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Architecting Systems of Systems

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

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Tutorial session – July 16th, 2016

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towards a SoS profile and supporting tools



Module 2 - outline

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

A. Babu

INTRO TO MDE AND SYSML BASIC MODELING CONSTRUCTS

P. Lollini

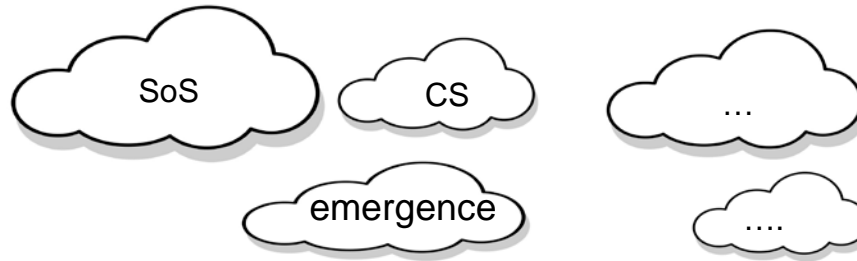
THE AMADEOS SYSML PROFILE: INTRO, OVERVIEW, ROLE IN MDE

Basic concepts and relationships

- Definition of **basic** SoS concepts
 - Not domain specific
 - Applicable to any SoS
- Definition of **relationships** among basic SoS concepts

From Conceptual to SysML modeling

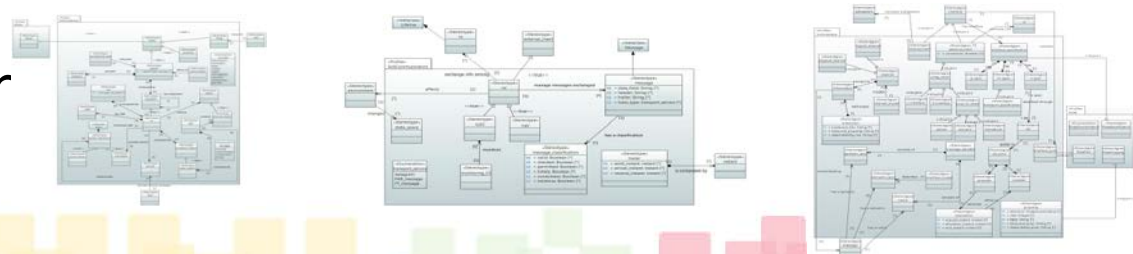
SoS Basic concepts



High-level representation



Semi-formalization

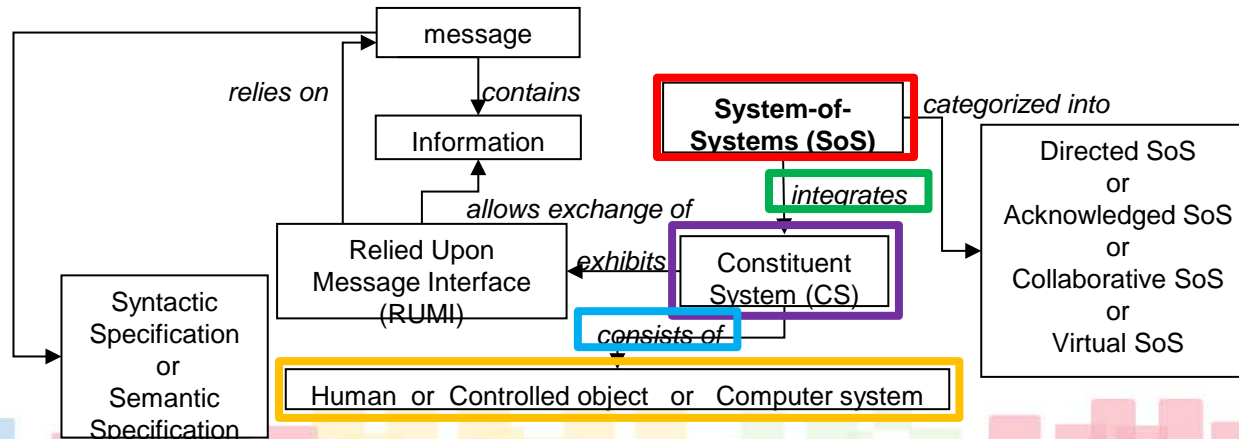


High-level representation

- Explicates relations among basic SoS concepts per viewpoint
- Supports their graphical visualization
- Semantic
 - **Boxes** represent concepts
 - **Arrows** represents semantic relationships among concepts (labels in natural language)

