

Model-Driven Engineering of Agent-based Simulations

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Outline

- 1 Introduction**
 - MDE and MDA in Software Engineering
 - Actual context
 - Simulation Engineering
- 2 ER/AOR Implementation Solution**
 - ER/AOR Simulation Framework
 - ER/AORSL - a MDA approach
- 3 Conclusions and Future Works**
 - Ongoing Works

... the MDA's "model to code" chain

- Model Driven Engineering (MDE) focuses on developing computationally complete models from which the source code can be automatically generated;
- **OMG's**¹ community proposed Model-Driven Architecture (**MDA**²) as a MDE approach based on the fundamental idea that the chain of modeling goes from a conceptual domain model (called *computation-independent model (CIM)* in MDA) via a *platform-independent design model (PIM)* to one or more *platform-specific implementation models (PSM)* (one for each target technology platform), which can be directly mapped to code;
- The main idea of MDA is that the system models at different levels of abstraction CIM/PIM/PSM are derived from one each other.

¹OMG - <http://www.omg.org/>

²MDA - <http://www.omg.org/mda/>

OMG's community

- is dominated by the software suppliers and consultants;
- delivers specifications of general-purpose standards such as: UML³, XMI⁴, BPMN⁵ or MOF⁶ with the purpose of interchange/share/reuse of system models;
- the above mentioned languages (both textually or graphically expressed) are just some data formats which are currently in use on the area of conceptual modeling;
- SysML⁷ is the OMG standard proposed to be used as an interchange simulation language;

³UML - <http://www.uml.org>

⁴XMI - <http://www.omg.org/spec/XMI/2.1.1/>

⁵BPMN - <http://www.bpmn.org/>

⁶MOF - <http://www.omg.org/mof/>

⁷SysML - <http://www.omgsysml.org/>

... in modeling and simulation area

- shows a tendency to adopt/adapt and learn from existing software engineering tools and techniques;
- leads naturally to the idea that computer simulations can be considered to be a special class of software programs;
- but, the simulation models are still expressed in general purpose programming languages such as: Java, C, etc.

The challenge is:

- to introduce the concept of **simulation engineering** as a MDE approach towards the definition of the simulation models chain;
- to establish a standard simulation interchange language (such as OMG's SysML) which is capable to express simulation models as computational-independent models (aka the level of domain modeling).

State of the Art

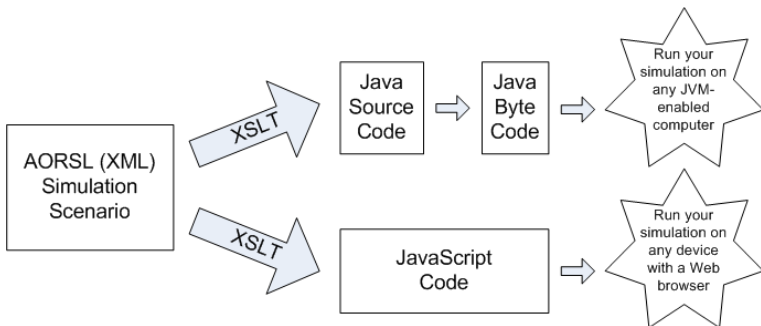
- only few interchange works exists e.g. SysML to AnyLogic (Schönherr et al, 2009) (Paredis et al, 2008), Modelling4All project to NetLogo/Repast/OpenSim (Kahn et al, 2009) or ER/AOR Simulation Framework;
- the main idea is to use the principles of MDE and to consider the simulation models at three different abstraction levels: the level of *domain modeling*, the level of (platform-independent) *design modeling*, and the level of (platform-specific) *implementation modeling*;
- MDE considers that: (1) the design model model is derived from the domain model, (2) the implementation models are derived from the design model, and (3) executable code is generated from the implementation models.

Generalities

- it supports both basic DES models without agents, also called Entity-Relationship (ER) simulations, and complex agent-based simulation models with agents having (possibly distorted) perceptions and (possibly false) beliefs, called Agent-Object-Relationship (AOR) simulations;
- distinctive features of the ER/AOR Simulation framework are: (1) its high-level rule-based simulation language ER/AORSL, (2) an abstract simulator architecture and execution model;
- both the behaviour of the environment (its causality laws) and the behaviour of agents are modelled with the help of rules, which support high-level declarative simulation modelling.

Simulation Engineering

- the simulation scenario is expressed with the help of the XML-based ER/AOR Simulation Language (ERSL/AORSL)



Simulation Engineering: PIM to PSM translations

- the ER/AOR simulation models are situated on the MDA PIM's level of abstraction;
- the class of simulation scenarios are translated to PSM languages Java⁸/JavaScript⁹ or OpenSimulator (Wagner, 2010).

⁸ER/AOR Simulation Framework -

<http://code.google.com/p/aor-javasim/>

⁹Simulario - <http://www.simulario.de/>

ER/AOR simulation model

- a simulation scenario comprises: (1) a simulation model, (2) an initial state definition and (3) a user interface which comprises statistics and animation definitions;
- a simulation model consists of: (1) an optional space model (needed for physical objects/agents), (2) a set of entity types, including different categories of events, messages, object and agent types, and (3) a set of environment rules which define causality laws governing the environmental state changes;
- the simulation model can be considered as a template/pattern for the construction of many simulation scenarios.

ER basic DES

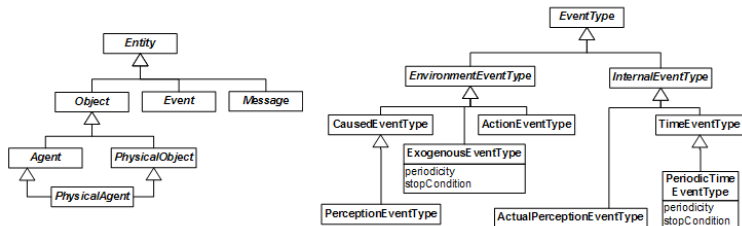
An Entity Relationship (ER) simulation model consists of:

- a set of entity type definitions, including different categories of event and object types;
- ... an entity type is defined by means of a set of properties (attributes and reference properties) and a set of functions;
- a set of environment rules, which define causality laws governing the state changes of the environment and the flow of events;
- there are two different kinds of event types: those that define exogenous events (typically with some random periodicity) and those that define caused events that follow from the occurrence of other events.

Agent-based DES: Agent Object Relationship (AOR)

An agent type is defined by means of:

- a set of (objective) properties;
- a set of (subjective) self-belief properties as well as an optional set of (subjective) belief entity types;
- a set of agent rules, which define the agent's reactive behaviour in response to perception events (and internal time events such as: periodic events and reminder events).



Simulation Engineering

- we have explained the merits and the potential of a MDE approach in the context of modeling and simulation - Simulation Engineering
- we have proposed the use of OMG's SysML emerging language for the purpose of simulation modelling at the domain level of abstraction in order to comply with the main MDE principles such as standardisation and reuse;
- we have presented our work in the context of Simulation Engineering: ER/AOR Simulation Framework.

Main References

- K. Kahn, H. Noble *The Modelling4All Project A web-based modelling tool embedded in Web 2.0* in Proceedings of the 2nd International Conference on Simulation Tools and Techniques (Simutools'09), 2009.
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- G. Wagner *Model-Driven Engineering of Second-Life-Style Simulations* in WSC'10 Proceedings of the Conference on Winter Simulation, 2010.

Questions ?

Model-Driven Engineering of Agent-based Simulations

Thank you for your attention!

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