



# Implementation of Deficit Round Robin Scheduling Algorithm

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# Road map

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- Introduction
- Quality of Service
- Scheduling
- Implementation of Deficit Round Robin
- Simulation scenarios and results
- Conclusions



# Introduction

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- Internet originally designed to offer one level of service: “best effort”.
- Original users of Internet were U.S. government researchers and contractors.
- Transfer of ownership from ARPA to Defense Communication Agency in 1975.
- New transmission protocol called TCP/IP on January 1, 1983.
- First graphical Web browser released in 1993.



# Quality of Service

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- Ability to provide guaranteed services to different applications.

“All animals are equal, but some animals are more equal than others” *Animal Farm*, George Orwell



# QoS parameters

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- Throughput: number of bits transmitted over a link in certain amount of time.
- Delay: time it takes packets to navigate from their source to their destination.
- Delay jitter: delay variation encountered by packets during transmission over a network.
- Packet loss: probability of packets being lost in a network.



# Providing QoS

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- End to end mechanisms
  - implemented at the two end sides of a connection: Connection Admission Control
- Edge mechanisms
  - implemented at the user-network interface: shaping and policing
- Core mechanisms
  - implemented in network nodes: buffering, queue management, and **scheduling**



# Core mechanisms

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- Implemented in network nodes (routers, switches).
- Classified into three categories:
  - buffering
  - queue management
  - scheduling.

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# Buffer architecture

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- Shared buffer:
  - incoming traffic is stored in the same physical memory.
- Per-flow:
  - traffic belonging to distinct flows is placed into different buffers.
- Current high-speed networks use per-flow buffers.



# Queue management

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- Ensure that the queue does not overflow.
- Devise criteria for dropping low priority packets before dropping high priority packets.
  - DropTail
  - Random Early Detection (RED)
  - Weighted RED (WRED)
  - RED with IN and OUT bits (RIO).



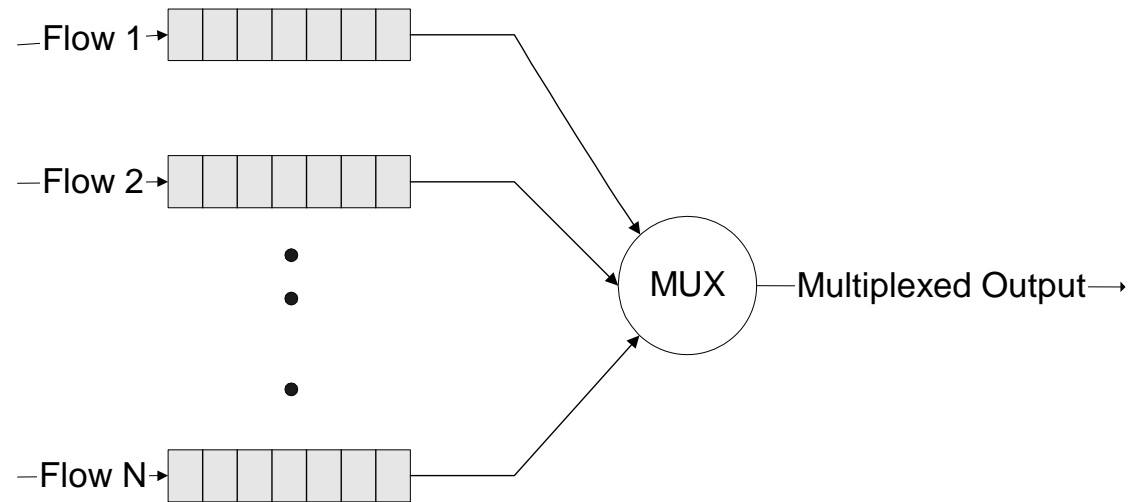
# Scheduling

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- Implemented in network switching nodes.
- Determines:
  - which packets get transmitted.
  - when packets get transmitted.
  - which packets get dropped in case of congestion.

# Scheduler elements

- Classifier: assigns packets to different queues.
- Scheduler: selects packets to be transmitted from queues.



Scheduler elements



# Deficit Round Robin (DRR)

- Shreedhar and Varghese (1995)
  - derived from Round Robin scheduling algorithm.
  - classifies packets into different queues.
  - associates a fixed **quantum** to each queue.
  - a **deficit counter** is used to keep track of the credit available to each queue.