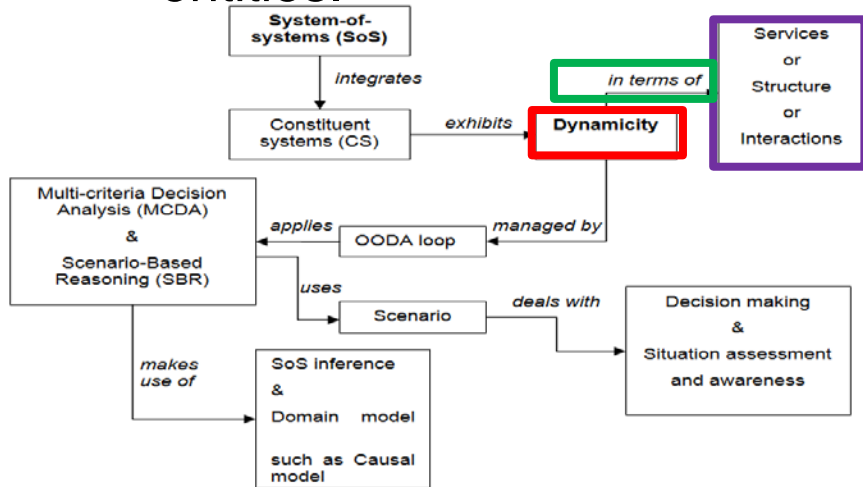
Relating basic SoS concepts in Structure view

- “**System-of-Systems (SoS)**: An SoS is an **integration** of a finite number of **constituent systems (CS)** which are independent and operable, and which are networked together for a period of time to achieve a certain higher goal.”
- “**Constituent System (CS)**: An autonomous subsystem of an SoS, **consisting of computer systems and possibly of a controlled objects and/or human** role players that interact to provide a given service.”

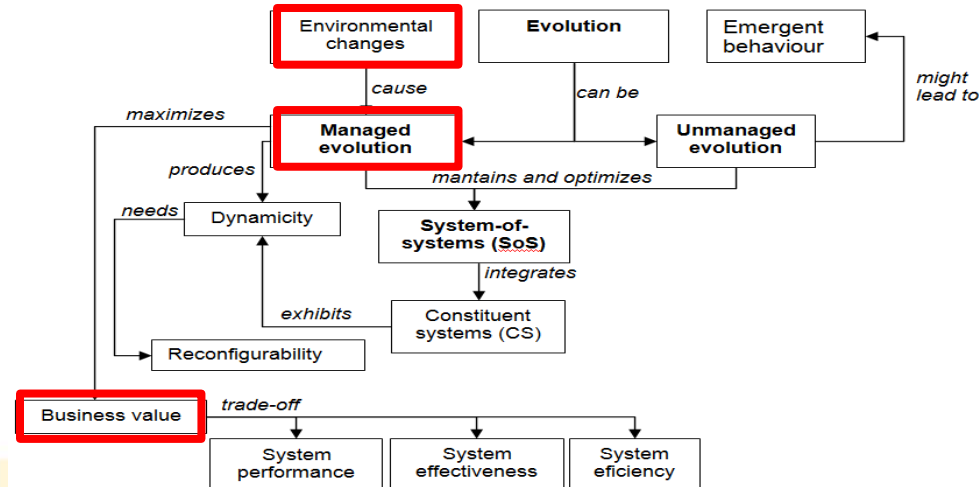


Dynamicity / Evolution

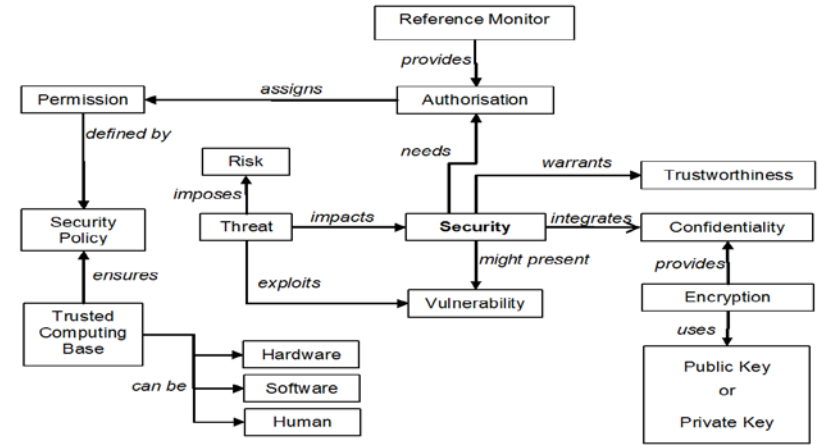
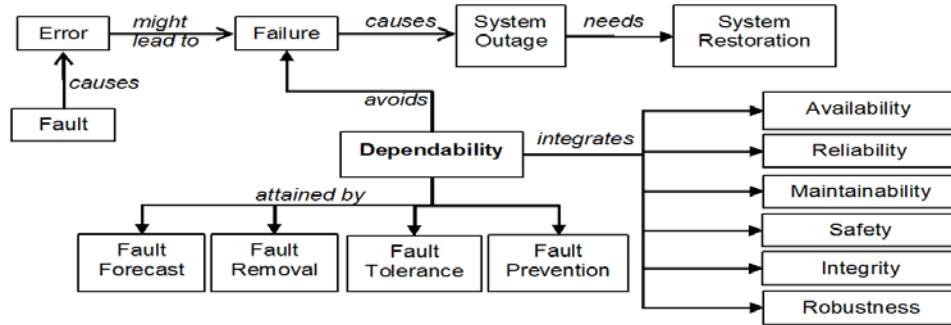
- “**Dynamicity**: The property of an entity that is constantly changing **in terms of** offered **services, built-in structure and interactions** with other entities.”



