Implementation of Deficit Round Robin Scheduling Algorithm

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Road map

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

Introduction

- 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

- 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

- 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

- 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

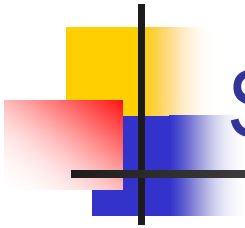
- Implemented in network nodes (routers, switches).
- Classified into three categories:
  - buffering
  - queue management
  - scheduling.

Buffer architecture

- 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

- 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).

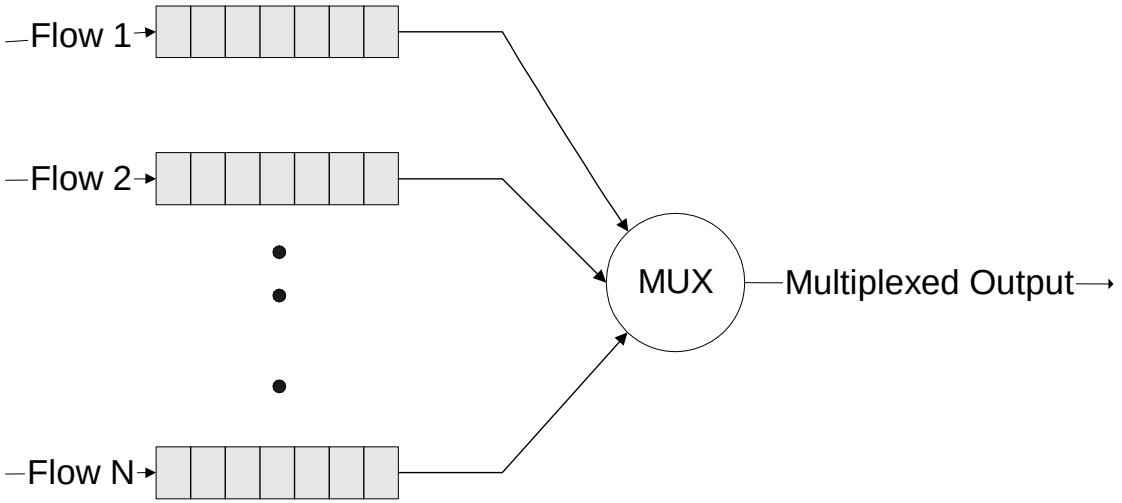


Scheduling

- 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.)

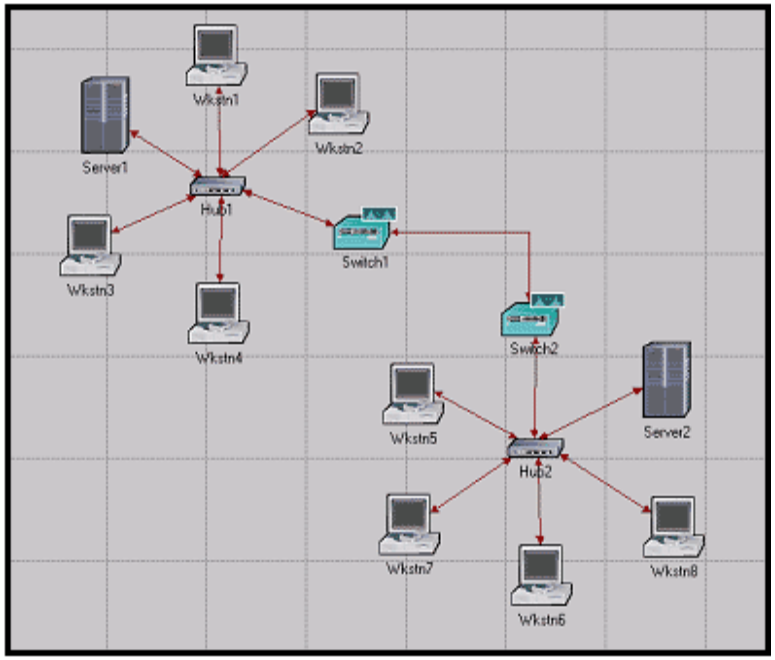
- The value of the Quantum is added to the Deficit Counter associated with that queue and will be used in the next service round.
- To avoid examining empty queues, the algorithm keeps an auxiliary list called the Active List, which is a list of indices of queues that contain at least one packet.
- Whenever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