# Deficit Round Robin (cont.)

- The variable Quantum is the number of bytes that each queue can transmit in each turn.
- The Deficit Counter is used to keep track of the credit (deficit) available to each queue.
- Each queue is allowed to send a given amount of bytes (Quantum) in each round of the robin.
- If the packet size at the front of the queue is larger than the amount of the Quantum, then the queue will not be serviced.



# Deficit Round Robin (cont.)

- The value of the Quantum is added to the Deficit Counter associated with that queue and will be used in the next service round.
- To avoid examining empty queues, the algorithm keeps an auxiliary list called the Active List, which is a list of indices of queues that contain at least one packet.
- Whenever a packet arrives in an empty queue, the index of that queue is added to the Active List.



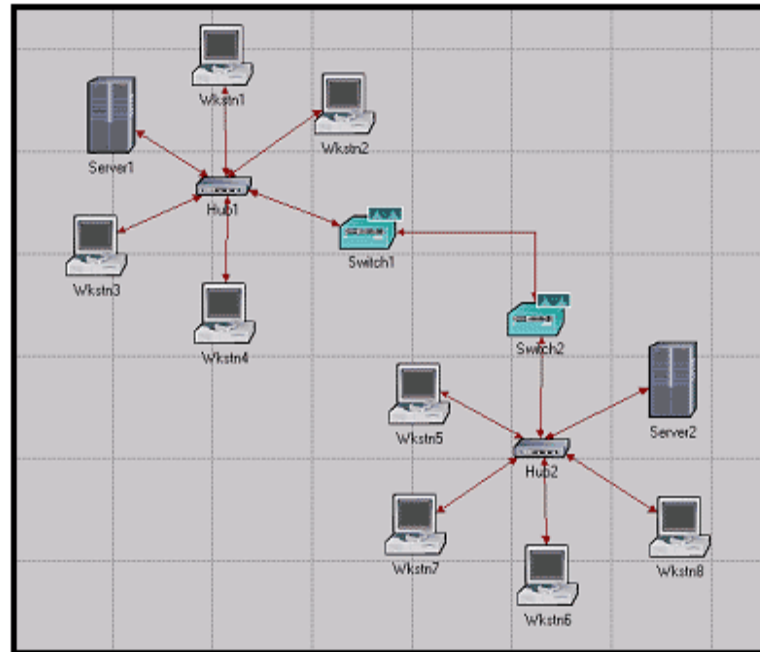
# OPNET simulation tool

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- Provides a comprehensive development environment for modeling of communication networks.
- Supports tools for all phases of study, including model design, data collection, simulation, and data analysis.
- Three layers of the hierarchical structure for each OPNET model: network, node, and process layer.

# Project editor

- Used to create and edit the overall topology of the communication network model



Project editor in OPNET

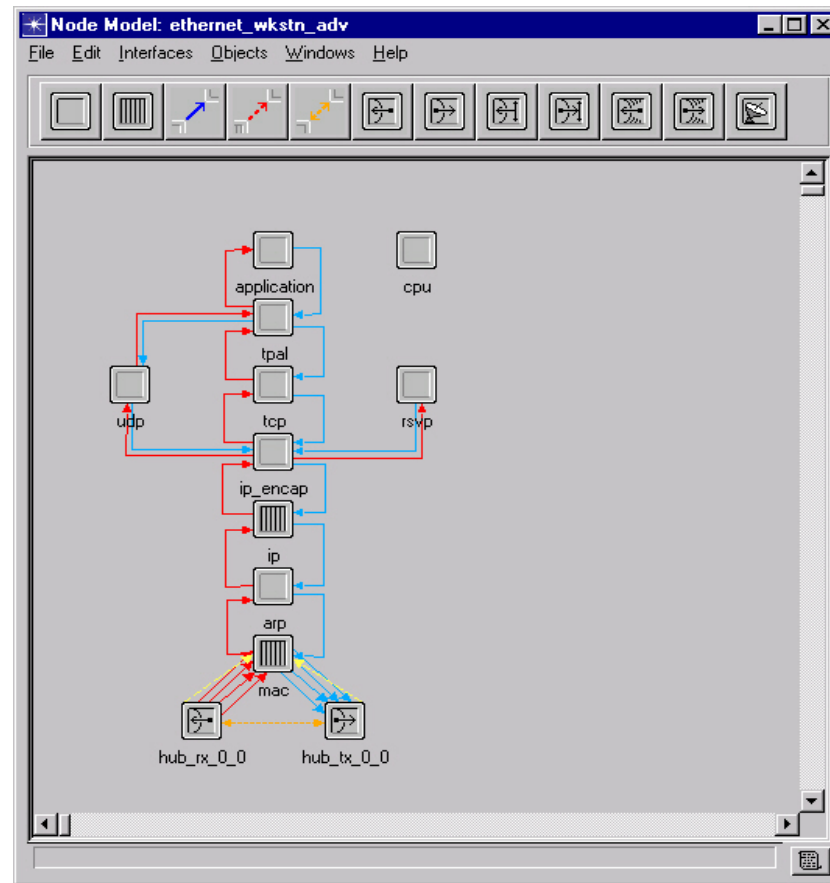
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# Node editor

