HOCHSCHULE
SRH HEIDELBERG

SRH University Heidelberg

Professional Technical Report

Task 2- Simulation Project

Traffic Shaper – Token Bucket Algorithm

Author:	Begihally Shanmukhaswamy, Harsha	Badhe Prajakta Rajendra
Matriculation Number:	11017207	11017541
Email Address:	11017207@stud.hochschule-heidelberg.de	11017541@stud.hochschule-heidelberg.de
Supervisor:	Prof. Dr. Zarrar Yousaf	
Project Begin Date:	25. February 2022	
Project End Date:	18. March 2022	

Table of Contents

Table of Figures

Abstract

Congestion control relates to the general problem of traffic management in packet switched networks. Congestion means a situation in which the number of transmission requests at a specific time exceeds the transmission capacity. Congestion usually results in overload conditions. The primary function of congestion control is to ensure good throughput and delay performance while maintaining a fair allocation of network resources to users. For the best possible throughput, a minimum number of packet losses should occur. There are several techniques which are being used for the congestion control. **Traffic Shaping** is one of the techniques used.

The objective of this project is to design, develop, simulate and analyze the performance of the token bucket-based traffic shaping node in the network using Omnet++ simulation modeling tool.

Introduction

Traffic shaping is a bandwidth management technique used on computer networks which delays some or all datagrams to bring them into compliance with a desired traffic profile. Traffic shaping is used to optimize or guarantee performance, improve latency, or increase usable bandwidth for some kinds of packets by delaying other kinds.

Traffic Shaping is a technique to control the amount and rate of the traffic sent to the network. Approach of congestion management is called Traffic shaping. Traffic shaping helps to control the rate of data transmission and lessen congestion. Also helps in ensuring better quality of service (QoS), reduce the latency, deliver high performance and maximum usable bandwidth. Without traffic shaping, any excess traffic that cannot be sent, will either be dropped or queued, which will cause delays in all packets. It will result in poor performance.

There are two types of traffic shaping algorithms.

1. **Token Bucket Algorithm**
2. **Leaky Bucket Algorithm**

In this project, Token Bucket algorithm is used to build the traffic shaping node in the network.

Token Bucket Algorithm

Token Bucket is an algorithm used in the packet switched networks where conform to the defined limits on bandwidth and burstiness is mandatory. It is one of the techniques used for congestion control mechanism, which takes care of the packet delay and packet loss problems.

The performance of this algorithm is clearly observed when there is an uncontrolled data packet flow to the ingress port. The ingress port is associated with large FIFO buffer queue where the incoming data packets store. The algorithm generates the tokens at a predefined rate ρ tokens per second and stores these tokens in a separate token buffer with capacity β tokens. Hence the maximum number of tokens that can be stored in the token buffer is β tokens. The core logic is to dispatch each data packet stored in the ingress buffer queue to the egress port at the expense of each token i.e., each token is removed from the token buffer. Hence limiting the egress data packet burst size to β packets. The dispatching process is halted when there are no tokens available in the token buffer. There shall be incoming data packet loss when the ingress buffer queue is full.

In this Project, Token-Bucket algorithm has been implemented in the traffic shaper and simulated in the Omnet++.