OPNET simulation tool

- 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

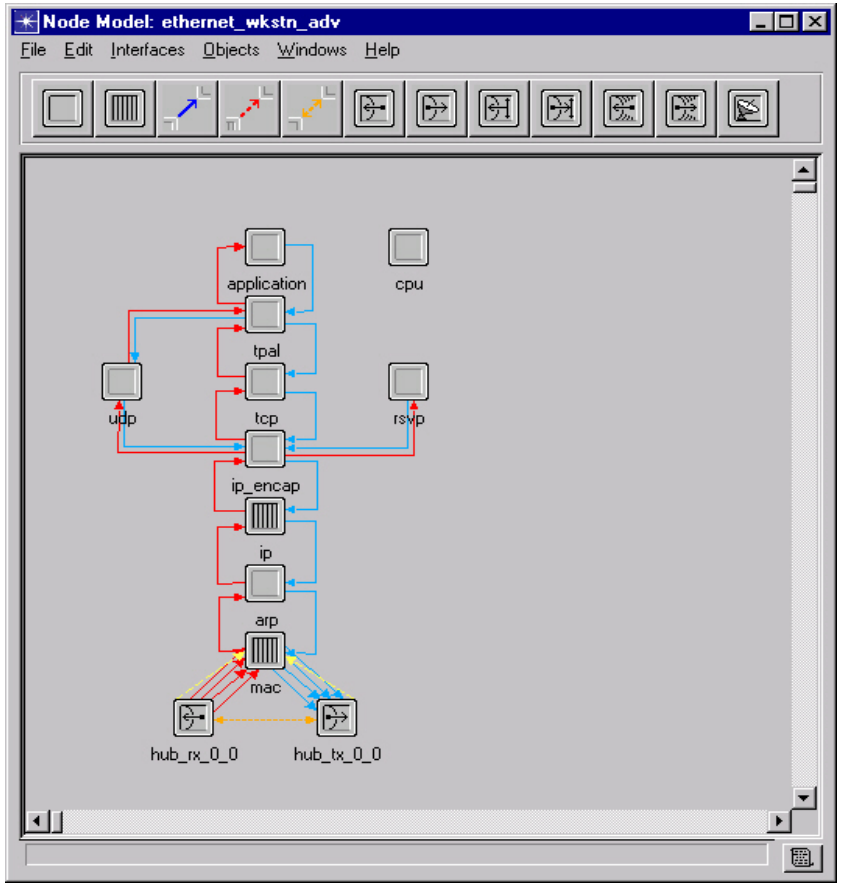


Project editor in OPNET

Node editor

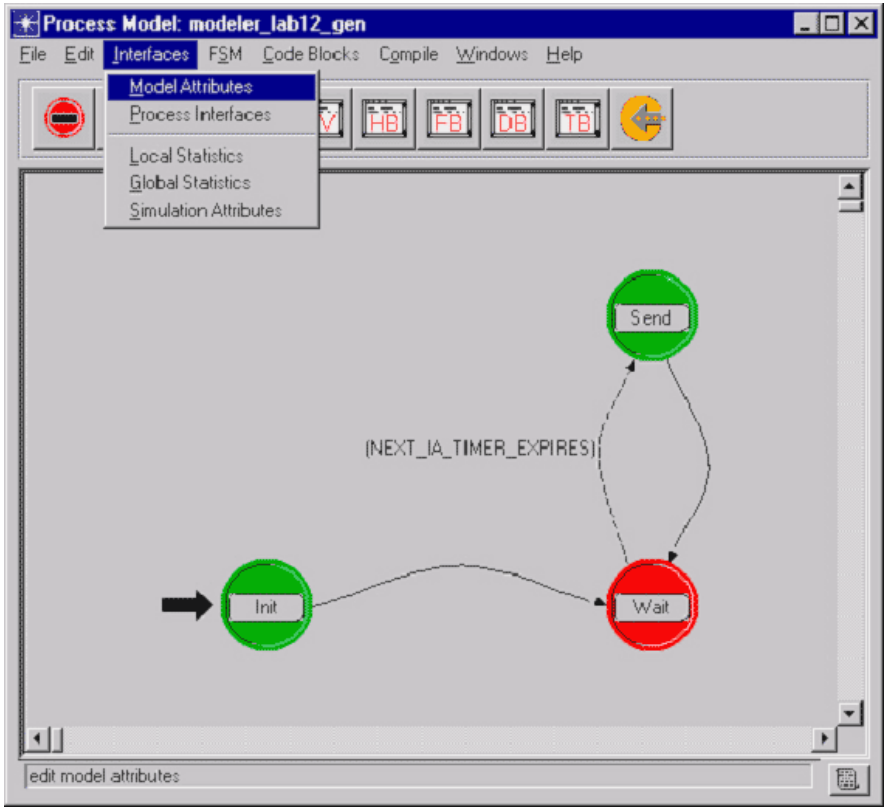
- Used to specify the structure of device models.
- Provides operations to support creation and editing of node models.
- Nodes consist of different types of objects called modules.

