Banff International Research Station
for Mathematical Innovation and Discovery

CanQueue 2006: 8th Annual Conference for Canadian Queueing Theorists and Practitioners September 14-16, 2006

MEALS

Breakfast (Continental): 7:00 - 9:00 am, 2nd floor lounge, Corbett Hall, Friday & Saturday (*included in workshop*)
Friday Lunch (Buffet): 12:00 noon - 1:30 pm, Private Function Room 4 & 5 (*included in workshop*)
Friday Dinner: 5:30 - 7:30 pm, Private Function Room 4 & 5 (*included in workshop*)
Coffee Breaks: As per daily schedule, 2nd floor lounge, Corbett Hall (*included in workshop*)

MEETING ROOMS

All lectures are held in Max Bell 159. Hours: 6 am - 12 midnight. LCD projector, overhead projectors and blackboards are available for presentations *Please note that the meeting space designated for BIRS is the lower level of Max Bell, Rooms 155-159. Please respect that all other space has been contracted to other Banff Centre guests, including any Food and Beverage in those areas.*

SCHEDULE (lectures are listed by last name of presenter)

Thursday	
16:00	Check-in begins (Front Desk - Professional Development Centre - open 24 hours)
Friday	
7:00-9:00	Breakfast, 2nd floor lounge, Corbett Hall
8:30-10:00	Lectures (Jayaswal, Rogers, Enns)
10:00-10:30	Coffee Break, 2nd floor lounge, Corbett Hall
10:30-11:30	Keynote lecture (Williamson)
11:30-12:00	Lecture (Bischak)
12:00-13:30	Lunch
13:30-15:00	Lectures (Kumar, Tavakoli, Stanford)
15:00-15:30	Coffee Break, 2nd floor lounge, Corbett Hall
15:30-17:00	Lectures (Brill, Down, Alfa)
17:30-19:30	Dinner (dinner presentation by Mandelbaum)
Saturday	
7:00-9:00	Breakfast, 2nd floor lounge, Corbett Hall
8:30-10:00	Lectures (Wu, Luo, Chakravarthy)
10:00-10:30	Coffee break, 2nd floor lounge, Corbett Hall
10:30-12:00	Lectures (Grassmann, Zhao, Mandelbaum)
	Checkout by 12 noon.

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ABSTRACTS
(in alphabetic order by speaker surname)

Presenter: **Arash Abadpour** (University of Manitoba) [poster presentation]
Title: *Information-Theoretic Sum Capacity of Reverse Link CDMA Systems in A Single Cell, An Optimization Perspective*
Co-authors: **Attahiru Sule Alfa** (University of Manitoba) and **Anthony C.K. Soong** (Huawei Technological Co. Ltd., TX, USA)
Abstract: The information-theoretic approach to maximizing the aggregate capacity of the reverse link in a CDMA system looks for the best pattern of transmission power of the stations. In this framework, where the transmission from each station is noise to all others, extra constraints should be considered to lead to a practically applicable solution. The previous research has suggested a minimum guaranteed quality of service plus bounds on individual transmissions and the aggregate one as constraints. However, extensive analysis has revealed that these two constraints are not enough to produce a solution which can be realized in an actual system. Basically, lack of any constraint including the maximum capacity of each station or dealing with the unfairness of the whole system has been found to be responsible for the partial solution in which all stations except for one are left to transmit at the lowest possible bandwidth, while the selected station is served with a non-realistic bandwidth of couple of hundreds more. In this paper we devise a maximum capacity constraint and give an algorithm for solving the problem. Then, empirical evidence are analyzed to show that the system actually becomes more balanced and practical when the new constraint is added.

Speaker: **Attahiru Alfa** (University of Manitoba)
Title: *Application of the Maximum Entropy Principle in the Analysis of Some Queueing Problems*

Speaker: **Diane Bischak** (University of Calgary)
Co-author: **Robert J. Oxoby** (University of Calgary)
Title: *The effect of waiting on bargaining behavior: theory, evidence, and extensions*
Abstract: An extensive literature has theorized about the ways in which individuals incorporate the cost of time in their decision processes. We analyze the effect of an unexpected occupied or unoccupied wait on individuals decision making behavior using a series of bargaining experiments (dictator and ultimatum games). Although we find no evidence of an effect due to the unexpected experience of occupied time, we find that experiencing an unexpected, unoccupied wait reduces individuals displayed inequity aversion and markedly increases individuals displayed negative reciprocity, suggesting that unoccupied waiting time can have significant effects on subsequent decision making. These results are consistent with theories from behavioral decision making, mental accounting, and the study of the psychology of queues and have implications for the management of queues.

