Model Transformation:
the Automation Booster for MBSE

Andrea D'Ambrogio

Department of Enterprise Engineering

University of Rome Tor Vergata

Rome, Italy

dambro@uniroma2.it

ABSTRACT

Model-based systems engineering (MBSE) is defined by the International Council on Systems Engineering (INCOSE) as "the formalized application of modeling to support system requirements, design, analysis, verification, and validation activities beginning in the conceptual design phase and continuing throughout development and later life cycle" [1]. The advantages obtained by the MBSE approach, in terms of enhanced communications, reduced development risks, improved quality, increased productivity and enhanced knowledge transfer, can be further scaled up by innovative model-driven approaches that treat models as the primary artifacts of development, by introducing a radical shift from a strictly contemplative use of models to a more productive and powerful model use. Model-driven engineering enhances the typical MBSE advantages by use of metamodeling techniques and model transformations, which allow system designers to obtain a significant increase of the level of automation throughout the system lifecycle [2].

A metamodel is a model used to describe a family of models, in other words it is a model that defines the primitives of a modeling language, which is used to specify models at user level. As an example, the UML metamodel is the model defining the primitives (i.e., class, association, state, etc.) that are instantiated in standard UML models. A model transformation is the specification of a set of mapping rules that are executed to transform a given model into a different model, which conforms to the same or to a different metamodel. Model-driven engineering enables a radical shift in terms of modeling activities, from a strictly contemplative use of models to a more productive and powerful model use.

The tutorial first illustrates the principles and standards of model-driven engineering and then shows a possible application to the simulation-based analysis of systems and processes specified by use of SysML and BPMN, respectively [3]. SysML (Systems Modeling Language) is the UML-based language that provides the modeling capability required in the systems engineering domain. SysML is now considered the standard modeling notation adopted in the MBSE context [4]. In addition, the recent adoption of the BPMN (Business Process Modeling and Notation) standard by the OMG (Object Management Group – the same body that defines and promotes UML and SysML), has introduced into the MBSE discipline the formalization of the business processes describing the interactions among the organizations that build and/or make use of systems [5].

The tutorial overviews existing methods that have been developed to automate the simulation-based analysis of systems and processes. Specifically, such methods enable the automated transformation of SysML [6][7] and BPMN [8][9] models into the corresponding simulation models, which are executed to yield the performance indices of interest. The proposed approach can be effectively used by system designers and business analysts who do not have specific expertise in the fields of simulation-based analysis, without requiring the acquisition of specific modeling and simulation know-how and the manual effort that is typically needed to define and implement simulation models. In addition, the extensive use of model-driven techniques contributes to provide a significant degree of customizability, which facilitates the tailoring of the proposed model transformations to specific needs (e.g., to make use of alternative modeling languages and/or simulation platforms) [10][11][12].

REFERENCES

[1] INCOSE, 2007. *Systems Engineering Vision 2020*, v.2.03, September, 2007.

[2] D. C. Schmidt, 2006. Model-driven Engineering, *IEEE Computer*, February 2006, pp. 25-31.

[3] D. Gianni, A. D'Ambrogio and A. Tolk, 2014. *Modeling and Simulation-Based Systems Engineering Handbook*, CRC Press, ISBN 9781466571457.

[4] OMG, 2010. Object Management Group, *System Modeling Language (SysML)*, v.1.2.

[5] OMG 2011. Object Management Group, *Business Process Model and Notation (BPMN)*, version 2.0.

[6] P. Bocciarelli, A. D'Ambrogio and G. Fabiani 2012. A Model-driven Approach to Build HLA-based Distributed Simulations from SysML Models, *Proceedings of the 2nd International Conference on Simulation and Modeling Methodologies, Technologies and Applications*, Rome, Italy, 28 - 31 July, 2012, pp. 49-60.

[7] P. Bocciarelli, A. D'Ambrogio, A. Giglio and D. Gianni, 2013. A SaaS-based automated framework to build and execute distributed simulations from SysML models. *Proceedings of the Winter Simulation Conference (WSC 2013)*, Washington, DC, USA, December 8-11, pp 1371-1382.

[8] P. Bocciarelli, A. D'Ambrogio, Automated performance analysis of business processes, *Proceedings of the 2012 Spring Simulation Multiconference*, SpringSim 2012; Orlando, FL; United States, pp. 266-274, March 26-30, 2012.

[9] P. Bocciarelli, A. D'Ambrogio, E. Paglia, A language for enabling model-driven analysis of business processes, *Proceedings of the 2nd International Conference on Model-Driven Engineering and Software Development* (MODELSWARD 2014), pp. 325-332, Lisbon; Portugal; January 7-9, 2014.

[10] P. Bocciarelli, A. D'Ambrogio, A. Falcone, A. Garro and A. Giglio. 2015. A Model-Driven Approach to Enable the Distributed Simulation of Complex Systems, *Proceedings of the Sixth International Conference on Complex Systems Design & Management*, CSD&M 2015, pp. 171–183, Paris, France, November 23–25, 2015.

[11] P. Bocciarelli, A. D'Ambrogio, D. Gianni, 4SEE: a model-driven simulation engineering framework for business process analysis in a SaaS paradigm, *Proceedings of the 2013 Spring Simulation Multiconference*, SpringSim 2013, pp. 218-225, San Diego, CA, USA, April 7-10, 2013.

[12] P. Bocciarelli, A. D'Ambrogio, A. Giglio, E. Paglia, D. Gianni, A Transformation Approach to Enact the Design-Time Simulation of BPMN Models, *Proceedings of the IEEE 23rd International WETICE Conference (WETICE 2014)*, pp. 199-204, Parma, Italy, June 23-25, 2014

AUTHOR BIOGRAPHY

Andrea D'Ambrogio is associate professor of computer science at the Department of Enterprise Engineering of the University of Roma "Tor Vergata" (Italy) and director of the post graduate Master degree in "Systems Engineering", established at the University of Roma "Tor Vergata" in 2012. Andrea D'Ambrogio's research interests are in the systems and software engineering field, specifically in the areas of system performance and dependability engineering, model-driven systems and software engineering, business process management, and distributed simulation. In such areas he has participated to several projects at both European and overseas level and has authored more than 100 journal/conference papers. He is general chair of the 49th Summer Computer Simulation Conference (SCSC 2017), general co-chair of the Summer Simulation Multiconference (SummerSim 2017), and has been general chair of the SCS/ACM/IEEE International Symposium on Theory of Modeling & Simulation (TMS 2014) and of the IEEE International Conference on Enabling Technologies: Infrastructure for Collaborative Enterprises (WETICE 2008). He has served as program chair and/or member of the program committee of various international conferences, among which IEEE WETICE, SCS/ACM/IEEE SpringSim, SCS/ACM SummerSim, IEEE/ACM PADS and INFORMS/ACM Winter Simulation Conference. He started the IEEE International Workshop on Collaborative Modeling and Simulation (CoMetS) in 2010 and the SCS/ACM/IEEE International Symposium on Model-driven Approaches for Simulation Engineering (Mod4Sim) in 2011. Andrea D'Ambrogio is associate editor of the Transactions of the Society for Modeling & Simulation International (SIMULATION journal), member of the editorial board the IAENG International Journal of Computer Science (IJCS) and has been member of the editorial board of the Simulation Practice and Theory (SIMPAT) journal. He is member of the management committee of the ICT COST Action on "Multi Paradigm Modelling for Cyber Physical Systems" (MPM4CPS). He is member of IEEE, IEEE Computer Society, ACM, SCS and INCOSE.