Comparing variation in congestion window size with time
64 Number of Nodes
Congestion Window size
Time
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
0
10
20
30
40
50
60
70
80
90


802_11.tcl Comparing variation in congestion window size with time
100 Number of Nodes
Congestion Window size
Time
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90


802_11.tcl Comparing variation in congestion window size with time
16 Number of Nodes
Congestion Window size
Time
0
1
2
3
4
5
6
0
10
20
30
40
50
60
70
80
90

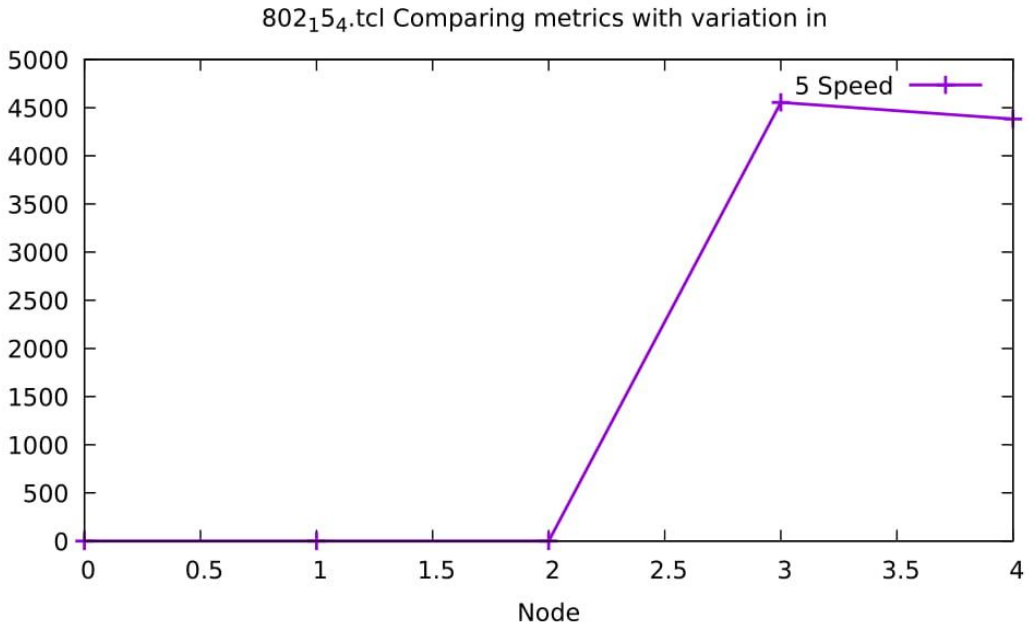

802_11.tcl Comparing variation in congestion window size with time
4 Number of Nodes
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90
1
1.5
2
2.5
3
3.5
4

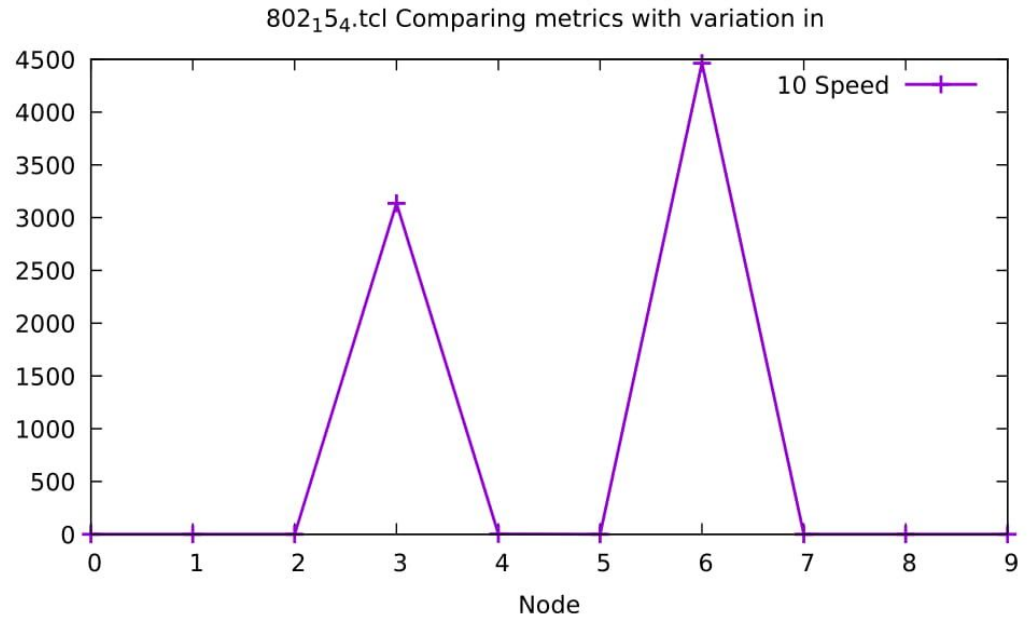

802_11.tcl Comparing variation in congestion window size with time
16 Number of Nodes
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90
0
1
2
3
4
5
6

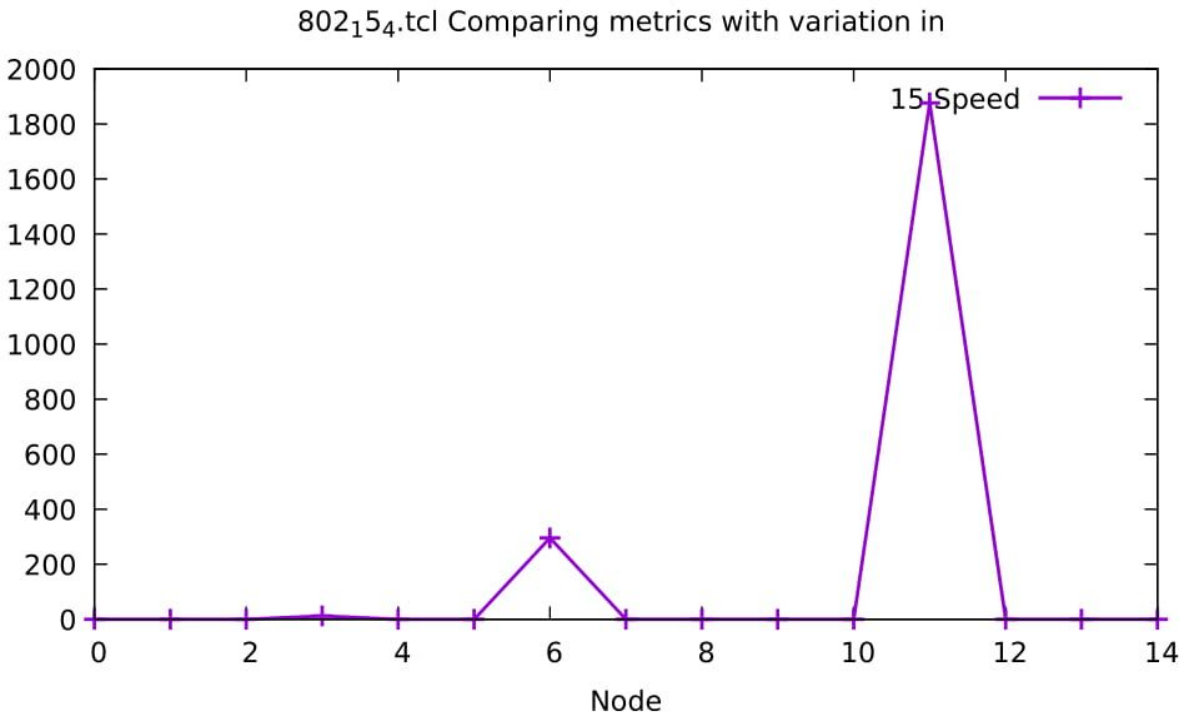
2. ***802.15.4***

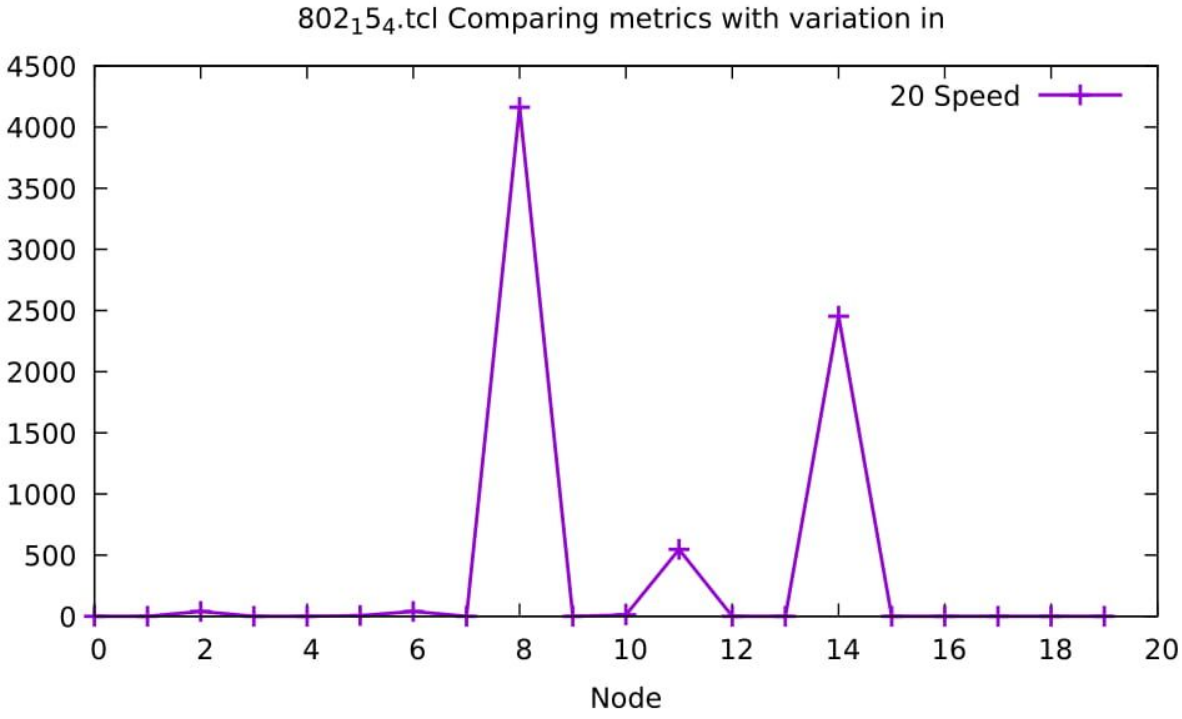
IEEE 802.15.4 is a technical standard which defines the operation of low-rate wireless personal area networks (LR-WPANs). The concept of IEEE 802.15.4 is to provide communications over distances up to about 10 metres and with maximum transfer data rates of 250 kbps.
Two sets of graphs are show, one with modifications to ns simulator, and another without modifications.

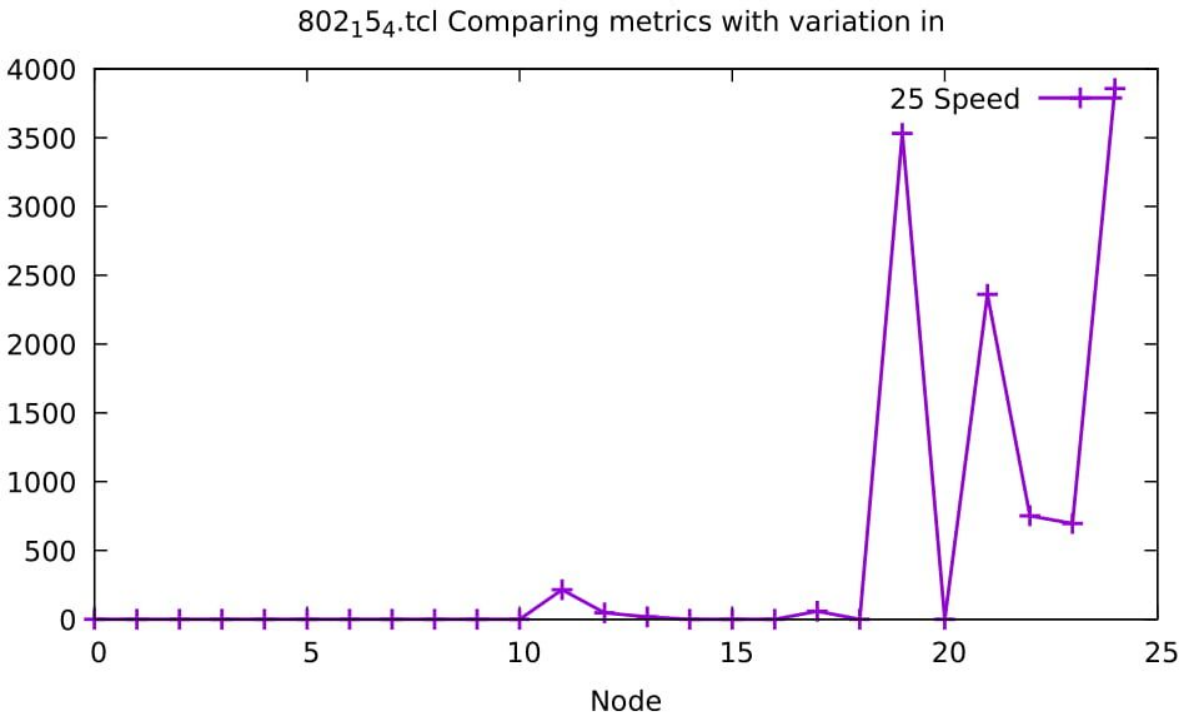
Modified

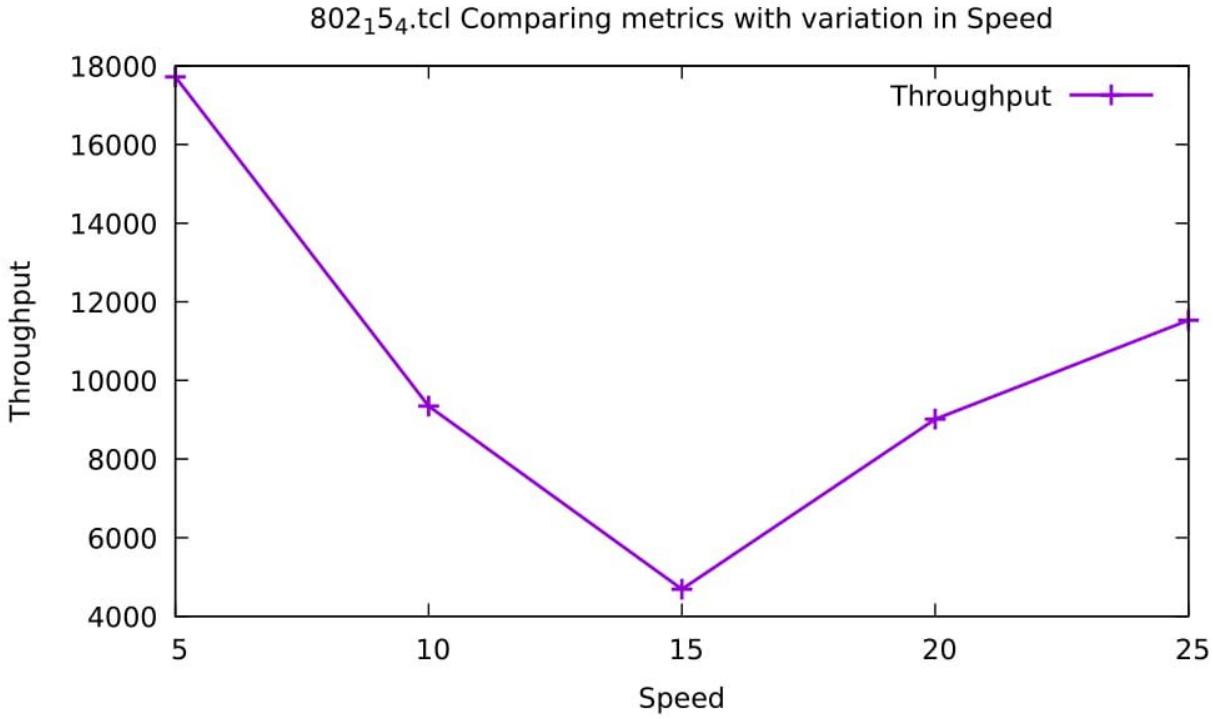


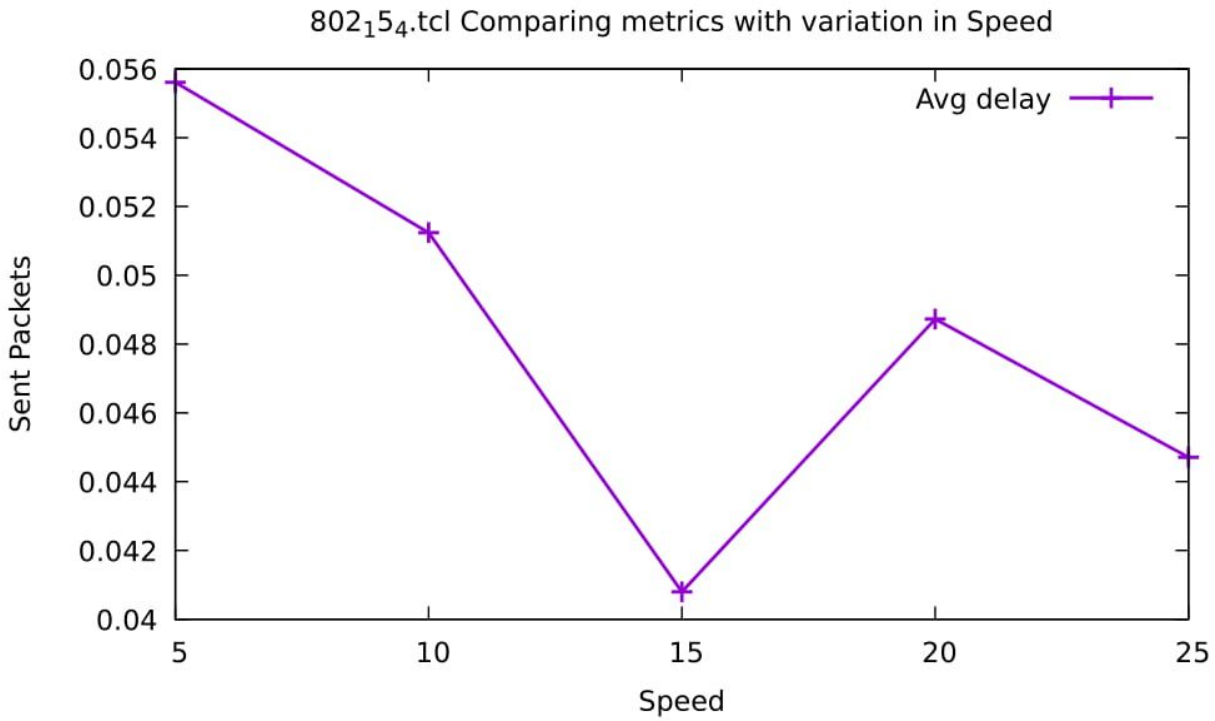


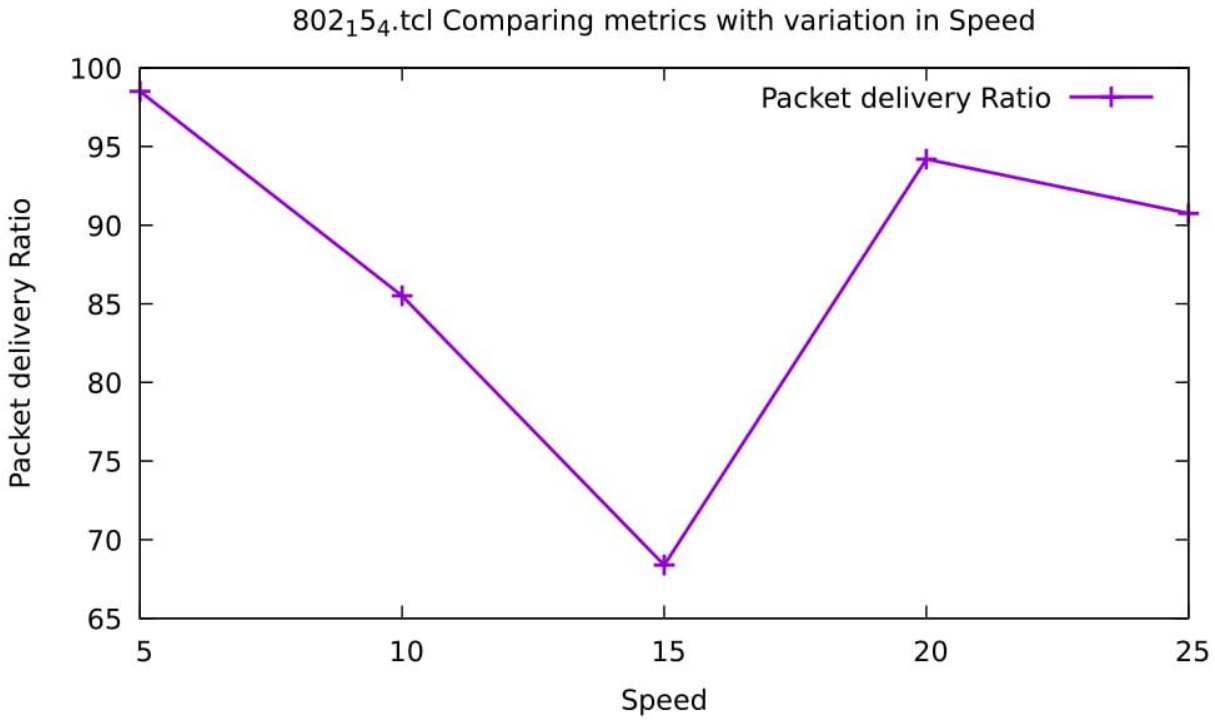

802_15_4.tcl Comparing metrics with variation in
15 Speed
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
2
4
6
8
10
12
14
Node

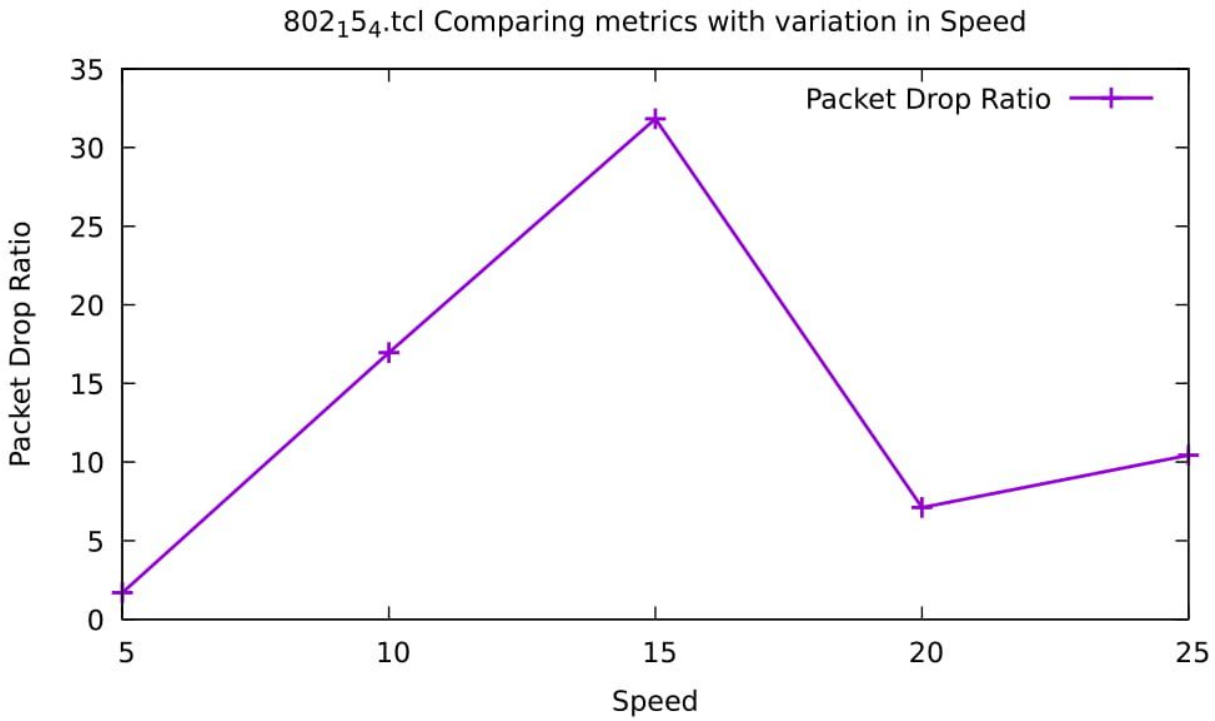

802_15_4.tcl Comparing metrics with variation in
20 Speed
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
2
4
6
8
10
12
14
16
18
20
Node

