OPNET Technologies, Inc.

OPNETWORK2011

Session 1020

Academic Instruction Using OPNET Software

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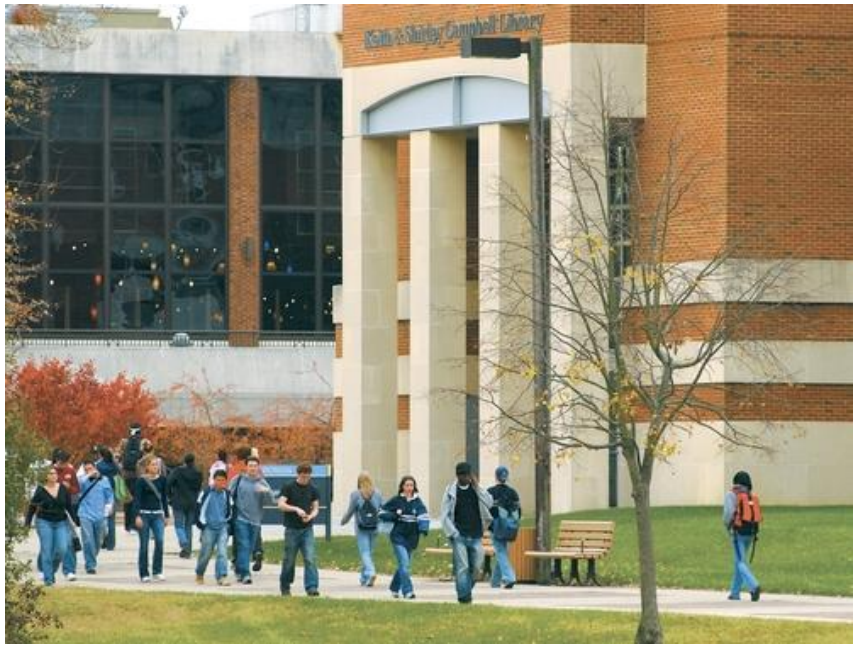
About Rowan University

- Founded 1923
- Located in Glassboro, NJ
- Provides undergraduate and graduate education
- Over 11,000 students
- Student-faculty ratio 15:1



About Rowan University

US News & World Report

- Rank Rowan University in the "Top Tier" of Northern Regional Universities

U.S.News EDUCATION COLLEGES

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Rowan University

COLLEGE | GRAD SCHOOL | RANKINGS

U.S. News Best Colleges Rankings

#23 Regional Universities (North)

Best Undergraduate Engineering Programs
At schools where doctorate not offered

#2 Chemical
At schools where doctorate not offered

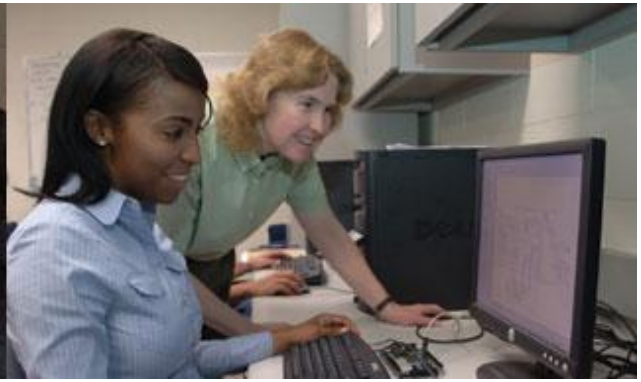
#10 Mechanical
At schools where doctorate not offered

#3 Top Public Schools

About Computer Science Department at Rowan University

- 11 full-time faculty
- Over 270 undergraduate students
- Around 20 graduate students
- M.S., B.S./M.S. programs
- No Ph.D. program
- Using OPNET since Fall 2003





Introduction: Why Use OPNET In Undergraduate Education?