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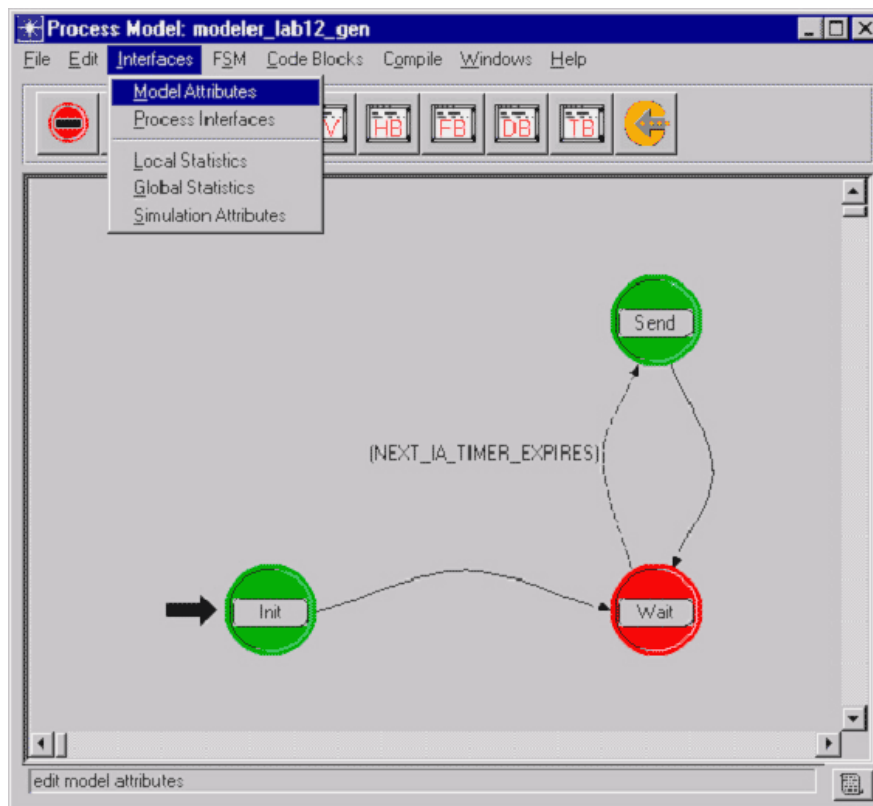
- Used to specify the structure of device models.
- Provides operations to support creation and editing of node models.
- Nodes consist of different types of objects called modules.