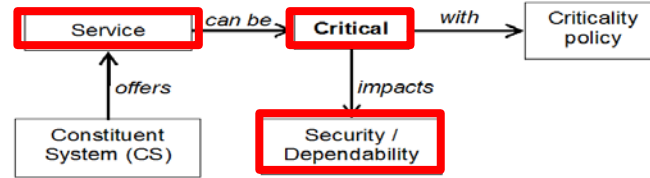
- “**Managed SoS evolution**: Process of modifying the SoS to keep it relevant in face of an ever-changing environment.”
- “**Business value**: Overarching concept to denote the performance, impact, usefulness, etc. of the functioning of the SoS”



Dependability / Security / Multi-criticality



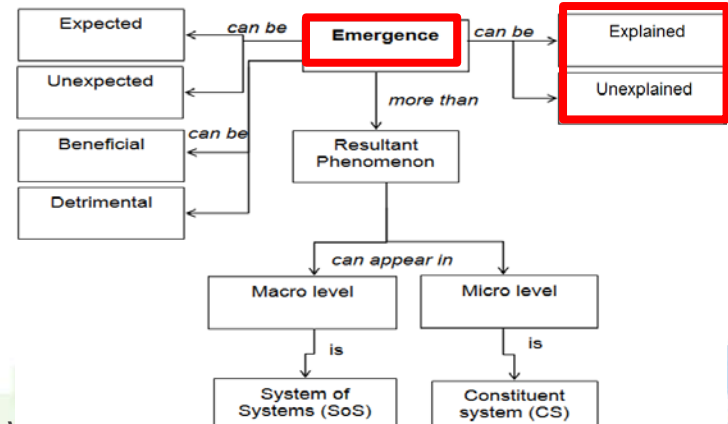
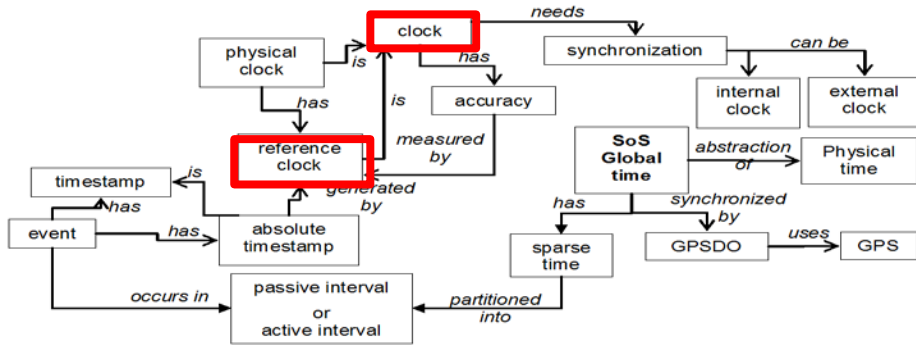
- **“Critical service:** A critical service is the service of a system that requires a specific criticality level.”
- **“Criticality level:** The criticality level is the level of assurance against failure.”



Time / Emergence

- **Clock:** A (digital) clock is an autonomous system that consists of an oscillator and a register. Whenever the oscillator completes a period, an event is generated that increments the register.
- **Reference clock:** A hypothetical clock of a granularity smaller than any duration of interest and whose state is in agreement with TAI.

- **Emergence:** A phenomenon of a whole at the macro-level is emergent if and only if it is new with respect to the non-relational phenomena of any of its proper parts at the micro level.
- **Explained emergence:** ...if a trans-ordinal law that explains the occurrence of the emergent phenomenon at the macro level out of the properties and interactions of the parts at the adjacent micro level is known.
- **Unexplained Emergence:** ... if, after a careful analysis of the emergent phenomenon, no trans-ordinal law that explains.... is known (at least at present).



