Comparison of RED vs. DropTail Queuing

Project 2

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The Topology

A ten node topology was constructed to simulate the DropTail and RED queues using ns-3. The connected nodes are shown below. Additionally, each link's bandwidth is shown below along with each link's delay time using a multiplier, *X*, for varying the RTT across simulation runs.

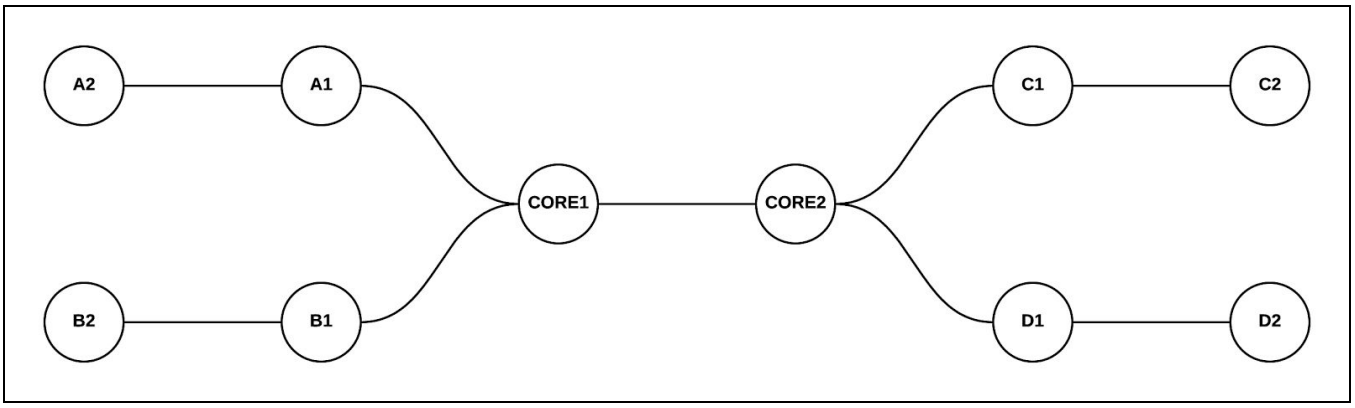


Figure 1. The connected topology shown with each node labeled.

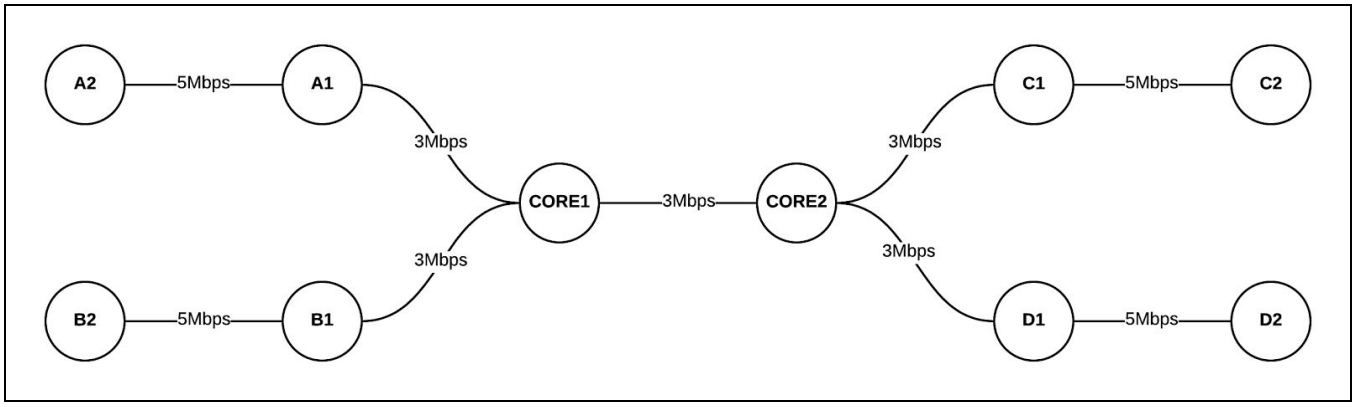


Figure 2. The link bandwidths for the topology.

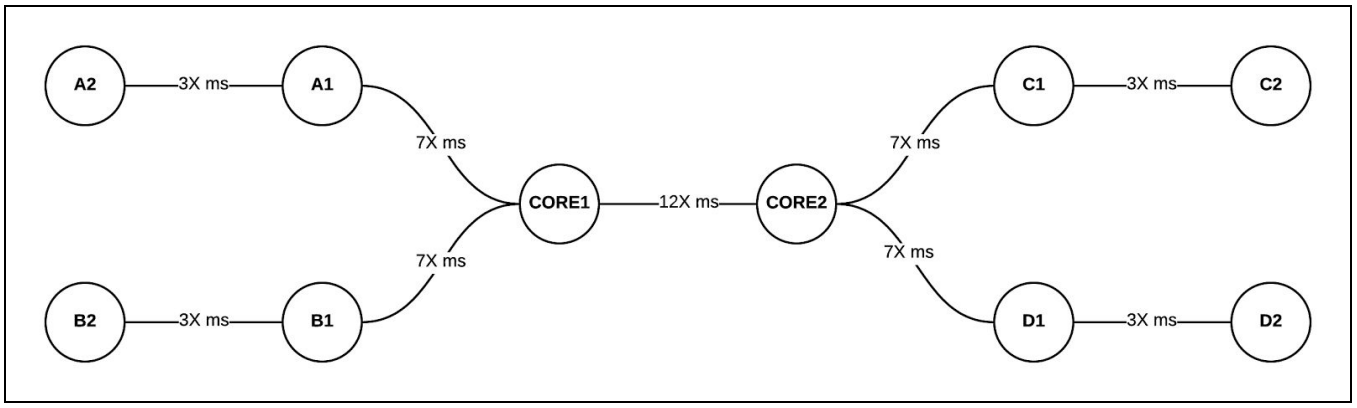


Figure 3. The delay times for each link, where *X* is in integer multiplier for varying the RTT for a simulation run.

From observing figure 3, we can see that the total RTT time from node A2 to either node C2 or D2 is 32*X*. For the scope of this project, the variable *X* was set to either 1, 2, 3, or 4 - giving RTTs of 64ms, 128ms, 256ms, and 512ms respectively.

