Service Engineering (Science, Management)

Mini-Course / Workshop

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10 Some Downloadable References

I shall now list several papers that provide helpful background (in the context of call centers):

First, two surveys (one general and one specific):

- Early Survey of Call Centers (Research and Practice):
  Gans, N., Koole, G., M. "Telephone Call Centers: Tutorial, Review and Research Prospects." Invited review paper by Manufacturing and Service Operations Management (M&SOM), 5, 79141, 2003.
  http://iew3.technion.ac.il/serveng/References/Gans-Koole-Mandelbaum-CCReview.pdf
- A "Light" Teaching Note on Erlang-A:
  M. and Zeltyn S. "The Palm/Erlang-A Queue, with Applications to Call Centers."
  http://iew3.technion.ac.il/serveng/References/Erlang_A.pdf

Next, starting points to four research directions:

- Statistical Analysis of Transaction-Level Call Centers Data:
  Brown, L., Gans, N., M., Sakov, A., Zeltyn, S., Zhao, L. and Haipeng, S. "Statistical Analysis of a Telephone Call Center: A Queueing-Science Perspective." Journal of the American Statistical Association (JASA), 100: 36-50, 2005.
  http://iew3.technion.ac.il/serveng/References/JASA_callcenter.pdf
- Model for The Basic Call Center: Erlang-A
  Garnett O., M. and Reiman M. "Designing a Call Center with Impatient Customers." Manufacturing and Service Operations Management, 4, 208-227, 2002.
  http://iew3.technion.ac.il/serveng/References/abandon.pdf
- Staffing of a Stationary Erlang-C (preliminary to Erlang-A):
  Borst S., M. and Reiman M. "Dimensioning Large Call Centers." Operations Research, 52, 17-34, 2004.
  http://iew3.technion.ac.il/serveng/References/Dimensioning.pdf
- Staffing in the Face of Time-Variable Demand:
  Feldman Z., M., Massey W.A. and Whitt W. "Staffing of Time-Varying Queues to Achieve Time-Stable Performance." Management Science. Management Science, 54, 324-338, 2008.
  http://iew3.technion.ac.il/serveng/References/Feldman2008pub.pdf

And, finally, a source for references to the research literature:

- Bibliographical Support, till 2006:
  M. "Call Centers. Research Bibliography with Abstracts." Version 7, May, 2006.
  http://iew3.technion.ac.il/serveng/References/US7_CC_avi.pdf

11 Preparatory Readings

Active learning is superior to passive learning. Thus, as a preparation for my lectures, I recommend that you read (at least "diagonally") the following material:

1. *Background and Introduction:*

   - Read the present note, at the depth-level that suits your personal interests.
   - "Telephone Call Centers: Tutorial, Review and Research Prospects," 2003, by Gans et al. Start reading Sections 1,2,3. Then go over the Table of Contents, to see what is in there, skimming through what you find most interesting. Section 4 is closely related to the call-center component of my lectures.
     http://iew3.technion.ac.il/serveng/References/Gans-Koole-Mandelbaum-CCReview.pdf
   - "Using Operations Research to Reduce Delays for Healthcare," 2008, INFORMS Tutorials, by Linda V. Green (Columbia U.). This is interesting reading throughout, but make sure you read Section 1 (Sources of Healthcare Delays) and Section 4 (Obstacles to using OR in Healthcare), especially &4.1 (Lack of data).
     http://www1.gsb.columbia.edu/mygsb/faculty/research/pubfiles/3874/OR

2. *A Data-View*:

   - "Statistical Analysis of a Telephone Call Center: A Queueing-Science Perspective," 2005, by Brown et al. Skim over the paper, focusing more on the last Section 7. (You will recognize this article as the source for some of the figures in my lectures.)
     http://iew3.technion.ac.il/serveng/References/JASA_callcenter.pdf
   - "Patient Flow in Hospitals: A Data-Based Queueing-Science Perspective," 2011, by Armony et al. Skim over the paper, reading at least Section 1 (Introduction) and Section 2 (Summary of Results).
     http://ie.technion.ac.il/serveng/References/Patient%20flow%20main.pdf
   - "The Workload Process: Modelling, Inference and Applications," 2011, M. Reich (advised jointly with Y. Ritov). The Offered-Load is a concept that is central for understanding the operational characteristics of a service system. For our purposes, the most relevant parts are the Introduction, Section 3 and briefly Section 5.
     http://ie.technion.ac.il/serveng/References/Michael_Reich_Thesis_withlinks.pdf
   - "Data Stories about (Im)Patient Customers in Tele-Queues," 2012, with S. Zeltyn. This is an empirical view of customers' impatience, while waiting for a phone-service. (The notion of impatience plays an important role beyond tele-services: see, for example, LWBS in hospitals.) This is easy non-technical reading, at your leisure.
     http://ie.technion.ac.il/serveng/References/impatience_data_stories_final.pdf

3. *Two Basic Models*:

   - "The Palm/Erlang-A Queue, with Applications to Call Centers," a teaching note with S. Zeltyn. Mathematically, Erlang-A, with "A" standing for Abandonments, is **only** a special

case of an ergodic Birth & Death model. But practically, it is (or should be) the central model in support of workforce management of call centers.
http://iew3.technion.ac.il/serveng/References/Erlang_A.pdf

- "Erlang-R: A Time-Varying Queue with ReEntrant Customers, in Support of Healthcare Staffing," 2011, with G. Yom-Tov and based on her PhD thesis. Erlang-R, with "R" standing for Returning or Recurrent customers, is a simple 2-station open queueing network. It has significant modeling powers, which are most pronounced in time-varying environments. If fact, it has been conceived to help stabilize performance, via staffing (e.g. physicians) in the face of time-varying demand (e.g. patients arriving to an Emergency Department): See Section 6, after reading Sections 1 and 3.
http://iew3.technion.ac.il/serveng/References/Erlang_R.pdf

4. *Beyond Basics: Staffing & Control of Some Simple Systems*: The role of the papers, from here to the end, is mainly to have you become aware of their existence.

