# JAMES II: Extending, Using, and Experiments

Jan Himmelspach
Institute for Computer Science
Albert-Einstein-Str. 22
Rostock, Germany
jan.himmelspach@uni-rostock.de

## ABSTRACT

JAMES II is a modeling and simulation framework designed to ease the creation of specialized M&S applications, to experiment with models, and to ease the experimentation with alternative data structures and computation algorithms. The flexibility of the framework is based on the plug'n simulate architecture which allows to have any number of alternatives coexisting, from modeling means over computation algorithms to experiment control and analysis, within a single software. Herein we show how alternatives are added to JAMES II, how JAMES II can be used to efficiently execute simulations, what can be reused to built specialized M&S software, and how this can be used to do a more fair comparison of the alternatives.

## Categories and Subject Descriptors

I.6.7 [**Simulation and Modeling**]: Simulation Support Systems—*Environments*; D.2.7 [**Software Engineering**]: Distribution, Maintenance, and Enhancement—*Extensibility, Enhancement*

## General Terms

Software, Performance Comparison

## Keywords

framework, plug-ins, experimentation, reuse

## 1. INTRODUCTION

The plug'n simulate architecture [8] has been developed to overcome diverse problems of software for the computational sciences as described in [16, 11, 18, 15]. It allows to share code over modeling means and application fields and supports, due to the strict separation of concerns, experiments with data structures and algorithms.

JAMES II (Java Based Multipurpose Environment for Modeling and Simulation) has been created based on this architecture and is being under development from 2003 on. More than 40 people have contributed, almost half a million lines of code have been produced, and JAMES II has been used in such diverse application fields as systems biology [22, 14], demography [25, 24], e-learning [17] and network simulation [19]. Therefore modeling means ranging from variants of DEVS [23], reaction networks [9], process algebra [10], multi level rule based modeling [13], multi agents [5], cellular automata [21] up to component based modeling [5] have been added to the framework and used for the applications. Experiments with algorithms have been made so far for DEVS [6, 7], reaction networks [9] and cellular automata [20]. The architecture is the base for further advanced research on M&S software, like using workflows for controlling the execution of experiments [21], the automatic selection of algorithms to be used to solve the job at hand with a good performance [2, 1] and work on parallelization of computations [3].


Simutools 2012, March 19-23, Desenzano del Garda, Italy

DOI 10.4108/icst.simutools.2012.247768

Working on all these diverse challenges was thereby eased by the fact that each single challenge has been resolved by using developments made to solve the others. For example, experimentation control has been widely reused by all the applications.

Herein we'll show first how JAMES II can be extended by using a computation algorithm for a reaction network as an example (cf Section 2). A simulation is defined and executed in the second part (cf Section 3). In Section 4 a specialized application is shown which uses JAMES II in its backend. Section 5 gives a short introduction on how JAMES II can be used for experimental algorithmics. In summary we will demonstrate the flexibility and potential of the architecture, and which benefits arise if a software built on such an architecture is consequently used for almost a decade.

## 2. EXTENDING JAMES II

The plug'n simulate architecture and thus JAMES II provides extendability on two levels

- plug-in types and
- plug-ins.

The first category defines types of plug-ins (an interface any plug-in has to implement which shall be available through this extension point) and the second category are the alternative implementations for the plug-in type (e.g., different random number generators). The plug-in schema has

been realized using the abstract factory and the factory patterns. Thereby the abstract factory has to filter the plug-ins available according to user selections and compatibility issues (e.g., selecting a computation algorithm for cellular automata if such a model shall be computed and not one for DEVS etc.) [8]. Each plug-in type definition comprises an xml file defining the type, an AbstractFactory, and a base factory for creating the instances the plug-in factories have to inherit from, and the interface definition which has to be implemented by the plug-ins. If no complicated filtering is required the main effort here is in the definition of the interface. Each plug-in comprises the class implementing the interface, a factory class inheriting from the base factory to create the instance of the plug-in and an xml file describing the plug-in. Plug-in types and plug-ins are automatically loaded by JAMES II and thus it is possible to extend JAMES II without any need to modify existing code.

# 3. SIMULATION WITH JAMES II

JAMES II provides a flexible and scalable experimentation layer which supports users on doing experiments with their models. The experimentation layer of JAMES II [4] allows to setup any M&S experiment from brute force parameter scans up to optimization and validation experiments. Thereby the control means required for computing single replications (e.g., number of replications, stop conditions, etc...) are realized as plug-in types and required alternatives can be added by everyone. A special emphasis is laid on how JAMES II tries to exploit the hardware available (multi core/multi cpu/multiple machines) [12, 3]. JAMES II provides a class named `BaseExperiment` which allows to setup all the parameters required. The most simple setup looks like

```
BaseExperiment experiment = new BaseExperiment();
experiment.setModel (path to your model);
```

This will setup a simulation with the model using default parameters. It can be started by calling the `execute` method of the experiment instance).

