The Harold and Inge Marcus Center
for Service Enterprise Engineering (SEE)

Data-Based Science & Teaching

June 2012

Dear Inge and Hal:
Thank you for your continuous
encouragement and support

The SEELab Team:

Avi Mandelbaum

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The William Davidson Faculty of Industrial Engineering and Management

Service Enterprise Engineering (SEE)
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Executive Summary of SEE Output 2007-2012

The **Center for Service Enterprise Engineering** (**SEE**) was established in February 2007, within the Faculty of Industrial Engineering and Management, Technion, through the generous support of **Hal and Inge Marcus**. The goal of SEE has been the support of research and teaching in the area of Service Systems. Specifically, SEE has been contributing to the development of engineering and scientific principles that support modeling, design and management of Service Enterprises, for example financial services (banking, insurance), health services (hospitals, clinics), government and tele-services (telephone, internet). SEE's main activity has been through the SEE Laboratory (SEELab), specifically creating, designing, maintaining and analyzing an accessible repository of resources and data. The original data-sources were telephone call-centers, but the scope has been now expanded to cover also hospitals, and first steps have been taken to expand into other services such as internet and emergency services.

Some notable SEE achievements are as follows:

- Inaugural Service Science Innovation Award (2009), for partnership of Academia, Industry and Government
- 8 Distinguished/plenary/keynotes lectures
- 4 Best-publication prizes for SEE-based papers
- 14 Publications in refereed journals (most top tier); 6 submitted; 8 in process
- 12 Publications in books or conference proceedings (most refereed)
- 18 Research papers by international scholars, using and acknowledging SEEdata
- 12 Technion-based publications using SEEdata
- Over 40 Presentations in international conferences, related to or using SEE data
- 6 PhD theses (leading to current 3 postdocs, at Harvard, Columbia U., Mayo Clinic)
- 12 MSc theses
- 15 Undergraduate projects (many elected to and some won "best project" awards)
- 18 SEE Technical Reports on Data Summary, Empirical Analysis, SEEStat Interface
- Over 20 International scholars visiting the SEELab (some regular visitors, some long- and medium-term)
- Over 10 lectures to industry

SEE Staff: Permanent and Ad Hoc

The founders of SEE are Professors **Paul Feigin** and **Avishai Mandelbaum**, both from the Faculty of Industrial Engineering and Management. Presently, Prof. Feigin is serving as the Technion's Senior Vice-President; hence Prof. Mandelbaum acts as the sole Academic Director. Prof. Mandelbaum also served, for two years, as the academic director of the OCR project, which was administered through and supported by SEE.

SEE employs three full-time researchers and programmers: Dr. **Valery Trofimov**, who is heading R&D, is the designer of SEE databases and applications; **Igor Gavako**, who is SEE's chief programmer; and **Ella Nadjarov**, who is in charge of SEE administration and statistical-development. **The SEE Team won the 2010 Technion Excellence Award for Research.**
In addition to the permanent staff, several students, graduate and undergraduate, work regularly at the lab: **Polyna Khudyakov** (PhD student), did her thesis on SEE-related topics and supervised

undergraduate projects – Polyna is now a post-doc at Harvard University; and Abir Koren, Ori Plonsky and Ofri Rom (BSc students), who were members of the IE&M Honor Program. (All three have continued to an MSc degree, interestingly in Information Science, Operations Research and Psychology.) On top of these "regulars", numerous graduate and undergraduate students, as well as research colleagues (locally and worldwide) have been involved in SEE activities, either regularly as part of their research or via ad hoc projects.

SEE Support of Teaching

The Technion "Service Engineering" Course

A unique Service Engineering course has been developed and taught at the Technion over the last decade. SEE's existence is taking this course to new levels. Indeed, today's students of Service Engineering can either install SEEStat on their own computers (this is SEE's interface machine), or access SEEStat via the SEEServer. In either case, students are accessing and using SEE data as part of their course homework.

The INFORMS Journal on Transaction on Education recently published (September 2010) an invited review paper of the Technion's Service Engineering course.
See www.informs.org/Pubs/ITE/Archive/Current-Issue.
The paper's title is "Service Engineering: Data-Based Course Development and Teaching," which is directly referring to the prominent role that SEE data and the SEELab have been playing in the course—past and present. Specifically, the paper describes how SEE material has been regularly used in course material (lectures, recitations, exams); how through this data, phenomena are being explained, demonstrated and tested, and theory either supported or refuted. Examples include empirical discussions of Little's Law, Service Durations, as well as Customer Impatience over the phone. A recent example, not included in the paper, is a queueing-focused modeling of the flow of patients through a hospital's Emergency Department, which constituted part of the MSc thesis of a recent Teaching Assistant of the course (course generation 2011W). Yet another example is the final project of the Service Engineering course, which is based on SEE data, and was prepared jointly with 2 graduates of the course who were employed by the SEELab.

Significantly, the Service Engineering course has been attended by Technion research partners. For two such examples: several members of the IBM Haifa Research Lab took the course, some going beyond merely listening to lectures and even performing all the required homework (which is a significant undertaking); and the Operations Manager of Rambam's Imaging Unit attended the course as well. These students then maintain close relations with SEE activities beyond the course. For example, one of IBM's members is now pursuing a graduate degree at the Technion; and the Rambam manager consulted graduate students in their theses and advised a colleague on SEE-related research.
The Service Engineering course website is accessible to researchers worldwide; it is frequently visited and its material used for support teaching and research: see http://ie.technion.ac.il/serveng

"Service Engineering" Courses Out of the Technion, Notably at Penn

The Service Engineering course was recently taught at 2 universities in the USA:

- Whitt, Ward & Yom-Tov, Galit, Columbia University, 2 Service Engineering courses, Spring, 2012: one for MSc students and one for PhD students.
- Pang, Guodong (Gordon), Penn State University, Service Networks: Empirical Analysis, Modeling and Management, Spring, 2012: Penn State IE is the alma mater of Hal Marcus, who provided the founding donation for SEE; Marcus gave an equal donation to Penn State, with the explicit hope for collaboration between the institutions. It is a significant manifestation of such collaboration that a Technion-developed course on Services is taught at Penn State.