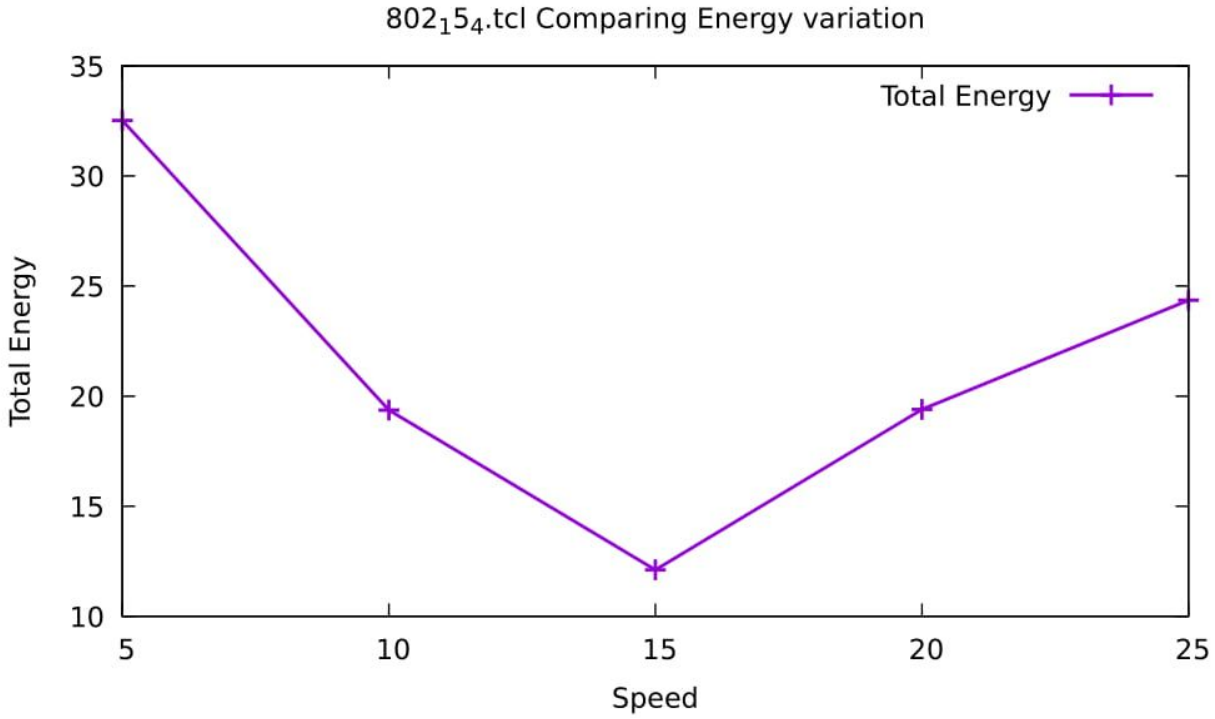

802154.tcl Comparing metrics with variation in
25 Speed
4000
3500
3000
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Node

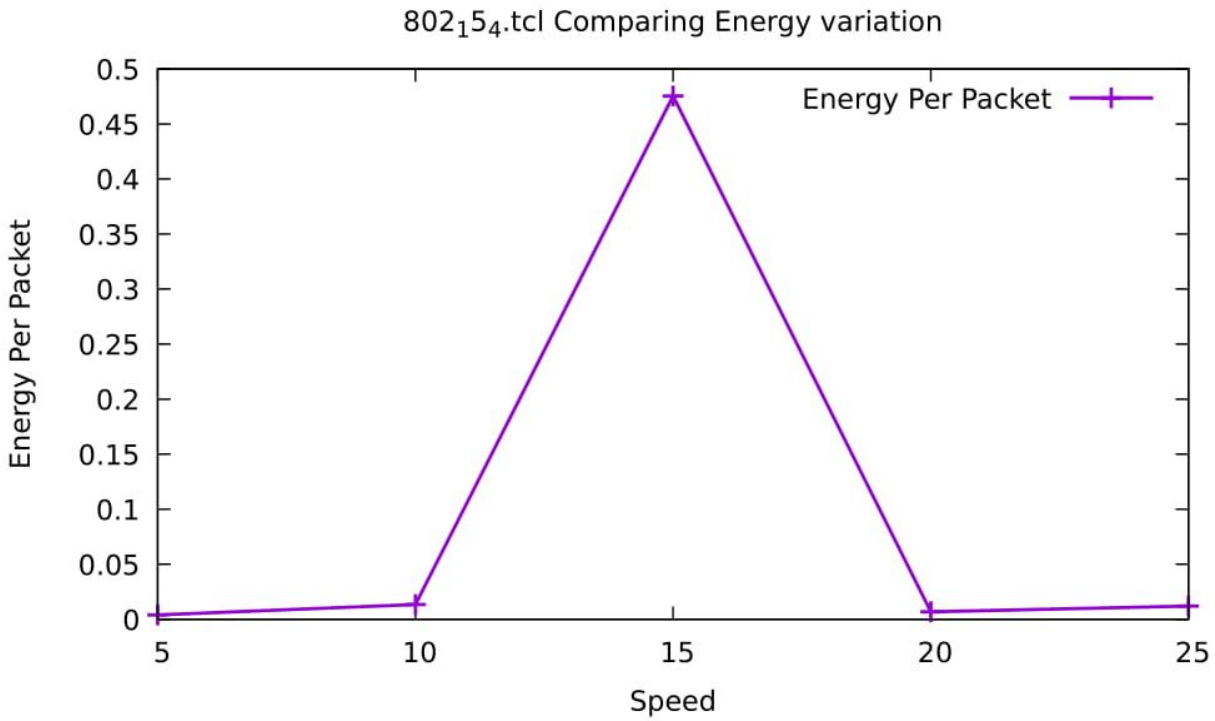

802154.tcl Comparing metrics with variation in Speed
Throughput
18000
16000
14000
12000
10000
8000
6000
4000
Throughput
5
10
15
20
25
Speed

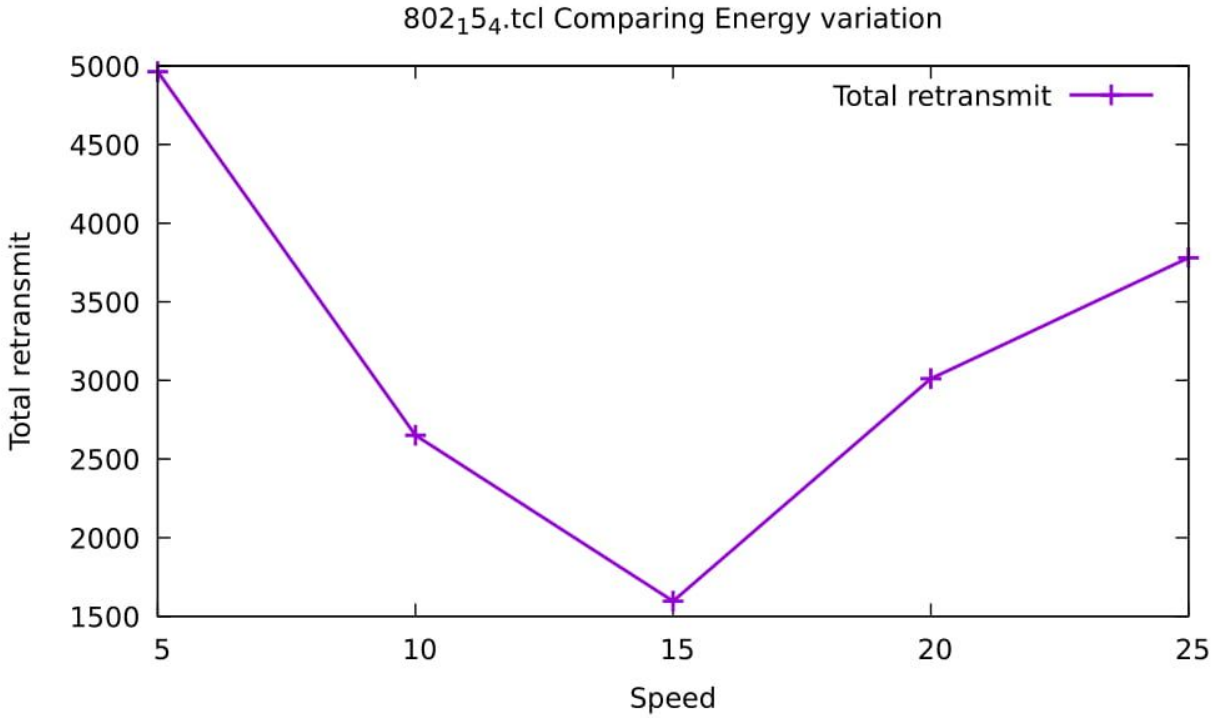

802_15_4.tcl Comparing metrics with variation in Speed
Avg delay
Sent Packets
0.056
0.054
0.052
0.05
0.048
0.046
0.044
0.042
0.04
5
10
15
20
25
Speed

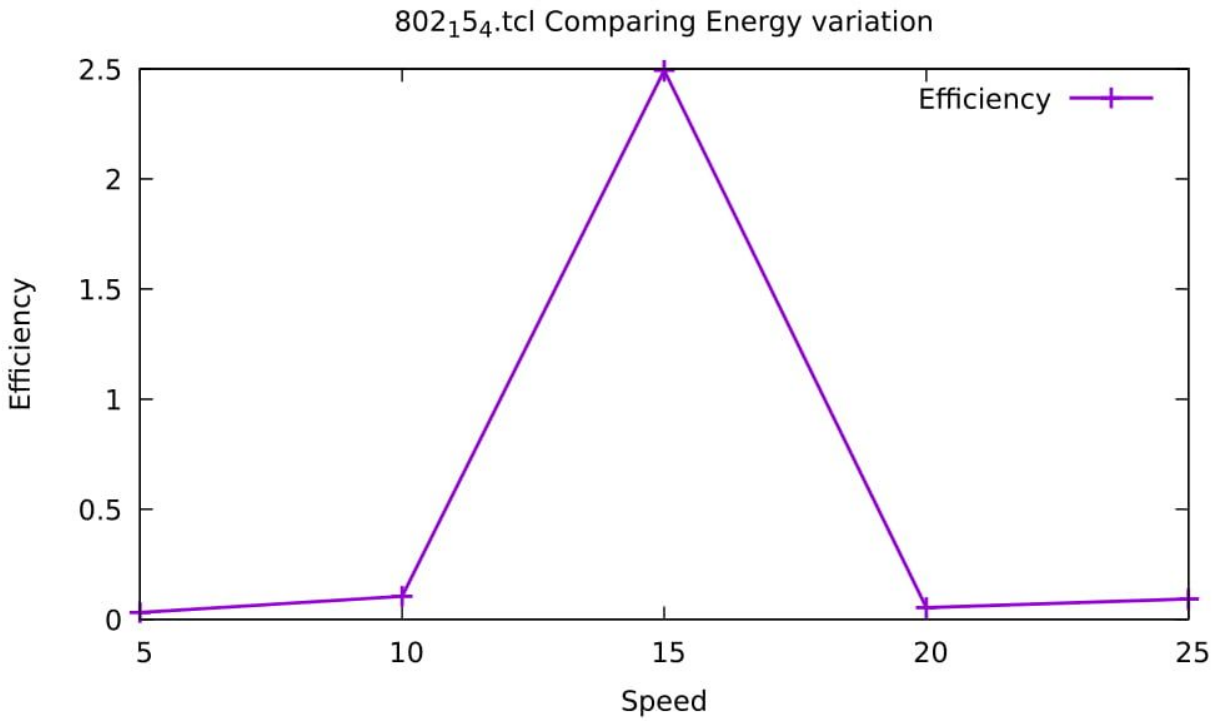

802_15_4.tcl Comparing metrics with variation in Speed
Packet delivery Ratio
Packet delivery Ratio
100
95
90
85
80
75
70
65
5
10
15
20
25
Speed

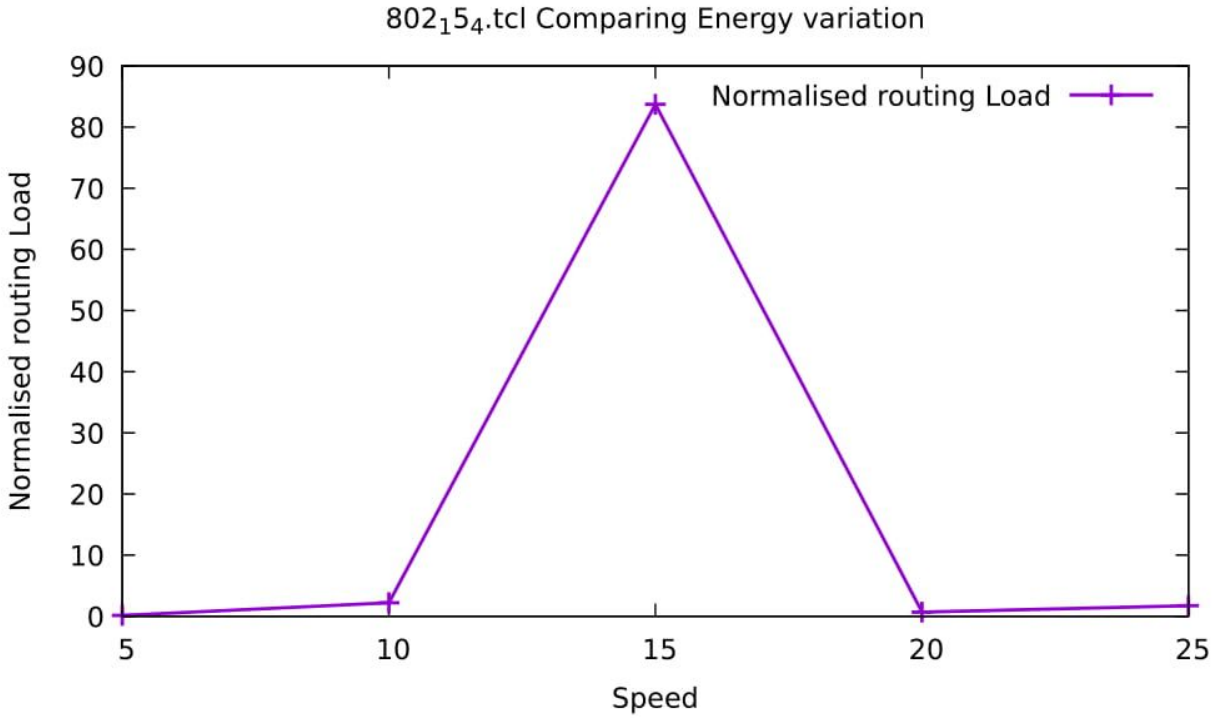

802_15_4.tcl Comparing metrics with variation in Speed
Packet Drop Ratio
Packet Drop Ratio
Speed
0
5
10
15
20
25
30
35
5
10
15
20
25

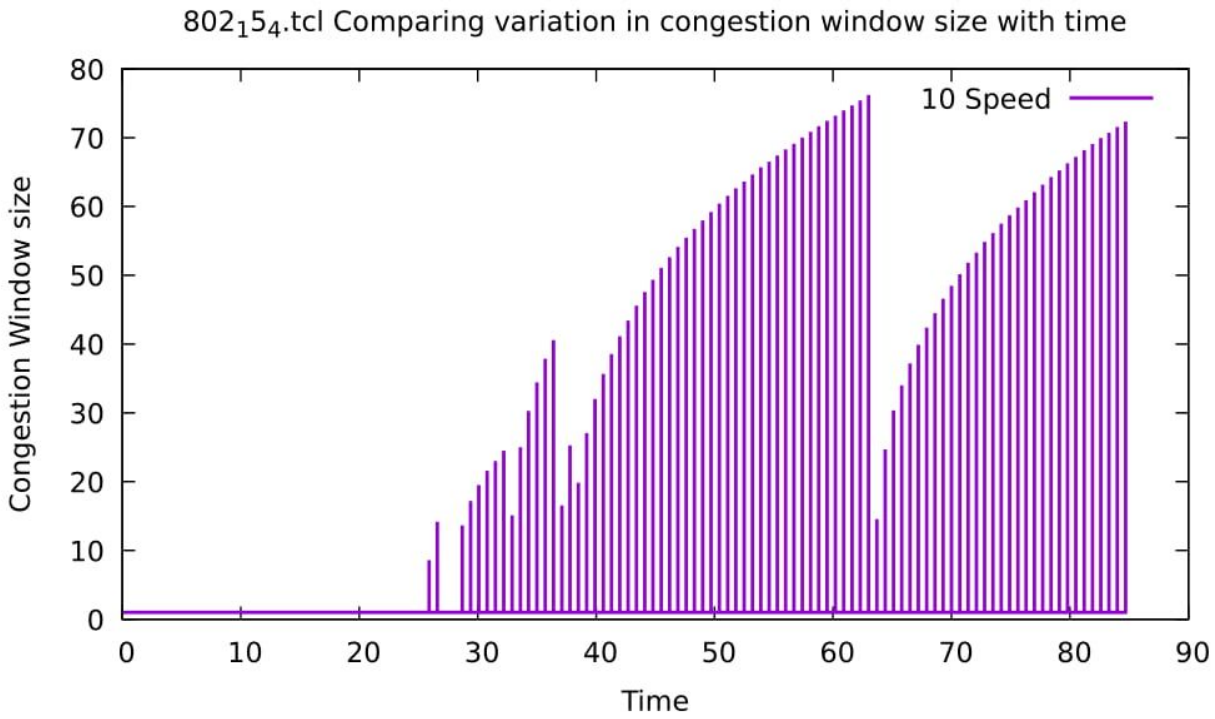

802_15_4.tcl Comparing Energy variation
Total Energy
Total Energy
Speed
10
15
20
25
30
35
5
10
15
20
25

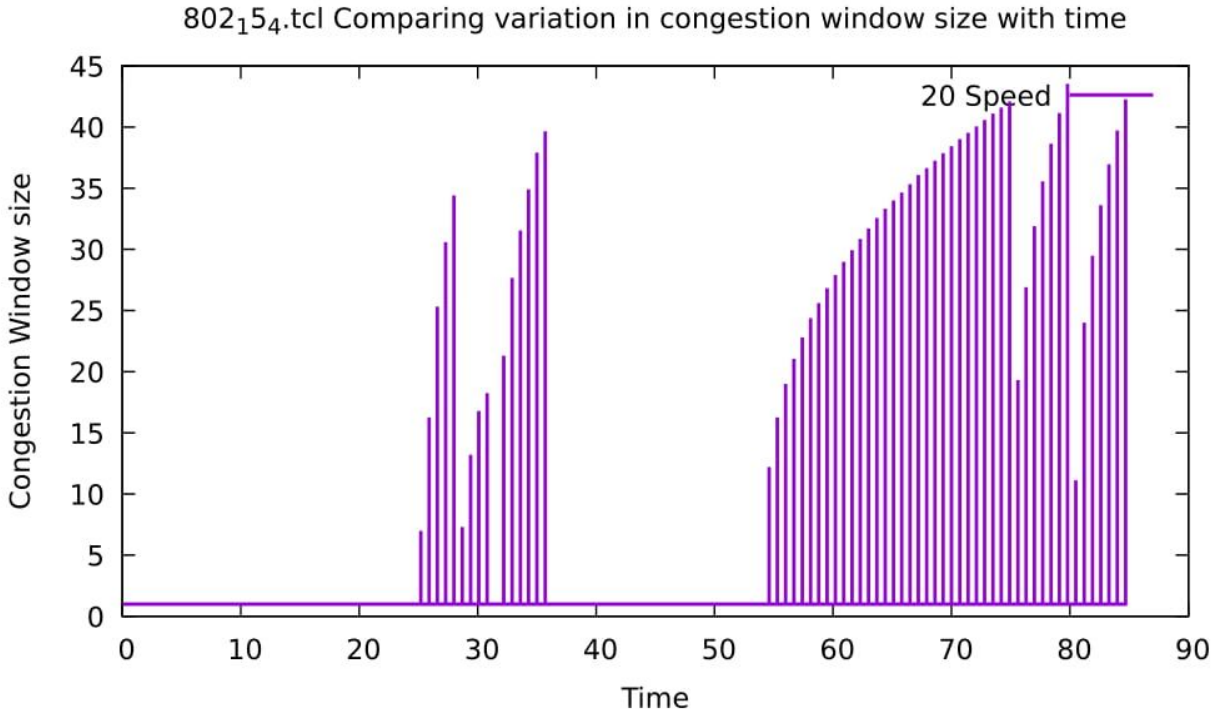

802154.tcl Comparing Energy variation
Energy Per Packet
Energy Per Packet
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
5
10
15
20
25
Speed

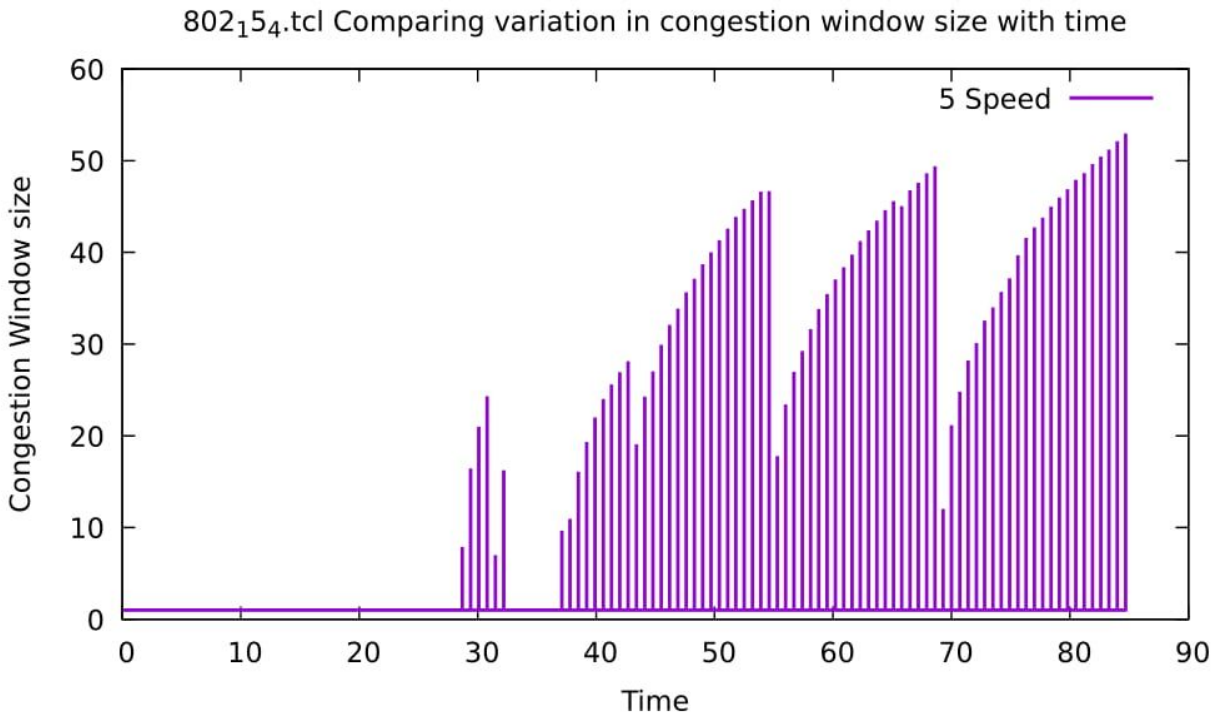

802154.tcl Comparing Energy variation
Total retransmit
Total retransmit
5000
4500
4000
3500
3000
2500
2000
1500
5
10
15
20
25
Speed