Node editor (cont.)



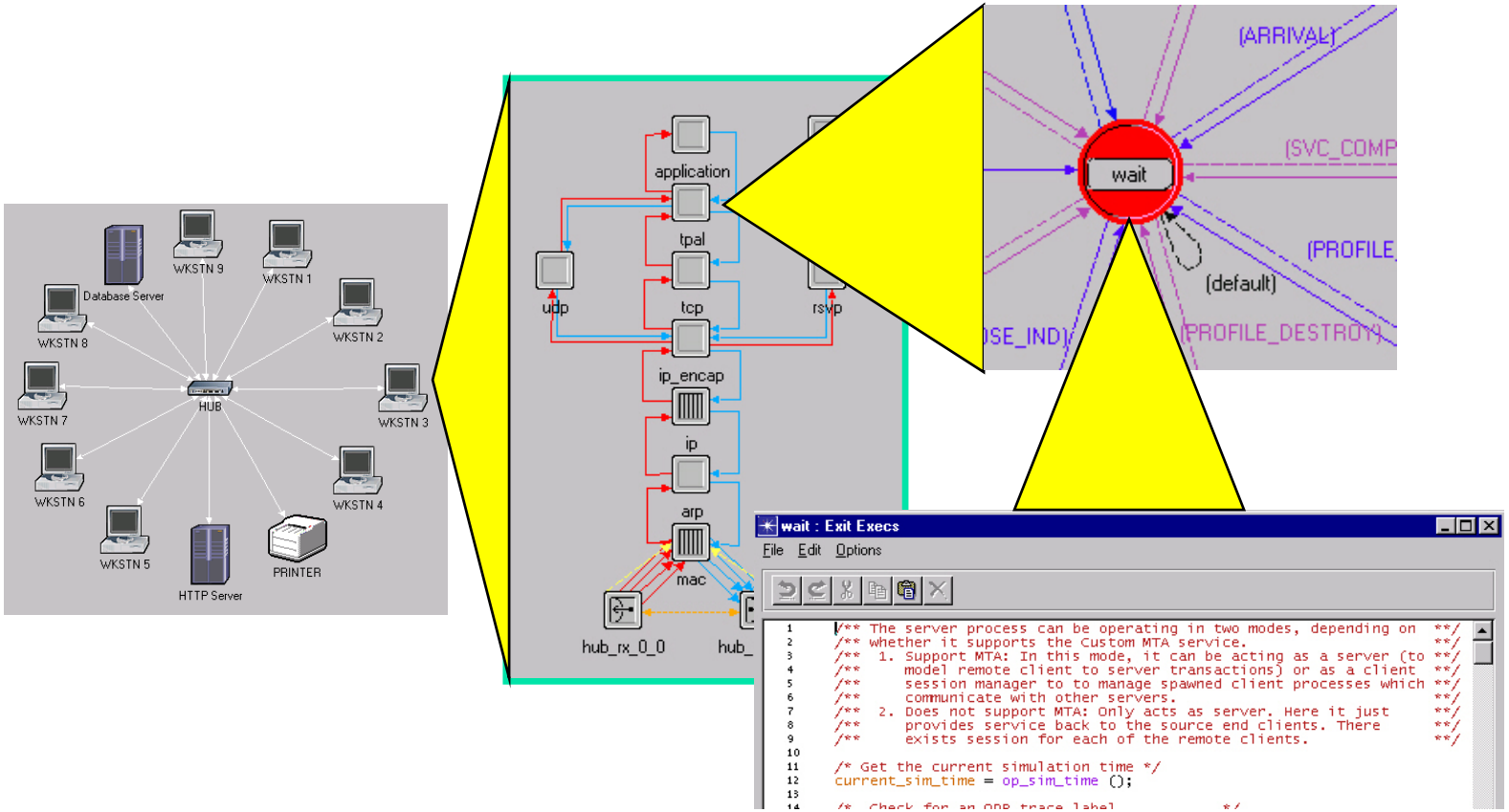
Node editor in OPNET

Process editor



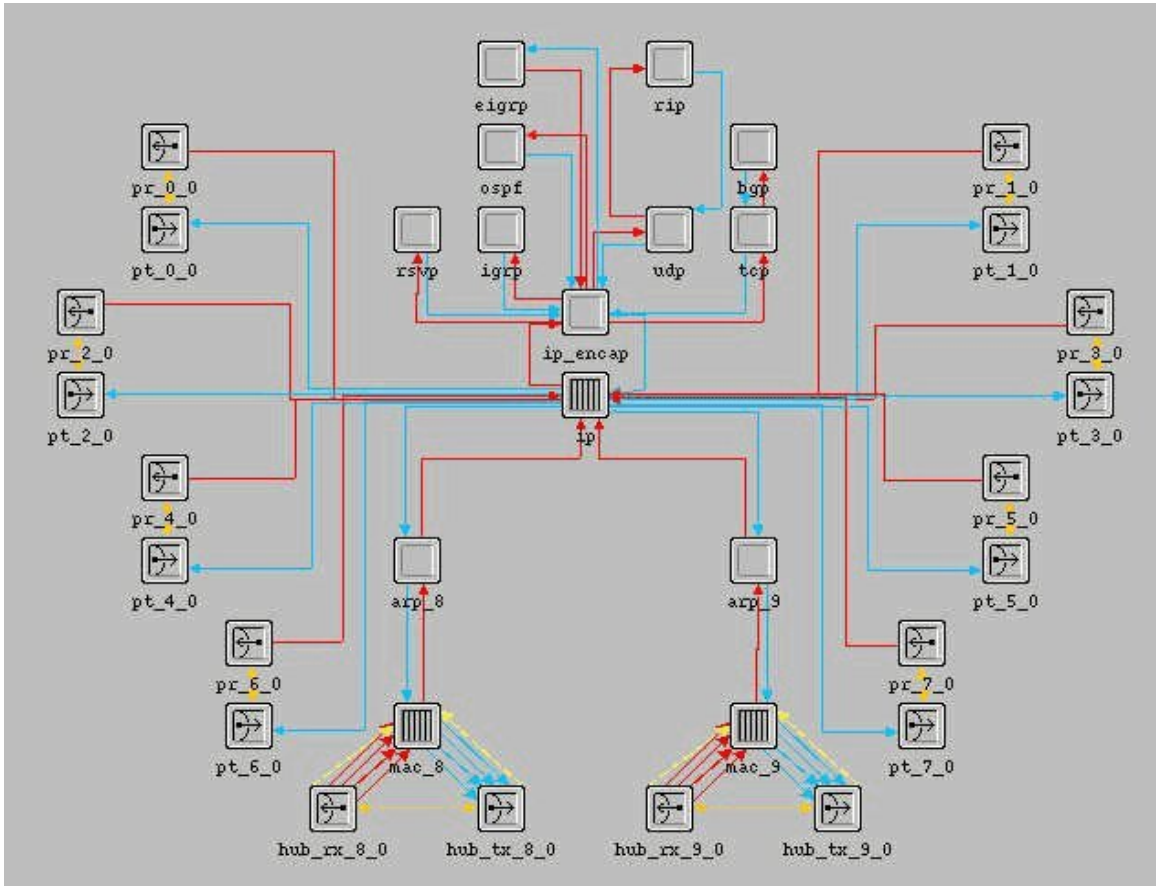