To simulate this topology, three data flows were used for generating traffic. In the diagram below, *Flow 1* and *Flow 3* consist of UDP traffic, while *Flow 2* consists of TCP traffic. These flows ensure coverage in testing a bottleneck link, while adding additional traffic to the rightmost links for seeing how an upstream flow affects the results.

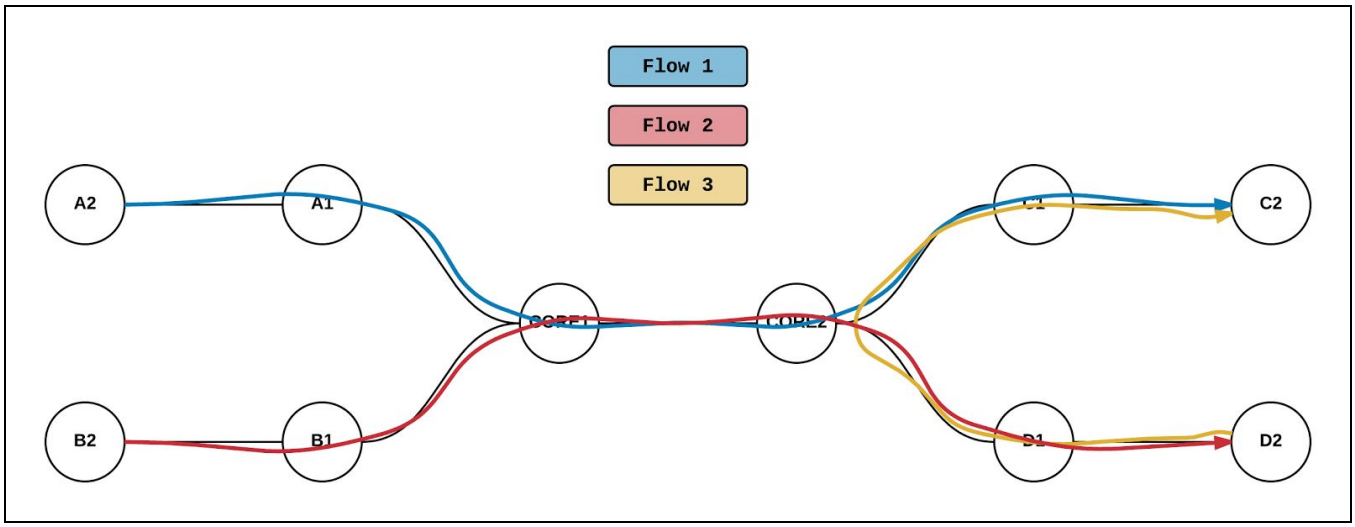


Figure 4. The TCP and UDP traffic flows.

The data rate for the generated flows was set using a method like that of the RTTs. For *Flow 1* and *Flow 2*, the data rate was set to 0.58*X*, while the data rate for *Flow 3* was set to 0.33*X*. The variable *X* was set to either 1, 2, or 3 - giving data rates of 0.58Mbps/0.33Mbps, 1.16Mbps/0.66Mbps, and 1.74Mbps/0.99Mbps respectively. This simulates the topology for medium, high, and overload traffic conditions.

Topology Verification

To verify that our topology was correctly constructed, we plot Packets/s vs. Time and Errors/s vs. Time from a trivial set of inputs in the two figures below. We can see that the packet rate is slightly higher for the DropTail queue, and we can also see that more errors are indicated for the RED queue. This is what we expect, so it is reasonable to say the topology is properly constructed.

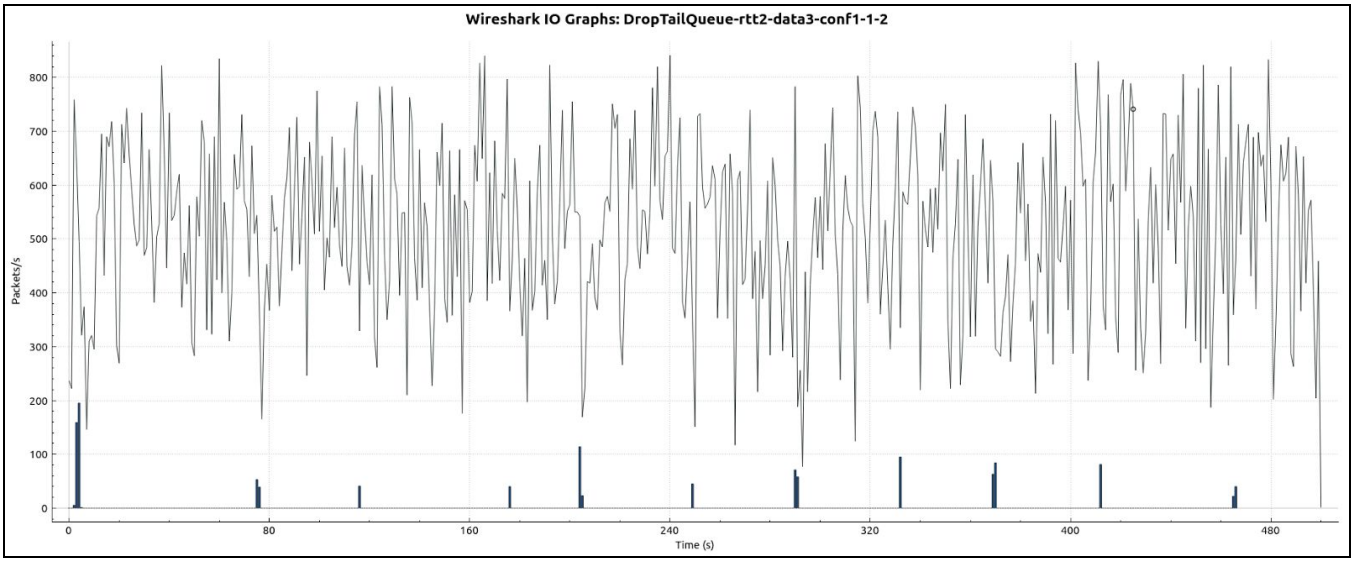


Figure 5. The IO graph when using a DropTail queue.

