

Advanced Topics in Systems, Control and Learning (048715):

## **Control of Queues and Stochastic Systems**

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**Course Site:** <http://webee.technion.ac.il/people/shimkin/QC048715/>

**Prerequisites:** Random Signals (044202), or another course on stochastic processes.

**Description:** This course focuses on the optimal control of discrete-event stochastic systems, and in particular queueing systems. The theoretical framework is that of Markov Decision Processes, complemented by additional tools such as stochastic coupling. Also discussed are non-centralized decisions by rational (selfish) customers or servers, in the framework of non-cooperative game theory. Applications to communication networks, computing systems, and service systems will be discussed.

**Grades:** 50% homework, 20% class presentations, 30% TBD

### **Reference Texts:**

- E.A. Feinberg and A. Shwartz and, *Handbook of Markov Decision Processes*. Kluwer Academic, 2002.
- R. Hassin and M. Haviv, *To Queue or not to Queue: Equilibrium Behavior in Queueing Systems*. Springer, 2002.
- M.L. Pinedo, *Scheduling: Theory, Algorithms and Systems*, 3<sup>rd</sup> ed., Springer, 2008
- M.L. Puterman, *Markov Decision Processes*, Wiley, 1994.
- S. Stidham., *Optimal Design of Queueing Systems*, Chapman-Hall, 2009.
- J. Walrand, *An Introduction to Queueing Networks*. Prentice-Hall, 1988.

## Course Outline (tentative)

1. Overview
2. Markov and Semi-Markov Decision Processes
3. Dynamic Programming
4. Markovian queues (basics)
5. Admission and service control in a single queue
6. Routing into parallel queues
7. Routing and service control in queueing networks
8. Scheduling:
  - deterministic
  - stochastic, finite number of jobs
9. Multi-Armed Bandits: Gittins indices
10. Server scheduling in parallel queues: the  $c\text{-}\mu$  rule
11. Server scheduling in Klimov networks
12. Fluid models: flow-level control
13. Queueing games: Strategic decisions in queues
  - Nash Equilibrium
  - Strategic arrivals, reneging and routing decisions
  - Server competition