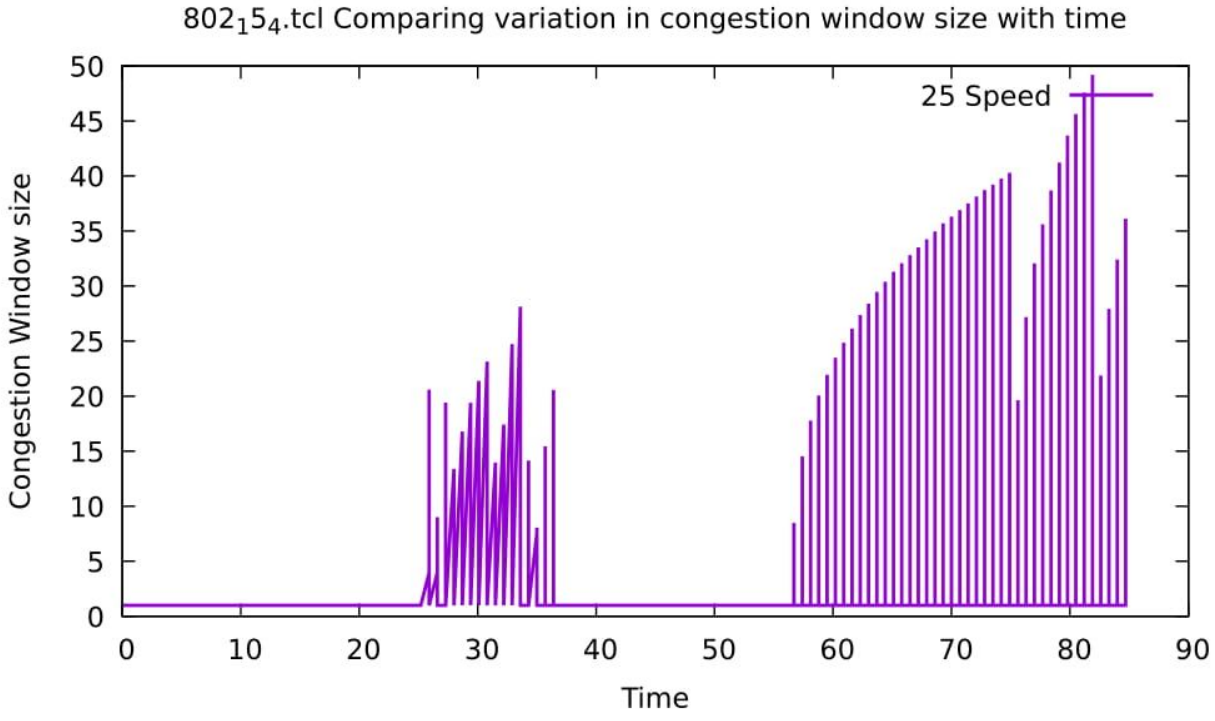

802_15_4.tcl Comparing Energy variation
Efficiency
Efficiency
Speed
0
0.5
1
1.5
2
2.5
5
10
15
20
25


802_15_4.tcl Comparing Energy variation
Normalised routing Load
Normalised routing Load
Speed
0
10
20
30
40
50
60
70
80
90
5
10
15
20
25

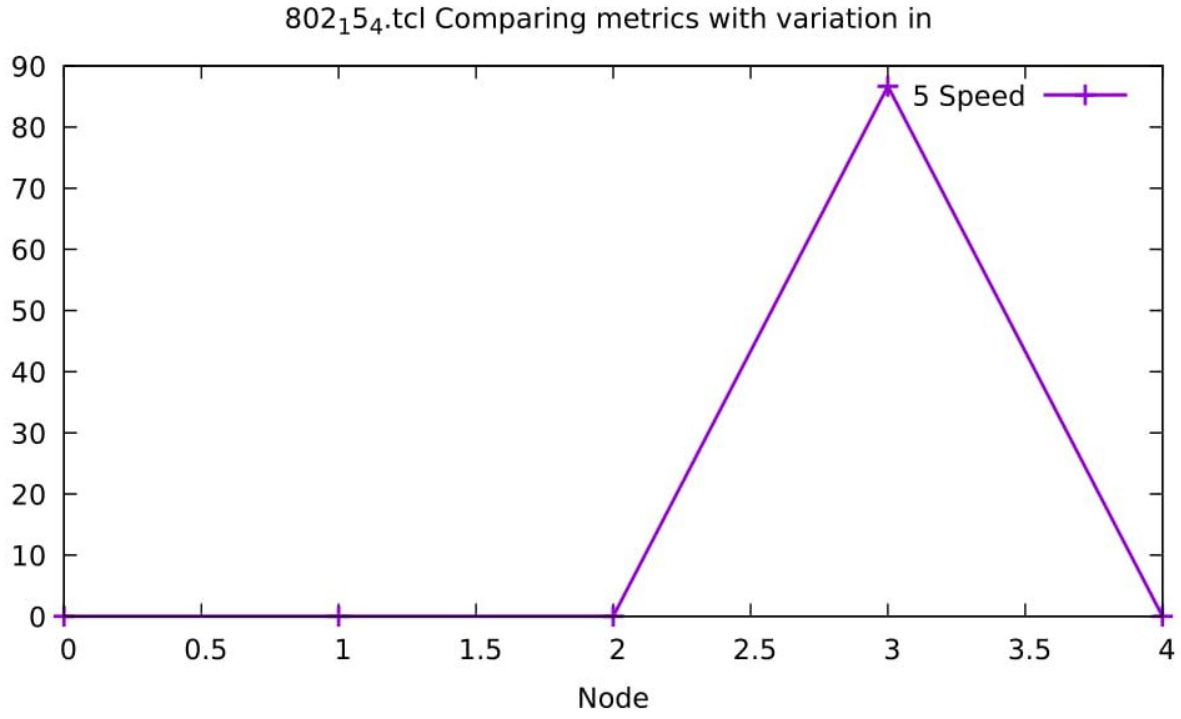

802$_1$5$_4$.tcl Comparing variation in congestion window size with time
10 Speed
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90

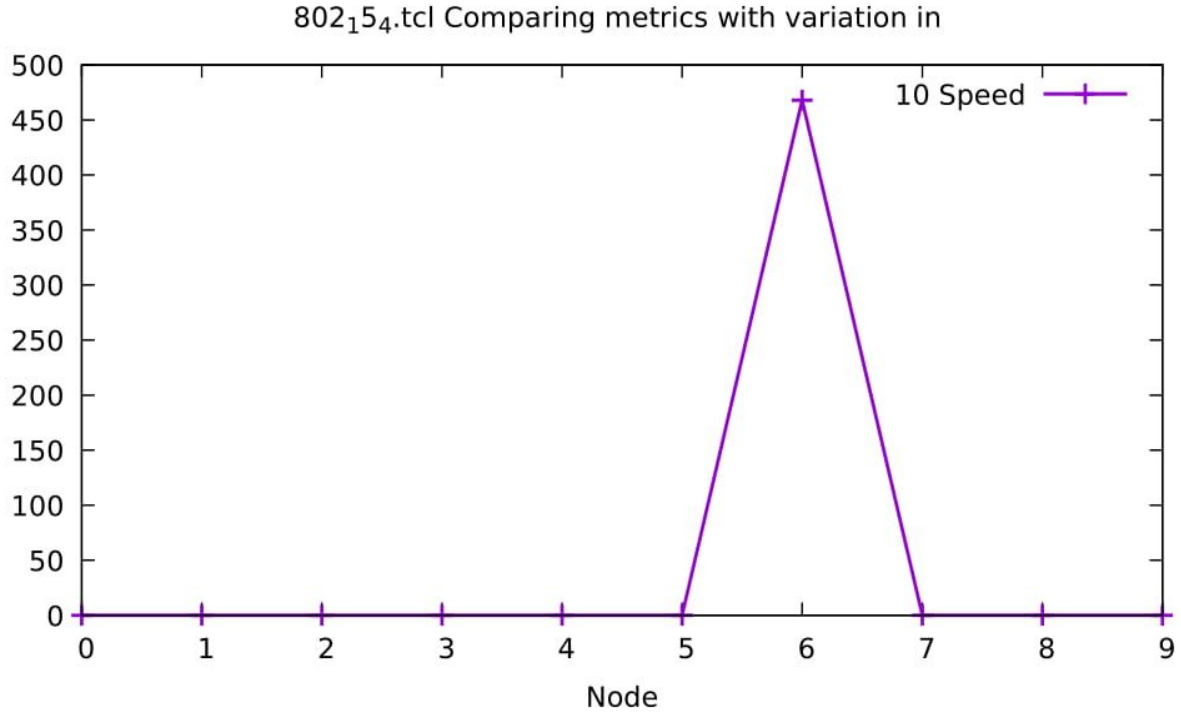

802$_1$5$_4$.tcl Comparing variation in congestion window size with time
20 Speed
Congestion Window size
Time
0
5
10
15
20
25
30
35
40
45
0
10
20
30
40
50
60
70
80
90

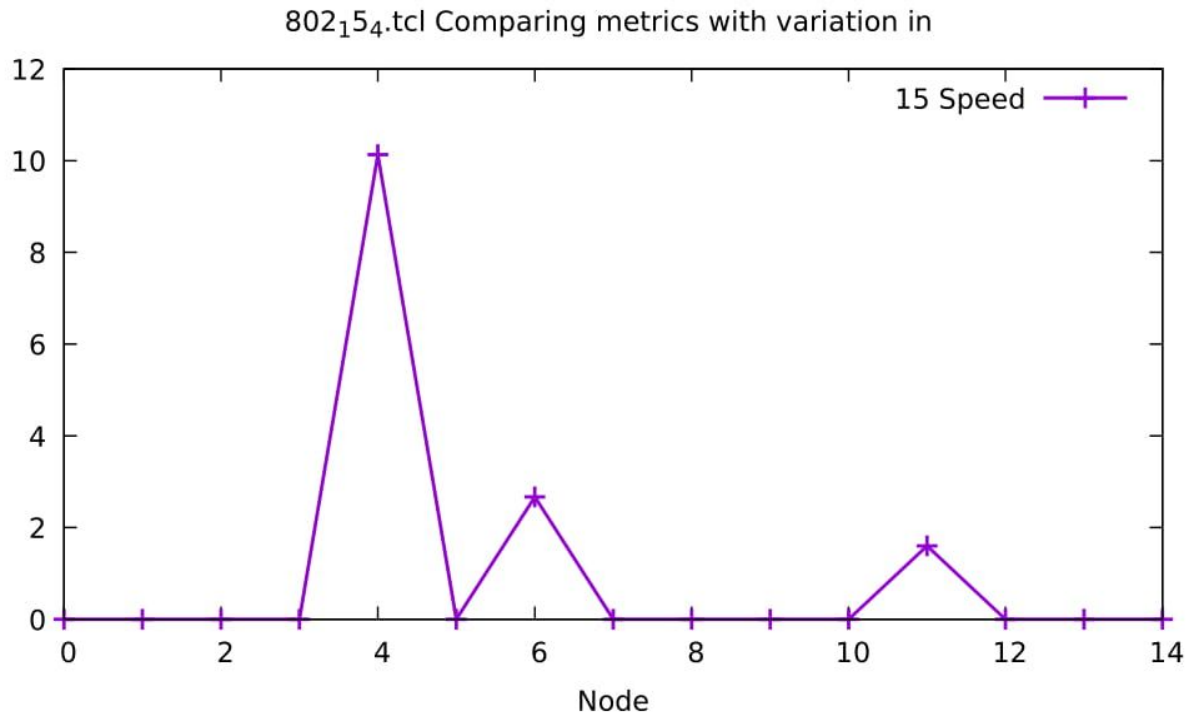

802$_1$5$_4$.tcl Comparing variation in congestion window size with time
5 Speed
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90

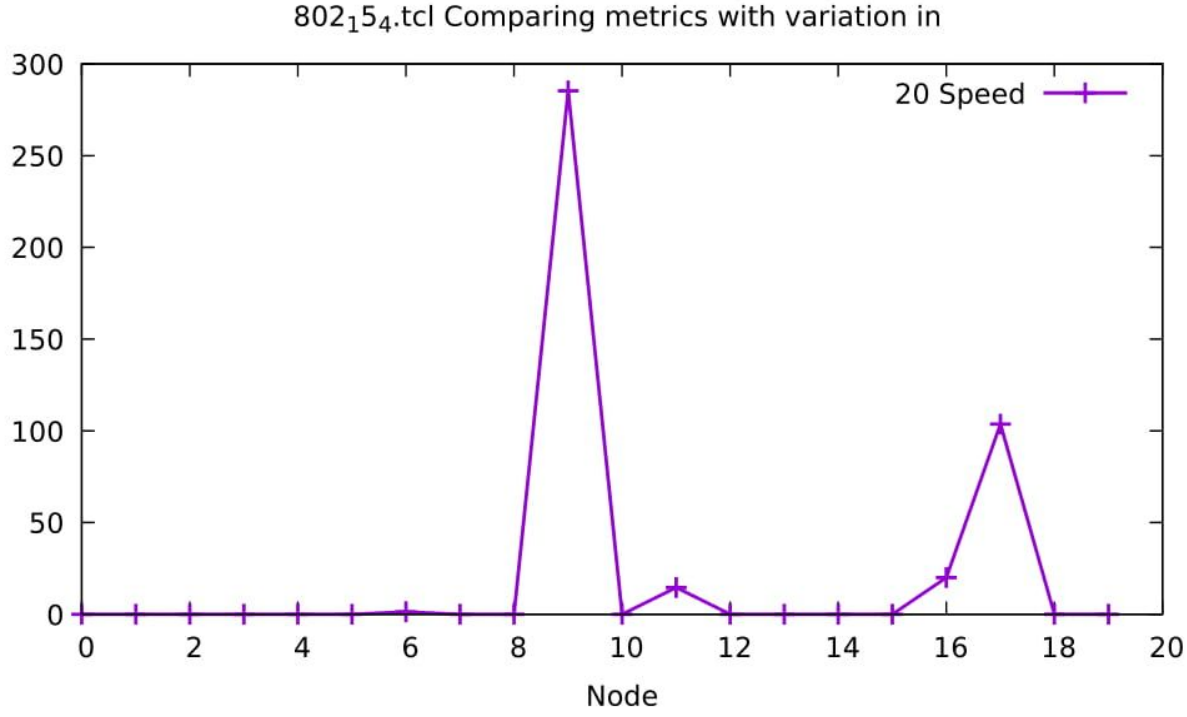

802$_1$5$_4$.tcl Comparing variation in congestion window size with time
25 Speed
Congestion Window size
Time
0
5
10
15
20
25
30
35
40
45
50
60
70
80
90

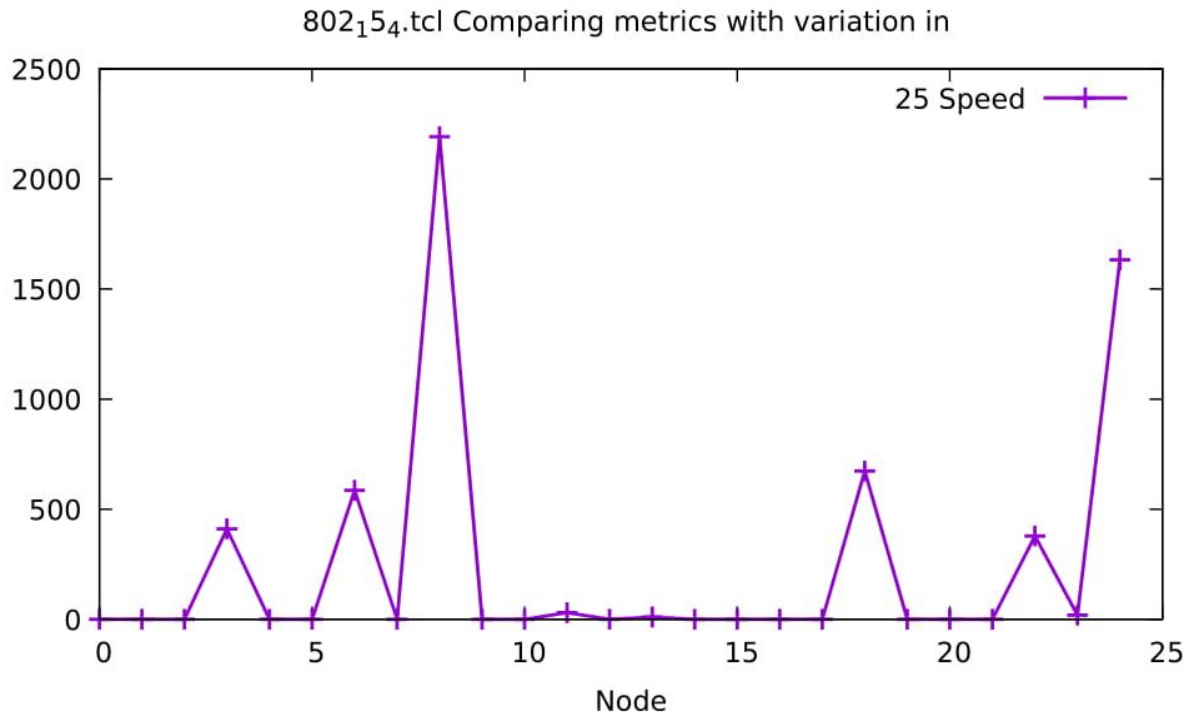
Unmodified

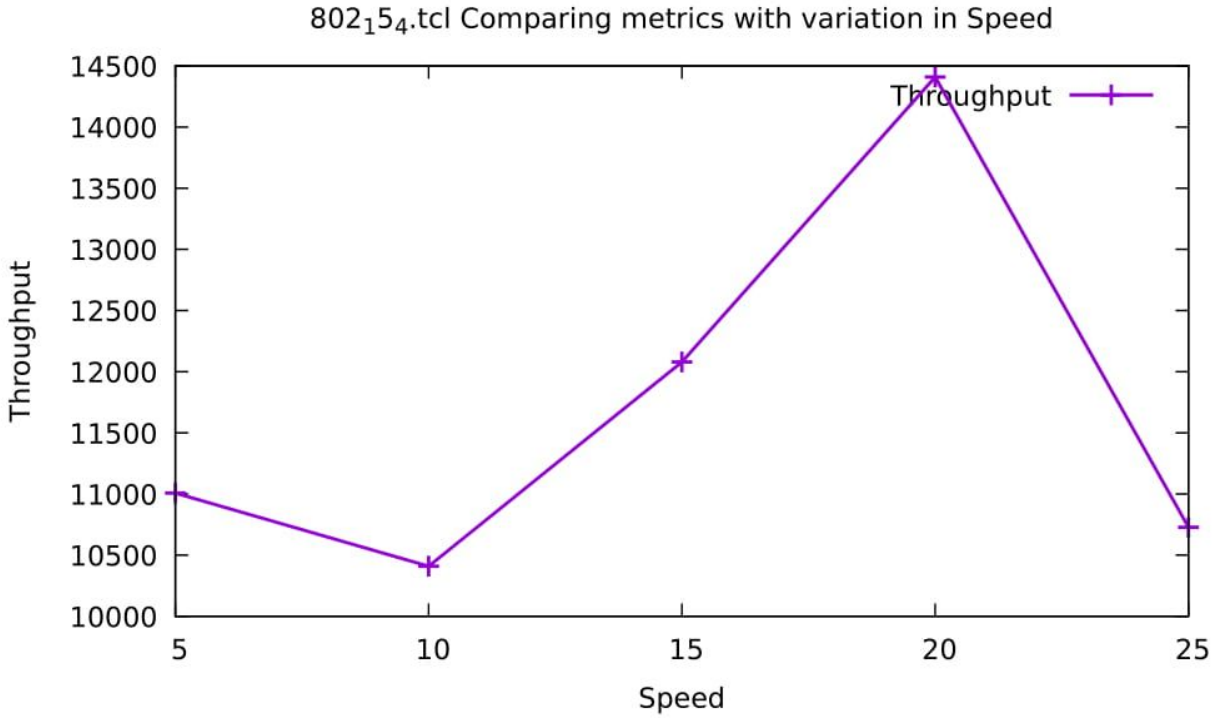

802$_1$5$_4$.tcl Comparing metrics with variation in
5 Speed
90
80
70
60
50
40
30
20
10
0
0
0.5
1
1.5
2
2.5
3
3.5
4
Node

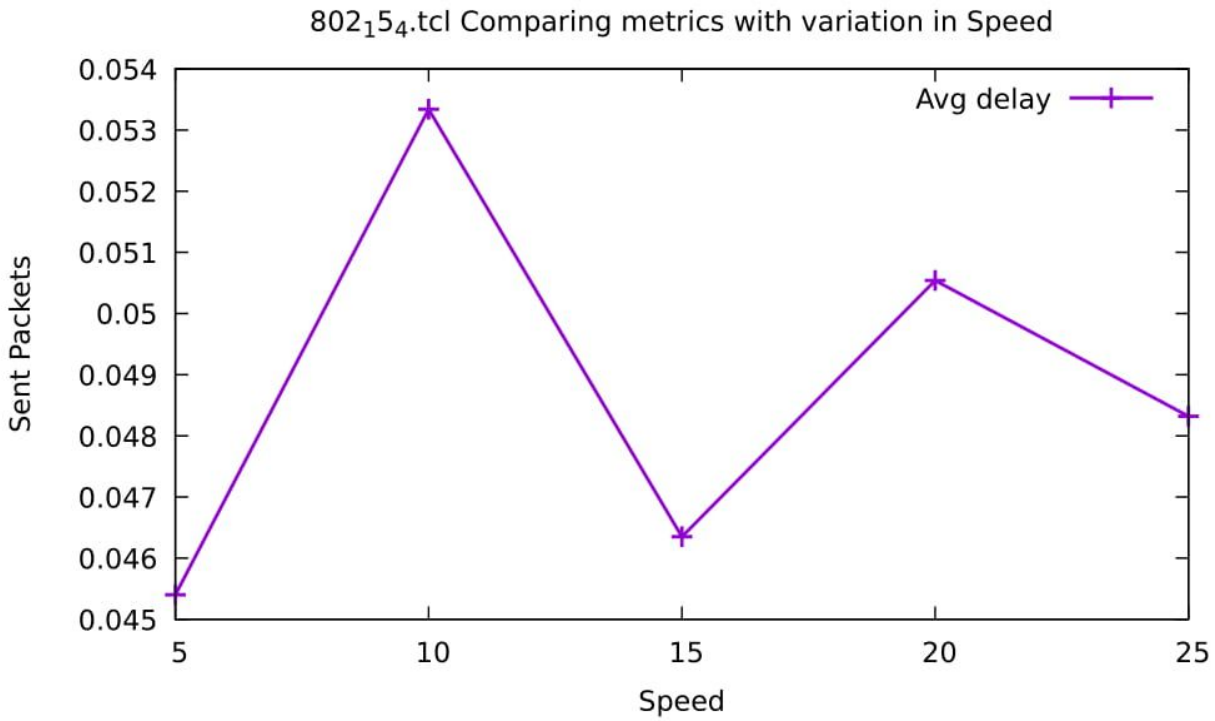

802$_1$5$_4$.tcl Comparing metrics with variation in
10 Speed
500
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
5
6
7
8
9
Node