Mini-courses, Seminars and Data on Service Engineering

A mini-course of Service-Engineering has been taught, in recent years, at the universities of Stanford, Columbia and Pennsylvania (Wharton). The course was attended by PhD students and faculty. Thus, SEE-generated knowledge, as well as SEE resources, is being disseminated worldwide.

Seminars on SEE-related topics: There have been two semester-long SEE-related seminars at the Technion, one dedicated to Call Centers and the other to Healthcare Call-Centers. These seminars were attended by students, faculty and outside visitors (from industry), exceeding 20 participants in attendance.

Data for Other Courses: SEE has provided data for other data-hungry courses at the Technion: Data-Mining and Time-Series. Both courses require fresh data for homework assignments and students' projects, and SEE data and its staff are ideally suited to provide such support.

Undergraduate Projects

During the 3rd or 4th year of studies, every undergraduate IE student must take a project-course, supervised jointly by industry and academia. In recent years, the SEELab has played an important role in many such projects. Specifically, these projects have been performed jointly with SEE partners (banks and hospitals), who provide the SEELab with its data. Examples of such projects include:

- Analysis of call-duration and call-structure at a large Israeli bank's call center.
- Fairness vs. Efficiency in the routing of patients from the emergency department to internal wards, in a large Israeli hospital.
- Fusing operational data with financial data towards profit prediction at a call center.
- Operational models and data infrastructure, in support of management and control of a Mass-Casualty-Event at a hospital.

In all the above examples, and others, SEE members have actively participated in project support and supervision, thus providing expert advice and a data-bridge between the students and their partner companies. There have been additional projects that took place in companies or institutions that have no data-relations with SEE. However, their data was imported to SEE and interfaced with SEEStat, so that the students and their industry partners could view and analyze the data in a mutually beneficial manner.

Graduate Theses and Future Service Courses

SEE data has been used by graduate students in their theses, and SEE staff has been continuously supportive of graduate students in their research – be it in research that is directly related to or directly uses SEE data, or sometimes research that utilizes tools that have been developed at SEE (e.g. survival analysis, smoothing, distribution fitting and more).

It is highly desirable to develop graduate courses that will provide a natural continuation of the basic Service Engineering course. Due to scarce teaching resources, this has been infeasible so far. But with the likely addition of faculty that specializes in Services (who are continuously sought after), developing such a course could become a reality. One desirable model is "Engineering of Healthcare Services", a course that could possibly be attended (at least parts of it) by students from the Technion medical school.

SEE Support of Research

Being a research laboratory within a research university naturally renders research as the primary goal of SEE. In concert with this, SEE has been providing empirical foundations and support for theoretical research, involving researchers and graduate students. It has taken some time for the research community to realize the potential of SEE resources, but the seeds have been planted and concrete promising outcomes are in the pipelines.

Theoretical Research

Specifically, SEE data has been incorporated into research that is both general in nature: e.g. testing the validity and accuracy of generic forecasting methods; or application-focused: e.g. staffing based on robust optimization methods, estimating customer impatience over the phone, or modeling the flow of calls through a call center's IVR (Interactive Voice Response, namely the phone's answering machine). As is often the case in theoretical research, a model that is developed for a particular use finds application in another: e.g. the IVR model turns out to be similar to a model of a hospital ward, and it is the data from the application areas (available in SEE) that gives credit to this similarity, thus making it useful. (The IVR model was developed in an M.Sc. thesis and the Ward's model in a Ph.D., both at the Technion.)

Empirical Research

Empirical research has been mostly lacking from the research agenda of traditional Industrial Engineering, Operations Research and Operations Management, as well as from the emerging disciplines of Service Engineering and Science. However, this state of affairs is starting to change, as manifested by conferences that are devoted to, say, Empirical Operations Management, or academic positions that require training in both theoretical and empirical research. SEE plays a central role (to be modeled after) in this ongoing change, and its significance will only increase in the future.
  Graduate Students

SEE has been supporting research of graduate students in many ways. SEE has also greatly enhanced these students' learning experience, by providing them with an environment and tools that enable data-penetration, in depths and breadth that are unavailable elsewhere. Some of the students that have directly enjoyed SEE resources are (Technion students unless mentioned

otherwise): Noa Zychlinsky (M.Sc., ongoing), Rony Gehbali (M.Sc., ongoing), Itamar Zaied (M.Sc., ongoing), Asaf Zviran (M.Sc., ongoing), Polyna Khudyakov (Ph.D., presently at Harvard as a post-doc), Galit Yom-Tov (Ph.D., presently at Columbia University as a post-doc), Yariv Marmor (Ph.D., presently at the Mayo Clinic as a post-doc), Michael Reich (M.Sc., ongoing), Daniel Nevo (M.Sc., ongoing at the Hebrew University), Arik Senderovic (M.Sc., ongoing), Yair Goldberg (Ph.D. 2009, the Hebrew University, spent a year at SEE and used its data in his thesis; using now SEE data in his research), Shimrit Maman (M.Sc. 2009), Yulia Tseytlin (M.Sc. 2008), Zohar Feldman (M.Sc. 2008, continuing for his Ph.D.), Luba Rosenshmidt (M.Sc. 2007) and Sivan Aldor (M.Sc. 2006; Ph.D. presently at Wharton – has used SEE data and support for both graduate degrees). The SEELab has also supported research of graduate students abroad, some actually visiting SEE to learn how to use its data.