Node editor in OPNET

Modeling approach



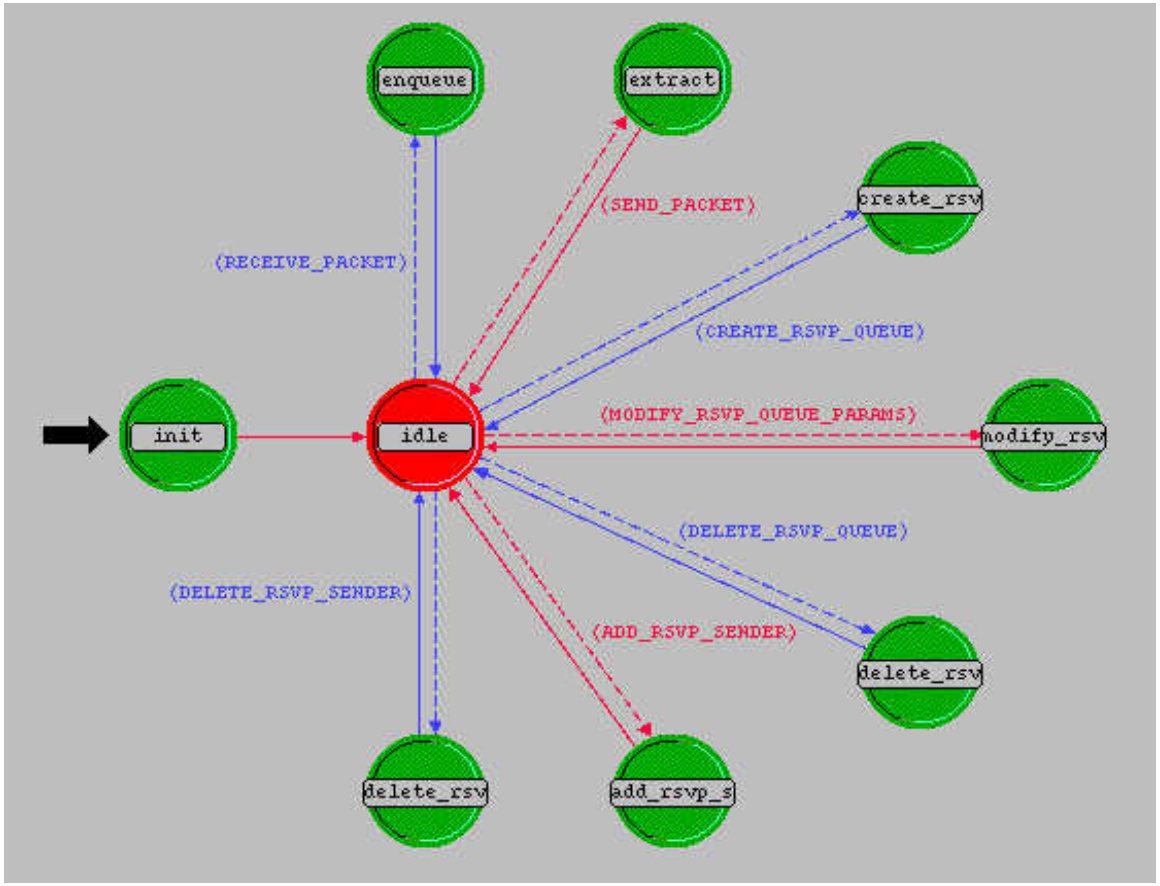
Interconnection of editors in OPNET