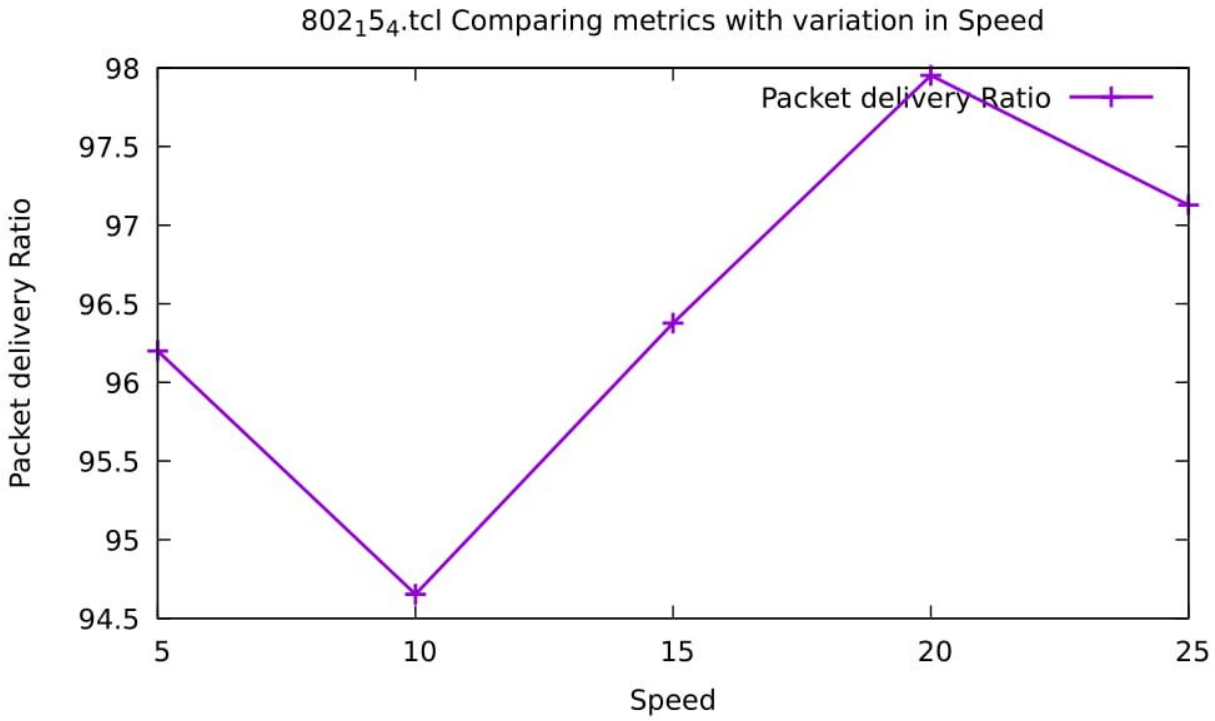

802$_1$5$_4$.tcl Comparing metrics with variation in
15 Speed
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
Node

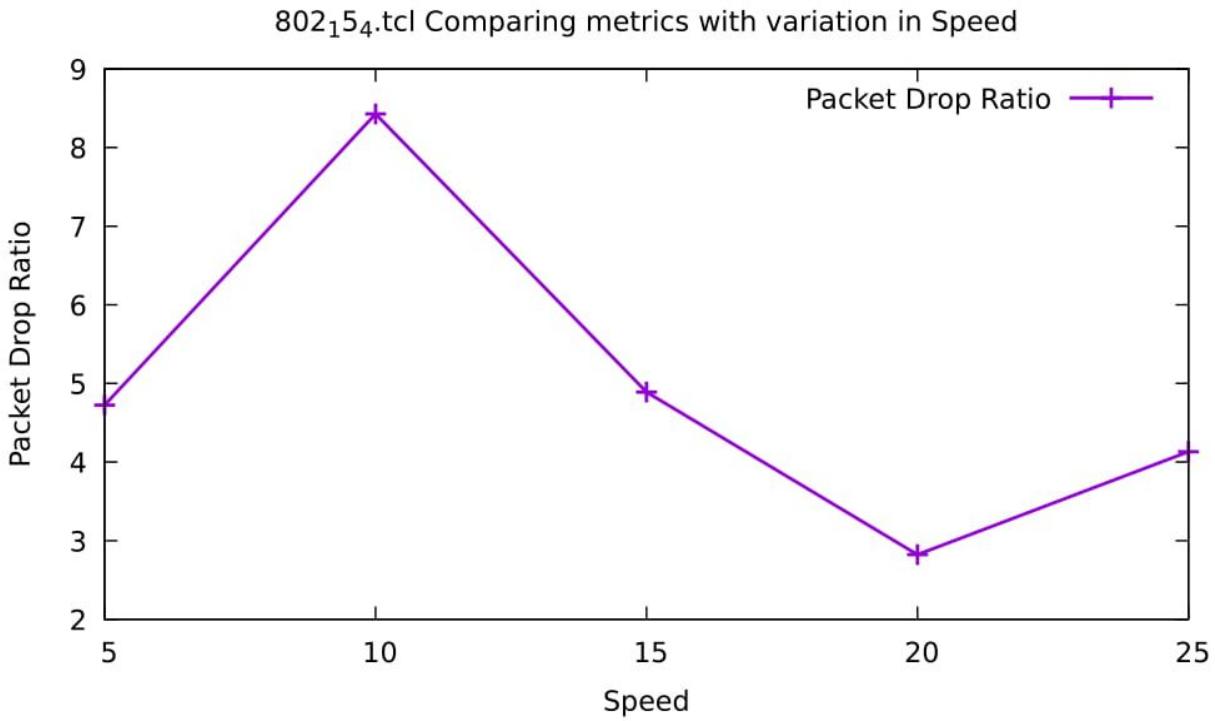

802$_1$5$_4$.tcl Comparing metrics with variation in
20 Speed
300
250
200
150
100
50
0
0
2
4
6
8
10
12
14
16
18
20
Node

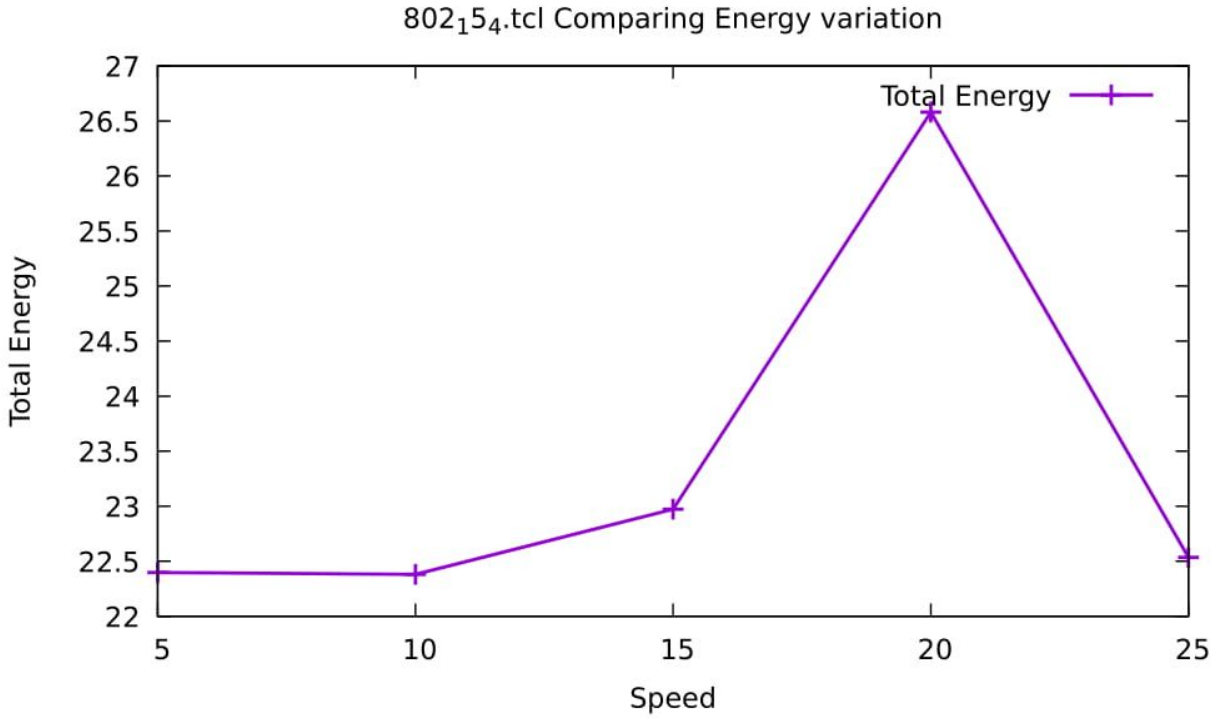

802_15_4.tcl Comparing metrics with variation in
25 Speed
2500
2000
1500
1000
500
0
0
5
10
15
20
25
Node

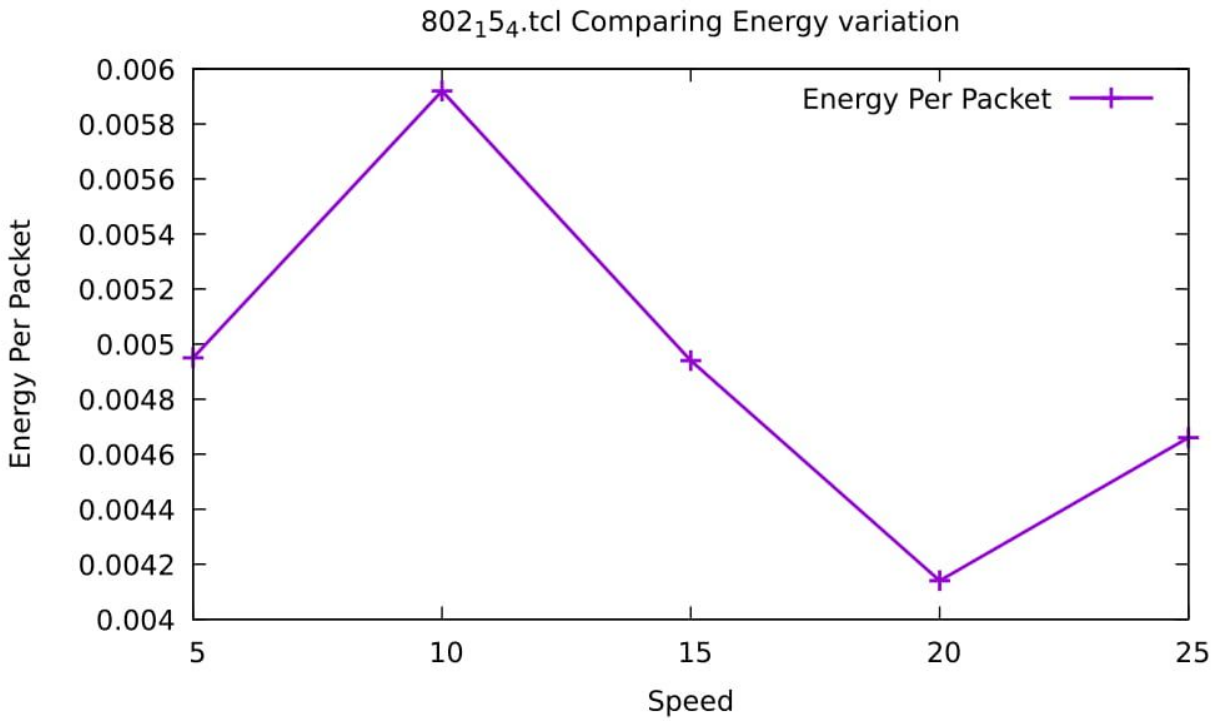

802_15_4.tcl Comparing metrics with variation in Speed
Throughput
14500
14000
13500
13000
12500
12000
11500
11000
10500
10000
5
10
15
20
25
Speed
Throughput

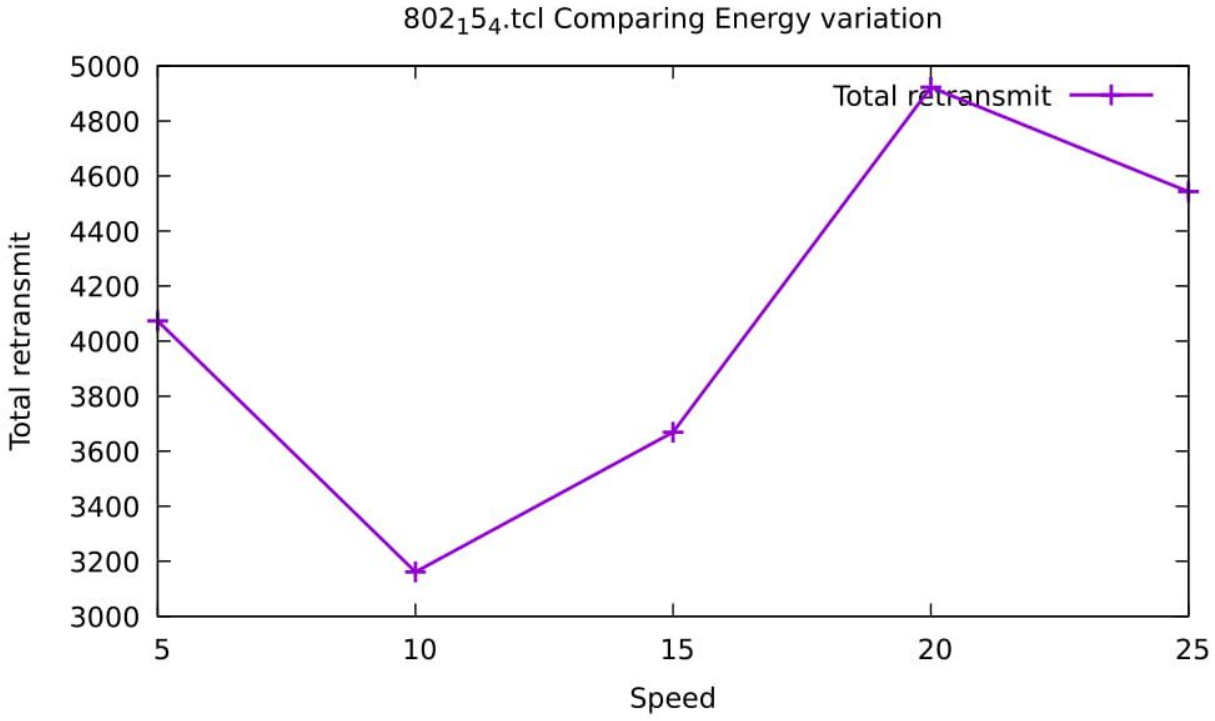

802_15_4.tcl Comparing metrics with variation in Speed
Avg delay
Sent Packets
0.054
0.053
0.052
0.051
0.05
0.049
0.048
0.047
0.046
0.045
5
10
15
20
25
Speed

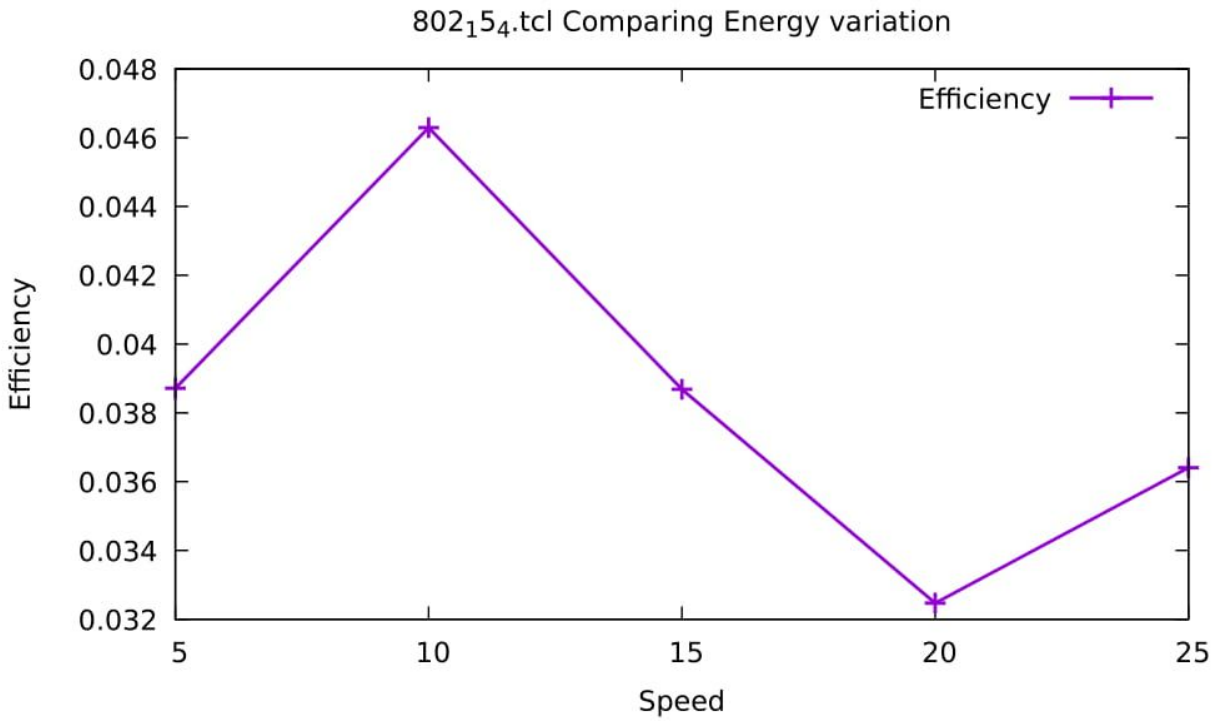

802_15_4.tcl Comparing metrics with variation in Speed
Packet delivery Ratio
Packet delivery Ratio
98
97.5
97
96.5
96
95.5
95
94.5
5
10
15
20
25
Speed

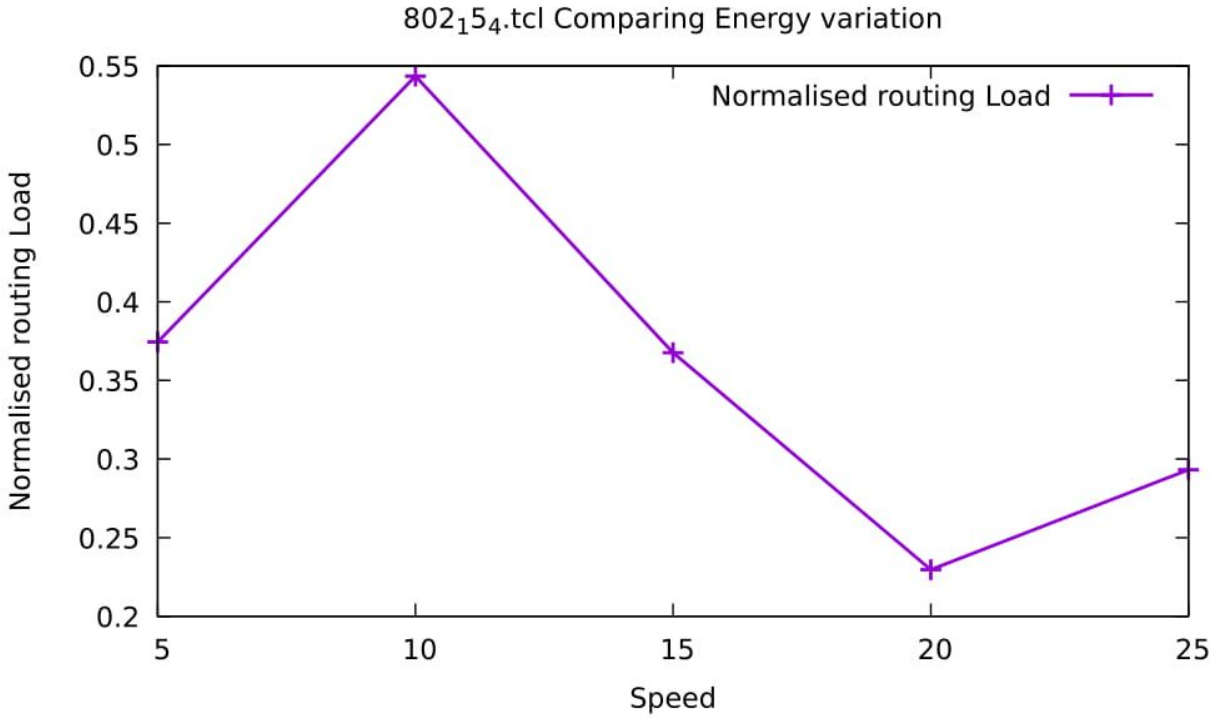

802_15_4.tcl Comparing metrics with variation in Speed
Packet Drop Ratio
Packet Drop Ratio
Speed
9
8
7
6
5
4
3
2
5
10
15
20
25

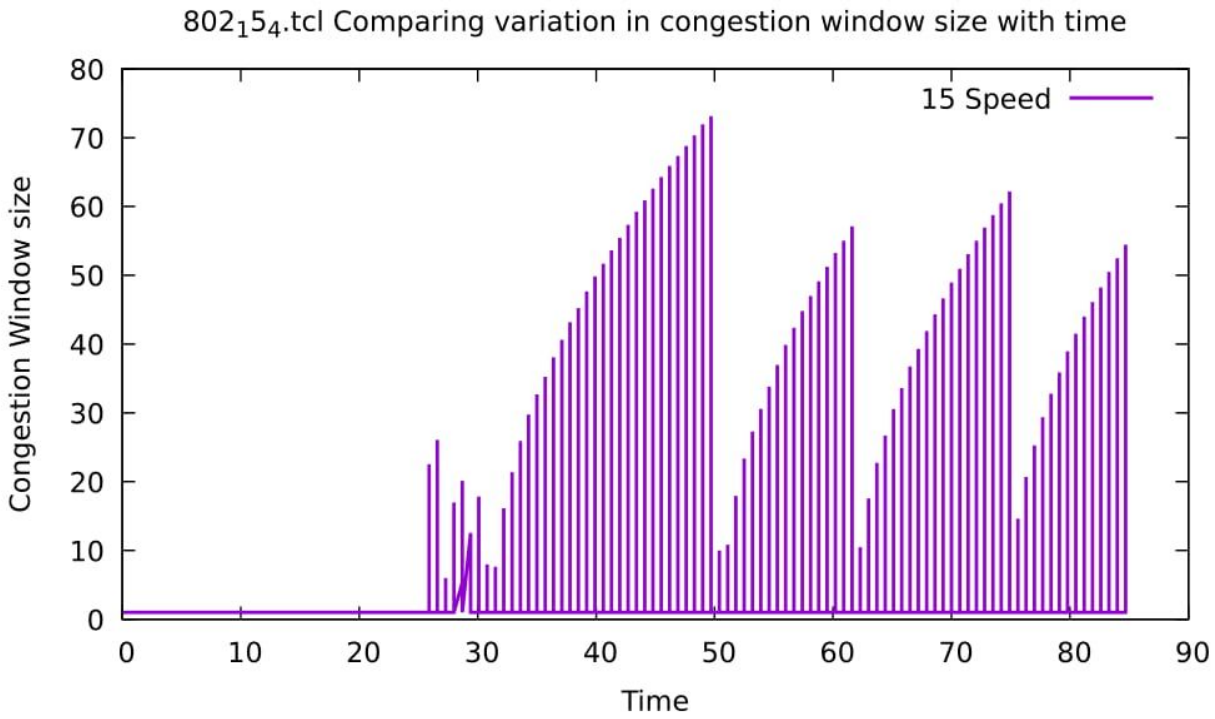

802_15_4.tcl Comparing Energy variation
Total Energy
Total Energy
Speed
27
26.5
26
25.5
25
24.5
24
23.5
23
22.5
22
5
10
15
20
25

