

EECS 863

Network Analysis, Simulation, and Measurements

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Course Information

- Semester: Spring 2015
- Text: "Queueing Modeling Fundamentals: With Applications in Communication Networks", 2nd Edition Chee-Hock Ng and Soong Boon-Hee, ISBN: 978-0-470-51957-8, 2008
- Alternate and Reference Texts:
 - "Computer Networks and Systems: Queueing Theory And Performance Evaluation", 3rd ed., T. G. Robertazzi, Springer, 2000.
 - "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design Measurement, Simulation, and Modeling," R. Jain, Wiley- Interscience, New York, NY, April 1991.
 - "Queueing Systems, Volume I and II", Leonard Kleinrock, Wiley, 1975.
 - "Internet Measurement: Infrastructure, Traffic and Applications" Mark Crovella, Balachander Krishnamurthy, Wiley, 2006
 - Simulation Modeling and Analysis 4th Edition, Averill Law, McGraw Hill, 2007.
 - Discrete Event Simulation using ExtendSim 8, Jeffrey Strickland, Lulu, 2011

Course Information

- Class Web Page:

http://www.ittc.ku.edu/~frost/EECS_863/index_Spring_2015.htm

- Office hours and Contact Information:

- 8:30 - 9:15 & 11:00-12:00 TR 2001 Eaton Hall

- Other times by appointment

- Phone:

- Eaton 864-4486

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Course deliverables

- Exams: 2 in class tests (open book & notes)
- Homework: problems will be assigned.
- Grading:
 - 2 - In class tests; open book & notes = 160 (80 points/test)
 - 2 - projects = 160 (80 points/project)
 - Homework = 80 points
 - Paper & Presentation = 120 points
 - Class participation & attendance = 40 pts
 - No Final
- Produce a written review and make an oral presentation to the class of a published paper, the paper will be selected by the student or execute a substantial measurement/simulation project, write up the results, and make an oral presentation to the class. The paper or project must be selected and approved by March 3, 2015.
- General guidelines: Only under very extreme conditions will make up tests be given. No late homework will be accepted

Tools Used for Class Assignments

- Wireshark
 - <http://www.wireshark.org/>
 - Free software at <http://www.wireshark.org/>
 - Install on your own machine, need to install and run as administrator
- Simulation: ExtendSim
 - Installed on all EECS Windows computers ← Suggest you use
 - <http://www.extendsim.com/>
 - Limited free version at:
http://www.extendsim.com/prods_demo.html
 - Can not save & print models
 - ExtendSim LT \$50.00 [not required]
- Wolfram CDF Player
 - Interactive documents
 - Installed on all EECS Windows computers
 - <http://www.wolfram.com/products/player/>

Initial Grading Scale

- 90 - 100 % A
- 80 - 89 % B
- 70 - 79 % C
- 60 - 69 % D
- 0 - 59 % F

Why Do Performance Analysis?

- System design
- Understand system behavior
- Understand system trade-offs
 - Cost vs Performance
- System management
 - “you can only manage what you can measure”
Tom Peters
- Guide system evolution

Role of Models

- Models are abstract descriptions of the physical world.
- Models are used to predict future system behavior.

Model Inputs

- Inputs
 - Controllable system parameters
 - Min/max packet size
 - Maximum burst size
 - Link capacities
 - Buffer size
 - Queue service disciplines
 - Queue priorities
 - Routing
 - Window size
 - Transmit signal power
 - Receiver sensitivity
 -
 - Traffic (workload)
 - Number of traffic sources
 - Packet size pdf
 - Packet interarrival time pdf
 - Geographical distribution of traffic sources
 - Motion of traffic sources
 -
 - Environmental parameters
 - Noise environment
 - Fading environment
 -

Model Outputs

- Outputs
 - Throughput
 - b/s
 - Packets/sec
 - Normalized throughput, S
 - Delay
 - Average Delay
 - Variance (SD)
 - pdf of delay
 - Loss
 - Others.....