SEE (International) Outreach

SEE's reputation is building up, and its resources are increasingly acknowledged and utilized. A sample of additional outreach activities is the following:

• Lecturing about SEE and its databases, including leaving SEE Data (via a DVD or hard disk): USA (Columbia, Stanford, UPenn, NYU); Turkey (Koc, Bogazici); Italy (LUISS), Germany (Berlin, Stuttgart, Ulm), Holland (Amsterdam, Eindhoven), China (Beijing, Shanghai), Argentina (Buenos Aires).

• Hosting a PhD student (Yair Goldberg) from the Hebrew University during 2008–2009; in the final year of his studies, the student learned to use SEE databases, which have been incorporated into his thesis. He is now a postdoc at the University of North Carolina, planning to cooperate with Prof. H. Shen on SEE-based research.

• Hosting a PhD student (Junfei Huang) from the National University of Singapore (NUS), between 10/2010 and 1/2011; and between 1/2012 and 6/2012. The student is learning to work with SEE data, with the goal of combining it with theoretical research. Furthermore, the expertise acquired will be exported to NUS, for the benefit of students as well as faculty. Additional visits of PhD students are planned for Dutch and US graduate students (jointly with their advisers).

• An excellent Technion graduate (Nitzan Yuviler) spent the academic year 2010-11 in China with her husband, who was enjoying a Chinese fellowship. Prior to her trip, Nitzan had spent time at the SEELab, learning how to use its programs and access its data. The idea was to try and export this knowledge to China, and it worked wonderfully. Indeed, Nitzan was hosted by the IE department at Tsinghua University (China's MIT), and conducted a workshop for faculty and graduate students. To quote Prof. Gavriel Salvendy, who is heading this IE department: "Nitzan was outstanding and has made the Technion proud. The data is outstanding and there are endless opportunities for seminal high impact contributions here. I sincerely hope that under Professor Zhao Xiaobo's leadership at our end and yours at the Technion, we will jointly move to the next level." Nitzan's visit gave rise to a joint research program is, between Tsinghua IE and the SEELab, with a possible submission of a proposal to the Chinese NSF.

• Hosting researchers from Israel and abroad for the purpose of demonstrating SEE capabilities. For example, Prof. H. Takagi, who is managing an academic program in Service Science and Engineering at Tsukuba University, came for a 2-day visit from Japan, exclusively to learn about our SEE data-resources and research activities. There have been many additional learning-visits from researchers and practitioners, from both USA and Europe.

• Hosting foreign exchange students (undergraduates), for example a student from Germany during the summer of 2009.

- Cooperating in and contributing to research, ongoing and proposed, in the U.S.

- Providing a home for OCR data (OCR = Open Collaborative Research, jointly The Rambam Hospital, IBM Research Labs in Haifa and IE&M at the Technion). Initial contacts have been initiated in Philadelphia, New York and Singapore, exploring the possibility of hosting data from U.S. and Singapore hospitals at SEE.

- In May 2010, the Technion hosted an important international conference: MSOM 2010 and its Special Interest Groups – SIG (http://msom.technion.ac.il/index.php?num=1). The SEE Center was a formal sponsor of this conference, and it played an important role in its program (and ultimate great success):

During the SIG on Services, Prof. Mandelbaum delivered a lecture on "Empirical Adventures in Call Centers and Hospitals", based on SEE data. The lecture was followed by a workshop for 15 international participants, who went over a self-teaching tutorial, prepared by the SEELab, that taught them, online, to work with SEEStat on SEE data. This workshop was a great success, and it inspired many additional MSOM participants to practice this tutorial at the SEELab, on an individual basis. The tutorial can be accessed at
http://ie.technion.ac.il/serveng/References/MSOM_2010/SEEStat%20Workshop%20Tutorial%20_solution_.pdf

Two full sessions, which included 7 lectures, were devoted to research that is based on SEE data. (It is noteworthy that MSOM is a competitive conference, namely these lectures had been pre-submitted to the conference and chosen among many others.) The lectures can be accessed at
http://ie.technion.ac.il/serveng/References/MSOM_2010/MSOM_Main_Page.htm.

SEE data has been used, with acknowledgements, in research publications worldwide. Examples include testing methods for arrival forecasting, phase-type fitting, (im)patience estimation, and more.

SEE Support of Practice (Service Engineering)

SEE's industry partners have been enjoying and benefitting from their collaboration with SEE. For a start, the import of data to SEE necessitates a thorough understanding of the data-structure, which included data cleaning, discoveries of inconsistencies, etc. Thus, at the end of the import process, the data-sources themselves have typically improved significantly.
SEE members are also consulted, by SEE partners, on problems that can find their solutions in SEE data. As an additional example, groups from a bank- and hospital-partner of SEE were hosted at the Technion for a full afternoon. The meetings centered on lectures by SEE members, on interesting findings from these partners' SEE data, which had been imported to the SEELab. These meetings were declared a major success and, since then, have helped all parties involved in their activities.

SEE Data and Software

Service center data is stored mainly in relational databases or in other formats, for example, in click stream files for Internet sites. The structure of these databases varies among service centers, depending mainly on the commercial software used by the center. Our precondition for creating a data repository of service was the design of the *uniform* representation of data, accommodating a wide variety of service centers.

In SEE, we first developed a data-model for call center analysis, entitled **DataMOCCA**, which is as independent as possible of the particular format of its source data. (DataMOCCA stands for Data <u>MO</u>del for <u>C</u>all <u>C</u>enter <u>A</u>nalysis**.)** This data-model, initially designed for call center data, has been extended to accommodate a generic service center, and the concept has been successfully used to integrate data from hospitals and internet sites.

The main challenge for the creation of such a data repository is the huge volume of data. For example, the largest database in our data repository has the size of around 50 GB. Even the most powerful SQL servers are too slow to extract data from a database of such a size, not to mention if a time-series for a long period of time is needed within a few seconds.
The objective was to create a system that could work on a PC, which is to be used by researchers and students outside SEE, and provide real-time access to data, with maximal delays of a few seconds. To achieve this objective, the concept of a *database partition* was developed and implemented.