- More effective, hands-on undergraduate education
- Ability to illustrate and try theoretical concepts with OPNET software
- New type of student
  - Task-oriented
  - Likes to try things out
  - Interested in hands-on activities rather than pure lecture
- Computer Science is active learning discipline
  - OPNET is a tool that enables active learning in the classroom

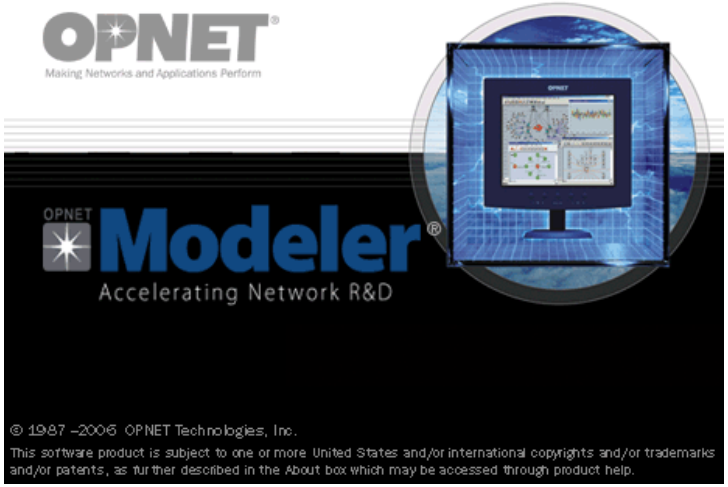
Introduction: Why Use OPNET In Undergraduate Education?

- Can help illustrate networking concepts
  - Various network phenomena
  - Performance comparison
  - Network configuration
- Students can work with networks and devices that are generally unavailable
- Actively involves students in learning process
- Increases student's interest in the subject
- Help understand the concepts discussed in class

Introduction

- Challenges of using OPNET in undergraduate education
  - Time and difficulty of learning all needed aspects of the software
  - Frequent software updates
- What OPNET software is appropriate for undergraduate education?
  - OPNET IT Guru
  - OPNET Modeler
  - ACE and Wireshark
- How to use OPNET in undergraduate education?
  - In class examples
  - Laboratory assignments
  - Research projects

OPNET Products For Undergraduate Education



- IT Guru and Wireshark
  - Relatively simple to use
  - Can be easily integrated into classroom
- Modeler
  - Steep learning curve
  - Can be used for independent research projects
- ACE
  - Specific to application
  - Can be used for independent research projects

Using OPNET In Undergraduate Education

- Appropriate for undergraduate and graduate networking courses
- Plan for introducing OPNET in the classroom:

1. Introduction to modeling and simulation with OPNET
   - **Topics**: What is modeling and simulation? Why is it needed? Overview of OPNET architecture and file structure.
   - **Duration**: 1 lecture.
2. Using OPNET Software
   - **Topics**: working with scenarios and projects, creating network topology, developing and deploying network applications, configuring individual network technologies, configuring and executing simulation model, and collecting and interpreting the simulation results.
   - **Duration**: 2 lectures
3. Advanced Topics:
   - **Topics**: coincide with material covered in class
   - **Duration**: as needed, ½ or ¼ of the lecture period.

Using OPNET In Undergraduate Education

- Important OPNET topics to be covered in class:
  - Creating scenarios/projects
  - Configuring Network Topology
  - Specifying traffic sources
    - Explicit Traffic Sources
    - Traffic Demands
    - Standard and Custom applications (e.g. applications and profiles)
  - Running simulation and collecting/analyzing results
  - Configuration of specific advanced technologies
- Good idea to
  - Provide several in-class examples
  - Give homework or laboratory assignments to reinforce understanding

OPNET Laboratory Assignments

- List of contributed OPNET laboratory assignments:

  http://www.opnet.com/university_program/teaching_with_opnet/textbooks_and_materials/index.html

- Frequent issues with available OPNET laboratory assignments:
  - Written for free educational version of OPNET IT Guru (i.e., version 9.1)
  - Laboratory assignments are tedious
    - Consist of exact step-by-step instructions
    - Easy to make a mistake or skip the step
    - Hard to debug
    - Do not teach students how to use OPNET software
    - Do not challenge the students
    - Students are focused on precisely following the steps instead of thinking about what they are doing