# Node editor (cont.)



Node editor in OPNET

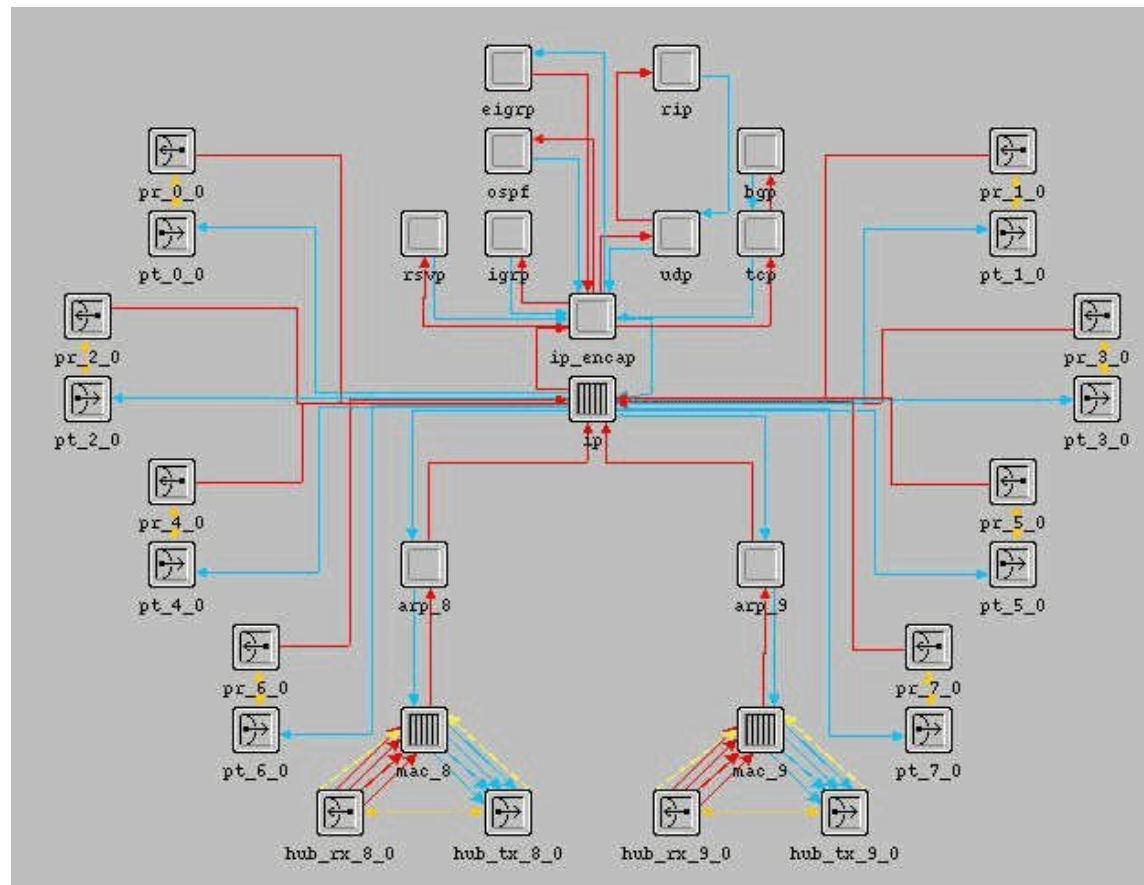
# Process editor



Node editor in OPNET