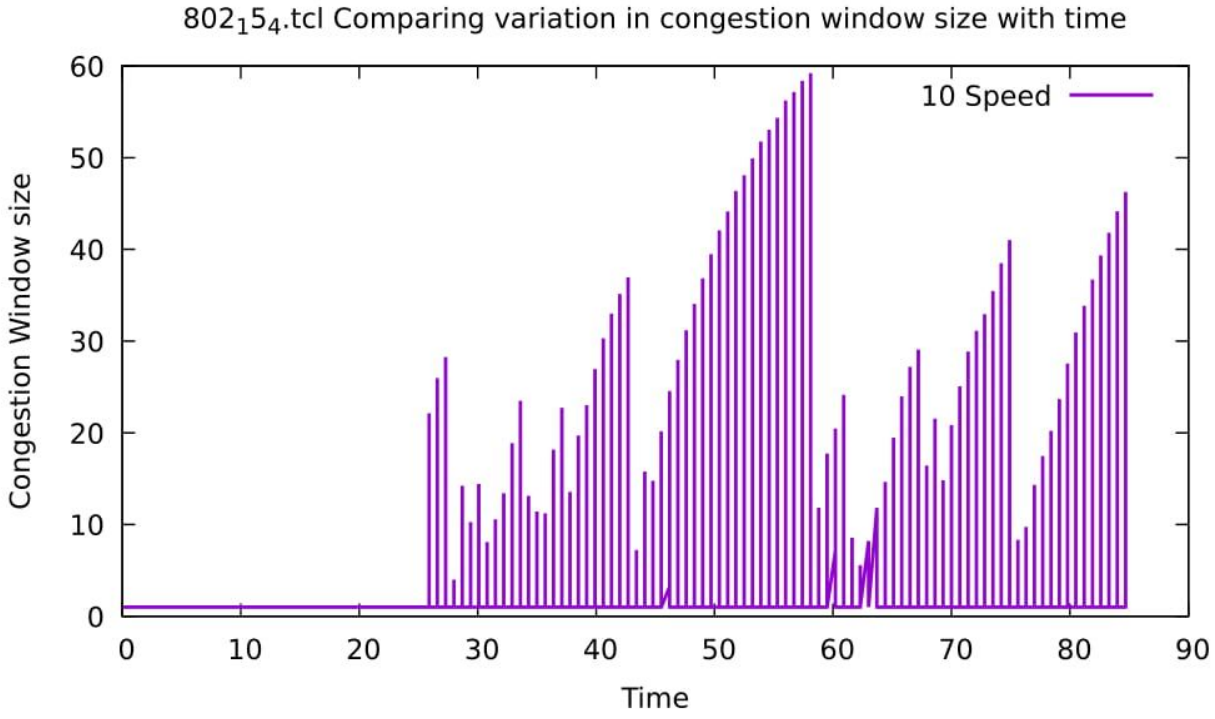

802154.tcl Comparing Energy variation
Energy Per Packet
Energy Per Packet
0.006
0.0058
0.0056
0.0054
0.0052
0.005
0.0048
0.0046
0.0044
0.0042
0.004
5
10
15
20
25
Speed

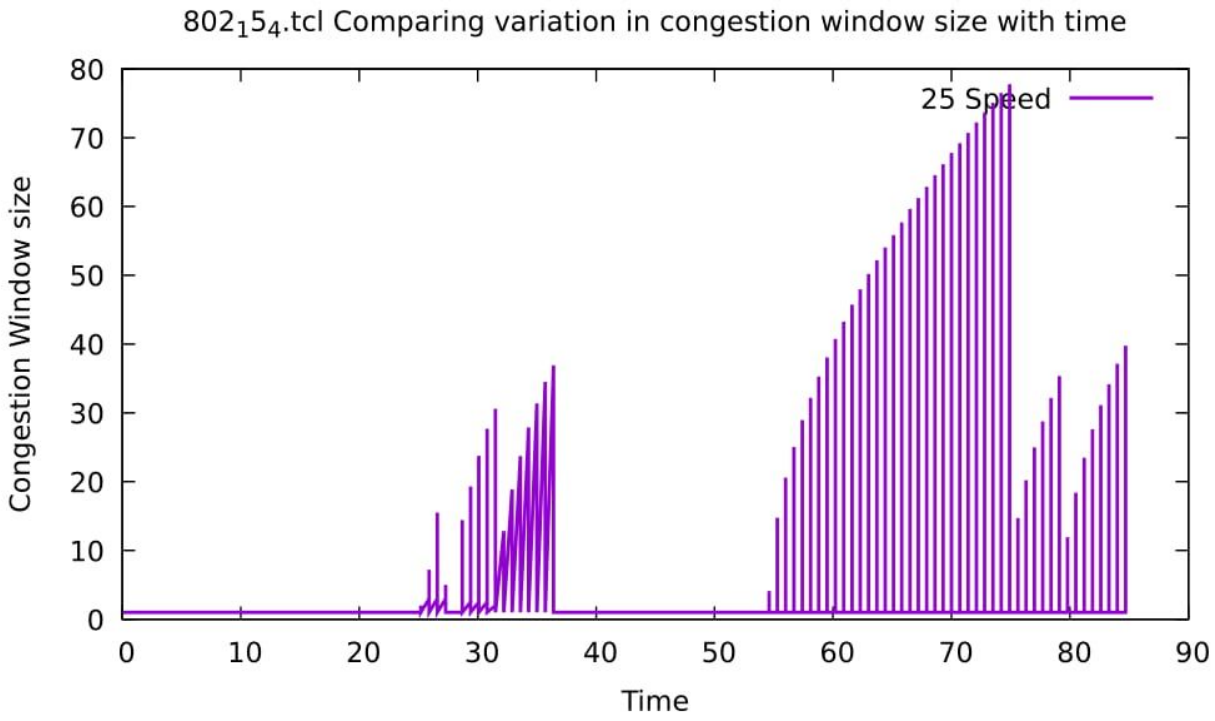

802154.tcl Comparing Energy variation
Total retransmit
Total retransmit
5000
4800
4600
4400
4200
4000
3800
3600
3400
3200
3000
5
10
15
20
25
Speed

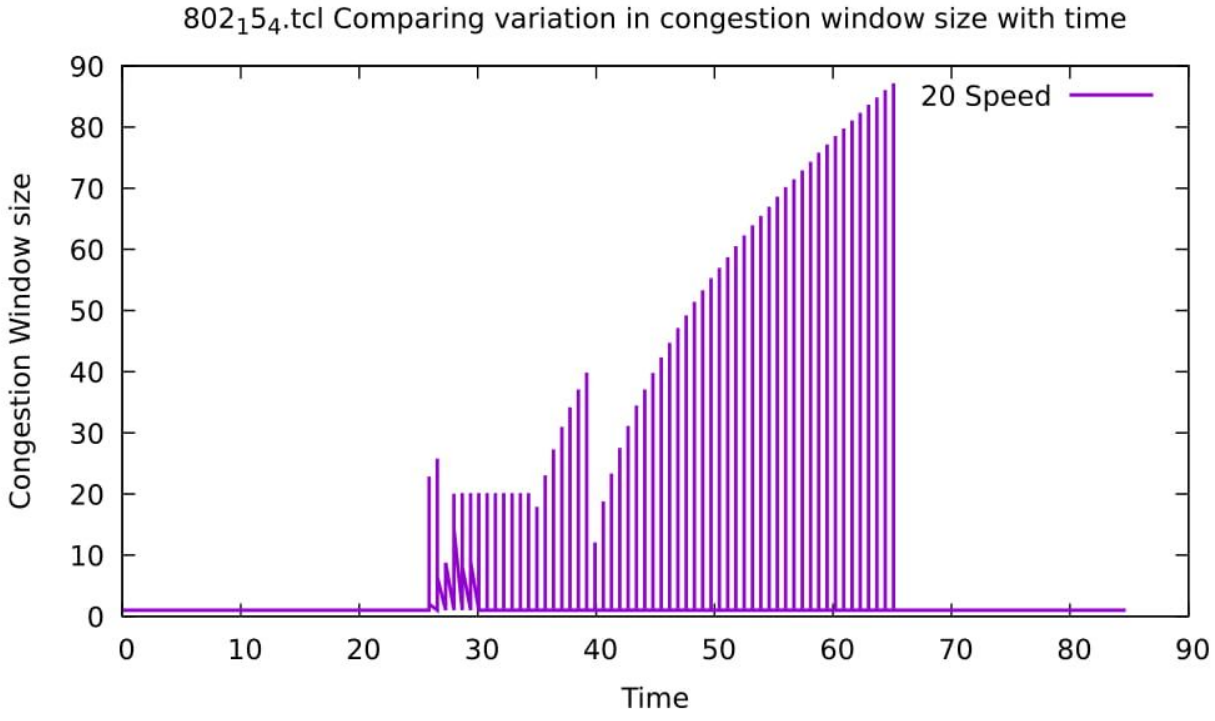

802154.tcl Comparing Energy variation
Efficiency
0.048
0.046
0.044
0.042
0.04
0.038
0.036
0.034
0.032
5
10
15
20
25
Speed

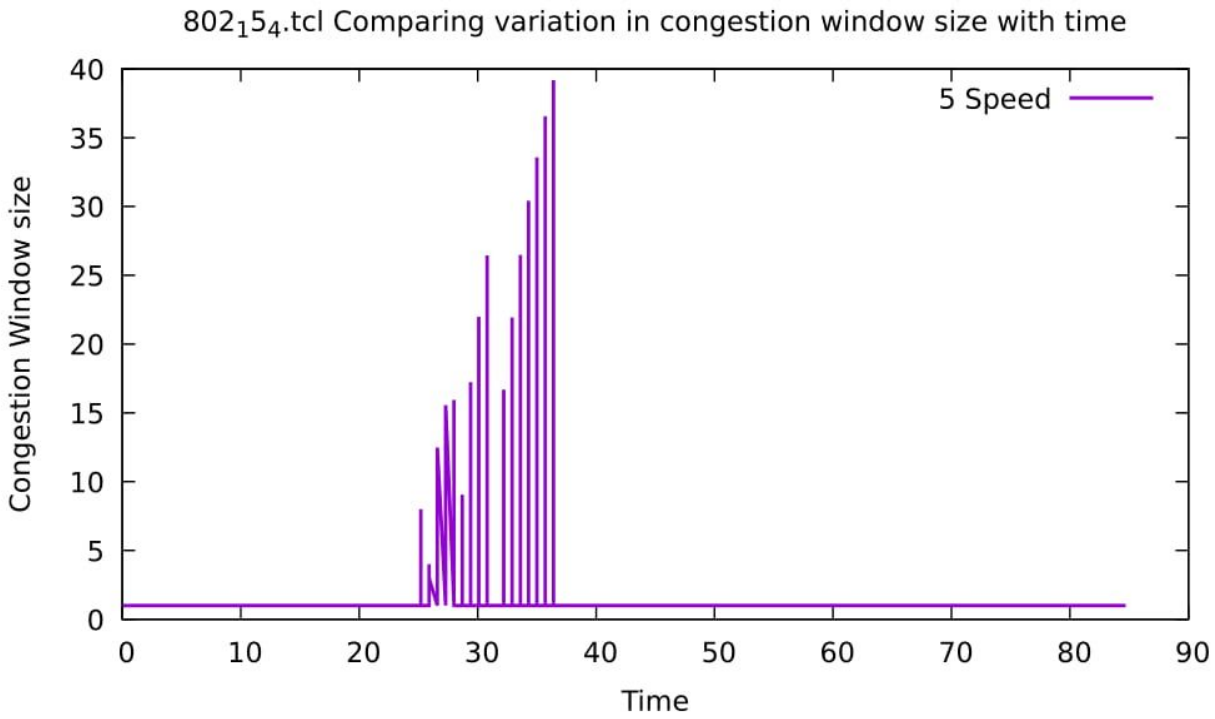

802154.tcl Comparing Energy variation
Normalised routing Load
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
5
10
15
20
25
Speed

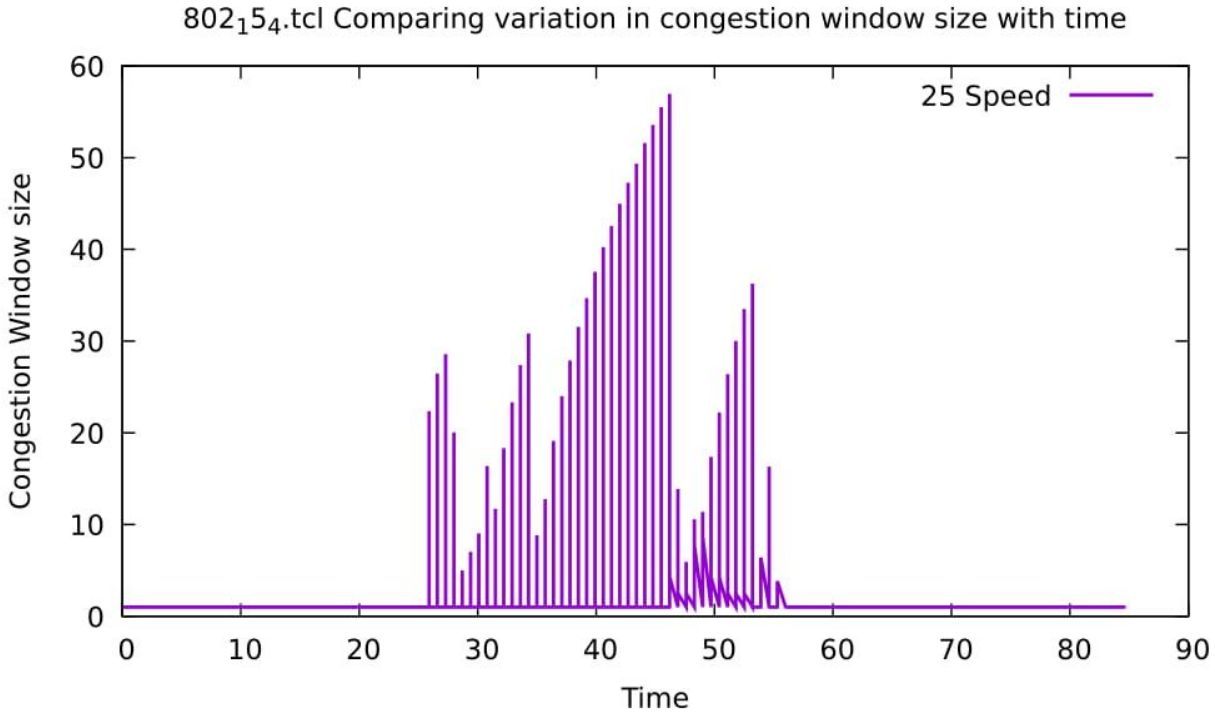

802$_1$5$_4$.tcl Comparing variation in congestion window size with time
15 Speed
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90


802$_1$5$_4$.tcl Comparing variation in congestion window size with time
10 Speed
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90


802$_1$5$_4$.tcl Comparing variation in congestion window size with time
25 Speed
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90


802$_1$5$_4$.tcl Comparing variation in congestion window size with time
20 Speed
Congestion Window size
Time
0
10
20
30
40
50
60
70
80
90


802_15_4.tcl Comparing variation in congestion window size with time
5 Speed
Congestion Window size
Time
0
5
10
15
20
25
30
35
40
0
10
20
30
40
50
60
70
80
90

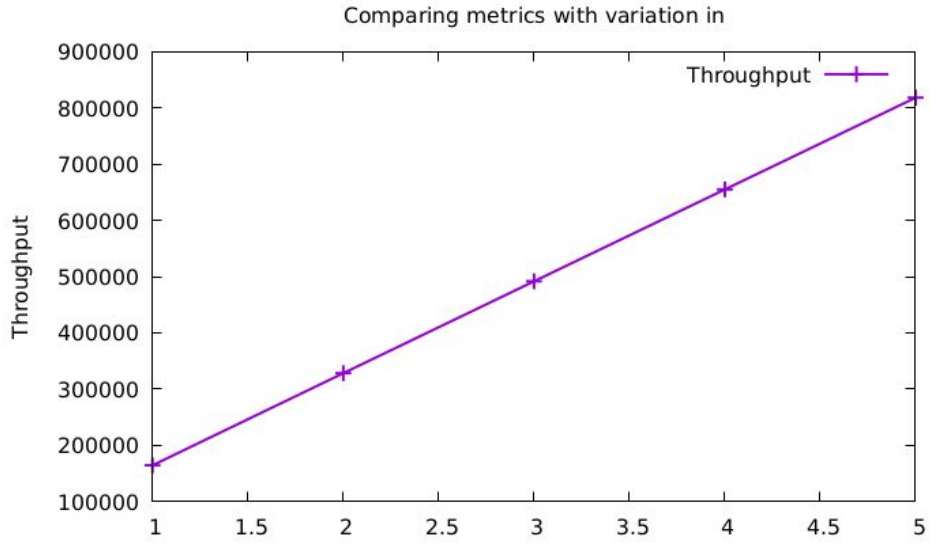

802_15_4.tcl Comparing variation in congestion window size with time
25 Speed
Congestion Window size
Time
0
10
20
30
40
50
60
0
10
20
30
40
50
60
70
80
90

Bonus:

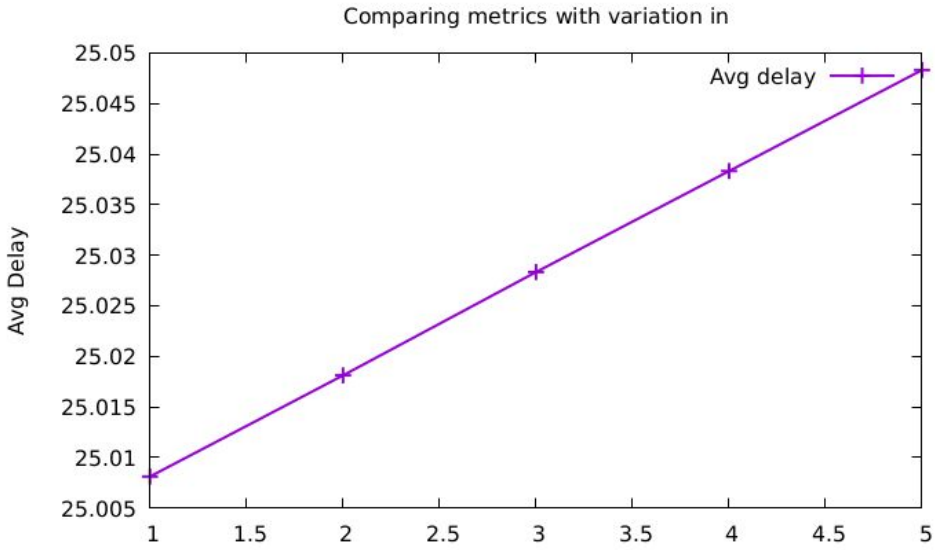
1. ***802.16***

Also known as "WiMAX" (from "Worldwide Interoperability for Microwave Access")
The simulation consists of n number of static mobile nodes, and a Base station connected to a sink node using wired connection. CBR traffic is generated in the wireless nodes, and travels to the sink_node through the base station. Following graphs are generated.

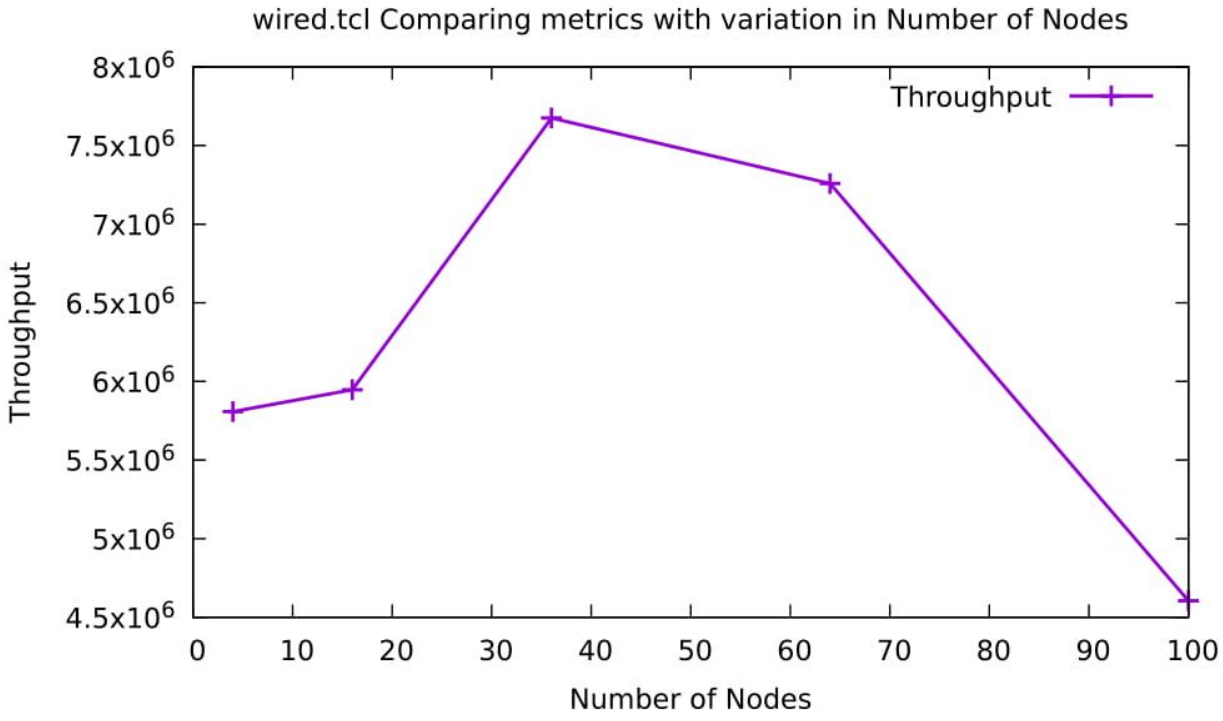
1. Throughput vs No. of nodes.

