ECE1549 Stochastic Networks (Spring 2026)

An introduction to stochastic analysis techniques for complex networked systems, covering queueing networks, random graphs, and stochastic geometry. Main topics include Jackson and Whittle networks, reversible network processes, network utility maximization, stochastic network optimization, Erdős-Rényi and Gilbert models, graph evolution and connectivity, random subgraphs, random point processes, Laplace functionals, marked point processes, and Palm probability.

Pre-requisite: ECE537 (Random Processes) or equivalent with continuous-time Markov chains.

Instructor:
Ben Liang (http://www.comm.utoronto.ca/~liang)

Lectures:
Mondays 2 – 5 pm (starting January 12)

Approximate Schedule: (Topics are tentative and may be adjusted based on progress and interest.)
Part I: Markovian Queueing Networks
- Network of queues, Jackson and Whittle networks, stationary distribution of Jackson processes, invariant measure of Whittle processes
- Reversible queuing networks, blocking in Markovian queueing networks

Part II: Network Control and Optimization
- Network utility optimization, Chiu-Jain distributed control, Lyapunov stability, primal and dual algorithms, Kelly mechanism
- Stochastic network optimization, Lyapunov drift control algorithm, dynamic backpressure algorithm, drift-plus-penalty algorithm

Part III: Random Graphs
- Erdős-Rényi and Gilbert models, graph evolution, vertex degrees, graph connectivity
- Random subgraphs, inhomogeneous graphs, small-world models

Part IV: Stochastic Geometry
- Stochastic geometry, Poisson point processes, Laplace functionals, marked Poisson point processes, short-noise and interference
- Palm probabilities, Slivnyak theorem, marked Poisson point processes, short-noise and interference, Voronoi tessellation

Main References *(all available online)**:***
- F. Kelly and E. Yudovina, *Lecture Notes on Stochastic Networks*, Cambridge University Press, 2014.
- M. J. Neely, *Stochastic Network Optimization with Application to Communication and Queueing Systems*, Morgan & Claypool, 2010.
- A. Frieze and M. Karonski, *Random Graphs and Networks: A First Course*, Cambridge University Press, 2023.
- M. Haenggi, *Stochastic Geometry for Wireless Networks*, Cambridge University Press, 2012.

Optional References:
- R. Serfozo, *Introduction to Stochastic Networks*, Springer, 1999.
- R. Mazumdar, *Performance Modeling, Stochastic Networks, and Statistical Multiplexing*, 2nd Ed, Morgan & Claypool, 2013.

- F. Kelly, *Reversibility and Stochastic Networks*, Wiley, 1979.
- R. Srikant, *The Mathematics of Internet Congestion Control*, Birkhauser, 2003.
- S. Shakkottai and R. Srikant, "Network Optimization and Control," *Foundations and Trends in Networking*, vol. 2, no. 3, 2007, pp. 271 – 379.
- L. Georgiadis, M. J. Neely, and L. Tassiulas, "Resource Allocation and Cross-Layer Control in Wireless Networks," *Foundations and Trends in Networking*, vol. 1, no. 1, 2006, pp. 1 – 144.
- R. van der Hofstad, *Random Graphs and Complex Networks*, Cambridge University Press, 2016.
- F. Baccelli and B. Blaszczyszyn, "Stochastic Geometry and Wireless Networks Volume I: Theory," *Foundations and Trends in Networking*, vol. 3, no. 3-4, pp. 249 – 449, 2010.
- F. Baccelli and B. Blaszczyszyn, "Stochastic Geometry and Wireless Networks Volume II: Applications," *Foundations and Trends in Networking*, vol. 4, no. 1-2, pp. 1 – 312, 2010.

Grading:

Homework assignment (50%) and one survey report and presentation (50%).