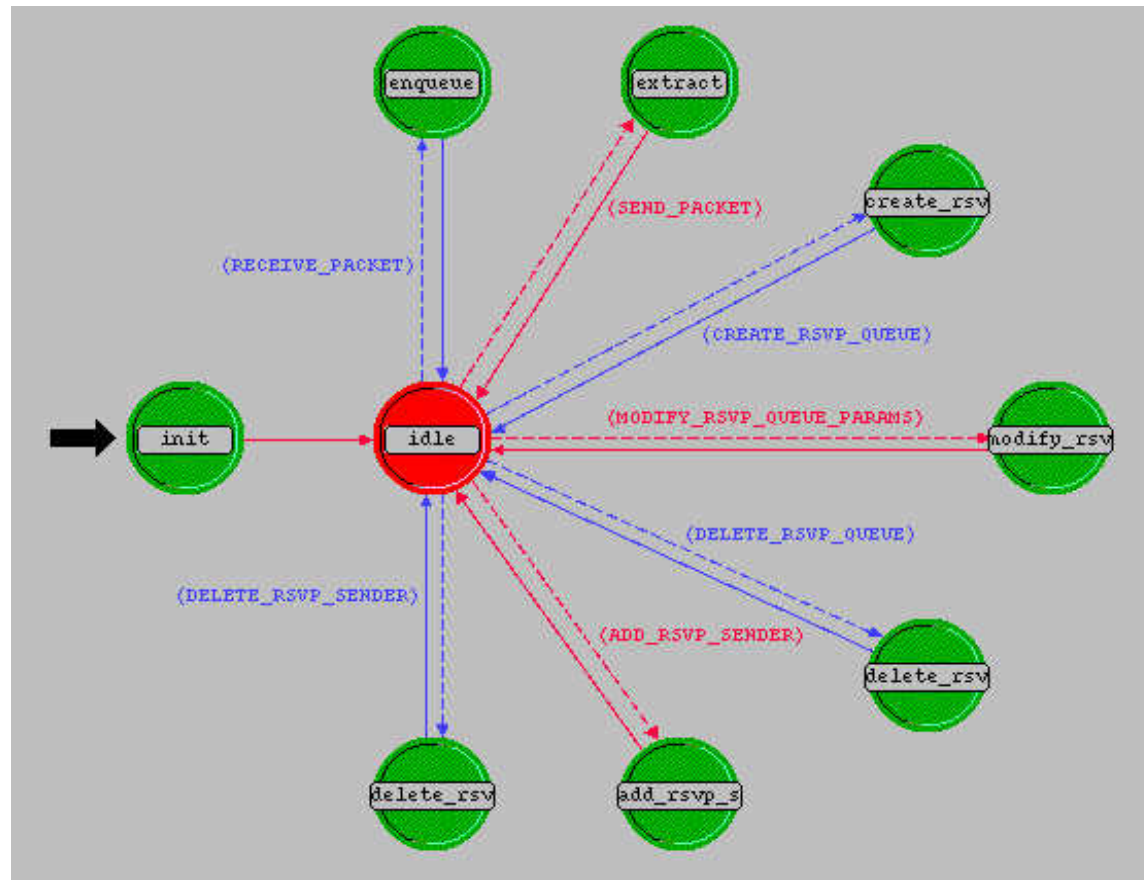


# DRR implementation



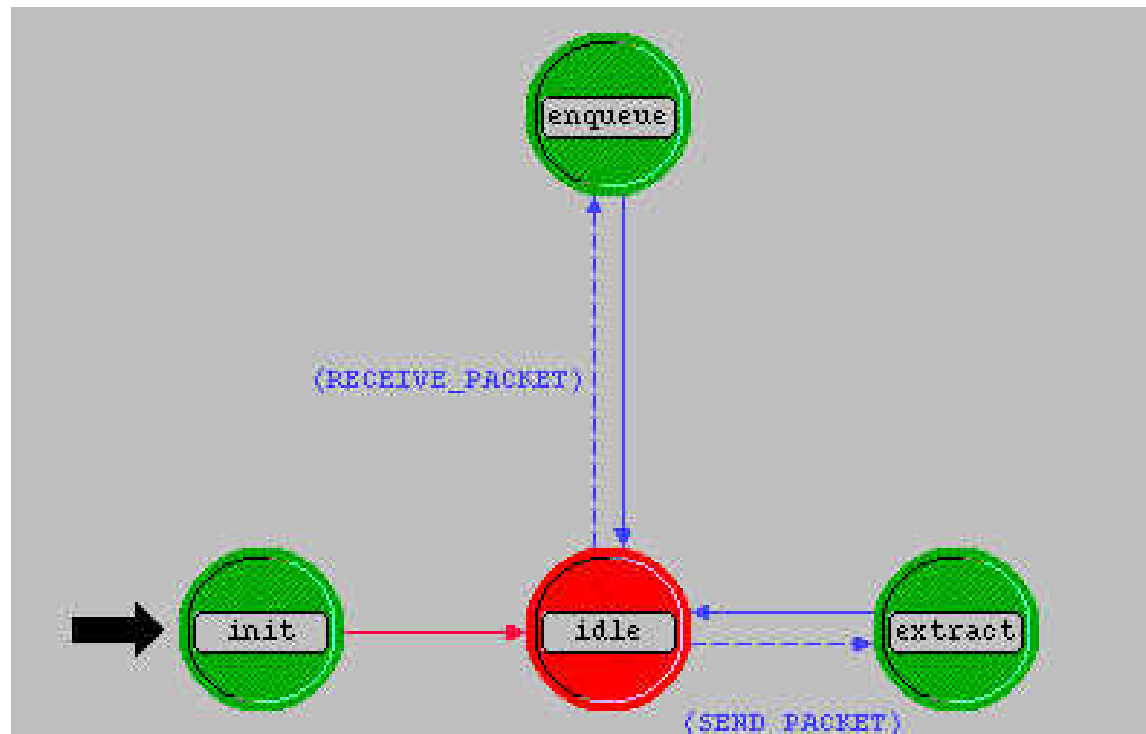
## Hierarchical structure of IP router node model

