Object-Oriented Modeling and Efficient Simulation of C^3-Systems

Objektorientierte Modellierung und effiziente Simulation von C^3-Systemen

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Abstract

English: Modern technical systems which use various **C**omputation and **C**ommunication technologies to accomplish a given **C**ontrol task are referred to as C^3-Systems. Among various analysis methods towards those systems, simulation-based approaches are featured by their capability to combine the continuous and discrete dynamics (hybrid dynamics). This work aims at laying a modeling and simulation framework for simulation-based analysis of C^3-Systems. Based on the object-oriented modeling language Modelica and its tool Dymola, a **N**etwork-**C**ontroller-**Lib**rary (*NCLib*) is developed. An object-oriented analysis and design (OOAD) approach is applied in the development of the library. According to the OOAD approach, the modeling of interactive complex discrete event systems is carried out on the basis of UML graphical representations and unambiguous conversion rules which correspond to the execution semantics of Modelica. Using UML diagrams as conceptual models improves the readability and extendibility of the resulting models. Additionally, a particular focus is laid on improving the simulation efficiency for C^3-Systems. Therefore, several design patterns for building event-minimized models and a separated simulation scheme are proposed.

German: Moderne technische Systeme, die verschiedene Technologien zum Rechnen (**C**omputation) und zur Kommunikation (**C**ommunication) nutzen, um eine gegebene Regelungsaufgabe (**C**ontrol) zu erledigen, werden als C^3-Systeme bezeichnet. Unter verschiedenen Analysemethoden für diese Art von Systemen zeichnen sich simulationsbasierte Ansätze durch die Fähigkeit aus, die kontinuierliche und diskrete Dynamik (hybride Dynamik) kombinieren zu können. Diese Arbeit entwickelt ein Modellierungs- und Simulations-Framework für die simulationsbasierte Analyse von C^3-Systemen. Basierend auf der objektorientierten Modellierungssprache Modelica und dem Werkzeug Dymola wird eine Netzwerk-Controller-Bibliothek (*NCLib*) entwickelt. Der Entwicklungsprozess der Bibliothek erfolgt mittels einer objektorientierten Analyse- und Design-Methode (OOAD-Methode). Gemäß der vorgestellten OOAD-Methode wird die Modellierung von interaktiven komplexen ereignisdiskreten Systemen auf Basis grafischer Darstellungen in Form von UML-Diagrammen durchgeführt. Dies geschieht unter Verwendung eindeutiger Konvertierungsregeln, welche der Ausführungssemantik der Modelica-Sprache entsprechen. Die Verwendung der UML-Diagramme als konzeptuelle Modelle erhöht die Lesbarkeit und die Erweiterbarkeit der resultierenden Modelle. Ein zweiter Schwerpunkt der Arbeit ist eine verbesserte Laufzeiteffizienz bei der Simulation von C^3-Systemen. Hierfür werden verschiedene Entwurfsmuster für die Erzeugung ereignisminimierter Modelle sowie ein separates Simulationsschema entworfen.

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