# 4. BUILDING A SPECIALIZED M&S APPLICATION

JAMES II has been used in the project MicMac, funded by the european union, to built a specialized M&S application to be used throughout statistical offices all over Europe [25]. For that purpose first a novel modeling formalism for describing of a demographic micro model based on empirical data has been added to JAMES II. Together with a newly created computation algorithm for the modeling means, which has been built based on additional plug-in types in the framework, e.g., event sets and random numbers, no further extensions nor any changes had to be done. The application has an own graphical user interface which allows to load a model and to start a simulation. This interface has been developed without using the user interface framework shipping with JAMES II and it just calls the experimentation control elements of JAMES II, parameterized with the model to be computed, and then "waits" for the framework to finish the computation. Using JAMES II has helped a lot on developing the application. Using plug-ins instead of hard-coded functionality experiments on the impact of implementation alternatives have been achievable and thus it was possible to figure out an efficient setup to compute the models on desktop computers in less than a minute. Currently the application does not make use of a number of additional features provided by the experimentation layer: neither the internal mechanisms for parameter scanning, optimization nor the support for parallel computations are used. But if any of those things are required in the future it will not require a lot of implementation work (if any) to make use of these. Further on, bug fixes, performance improvements etc ... applied to the code reused are automatically available in the next build of the specialized application - which reduces maintenance effort and costs.

# 5. EXPERIMENTS WITH ALGORITHMS

Good experiments with algorithms are hard to achieve. According to literature about experimental algorithmics a number of preconditions need to be fulfilled if such experiments shall really reveal insights. Among those fair comparisons of the competing algorithms (something which may be hard to achieve in case that all alternatives are implemented by the one who wants to show that his algorithm performs better), a fair testing environment (only the algorithm under test should be evaluated and not an unknown combination of data structures and additional algorithms in the test setup), and fair problem instances [11]. The plug'n simulate concept allows to provide any number of alternative algorithms for an extension point, and thus allows any number of, e.g., computation algorithms for a modeling means. Any of those can be parameterized with additional plug-in types, e.g., event sets. If an algorithm is added it can be compared to those already available for an extension point (reducing the "my code shall perform better" bias). Additionally, if someone doubts the results of the comparison he can add his own alternative implementations of the competitive algorithms, even if implementations of the algorithms already exist, and repeat the experiments. The separation of concerns helps to avoid or at least reduce side effects. Further on JAMES II provides some tools, developed for research on the automatic selection of algorithms, which support experiments with algorithms [1].

# 6. SUMMARY

This demo shows how JAMES II can be used for diverse tasks in research and application in the computational sciences. According to our experience using JAMES II consequently for the research questions in our group had a number of important advantages: implementations of core parts (e.g., plug-in management, experimentation control) have been widely reused and thus tested, implementations of formalisms and computations algorithms have been used for applications and for experimental algorithmics, and we have been able to exploit the implementations done for further research projects like the automatic selection of algorithms. The software created based on the plug'n simulate architecture is available as open source (`http://www.jamesii.org`[1]), containing examples for most of the aforementioned uses.

# 7. ACKNOWLEDGMENT

This work has been mostly funded by the DFG in the projects CoSA, diermosi, and the research training group dIEM oSiRiS.

[1] accessed, January 2012

The work done described here has been done and supported by more than 40 colleagues and students for what I'm very thankful.

## 8. REFERENCES


[1] R. Ewald. *Automatic Algorithm Selection for Complex Simulation Problems*. Phd thesis, Faculty of Computer Science and Electrical Engineering, University of Rostock, Vieweg+Teubner, 2011.

[2] R. Ewald, J. Himmelspach, and A. M. Uhrmacher. An algorithm selection approach for simulation systems. In *Proceedings of the PADS*, pages 91–98, Rome, Italy, June 2008. IEEE Computer Society.

[3] J. Himmelspach, R. Ewald, S. Leye, and A. M. Uhrmacher. Enhancing the scalability of simulations by embracing multiple levels of parallelization. In *Proceedings of the 2010 International Workshop on High Performance Computational Systems Biology*. IEEE CPS, Sept. 2010.

[4] J. Himmelspach, R. Ewald, and A. M. Uhrmacher. A flexible and scalable experimentation layer for JAMES II. In S. Mason, R. Hill, L. Moench, and O. Rose, editors, *Proceedings of the Winter simulation conference*, pages 827–835. Winter Simulation Conference, Dec. 2008.

[5] J. Himmelspach, M. Röhl, and A. M. Uhrmacher. Component based modelling and simulation for valid multi-agent system simulations. *International journal for Applied Artificial Intelligence*, 24(5):414–442, May 2010.

[6] J. Himmelspach and A. M. Uhrmacher. Sequential processing of PDEVS models. In A. G. Bruzzone, A. Guasch, M. A. Piera, and J. Rozenblit, editors, *Proceedings of the 3rd EMSS*, pages 239–244, Barcelona, Spain, Oct. 2006. Piera, LogiSim.