DRR implementation



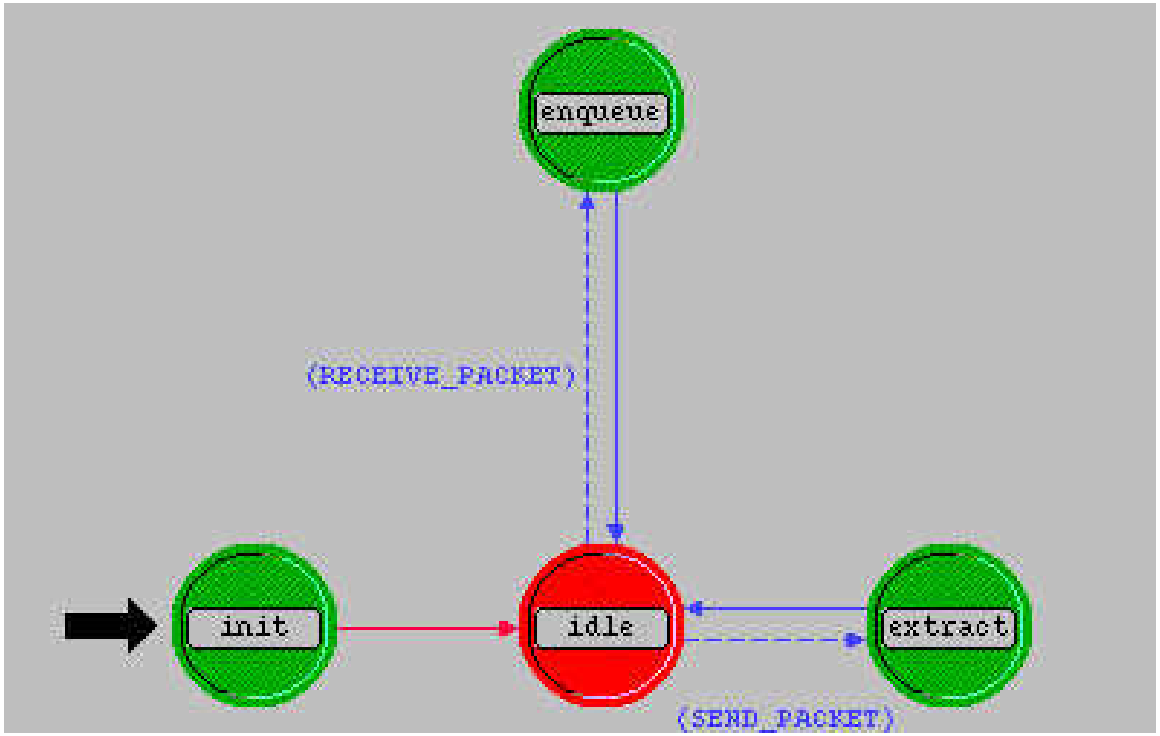
Hierarchical structure of IP router node model