   - "Service Level Differentiation in Call Centers with Fully Flexible Servers," 2008, with Gurvich and Armony: Skills-Based Routing (SBR) of a single-pool system.
   http://iew3.technion.ac.il/serveng/References/Vdesign_pub.pdf
   - "On Fair Routing From Emergency Departments to Hospital Wards: QED Queues with Heterogeneous Servers," 2011, with Momcilovic and Tseytlin, 2010: An example of Fair Routing from the Emergency Department to Internal Wards.
   http://iew3.technion.ac.il/serveng/References/fr6.pdf
   - "Routing and Staffing in Large-Scale Service Systems: The Case of Homogeneous Impatient Customers and Heterogeneous Servers," 2010, with Armony: Routing and Staffing *jointly*.
   http://www.stern.nyu.edu/om/faculty/armony/research/IV_abandon.pdf

5. *(More) Complex Models*: As mentioned, just skim in order to become aware of existence.

   - "Control of Many-Servers Queueing Systems in Heavy Traffic," 2007, G. Shaikhet (advised jointly with Atar): Especially Part 3 on "Simplifying controls of the full SBR topology".
   http://iew3.technion.ac.il/serveng/References/PhD_gennady.pdf
   - "Fork-Join Networks in Heavy Traffc: Diffusion Approximations and Control," 2011, A. Zviran (advised jointly with R. Atar): We are capturing here a prevalent feature in heathcare (Fork-Join), within a control-model that thrives to maximize throughput.
   http://iew3.technion.ac.il/serveng/References/ZviranMScThesis.pdf
   - "Excursion-Based Universal Approximations for the Erlang-A Queue in Steady-State," 2012, with I. Gurvich and J. Huang. A major reason for the success of Erlang-A and Erlang-R is that they are amenable for practical approximations (fluid and diffusion). In the case of Erlang-A, this has given rise to a plethora of asymptotic regimes, and Universal Approximations provide a way to circumvent the challenge of choosing which regime is most appropriated for a particular application. To understand the idea, it suffices to go over Sections 1 and 2. The results and their applications appear in Section 3.
   http://ie.technion.ac.il/serveng/References/Universal_040712_Final.pdf

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Service Engineering: Data-Based Course Development and Teaching

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In this exposition, we discuss empirically based teaching in the newly emerging field of "service engineering." Specifically, we survey a service engineering course, taught at the Technion–Israel Institute of Technology. The course was "born" about 15 years ago as a graduate seminar and ultimately took its present form as a core course for the undergraduate program in industrial engineering and management. The role of measurements and data as teaching-enhancers and research-drivers is underscored. In addition, we emphasize that data granularity must reach the individual-transaction level. We describe customized databases and software tools that facilitate operational and statistical analysis of services; this includes the use of SEEStat, a data-user interface that was developed at the Technion's SEE Laboratory, for research and educational purposes. Some unique aspects of the course are the incorporation of state-of-the-art research and real-world data in lectures, recitations, and home assignments, as amply presented throughout this work. The application focus of the surveyed course has been telephone call centers, which constitute an explosively growing branch of the service industry. The course is now expanding to also cover healthcare, especially hospitals; some examples from other service areas (e.g., the justice system) are described as well.

Key words: teaching engineering; teaching queueing; teaching service operations management; interdisciplinary teaching; service science
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1. Introduction to Service Engineering

1.1. Motivation and Contents of the Paper

The service sector is central in the life of postindustrial societies—more than 70% of the gross national product in most developed countries is attributable to this sector. In concert with this state of affairs, there exists a growing demand for high-quality multidisciplinary research in the field of services, as well as for a significant number of *service engineers*, namely, scientifically educated specialists that are capable of designing service systems, as well as solving multifaceted problems that arise in their practice. (Readers are referred to Fitzsimmons and Fitzsimmons 2004, especially Part 1, for background on services, including some distinguishing characteristics of services relative to manufacturing.)

In the United States, the academic home for the area of services has traditionally been the business school, where services have been taught most often as "service marketing." Another business school option is "service management," either within operations management courses or, rather rarely, as a standalone service operations course. As an engineering discipline, the natural home for services are industrial engineering units. Indeed, our original use of the term "service engineering" was conceived by combining the relevant words in "*service* management" and "industrial *engineering*." We had roughly in mind a "*New Age Industrial Engineer* that must combine technological knowledge with process design to create the delivery systems of the future (Frei et al. 1998, p. 33)."

It is our belief that there exists a broad gap between academia's supply and the demand for service science and engineering. Focusing on the education, universities either do not offer service engineering courses or, when they do so, the education quality is typically not at par with that of the traditional engineering disciplines, in particular that provided by leading industrial engineering units.

The goal of the *service engineering* (ServEng) course, "born" at the Technion–Israel Institute of Technology

Service Engineering: Data-Based Course Development and Teaching

Full Version *

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*There exists an abbreviated version of the present document [65]. In that version, we reduce to a minimum the description of lectures and homework (Sections 4 and 5), and we omit Section 6, on The Fusion of Research and Teaching.

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