INCOSE (MBSE)
Model Based System Engineering
(SoS) System of Systems Activity Introduction

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MBSE Wiki page: http://www.omgwiki.org/mbse
MBSE SoS/Enterprise Modeling Wiki page:
Outline

• Introduction
• Conceptual Model Summary for SoS
• Concept Representations
  – Languages
  – Frameworks
  – Patterns
• MBSE SoS Challenges
• Systems Language Models for SoS
  – SysML (System Modeling Language)
• Architecture Framework (AF) Models for SoS
  – UPDM (UML(Unified Modeling Language) Profile for DoDAF/MODAF
• MBSE SoS Case Studies
  – Architecture Eco-System Efforts
  – UPDM and DoDAF 2.0 DM2
  – UPDM and SysML, SoaML, BPMN, BMM, etc.

• Questions…hold for the end of the session
Introduction

MBSE System of Systems

• System of Systems (SoS)…one of many definitions/characterizations
  – A class of problems that have unique characteristics, distinguishing them for “classic” systems.
    • For example, unbounded context and usage, potentially emergent behaviors, large number of complex interactions, costly to fully verify and validate a priori,…
  – These unique characteristics have lead the SE and Architecting community to investigate new languages and frameworks to help better define these key SoS characteristics

• SoS Engineering
  – Modeling is increasingly critical to understanding, managing and validating
  – SoS modeling (e.g. SysML, MARTE, Modelica, eXtend, SimuLink, …)

• SoS Architecting
  – Architecture Frameworks (DoDAF, MODAF, FEAF, Zachman, TOGAF, …)
  – Model Based Frameworks (e.g. UPDM - Unified Profile for DoDAF/MODAF)
Introduction SoS Engineering
Key Concepts


SoS Engineering Key Concepts

- Legacy Systems
- Dynamic Reconfiguration of Architecture
- Service Oriented Architecture Enabler
- Protocols and Standards to Enable Interoperable Systems
- Added “ilities” or Quality Attributes
- Federated Acquisition
- Independent Systems
- Concept of Operations Critical
- Ongoing Experimentation
- Converging Spirals

SoS Modeling Implications →
## Introduction

### ...SoS MBSE Implications

| Legacy Systems | ⇒ Models for behavior, interfaces, requirements, performance, e.g. SysML, Modelica, MARTE |
| Dynamic Reconfiguration of Architecture | ⇒ Dynamic Reconfigurable models of architecture, e.g. UPDM with UML/SysML model version management |
| Service Oriented Architecture Enabler | ⇒ SOA modeling language, e.g. SoaML, SOA Patterns |
| Protocols and Standards to Enable Interoperable Systems | ⇒ Models for protocols, standards, interoperability, e.g. UPDM, DoDAF 2 MetaModel |
| Added “ilities” or Quality Attributes | ⇒ Specialty Engineering models, e.g assurance |
| Federated Acquisition | ⇒ Models for acquisition project synergy, e.g. UPDM, MODAF, DoDAF 2 MetaModel |
| Independent Systems | ⇒ Models for independence in system functionality, e.g. Agent Based, federated models |
| Concept of Operations Critical | ⇒ Models for CONOPs including Mission, Objectives, Courses of Action, etc. e.g. UPDM Operational Viewpoint, BPMN Business Processes |
| Ongoing Experimentation | ⇒ Analysis of Alternatives models for all viewpoints and model versioning |
Some MBSE SoS Challenges

- Core Concepts have a wide range of interpretations and definitions across modeling languages
  - Duality: System of Systems and Model of Models
  - OMG Initiative: “Ecosystem” of Languages/Models
- Methodology / Discipline differences expand into SoS Engineering
  - Object Oriented vs Structured/Functional
  - Enterprise vs SoS vs System
  - Business vs Engineering Models (BPMN vs UML vs SoaML vs SysML)
  - Enterprise, Business and Technical Architecture Models (pick your favorite Architecture Frameworks)
- Example Concepts with several interpretations
  - Capability
  - Function
  - Activity
  - Requirement
  - View
  - Viewpoint
- Example Languages with overlap
  - BPMN and UML (SysML, UPDM)

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**UML/BPMN Integration Straw Poll** (source OMG)

<table>
<thead>
<tr>
<th>Option</th>
<th>Votes</th>
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</thead>
<tbody>
<tr>
<td>They remain separate standards</td>
<td>3</td>
</tr>
<tr>
<td>BPMN is a UML profile with notation</td>
<td>6</td>
</tr>
<tr>
<td>Create a unified model encompassing both</td>
<td>13</td>
</tr>
<tr>
<td>Semantic models with UML and BPMN viewpoints</td>
<td>9</td>
</tr>
<tr>
<td>BPMN replaces UML activity diagrams</td>
<td>4</td>
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<tr>
<td>BPMN grows to make UML not required</td>
<td>0</td>
</tr>
<tr>
<td>BPMN and UML are separate models, mapped with QVT</td>
<td>2</td>
</tr>
<tr>
<td>There are ways to make links between them</td>
<td>3</td>
</tr>
</tbody>
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Systems Language Models for SoS

- **SysML Core Concepts**
  - Structure, Behavior, Requirements, Parametrics
    - View, Viewpoint, Block, Part, Role, Connector, Interface, Item, ItemFlow, Activity, State, Transition, Requirement, Constraint Block,…
  - SoS Core Concepts

- **SysML/SoS Mapping Example (one of several approaches)**
  - Structure (Block,…)
  - Behavior (Activity, State,…)
    - Function, Task, Activity, Scenario, Workflow,
  - Requirement
    - Policy, Constraint, Standard,…
  - Parametrics
    - MoE’s, KPP’s, “ilities”…

See UPDM and DoDAF Meta model References for mapping standards efforts
Architecture Framework (AF) Models for SoS

- Zachman Framework
  - Perspectives, Interrogatives, Checklist
- TOGAF 9 (The Open Group AF)
  - Architecture Development Model
- FEAF (Federal Enterprise AF)
  - Reference Models (Business, Technical, Information, …)
- DoDAF 2 / MODAF / NATO AF /…
  - Viewpoints, Products for Capability, Operational, System, Service, Technology Standards, Information, … Views
- …and many additional variants of various combinations of the above frameworks
MBSE SoS Case Studies

• Architecture Eco-System Efforts
  – Special Interest Group at OMG
  – Co-Chairs:
    • Jim Amsden (IBM)
    • Cory Casanave (Model Driven Solutions)

• UPDM and DoDAF 2.0
  – UPDM 1.0 official OMG standard
    • Co-Chairs
      – Jim Rice, NoMagic
      – Graham Bleakley, IBM
      – Matthew Hause, Atego
    • DoD
      – Walt Okon, OSD
      – Len Levine, DISA