Investigating the Model-Driven Development for Systems-of-Systems

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Agenda

• Introduction
• Systematic Review
• Discussion
• Conclusions
Introduction

- Systems-of-Systems (SoS) use capabilities of existing systems to synergically provide new functionalities
- SoS are large, complex, and physically distributed
- SoS characteristics lead to a model-centric development approach
- Model-Driven Development (MDD) can support the creation of SoS with better quality
- Motivation:
  - Lack of a complete and broad overview on the use of MDD for developing SoS
Introduction

• Main objective is to:
  – Investigate how MDD has been applied for developing and maintaining SoS

• Method: Systematic Literature Review (SLR)

• Expected results:
  – Panorama of the topic of research
  – Research perspectives
  – Promotion of MDD into the context of SoS
Systematic Review

• Phase 1 - Planning
• Phase 2 - Conduction
• Phase 3 - Reporting
Systematic Review: Planning

• Research Questions (RQ):
  • RQ 1: Which model-driven approaches have been applied in software-intensive SoS?
  • RQ 2: Which models have been used to represent software-intensive SoS in model-driven approaches?
  • RQ 3: Which tools and technologies have been developed or applied to use model-driven approaches into the context of software-intensive SoS?
  • RQ 4: Which quality attributes of SoS are addressed through a model-driven perspective?
Systematic Review: Planning

• Search sources:
  • ACM Digital Library
  • IEEEXplore
  • ISI Web of Knowledge
  • Scopus

• Search string:

(system of systems OR system-of-systems OR systems of systems OR systems-of-systems) AND (Model-Driven Development OR Model-Driven Engineering OR Model-Driven Architecture OR Model-Based System Engineering OR Model-Based Software Development OR Model-Driven Software Development OR MDA OR MDE OR MDD OR MDSD OR Model-Driven OR Model-Based OR Model Based)
Systematic Review: Planning

• Inclusion Criteria (IC):
  – IC 1: The primary study uses MDD to automatically generate software-intensive SoS from models
  – IC 2: The primary study proposes a model-driven approach to automatically generate software-intensive SoS from models
  – IC 3: The study is a literature review

• Exclusion criteria
  – Exclude primary studies not associated to MMD for SoS synthesis
  – Exclude primary studies in other languages than English
  – Exclude primary studies without abstract or that do not add evidences (invited talk description, conference description, etc.)
Systematic Review: Conduction

- Obtained studies: 177
- First selection: 67
- Second selection: 12
- Each study was independently evaluated by two reviewers
## Systematic Review: Conduction

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<td>Bay</td>
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<td>Feiler et al.</td>
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<td>Gokhale et al.</td>
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<td>Lang and Schreiner</td>
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<td>Neema et al.</td>
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<td>Lewis et al.</td>
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<td>Ramos et al.</td>
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<td>Mittal and Risco Martin</td>
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<td>Bryans et al.</td>
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Systematic Review: Conduction

- Publication of primary studies per year:
Systematic Review: Reporting

- RQ 1: Which model-driven approaches have been applied in software-intensive SoS?
  - Four studies (~33%) focused on SoS software code generation
  - Two studies (~17%) used MDD to manage interoperability among constituents
  - Four studies (~33%) focused on both code generation and interoperability
  - One study (~8%) used MDD for interface generation
  - One study (~8%) proposed the use of an Architecture Description Language (ADL) to support code generation
RQ 2: Which models have been used to represent software-intensive SoS in model-driven approaches

- UML (50%)
- OCL (25%)
- DoDAF or MoDAF (25%)
- SysML (25%)
- DEVS, BPMN, AADL, SelfMML, OCML, and XML (~8%)
RQ 3: Which tools and technologies have been developed or applied to use model-driven approaches into the context of software-intensive SoS?

- INGENME
- SPICE
- MATLAB
- Xtext
- oAW
- Portico; Modisco (based on GMT)
- ACTUAL – based on GMF
- Cosmic
- Not used
- Customized (no name)
- Based on GMF/EMF
Systematic Review: Reporting

- RQ 4: Which quality attributes of SoS are addressed through a model-driven perspective?
Discussion

• Perspectives of research:
  – Application of processes, tools, techniques, methods, models, and practices from MBSE to an MDD-SoS
  – Investigation of how middleware can be engineered to SoS
  – Extension of MDD techniques to SoS software engineering
  – Application of solutions from Model-Driven Middleware community to ease interoperation of constituents
Conclusions

• MDD has good perspectives in supporting the development of SoS

• We observed a recent, increasing interest in this research area

• Nonetheless, more studies are still necessary to consolidate MDD in the context of SoS

• Open research perspectives on the use of MDD for SoS development
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