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TRANSIENT THERMAL SYSTEM MODELING AND CONTROL

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ABSTRACT:

In this talk we will discuss the transient modeling of thermal systems. We introduce a modeling approach that we have taken for understanding and predicting transient dynamic phenomena in systems containing Vapor Compression Cycles as the primary source of thermal system management. These include standard AC/R units as well as those involving secondary loop systems. The overall goal of the modeling process is to develop systems-level models that are sufficiently flexible to be used on a variety of different applications. These models balance complexity with accuracy to obtain models that are sufficient for dynamic optimization and design as well as decision and control algorithms.

The systems are represented by interconnected modules consisting of component models. The modular framework is chosen so as to maximize modeling flexibility. The components are connected using typical thermodynamic relationships. The system components can be separated along fast and slow time scales with the fast time scale components being reduced to static functions. The slow dynamic components are the elements that store thermal energy, such as heat exchangers via their thermal capacitance. A hybrid dynamical systems model for multi-phase heat exchangers is used to compactly represent these systems in a form amenable to diagnostics and control. In addition to the modeling developments, a modular simulation environment using a MATLAB/Simulink platform will be presented. It allows for a rapid model development, modification, and verification. Additionally, it allows for real-time embedded model deployment. Representative examples of the modeling approach, as well as the model validation, will be presented.

In addition to the modeling exposition, we will also demonstrate how we develop controller design approaches for these systems. Among the particular controller designs discussed will be the use of optimization strategies for enhancing current practice in many AC/R systems. Demonstration of the controller benefits will be given on experimental testbeds.

BIOGRAPHY:

Professor Alleyne received his B.S. in Engineering Degree from Princeton University in 1989 in Mechanical and Aerospace Engineering. He received his M.S. and Ph.D. degrees in Mechanical Engineering in 1992 and 1994, respectively, from The University of California at Berkeley. He joined the Department of Mechanical and Industrial Engineering at the University of Illinois, Urbana-Champaign in 1994 and is also appointed in the Coordinated Science Laboratory of UIUC. He currently holds the Ralph M. and Catherine V. Fisher Professorship in the College of Engineering. He was awarded the ASME Dynamics Systems and Control Division's Outstanding Young Investigator Award and was a Fulbright Fellow to the Netherlands where he held a Visiting Professorship in Vehicle Mechatronics at TU Delft. He is the recipient of the 2008 ASME Gustus L. Larson Memorial Award and is also a Fellow of ASME. His research interests are a mix of theory and implementation with a broad application focus. In addition to research he has a keen interest in education and has earned the College of Engineering's Teaching Excellence Award and the UIUC Campus Award for Excellence in Undergraduate Education. He has been active in the ASME, the IEEE, and several other societies. Additionally, has been active on several boards including the Scientific Advisory Board for the U.S. Air Force. Further information may be found at: http://arg.mechse.illinois.edu/