Learning Goals for IN5110

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After the lecture, the students are able to...

1 Introduction

- explain what we mean by "correctness" and how formal methods and model checking can be used to asses it.
- explain advantages and restrictions of model checking compared to testing and argue, when to use model checking.

2 Logic

- define propositional and first-order logic and explain differences.
- explain the difference between syntax and semantic.
- use these logics to express properties of systems and describe their limitations.

3 Transition Systems and Temporal Logic

- provide the definition of labeled transition systems.
- build transition systems as models for provided systems.
- build the transition system for a provided program.
- use the asynchronous product to build a model for systems running in parallel.
- use temporal logic to describe provided, informal properties.
- decide if a system is a model for a (simple) temporal property.

4 LTL Model Checking

- define LTL formulas.
- name the temporal operators and explain their semantics.
- explain the concept of dual connectives and complete sets of operators.
- know different classes of LTL formulas and identify them for provided formulas.
- provide the general approach of LTL model checking.
- define and explain the concept of a (generalized) Büchi automaton.
- transform a provided transition system into an equivalent Büchi automaton.
- explain in which cases one wants to use "stutturing".
- provide an equivalent Büchi automaton for a provided LTL formula.
- define maximal consistent sets and build them for a provided LTL formula.
- explain the algorithm to construct a generalized Büchi automaton for a LTL formula.
- explain the construction to turn generalized Büchi automata into Büchi automata and show it on provided examples.
- construct an automaton for the intersection of the languages of two Büchi automata.
- explain the general algorithm to check emptiness of a Büchi automaton.
- define SCCs and identify them in a provided Büchi automaton.
- explain how SCCs can be used to check for emptiness of Büchi automata.
- name the complexity of LTL model checking and explain why it is such.

5 Markov Chain Model Checking

- define Markov chains.
- explain why it can make sense to model a systems as a Markov chain.
- model a given example as a Markov chain.
- explain what a reachability property is.
- calculate the probability of a reachability property for a given Markov chain.

- explain the difference between the qualitative and quantitative model checking problem.
- sketch the algorithm for quantitative linear-time property model checking using reachability properties.
- define deterministic Muller automata.
- define BSCCs and accepting end components.
- identify BSCCs and accepting end components for provided examples.

6 Markov Decision Process Model Checking

- define Markov decision processes
- model a given example as an MDP.
- explain the relation between Markov chains and Markov decision processes.
- define memoryless schedulers.
- explain how an induced Markov chain can be obtained from a Markov decision process given a scheduler.
- given a scheduler, construct a Markov chain from a Markov decision process.
- explain the concept of optimal schedulers.
- define Markov decision processes with costs.
- name examples where costs can be useful.