Speaker: **Percy Brill** (University of Windsor)
Co-author: **Mei Ling Huang** (Brock University)
Title: *Discussion of Reneging in Queues*
Abstract: We define a *staying* function for the population of customers arriving to a queue, which is used to model reneging. We give examples with emphasis on M/G/1 models. We address statistical estimation of the staying function, including a method using censored data.

Speaker: **Srinivas R. Chakravarthy** (Kettering University)
Title: *A multi-server synchronous vacation model with thresholds and a probabilistic decision rule*
Abstract: In this paper a multi-server queueing model with Markovian arrivals and synchronous phase type vacations is studied using a probabilistic rule and controlled thresholds. The steady-state analysis of the model is presented. An optimization problem and some interesting numerical results are discussed.

Speaker: **Doug Down** (McMaster University)
Title: *Queueing Networks with Limited Flexibility*
Abstract: Suppose one is given a queueing network and a set of potential service rates for a set of flexible servers. If one chooses to train a server to work at a node, it does so at its potential service rate. With throughput as a performance measure, we are interested in the question of whether one can do a limited amount of training and achieve the same performance as full flexibility, i.e. when the maximum amount of training is done and all potential service rates realized. The main result is a negative one, we show that even a grossly simplified version of the problem is NP-Hard if the servers are not identical. With this in mind, possible future research directions in this area will be discussed.

Speaker: **Van Enns** (University of Calgary)
Title: *Investigating Queues in Batch Manufacturing*
Abstract: Discrete-parts batch manufacturing systems can be viewed as queuing networks, where the entities are batches of parts. Batches require a setup and processing time at each capacity-constrained resource. Queuing relationships can be used to select batch sizes which minimize flow times (or inventory) if adjustments are made for autocorrelation. However in practice the objective is often to minimize inventory subject to some level of delivery performance, where additional decision variables relate to replenishment (e.g. reorder points, Kanbans or planned lead times). This research compares performance optimization based on using queuing with that based on using response surface methods.

Speaker: **Winfried Grassmann** (University of Saskatchewan)
Title: *A Bayesian Approach to Find Random-Time Probabilities in M/G/1 and GI/M/1 Queues*
Abstract: To find steady-state probabilities in $M/G/1$ and $GI/M/c$ queues, one traditionally first finds arrival, respectively, departure time probabilities, which are then converted into random-time probabilities by using a Markov renewal process. We have suggested a Bayesian approach as an alternative. The Bayesian approach is much easier to handle, especially if arrival and/or departures depend on the number of customers in system.

Presenter: **Armann Ingolfsson** (University of Alberta) [poster presentation]
Title: *Queueing Models of Emergency Medical Services: Open Problems*
Abstract: The most influential queueing model of emergency medical service (EMS) operations is Larson's (1974) Hypercube Queueing model. We highlight some of its assumptions and important generalizations that have yet to be developed, including allowing service rates to vary by both server class and customer class, and allowing servers to move between classes. We also outline queueing models that might be used to understand important interactions of EMS with fire services and with hospital emergency departments.

Speaker: **Sachin Jayaswal** (University of Waterloo)
Co-author: **Elizabeth Jewkes** (University of Waterloo)
Title: *Exact performance measures for an assemble-to-order system*
Abstract: An assemble-to-order (ATO) system operates by making semi-finished components to stock, while delaying the assembly into final products until a customer demand occurs. Each customer order typically requires a number of semi-finished components, thus creating correlated demand for these items. Evaluation of order-based performance measures, therefore, possesses a considerable computational challenge. We study an ATO system with several semi-finished items and compute exact order-based performance measures. Unlike the existing literature, we explicitly consider both the assembly time and the component production lead time. This makes the problem more realistic, yet complex. We model the evolution of the system as a continuous-time Markov Chain, which is solved using Matrix geometric methods..

Speaker: **Sunil Kumar** (Stanford University)
Title: *Congested Systems with Rational Users: When Economics meets Queueing Theory*
Abstract: There is a long history of economic models that include queueing phenomena in them, going back to Naor. However, most of these models appear to have been developed by economists and game theorists rather than queueing theorists. As a result, these models tend to use simplistic delay/performance estimates in demand and utility functions. Moreover, they tend to ignore lower level decisions, like routing and scheduling, that could considerably alter the outcomes. In this informal talk, I will present three substantive problems in which this deficiency can be remedied by better analysis of the underlying queueing systems. By doing so, I hope to provoke discussion and interest in this fertile field among the researchers at CanQueue.