[7] J. Himmelspach and A. M. Uhrmacher. The event queue problem and PDEVS. In *Proceedings of the DEVS Integrated M&S Symposium*, pages 257–264, Norfolk, VA, Mar. 2007. SCS.

[8] J. Himmelspach and A. M. Uhrmacher. Plug'n simulate. In *ANSS '07: Proceedings of the 40th Annual Simulation Symposium*, pages 137–143, Washington, DC, USA, Mar. 2007. IEEE Computer Society.

[9] M. Jeschke. *Efficient Non-Spatial and Spatial Simulation of Biochemical Reaction Networks*. PhD thesis, Universität Rostock, Rostock, 2010.

[10] M. John. *Reaction constraints for the pi-calculus : a language for the stochastic and spatial modeling of cell-biological processes*. Logos Verlag, Berlin, 2011.

[11] D. Johnson. A theoretician's guide to the experimental analysis of algorithms. In *Fifth and Sixth DIMACS Implentation Challenges*, 2002.

[12] S. Leye, J. Himmelspach, M. Jeschke, R. Ewald, and A. M. Uhrmacher. A grid-inspired mechanism for coarse-grained experiment execution. In D. Roberts, A. E. Saddik, and A. Ferscha, editors, *Proceedings of the 12th IEEE International Symposium on Distributed Simulation and Real-Time Applications*, pages 7–16, Los Alamitos, CA, USA, Oct. 2008. IEEE Computer Society. DSRT 08 (Vancouver, British Columbia, Canada).

[13] C. Maus, S. Rybacki, and A. M. Uhrmacher. Rule-based multi-level modeling of cell biological systems. *BMC Systems Biology*, 5(166), 2011.

[14] O. Mazemondet. *Spatio-temporal Dynamics of the Wnt/ß-catenin Signaling Pathway: A Computational Systems Biology Approach*. PhD thesis, University of Rostock, Rostock, 2011.

[15] Z. Merali. ... why scientific programming does not compute. *Nature*, 467:775–777, Oct. 2010.

[16] N. Minar, R. Burkhart, C. Langton, and M. Askenazi. The SWARM simulation system: A toolkit for building multi-agent simulations. Technical report, Santa Fe Institute, Juni 1996.

[17] M. Oertel, J. Himmelspach, and A. Martens. Teaching and training system plus modeling and simulation – a plugin based approach. In *Proceedings of the Tenth International Conference on Computer Modeling and Simulation*, pages 475–480, Los Alamitos, CA, USA, 2008. IEEE Computer Society.

[18] K. Perumalla. $\mu$sik: a micro-kernel for parallel/distributed simulation systems. In *ACM/IEEE/SCS Workshop on Parallel and Distributed Simulation (PADS)*, pages 59–68, Monterey, CA, Juni 2005. IEEE Computer Society Press.

[19] M. Röhl, B. König-Ries, and A. M. Uhrmacher. An experimental frame for evaluating service trading in mobile ad-hoc networks. In *Mobilität und Mobile Informationssysteme (MMS 2007)*, volume 104 of *Lect. Notes Inform.*, pages 37–48, 2007.

[20] S. Rybacki, J. Himmelspach, and A. M. Uhrmacher. Cpu and gpu based simulation of cellular automata - a performance comparison. In *Proceedings of the 1st SIMUL*, pages 62–67. IEEE Computer Society, Sept. 2009.

[21] S. Rybacki, J. Himmelspach, and A. M. Uhrmacher. Worms- a framework to support workflows in m&s. In S. Jain, R. R. Creasey, J. Himmelspach, K. P. White, and M. Fu, editors, *Proceedings of the 2011 Winter Simulation Conference*, Piscataway, New Jersey, 2011. Institute of Electrical and Electronics Engineers, Inc.

[22] A. M. Uhrmacher, R. Ewald, J. Himmelspach, M. Jeschke, M. John, S. Leye, C. Maus, and M. Röhl. One modelling formalism & simulator is not enough! – A perspective for computational biology based on JAMES II. In J. Fisher, editor, *Proceedings of the the 1st FMSB Workshop*, number 5054 in LNBI, pages 123–138, Cambridge, UK, June 2008. Springer.

[23] A. M. Uhrmacher, J. Himmelspach, and R. Ewald. *Discrete-Event Modeling and Simulation: Theory and Applications*, chapter Effective and efficient modeling and simulation of DEVS variants, pages 139–176. Taylor and Francis, Dec. 2010.

[24] S. Zinn. *A Continuous-Time Microsimulation and First Steps Towards a Multi-Level Approach in Demography*. PhD thesis, University of Rostock, Rostock, 2011.

[25] S. Zinn, J. Himmelspach, J. Gampe, and A. M. Uhrmacher. Miccore: A tool for microsimulation. In R. R. H. M. D. Rossetti and, B. Johansson, A. Dunkin, and R. G. Ingalls, editors, *Proceedings of the 2009 Winter Simulation Conference*, pages 992–1002. Winter Simulation Conference, Dec. 2009.