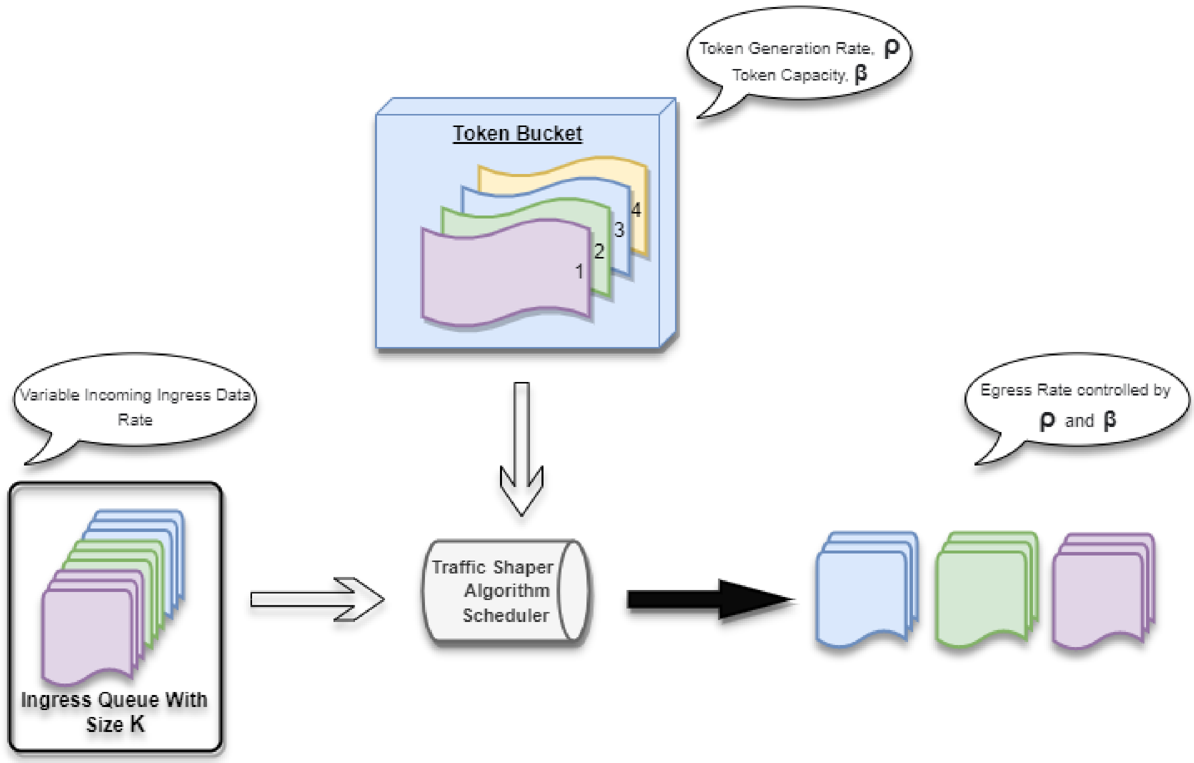

Figure 1: Token Bucket Algorithm Block Diagram

State Diagram of a Node:

The Figure 2 represents the state diagram of each node of the network in the Omnet++ environment. All the three nodes created in this project shall comply to this state diagram.

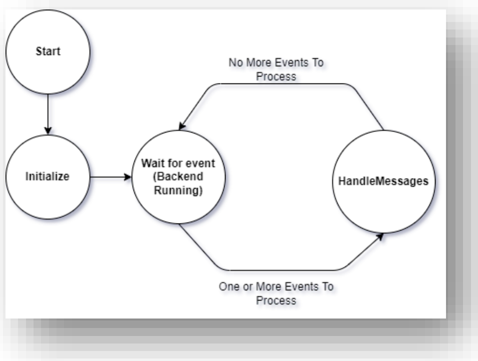

Figure 2: State Diagram of a node in the Omnet++.

Transmitter Node

Description:

The main purpose of the transmitter node in this project is to send the variable bit rate (VBR) data to the traffic shaper node. It is designed to send variable burst size data at random intervals. The randomness is generated using the exponentially distributed random generator. The data packet size shall be constant and each packet is numbered for debugging and tracking purposes.

Flow Diagram:

Figure 3 represents the software architecture flow in the transmitter node of the token bucket algorithm-based Traffic Shaper system.