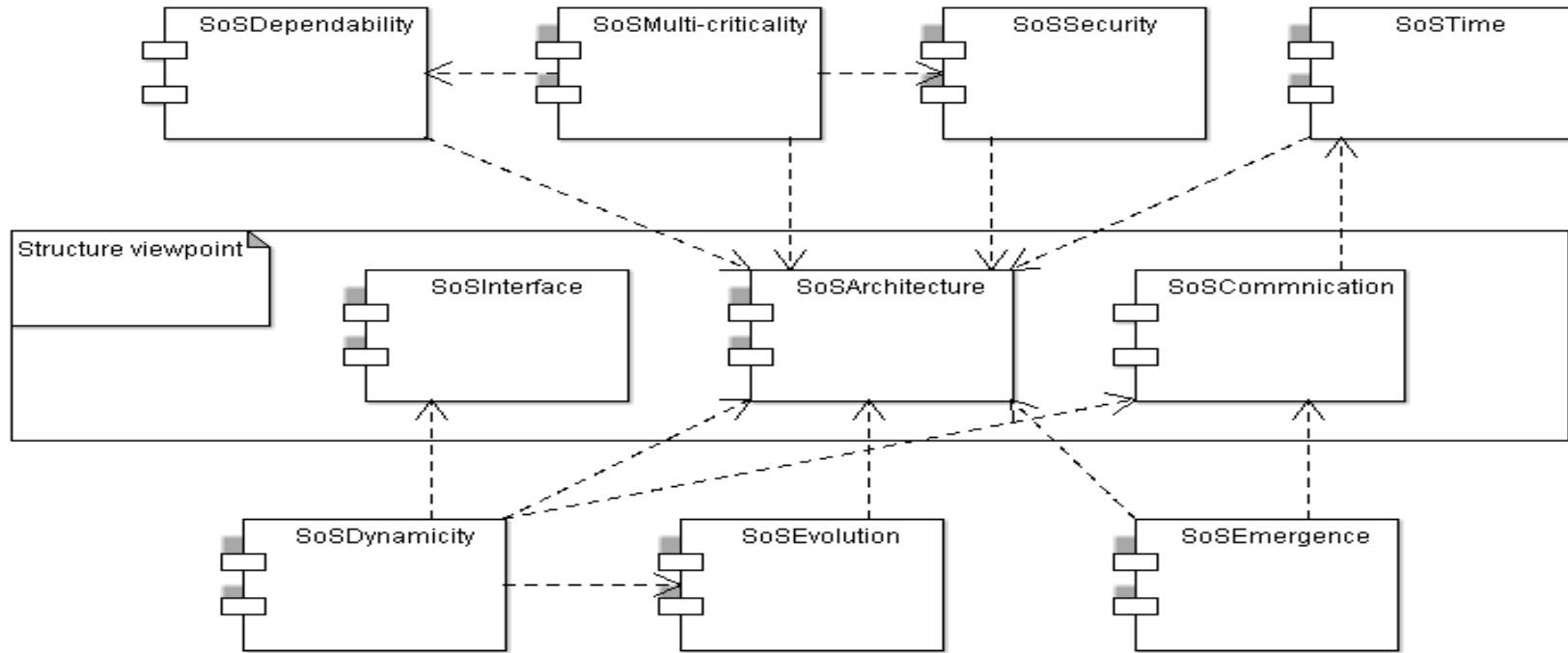
Towards a semi-formal representation

- Describe AMADEOS viewpoints via a SysML profile
- UML-like representation
 - **Improve the understanding** by using different levels of abstraction and different views
 - **Foster information sharing** and **reuse** among SoS stakeholders
 - **Enable analysis** and **experimentation** at early stage of the SoS lifecycle process

AMADEOS SoS Profile: Rationale

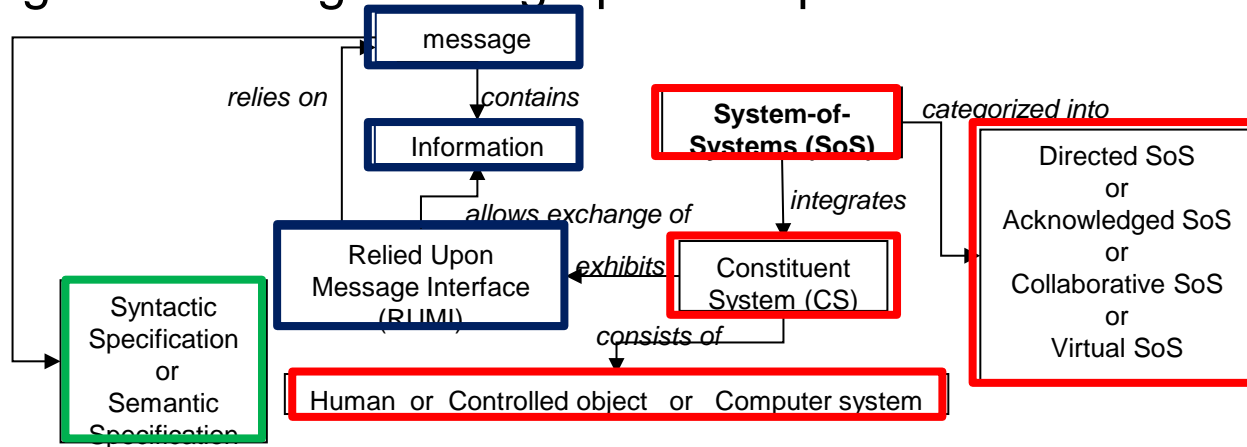
- A SysML profile to implement SoS basic concepts and their relationships
 - Strong focus on conceptual modelling
 - Capturing both static structure and dynamic behavior
- Organized in viewpoints driven-components
- Profile implementation
 - Open source Eclipse integrated development environment along with Papyrus plug-in