DRR process model



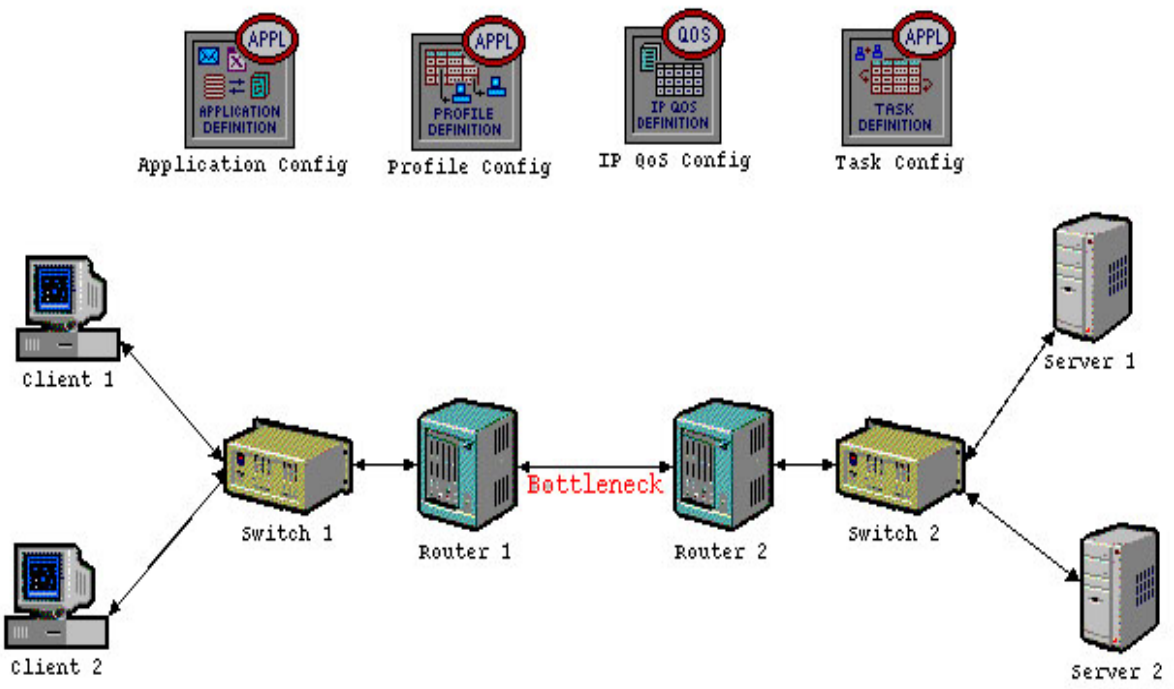
State transition of output interface process model