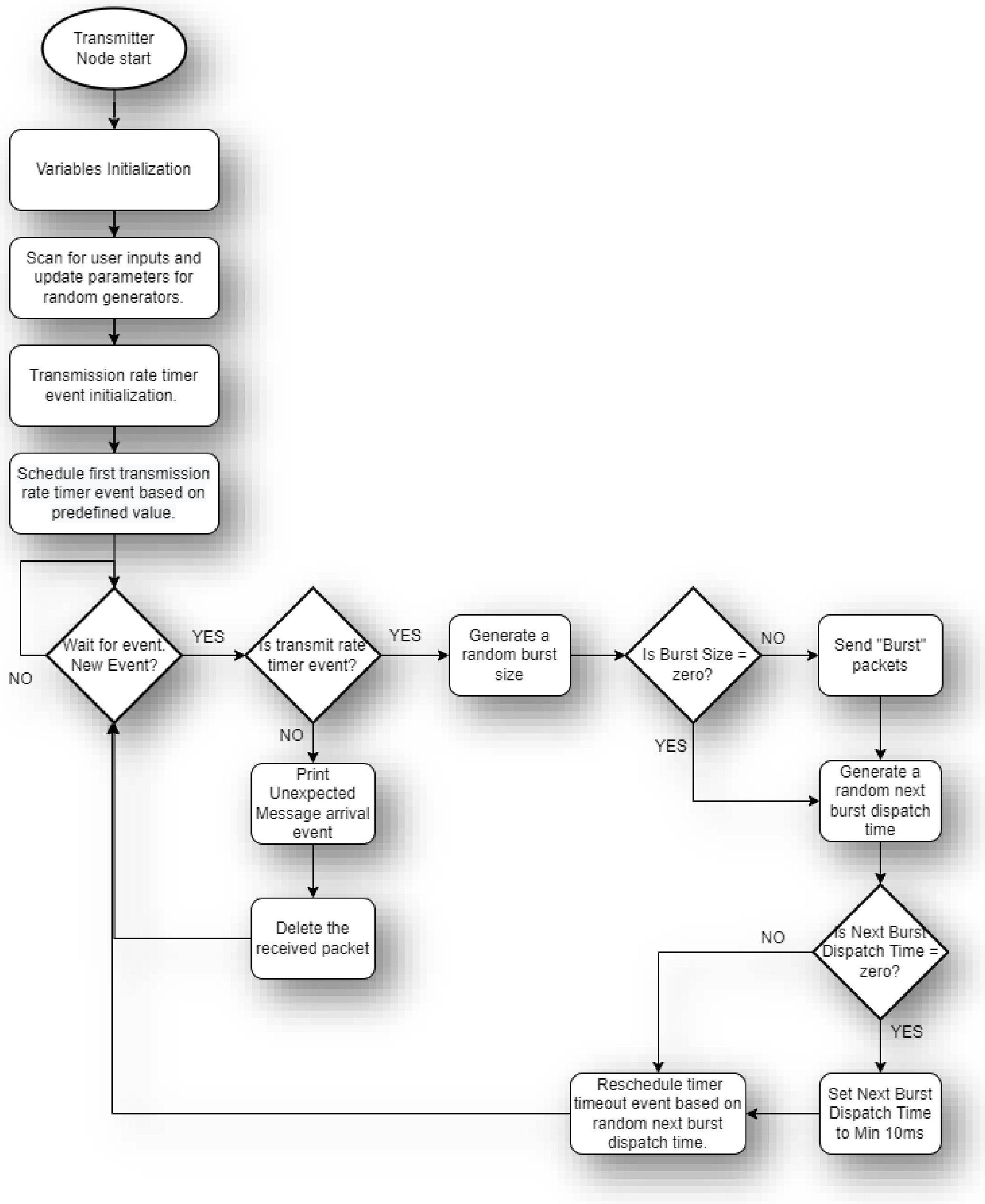

Figure 3: Transmitter Node Flow Chart

Traffic Shaper Node

Description:

The Traffic Shaper node is the core of this project and it is based on the token bucket algorithm. Its function is to receive the variable bit rate (VBR) data from the transmitter node and send to the receiver at the constant bit rate and with limited maximum burst size. The constant bit rate is based on the rate at which the token is generated and the maximum burst size depends on the token bucket capacity i.e., the maximum number of tokens that can be stored. This node has been implemented with the FIFO queue to handle the generated token PUSH and POP operations. It shall also implement ingress buffer to store the VBR data from the transmitter. When the ingress FIFO buffer is full the next incoming packets are dropped.

Flow Diagram:

Figure 4 represents the software architecture flow of the traffic shaper node in the system.

