

Term Project

Bid for your preferred method/date due 7:20 pm, Tuesday, March 4

Reading assignments list or materials for the class due one week before your presentation

Power Point Presentations due 24 hours before your presentation

The purpose of your project will be to study a method for extension from Markovian queues, or approximation for analyzing the performance of queueing networks when closed form solutions are difficult to obtain or simply not available. The first part of the project will be to investigate available literature about a method. The second part of the project will involve actually implementing and testing the method. You may investigate a method of your choice or even a method that you design. The Term Project weights 50% of the overall grade: 30% for the first part, and 20% for the second part.

Topics of Choice

Available topics with references are listed below. It is a good idea to search for additional references on the topic you select, particularly for those topics not covered in the textbook.

1. **General Arrival or Service.** See Chapter 5 of textbook. It discuss queues when arrivals are general (G/M/1) or when services are general (M/G/1).
2. **General Arrival and Service.** See Chapter 6 of textbook. It discuss queues when both arrivals and services are general (e.g., G/G/1).
3. **Bounds and Approximations.** See Sections 7.1 and 7.2 of textbook. It gives useful bounds and approximations to non-Markovian queues.
4. **QNA.** The Queueing Network Analyzer (QNA) developed by Ward Whitt at Bell Laboratories. The general approach of QNA is to approximately characterize the arrival process by two moments and then analyze individual queues individually. Good starting references include:
 - a. Section 7.3 of the 4th Edition of Textbook (not published yet, see instructor).
 - b. "The Queueing Network Analyzer", by W. Whitt, The Bell System Technical Journal, November 1983. (It's not easy to find - GMU has it on microfilm).
5. **QNET.** The QNET Method developed by Michael Harrison at Stanford University. The general approach of QNET is to replace the original queueing network by an approximating Browning system model, and then compute the stationary distribution of the Browning model. Just as with QNA, the required inputs are the first and second moment data. Some good references are:

- J. M. Harrison and Nguyen, V., "The QNET method for two-moment analysis of open queueing networks", *Queueing Systems*, 6, 1-32, 1990.
 - J. G. Dai and J. M. Harrison, "The QNET method for two-moment analysis of closed manufacturing systems", *Annals of Applied Probability*, Vol 3, 968-1012, 1993
 - J. G. Dai, Din-Horng Yeh and Chen Zhou, "The QNET method for re-entrant queueing networks with priority disciplines". *Operations Research*, Vol 45. July 1997.
6. **Transient Queues.** This class focuses on steady state of queues. There is limited success of extension to transient analysis. See "Transient Analysis" in the subject index of textbook. In addition, the paper "Decomposition Algorithms for Analyzing Transient Phenomena in Multiclass Queueing Networks in Air Transportation" by Michael D. Peterson, Dimitris J. Bertsimas, and Amedeo R. Odoni at MIT offers an effective approach and good application to air transportation. It is published at *Operations Research*, Vol. 43, No. 6. (Nov. - Dec., 1995), pp. 995-1011.

Part 1: Method Investigation and Presentation

You extensively investigate the topic of your choice and then give a presentation to the class. The length of presentation is 50 ~ 60 minutes. Please use power point to make your presentation, which will be distributed to the class after your presentation. You have to email your presentation to the instructor at least 24 hours in advance. In your presentation, please consider to include the following items:

- Introduction
- Basic ideas & fundamentals
- Theoretical development
- What are the strengths and weaknesses?
- What are the state-of-the-art?
- Where and how to apply?

The presentation will be graded by both the instructor and the class. If you have reading assignments for the class, please email the list or the materials (if they are not in the textbook) to the to the instructor at least one week before your presentation. Then the instructor will distribute them to the class. All students are required to read them before presentation and so will be able to ask good in-depth questions at the presentation.

Presentations of Part 1 are scheduled on 4/8, 4/15, and 4/22.

Part 2: Method Design, Testing, and Presentation

For the second part of the project, you design an algorithm by utilizing the method you are studying and then test it. By actually designing and testing an algorithm, you will learn fully about the details of the method. While not required, you are strongly encouraged to test the two basic examples given below. In addition, you may test your algorithm on any models that you find them useful or interesting to demonstrate. For example, if you are interested in communication systems, then a model of a specific type of communication system would provide an interesting test case for your algorithm. Alternatively, you may simply cook up some examples based on your method's natures. When you develop your testing examples, please consider to demonstrate/document the following issues:

- How well does your algorithm work in terms of providing good approximation?
- In what conditions does your algorithm work particularly well?
- In what conditions does your algorithm work particularly poor?
- Computational complexity or savings.