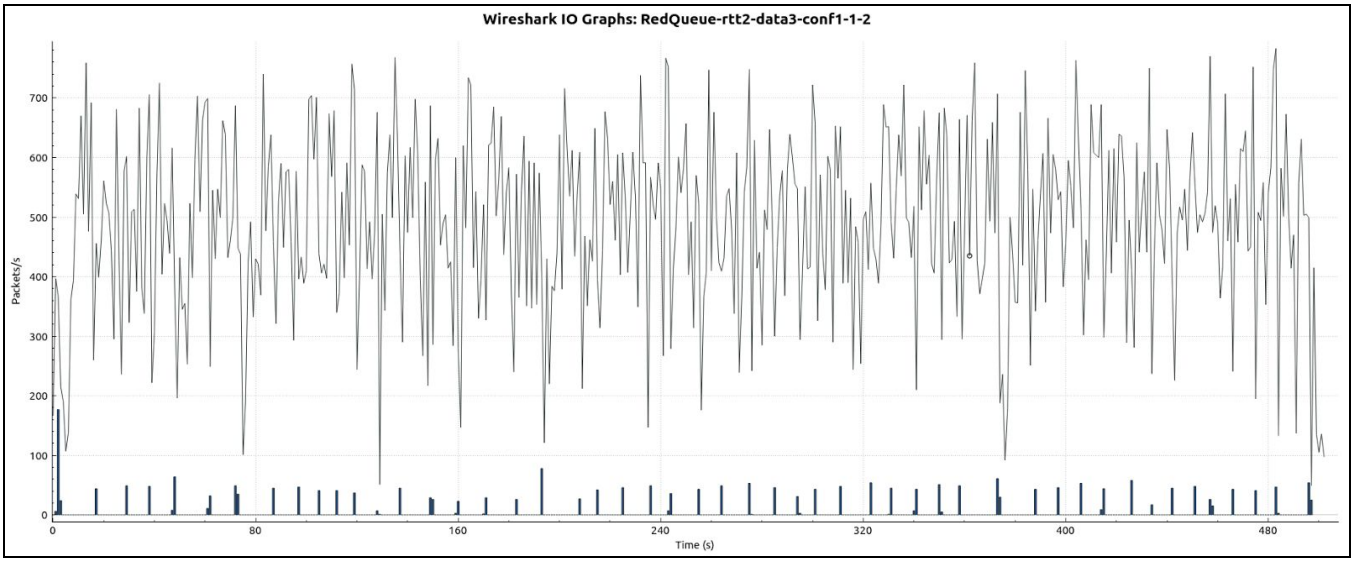


Figure 6. The IO graph when using a RED queue.

Running The Simulations

Along with the RTTs and data rates specified near the end of the first section, the queue parameters were divided into three configuration sets. Each set consists of an XML file defining either DropTail or RED queue parameters. When launching a simulation, the XML file is passed in as a parameter and its contents is used to configure the queues. The type of queue that gets used during simulation is an additional parameter that is given to the program - outside the scope of the XML configuration files.

These three configuration sets are referenced in the subtitle of each result set. Below, an overview of each configuration is shown. TCP Tahoe was used for all simulations.

- *ns3-config1.xml*
  - TcpSocketBase::MaxWindowSize: `64000`
  - DropTailQueue::MaxPackets: `100`
  - RedQueue::MeanPktSize: `400`
  - RedQueue::MinTh: `5`
  - RedQueue::MaxTh: `15`
  - RedQueue::QueueLimit: `25`
  - RedQueue::QW: `0.002`
  - RedQueue::LinkBandwidth: `1.5Mbps`

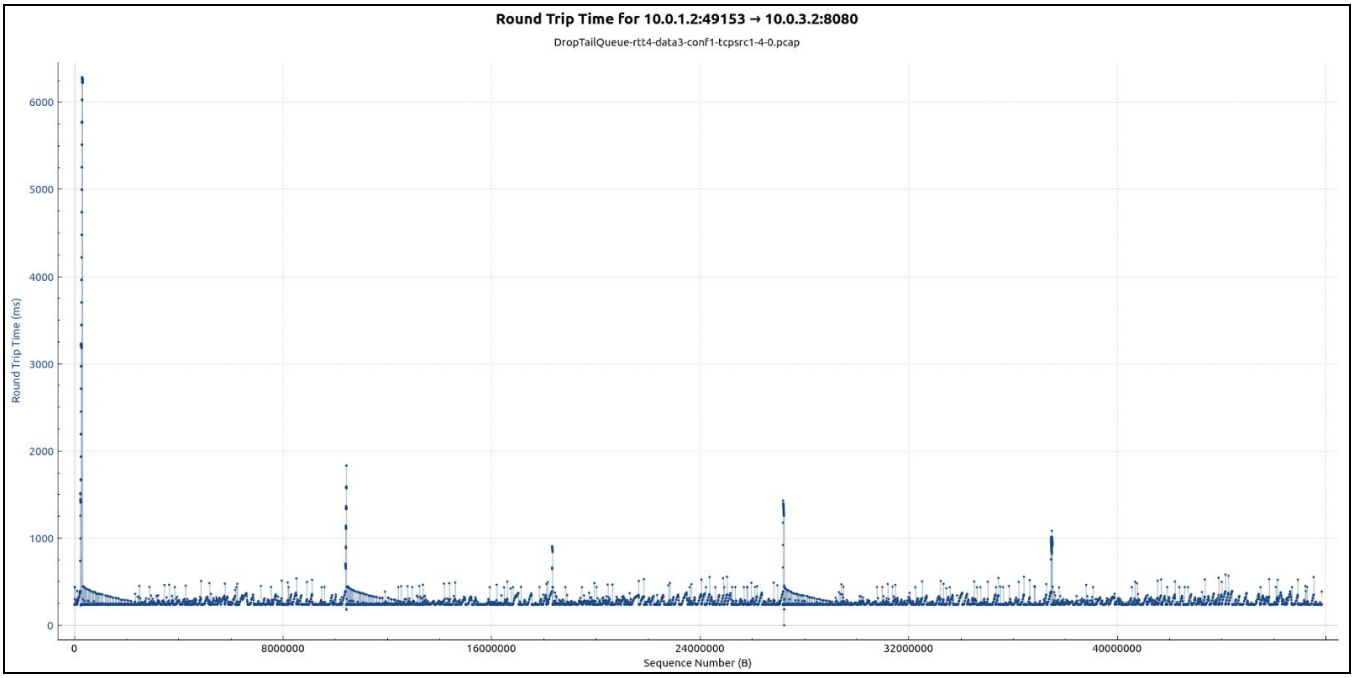
- *ns3-config2.xml*
  - TcpSocketBase::MaxWindowSize: `64000`
  - DropTailQueue::MaxPackets: `50`
  - RedQueue::MeanPktSize: `500`
  - RedQueue::MinTh: `2`
  - RedQueue::MaxTh: `10`
  - RedQueue::QueueLimit: `20`
  - RedQueue::QW: `0.002`
  - RedQueue::LinkBandwidth: `1.5Mbps`