Presenter: **Song Li** (University of Saskatchewan) [poster presentation]
Title: *Analysing Stochastic Call Demand With Time Varying Parameters*
Abstract: In spite of increasingly sophisticated workforce management tools, a significant gap remains between the goal of effective staffing and the present difficulty predicting the stochastic demand of inbound calls. We have investigated the hypothesized nonhomogeneous Poisson process model of modem pool callers of the University community. In our case, we tested if the arrivals could be approximated by a piecewise constant rate over short intervals. For each of 1 and 10-minute intervals, based on the close relationship between the Poisson process and the exponential distribution, the test results did not show any sign of homogeneous Poisson process. We have examined the hypothesis of a nonhomogeneous Poisson process by a transformed statistic. Quantitative and graphical goodness-of-fit tests have confirmed nonhomogeneous Poisson process. Further analysis on the intensity function revealed that linear rate intensity was woefully inadequate in predicting time varying arrivals. For sinusoidal rate model, difficulty arose in setting the period parameter. Spline models, as an alternative to parametric modelling, had more control of balance between data fitting and smoothness, which was appealing to our analysis on call arrival process.

Speaker: **Jingxiang Luo** (University of Calgary)
Co-author: **Carey Williamsson** (University of Calgary)
Title: *A queueing system with stochastic capacity - an analysis and some preliminary results*
Abstract: We study queueing systems with finite, stochastic capacity, which naturally arise in applications especially wireless communications. As the first step, we consider a system with parallel channels, exponential inter-arrival and service times, and a time-varying capacity. The times between capacity changes are assumed to follow an arbitrary distribution. We are interested in the probability of blocking and dropping (dropping occurs when the system capacity falls below its current number of admitted clients). We apply the Markov regenerated process (MRGP) as an analytic tool, and use both transient and stationary analysis. From this study we give some preliminary results to help gain insight on the performance implications of stochastic capacity.

Presenter: **Mike MacGregor** (University of Alberta) [poster presentation]
Co-author: **K. Andrusky** (University of Alberta)
Title: *Effects of parameter uncertainty on optimal queue control*
Abstract: Stochastic dynamic programming can be used to calculate optimal policies for controlling queueing systems. These policies can be structured as tables which require only a single lookup to determine the action the system should take given the current state. The benefit of calculating the policy offline is that run-time overheads can be avoided. However the results may only be "near-optimal" if the parameter values used to compute the policy do not match those of the real system. We find that for one particular system - batch admissions to a buffer - performance is actually quite close to optimal even with significant mismatch in expected batch size.

Speaker: **Marvin Mandelbaum** (York University)
Co-authors: **Myron Hlynka** (University of Windsor)
Title: *Non-Homogeneous Geometric Distributions*
Abstract: In an $M/M/1$ queueing system with arrival rate lambda and service rate mu, it is well known that the limiting probabilities form a geometric distribution. If the parameters are state dependent, then the limiting probabilities form a geometric type distribution but with changing parameters. If the queueing system also has a finite buffer, then the limiting probabilities form a right truncated changing parameter geometric distribution. Here we show that the class of changing parameter geometric distributions (CPG) is identical to the class of all discrete distributions (D) on the nonnegative integers. We show how to convert from CPG to D and from D to CPG. We suggest reasons why it might be sometimes advantageous to look at distributions from the CPG point of view.

Presenter: **B. H. Margolius** (Cleveland State University) [poster presentation]
Title: *Transient and periodic solution to the time-inhomogeneous $M/M/c$ Queue with Disasters*
Abstract: We derive the transient distribution and periodic family of asymptotic distributions and the transient and periodic moments for the $M/M/c$ queue with time-varying periodic rates with disasters. Customers arrive to the system according to a Poisson distribution with time-varying periodic rate. Service is exponential. The service rate may also vary periodically. The system breaks down randomly with rate $\gamma(t)$. When there are multiple servers all servers fail and all customers leave the system. The server is repaired at rate $\eta(t)$. When the system breaks down, customers continue to arrive to the system. These customers abandon the system at rate $\xi(t)$. In studying this system, we are interested in how the distribution of number in queue compares with the time-varying random walk and the time-varying multiserver queue.