Modeling Approaches

- Closed form mathematical models (analytical)
- Simulation
- Measurement- Empirical

Steps in Performance Analysis

- Understand who is the customer and what is their expectation
- Clearly define goals for the analysis, what is the question to be answered
- Define the system
- Articulate the outcomes of the analysis
- Select metrics (outputs)
- Select fixed system parameters
- Select system variables (factors) to study (define the x-y axis on output performance plots)
- Select environmental parameters
- Select traffic model (workload)
- Select modeling approach (evaluation technique)
- Clearly state and understand modeling assumptions
- Design and execute the analysis, e.g., simulation experiments
- Analyze and interpret data
- Present results
- Plan for success, the customer will say, “that is informative, but can you answer this related question.....”

Common Mistakes in Evaluation

- No goals, question is not well defined
- Biased goals: ``to show that OUR system is better than THEIRS''
- Lack of in-depth understanding of the system
- Selection of wrong evaluation technique
- Analysis without understanding the problem
- Selection of inappropriate performance metrics
- Selection of inappropriate traffic models
- Overlook important system or environmental parameters
- Focus on insignificant factors while missing important ones
- Inappropriate experimental design – **you are an explorer; exploring the design space**

Common Mistakes in Evaluation

- Inappropriate level of modeling detail
- Flawed analysis
- Ignores system sensitivity to changes in factors
- Errors in specification of input parameters and range of factor values – Exploring wrong part of the design space
- Improper treatment of outliers
- No consideration of system evolution
- Lack of understanding the impact of assumptions and limitations of the evaluation methodology
- Poor and/or improper presentation of results

Checklist for Avoiding Common Mistakes

- Is the system correctly defined and the goals clearly stated?
- Are the goals stated in an unbiased manner?
- Is the problem clearly understood before analyzing it?
- Have all the steps of the analysis followed systematically?
- Are the performance metrics relevant for this problem?
- Is the traffic model correct for this problem?
- Is the evaluation technique appropriate?
- Is the list of parameters that affect performance complete?
- Have all the important factors been identified?

Checklist for Avoiding Common Mistakes

- Is the experimental design efficient in terms of time and results?
- Is the level of detail proper?
- Is the measured data presented with analysis and interpretation?
- Is the analysis statistically correct?
- Has the sensitivity analysis been done?
- Would errors in the input cause an insignificant change in the results?
- Have the outliers in the input or output been treated properly?
- Has the evolution of the system and traffic been considered?
- Has the variance of input been taken into account?

Checklist for Avoiding Common Mistakes

- Has the variance of the results been analyzed?
- Is the analysis easy to explain?
- Is the presentation style suitable for its audience?
- Have the results been presented graphically as much as possible?
- Are the assumptions and limitations of the analysis clearly documented?

Course Outline

- Introduction
- Theoretical Background: Markov Processes
 - Obtain understanding of key assumptions
 - Learn terminology of Markov chains
 - Develop techniques to solve Markov systems
- Application of Markov Processes to Queueing and Blocking Systems
 - Blocking analysis
 - Delay analysis of queueing systems with Markov service process
 - Little's Result
- Application of Markov Process to systems with arbitrary service process
 - M/G/1 analysis
 - Develop the concept of Residual Life
 - Analyze M/G/1 systems with vacations
 - Analyze Priority Systems
 - Scheduling Algorithms

----- Exam 1

Course Outline

- Simulation of Communication Networks
 - Building simulation models
 - Verification and validation of communication network simulation models
 - Deriving statistically significant results from simulation models
- Network Measurements
 - Role of Measurements
 - What to Measure
 - How to Measure
 - Passive
 - Active
 - Role of time
 - Bandwidth measurements
 - How to plan for measurements
 - Measurement repositories

Course Outline

- Analysis of Networks of Queues
 - Analysis of open networks
 - Analysis of closed networks and application to analysis of window flow control techniques
- Topological Design of Networks.
- Routing Algorithms of Networks.

----- Exam 2