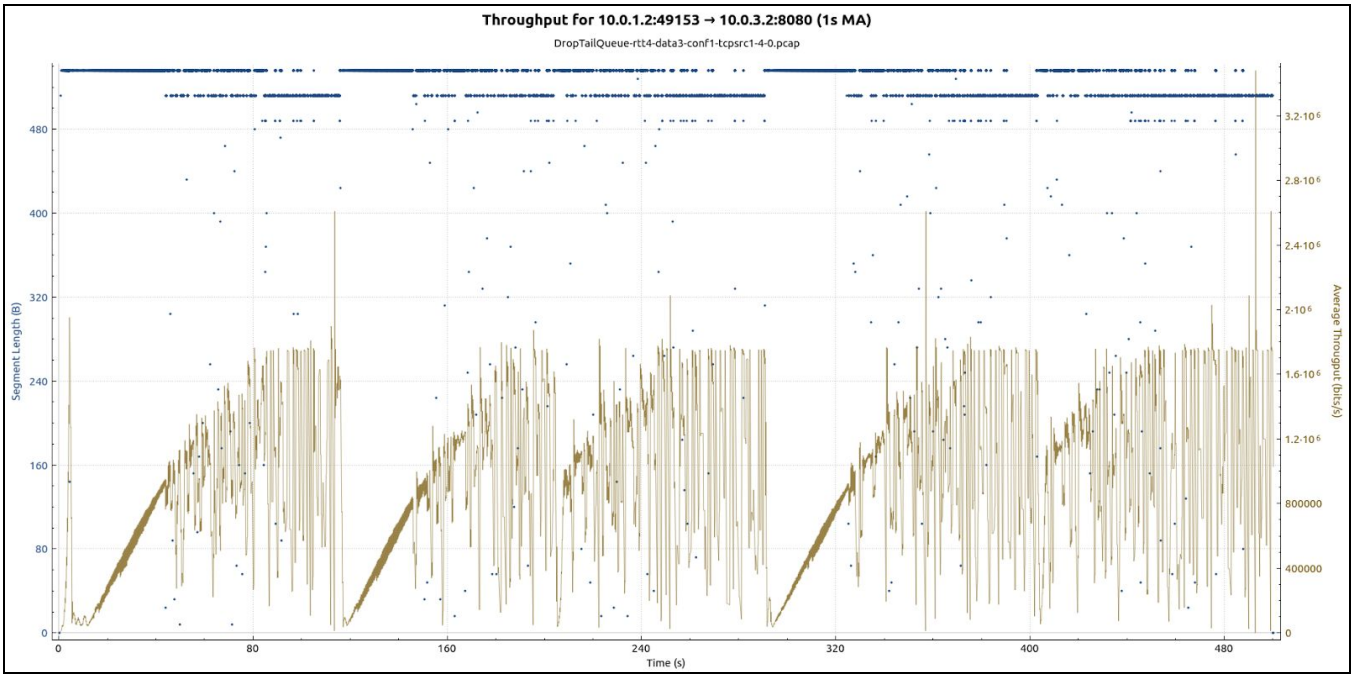
- *ns3-config3.xml*
  - TcpSocketBase::MaxWindowSize: `32000`
  - DropTailQueue::MaxPackets: `150`
  - RedQueue::MeanPktSize: `500`
  - RedQueue::MinTh: `10`
  - RedQueue::MaxTh: `18`
  - RedQueue::QueueLimit: `30`
  - RedQueue::QW: `0.004`
  - RedQueue::LinkBandwidth: `2Mbps`

Results

Each simulation was run for 500 seconds. Notable observations and analysis are in this section.