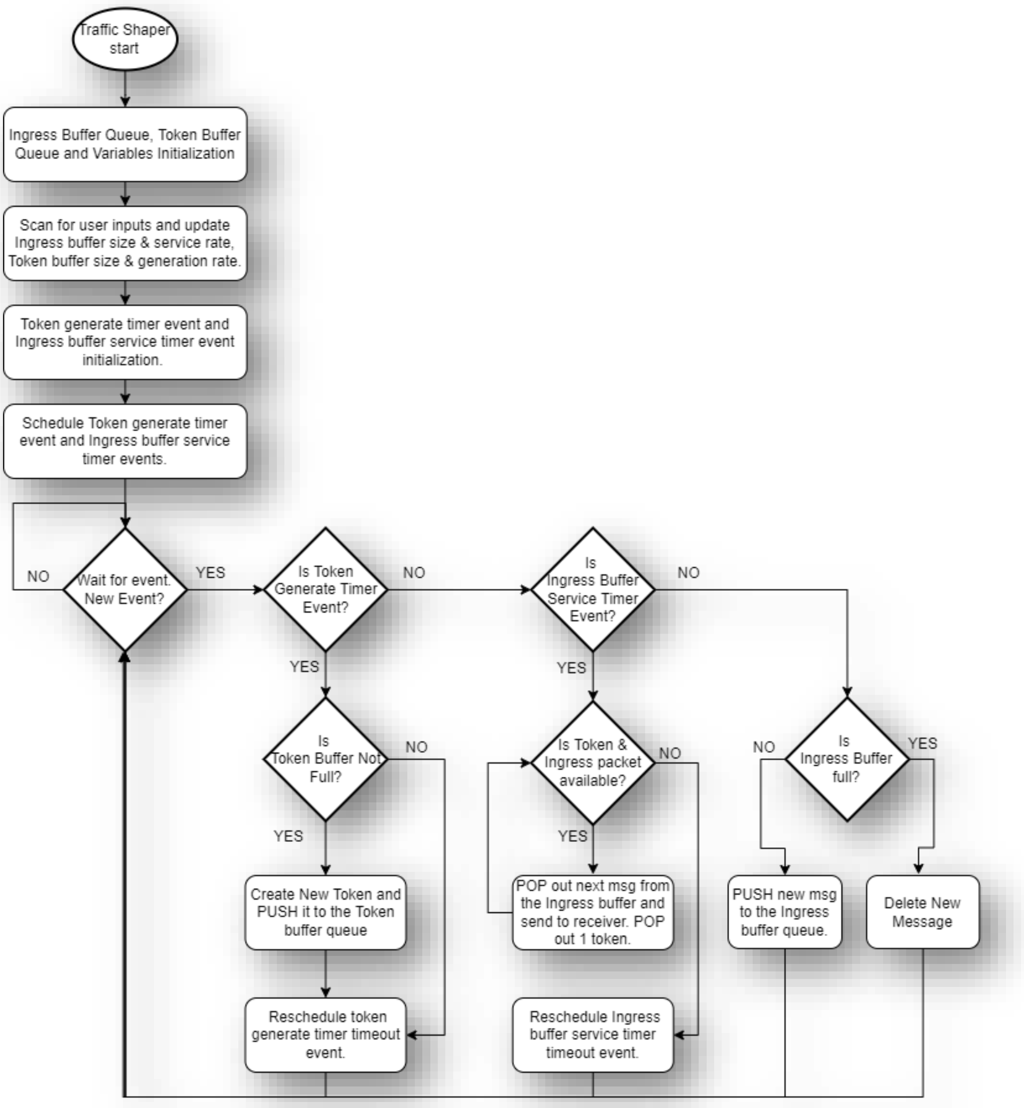

Figure 4: Traffic Shaper Node Flow Chart

Receiver Node

Description:

The purpose of the receiver node in this project is to receive the constant bit rate (CBR) data from the traffic shaper node. The data packets received shall be printed for debugging and tracking purposes. Finally, every packet received shall be destroyed.

Flow Diagram:

The Figure 5 represents the software architecture flow of the receiver node in the token bucket algorithm-based Traffic Shaper system.