The successful integration of health care data into DataMOCCA demonstrates that this system design is general and flexible enough. It can accommodate various types of Service data and, thus, could become a standard tool for Service Science and Engineering research and application.

SEE data repository consists of *studies*. Despite the splitting of the database into dozens and hundreds of daily or monthly tables, the system works as an integrated database, using structures created at the study level, such as study calendar, dictionaries and database table descriptions. SEE now hosts three large call center studies: a large call center of a U.S. bank, which provided us with 2.5 years' worth of transaction-level data (around 218 million calls), an Israeli Telecom Company with over 3 years' worth of data (175 million calls), and an Israeli Bank with over 1 year of data (26 million calls). An additional small call center study was integrated from the Anonymous Bank research project – this was a pioneering research effort, during 1999–2003, which culminated in a joint Wharton-Technion empirical research that set the stage for the data-based research of call centers.

The SEE data repository now hosts also two health care studies: Emergency Rooms (EDs) of 5 Israeli hospitals (each with about 2 years' data); and a comprehensive database (ED, Wards, Operating Rooms, Labs, and more), still active, from a partner Israeli Hospital, spanning a period of 4 years.

As described above, in 2009, a new study was initiated at the call-center of an Israeli mid-size bank. In this study, the data-transfer process is unique in that operational data is fed into the SEELab on a **daily basis**. In other words, every night, after the bank archives its call-center daily data, that data is deposited in a "safe" at the SEELab, and then automatically incorporated (after cleaning and validation) into the corresponding SEE study. The plan, in the not-too-distant future, is to expand the flow of operational data to also cover financial data—needless to say, this planned combination of operational and financial data, which has never yet been achieved, promises endless opportunities for research (empirical and theoretical) and applications. It will also pave the way for analogous data-gathering efforts in hospitals, which will combine operational and clinical data.
SEE also contains a study from the IE&M Faculty website, based on Internet click stream data over 4 years.

SEEGraphs: Graphs and flow charts

Service experiences (phone calls, patient sojourns in hospitals, Internet site visits) consist of several steps. For example, a customer enters the call center through the VRU; then the call is transferred to the queue, to the agent; it could go back to the VRU, or to another

queue or agent, etc. Similarly, a patient in the hospital could enter the emergency department or one of the hospital departments directly, and could be later transferred to another department (e.g. ICU). And the visitor of an Internet site is also navigating through the site, visiting various pages and documents. A *graph* is a natural model for describing this customer dynamics, thus bridging between the data and subsequent analysis of the model and the service process.

