Advanced Topics in Stochastic Processes

(16:330:559:03 – Advanced Topics in Communication)
Fall 2013
Registration Index Number 40152

This course provides a graduate level introduction to systems and processes that are described by sequences of discrete events. Topics to be covered include Poisson processes, the renewal theorem, discrete and continuous time Markov chains, semi-Markov processes, time reversibility, martingales and large deviations. Applications to queueing, networks, optimization and gambling would be discussed. Understanding of this subject has become useful for the study of networks. The material is applicable to traffic modeling, performance analysis, and a variety of network resource allocation problems.

- **Text:** R.G. Gallager, *Stochastic Processes: Theory for Applications*, online at `http://www.rle.mit.edu/rgallager/notes.htm`.
- **Prerequisites:** Familiarity with probability and stochastc processes at the level of *16:332:541 Stochastic Signals and Systems*
- **Other Information:** One lecture/week, Monday 5-8PM, ARC-104 One take-home exam, one final examination.
- **Instructor:** Roy Yates (WINLAB, CoRe-515, ryates@winlab.rutgers.edu)

Approximate Weekly Outline (1-2 weeks per topic)

1. Review of probability: events, random variables, expectation, basic inequalities and limit theorems
2. Poisson Processes: definitions, combining and splitting, conditional arrival densities
3. Gaussian random vectors and processes: covariance matrices, conditional PDFs, Gaussian processes, circularly symmetric complex random vectors
4. Finite state Markov chains: state classification, matrix representation, Markov chains with reward, Markov decision theory
5. Renewal processes: strong law of large numbers, renewal-reward processes, stopping times
6. Countable state Markov chains: first passage times, renewal theory for Markov chains, reversibility, branching processes
7. Markov Processes with countable state space: steady state behavior, Kolmogorov differential equation, uniformization,
8. Random walks, large deviations, martingales: integer valued walks, G/G/1 queueing delay, threshold crossing probabilities, Wald's identity, submartingales, supermartingales, Markov modulated random walks