Traffic 3, RTT 4, Config 1, DropTail Queue

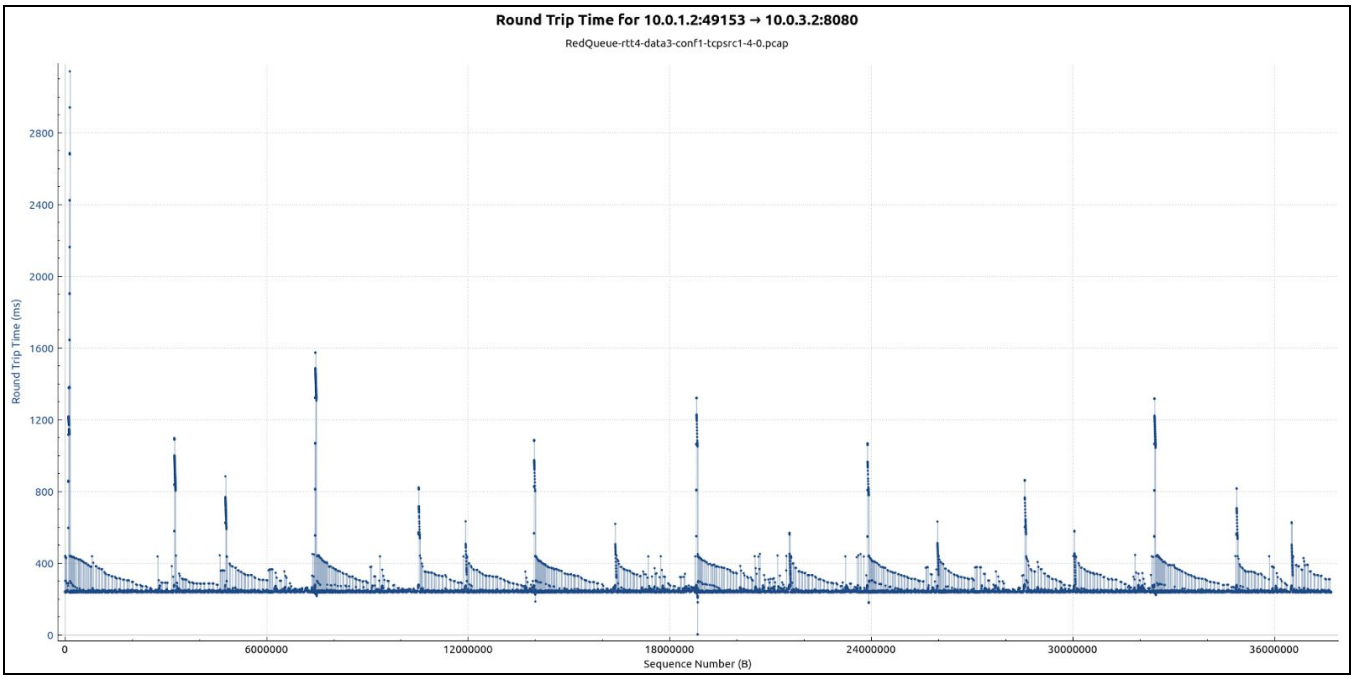


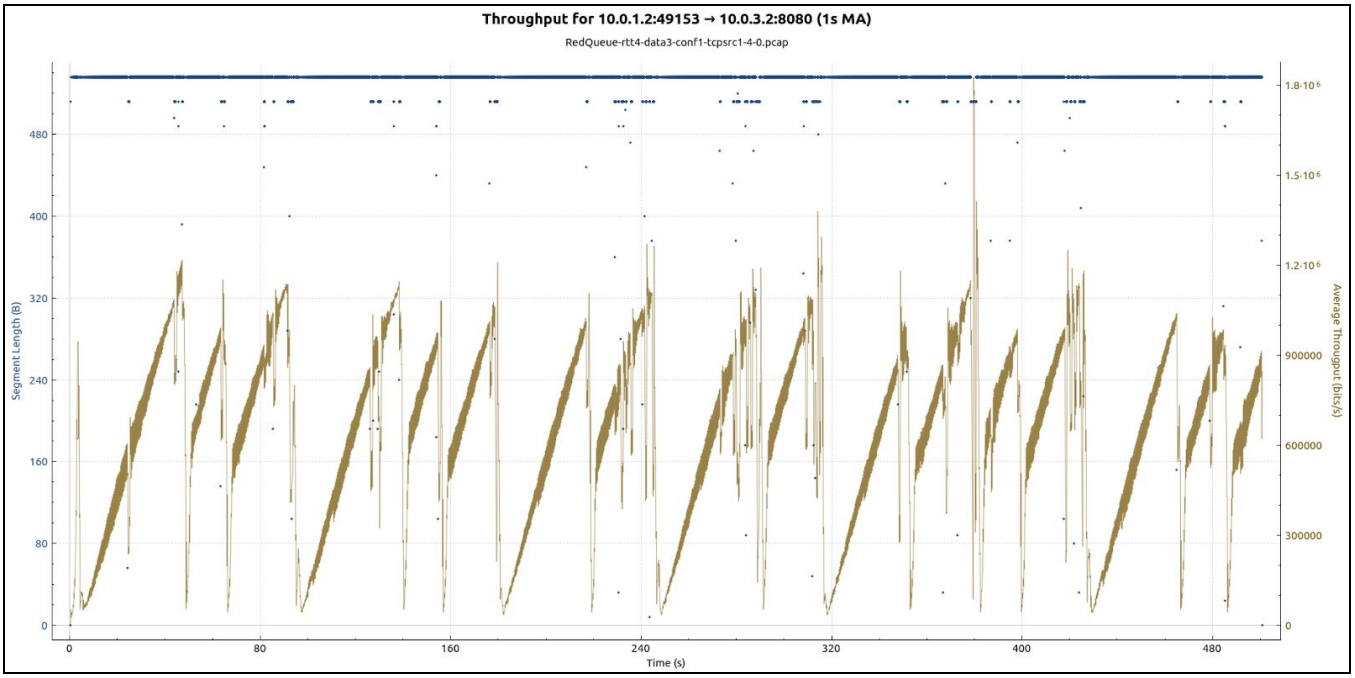


Shown above are the results for DropTail queues on an overloaded network with maximum delay links. This will be the base case for future comparisons, and we will see how the RTT and throughput graphs shown an increase or decrease in network performance. For these two graphs, it's important to note how the throughput appears to suffer from packet loss for 60%+ of each congestion window period.

TCP Goodput: 546.198 bytes/sec.

