2. Status of the Effort

We have continued development of an architectural approach to managing consistency across heterogeneous models used for design and verification of embedded control systems. A new cyber-physical system (CPS) architectural style has been developed in which components and connectors for physical systems are first-class elements along with the components and connectors used in traditional software architecture description languages (ADLs). The multiple models and modeling formalisms used for embedded control system design are integrated as architectural views of the base CPS architecture for a system. This architectural approach is currently being applied and evaluated for the STARMAC quadrotor.

3. Accomplishments and New Findings

3.1.1 Embedded Systems Modeling and Deep Compositionality (Krogh, Tomlin, Sastry)

The CPS architectural style has been implemented in ACMEStudio with annotations on components and connectors to encode behavioral semantics using finite state processes (FSP) and linear hybrid automata (LHA). Plug-ins generate models for existing verification tools, providing an integrated framework for analysis using heterogeneous models and tools. We are demonstrating through a set of test cases how the CPS architecture becomes a unifying context for maintaining consistency between models and drawing implications from multiple verification activities through assume-guarantee constructs.

3.1.2 Hierarchies of Robust Hybrid and Embedded Systems (Tomlin, Krogh, Sastry)

We have investigated the use of simulation relations between hybrid automata as a tool for performing assume-guarantee (AG) reasoning, illustrating the two fundamental issues that limit scalability of the AG approach to hierarchical and large-scale applications: finding assumptions that serve as provably correct environments for components, and computing simulation relations algorithmically. We have developed a set of heuristics to address both of these problems and have demonstrated their effectiveness for a set of case studies. We are currently investigating ways to characterize the types of problems for which these heuristics are effective in general and are extending the studies to hierarchical decompositions of embedded control systems.

4. Personnel Supported

CMU

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Matthias Althoff, Post Doc, Dept. of ECE, CMU

5. Publications

A. Rajhans, S-W Cheng, B. Schmerl, D. Garlan, B. H. Krogh, C. Agbi, A. Bhave, An architectural approach to the design and analysis of cyber-physical systems, Proceedings of the 3rd International Workshop on Multi-Paradigm Modeling (MPM 2009), Denver, CO, Oct 2009.

Ajinkya Bhave, David Garlan, Bruce H. Krogh, Akshay Rajhans, and Bradley Schmerl, Architectural Modeling and Analysis of Cyber-Physical Systems, Embedded Real-Time Software and Systems, Toulouse, May 2010.