# DRR process model



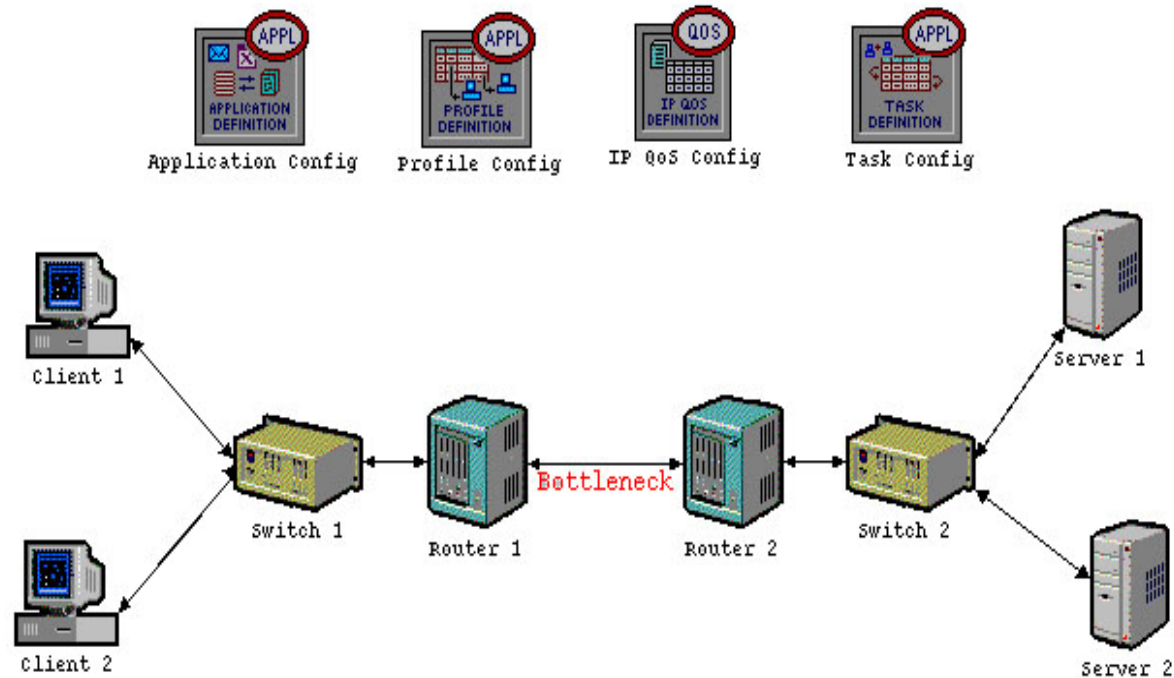
State transition of output interface process model