In SEE, we are now developing tools to extract data needed for the construction of graphs from databases, in order to analyze the graph using graph algorithms and to draw corresponding flow charts. Our graph library is under construction. It includes a variety of graph algorithms, as well as graph layout algorithms that are needed for graph drawing. Graph classes that are based on our core libraries have been designed as well.
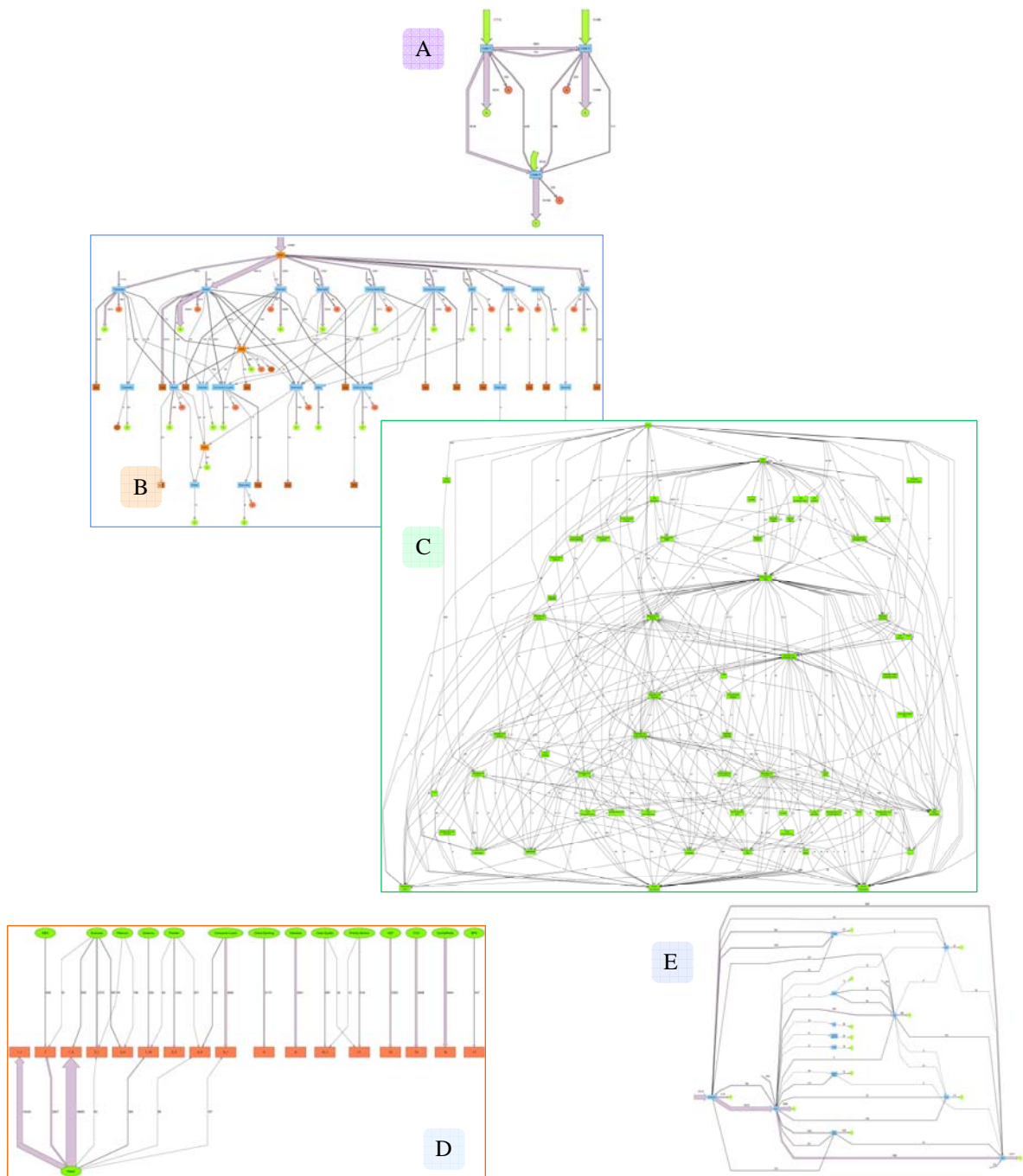
Examples of Graphs (Hospital data)
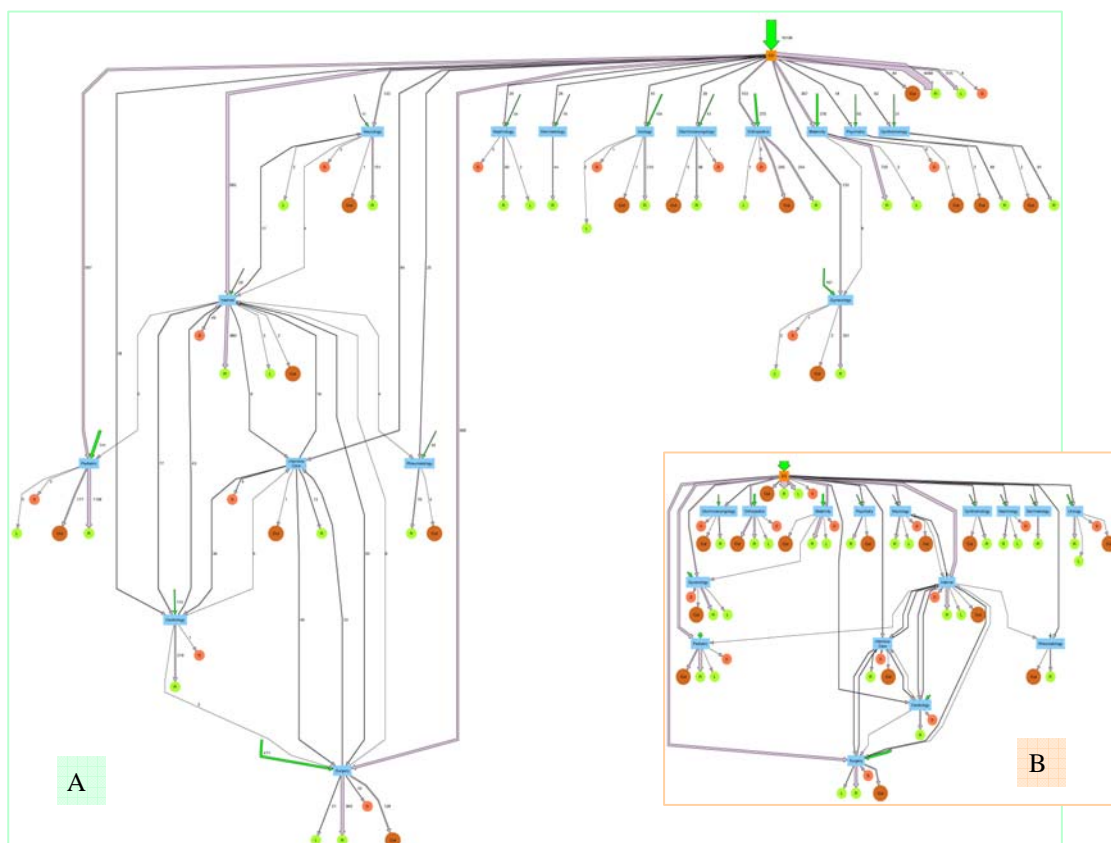
A: Patient flow

B: Patient flow (same data with layout without edge labels)

Examples of Graphs (Call Center data)

A: Interqueue - zoom out system (Overflows among 3 call centers, in NYC, Boston and Philadelphia).

B: Calls flow Layers graph - overall customer flow through the answering machine, waiting in queue, being served or abandoning, by customer sub calls.

