

# Plenary Lectures

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**Title:** A computationally tractable theory of performance analysis in stochastic systems

**Speaker:** Dimitris Bertsimas, Sloan School of Management, Massachusetts Institute of Technology, USA

**Time and Location:** 08:30-09:30, Wed 17 July, HG F30/F1/F7

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**Abstract:** Modern probability theory, whose foundation is based on the axioms set forth by Kolmogorov, is currently the major tool for performance analysis in stochastic systems. While it offers insights in understanding such systems, probability theory is really not a computationally tractable theory. Correspondingly, some of its major areas of application remain unsolved when the underlying systems become multidimensional:

Queueing networks, network information theory, pricing multi-dimensional financial contracts, auction design in multi-item, multi-bidder auctions among others.

We propose a new approach to analyze stochastic systems based on robust optimization. The key idea is to replace the Kolmogorov axioms as primitives of probability theory, with some of the asymptotic implications of probability theory: the central limit theorem and law of large numbers and to define appropriate robust optimization problems to perform performance analysis. In this way, the performance analysis questions become highly structured optimization problems (linear, conic, mixed integer) for which there exist efficient, practical algorithms that are capable of solving truly large scale systems.

We demonstrate that the proposed approach achieves computationally tractable methods for (a) analyzing multiclass queueing networks, (b) characterizing the capacity region of network information theory and associated coding and decoding methods generalizing the work of Shannon, (c) pricing multi-dimensional financial contracts generalizing the work of Black, Scholes and Merton, (d) designing multi-item, multi-bidder auctions generalizing the work of Myerson.

This is joint work with my doctoral student at MIT Chaithanya Bandi.

**Biography:** Dimitris Bertsimas is currently the Boeing Leaders for Global Operations Professor of Management and the co-director of the Operations Research Center at the Massachusetts Institute of Technology. He has received a BS in Electrical Engineering and Computer Science at the National Technical University of Athens,

Greece in 1985, a MS in Operations Research at MIT in 1987, and a Ph.D. in Applied Mathematics and Operations Research at MIT in 1988. Since 1988, he has been in the MIT faculty. His research interests include optimization, stochastic systems, data mining, and their applications.

In recent years he has worked in robust optimization and health care analytics. He has published over 150 papers and 3 graduate level textbooks. He is a member of the National Academy of Engineering and he has received several research awards including the Farkas prize, the SIAM Optimization prize and the Erlang Prize. He has supervised 50 doctoral students at MIT and he is currently supervising 12 others.

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**Title: Control for smart grids: Applications and opportunities in the customer domain**

**Speaker: Tariq Samad**, Honeywell Automation and Control Solutions, Minneapolis, USA

**Time and Location: 08:00-09:00, Thu 18 July, HG F30/F1/F7**

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**Abstract:** One of the principal points of differentiation between smart grids and traditional power systems is the importance the former accord to electricity consumers and customers—residential, commercial, and industrial facilities are an integral part of the smart grid system of systems. Furthermore, the portfolio of energy assets in homes, buildings, and factories is being dramatically enhanced; distributed generation and storage, in addition to heterogeneous loads and in grid-connected implementations, manifest that “demand-side” management is not just about demand any longer. Realizing the smart grid vision of clean, low-cost, and securely supplied energy depends crucially on the active engagement of facility owners, operators, and assets. With measurement, communication, and computing becoming pervasive in the expanded end-to-end electricity infrastructure, the stage is set for control technologies. Notable progress has been made already. Several innovative and exciting projects are under way worldwide and significant economic and societal benefits have been achieved, especially in areas such as automated demand response, optimal microgrids, and energy analytics. Yet we have just scratched the surface of possibility. Faster dynamics, larger-scale systems, more diverse assets, dynamic pricing, humans in the loop, and other complexities and trends all suggest opportunities for control research with the promise of tremendous impact on society and industry.

**Biography:** Tariq Samad is Corporate Fellow at Honeywell Automation and Control Solutions, in Minneapolis, U.S.A. During his 27 years with Honeywell he has contributed to and led automation and control developments for applications in electric power systems, the process industries, building management, automotive engines, unmanned aircraft, and clean energy. His research interests relate broadly to automation, intelligence, and autonomy for complex engineering systems.

Dr. Samad served as President of IEEE Control Systems Society in 2009 and is President Elect of the American Automatic Control Council. He is an IEEE Fellow and the recipient the 2008 IEEE CSS Control Systems Technology Award and other distinctions. He was editor-in-chief of IEEE Control Systems Magazine during 1998 – 2003 and General Chair for the 2012 American Control Conference. His recent publications include The Impact of Control Technology. Dr. Samad holds a B.S. from Yale University and M.S. and Ph.D. degrees from Carnegie Mellon University.

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**Title: Synthetic biology: From parts to modules to therapeutic systems**

**Speaker: Ron Weiss**, Department of Biological Engineering, Massachusetts Institute of Technology, USA

**Time and Location: 08:00-09:00, Fri 19 July, HG F30/F1/F7**

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**Abstract:** Synthetic biology is revolutionizing how we conceptualize and approach the engineering of biological systems. Recent advances in the field are allowing us to expand beyond the construction and analysis of small gene networks towards the implementation of complex multicellular systems with a variety of applications. In this talk I will describe our integrated computational / experimental approach to engineering complex behavior in living systems ranging from bacteria to stem cells. In our research, we appropriate design principles from electrical engineering and other established fields. These principles include abstraction, standardization, modularity, and computer aided design. But we also spend considerable effort towards understanding what makes synthetic biology different from all other existing engineering disciplines and discovering new design and construction rules that are effective for this unique discipline. We will briefly describe the implementation of genetic circuits and modules with finely-tuned digital and analog behavior and the use of artificial cell-cell communication to coordinate the behavior of cell populations. The first

system to be presented is a genetic circuit that can detect and destroy specific cancer cells based on the presence or absence of specific biomarkers in the cell. We will also discuss preliminary experimental results for obtaining precise spatiotemporal control over stem cell differentiation for tissue engineering applications. We will conclude by discussing the design and preliminary results for creating an artificial tissue homeostasis system where genetically engineered stem cells maintain indefinitely a desired level of pancreatic beta cells despite attacks by the autoimmune response, relevant for diabetes.

**Biography:** Ron Weiss is an Associate Professor in the Department of Biological Engineering and the Department of Electrical Engineering and Computer Science at the Massachusetts Institute of Technology. Weiss received his PhD from MIT in 2001 and currently serves as the Director of MIT's newly formed Synthetic Biology Center. His research focuses on synthetic biology, where he programs cell behavior by modeling and experimentally constructing artificial cellular pathways. A major thrust of his work is the synthesis of gene networks that are engineered to perform in vivo analog and digital logic computation. He is also interested in programming cell aggregates to perform coordinated tasks using engineered cell-cell communication. He has constructed and tested several novel in vivo biochemical logic circuits and intercellular communication systems in bacteria and yeast. More recently, the Weiss lab has focused on mammalian synthetic biology and several therapeutic application areas including programmed tissue engineering, diabetes, and cancer.