DRR process model



State transition of Deficit Round Robin process model

Simulation scenario

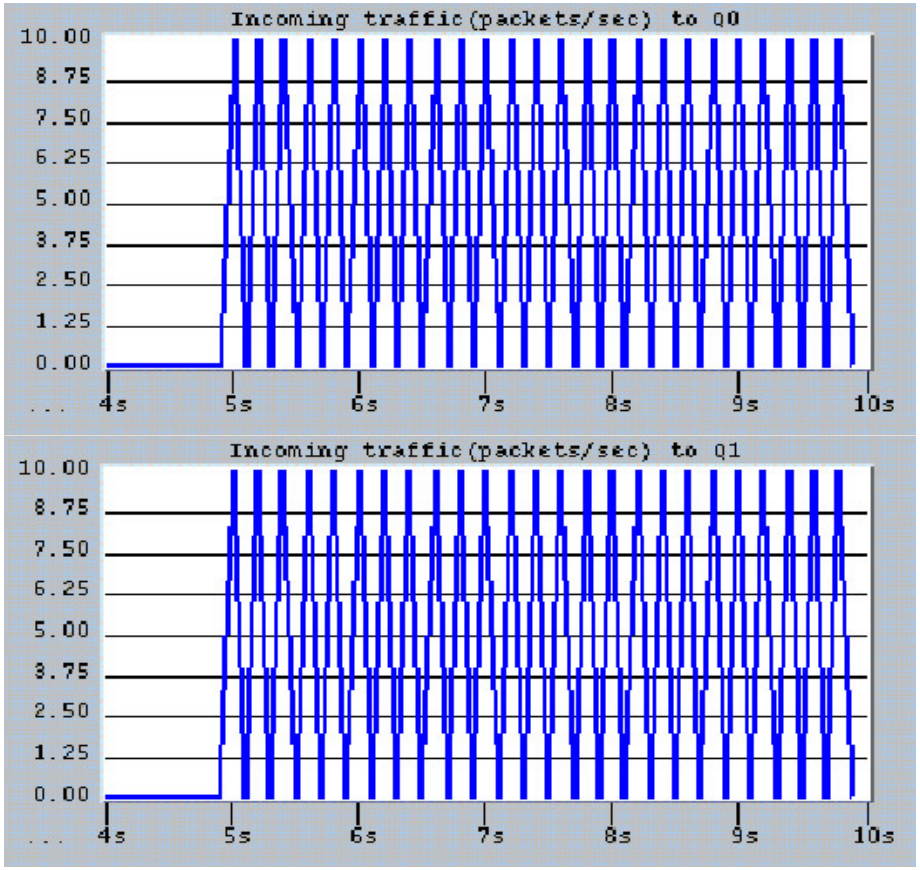


Simulation scenario for the Deficit Round Robin algorithm

Scenario 1

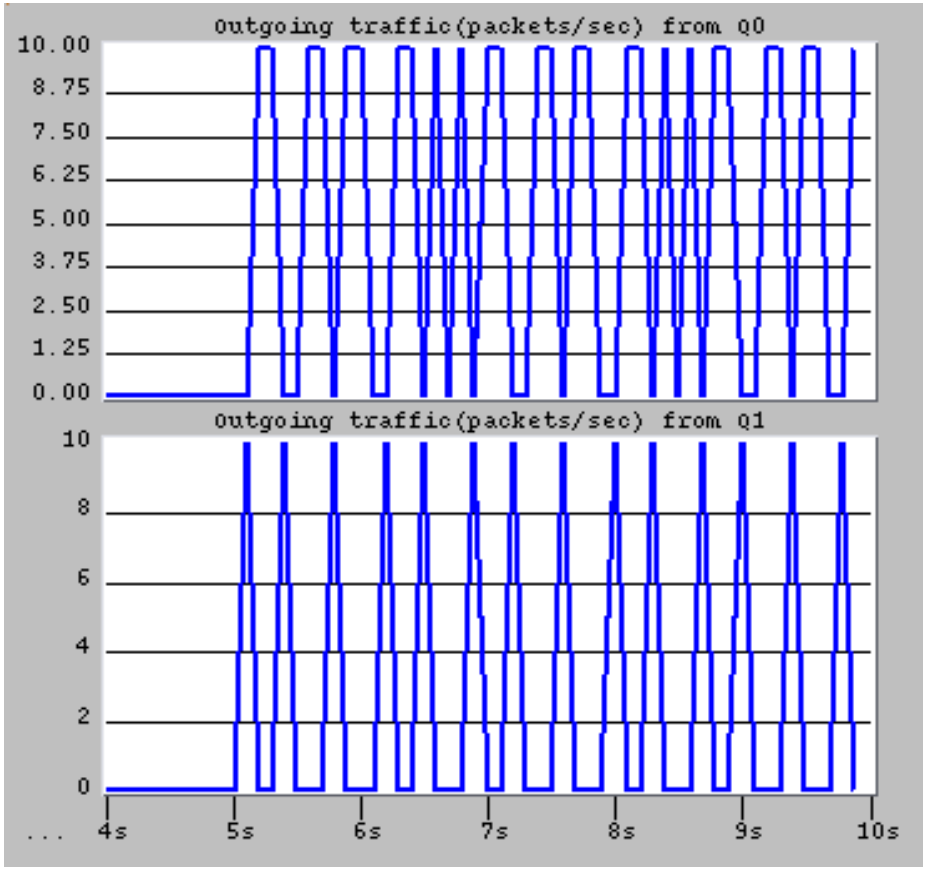
- Configuration:
  - Client 1: 5 packets/sec
  - Client 2: 5 packets/sec
  - packet size: 1,024 bytes for Client 1
  - packet size: 512 bytes for Client 2