C: Calls flow Spaghetti graph - overall customer flow through the answering machine, waiting in queue, being served or abandoning, by service group and service type.
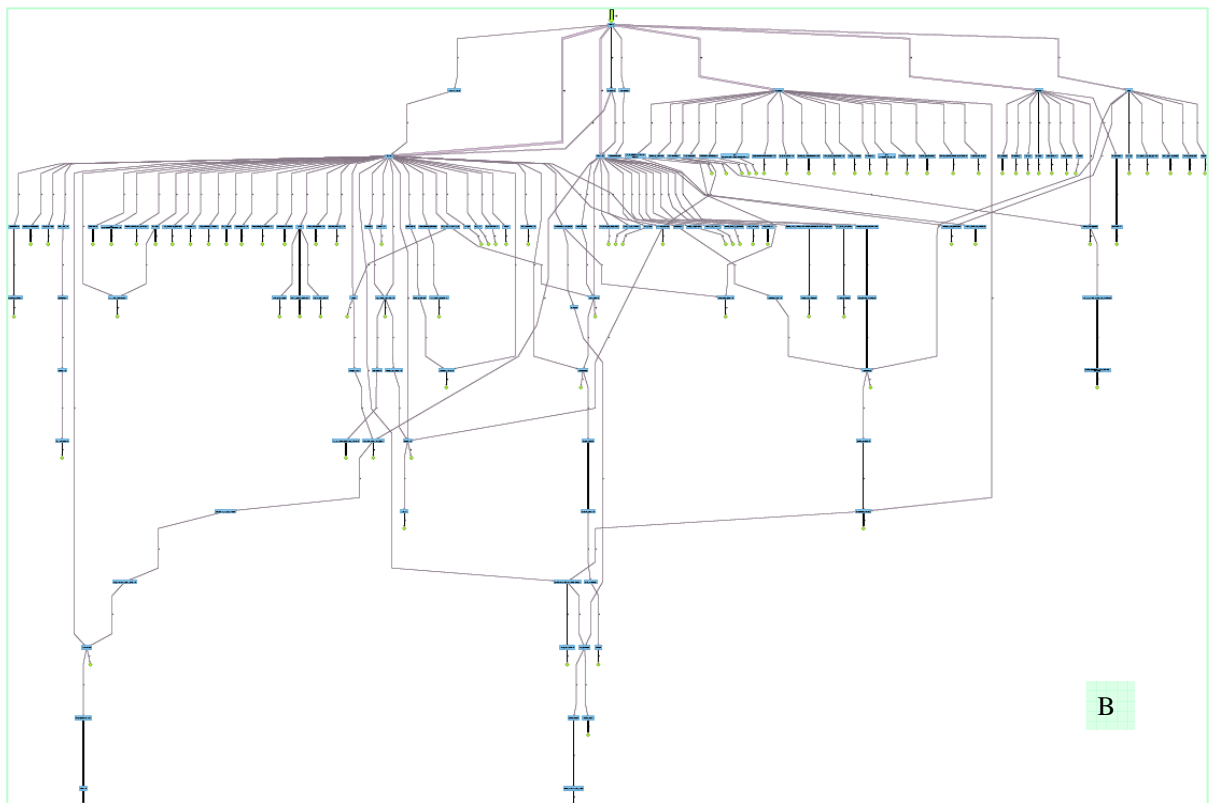
D: Skills Based Routing - zoom in on skills-needs matching, that is flow from queues of customers (needs, in green) to pools of agents (skills, in orange).

E: IVR (Interactive Voice Response, or simply an answering machine) - zoom in.

## Examples of Graphs (Internet data)
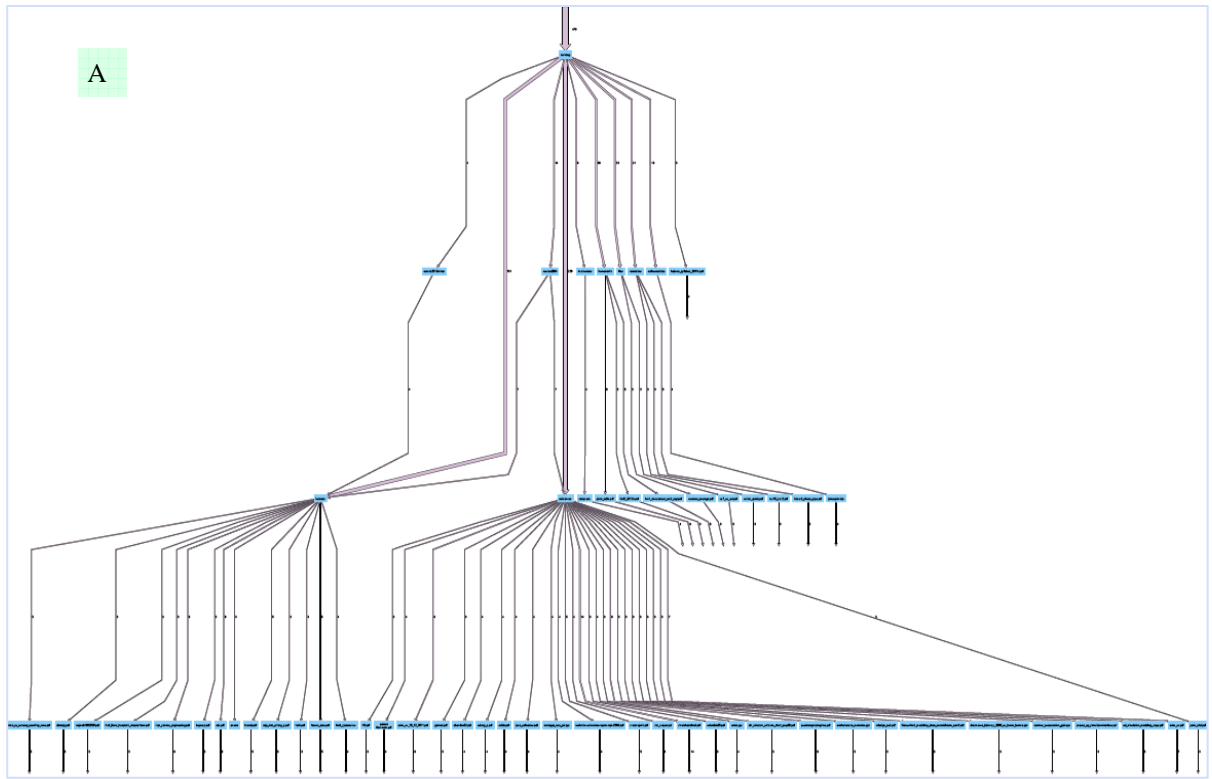
*A: Flow structure, at the Service Engineering website*

*B: Actual flow with "spiders" (e.g. Google).*

SEEStat: Environment for graphical EDA in real-time

SEEStat is a system that enables users to easily conduct operational and performance analyses of massive datasets; in particular, datasets representing operational histories of large service operations, as available through the SEELab server (**free for academic use**). In addition to analysis, the SEEStat system can automatically create sophisticated reports in Microsoft Excel, which can support research and teaching.

