Course Title: EE465: “Probabilistic Methods in Computer Systems Modeling”

Semester: Fall Semester 2002

Lecture: Morning Session, TTH 11:00 AM-12:20 PM, OHE 100
Evening Session, TTH 5:00 PM-6:20 PM, SLH 100

Instructor: Professor A. Zahid

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Teaching Assistant: Mr. Marco Zuniga & Mr. Congzhou Zhou

T/A Office and Office Hours: EEB 201; Marco Zuniga, M 10:00 AM~12:00 PM;
Congzhou Zhou, W 1:00 PM~3:00 PM

Graders: Mr. Yossapon Sutharattanachaiporn, Miss Sonal Patil & Miss Yan Zhou

Grader Office and Office Hours: EEB 201; Yossapon, TTh 3.30 PM~4.30 PM;
Sonal Patil, W 11:00 AM~12:00 PM;
Yan Zhou, M 2:00 PM~3:00 PM

Grading: Midterm 40%, Final 40%, Simulation Task 10%, and HW 10%

Grading Scales: (85-100, A- to A), (70-84, B- to B+), (55-69, C- to C+),
(45-54, D- to D+), (0-44, F). There is absolutely no curve.

Required Textbook: Introduction to probability Models, 7th edition, by Sheldon Ross

Recommended Textbook: Queuing Systems, Volume 1, by L. Kleinrock

Exams Dates: Midterm, Oct 17; Final, Dec 12.
No Make-up exams no matter what your reasons are.

Homework: Assigned weekly. No late or electronic Homeworks are accepted. Remote Location students should contact DEN for a fax number or e-mail address.

**Catalog Description:**

Review of Probability; Random Variables; Stochastic Processes; Markov Chains and Queuing Theory. Applications to Program and Algorithm Analysis; Computer Systems Performance and Reliability Modeling. Prerequisite: MATH 407.

**Course Description:**

This is a senior-level course in performance modeling of computer systems and networks. It is designed to provide students with the necessary fundamental concepts and mathematical tools to conduct performance analysis. Both analytical models and simulation models are considered. To establish the necessary background, the course starts with basic probability theory, random variables, transform theory and discrete mathematics. It then builds up to the more advanced topics such as Markov models, single queue models and queuing networks. Several case studies shall be conducted throughout the course as they relate to different performance measures such as throughput, capacity, utilization, response time, data flow, shortest path routing, availability and reliability of computer systems and networks. The course assumes that the student have already studied calculus, discrete mathematics, basic probability (MATH 407 or EE464), have some knowledge of computer system architecture and have done some programming. This course will be extremely useful and necessary if you are planning to take EE549: Queuing Theory and EE550: Computer Communications, Analysis and Design, along with a group of graduate level courses in computer system architecture.
Course Outline

Introduction to Probability Theory and Random Variables

• Basic Probability Models
  * Review of Set Theory
  * Sample Space and Events
  * Laws of Probabilities
  * Conditional Probabilities
  * Independence
  * Bayes Theorem
  * Combinatorics: Deriving Discrete Probabilities

• Random Variables
  * Classifications of Random Variables
  * Discrete Random Variables
    ▪ The Bernoulli Random Variable
    ▪ The Binomial Random Variable
    ▪ The Geometric Random Variable
    ▪ The Poisson Random Variable
  * Continuous Random Variables
    ▪ The Uniform Random Variable
    ▪ The Exponential Random Variable
    ▪ The Normal Random Variable
  * Moments and Moments Generating Functions
  * Reliability Modeling

Introduction to Transform Theory

• Definition of a Transform
  * The $z$-Transform
  * The Laplace Transform
  * Transforms in Probability Theory

Markov Models

• Discrete-Time Markov Chains
  * State Classifications
  * Steady State Probabilities
  * Multi-step Transitional Probability Matrix
  * Mean First Passage and Recurrence Times

• Continuous-Time Markov Chains
  * Transition Rate Matrix
  * Steady State Probabilities
Introduction to Queueing Theory

• **Description and Classifications of Queues**
  * Population, Arrival Patterns, Service Time Distribution, System Utilization, Queuing Disciplines, etc…
  * Birth & Death Process Models, Little’s Formula
  * The M/M/1 Queuing Model
  * The M/M/∞ Queuing Model
  * The M/M/c Queuing Model
  * The M/M/1/K Queuing Model
  * The M/M/1/K/M Queuing Model
  * The M/D/1 Queuing Model
  * Priority Queuing
  * Networks of Queues : Open and Closed Networks, Jackson's Networks

Simulation Modeling

• **Generation of Random Numbers**
  * Uniform and Non-Uniform Distributions
  * Inverse Transformation Techniques
  * Accept/Reject Techniques
  * Composition Techniques

• **Programming Simulations**
  * Time-based Simulations
  * Event-based Simulations
  * Analyzing Simulation Results: Variability, Confidence Intervals, etc…
  * Case Study: Simulating an M/M/1 Queue

Introductory Topics in Internet Traffic Modeling

• **Overview of the Following Topics (Time permitting Only)**
  * Self-Similar Traffic Modeling
  * Brownian and Fractional Brownian Motion Processes
  * Long Range and Short Range Dependence
  * Heavy-Tailed Distributions-Pareto
  * Performance Issues in Self-Similar Traffic
  * On-Off Modeling of LAN Traffic
  * Packet-Voice Traffic Modeling