

ETMCC: Model Checking Performability Properties of Markov Chains

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Model Checking Markov Chains

Markov chains are widely used for modelling the behaviour of computer and communication systems. A common goal of modelling is the estimation of performance and dependability measures of the system under study, such as throughput, buffer occupancy or mean time to failure. With model checking, the angle is somewhat different: Instead of conducting an analysis whose aim it is to derive measures, one first specifies requirements (with the help of a temporal logic) which are then checked automatically. Model checking of stochastic systems has developed into an active area of research. The logic PCTL, an extension of CTL, and the associated model checking algorithms allow one to specify and verify properties of DTMCs and Markov decision processes. In the continuous time setting, the logic CSL [1, 2] has been developed for model checking properties of CTMCs. While PCTL and CSL are based on the labelling of states with elementary properties (atomic propositions), the logic aCSL [3] is based on action-labelled transitions, which is advantageous if used in the context of modelling formalisms such as stochastic process algebra where the basic unit of behaviour is that of a named action.

The Erlangen-Twente Markov chain checker (ETMCC) is a software tool which supports the automatic checking of performability properties given as CSL or aCSL formulas. The model to be checked is a finite CTMC labelled with atomic propositions and/or transition names.

ETMCC Tool Architecture

ETMCC is written in Java, which guarantees platform independence, and consists of the following components: The **Graphical user interface** enables the user to load, modify and save verification projects (a project consists of a model and the properties to be checked). It contains the “Property Manager” which allows the user to construct and edit properties. Verification parameters for the numerical analysis and logging levels can be set through the GUI. The **Tool driver** controls the model checking procedure. It generates the parse tree corresponding to the property at hand and calls the respective verification objects that encapsulate the verification algorithms. These objects, in turn, use the

analysis and/or numerical engine. The **Analysis engine** supports standard model checking algorithms for CTL-style until-formulas, as well as graph algorithms, for instance to compute the bottom strongly connected components of a Markov chain. The former algorithms are used in a pre-processing phase during the checking of probabilistic until-formulas while the latter is needed when calculating steady state properties. The **Numerical engine** provides several methods for the numerical analysis of the CTMC such as linear solvers, methods for numerical integration and uniformisation. These are used to solve systems of linear or integral equations. The **State space manager** represents the model in sparse matrix format. It maintains information about the validity of atomic propositions and of sub-formulas for each state.

Status and Availability

ETMCC has been used successfully in several non-trivial case studies, e.g. a cyclic server polling system and a multiprocessor mainframe with software failures. Its efficient numerical analysis methods enable users to check performability properties for models of up to several millions of states. The tool is available free of charge for academia, see <http://www7.informatik.uni-erlangen.de/etmcc/>, the current download being version 1.4. A detailed description of ETMCC can be found in [4].

References

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¹Supported by the DFG/NWO project VOSS.