AMADEOS profile components



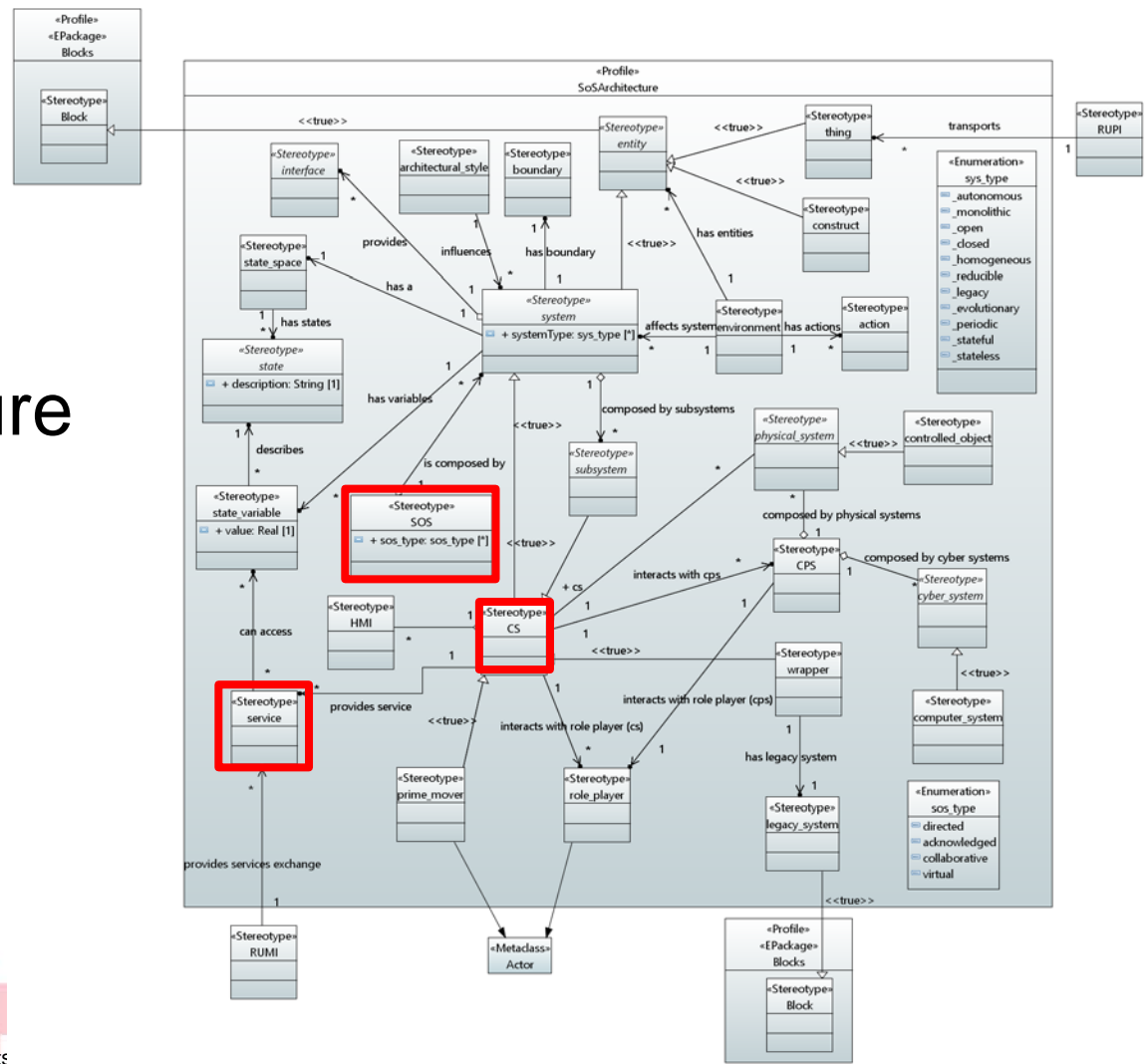
Mapping structure view into AMADEOS SoS profile

- Starting from the high-level graphical representation of Structure...