Scenario 1: results



Arriving packets to queues Q0 and Q1 vs. time

Scenario 1: results

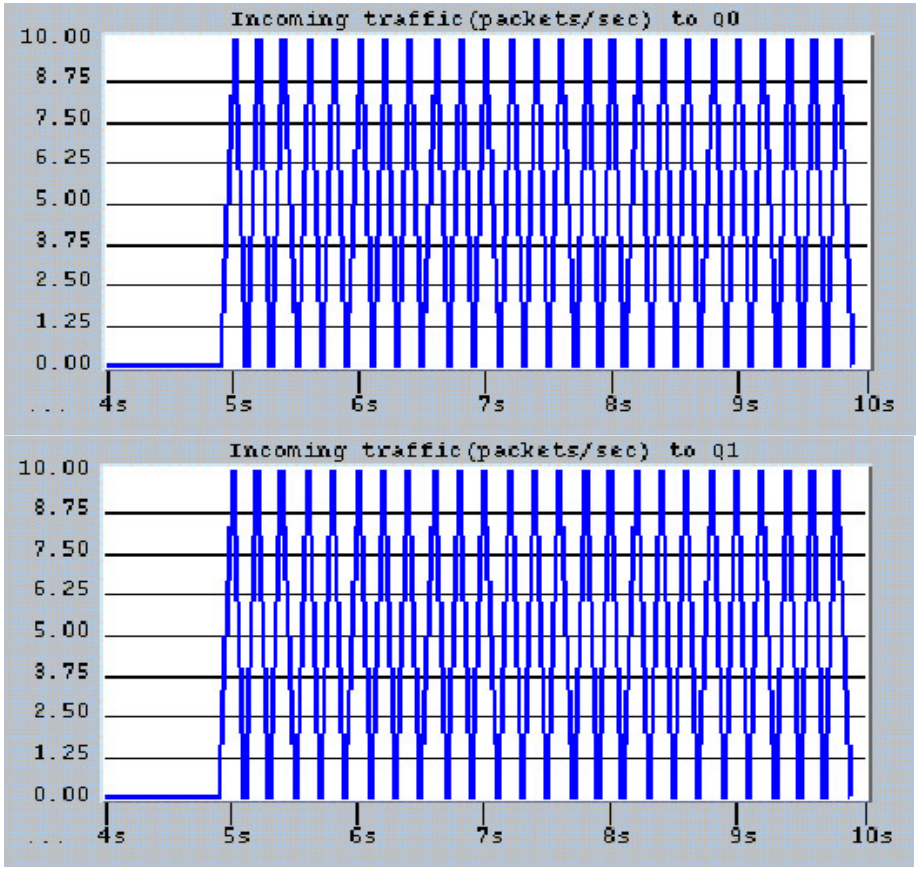


Outgoing packets from queues Q0 and Q1 vs. time

Scenario 2

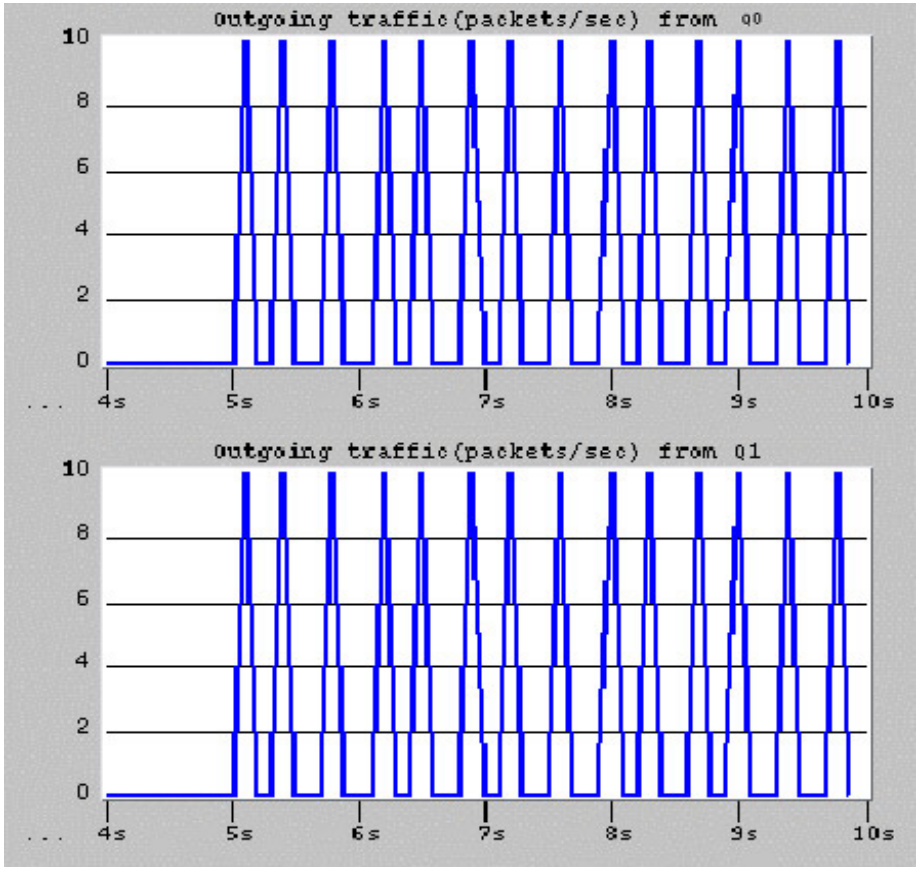
- Configuration:
  - Client 1: 5 packets/sec
  - Client 2: 5 packets/sec
  - packet size: 512 bytes for Client 1
  - packet size: 512 bytes for Client 2

Scenario 2: results



Arriving packets to queues Q0 and Q1 vs. time

Scenario 2: results



Outgoing packets from queues Q0 and Q1 vs. time

Conclusions

- 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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