PRIMA 2022

TUTORIAL INFORMATION

Title	Automated Verification of Multi-Agent Systems. Why, What, and Especially: How?
Status (Online or Onsite)	Onsite
Tutors	Wojciech~Jamroga and Wojciech Penczek
Abstract	The course offers an introduction to some recent advances in formal verification of intelligent agents and multi-agent systems. The focus is on accessible presentation and simple examples, without going too deep into the involved mathematical machinery. Automated verification of discrete-state systems has been a hot topic in computer science for over 35 years. The idea found its way into AI and multi-agent systems in late 1990's, and techniques for verification of such systems have been in constant development since then. In this tutorial, we present a lightweight introduction to the topic, and mention relevant properties that one might like to verify this way. Then, we describe some very recent results on incomplete model checking and model reductions, which can lead to practical solutions for the notoriously hard problem. We conclude by a presentation of the experimental tool for verification of strategic ability, being developed at the Polish Academy of Sciences.
Prerequisites	none

Outline if available	The tutorial consists of the following parts.
	
	1. Gentle introduction to model checking for multi-agent systems.
	    1. Formal verification: why, when, and what.
	    2. Modeling MAS.
	    3. Specification of properties: temporal, epistemic, and strategic logic.
	    4. Motivating example: voting, coercion, and coercion-resistance.
	2. Verification of strategic properties.
	    1. Modal logic meets game theory: standard fixpoint model checking algorithm for perfect information games.
	    2. Abilities under imperfect information: problems with strategies. Imperfect information ATL.
	    3. Complexity of model checking for semantic variants of ATL.
	3. Practical model checking algorithms.
	    1. Practical complexity: state-space, transition-space, and strategy-space explosion.
	    2. How to overcome the complexity, pt. I: approximate and incomplete verification.
	    3. Fixpoint approximation of strategic ability.
	    4. Incomplete brute-force search and optimizations based on strategic dominance.
	    5. Experimental results.
	4. Model reductions.
	    1. Factors of complexity: models vs. formulas.
	    2. How to overcome the complexity, pt. II: model reductions.
	    3. Bisimulation-based reduction for ATL with imperfect information.
	    4. Partial-order reduction.
	5. Tools and examples.
	    1. Tools for model checking: STV.
	    2. Case study: verification of the SELENE voting protocol.

Bio of the tutors	**Wojciech Jamroga** is an associate professor at the Polish Academy of Sciences and a research scientist at the University of Luxembourg. His research focuses on modeling, specification and verification of interaction between agents. He has coauthored over 100 refereed publications, and has been a Program Committee member of most important conferences and workshops in AI and multi-agent systems. According to Google Scholar, his papers have been cited over 2600 times, and his H-index is 25. The research track of Prof. Jamroga includes the Best Paper Award at the main conference on electronic voting (E-VOTE-ID) in 2016, and a nomination for the Best Paper Award at the main multi-agent systems conference (AAMAS) in 2018. His teaching record includes numerous courses at ESSLLI (European Summer School in Logic, Language and Information) and EASSS (European Agent Systems Summer School), a tutorial at ECAI '16, and several courses at doctoral schools -- all of them on logical aspects of multi-agent systems. **Wojciech Penczek** is the Director of the Institute of Computer Science, Polish Academy of Sciences (PAS), and the chair of the Committee on Informatics of PAS. He has coauthored more than 220 refereed scientific papers on Petri nets, distributed systems, timed systems, model checking, temporal, epistemic and strategic logics, verification of security properties, and web services. According to Google Scholar, his papers have been cited over 3400 times, and his H-index is 33. Among other awards, he received the Best Paper Award at AAMAS in 2004 and a Best Paper Nomination at AAMAS in 2018. His teaching record includes lectures at Advanced Course on Petri Nets 2010, ESSLI 2010, and EASSS in 2006, 2007, and 2017. Prof. Penczek has been a project leader of the EC-founded project CRIT-2, and played a main role in several national projects. He was a conference chair of ICATPN '10, TIME '18, and ACSD '19, and served as a PC member of over 90 conferences in Computer Science. He is an editor of Fundamenta Informaticae, and the LNCS Transactions on Petri Nets and Other Models of Concurrency (ToPNoC). His scientific activities include also membership in the working group WG2.2 IFIP (International Federation of Information Processing) since 2002. His achievements have

	been recognized at the national level in Poland. In 2005, the President of Poland awarded him with the Silver Cross of Merit, one of the highest Polish distinctions for his outstanding academic service.