Concurrency-aware eXecutable Domain-Specific Modeling Languages as Models of Concurrency

2nd International Workshop on Executable Modeling (EXE 2016)

co-located with MODELS 2016 in Saint-Malo, France

@see: `http://gemoc.org/exe16/`

2016 - 10 - 03

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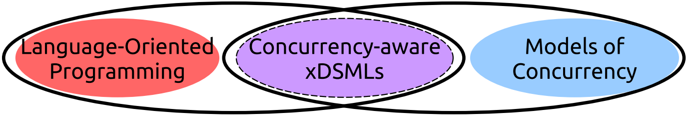
Overview

A Synergetic Language Design Approach



- Introduced by Benoit Combemale *et al.* in SLE 2012 and 2013.
- xDSML design approach with a **separation of concerns** in the operational semantics.
- Concurrency concerns expressed using a Model of Concurrency **at the language level**.

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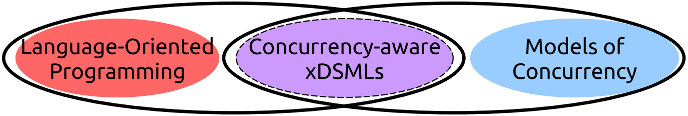

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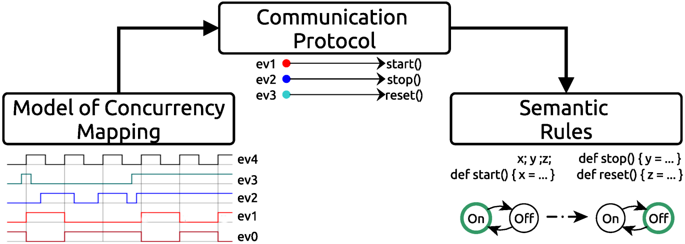
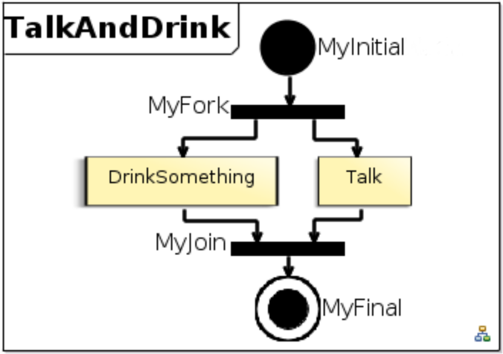


Overview

Structural Elements

Example xDSML:



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- Abstract Syntax (*metamodel*)

The concurrent aspects are *underspecified*.
$\Rightarrow$ Several possible executions.

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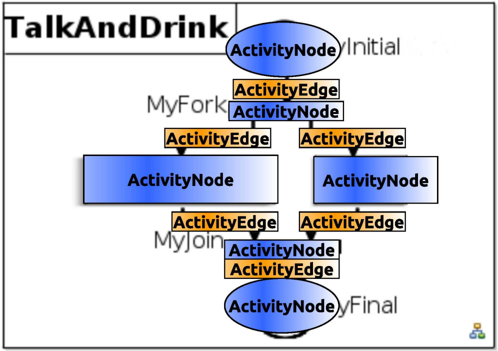

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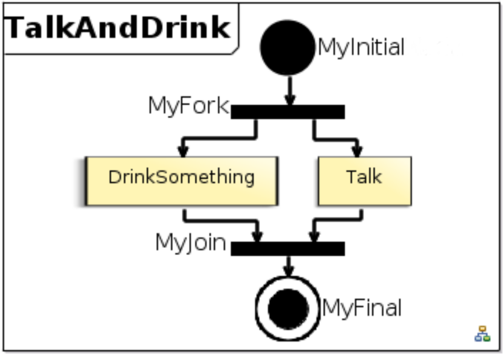

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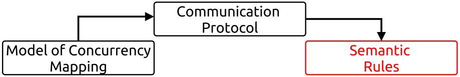
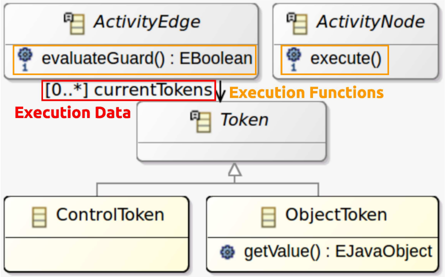
Semantic Rules



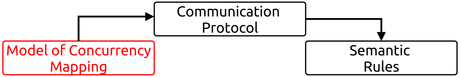
Definition

Dynamic data (**Execution Data**) and their evolution (**Execution Functions**).

