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Modeling and Control of Complex Building Energy Systems

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ABSTRACT:

The seminar will begin with an overview of Dr. Kelkar's overall research program with a brief description of key research projects and new research initiatives. The second part of the talk will focus on the work of his research team in the area of modeling and control of building energy systems. This work was recently recognized by the ASME DSCD's 2021 Kalman Best Paper Award. Buildings is one of the major sources of energy consumption in the United States and it accounts for approximately 40% of the nation's total energy consumption. As such, any measure that can be taken to make buildings more energy efficient will not only greatly reduce the overall energy consumption but also help reduce the greenhouse gas emissions. The major share of building energy consumption comes from Heating, Ventilation, and air-conditioning (HVAC) system and, as a result, control of HVAC system has been the primary target of this research. This presentation will focus on modeling and control of a typical HVAC system configuration. The Pacific Northwest National Laboratory (PNNL)-DOE Laboratory- has invested millions of dollars in designing and building a multi-agent control platform called, VOLTTRONTM, that is being deployed in medium- and large-scale commercial buildings to enable control designers to implement custom-designed controls in building management system for increased efficiency. This talk will discuss different modeling and control methodologies developed and present experimental results from hardware implementation of some of these control strategies on a real research building using VOLTTRAN platform to demonstrate the energy savings. Two different control methodologies that will be presented include: A VOLTTRONTM based implementation of supervisory control using multi-agent based generalized gossip algorithm and passivity-based framework using Brayton-Moser formulation. Various simulation results will also be presented to demonstrate the energy savings that can be accomplished in smart buildings using the proposed control methodologies.

BIOGRAPHY:

Dr. Kelkar is the D. W. Reynolds Distinguished Professor and Department Chair of Mechanical Engineering at Clemson University. Prior to joining Clemson University, he was the Program Director of Dynamics Control and System Diagnostics Program in CMMI Division at National Science Foundation. Dr. Kelkar was an Associate Chair for Research and Technology Transfer in Mechanical Engineering and also the Professor-in-Charge, Industry Research and Entrepreneurship for College of Engineering at Iowa State University where he was faculty for 18 years. He received his Ph.D. degree in Mechanical Engineering from Old Dominion University, Norfolk, Virginia, in 1993 while working as a Research Scientist at NASA Langley Research Center, Hampton, VA. Dr. Kelkar is a Fellow of ASME, Associate Fellow of AIAA, and Senior Member of IEEE. He is a recipient of NSF's prestigious CAREER award in his early faculty career. He continues to lead various leadership activities in ASME and IEEE professional societies. He has held the positions of Associate Editor for key ASME and IEEE journals, served on Program Committees for various IEEE and ASME conferences, and organized and chaired several technical sessions at these conferences. His research has led to several patents and more than 150 archival publications which include several conference and journal articles, handbook chapters, and research monograph. His research has been in a general area of dynamics and control with focus on modeling and control of aerospace systems, control theory, active control of vibrations and noise, and very recently, in energy technologies. Dr. Kelkar is also a co founder of five different technology start-ups which are very successful in acquiring competitive projects from NSF, NASA, and DoD. Three of these companies have also won awards at the state level and have successfully commercialized technologies developed by Dr. Kelkar. His research and entrepreneurial success has led to several newspaper and magazine articles and interviews on national and local public radio stations and local TV stations.