MODELING AND ANALYSIS METHODS FOR MULTI-AGENT SYSTEMS USING PETRI NETS

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ABSTRACT

The assessment of properties of multi-agent systems is of critical importance. Past and current research in distributed artificial intelligence has resulted in the development of several multi-agent frameworks and multiple applications on the control and optimization of complex systems. One of the most important challenges in this field is the development of theoretical based methods to assess key properties of such systems. This work is an investigation on properties and methodologies for modeling and analysis of multi-agent systems frameworks, specifically in the interaction protocols area. Petri nets are applied as a modeling tool to assess the structural and behavioral properties of the multi-agent system.

This methodology consists in defining a multi-agent system based on the abstract architecture for intelligent agents. The abstract architecture is modeled as a discrete-event system using Petri nets, structural and behavioral analysis provides an assessment of the interaction properties. Deadlock avoidance in the multi-agent system is considered as an initial key property, and it is evaluated using liveness and boundedness properties of the Petri net model.

The contribution of this work consists in the definition of an abstract architecture for multi-agent systems with indirect interaction, analogous to the abstract architecture for intelligent agents. The proposed architecture allows the description of agent-to-agent interactions via changes in the environment and serves as an initial description of the discrete-event system dynamics of the multi-agent system. In addition, this work presents an algorithm to obtain a Petri net model of a multi-agent system, leveraging from the multi-agent system's abstract architecture. Finally, a methodology to ensure that the multi-agent system is deadlock free is presented; it is based on the analysis of the discrete-event properties of the Petri net model.

In particular, we present results for the analysis of a simple multi-agent system consisting of two agents performing a common task. The multi-agent system is described using the abstract architecture for multi-agent systems, as well as a Petri net model of the discrete-event dynamics of the system. The reachability graph and

the net invariants are presented to assess liveness and boundedness properties of the system and to prove that the multi-agent system is deadlock free with respect to the agent-to-agent interactions in the overall environment.