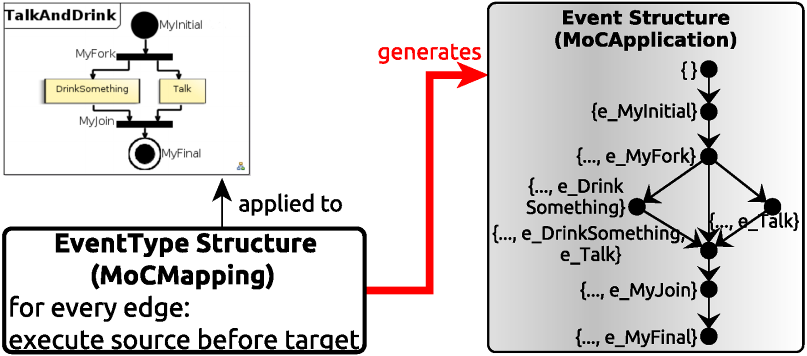
- fUML Execution Data:
  `Tokens` held by `ActivityEdges`.
- fUML Execution Functions:
  `ActivityNode.execute()`,
  `ActivityEdge.evaluateGuard()`.



Model of Concurrency Application & Mapping



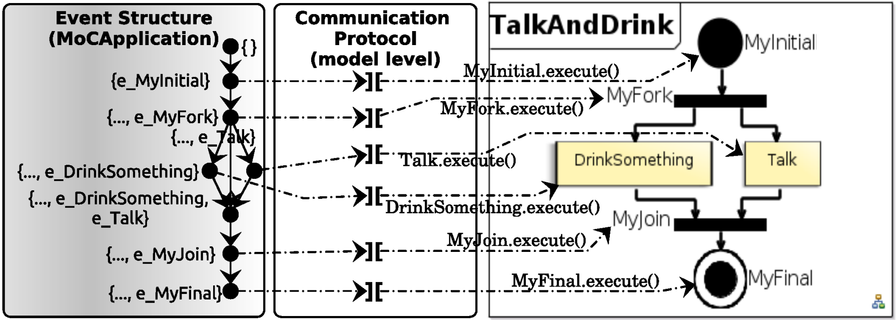
- MoCApplication: Concurrent aspects of a model.
- Conforms to a Model of Concurrency (initially only **Event Structure**).
- Generated based on the **MoCMapping** (EventType Structure).



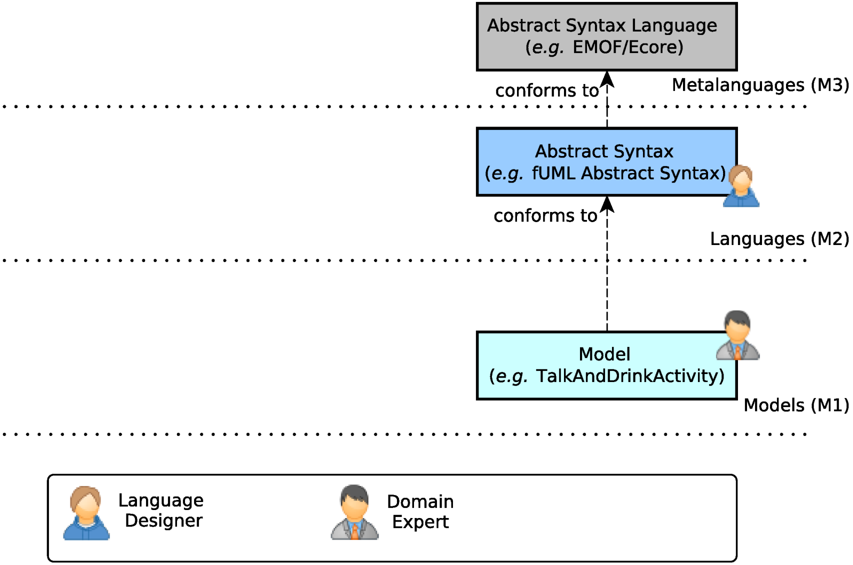
Communication Protocol

Definition

Mappings between the **MoCTriggers** (abstract actions of the MoCMapping) and the **Execution Functions** (concrete actions of the Semantic Rules).