Speaker: **Paul Rogers** (University of Calgary)
Title: *Optimal workload control for the M/M/1 queuing system*
Abstract: A workload control policy has been developed for the $M/M/1$ queuing system facing the following conditions: (i) due dates for arriving jobs are defined based on a fixed flow allowance; (ii) processing times are known at the point of job arrival; (iii) tardiness or earliness penalty functions for jobs not completed exactly on their due time are linear functions with different slopes; (iv) an arriving job can be rejected, if tardiness or earliness penalties may be too large, incurring only a loss of net revenue for that job. The policy aims to minimize the steady-state sum of losses from job rejection, tardiness, and earliness by iteratively solving a linear programming problem that chooses optimal start times for a known set of jobs whenever a new job arrives. The new job is rejected if its acceptance would lead to insufficient incremental net revenue. Results on the performance of the new policy are presented.

Speaker: **David Stanford** (University of Western Ontario)
Co-authors: **Elizabeth Renouf** (University of Western Ontario) and **Vivian McAlister M.D.** (University of Western Ontario and London Health Sciences Centre)
Title: *Transplant Queues*

Speaker: **Javad Tavakoli** (UBC Okanagan)
Co-author: **Winfried Grassmann** (University of Saskatchewan)
Title: *The Continuous Spectrum for the M/M/c Queue*
Abstract: Transient solutions for $M/M/c$ queues are important for many purposes, in particular for staffing facilities such as call centers. In this paper, we show how to use spectral analysis to find such solutions. The difficulty is that unless the number in line is bounded, one has to deal with matrices of infinite size, and hence with a countable infinite number of eigenvalues. This problem can be overcome by noting that the spectrum is dense with only few exceptions. We also show how many discrete eigenvalues remain. Our theory may also work to obtain spectra for other infinite dimensional matrices. Numerical properties of our approach are explored.

Speaker: **Carey Williamsson** (University of Calgary) [keynote]
Title: *Performance Modeling of Stochastic Capacity Networks*
Abstract: In some network environments, the physical transmission capacity can vary unpredictably with time. This stochastic variation may degrade system performance. Traditional performance modeling often ignores stochastic capacity variation, and thus may overestimate actual system performance. In this talk, I discuss the impacts from stochastic capacity variation, using analysis and simulation. We build a two-dimensional MRGP stochastic capacity model and study the impacts from selected parameters, including mean, variance, frequency, and correlation of capacity variation. Our numerical and simulation results show that the frequency and variance of capacity changes can have a pronounced adverse impact on call blocking performance. However, correlations in the capacity value process or the traffic arrival process can be beneficial. These preliminary results lead us toward an "equivalent capacity" model for stochastic capacity networks.

Speaker: **Rong Wu** (McMaster University)
Co-author: **Doug Down** (McMaster University)
Title: *On Size Based Routing for Parallel Server Systems*
Abstract: We consider a system with a dispatcher and several identical servers in parallel. Task processing times are known upon arrival. We propose a policy with multi-layered round robin routing followed by an easily implementable priority server scheduling policy RRK-KLP. Depending on how we choose the task types, our numerical results show that the performance (mean waiting time) of RRK-KLP could be significantly better than a size based policy good for high task processing time variance, where tasks with similar sizes are grouped together at each server and served in FCFS. The performance of RRK-KLP in terms of slowdown is also shown to be quite good. Our analysis involves a combination of comparing analytic models, heavy traffic asymptotics and numerical work.

Presenter: **Zhidong Zhang** (University of Saskatchewan) [poster presentation]
Title: *Analysis of a call center with IVRU and state-dependent balking*
Abstract: We analyze a call center with IVRU and state-dependent balking. The model is a Markovian semiopen network model with two stations in series. The first station represents pool of IVRU and the second one represents pool of agents. After finishing IVRU process, the call chooses to join the second station with a state-dependent balking probability. We show that this model has product-form solution and give the expressions of blocking and delay probabilities. For constant balking probability, we implement an efficient searching algorithm to find the smallest (S, N) pair with respect to a certain cost ordering subject to the blocking and delay constraints. Here S is the number of agents and N is the number of trunk lines. Numerical examples are given.

Speaker: **Yiqiang Q. Zhao** (Carleton University)
Title: *Methods on Tail Asymptotics*
Abstract: Methods for detailed tail asymptotics include at least the following: 1) Analytic function extension and analysis of singularities; 2) Probabilistic arguments based on most likely paths to infinity; and 3) the matrix-analytic approach. In this talk, we will emphasize on the matrix-analytic method and use examples to demonstrate advantages and challenges of this method.