EECS 863
Network Analysis, Simulation, and Measurements

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Course Information

- Semester: Spring 2014
- 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”, 3nd 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.

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Course Information

- Class Web Page:
http://www.ittc.ku.edu/~frost/EECS_863/index_Spring_2014.htm

- Office hours and Contact Information:
  - 2:30 - 4:30 TR 3016 Eaton Hall
  - Other times by appointment
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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 1, 2014.

- General guidelines: Only under very extreme conditions will make up tests be given. No late homework will be accepted

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Initial Grading Scale

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

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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

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Role of Models

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

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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
    - ……

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Model Outputs

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

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Modeling Approaches

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

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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…..”

Modified From: R. Jain, "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design Measurement, Simulation, and Modeling," Wiley- Interscience, New York, NY, April 1991.

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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

Modified From: R. Jain, "The Art of Computer Systems Performance Analysis: Techniques for Experimental Design Measurement, Simulation, and Modeling," Wiley- Interscience, New York, NY, April 1991.

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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

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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?

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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?

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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?

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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

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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

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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

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