The Concurrency-related Specifications



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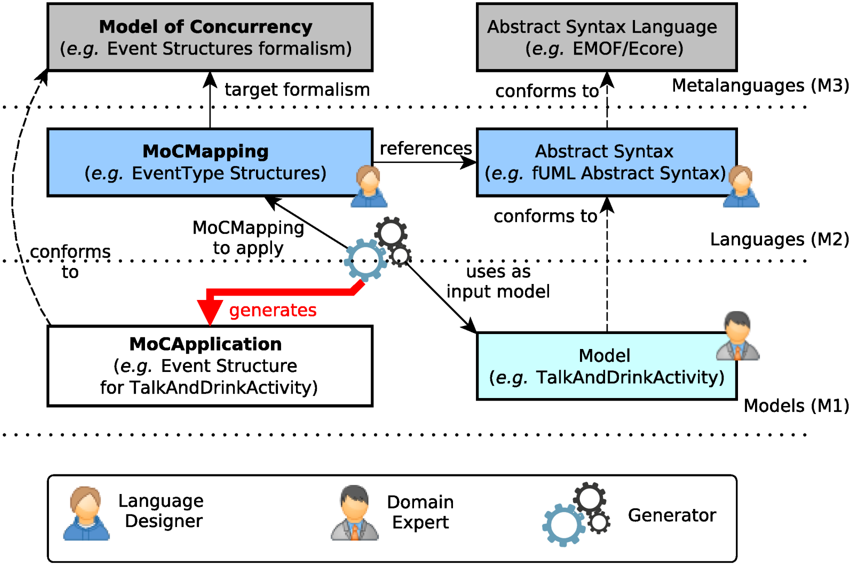


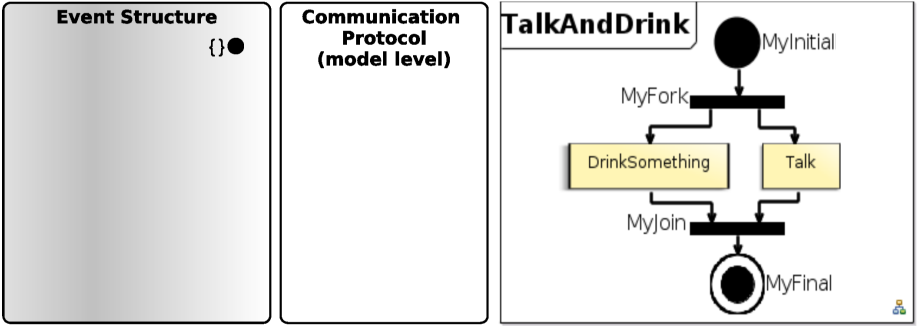
Overview

The GEMOC Concurrency-aware xDSML Approach

- Overview of the Approach
- Specification
- Execution
- Benefits

Execution

The runtimes for each concern are coordinated by the **Execution Engine**.



Possible execution step(s):

$e\_MyInitial \rightarrow][\rightarrow$ `MyInitial.execute()`

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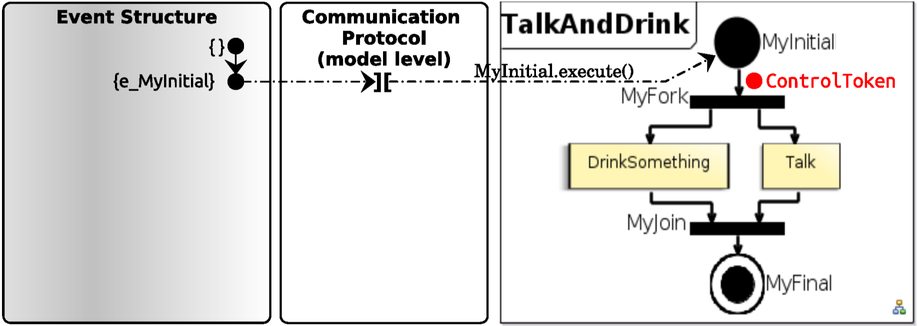

