

# Java Modelling Tools: an Open Source Suite for Queueing Network Modelling and Workload Analysis

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## Abstract

*The Java Modelling Tools (JMT) is an open source suite for performance evaluation, capacity planning and modelling of computer and communication systems. The suite implements numerous state-of-the-art algorithms for the exact, asymptotic and simulative analysis of queueing network models, either with or without product-form solution. Models can be described either through wizard dialogs or with a graphical user-friendly interface. The suite includes also a workload analysis tool based on clustering techniques.*

## 1. Introduction

The use of modelling techniques for performance evaluation of computer and communication systems is a well known methodology for capacity planning, tuning, optimization and procurement studies. This process requires the use of analytical or simulative methods, often based on queueing network models. Despite the numerous research efforts devoted in the past to the efficient solution of these models [3], there are very few free open-source Java suites for conducting a complete performance evaluation study based on queueing networks, from the workload characterization to the modelling phases.

In this paper we introduce the Java Modelling Tools (JMT), a new integrated performance evaluation suite, based on queueing network models, distributed under the GNU General Public Licence. The suite has been developed in the Java language and incorporates an XML data layer that enables full portability across different hardware and software platforms (e.g., Linux, Windows, Mac). JMT has been developed with two main objectives: (1) to support performance evaluation scientists and practitioners in the analysis of complex systems; (2) as a didactic tool to

help students to understand the basic principles of performance evaluation and modelling. In the following we summarize the fundamental modules of the suite, focusing on their main features.

## 2. Suite Main Features

The JMT suite is composed of five tools that support different analyses frequently used in capacity planning studies. The organization of the suite is depicted in Figure 1. The main features of each tool follows.

**JSIM:** a discrete-event simulator for the analysis of queueing network models. An intuitive sequence of wizard windows helps specifying network properties. The simulation engine supports several probability distributions for characterizing service and inter-arrival times, e.g., exponential, hyperexponential, uniform, Erlang and Pareto. Random number generation is based on the Mersenne twister engine [4]. It is also possible to reproduce a given sequence of random numbers, in order to simulate real workloads from collected log files. Load-dependent strategies using arbitrary functions of the current queue-length can be specified.

JSIM supports state-independent routing strategies, e.g., Markovian or round robin, as well as state-dependent strategies, e.g., routing to the server with minimum utilization, or with the shortest response time, or with minimum queue-length.

Performance indices like throughputs, utilizations, response times, residence times, queue-lengths are evaluated. The simulation engine supports several extended features not allowed in product-form models, namely, finite capacity regions (i.e., blocking), fork-join servers, and priority classes. Finite capacity regions may include either shared or class-specific population constraints.

The analysis of simulation results employs on-line transient detection techniques based on spectral analysis. What-if analyses, where a sequence of simulations is run for different values of parameters, are also possible.

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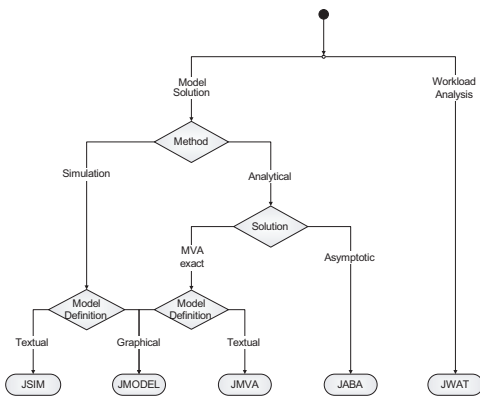


Figure 1. JMT Suite Organization

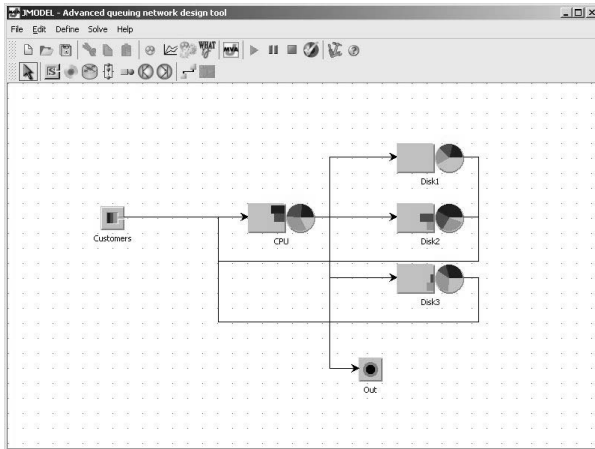


Figure 2. JMODEL Graphical Workspace

**JMODEL:** a graphical user-friendly interface for the simulator engine used by JSIM. It integrates the same functionalities of JSIM with an intuitive graphical workspace as shown in Figure 2. This allows an easy description of network structure, as well as a simplified definition of the execution features like blocking regions. Further, network topology can be saved for later use, e.g., for classroom demonstrations or homeworks.

**JMVA:** meant for the exact analysis of single or multiclass product-form queueing network models, either processing open, closed or mixed workloads. The classic MVA solution algorithm is used [5]. Network structure is specified by textual wizards, with conversion functions from probabilities to average visit ratios (and viceversa). The computed performance indices are the same of JSIM. What-if analyses are allowed.

**JABA:** a tool for the identification of bottlenecks in closed product-form networks using efficient convex hull algo-

rithms [1]. The tool supports models with up to three job classes. It is possible to identify potential bottlenecks corresponding to the different mixes of customer classes. Models with thousands of queues can be analyzed efficiently. The saturation sectors, i.e., the mixes of customer classes that saturate more than one resource simultaneously, are identified.

**JWAT:** supports the workload characterization phase, with emphasis on Web log data. Some standard formats for input file are provided (e.g., Apache HTTP log files), and customized formats may also be specified. The imported data can initially be analyzed using descriptive statistical techniques (e.g. means, correlations, pdf histograms, box-plots, scatterplots), either for univariate or multivariate data. Algorithms for data scaling, sample extraction, outlier filtering, k-means and fuzzy k-means clustering for identifying similarities in the input data are provided. These techniques allow to determine cluster centroids, and then estimate mean workload and service demands to be used for model parametrization. The tool includes also an interface to the similarity clustering tool CLUTO [2].

### 3. Conclusions

Java Modelling Tools is a comprehensive suite for system modelling using queueing networks and workload characterization. The latest JMT release, including binaries, user manual, examples and source code can be downloaded from the project homepage

<http://jmt.sourceforge.net/>

The participation to this project is open to the performance community.

### References

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