# DRR process model



## State transition of Deficit Round Robin process model

# Simulation scenario



## Simulation scenario for the Deficit Round Robin algorithm

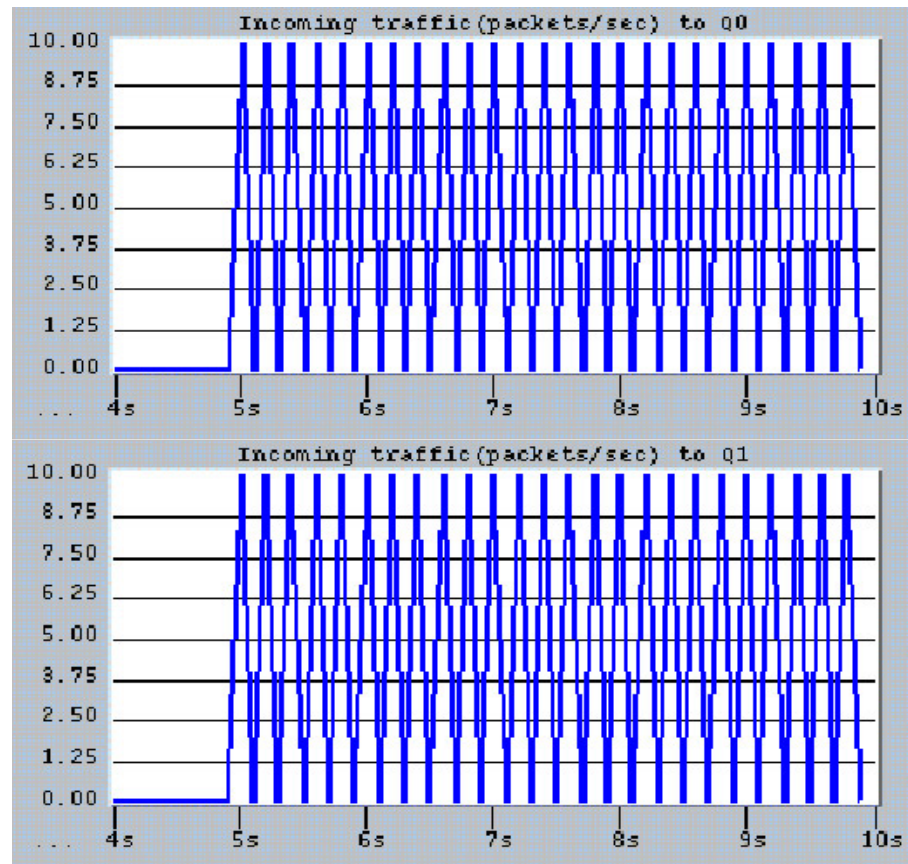


# Scenario 1

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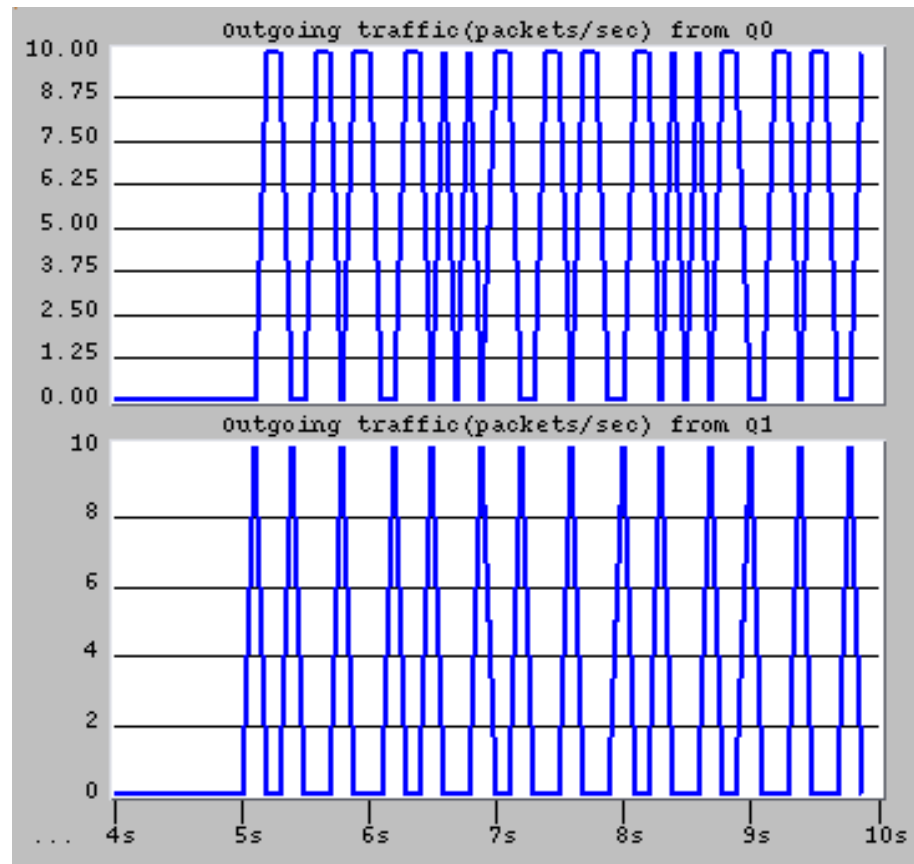
- Configuration:
  - Client 1: 5 packets/sec
  - Client 2: 5 packets/sec
  - packet size: 1,024 bytes for Client 1
  - packet size: 512 bytes for Client 2