"The Practical OPNET User Guide for Computer Network Simulation"

- We try to address these issues in the book
- The book is divided into two portions:
  - Main part:
    - Careful account of available OPNET features and
    - Detailed description of steps for creating simulation using OPNET software
  - Practical laboratory assignments part:
    - Contains laboratory assignments which illustrate various OPNET features discussed in the main portion of the book
    - Each lab separates the design and objectives of the simulation study from the specifics of OPNET GUI.
    - Each lab contains references to the main part of the book which contains the instructions for configuring the necessary OPNET features

"The Practical OPNET User Guide for Computer Network Simulation"

- Practical laboratory assignments:
  - Do not provide step-by-step instructions
  - State assignment tasks in a form of objective (e.g. create the following topology, configure the protocol as follows, etc).
  - First few laboratory assignments are dedicated to teaching basic OPNET features
  - Remaining assignments concentrate on advanced OPNET features and specific networking technologies
  - The majority of the laboratory assignments are complete separated from OPNET GUI

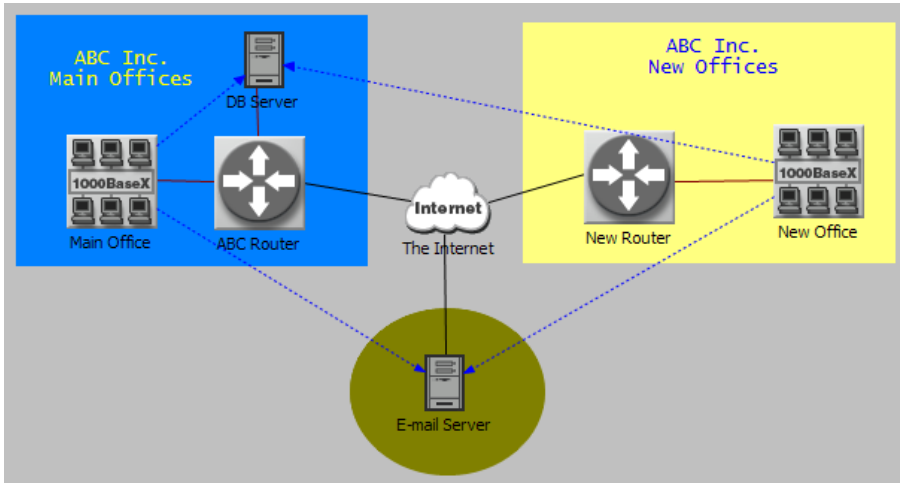
List of Practical Laboratory Assignments

1. Introduction to OPNET (traffic generation parameters)
2. Simple Capacity Planning (traffic flows)
3. Introduction to Standard Applications
4. HTTP Performance
5. Modeling Custom Applications
6. Influence of the Maximum Transfer Unit (MTU) on Application Performance
7. Transport Protocols – TCP vs. UDP
8. TCP Features
9. IP Addressing and Network Address Translation (NAT)
10. Routing with RIP
11. Routing with OSPF
12. Providing Quality of Service Support
13. Ethernet
14. Wireless Communication

Example of Laboratory Assignment: *Simple Capacity Planning*

- Assignment:
  - *ABC Inc., a small private company, is in the process of expansion and would like to add another office located on the other end of town. The company plans to double the new office size in the future. In this laboratory assignment you will help ABC Inc. to determine the best option for provisioning the links connecting their offices to the Internet.*

- Network configuration:



Object Name	Object Model
DB Server	*ethernet_server* node object
E-mail Server	*ppp_server* node object
Main Office New Office	*1000BaseX_LAN* node object
ABC Router New Router	*ethernet4_slip8_gtwy* node object
The Internet	*ip32_cloud* node object
Main Office <-> ABC Router Link DB Server <-> ABC Router Link New Office <-> New Router Link	*1000BaseX* link object
ABC Router <-> The Internet Link New Router <-> The Internet Link	*PPP_DS1_int* link object
The Internet <-> E-mail Server Link	*PPP_DS3* link object