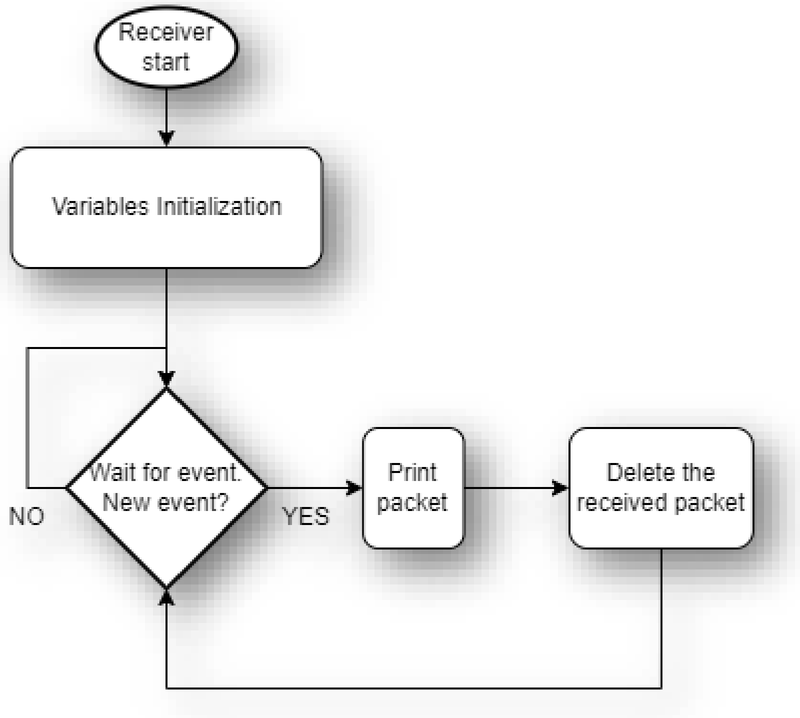

Figure 5: Receiver Node Flow Chart

Simulation Graphs:

The below set of figures represents the performance plots of the traffic shaper network implemented based on token bucket algorithm. These plots have been generated with different token generation rate and different token buffer capacity with ingress variable data rate. The packet loss is also simulated by limiting the ingress buffer capacity and decreasing the token generation rate. The maximum egress burst size is tested with different token buffer capacity.