Traffic 3, RTT 4, Config 1, RED Queue

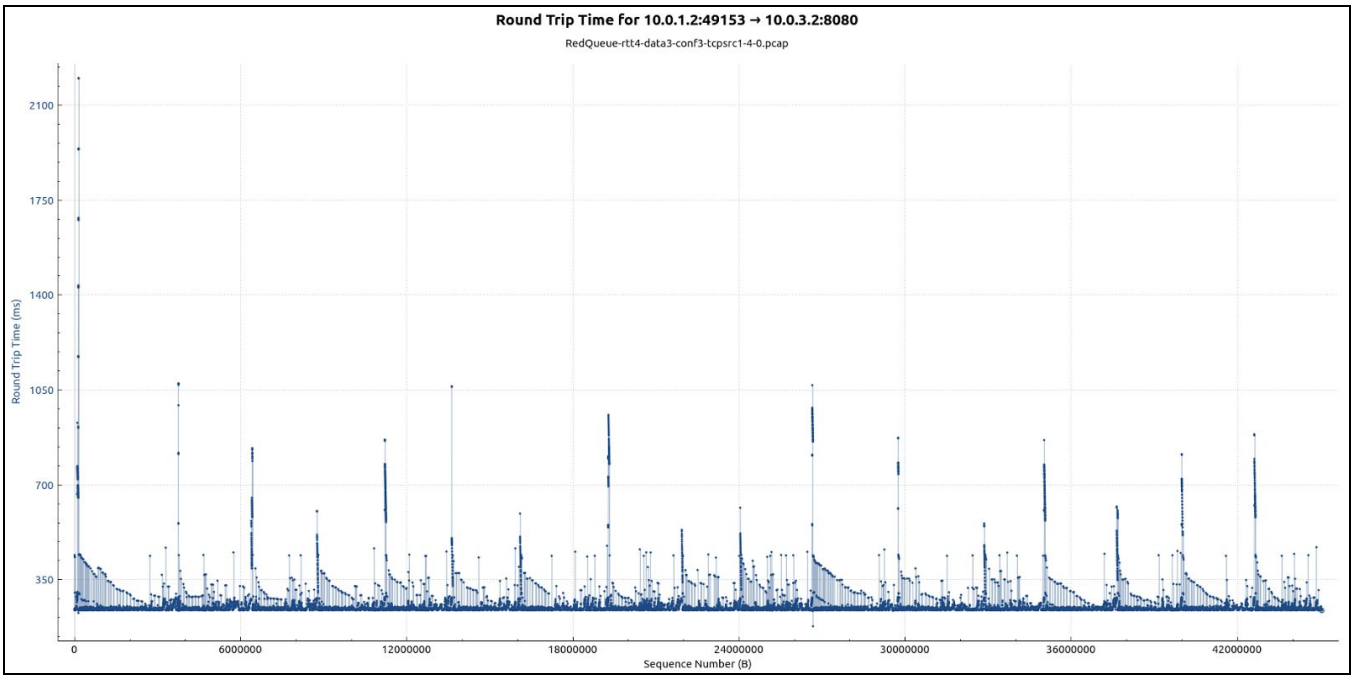


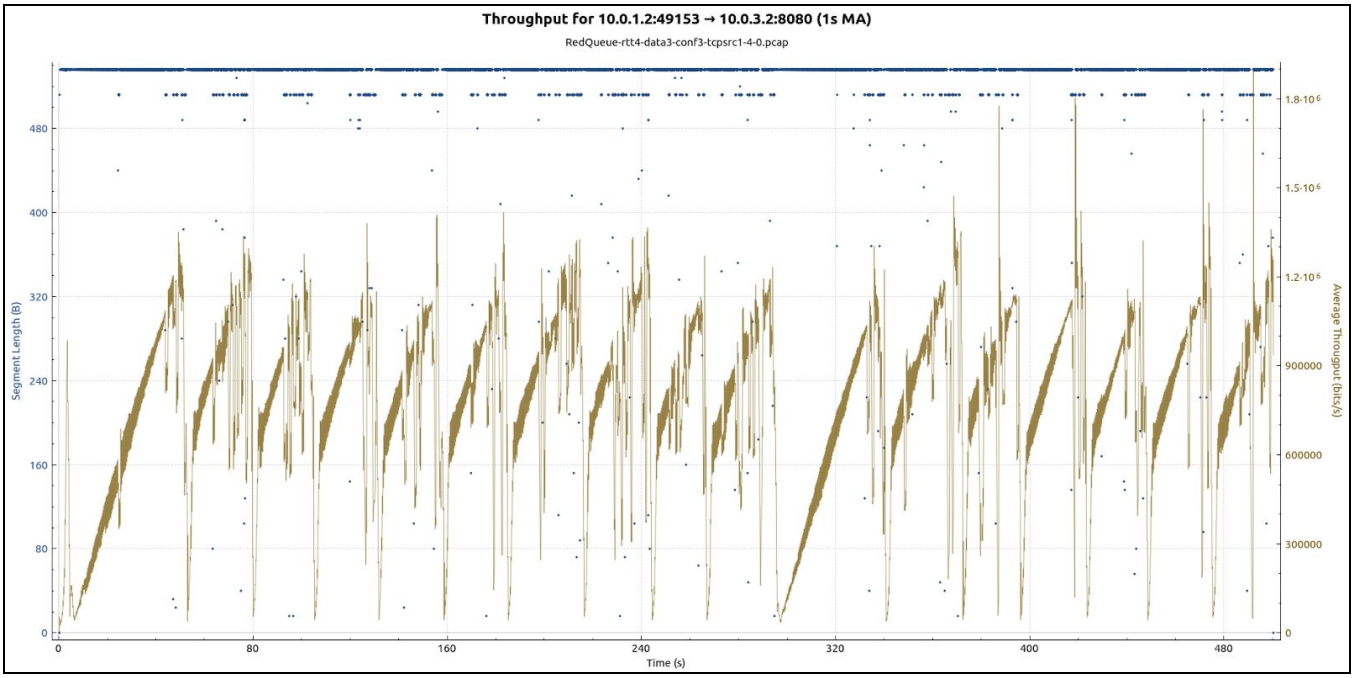


Holding everything about the network constant, except using RED queues in place of the DropTail queues yields us the results shown above. We can see that there appear to be many more RTT timeouts occurring in this case. As a result, we see that the throughput looks closer to what a congestion window's graph would look like.

TCP Goodput: 1671.52 bytes/sec.

