Course Outline for MIE 1699: Queueing Models in Healthcare

Fall 2010
Thursdays 4-6pm., BA8119
Instructor: David Stanford (stanford@stats.uwo.ca)

Overview: This course investigates situations where congestion contributes to the delays arising in health care, whether in hospital settings, in primary care, or in the context of waitlists for transplants and related procedures. Through a wide-ranging set of illustrative examples the impact of four key queueing principles on the delay that patients can experience will be investigated: the effect of occupancy and of variability in the arrivals and procedure times, the impact of pooling resources, and the consequences for all patient groups of implementing one of many priority patient selection disciplines. The inherent tradeoffs in pooling resources versus reducing variability will be discussed. Consideration will also be given to the allocation of resources to manage overall delays.

Evaluation Methods and Values: The final grade in this course will be based on three assignments, given out at monthly intervals roughly, worth 10% each, classroom involvement worth at least 10%, a take-home midterm worth at least 15%, a final exam worth at least 40%, and an extra 5% given to the single best of the classroom, midterm and final marks. Classroom involvement includes out-of-class interaction.

Mathematical Prerequisites: Suitable for most graduate students in an Engineering, Statistics, or Applied Mathematics program or Ph.D. students in a Business program. What is most needed is familiarity with elements of Markov chains, to the level of determining steady-state distributions.

Week by week guide to subject matter: This list should be viewed as a guide only, as there may be notable variations in weekly progress. Roughly speaking, the first third of the course is intended to equip students with the necessary skills from the theory of queues, which will then be used throughout the remainder of the course.

September 16th: This overview "issues" lecture will illustrate how resource occupancy, variability in the inter-arrival and treatment times, pooling of resources, and priority disciplines each impact the congestion level. Each of these will be introduced via examples drawn from the health care sector, including an endoscopy suite, an ED department, and transplant waitlists. The utility of queuing networks in describing how various facilities in the health care setting interact will also be explored.

The role of analytical mathematical models in capturing the qualitative impacts of key factors is described via the "caricature" analogy, as well as the complementary role played by simulations.

September 23rd: This analytical lecture starts with a review of the key assumptions behind the continuous-time Markov chain structure underlying all Birth and Death queueing models. We address the mathematical necessity of these assumptions as well as the frequency with which they are borne out in real life. The means and distributions of delay in the classical multi-server Poisson-arrival, exponential service queue are derived, as the link to multi-server loss systems is established. In order to illustrate the over-riding role played by the occupancy level in congestion, the resulting formulas are used in a series of examples designed to quantify the delay impact of increases and reductions in the demand rate and the mean treatment time.

September 30th: This analytical lecture extends the previous week's descriptions in two directions. First. we quantify the benefits of pooling resources, and explore the "401 effect" of congestion in large pooled systems. Next, we investigate the impact of variability in treatment times through the introduction of the M/G/1 queue. By analogy to pure scheduled systems with no variability, we motivate some standard approximations for average delay in single and multi-server queues. Introduction to delay analysis in non-Markovian systems.

October 7th: Continuing from previous lecture, we start with a high-level description of transform techniques for delay distribution and their numerical inversion. Other aspects of queuing theory: Time-varying queues. Periodic queues. Discrete-time queues.

October 14th: 2nd "issues" lecture motivated by ED department. Introduction of priority models and their mean value analysis. The Kleinrock model.

October 21st: Introduction to Litvak's work at distinguishing and separating scheduled flow from ED flow. Tradeoffs between pooled ED work and specialized silo-like models to increase throughput.

October 28th: Analytical lecture on priority queues: traditional head of line priority. Preemptive priority. The delay cycle and its implication for low-er priority customers. The Kleinrock time-varying priority model.

November 4th: Transplant waitlists. Quantification of various options to reduce delay. Queueing aspects of the specifics of kidney, liver, and heart transplants. Differing views of admission to transplant waitlists (British vs. Canadian). Focus on the transplanted organ as the limiting resource.

November 11th: 3rd "issues" lecture focussing on the acute to sub-acute transfer. Push versus pull. Identification of downstream elements: rehabilitation, long-term care, rehab and treatment in the home. Discussion of bed blocking, 5 vs 7 cycles to health care facilities, and issues related to alternate level of care, viewed from the perspective of minimization of consumption of limited resources.

November 18th: Analytic models in the literature of the elements discussed in the preceding week.

November 25th: 1st open theme lecture.

December 2nd: Remote 2nd open theme lecture from Melbourne, Australia.