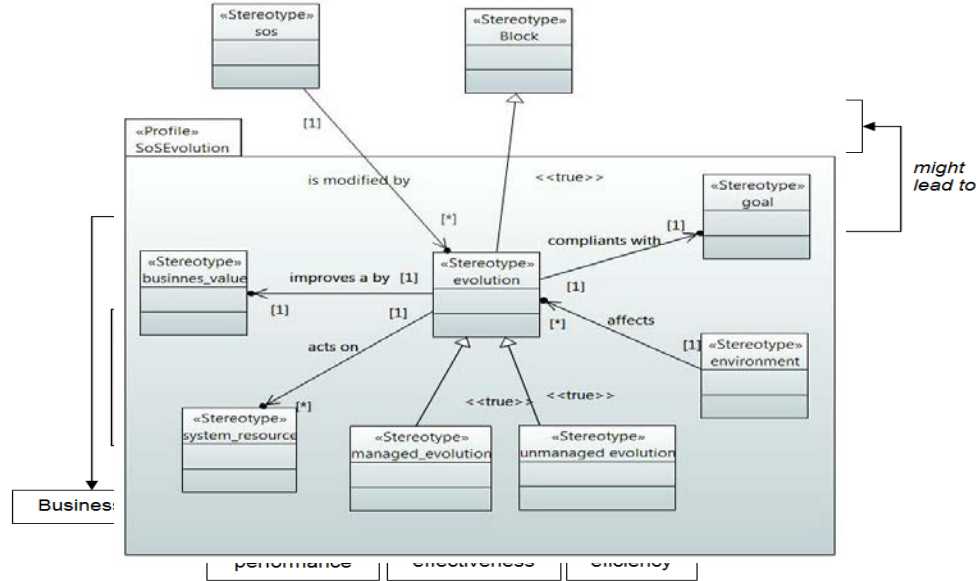
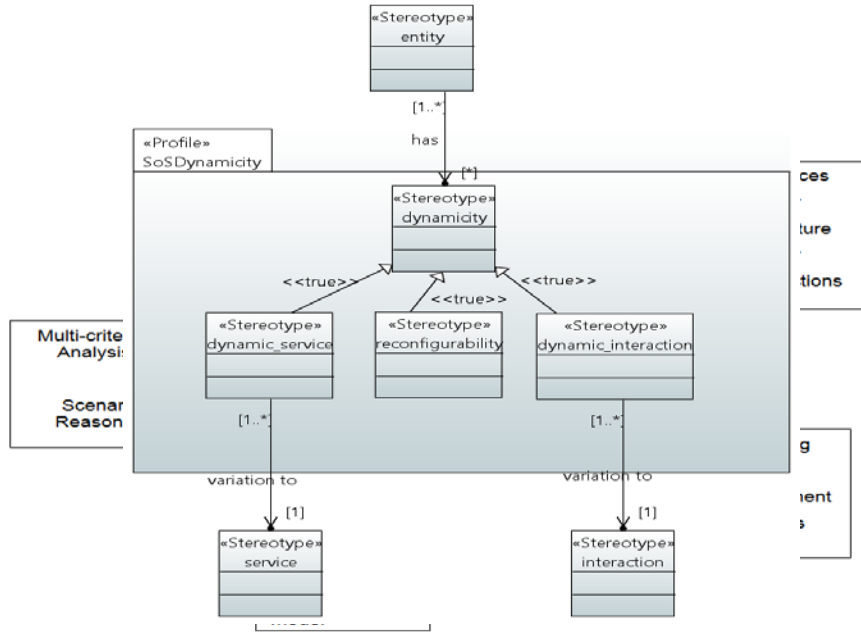


-we implemented three SysML profile components:
 - **SoSArchitecture** component
 - **SoSCommunication** component
 - **SoSInterface** component