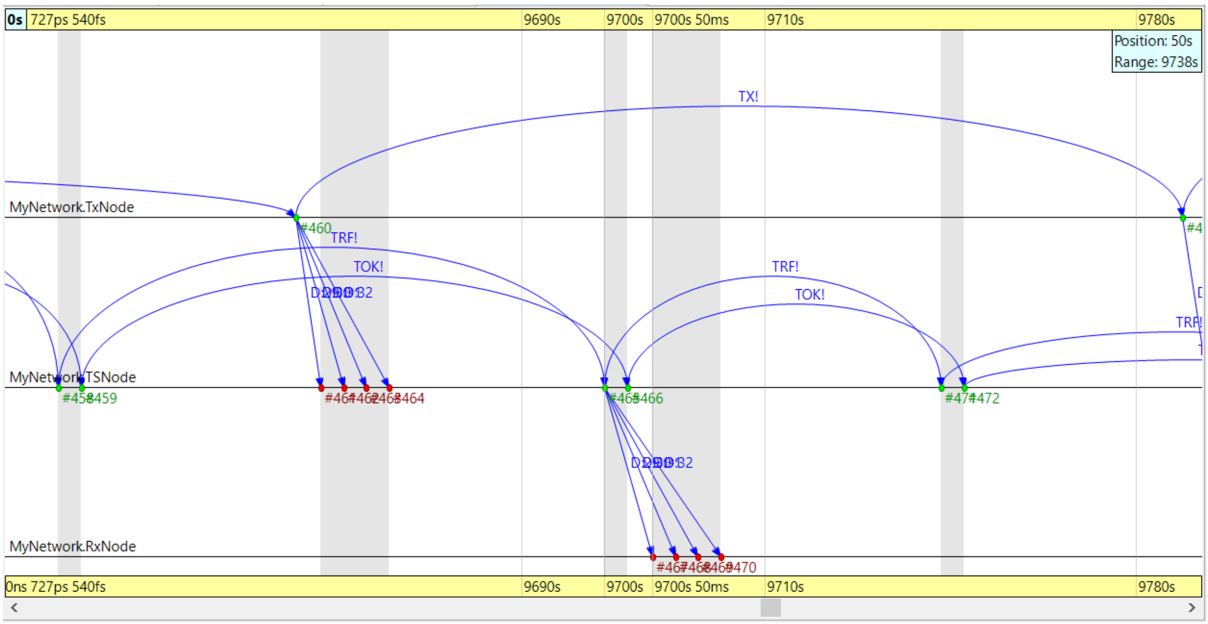

Figure 6: Ingress Burst < Token Availability

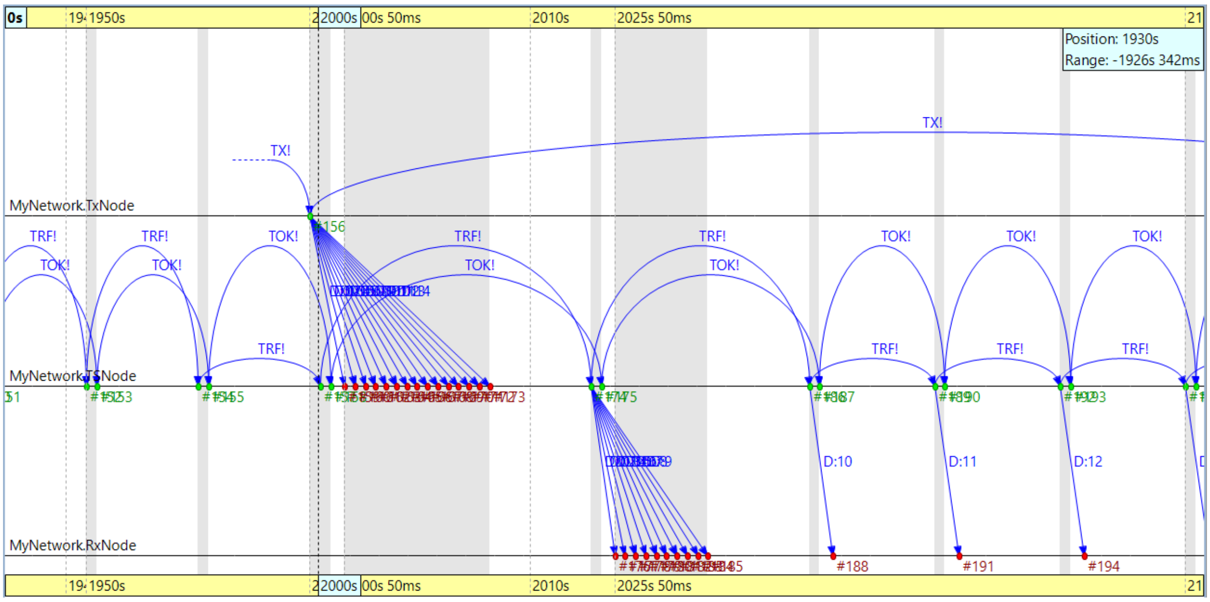

Figure 7: Ingress Burst > Token Availability – Maximum Burst Size

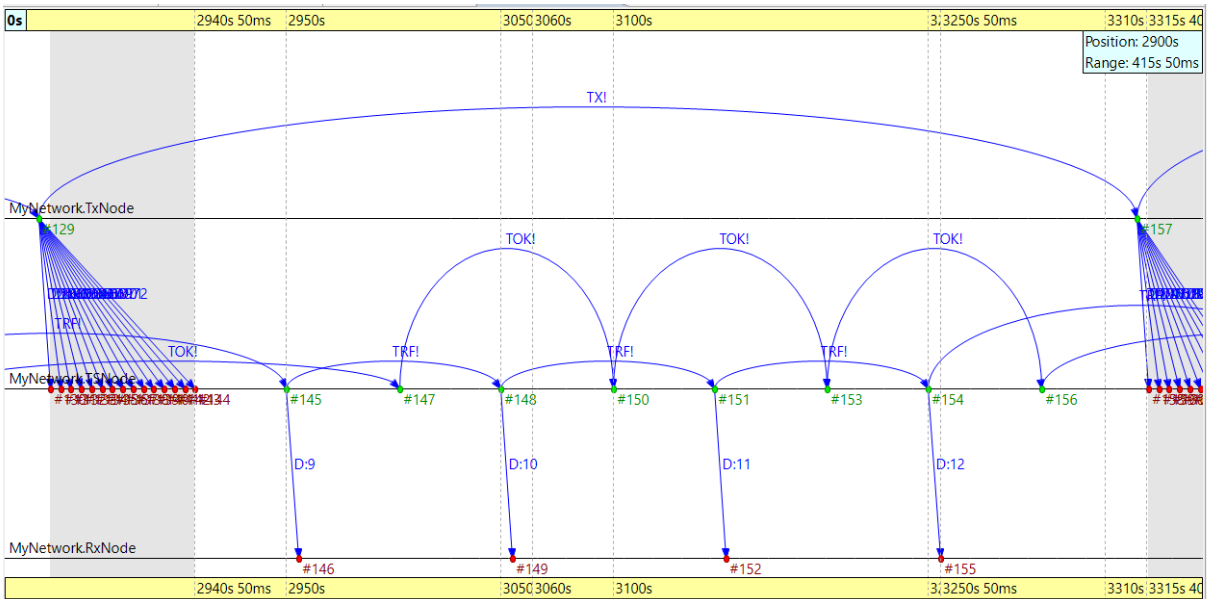

Figure 8: Controlled Constant Egress Data Rate

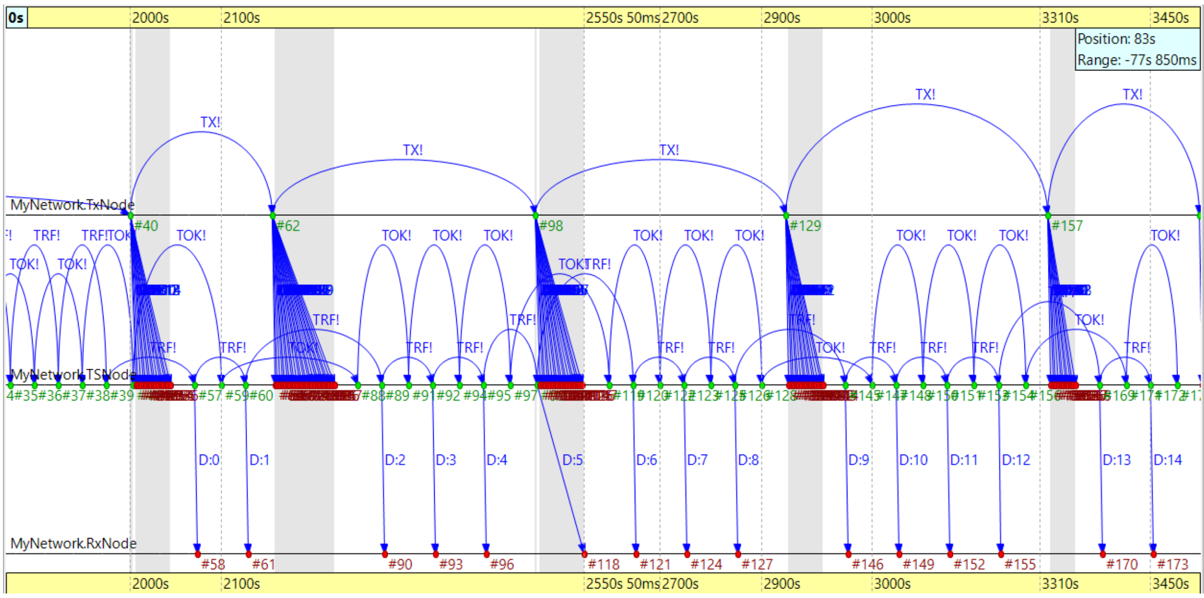