Examples of SEEStat Outputs (Call Center data, Waiting Times)
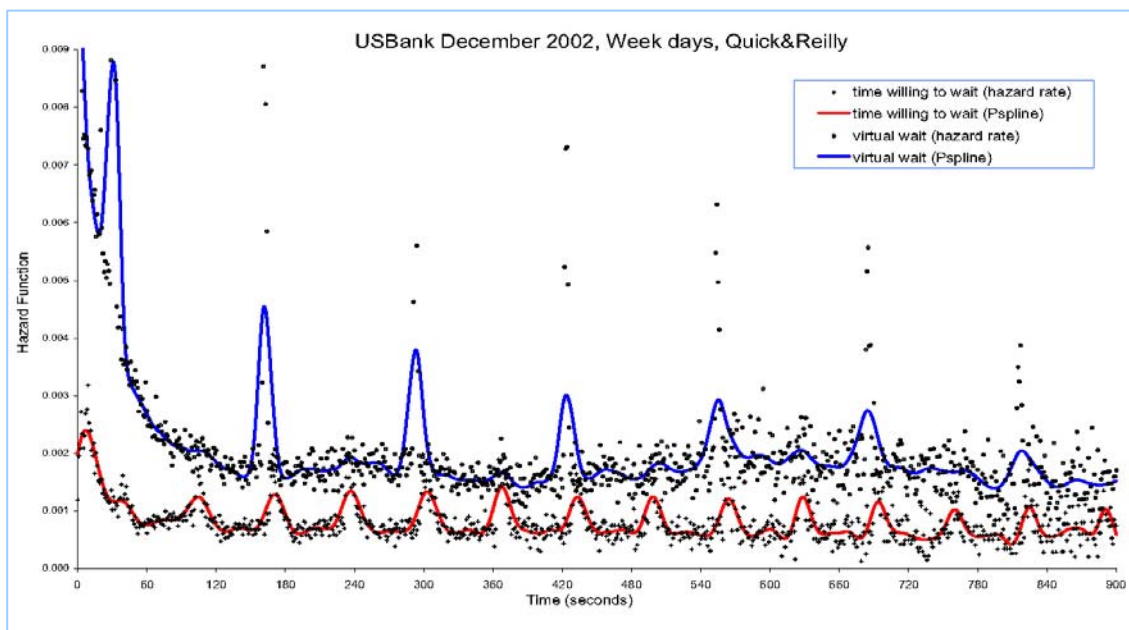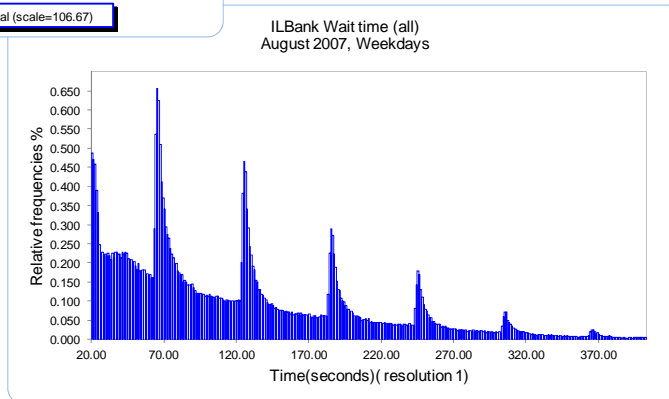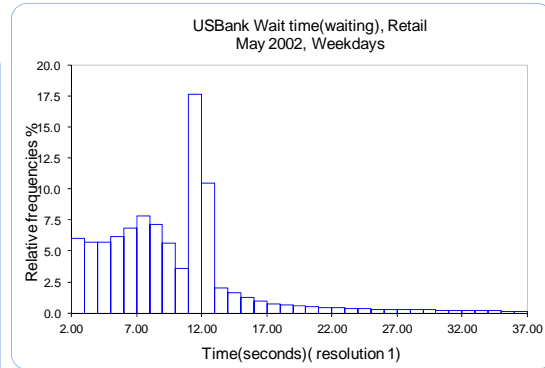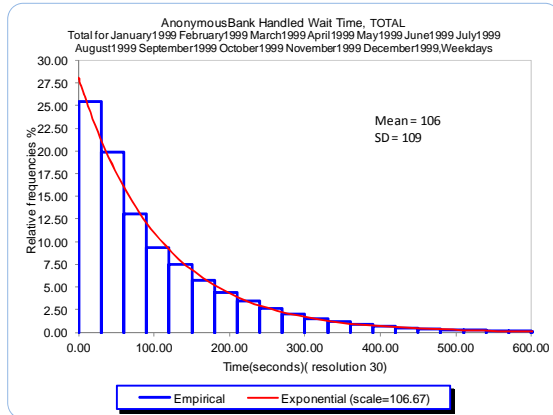
Examples of SEEStat Outputs (Hospital data, 2004-2007, weekdays)
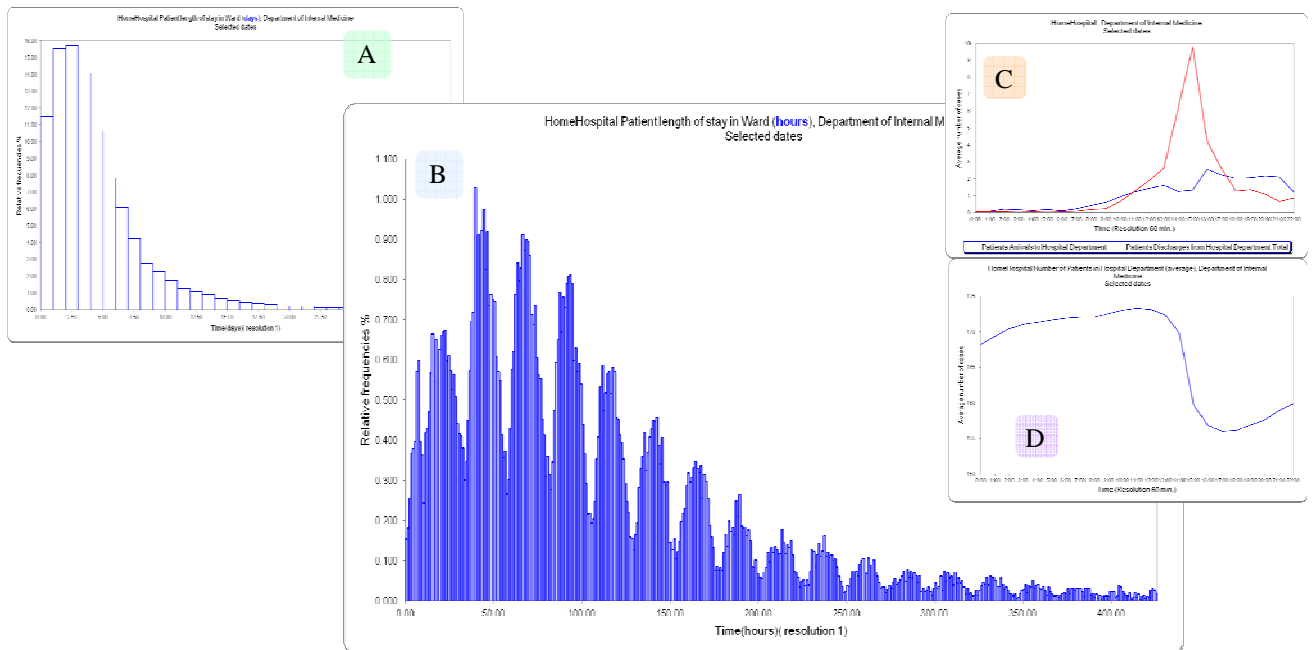
A: Distribution of patient length of stay in Departments of Internal Medicine, in days.