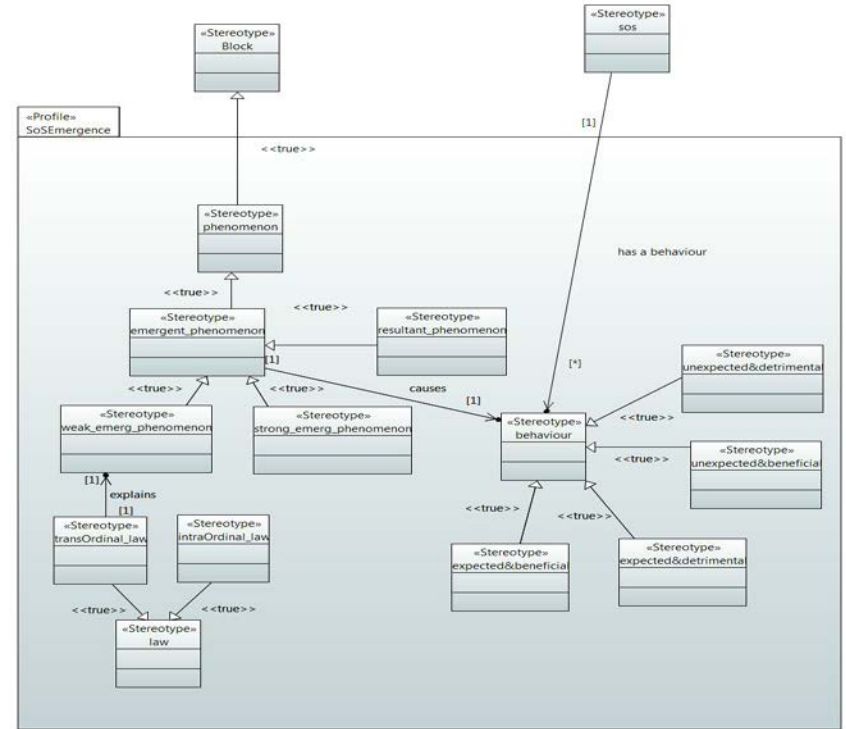
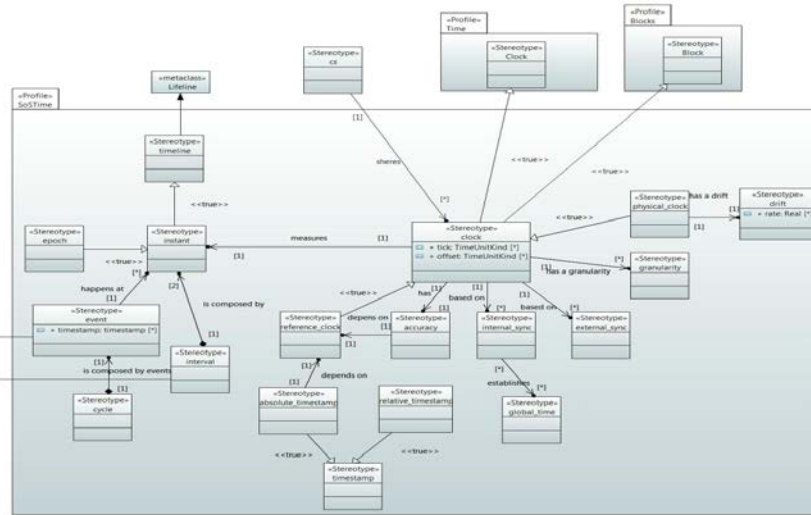
SoSArchitecture package



Dynamicity / Evolution



Time / Emergence



Role in MDE

- SysML SoS profile as a **Platform Independent Model**
 - It provides a set of concepts involving SoS without losing the platform independent characteristics.
- **Platform-Specific Models**
 - can be defined and used at different stages of system design and validation

Profile's applications

- The profile can be **integrated** into existing SysML MDE tool-chain platforms, to perform e.g.
 - System analysis
 - E.g. Hazard Analysis (HA), Failure Mode and Effect Analysis (FMEA), Fault Tree Analysis (FTA)
 - Interface compatibility checking
 - **Causal loop detection for detrimental emergence prevention**
 - Source code generation
 - System simulation
 - System testing

Causal loops detection

- **Causal loops**
 - are formed by the information transfer via **cyber-channels** and **stigmergic channels**
 - can be the cause for the appearance of **emergent phenomena**.
- SysML profile captures the dependences between CSs at the interface level
 - to **automatically detect causal loops**
 - Thus discovering the potential for **emergent phenomena** at design time.