Figure 9: Variable Ingress Burst Size and Rate

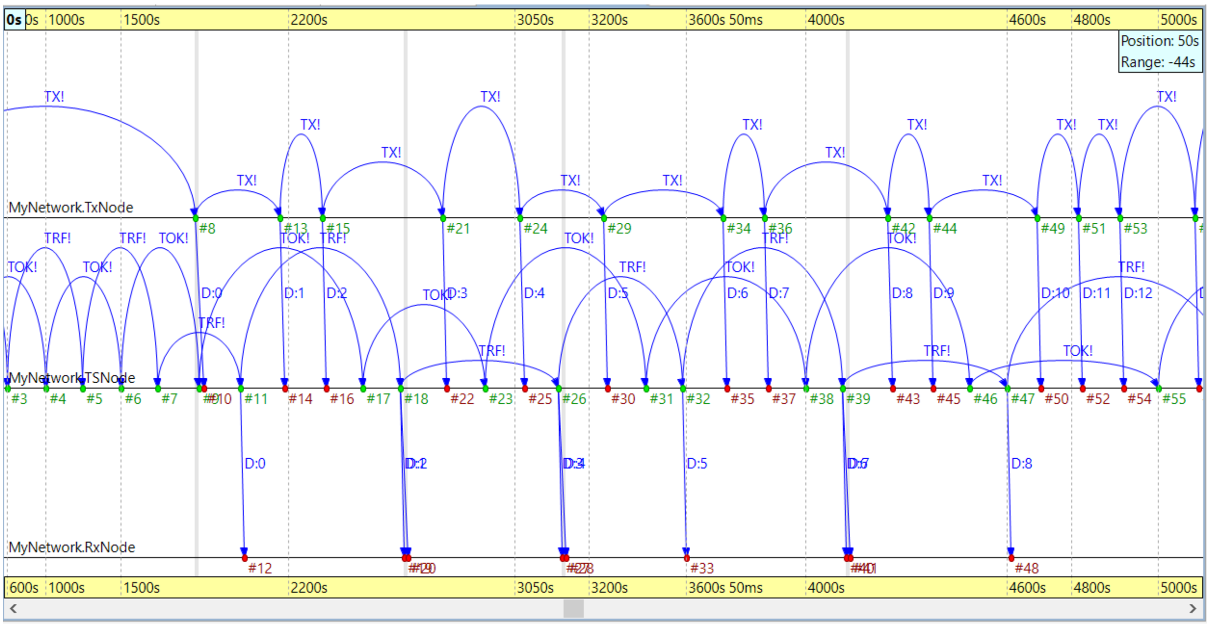

Figure 10: Ingress Variable Interpacket Arrival Time

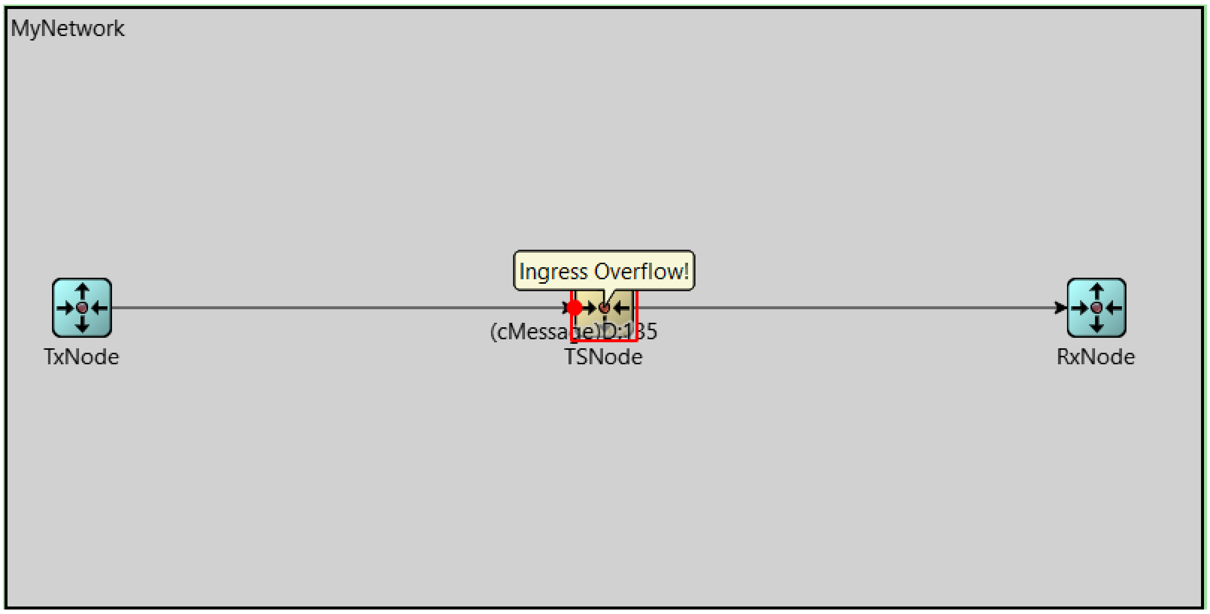

Figure 11: Ingress Buffer Queue Overflow and Packet Loss

Bibliography:

1. **Lecture Notes 06** by Dr.-Ing Faqir Zarrar Yousaf
2. Data and Computer Communication- Eighth Edition- By William Stallings
3. https://docs.omnetpp.org/
4. https://doc.omnetpp.org/omnetpp/manual/
5. https://omnetpp.org/documentation/
6. https://en.wikipedia.org/wiki/Data_link_layer
7. https://en.wikipedia.org/wiki/Traffic_shaping
8. https://en.wikipedia.org/wiki/Token_bucket