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Architecting Systems of Systems: from basic concepts towards a SoS profile and supporting tools

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towards a SoS profile and supporting tools



Outline

- AMADEOS introduction
- Motivations and objectives of the tutorial
- Tutorial's structure

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AMADEOS INTRODUCTION



- **AMADEOS: Architecture for Multi-criticality Agile Dependable Evolutionary Open System-of-Systems** - ICT-2013.3.4
- 3Years European FP7 project, started in Oct 2013.
- With the Goal To bring **time awareness** and **evolution** into the design of (Cyber-Physical) System-of-Systems (SoS),
 - to establish a sound **conceptual model**,
 - a generic **architectural framework** and
 - a **design methodology**, **supported by some prototype tools**,
for the modeling, development and evolution of time-sensitive SoSes with possible **emergent behaviors**.

Consortium

	Partners	Country	Type
1	Università degli Studi di Firenze	Italy	University
2	Technische Universitaet Wien	Austria	University
3	Université Grenoble Alpes	France	University
4	ResilTech srl	Italy	SME
5	Thales Netherlands B.V.	Netherlands	Large Company
6	European Network for Cyber Security	Netherlands	Research ORG.

Scientific and Technical Challenges - 1

- Guaranteed Responsiveness
 - In a timeless SoS:
 - Difficult to guarantee **strict deadlines**;
 - Each Constituent System (CS) uses its own **unsynchronized** clock → difficult to make assumptions on the execution speeds and message delivery delays;
 - **Complex distributed protocols** for cooperation and interaction of CS;
 - **Handling device failures** can be extremely challenging;

Scientific and Technical Challenges - 2

- Dynamicity and Evolvability
 - SoS dynamicity: cope with **short-term** discontinuities
 - It includes the adequate reconfiguration of SoS in specific situations
 - E.g., after the occurrence of a fault
 - SoS evolvability: cope with **long-term** adaptation
 - It includes necessary modifications that are required to keep a system services relevant in the face of the ever-evolving society
 - e.g., new legal requirements, business cases.
- Emergence
 - (Unexpected) emergent properties caused by the interactions among autonomous CS may have **beneficial** or **detrimental** effects. Govern and manage the emergence so to have only 'good' emergence

Main results

- A **Conceptual Model** for SoS.
- A proof-of-concept prototype of a **Resilient Master Clock** (RMC), to guarantee a resilient global time base across the SoS.
- Thorough investigations of the **emergence phenomena** in cyber-physical SoS.
- Deep understanding of the key role of **stigmergic channels** between Constituent Systems.
- An **Architectural Framework** and design methodology for dynamic SoS, supported by a
 - **SySml profile** for SoSes
 - *Eclipse-compliant* editor extensions

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MOTIVATIONS AND OBJECTIVES OF THE TUTORIAL

Motivations

- The **major cost elements** during the specification, design, operation, evolution and maintenance of a large CPSoS are accrued in the ***non-physical domain***.

Engineering effort costs >> Hardware costs

- *Engineering effort* depends to a considerable degree on **the cognitive complexity**, i.e., the **time needed to understand the behavior of a system**.
 - Any reduction of the cognitive complexity of a large system
 - is of utmost economic significance
 - reduces the probability of the occurrence of design errors.

Complexity

Complexity

Complexity as a Property

Structural

Dynamic

- Topological
- Components
- Links

- Behavior
- Causality
- Feedback

Complexity as a Relation

Cognitive

Relation between
a Scenario and
an Observer

Socio-
Political

Relation between
a Scenario and
Society

Cognitive Complexity

Cognitive complexity is concerned with the question:

How much mental effort is required in order to understand a given scenario for the given purpose by an identified user?

The **time** it takes for an *average representative* from the *intended user group* to *understand* the scenario is linked to the **cognitive complexity** of a scenario.

The time required for understanding will depend upon

- the **conceptual basis** of the intended user group
- the purpose of understanding
- the inherent characteristics of the scenario
- the representation of the scenario

Tutorial: Primary learning objective

- Raise consciousness on the necessity **to reduce the cognitive complexity** when modelling large SoSs.
- This major objective will be achieved:
 - demonstrating the clarification effects and usefulness of the key elements of the **conceptual model**;
 - illustrating the usefulness of adopting the **SysML profile** for the high-level design of a SoS architecture;
 - showing the potentialities of the supporting **Google Blockly tool** for the integrated design of the different SoS viewpoints

Tutorial's structure - 1

Module 1: *Insights on Key SoS Concepts*

- Discussion on key SoS concepts per viewpoint
 - Structure, Dynamicity, Evolution, Dependability, Security, Time, Multi-criticality, Emergence

Module 2: *The AMADEOS SysML profile to support SoS conceptual modeling*

- Intro to MDE and SysML basic modeling constructs
- The AMADEOS SysML profile
 - Introduction, overview, role in MDE
 - Examples of profile's applications, demos, exercises

Tutorial's structure - 2

Module 3: *The AMADEOS architectural framework*

- Overview
- Details on conceptual, logical and implementation level

Module 4: *AMADEOS supporting facilities for designing SoS*

- Google Blockly intro, characteristics, support to the Architectural Framework
- Application to toy examples, also comparing with SysML modeling
- Description of the selected Use-cases
- Live demos
- Exercises

General discussion and feedback

- Fill forms – Questions, Comments, Issues, Suggestions, Improvements

Agenda - morning

Time	Argument
8:00	Introduction
8:30	Module 1: <i>Insights on Key SoS Concepts, per viewpoint</i>
9:30	Break
10:00	Module 2: <i>The AMADEOS SysML profile to support SoS conceptual modeling</i>
11:40	Module 3: <i>The AMADEOS architectural framework</i>
12:00	Lunch

Agenda - afternoon

Time	Argument
13:30	Module 4: <i>AMADEOS supporting facilities for designing SoS</i>
15:00	Break
15:30	Module 4 (cont.): <i>AMADEOS supporting facilities for designing SoS</i>
16:30	<i>General discussion and feedback</i>
17:00	Close

References

- AMADEOS website:
 - <http://amadeos-project.eu/>
- AMADEOS – Public deliverables
 - <http://amadeos-project.eu/documents/public-deliverables/>
- List of publications produced within AMADEOS
 - <http://amadeos-project.eu/documents/publications/>