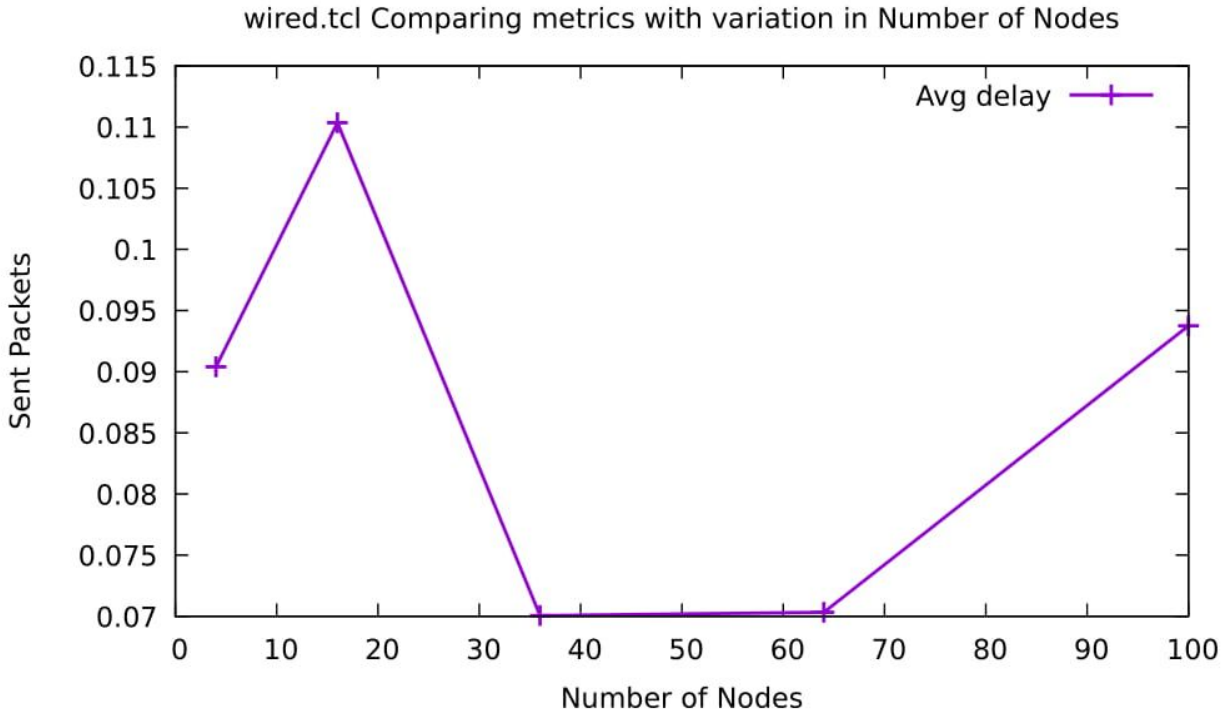


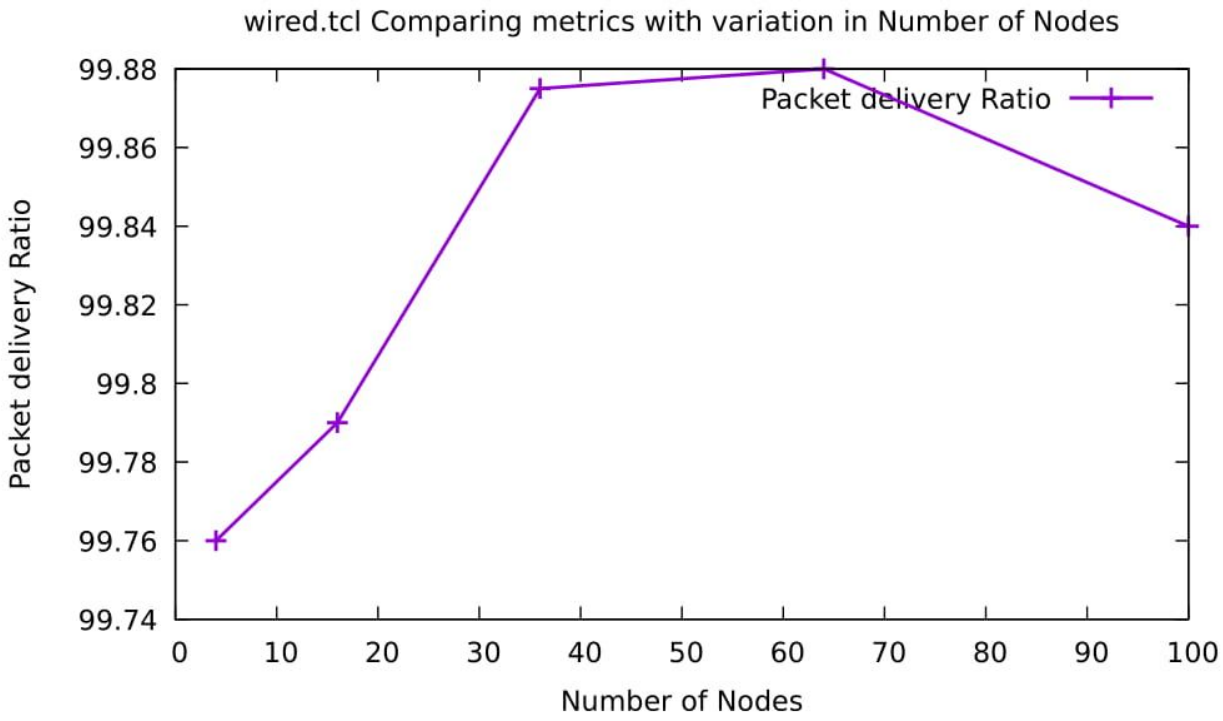
2. Average end-2-end delay vs Number of nodes.

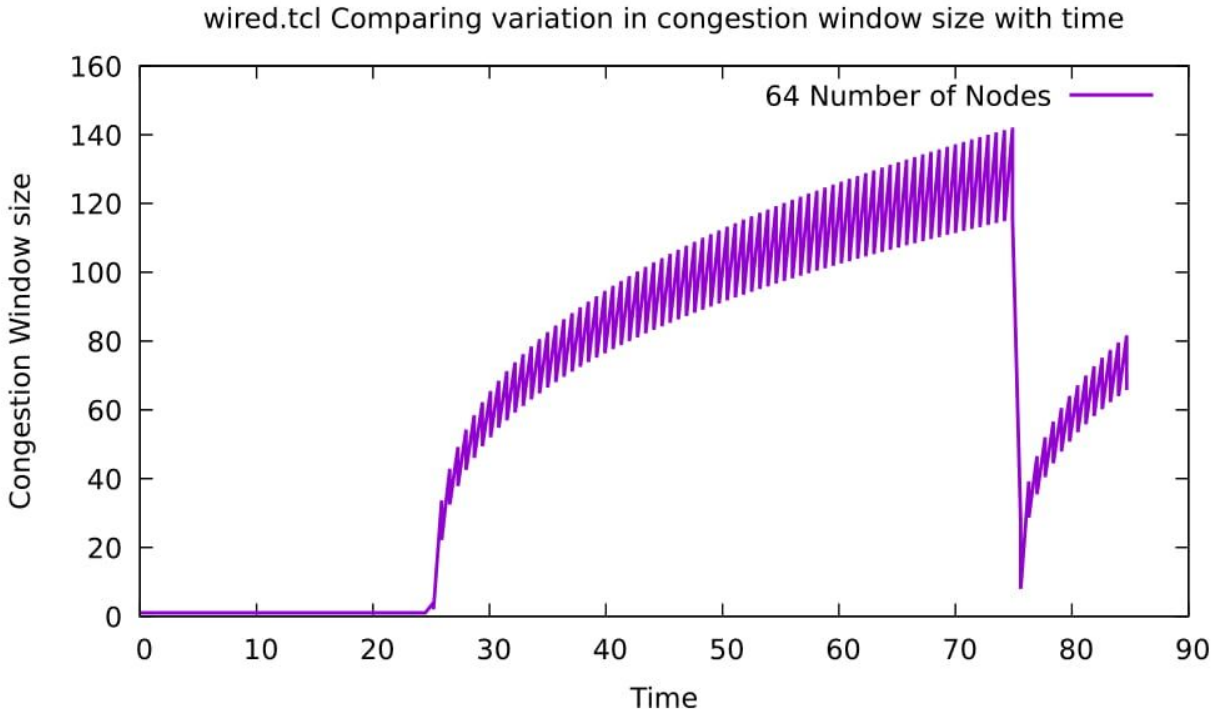


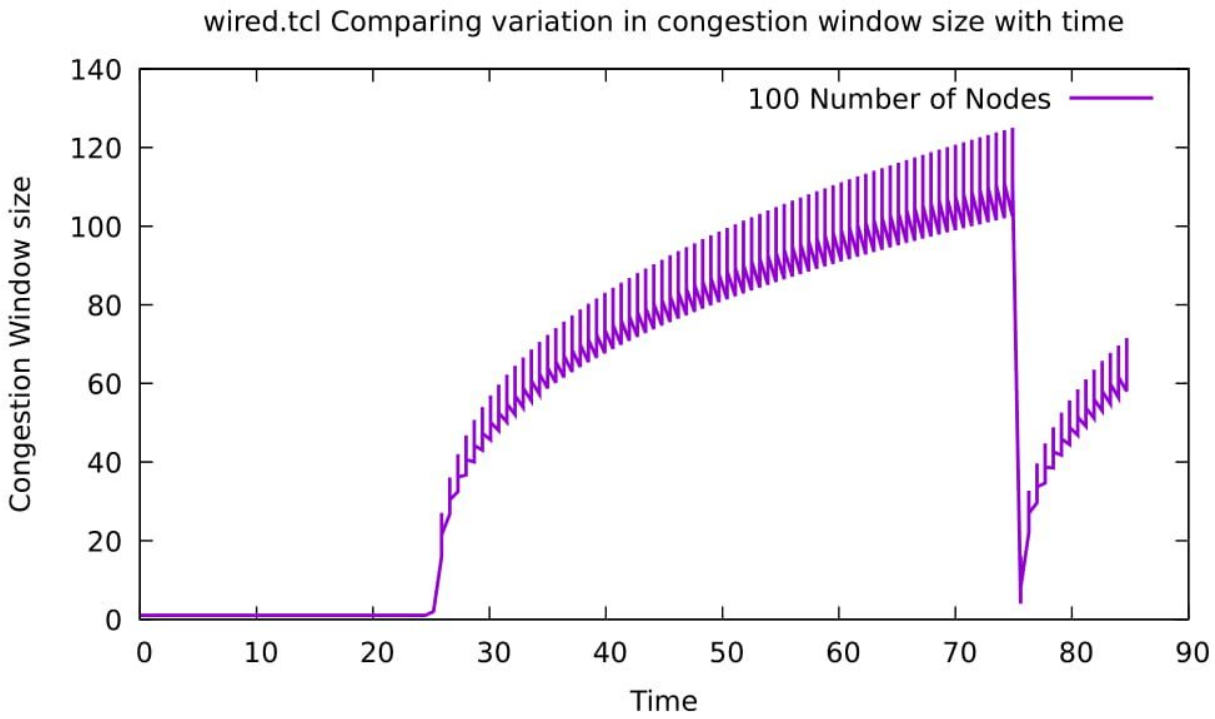
Wired :
Wired Connection consisting of n number of nodes in random topology.

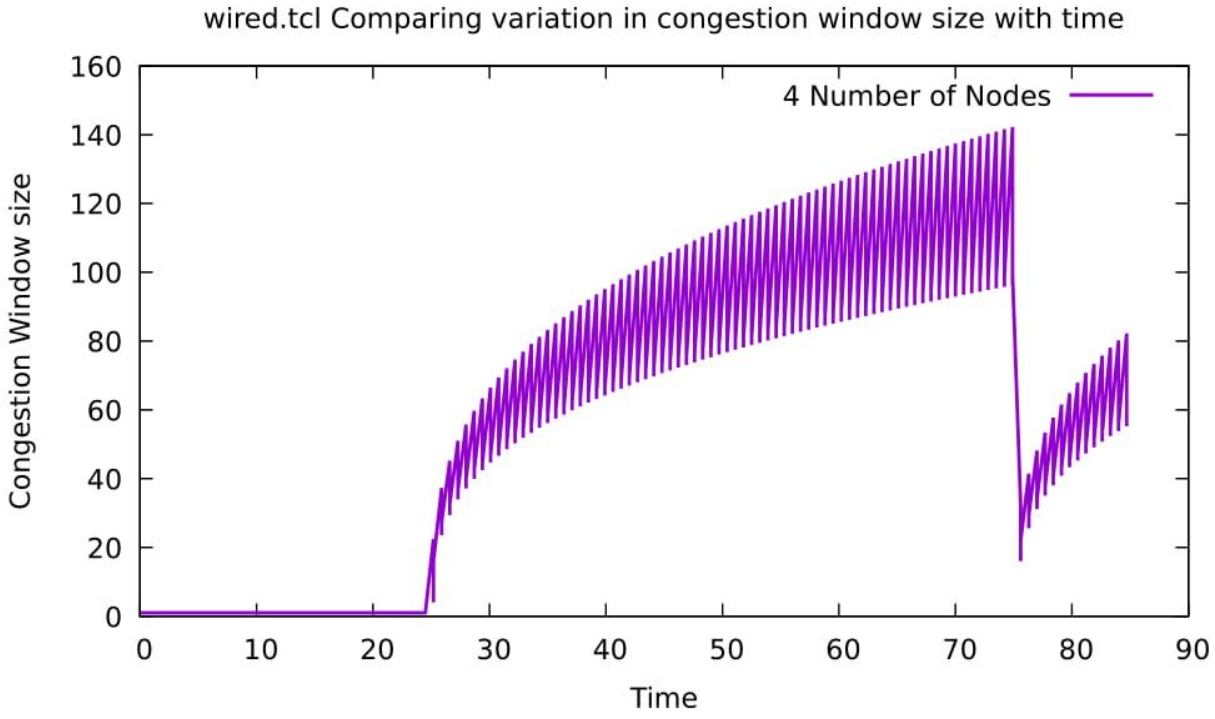


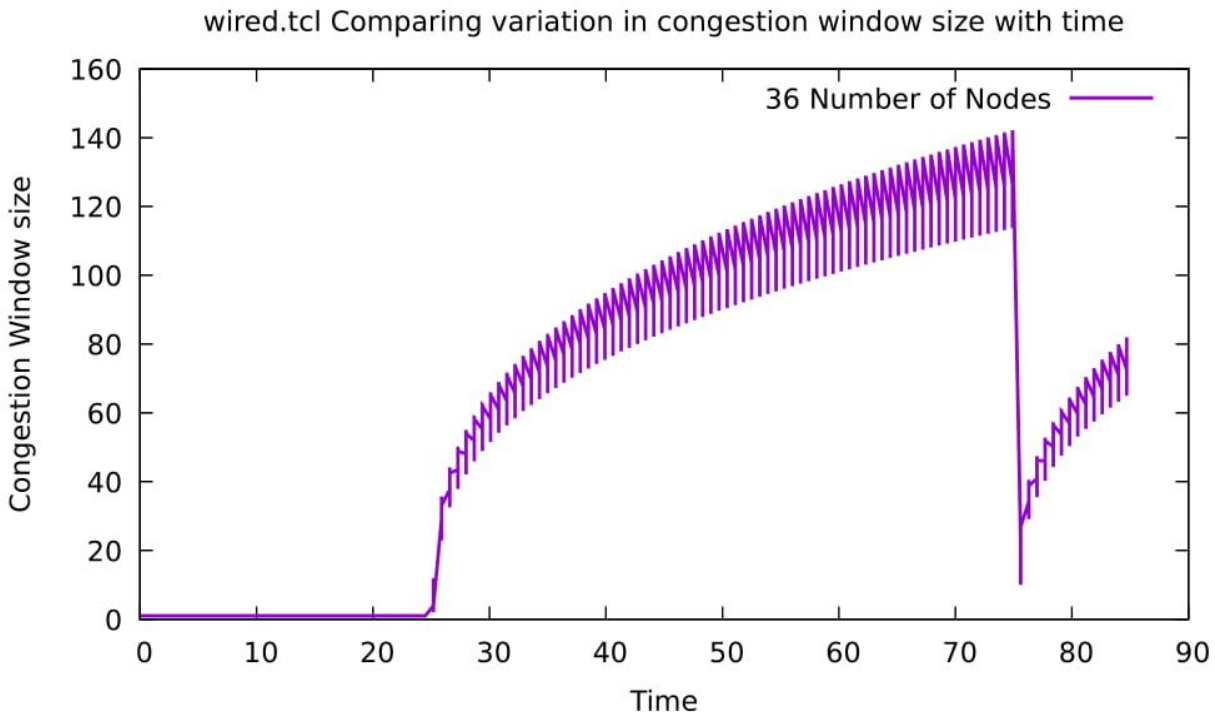


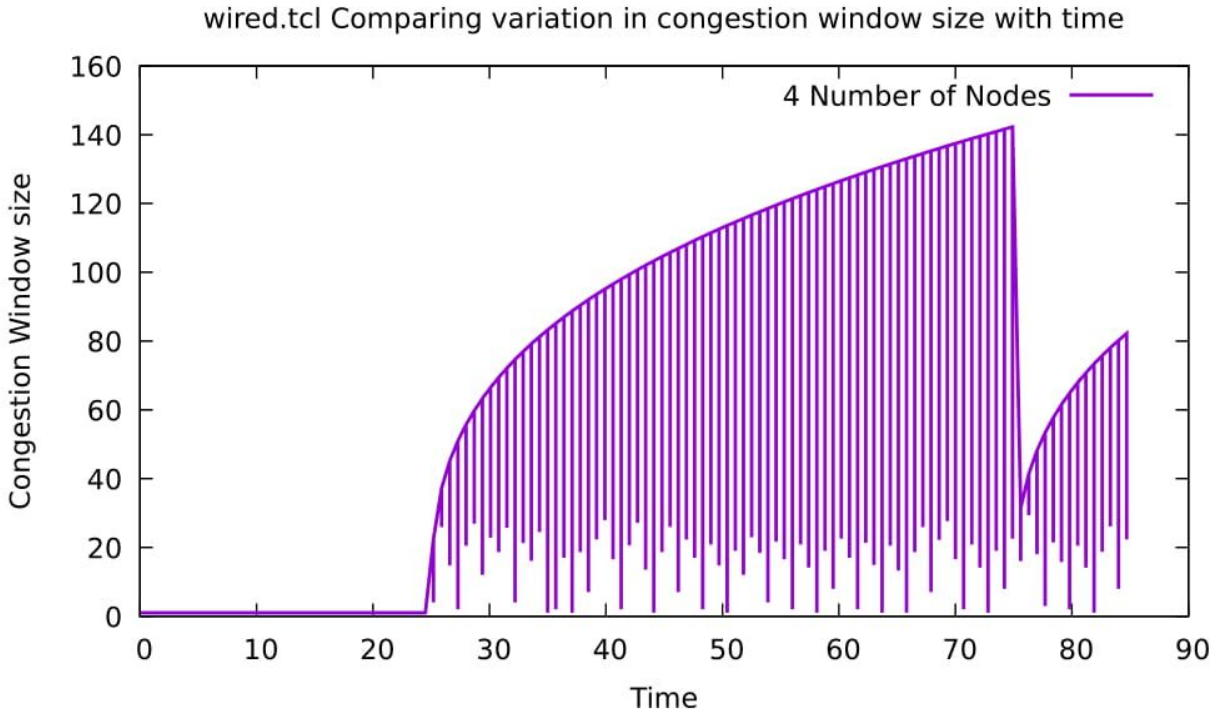

wired.tcl Comparing metrics with variation in Number of Nodes
Packet delivery Ratio
Packet delivery Ratio
99.88
99.86
99.84
99.82
99.8
99.78
99.76
99.74
0
10
20
30
40
50
60
70
80
90
100
Number of Nodes


wired.tcl Comparing variation in congestion window size with time
64 Number of Nodes
Congestion Window size
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
Time

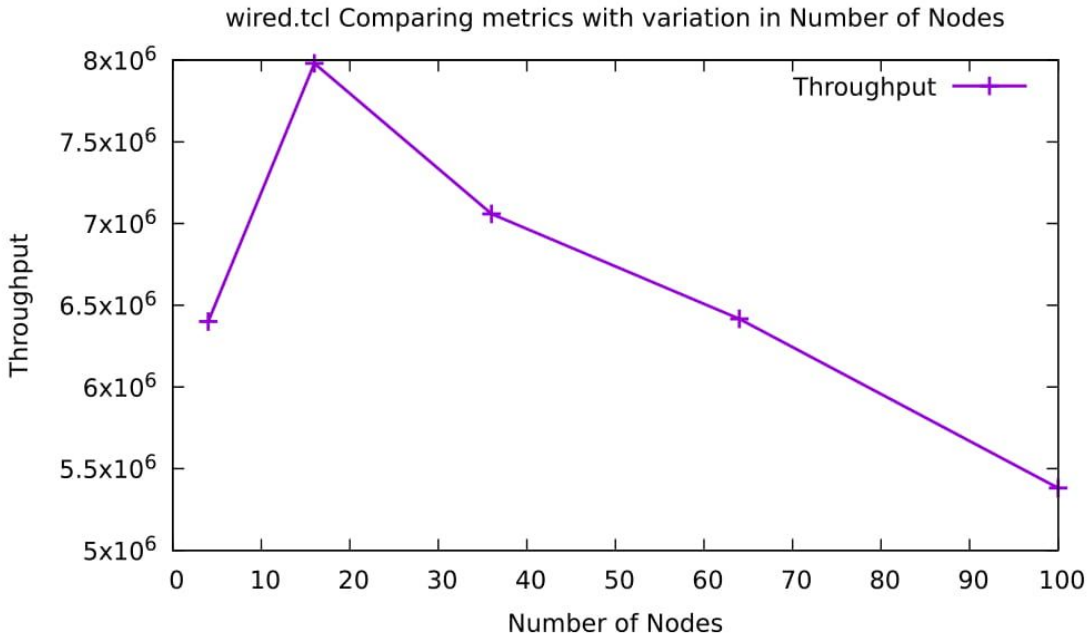

wired.tcl Comparing variation in congestion window size with time
100 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80
90

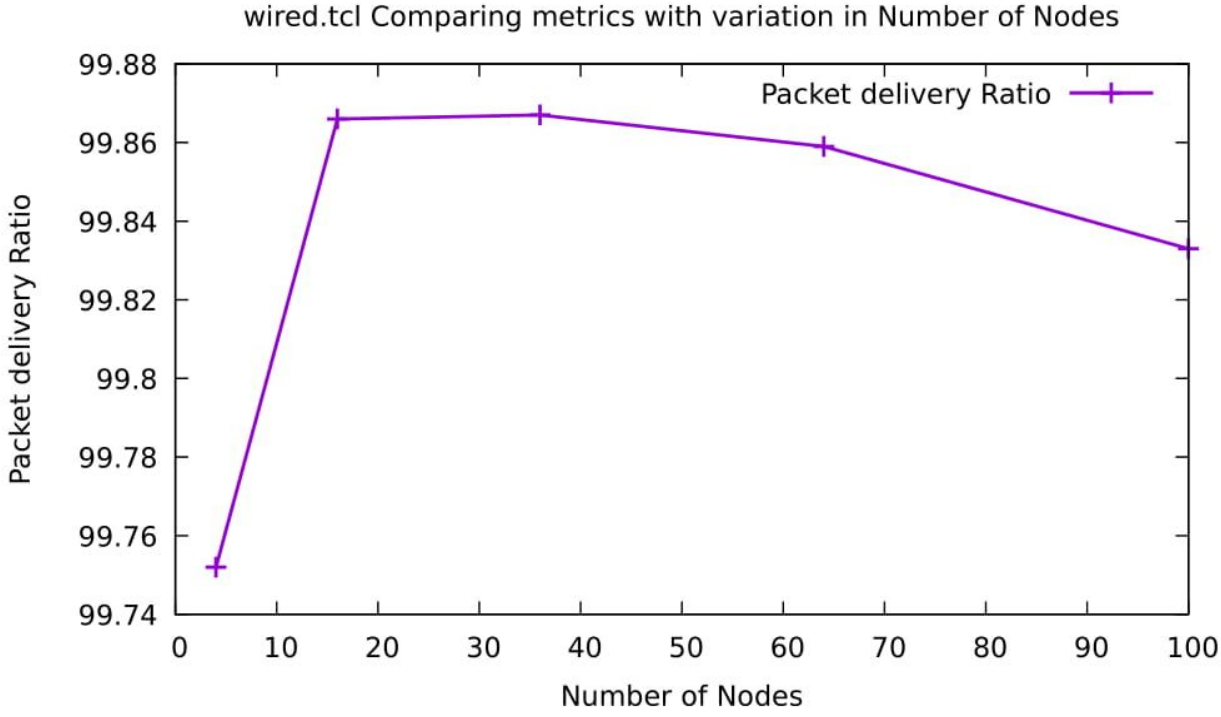

wired.tcl Comparing variation in congestion window size with time
4 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

