02224 Modelling and analysis of real-time systems

Overview of Uppaal SMC

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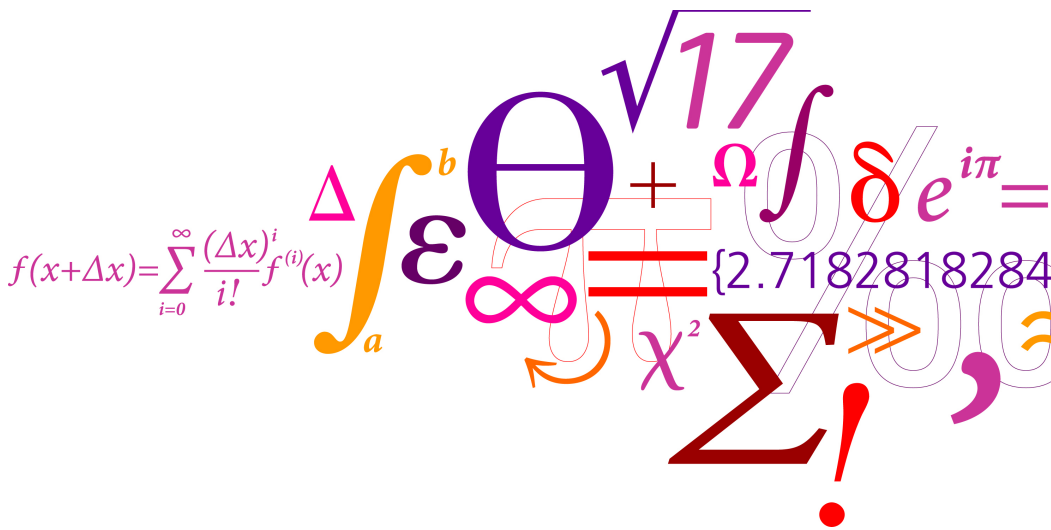

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Overview

- Stochastic semantics of networks of timed automata
- Query language
- Modelling tricks (see tutorial)

Stochastic semantics of networks of TA (I)

Component Timed Automata:

- input-enabled and deterministic
- discrete probabilistic choice
- disjoint set of output actions
- uniform distributions – bounded delay
- exponential distributions – unbounded delays

Stochastic semantics of networks of TA (II)

Given a network of independent TA.

Semantics is give by a repeated race:

- All (relevant) components propose a delay and an output
- Smallest delay is chosen
- Broadcast of chosen output – synchronization with the TA that can receive

Uppaal SMC supports a powerful notion of cost that can capture, for example,

- prices
- stopwatches
- ode – hybrid systems

Have a look in the SMC tutorial

Query language: Simulation

Forms: `simulate N [ <= bound] {E1, .., Ek}`
`simulate [ <= bound; N] {E1, .., Ek}`

dependent of version

- N is the number of simulations
- bound is the time bound on the simulations
- Ei is a state expression that is monitored

Remark: time bounds can be replaced by more general cost bounds or bounds on the number of discrete steps

Query language: estimation

Forms: `Pr[<= bound] (<> BE)` or `Pr[<= bound] ([] BE)`

- bound is the time bound on the simulations
- BE is a Boolean state expression

Remark: time bounds can be replaced by more general cost bounds or bounds on the number of discrete steps

Query language: Hypothesis testing

Forms: `Pr[<= bound](F)` $\geq p$ or `Pr[<= bound](F)` $\leq p$

- p is a probability
- bound is the time bound on the simulations
- F is a formula

Checks whether the hypothesis holds based on a computed number of simulation needed for a given significance level

Remark: time bounds can be replaced by more general cost bounds or bounds on the number of discrete steps

Query language: Probability comparison

Forms: `Pr[<= bound1](F1)` $\geq$ `Pr[<= bound2](F2)`

- boundi is the time bound on the simulations
- Fi is a formula

Checks whether the comparison holds based on a computed number of simulation needed for a given significance level

Remark: time bounds can be replaced by more general cost bounds or bounds on the number of discrete steps.

Query language: Expected value

Forms: `E[<= bound;N](min: expr)` or
`E[<= bound;N](max: expr)`

- bound is the time bound on the simulations
- N is the number of simulations
- expr evaluates to a clock or integer value

Computes expected value of the min or max expression.

Remark: time bounds can be replaced by more general cost bounds or bounds on the number of discrete steps.

Query language: Estimation for MITL

Forms: `Pr F`

- F is a formula of Metric Interval Temporal Logic

Computes an approximation interval for the (unknown) probability based on a computed number of simulation needed for a given confidence

Formula F can have one of the forms:

- Boolean state expression
- $(F_1 \wedge F_2)$
- $(F_1 \vee F_2)$
- $(F_1 \mathtt{U}[a,b] F_2)$
- $(F_1 \mathtt{R}[a,b] F_2)$
- $(<>[a,b] F)$
- $([][a,b] F_2)$

where a, b are natural numbers and $a \leq b$