Possible execution step(s):

e_MyFork →][→ `MyFork.execute()`

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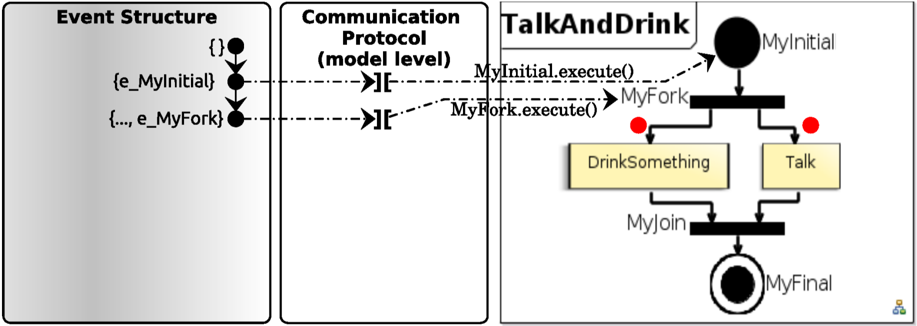

Possible execution step(s):

$e\_Talk \rightarrow$][$\rightarrow$ `Talk.execute()`
OR $e\_DrinkSomething \rightarrow$][$\rightarrow$ `DrinkSomething.execute()`
OR both

Execution

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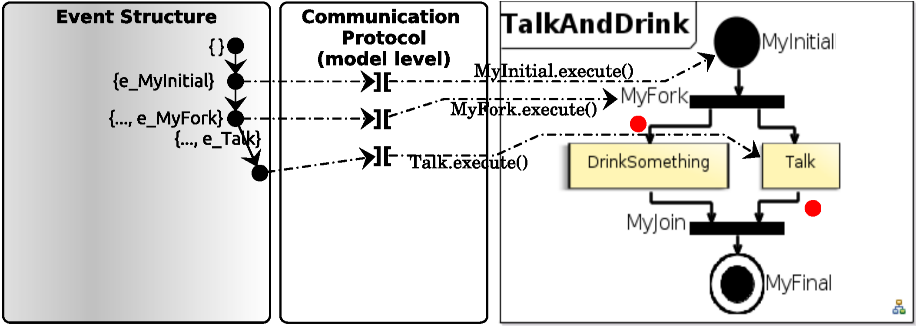

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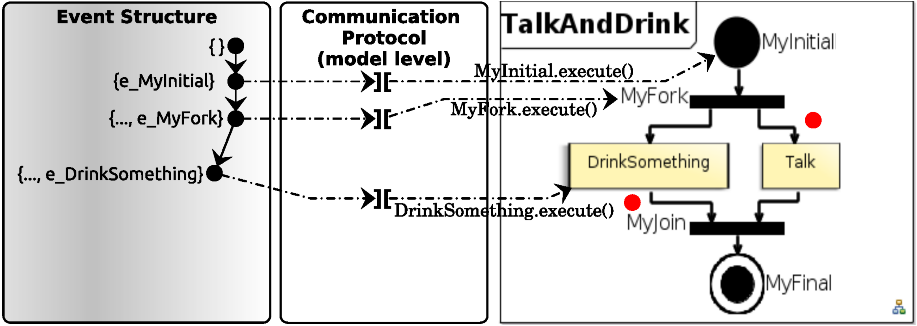

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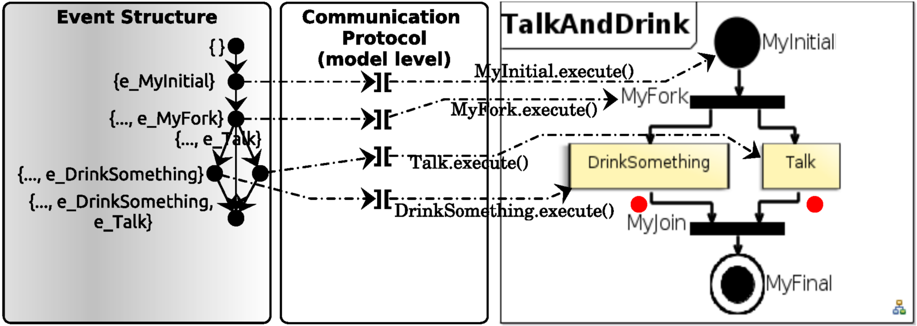