Example of Laboratory Assignment: *Simple Capacity Planning*

- Configuration Steps:
  - *Create a new project and empty scenario named **Assignment 02** and **ABC_Network** respectively (Section 1.6.2).*
  - *Create the network topology as shown in Figure L2.1. Make sure that you use node and link models as specified in Table L2.1 (Section 2.4).*
  - *Verify link connectivity (Section 2.6.2).*
  - *Add and configure traffic demands (Section 6.6). Add and configure four **ip_traffic_flow** demand models as follows:*
    - *All demands should be configured to have 1.0% of traffic modeled as explicit traffic (attribute **Traffic Mix**).*
    - *All demands should start transmitting data at time 100 seconds.*
    - *All demands should continue transmitting data until the end of simulation.*
    - ***Main Office → DB Server** and **New Office → DB Server** IP demands transmit data at constant rates of 1200 Kbps and 100 packets per second respectively.*
    - ***Main Office → E-mail Server** and **New Office → E-mail Server** IP demands transmit data at constant rates of 800 Kbps and 10 packets per second respectively.*

Example of Laboratory Assignment: *Simple Capacity Planning*

- Configuration Steps:
  - *Configure your simulation to collect the following statistics:*
    - *All **Demand** Statistics (Section 6.8).*
    - *All **Link** statistics in the category **point-to-point** (Section 4.2.3).*
  - *Execute the simulation for 1 hour (Section 4.3.7) and then examine the following collected statistics (Section 4.5):*
    - *Traffic sent by each of the traffic demands.*
    - *Utilization on all the links connected to The Internet node.*
    - *Traffic received by each of the demand destinations.*
    - *End-to-end delay experienced by the demand packets. Note that if you did not configure your demands to generate traffic explicitly (i.e., set Traffic Mix attribute to a value greater than 0%), then this demand statistic will report no data.*

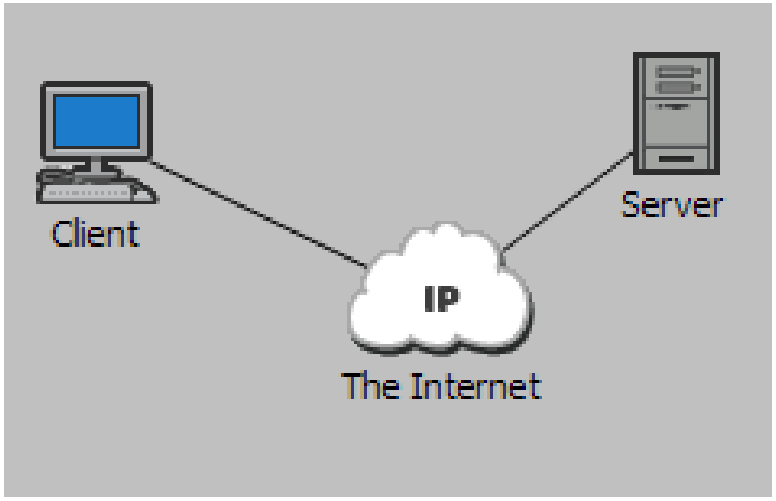
Example of Laboratory Assignment: *Simple Capacity Planning*

- End of the lab questions:
  - *What was the traffic sending rate by each demand? Did the simulation results correspond to the demand configuration?*
  - *What was the utilization on the links connected to The Internet? Why? (Hint: What are the capacities of 1000Base-T, DS-1 and DS-3 links? What are the transmission rates of each demand?)*
  - *What was the rate at which traffic arrived at each demand's destination? Why?*
  - *What was the packet end-to-end delay for each of the demands? Why?*
  - *In your opinion, what is the problem with the current network configuration? Which link in the network is the bottleneck?*