Traffic 3, RTT 4, Config 3, RED Queue

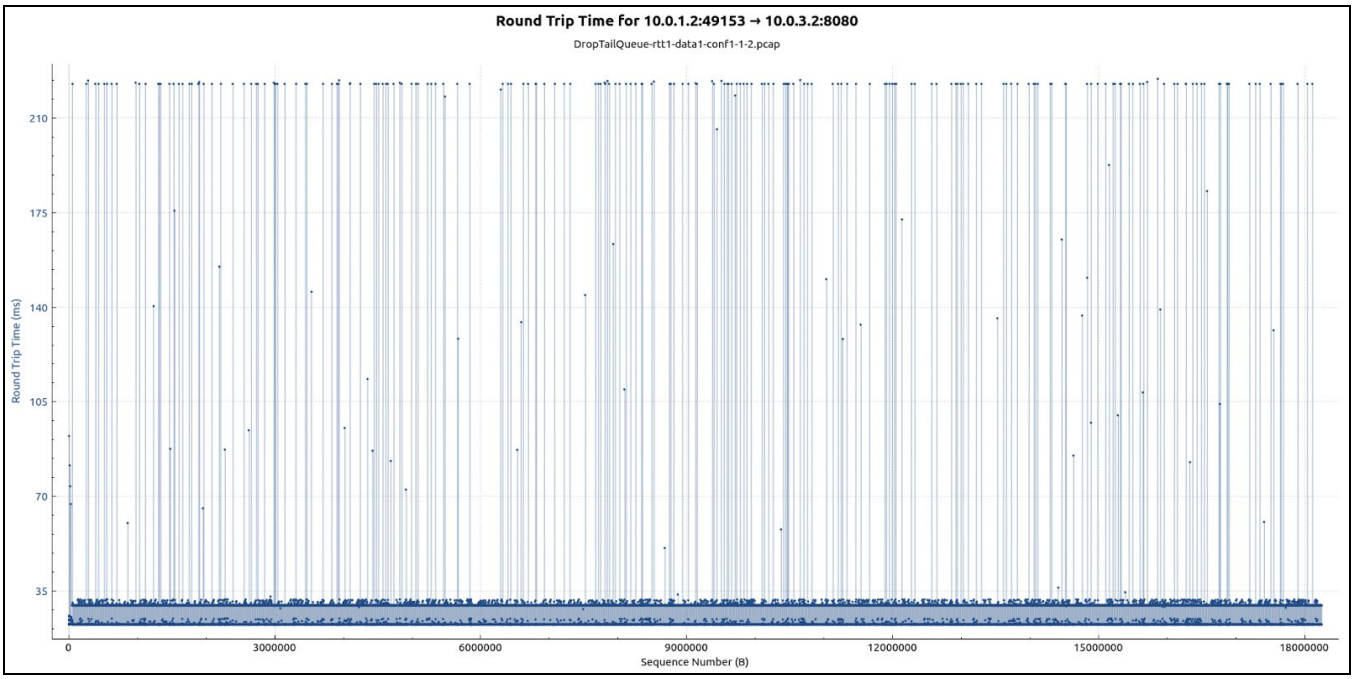


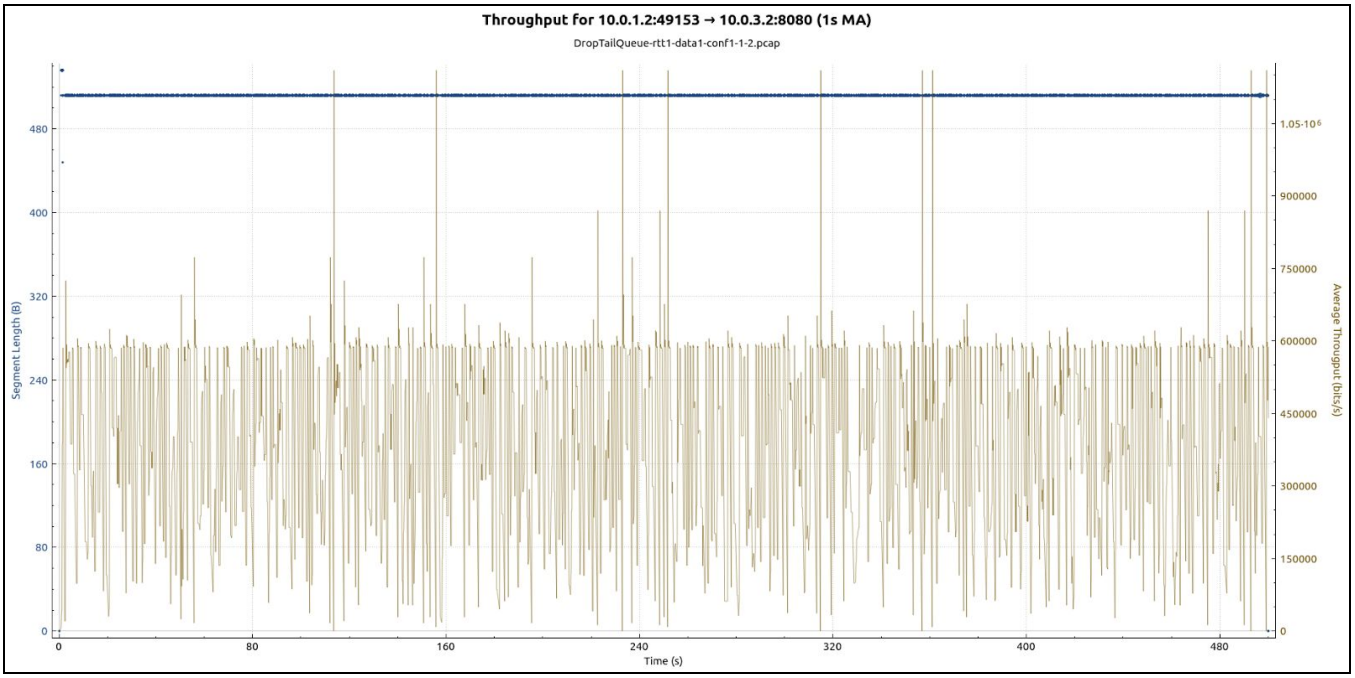


Even when decreasing the queuing capacity's parameters, the RED queue holds a relatively steady connection compared against the original base case. We can see in these graphs the network changes from looking at the increased randomness between the RTT [assumed to be] timeouts in the RTT graph. The increased goodput for this simulation is likely a result of doubling the receiver side window from 32kbytes to 64kbytes.

```
TCP Goodput: 1675.69 bytes/sec.
```