Possible execution step(s):

$$e\_MyJoin \rightarrow][\rightarrow \texttt{MyJoin.execute()}$$

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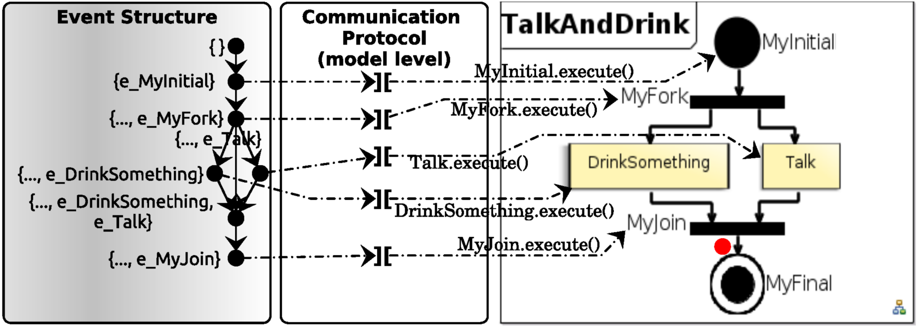

Possible execution step(s):

$$e\_MyFinal \rightarrow][\rightarrow \texttt{MyFinal.execute()}$$

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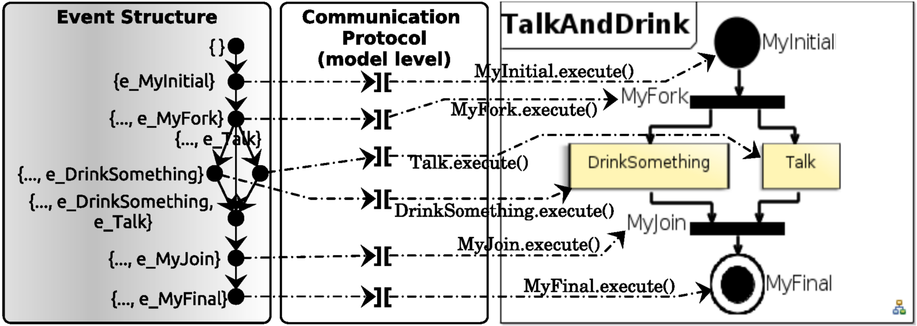


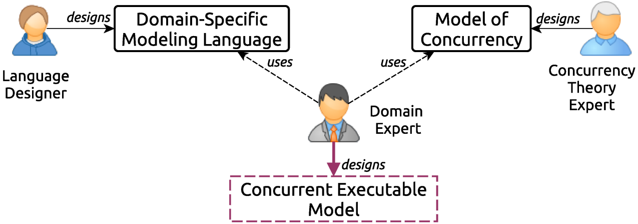
Possible execution step(s):

$\emptyset$

Overview

Systematic Use of a Model of Concurrency

- Concurrency concepts are not manipulated by the domain experts.
- By construction, the MoC is used correctly.



- The different concerns can be implemented and debugged separately.
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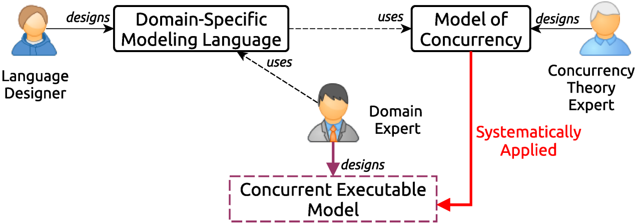