Example of Laboratory Assignment: *TCP Features: Nagle's algorithm*

- Assignment:
  - *Nagle's algorithm addresses the issue of small packet size. Instead of immediately transmitting small data packets, each of which would carry 40 bytes of TCP and IP header information, Nagle's algorithm suggests buffering the data until the application provides more data to transmit or until all of its outstanding packets have been acknowledged. In this portion of the assignment, you will examine how Nagle's algorithm influences the application delay and the amount of traffic sent over the wire.*

- Network configuration:



Object Name	Object Model
Client	*ppp_wkstn* node object
Server	*ppp_server* node object
The Internet	*ip32_cloud* node object
All links in the network	*PPP_33K* link object

Example of Laboratory Assignment: *TCP Features: Nagle's algorithm*

- Configuration Steps:
  - *Create a new project and an empty scenario named **Assignment 08** and **Nagles Algorithm**, respectively (Section 1.6.2).*
  - *Create the network topology as shown in Figure L8.1 using node and link models specified in Table L8.1 (Sections 2.3 and 2.4). Verify link connectivity (Section 2.6.2).*
  - *Add **Application Config** and **Profile Config** node objects.*
  - *Create a **Remote Login** application, let us call it **Telnet**, which generates 1 byte commands to and from the terminal (Section 5.4.6).*
    - *To simplify the data analysis, use a constant distribution to specify the size of the command.*
    - *Promote the attribute **Inter-Command Time (seconds)** by clicking the button **Promote**.*
  - *Configure a profile, let us call it **Telnet User**, that runs the **Telnet** application with the default setting (Section 7.2).*
  - *Deploy the defined profile in the network so that **Client** operates as source and **Server** is a **Remote Login** server for the **Telnet** application (Section 7.4).*

Example of Laboratory Assignment: *TCP Features: Nagle's algorithm*

- Configuration Steps:
  - *Specify the node configuration as follows:*
    - *Set packet latency in The Internet node to 100 milliseconds by specifying the value of the attribute **Performance Metrics…Packet Latency (secs)**.*
    - *Promote the attribute **TCP…TCP Parameters...Nagle Algorithm** at both Client and Server nodes.*
  - *Configure the simulation to collect the following statistics:*
    - ***Response Time (sec)** from the Client Remote Login node statistic category.*
    - *All **point-to-point link** statistics.*
  - *Specify the values of the promoted attributes as follows:*
    - *Set the value of the **TCP Parameters...Nagle Algorithm** attribute to **Disabled** and **Enabled**.*
    - *Set the value of the attribute **Inter-Command Time** to **exponential (0.1)** and **exponential (10)**.*
  - *Run the simulation for 1 hour.*

Example of Laboratory Assignment: *TCP Features: Nagle's algorithm*

- End of the lab questions:

Examine the application response time and display a graph for the following four situations:

- *Nagle's algorithm is disabled and inter-command time is set to 0.1 seconds.*
- *Nagle's algorithm is enabled and inter-command time is set to 0.1 seconds.*
- *Nagle's algorithm is disabled and inter-command time is set to 10 seconds.*
- *Nagle's algorithm is enabled and inter-command time is set to 10 seconds.*

- How does the application response time vary when Nagle's algorithm is enabled and when it is disabled? Why?
- Which of the above four scenarios resulted in the lowest and in the highest application response time? Why?

Example of Laboratory Assignment:
TCP Features: Nagle's algorithm

- End of the lab questions:

Examine the throughput on the link between **Client** and **The Internet**, display a graph that compares the link throughput in the above four scenarios, and answer the following questions:

- How does the link throughput vary when Nagle's algorithm is enabled and when it is disabled? Why?
- Which of the above four scenarios resulted in the lowest and in the highest throughput on the link between **Client** and **The Internet**? Why?

Challenges Of Using OPNET

- OPNET frequently releases new versions of its software
- However, new releases
  - Contain few GUI changes
  - Are mostly backward compatible
  - Configuration steps used in previous releases are still applicable
- Thus
  - Most of the described features and configuration steps will be available and applicable to the new software releases
  - The majority of laboratory assignments will remain unchanged

QUESTIONS?