Simulation of Hybrid Reo Connectors

Ebrahim Ardeshir-Larijani[1,2], Alireza Farhadi[5], Farhad Arbab[3,4], and Mohammad Izadi[5]

[1] Department of Computer & Data Science, Faculty of Mathematical Sciences
Shahid Beheshti University (SBU), Tehran, Iran
[2] School of Computer Science
Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
e.a.larijani@ipm.ir
[3] Centrum Wiskunde & Informatica (CWI), Amsterdam, Netherlands
[4] Leiden University, Leiden, Netherlands
farhad.arbab@cwi.nl
[5] Department of Computer Engineering, Sharif University of Technology (SUT), Tehran, Iran
izadi@sharif.edu,alirezafarhadi@ce.sharif.edu

Abstract. The prevalence of complex cyber-physical systems (CPS) as an increasingly ubiquitous technology, necessitates incorporation of component based and compositional design methods for development and deployment of such systems. The basic setup of CPSs consists of a network of sensors and actuators plus a control software, working together to interact with a physical environment. In this paper we use a hybrid coordination framework to specify CPSs with components, and use the resulting models to analyse the behaviour of those systems using statistical model checking (SMC). We use SMC because with models of systems with a level of uncertainty and unpredictability (e.g., the physical environment with which a CPS interacts), simulation-based verification approaches, where properties are guaranteed with a degree of confidence, are more feasible and yield more meaningful results. To demonstrate the main idea of our paper, we chose Reo as the language for specification of hybrid components coordination, where both continuous and discrete state transitions can occur inside components. We introduce new primitives for modeling of hybrid Reo connectors and extend its operational semantics in terms of hybrid constraint automata. Next, we introduce a transformation that takes the specification of a connector in the language of hybrid Reo, into a network of hybrid timed automata, a commonly used semantic model in SMC. Our approach takes advantage of compositionality of hybrid Reo components along with SMC simulation and verification techniques, leading to a better design cycle for complex CPSs, where coordination at the top level of system specification is often neglected. To implement our approach, we used UPPAAL SMC along with the new version of the Reo compiler. Our tool automatically translates a system of composed hybrid Reo connectors to a network of hybrid timed automata and then uses UPPAAL SMC for simulation and verification of this system. To show the usefulness of our approach, we also give a number of examples in the paper.