Traffic 1, RTT 1, Config 1, DropTail Queue

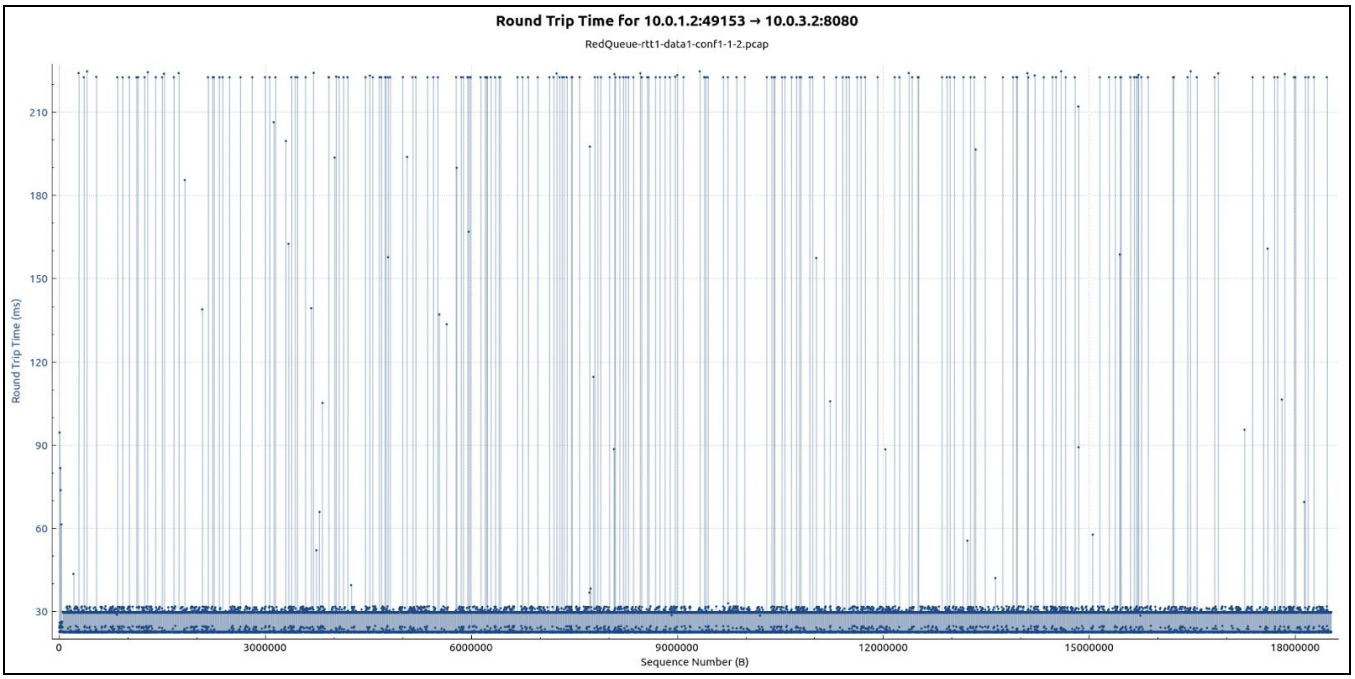


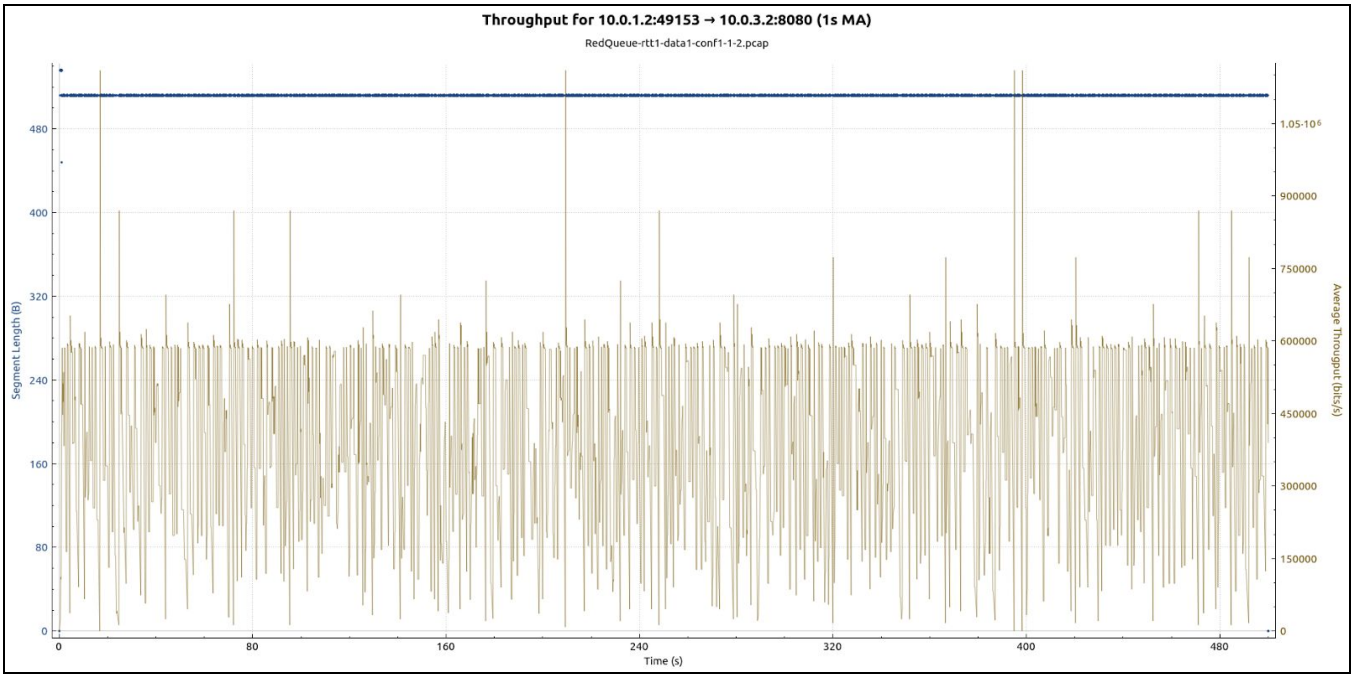


Here, we are shown the results for using DropTail queues for a network with less than 50% utilization and minimum delay links.

TCP Goodput: 208.371 bytes/sec.

Traffic 1, RTT 1, Config 1, RED Queue





Here, we are shown the results for using RED queues for a network with less than 50% utilization, minimum delay links, and a medium queuing capacity. There very little difference between the RED queues and DropTail queues at this utilization level. However, we still see mucher greater goodput performance with the RED queues due to the bottleneck link in the topology.

TCP Goodput: 821.42 bytes/sec.

All Results

The list of results for all of the simulations performed are shown here. The most interesting ones being lines that are highlighted with the TCP goodput in bold font.

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