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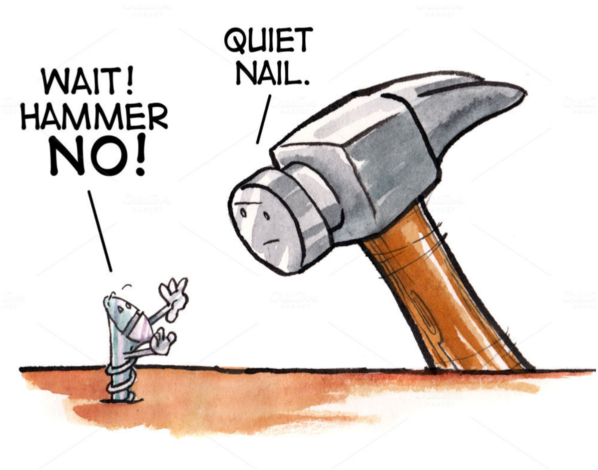
The GEMOC Concurrency-aware xDSML Approach

Tailoring Models of Concurrency to xDSMLs

Conclusion and Perspectives

Overview

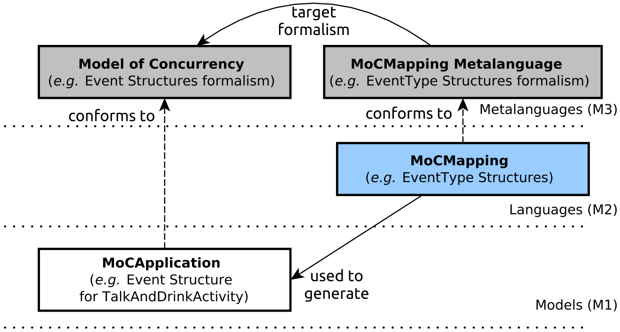
Adequacy of a Model of Concurrency



- In "Why Do Scala Developers Mix the Actor Model with Other Concurrency Models?", *inadequacies* of the actor model.
- In the GEMOC project, MoCCML was designed as a merge of CCSL and automata.

Integration of new Models of Concurrency

Defining and integrating a Model of Concurrency = MoC + MoCMapping + tools (rich editor, generator, runtime)



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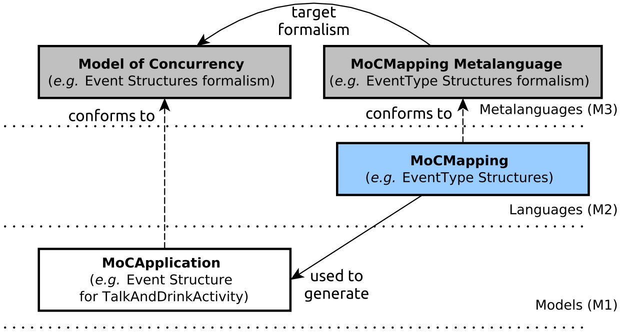
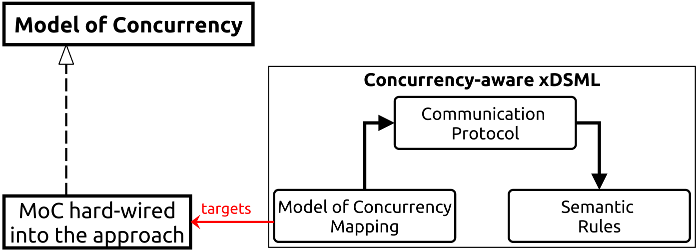


- MoCMapping metalanguage often not pre-existing.
- Identifying the MoCTriggers of the MoCMapping.

A Recursive Definition of the Approach



For an xDSML $\mathcal{L}_{\text{DOMAIN}}$:

- MoC → Another concurrency-aware xDSML, hereafter $\mathcal{L}_{\text{MoC}}$.
- MoCMapping → Model transformation from $\mathcal{L}_{\text{DOMAIN}}$ to $\mathcal{L}_{\text{MoC}}$.
- MoCTriggers → Mappings of the Communication Protocol of $\mathcal{L}_{\text{MoC}}$.
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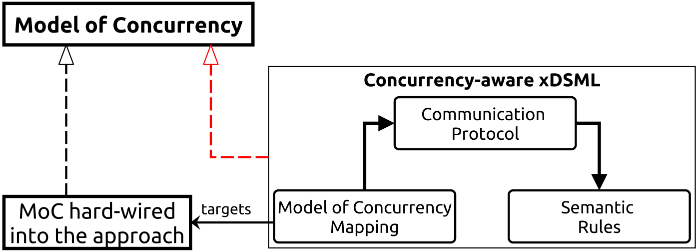