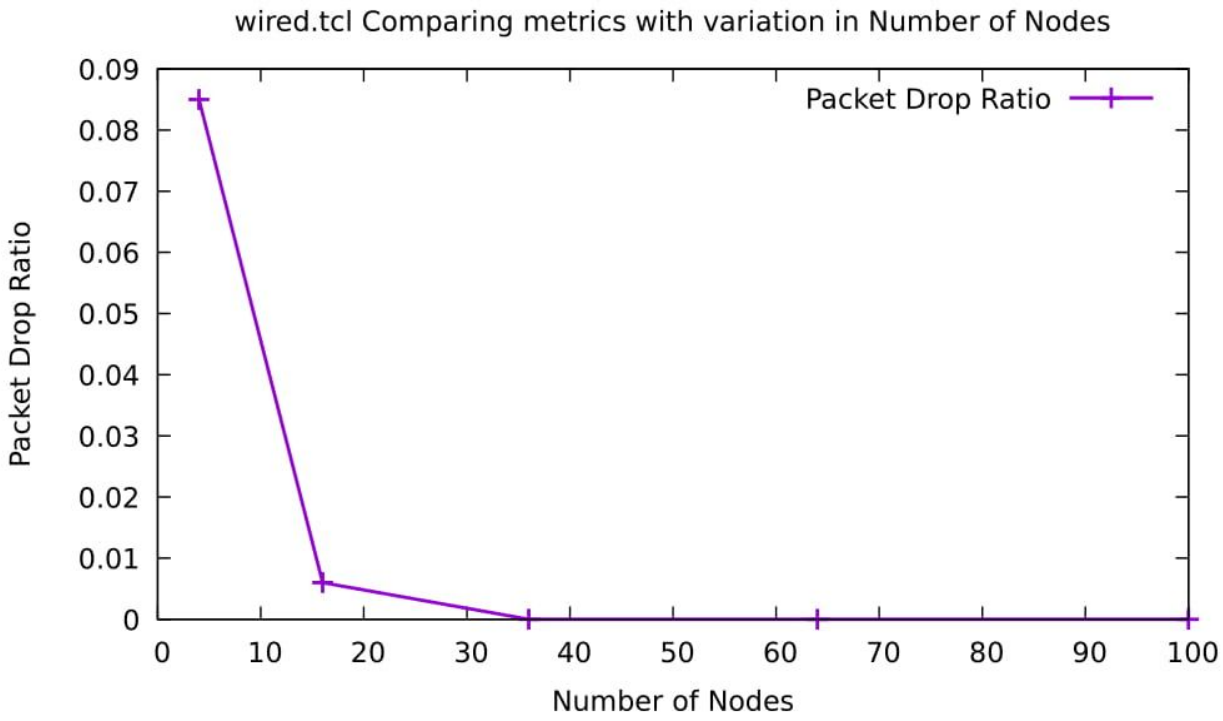

wired.tcl Comparing variation in congestion window size with time
36 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

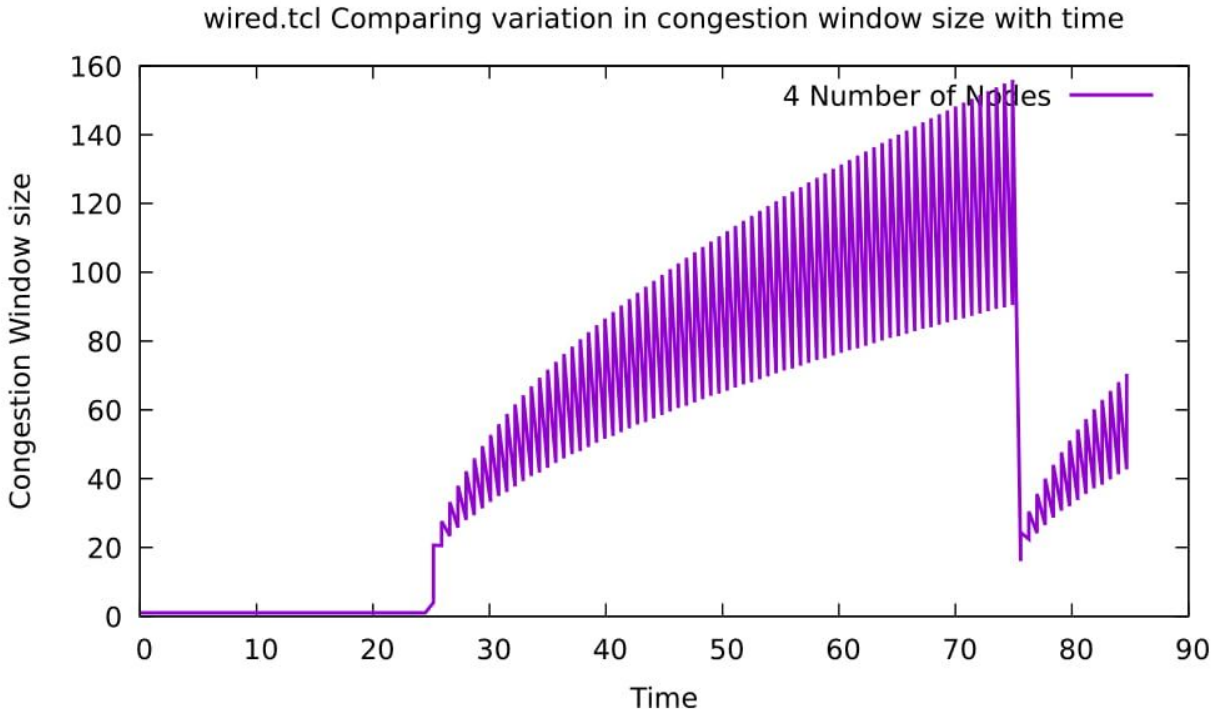

wired.tcl Comparing variation in congestion window size with time
4 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

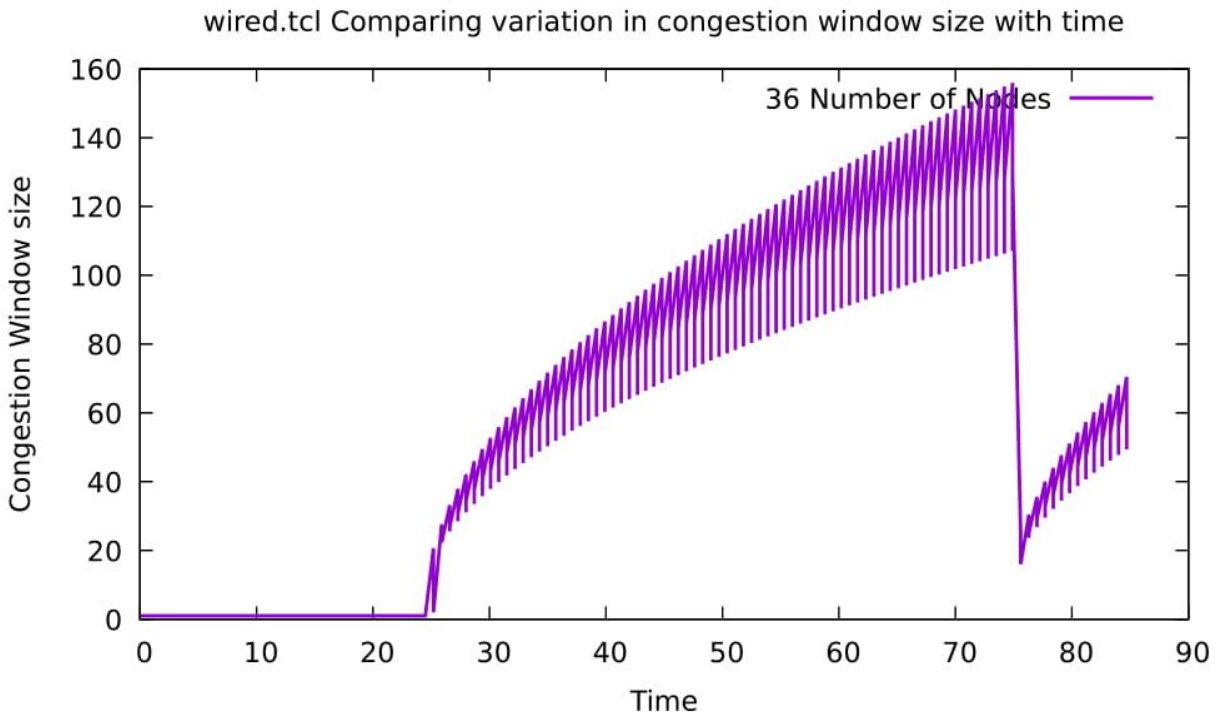
Modified

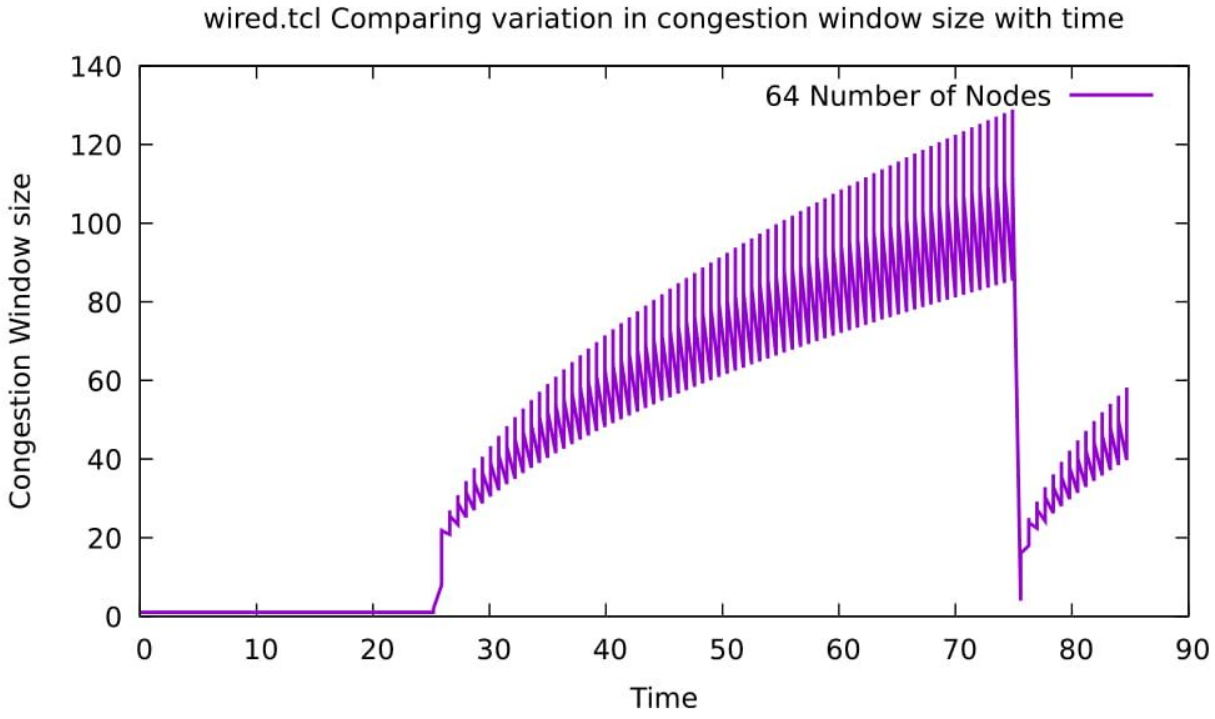

wired.tcl Comparing metrics with variation in Number of Nodes
Throughput
Number of Nodes
8x10^6
7.5x10^6
7x10^6
6.5x10^6
6x10^6
5.5x10^6
5x10^6
0
10
20
30
40
50
60
70
80
90
100

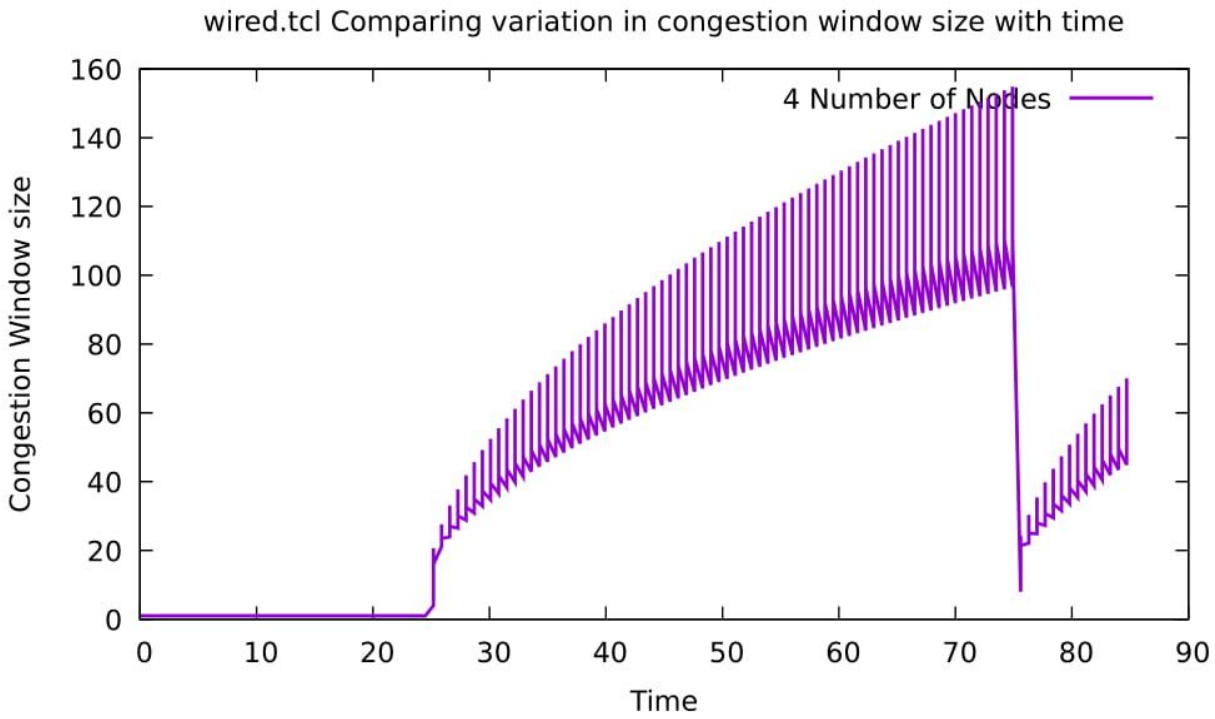

wired.tcl Comparing metrics with variation in Number of Nodes
Packet delivery Ratio
Number of Nodes
99.88
99.86
99.84
99.82
99.8
99.78
99.76
99.74
0
10
20
30
40
50
60
70
80
90
100

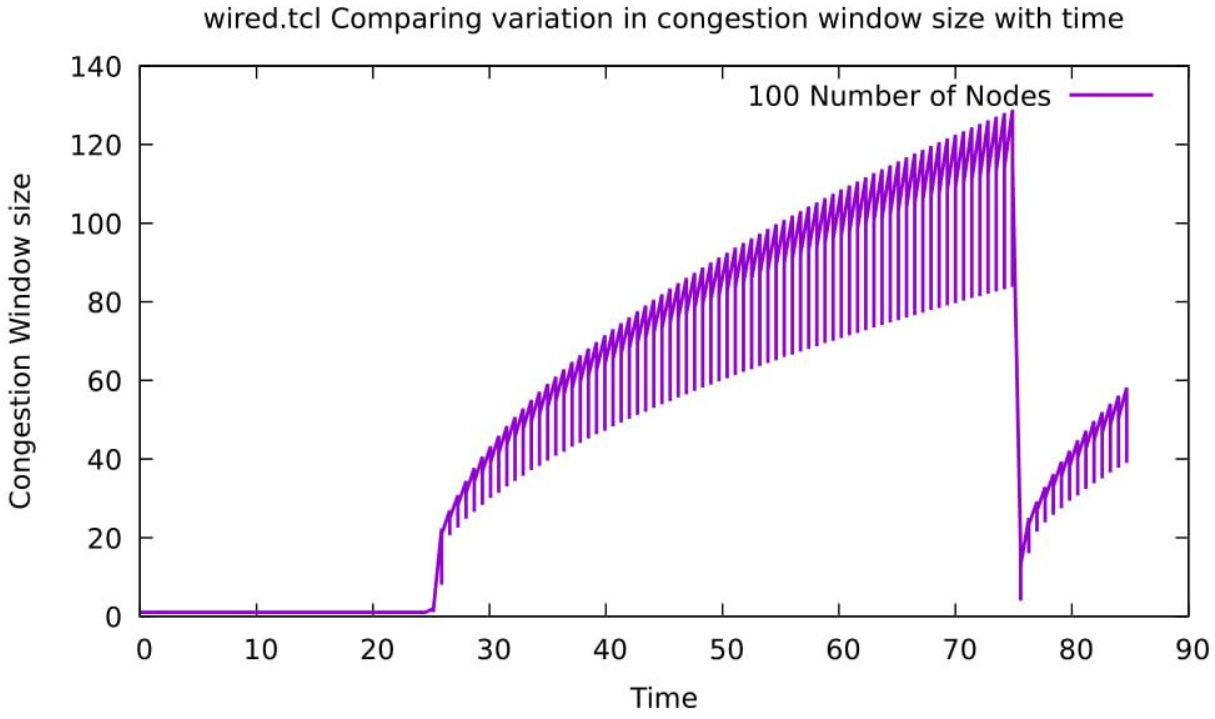

wired.tcl Comparing metrics with variation in Number of Nodes
Packet Drop Ratio
Packet Drop Ratio
0.09
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
0
10
20
30
40
50
60
70
80
90
100
Number of Nodes

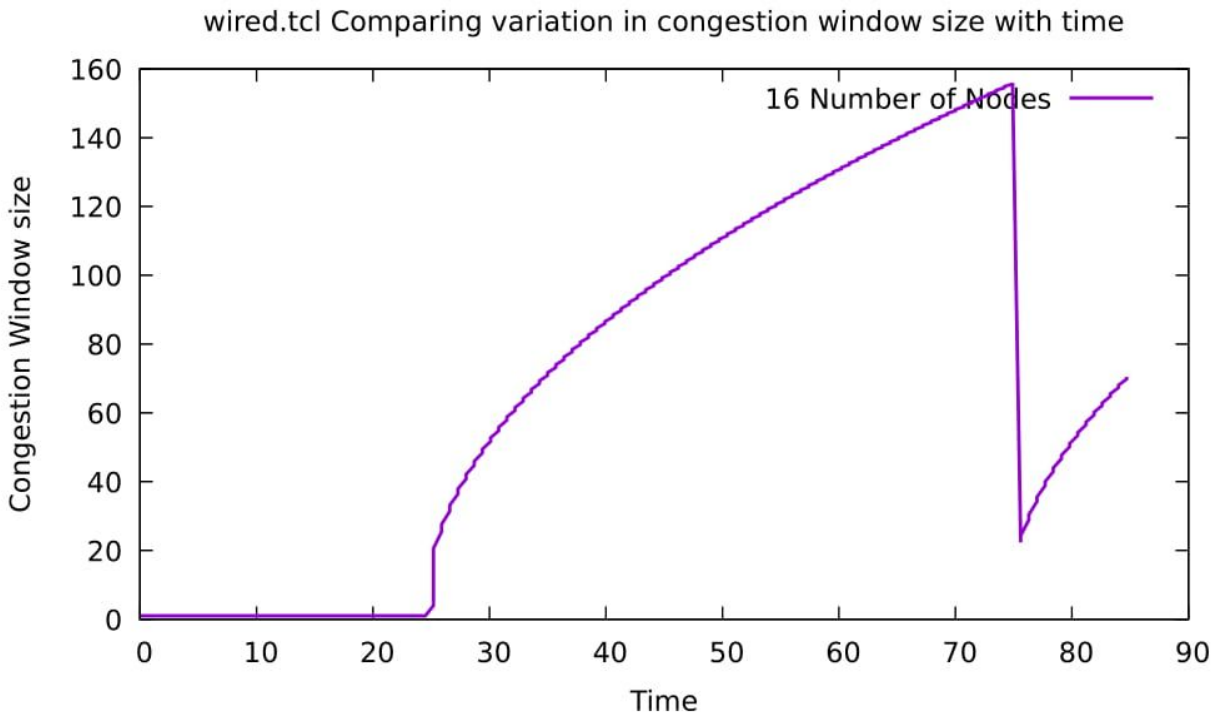

wired.tcl Comparing variation in congestion window size with time
Congestion Window size
4 Number of Nodes
160
140
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
Time

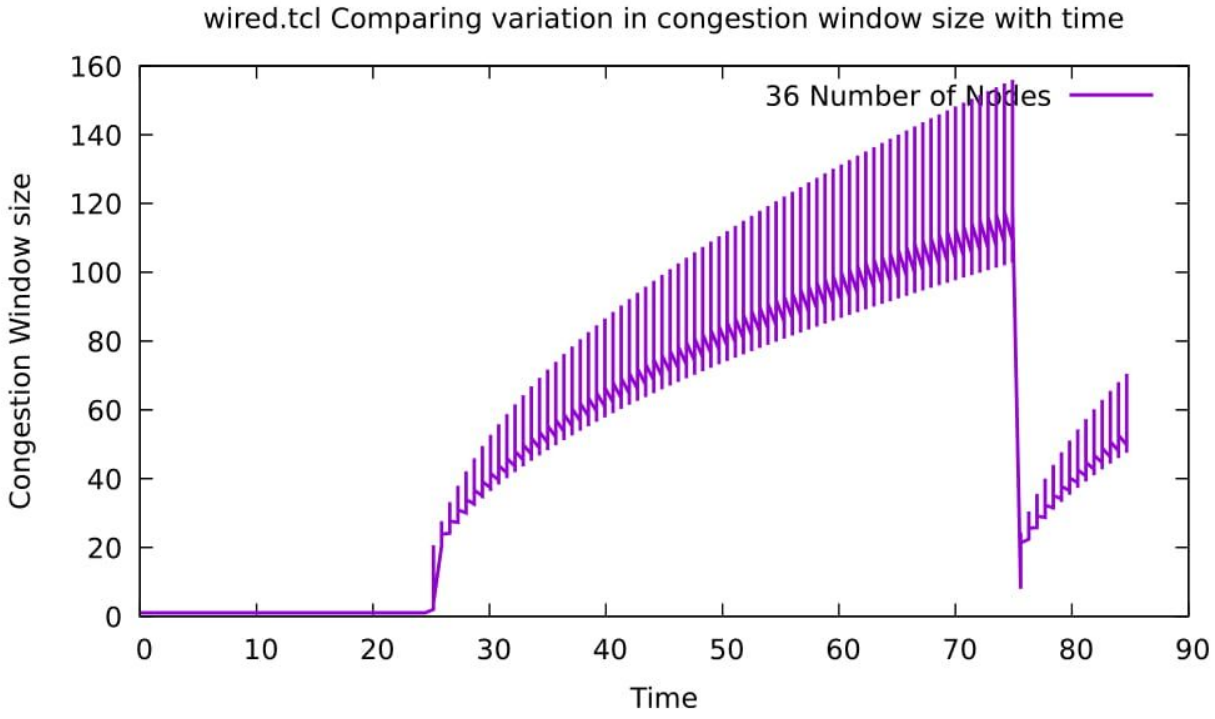

wired.tcl Comparing variation in congestion window size with time
36 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