To actually know how well your method is performing, you need to know (or approximate well) the true queueing performance of your model. If you are considering models for which the true performance is not known (or able to be calculated), then you can compare results from your algorithm with simulation results. Since no approximation is made in simulation modeling, the simulation results can be considered a good estimate of the true performance. You can use any software (such as Arena) or language to develop your simulation models.

Section IV of the following paper shows some nice example of such testing and comparison:

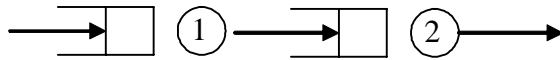
"An Approximation Approach of the Standard Clock Method for General Discrete Event Simulation," by C. H. Chen and Y. C. Ho, *IEEE Transactions on Control Systems Technology*, Vol. 3, No. 3, pp. 309-317, September 1995

You also have to give a short presentation about your testing results (up to 10 minutes). You can do this presentation either together with your Part 1 presentation, or separately on 4/30. In the later case, please also give a brief summary about your method at the beginning of your presentation.

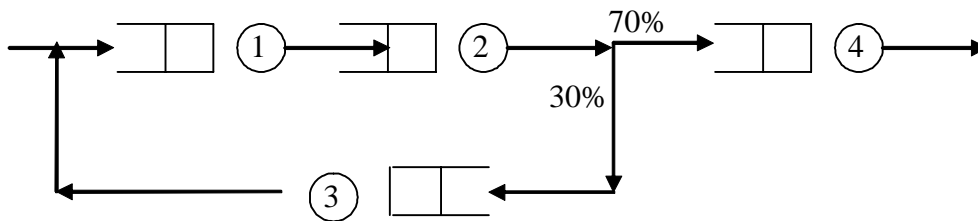
Basic Examples for Testing

Regardless of which method you are studying, you are encouraged to design an algorithm to test the following two basic examples:

Example 1. Two-node tandem queue shown in the following figure. The inter-arrival times are uniformly distributed between 6 and 10 minutes. Service times at Node 1 are uniformly distributed between 2 and 8 minutes, while Service times at Node 2 are uniformly distributed between 0 and 12 minutes.



Example 2. This system has 4 nodes with reentrant process. After node 2, 30% of customers go to node 3, while the remaining 70% go to node 4. The departure of node 3 merges with new arrivals into node 1. The inter-arrival times are uniformly distributed between 6 and 10 minutes. Service times at all nodes are i.i.d random variables with uniform distribution between 1 and 7 minutes.



Team Work

A team has two members. You can choose your partner (preferred) or be matched by the bids.

Selection of Method and Presentation Date

Please use the following form to choose the method you want to investigate and the date of your presentation. You have to turn in this form by March 4. Failing to do so, you will be assumed that you are completely flexible and will be assigned a method/date which is left.

A team has to submit a single form of bidding. If you have not found a team partner, you submit your own bid and your partner will be assigned based on the match of bids.

You have a total of 100 points to bid for your preferred method/date. If you have found your partner, a team submits a single bid. However, the total is increased to 120 points.

Names:

Method and Presentation Date Alternatives	Your Bid (≥ 0) [*]	No ⁺
Topic 1. General Arrival or Service		
Topic 2. General Arrival and Service		
Topic 3. Bounds and Approximations		
Topic 4. QNA		
Topic 5. QNET		
Topic 6. Transient Queues		
Presentation on 4/8		
Presentation on 4/15		
Presentation on 4/22		
Total points of your bids (should be ≤ 100 or 120) [*]		

* In the 2nd column, you place your bids based on your preference on the topics and dates. The higher bid you place, the higher chance you will get them. The total bid is 100 points if submitted by a single person, and 120 points if submitted by a team of two persons.

+ In the 3rd column of No list, you can choose up to 1 item (topic/date) that you absolutely don't want. For example, you can use this to avoid the conflicting date for presentation.