B: Distribution of patient length of stay in Departments of Internal Medicine, in hours

C: Patients arrivals and departures, Department of Internal Medicine.

D: Number of patients in Department of Internal Medicine.

SEEMulators: Developing simulators at the Technion SEELab

A desirable direction to enhance teaching capabilities of the SEECenter is the development of a Call Center simulator, which could be later expanded to Emergency Departments. This simulator is planned to be integrated into the *teaching* of Service Engineering, to be used by students in their homework and research activities.

Developing the simulator will involve *students*, both graduates working on their theses and undergraduates on their yearly projects. The students will join forces with the experienced researchers of the SEELab, thus acquiring useful practical tools. The planned simulator will narrow the *gap* between available tools for modeling and simulation on the one hand and the complex reality of call centers and emergency departments on the other hand. It will thus facilitate job-finding for students skilled in its operation.

The research activities will be mainly focused on the development and testing of models for the simulation module and creation of the simulation software. The simulation module will be developed as an integral part of the existing software system (DataMOCCA and SEEStat). Finally, an interface will be designed and created, which connects the simulation module, through the statistical module, to source data, in order to provide input parameters according to model specification. The plan is to expand our existing SEEStat output interface, which currently covers tables and charts, to accommodate also a flow chart's interface. Significant progress has been achieved in this direction.

Letter to Hal Marcus

Technion , Year 2012

Dear Hal and Inga:

All of us at the SEE Laboratory were thrilled to learn that Hal receives a Technion honorary doctorate - needless to say, we can think of no one more deserving - congratulations indeed. We are only sorry that you are unable to visit us and witness, first hand, the research and teaching evolution that we have been experiencing. Allow us therefore to briefly fill you in on that.

We have continued to develop our data resources, together with tools that facilitate data analysis. Specifically, our present data-partner, a central Israeli Bank, is depositing its call centers data at the SEELab on a daily basis, which opens up novel data-based applications; and we now have pilot capabilities of encoding the dynamics of complex service systems, which will eventually enable the creation of system simulators, in support of researchers, engineers and ultimately managers.

The most exciting news, however, is that at this present time, a course on Service Engineering is being taught at two leading U.S. universities – most importantly, Penn State at the Harold and Inge Marcus Department of Industrial and Manufacturing Engineering, as well as at Columbia University IE; and both courses have been continuously supported by your Technion SEE Center.

The teacher at Penn IE, Professor Guodong Pang, visited us at the SEELab, learned how to use our data resources, became familiar with the Technion Service Engineering course, and since then has used all this knowledge in teaching the Penn State course. An important unique element of the learning process is hands-on experience with data: here Penn State students have been using SEE data within our own-developed exploratory-data-analysis platform, which is accessible via the Internet at the Technion SEE Server.

At Columbia University IE, there are actually 2 Service Engineering courses presently taught: one for undergraduate and MSc students, which is exactly the Technion course, relying heavily on our SEE data; and the other is for PhD students, focusing on theoretical foundations. Both courses are taught, jointly, by Professor Ward Whitt, one of the world leaders in our research field, and Dr. Galit Yom-Tov, who is a postdoc of Professor Whitt. Galit is actually a Technion graduate. She started her PhD exactly when the SEELab was born and her PhD thesis centered around SEELab-data. Her SEE experience and expertise is now being exported to Columbia University. Galit will be closing a circle next year by returning to the Technion as a faculty member, to be teaching Service Engineering at the Faculty of Industrial Engineering.

The universal accessibility of our data-bases renders them useful worldwide, starting naturally with our own Technion students and faculty, continuing with the above 2 courses and with researchers at Wharton and Kellogg (top business schools), reaching all the way to Hong Kong University of Science & Technology, National University of Singapore and China's Tsinghua University. As you can see, your pioneering vision of the field of Service Engineering growing and blossoming, with SEE data providing the foundation and the framework, is becoming a reality.

It was wonderful having Inge visit us last year. We are looking forward to many future visits of you both, and we cannot be grateful enough for your continuing support and encouragement over the years.

Congratulations again on this wonderful highly deserving honorary doctorate.

Sincerely,

Avi Mandelbaum

Valery Trofimov

Ella Nadjharov

Igor Gavako

Abir Koren,

also on behalf of all the students and researchers that are and have been benefiting from the Technion SEELab.

11 AM - 12 PM