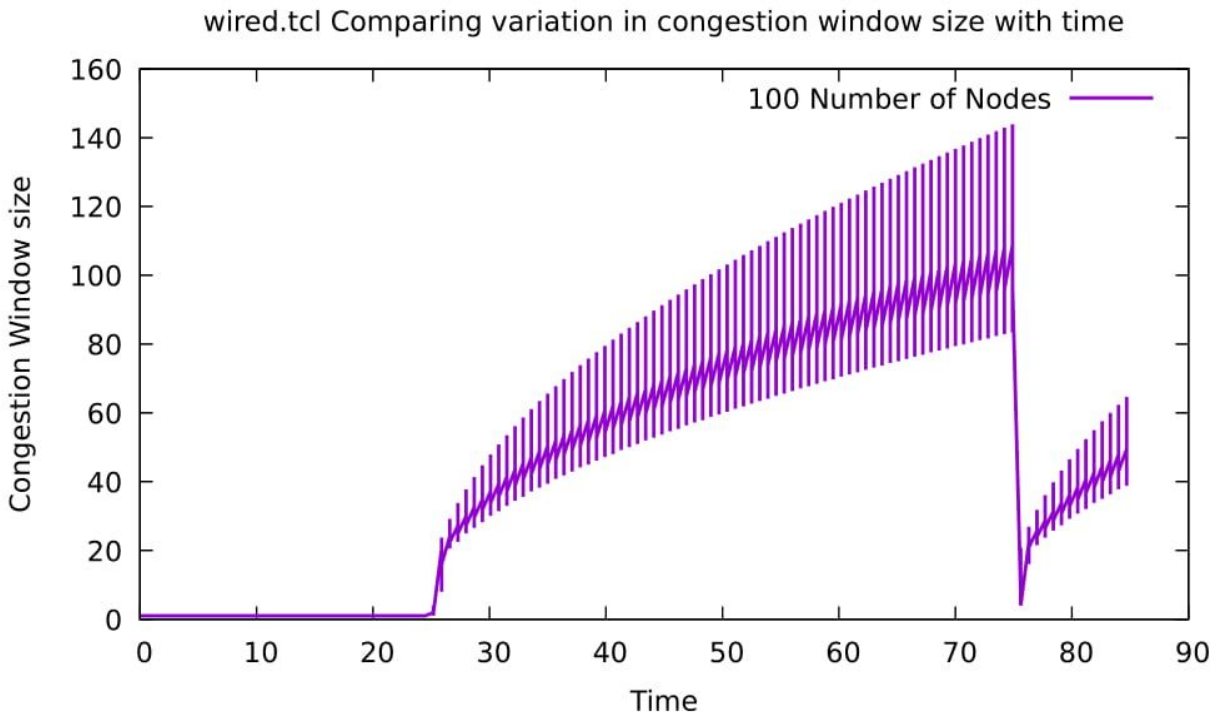

wired.tcl Comparing variation in congestion window size with time
64 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80
90

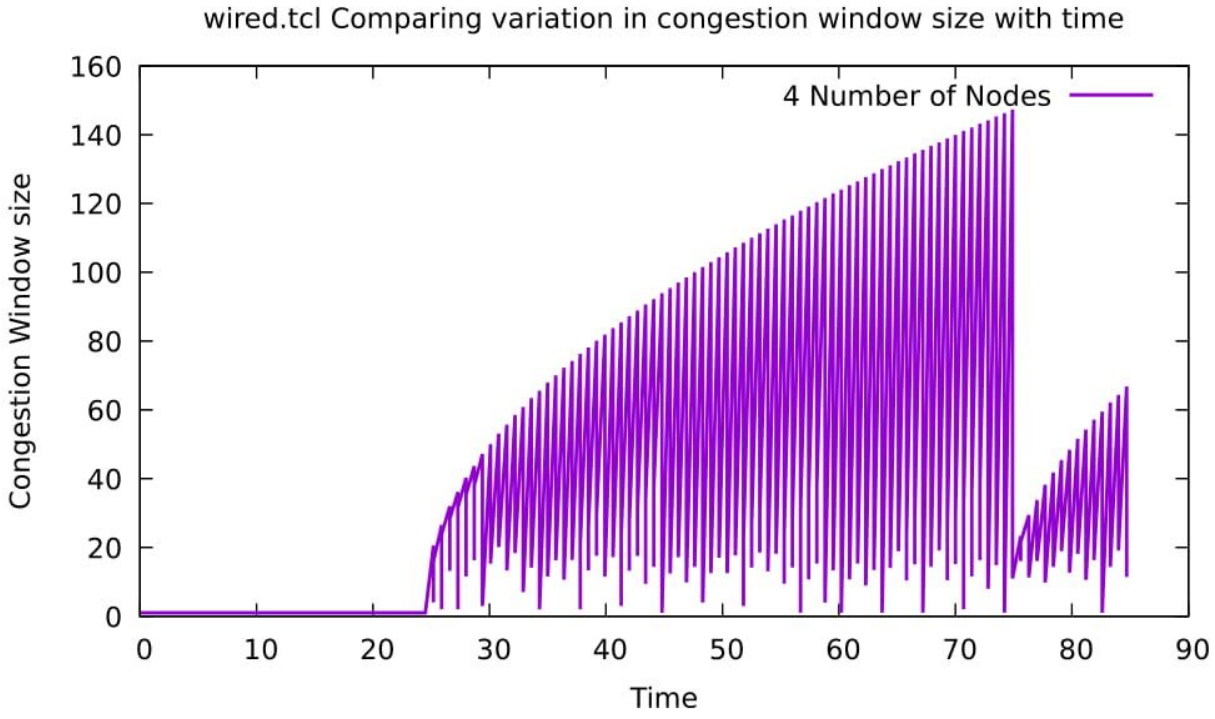

wired.tcl Comparing variation in congestion window size with time
4 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

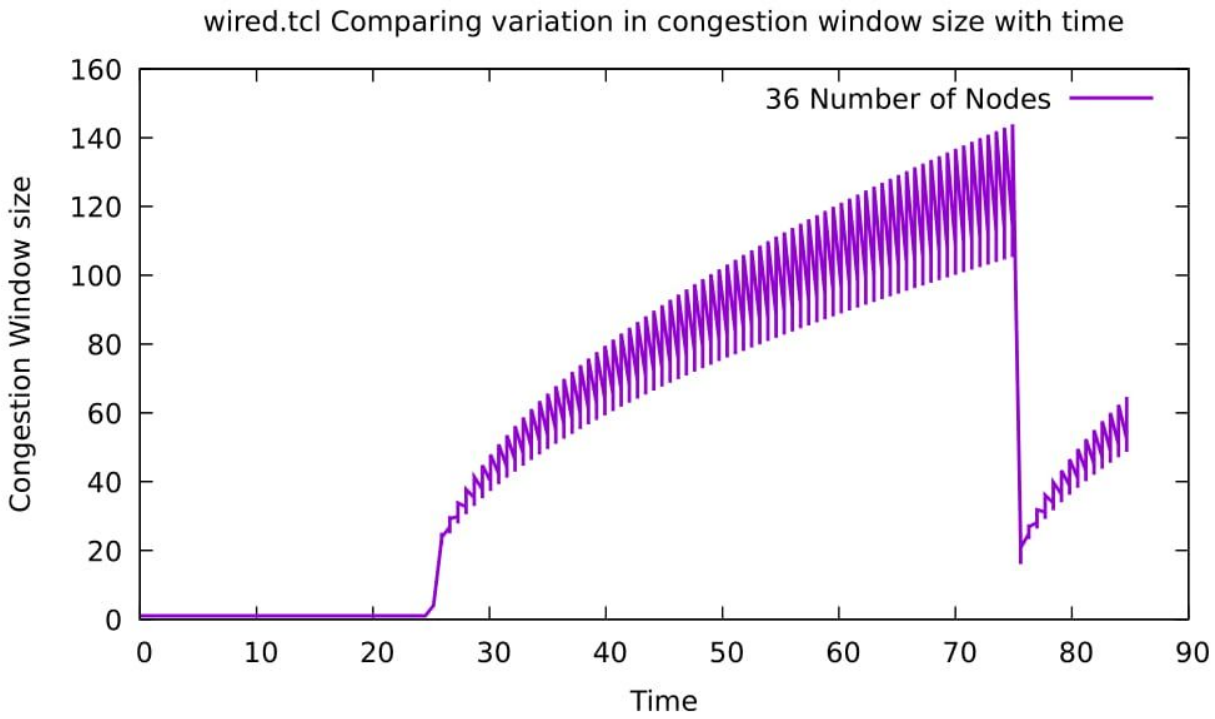

wired.tcl Comparing variation in congestion window size with time
100 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
0
10
20
30
40
50
60
70
80
90

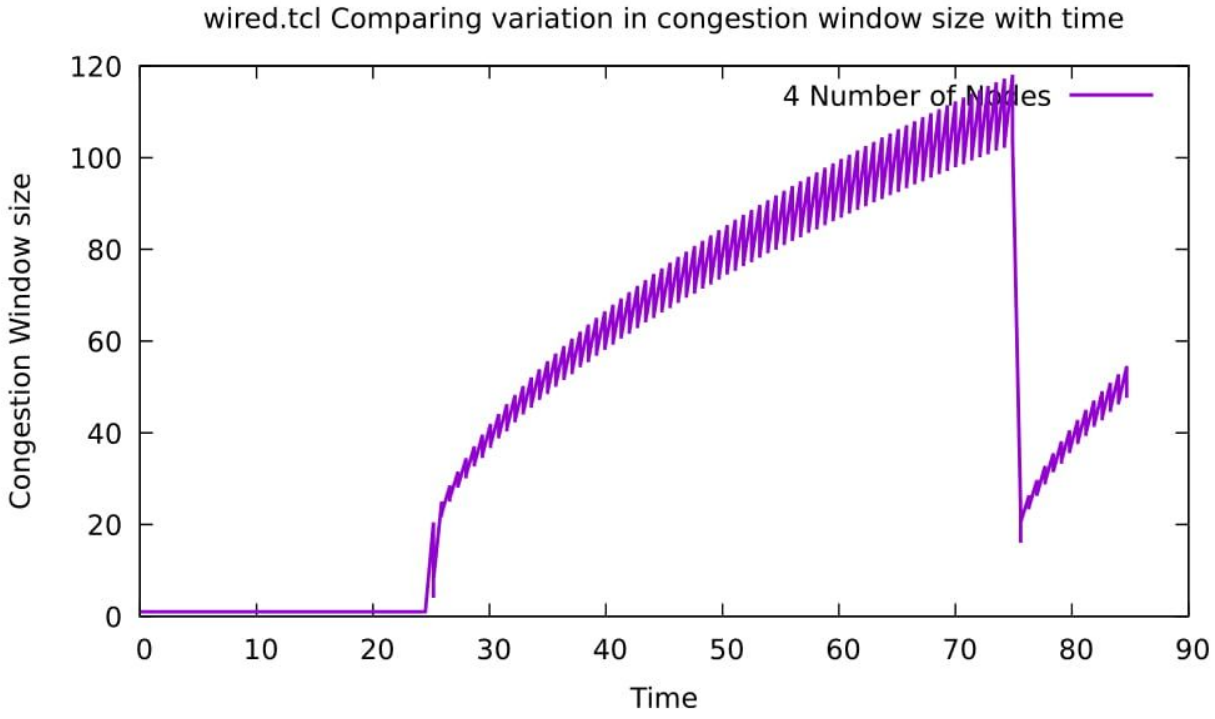

wired.tcl Comparing variation in congestion window size with time
16 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

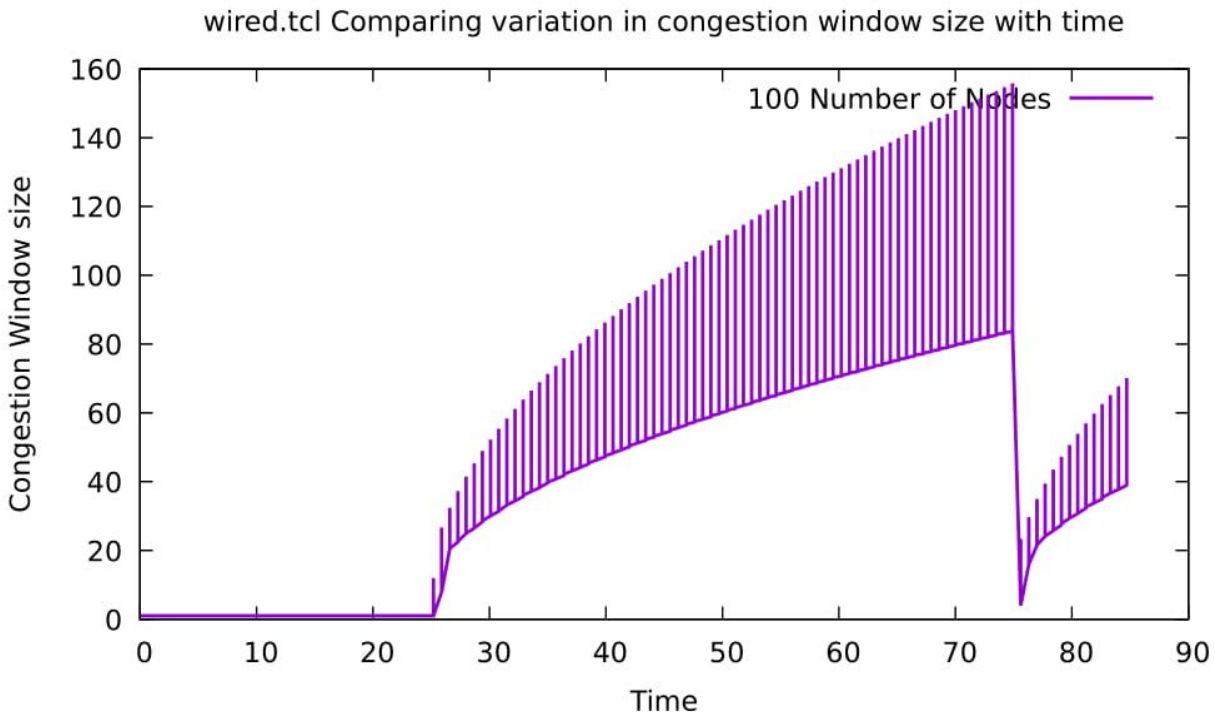

wired.tcl Comparing variation in congestion window size with time
36 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

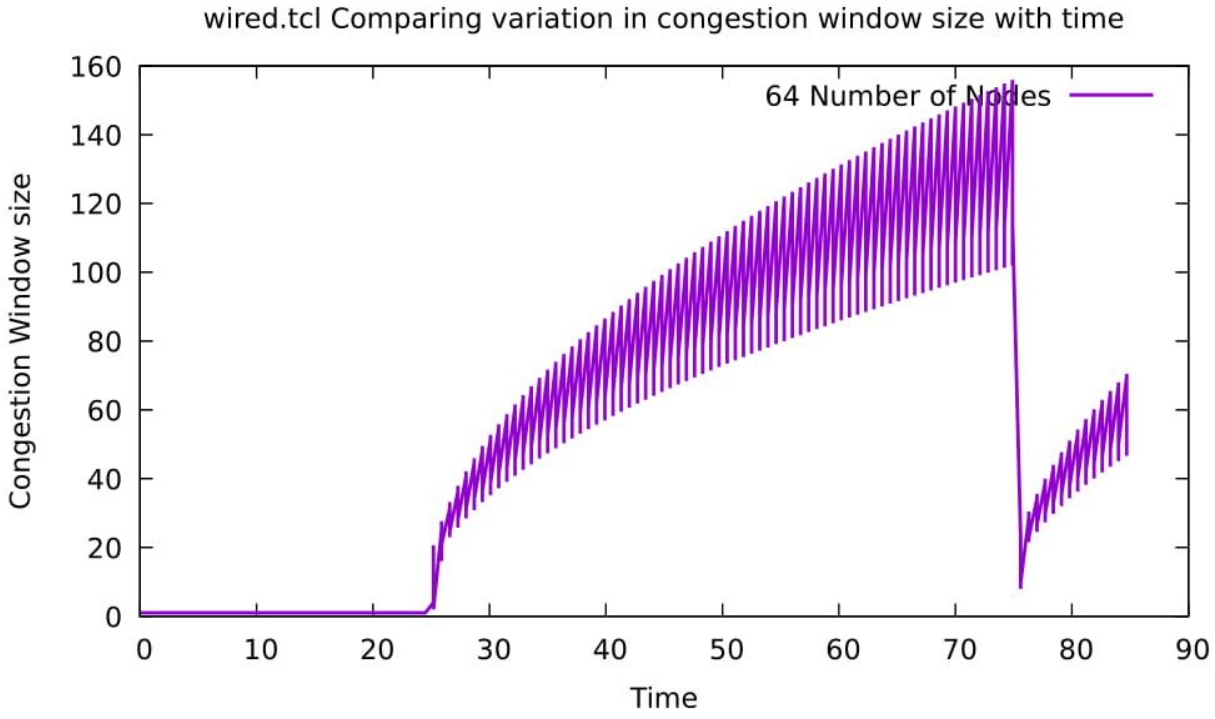

wired.tcl Comparing variation in congestion window size with time
100 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

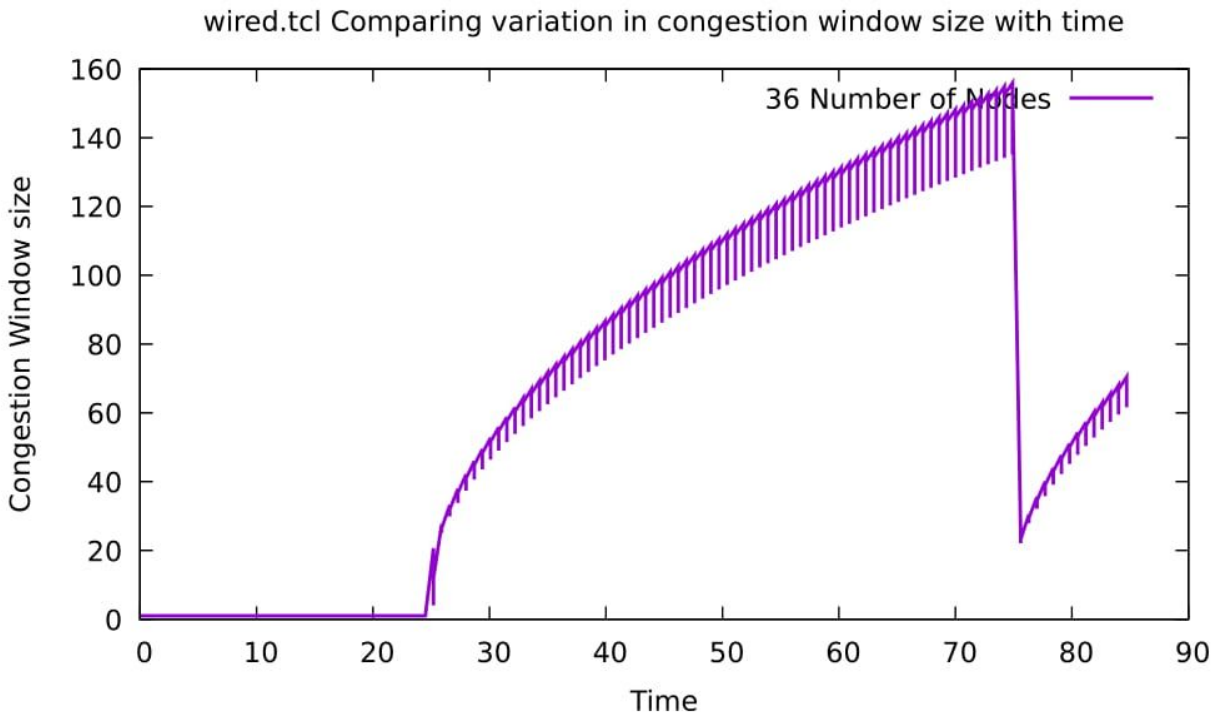

wired.tcl Comparing variation in congestion window size with time
4 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

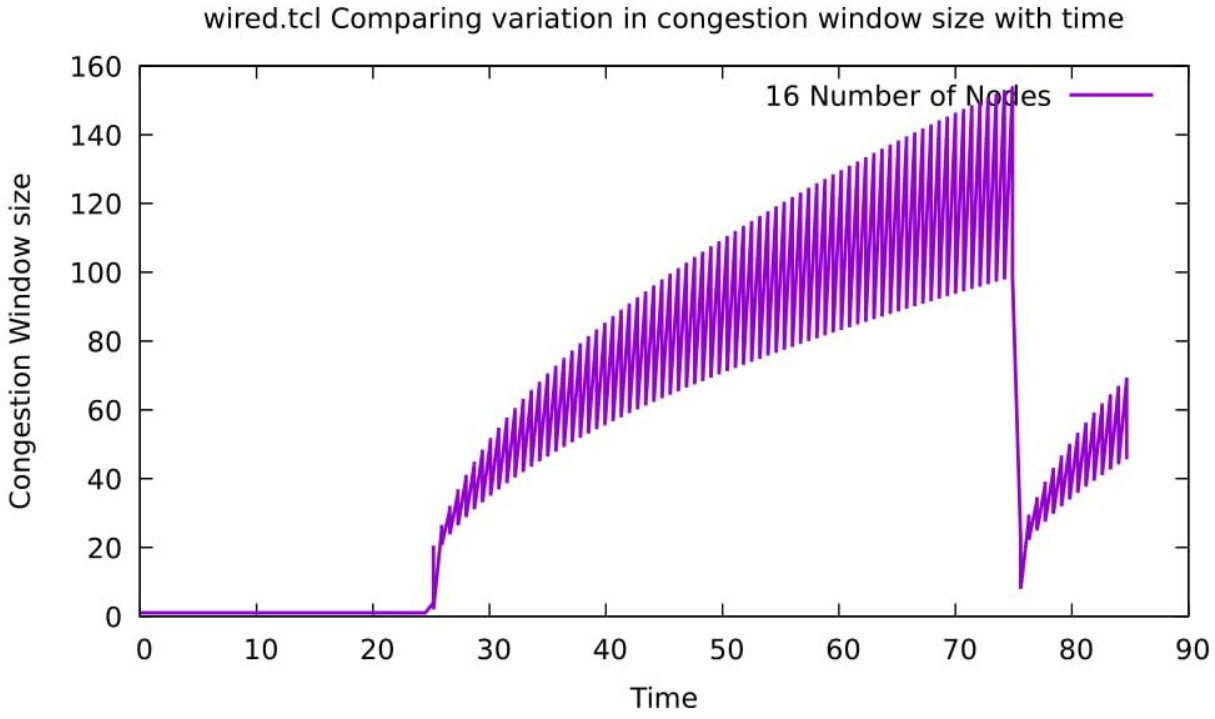

wired.tcl Comparing variation in congestion window size with time
36 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90


wired.tcl Comparing variation in congestion window size with time
4 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
0
10
20
30
40
50
60
70
80
90


wired.tcl Comparing variation in congestion window size with time
100 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90


wired.tcl Comparing variation in congestion window size with time
64 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90


wired.tcl Comparing variation in congestion window size with time
36 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90


wired.tcl Comparing variation in congestion window size with time
16 Number of Nodes
Congestion Window size
Time
0
20
40
60
80
100
120
140
160
0
10
20
30
40
50
60
70
80
90

Wired & wireless

A combination of wired and wireless nodes. No variation of parameters have been done unfortunately. 3 wireless nodes Communicate via base station to the other 3 wired nodes.
The tcl file ***wired_wireless.tcl*** contains the code. The awk file to be used is ***awk_tcp.awk***.
Parameters obtained from awk file:

```
Time:         90.00000
Throughput:    304238.22222
AverageDelay:       210.75369
SentPackets:          3967.00
ReceivedPackets:          3292.00
DropPackets:            19.00
PacketDeliveryRatio:       82.98
PacketDropRatio:       0.48
```

Summary :

- Congestion window vale cwnd_ has been plotted for every single iteration.
- The simulator is run for a total of 4 iterations for each variation, and and average value is taken to improve consistency.
- It can be seen from the cwnd_ plot that the modifications in the simulator improved congestion control.
- Also, the throughput has a slightly larger value for the modified one.

References :

[1] Implementation of New TCP Congestion Control Mechanism over Long Term Evolution Advanced Networks
https://www.academia.edu/20743570/Implementation_of_New_TCP_Congestion_Control_Mechanism_over_Long_Term_Evolution_Advanced_Netwo

rks?fbclid=IwAR1DwoTvg2wPSo3RBUlKl6cmfdzIjzjAObUClxmAPB-emq9cts_QfkhhrYo

[2] The Effects of Using Change Detection Algorithms in Estimation of the Average RTT
http://www.satnac.org.za/proceedings/2004/ModellingSimulation/No%2068%20-%20Ngwenya.pdf

[3] Wimax Patch
https://drive.google.com/file/d/0B7S255p3kFXNOWtxUnJhY094c0k/view