Course description. Introductory course aimed at providing an analytic perspective to data networks with telephone networks and the Internet being primary applications. Basic tools for modeling and performance analysis will be taught accompanied by elementary, meaningful simulations. Insights will be developed for large networks by means of simple approximations. This self contained course will draw upon concepts from queueing and optimization.

Pre-requisite. Knowledge of basic probability (6.041/6.431) or instructor’s consent.

Grading policy. 6 home-works (20%), a mid-term (30%), and a final (50%).

Course staff. The contact information of course staff:

- Instructor. Prof. Devavrat Shah, 32-D670, x34670, Email: devavrat@mit.edu.

- TA. Tauhid Zaman, Email: zlisto@mit.edu.

- Admin. Lynne Dell, 32-D664, x23679, Email: ldell@mit.edu.

Course text. A combination of


Handwritten, electronic, detailed class-notes by the instructor.
Lecture schedule. The following is the lecture schedule.

- Introduction and fundamentals
  - [L1] Course logistics, History of communication, Overview and Little’s Law
  - [L2/L3] Markov chain, stationary distribution and balance equation, Geom/Geom/1 queue, M/M/1 queue, M/M/m/m queue, M/M/∞ queue.

- Telephone network and optimization
  - [L4] Loss network model, product form distribution, loss probability and Erlang’s formula, mean-field approximation for large network.
  - [L5] Elements of convex optimization

- Internet architecture: introduction
  - [L6] Packet switched (MUX effect), end-to-end philosophy, and layered physical (telephone, wireless, LAN, wired and optical); data (IP, routing); transport (TCP, UDP, congestion control); application (email, video, P2P); other architectural issues: security, QoS, provisioning.

- Physical: medium access protocols for wireless/(old)LAN
  - [L7] Slotted Aloha – 1/2e and 1/e results.
  - [L8] Slotted Aloha – mean-field model
  - [L9] Carrier Sense Multi Access (CSMA) protocol

- Physical: packet switched routers
  - [L10] Output queued switch architecture, Pollaczek Khinchine.
  - [L11,12,13] Input queued switch architecture, scheduling algorithm, fluid model and performance under overload.

- Physical: optical core architecture
  - [L14] Circuit-switched model and ‘burst’ switching

- Data: routing
  - [L15] BGP and shortest path algorithm
  - [L16] Ideal routing using flow level optimization model with cost inspired by PK formula; ‘selfish’ routing and relation to the ideal model, and correction.

- Data: congestion control
  - [L17] Windowed TCP, differential equation approximation, drop probability approximation under RED.
- [L19] Relation of TCP differential equation model and primal/dual algorithm; insights on design of ‘better’ congestion control; and overall routing, congestion control resource allocation.

- Some router algorithms

- Application
  - [L22] Server scheduling and load balancing. Mean-field analysis.