# Scenario 1: results



Arriving packets to queues Q0 and Q1 vs. time

# Scenario 1: results



Outgoing packets from queues Q0 and Q1 vs. time

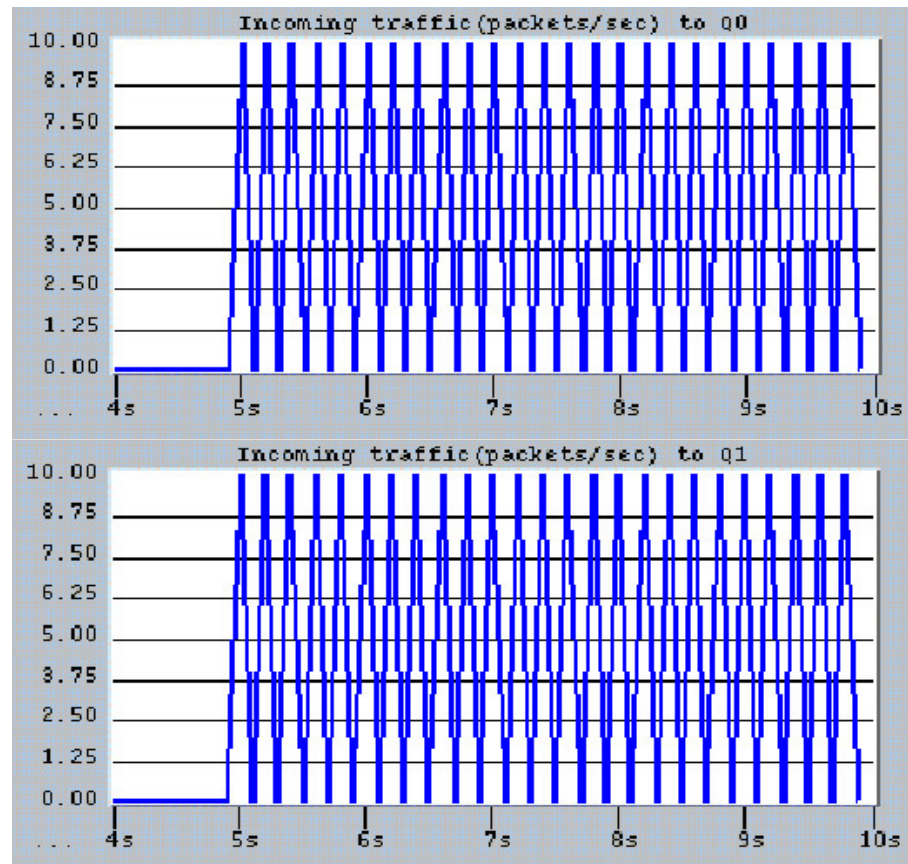


# Scenario 2

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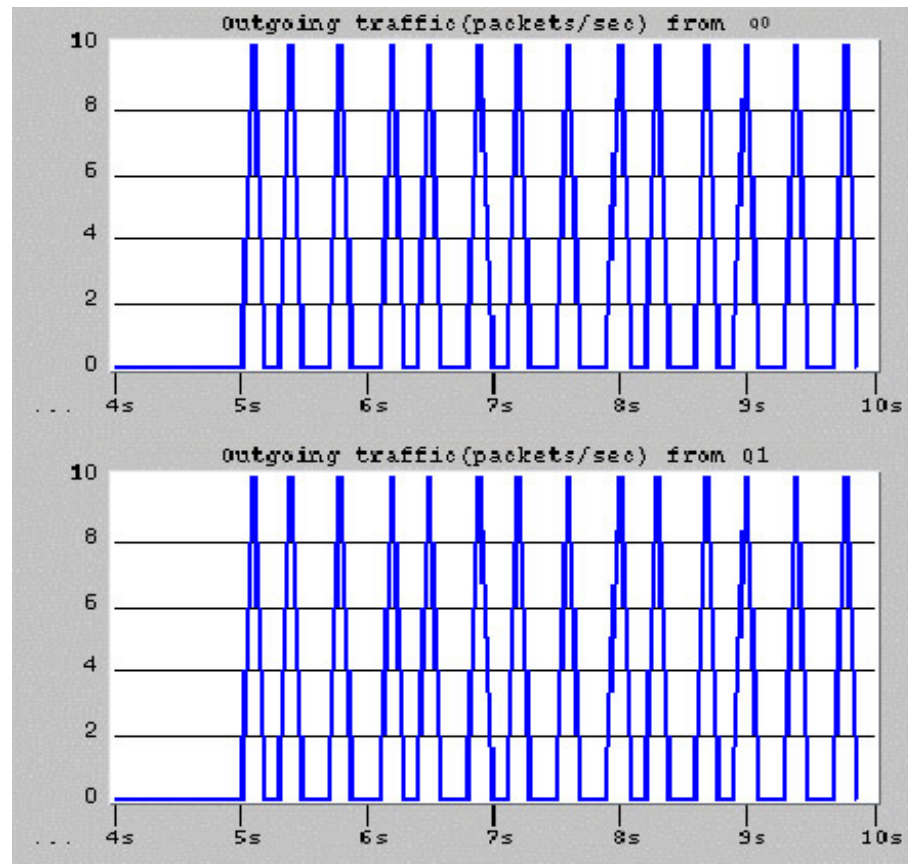
- Configuration:
  - Client 1: 5 packets/sec
  - Client 2: 5 packets/sec
  - packet size: 512 bytes for Client 1
  - packet size: 512 bytes for Client 2

# Scenario 2: results



Arriving packets to queues Q0 and Q1 vs. time

# Scenario 2: results



Outgoing packets from queues Q0 and Q1 vs. time

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# Conclusions

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- The concept of Quality of Service (QoS) was used along with various methods for providing QoS.
- We described in details the implementation of the Deficit Round Robin scheduling mechanism using the OPNET simulation tool.
- The fairness of the Deficit Round Robin model was verified in various network simulation scenarios.
- Future work: implementation of Deficit Round Robin++ and comparing it to the performance of other scheduling algorithms.

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