Imperial College London

UCL

Professor Lorenz T. Biegler
Carnegie Mellon University

On-line Dynamic Process Optimization: Making It Real

In the Chair: **Professor Nilay Shah, Director, Centre for Process Systems Engineering, Imperial College London**

Vote of Thanks: **Professor David Bogle, Department of Chemical Engineering, UCL**

Abstract: Optimization-based operations have long been a goal in process systems engineering. Starting from the pioneering work of Prof. Sargent, effective dynamic optimization models and efficient solution strategies have been developed and applied on challenging process systems. Current practice in real-time optimization (RTO) consists of two layers, with steady state nonlinear programming (NLP) models solved at regular intervals to determine optimal operation. These models provide the setpoints for the faster model predictive control (MPC) layer, whose behavior is determined by linear dynamic models. Implicit in this two-layer structure is a separation of time scales, where disturbance rejection and setpoint tracking can be handled between optimization intervals. On the other hand, the two-layer RTO structure is unsuitable for processes that are never really in steady state, such as batch processes, cyclic processes and continuous processes operate over multiple stages that require frequent transitions. For these processes, a single layer dynamic real-time optimization (D-RTO) approach is needed. Moreover, with the development of efficient strategies for the optimization of differential-algebraic equation (DAE) systems, on-line optimization of dynamic systems can be realized even for large-scale models. This talk will explore recent results in the development of this single-layer D-RTO framework. To develop this approach, we consider Nonlinear Model Predictive Control (NMPC) as a natural vehicle for Dynamic Real-time Optimization (D-RTO). It can incorporate first principle DAE models and provides compatibility with the controller and dynamic optimization problem, and is readily adapted to handle on-line uncertainties due to noise and process variations. More importantly, stability and robustness properties of NMPC are well understood, and recent work has even extended these properties from setpoint tracking objectives to more general stage costs that are economically based. On the other hand, realization of NMPC requires the application of a fast nonlinear programming (NLP) solver for time-critical, on-line optimization, as well as efficient NLP sensitivity tools that eliminate computational delay and guarantee stability and robustness. Algorithms that meet these demands will be explored and an "advanced step framework" will be outlined for NMPC, state estimation and D-RTO. Finally, a number of challenging real-world case studies will be presented that demonstrate the effectiveness of this approach.

Biography: Lorenz T. (Larry) Biegler is currently the Bayer University Professor of Chemical Engineering at Carnegie Mellon University, which he joined after receiving his PhD from the University of Wisconsin in 1981. His research interests lie in computer aided process engineering (CAPE) and include flowsheet optimization, optimization of systems of differential and algebraic equations, reactor network synthesis and algorithms for constrained, nonlinear process control. Prof. Biegler has been an institute fellow at the National Energy Technology Lab, a visiting scholar at Northwestern University and Lehigh University, a scientist-in-residence at Argonne and Sandia National Labs, a Distinguished Faculty Visitor at the University of Alberta, a Cheung Kong (Yangtze) scholar at Zhejiang University, a Gambrinus Fellow at the University of Dortmund, a Fulbright Fellow at the University of Heidelberg, a Distinguished Jubilee Lecturer at IIT-Bombay and the Hougen Visiting Professor at the University of Wisconsin. Honors include the Warren K. Lewis Award and the Computers in Chemical Engineering Award, given by AIChE, the Curtis McGraw Research Award and CACHE Computing Award, given by ASEE, and the INFORMS Computing Prize. He is an author on over 300 archival publications and two books, and has given numerous invited presentations at national and international conferences.

Thursday 1 December 2011 • 17.30

Lecture Theatre 1 (Room 250), Department of Chemical Engineering, ACE Extension Building, South Kensington Campus, Imperial College London SW7 2AZ

Tea and coffee will be served before the lecture from 16.30 in the Common Room (Room 228), Department of Chemical Engineering, Level 2, ACE Extension Building

The Eighteenth Professor Roger W.H. Sargent Lecture

The Professor Roger Sargent Lecture is an annual event the Centre for Process Systems Engineering inaugurated as a tribute to Professor Sargent's vision, leadership, significant technical contributions and to his legacy in the field of Process Systems Engineering.