Simplifying (and enriching) SysML to perform functional analysis and model instances

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# Thales: A Wide Spectrum of Complex Systems

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Models, What For?

- **Answer questions**
  - About the system
    - What is it, how does it work, is the performance adequate, what happens if something breaks?
  - About the design
    - Is it complete, does it support required analyses, does it support impact analysis?

- **Ensure consistency**
  - Across different views, between upstream and downstream engineering, etc.

- **Generate artefacts**
  - Documentation (specification, architecture, interfaces)
  - Pieces of code, database schemas, configuration data, deployment data, etc.
Choose (and adapt) the right modeling solution for your objectives!
Arcadia and Capella

MODEL-BASED METHOD FOR ARCHITECTURAL DESIGN AND ITS SUPPORTING OPEN SOURCE MODELING WORKBENCH
Capella: An Open Source Modeling Workbench Supporting Arcadia

Not a talk about Capella features, but….

- Methodological browser
- Semantic browser
- Computed graphical views
- Advanced diagram mgt.
- Validation & quick fixes
- Semantic delete
- Replicable elements
- Patterns
- HTML generation
- Transition to sub-systems
- Multi-viewpoint mgt.
Arcadia-Capella versus and SysML

NOT A PROFILE, NOT A DSL, BUT AN HYBRID APPROACH

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Tooling a Model-Based Engineering Method

Existing language?

Yes

Customization of an existing language?

No

DSML

Customization of the tool?

No

Yes

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Back in the past (2003-2008)
Capella Core Concepts: The Wheel is Not Reinvented…
Things Are Just Simpler... when possible

Functions = Green

Components = Blue

Interfaces = Pink
Focus on Functional Analysis

- MANAGING FUNCTIONAL BREAKDOWNS
- DATA VS CONTROL FLOWS
Functional Analysis Workflows

1. Top-down

2. [Diagram with a top-down structure showing nodes and connections]
Functional Analysis Workflows

1

2

Bottom-Up
Functional Analysis Workflows

1

Bottom-Up

2
SysML Activity Diagrams vs Capella Functions

Rigid encapsulation and delegation mechanism, with (at least) three different kinds of « functions »

- F11, F121, F122, F21, F22 are OpaqueActions
- F1, F2, F12 are CallBehaviorActions referencing Activities

No delegation. When the design is complete, only leaf functions are supposed to have incoming/outgoing exchanges.
Functional Analysis with Capella

F1

F2

F21

F22
Functional Analysis with Capella

MODEL

VIEW
Graphical simplification: Ports on F21 and F22 do not actually «belong» to F21 and F22 but to their children functions.
Graphical simplification: Ports on F2 do not actually «belong» to F2 but to its children functions.
Graphical simplification: Ports on F1 and F2 do not actually «belong» to F1 and F2 but to their children functions.
Introduction of the « Category » concept
Graphical simplification based on the « Category » concept
Language and tooling work together to address practitioner’s engineering challenges and support different workflows.

Computed graphical simplifications are key to manage complexity.
How to deal with Sequence Flows (aka Control Flows)?

Example: Vehicle service checkup

Mr Jones

Hot engine scenario:
1. Change the oil
2. Wait for engine to be cold
3. Check coolant

Mr Smith

Cold engine scenario:
1. Check coolant
2. Warm engine up
3. Change the oil
Pure Control Flows: Contradictory with Dataflow Principles?

Example: vehicle service checkup

8:00 AM
Mr Jones
Engine is hot

10:00 AM
Mr Smith
Engine is cool

Issues

> Two antagonist dataflows: cannot coexist as is
> Do not express functional dependency

- E.g. ‘Change the oil’ does not expect anything likely to come from ‘Check & add coolant’
Control Flows Preclude True Functional Analysis

- Focusing on what each function has to deliver and what it needs for so should prevail
  - This one is better from this point of view

But it is not yet optimal
  - If engine is hot, no need to heat it first
Functional Dataflow Must Address All Use Cases and Contexts

- Checking all possible providers of an input leads to better analysis
  - This one is the most precise, leaving room for several use cases
Scenarios/functional Chains describe Contextual Behaviour

Mr Jones context

- Applicable only inside one context (Capability, Mode, State…)
- Express the « Use » of the dataflow inside this context
Focus on Instance-Driven Modeling
Instance-Driven Modeling

Most systems engineers think in terms of instances, not types!
Instance-Driven Modeling

SysML

- Blocks have Parts, typed by other Blocks
- Blocks can have the “PropertySpecificType” stereotype, emulating an instance-level modeling
- Activities have Partitions
- CallBehaviorActions belong to Partitions and invoke Activities
- Partitions represent either by Blocks or Parts
- Activities have ParameterNodes
- Actions have Pins
- Blocks have FlowPorts
- Blocks are related to each other via Associations
- Parts do not have their own FlowPort “instances”
- No diagram showing simultaneously Component and Activity/Actions

Arcadia-Capella

- Functions are allocated to Components
- By default, one Component == one Part
- Functions and Components have Ports
- Any set of element can be part of a REC (record) or a RPL (replica)
- Content is synchronized between RPL and RECs
Instance-Driven Modeling

**SysML**
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- Activities have Partitions
- CallBehaviorActions belong to Partitions and invoke Activities
- Parts do not have their own FlowPort "instances"
- No diagram showing both Component and Activity/Actions

**Arcadia-Capella**
- Functions are allocated to Components
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**Extremely rich (but complex) language**

The same language concepts are used both for type and instance modeling
Trying with SysML Concepts

Struggling with our “simple” needs

➤ How do we specify “at type” level what Activities or Actions can be / are performed by a block? …

➤ … in order to constraint the Activities or Actions that can be in a Partition representing a Part by what has been defined on its typing Block?

➤ How can we model building block, assembly rules, and deployments that are consistent with each other?
   - Including the Activities and Actions “instances” at each level?
   - Including Port and Connection “instances” at each level?
Instance-Driven Modeling: The Capella Solution

The context and the model organization define whether an element is part of a Type or part of an Instance. Examples:

- Library (REC) vs projects (RPL)
- Assembly description (REC) vs deployment description (RPL)
- Building block (REC) vs assembly description (RPL)

An element can be simultaneously part of a REC and of a RPL
Instance-Driven Modeling: The Capella Solution

A « type » can be anything, including multi-root sets of elements.
Instance-Driven Modeling: The Capella Solution

Support of multiple workflows
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https://twitter.com/capella_arcadia
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Capella forum:
https://polarsys.org/forums/index.php/f/13/
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