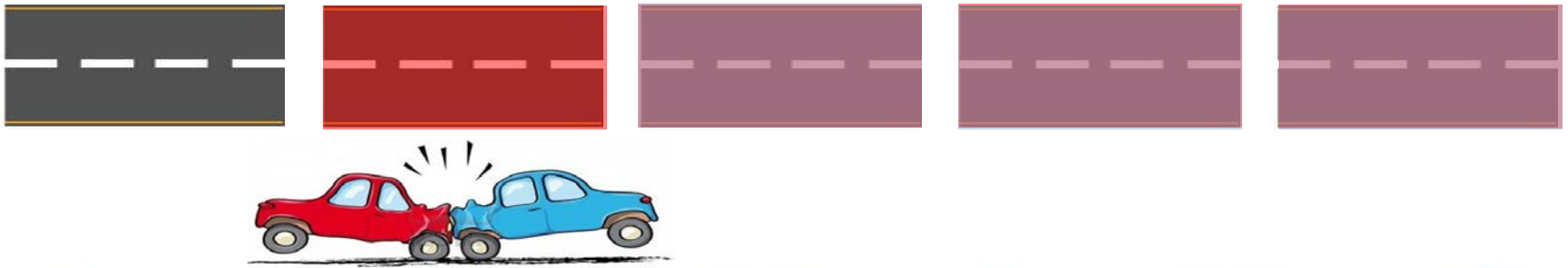
Traffic Flow

Traffic flows if section of road in front of a car is empty



Traffic Jam

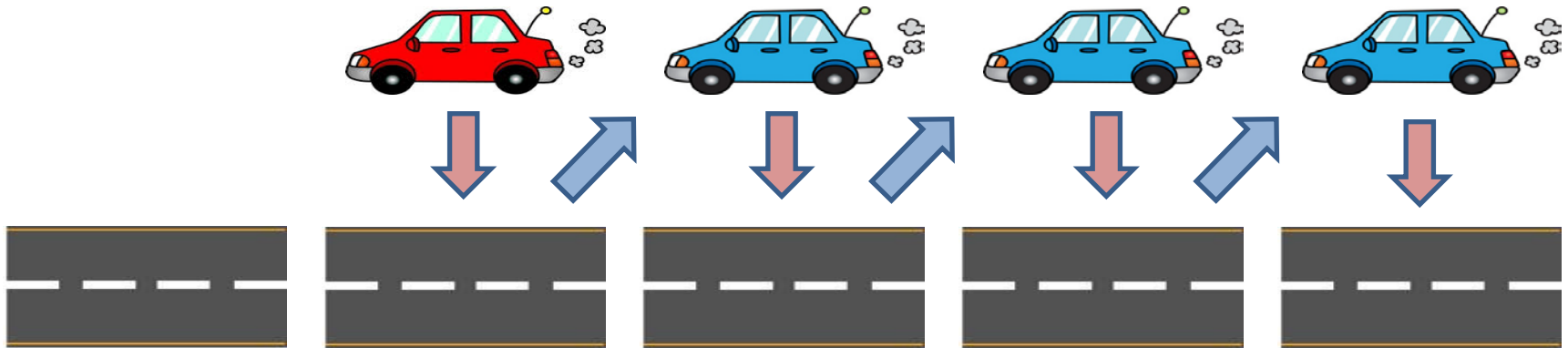
In case of a disturbance, a car does not free the current section of road as fast as expected =>
Following cars cannot free their sections either



Causal Loop

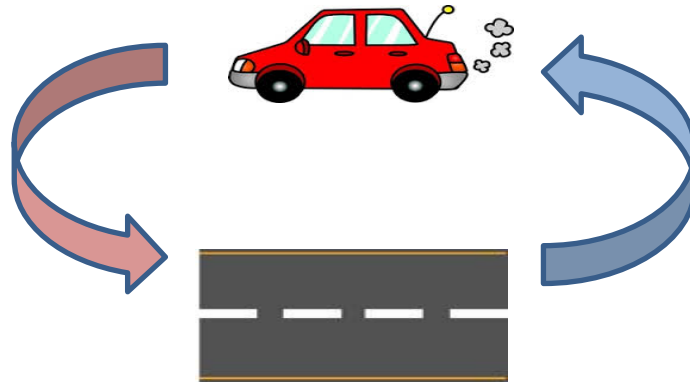
A **causal loop** exists between the **environment** (road) and **each vehicle**:

- A car causes a road section to be blocked
- A blocked road section causes the next car to block the subsequent section



Abstraction of SoS

The abstract description of this SoS highlights the **cyclic dependence** between the vehicle and its environment



Conclusion

- Viewpoint-driven approach to design SoSs by adopting a SysML profile
- Implementing the profile in the Eclipse integrated development environment jointly with Papyrus
- Applicability of the profile for SoS description and analysis

References

AMADEOS – Public deliverables (<http://amadeos-project.eu/documents/public-deliverables/>)

- D2.1 - Basic SoS concepts, glossary and preliminary conceptual model
- D2.2 - AMADEOS Conceptual Model.
- D2.3 AMADEOS conceptual model – Revised (to appear – end of 2016)

- M. Mori, A. Ceccarelli, P. Lollini, A. Bondavalli and B. Frömel. “A holistic viewpoint-based SysML Profile to Design Systems-of-Systems”. IEEE 17th International Symposium on High Assurance Systems Engineering (HASE), 2016.

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EXAMPLES OF PROFILE'S APPLICATIONS, DEMOS, EXERCISES