Operational Experience With a Virtual Network Laboratory

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SIGCSE Paper

- Operational experience
  » Open Network Laboratory (ONL), a virtual laboratory
- Educational opportunities and challenges
  » ONL’s large feature set
    • monitoring/displays, control knobs
  » research (custom) hardware/software
  » only four routers
- Course support from ONL staff
- Instructor considerations
  » mental model vs ONL conceptual model
    • subtle differences
- Instructor interaction data
  » with students, with ONL staff
Visible Signs of Student Thinking?

- Instructor e-mail interaction (SIGCSE paper)
  » are students more engaged? think more precisely?
- Experience of undergraduate students with ONL
  » how do undergraduates learn? (surveys, interviews)
- Networking concept inventory
  » are results similar to those in intro physics courses?
- Extreme concept quizzes
  » what can students learn with partial knowledge?
- Session-sharing and session-recording tools
  » where/how are students going wrong?
- Tutorial search statistics
  » where is help most needed?
UMass Interaction Data

ONL-Based:

- Student (not lab)
- Student (lab)
- Lab staff

Traditional:

- Student (not lab)
- Student (lab)
- Lab staff

Number of emails over time:
- Course start
- Lab 1 due
- Lab 2 due
- Lab 3 due
- Lab 4 due
- Course end
Undergraduate Students in Networking

Fall 2007 networking course (undergrads)
  » four (4) ONL labs
    • students submitted lab reports
  » almost weekly concept quizzes
  » Lab 2 involved modifying client/server program
  » six students interviewed about first two labs

Selected observations:
  + very little trouble using the GUI to build a network
  + viewed experience with real hw/sw as positive
  – most didn’t do analysis prior to writing lab report
Example

- Queueing behavior?
- Effect of interference?
- Design of reliable delivery protocols?
- Forward error correction network plugin?
Related Activity

- Core concept lecture on pkt queuing
  - Operational definition of queuing
  - Packet-time view of queuing
  - ONL monitoring
- Concept quizzes
- Paper-pencil exercises
- Lab assignment (given traffic generator)
  - Base line experiment (verify example analysis)
  - Basic exploration experiments (e.g., queue size)
  - Multiflow experiments
- Sender/Receiver programming
- Design an experiment ...
The Concept Quiz in Networking

Inspired by concept inventory in physics
  » Questions avoid plug-and-chug

Our experience
  » Summer 2007
    • Wrote question bank of network physics questions
    • Reviewed by two networking instructors
  » Aug 2007
    • Piloted questions with 5 graduate assistants
  » Fall 2007
    • Some questions used in undergraduate networking course as prelude to lab assignments

Observation
  » Difficult problems: Students tried to use the find-the-right-equation approach ... like physics students
  » Many students were having problems with some labs
A Traditional Concept Quiz Question

- Host A sends two large packets back-to-back to Host B with pkt lengths 2L and then L/2.
- Which statement is true of the second packet if no losses occur?
  a) It will have queueing delays at both R1 and R2.
  b) It will NOT have a queueing delay at R1 or R2.
  c) It will have a queueing delay at R1 but not at R2.
  d) It will have a queueing delay at R2 but not at R1.
  e) None of the above.

C = link capacity
P = propagation delay
An Extreme Concept Quiz Question

Traffic: Host A sends 1000-byte pkts to B using a tripling slow-start algorithm until an ACK pkt is lost.

Goal: Determine the sequence number of the first pkt that will be dropped if the R1 queue can hold 10 MB

Questions to students:
» What principles apply?
» Give bounds on the solution.
» Sketch graphs of the key traffic rates and queue lengths.

You have 10 minutes!

Team solutions in next class
The Extreme Concept Quiz

■ Motivation
  » Lab assignments: reflection and integration
  » But some students couldn’t make forward progress if they encountered a problem

■ Extends
  » Concept inventory + peer instruction
    • Class takes concept quiz (label answer with confidence level)
    • Students can change answer after discussing with another student

■ Instructional Goals
  » Identify misconceptions
  » Peer instruction
  » + Make forward progress even with incomplete info
The Lab Solution

10 Mbps link

sndr

rcvr

theory: pkt 16,499

RTT log file

pkt 16,499

10 Mbps link

30 Mbps

10 Mbps link

sndr

rcvr

RTT log file

See rttlog.txt file for RTT log
Running the ONL Experiment

Peak RTTs (max RTT & sn, min RTT  & sn) :
843  120  799  121
929  363  799  364
1188 1092  799  1093
1666 3279 1750 3280

See rttlog.txt file for RTT log
onl1012> exit
logout
Connection to onl1012 closed.
onlusr> ssh $nip2
Last login: Wed Mar  5 16:15:11 2008 from
onlusr.arl.wustl.edu
onl1012> cd src/sigcse08/
onl1012> s:
onl1012> snd:

onl1011> s:
onl1011> rcv:
rcvr_accept = 0
first reject at sn = 16495

onl1011> exit
logout
Connection to onl1011 closed.
onlusr> ssh $nip3
Last login: Wed Mar  5 16:15:16 2008 from
onlusr.arl.wustl.edu
onl1011> cd src/sigcse08/
onl1011> s:
onl1011> rcv:
On-Going/Future Work

- Session-sharing
  - beta version within weeks
- Session-recording
  - beta version within weeks
- Network-processor routers (14)
  - spring 2008 adv architecture course
- Helper vs Wiki
  - fall 2008
- Instructor resources
  - concept quiz bank
  - lab assignments and solutions
  - active learning orientation
  - in progress for fall 2008
14 New Network-Processor Routers

- Configure with RLI
- Multithreaded plugins

IXP 2800 Network Processor

TCAM

3 RDRAM banks

10x1 GbE IO Card
The End

online.wustl.edu or www.online.wustl.edu

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