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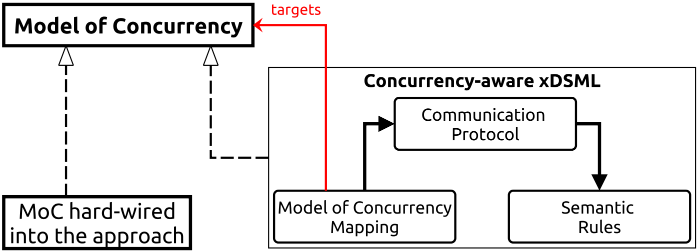

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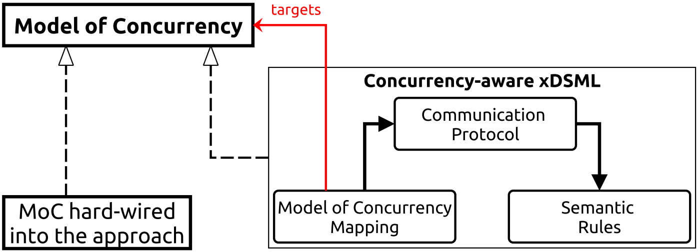

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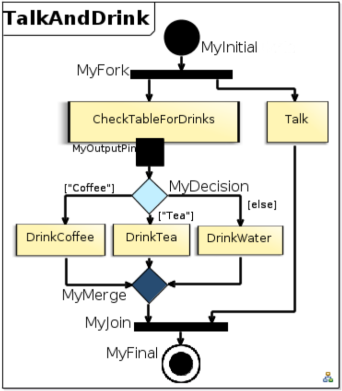
Illustration on fUML



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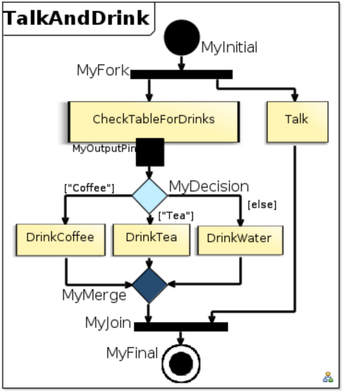
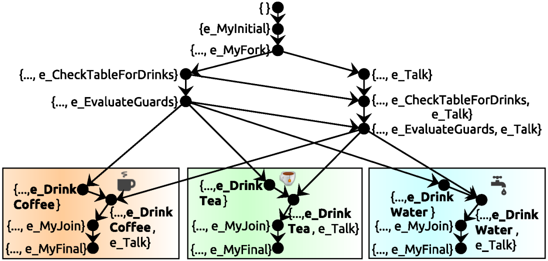
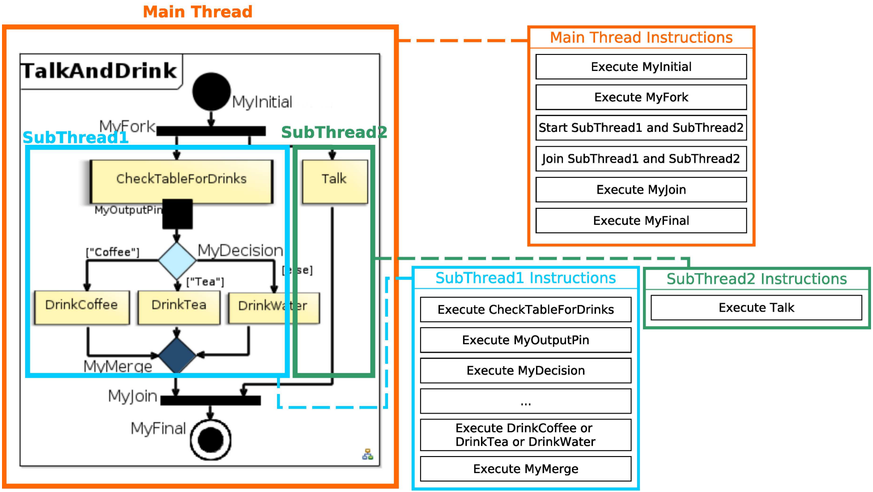


With the Event Structures MoC…



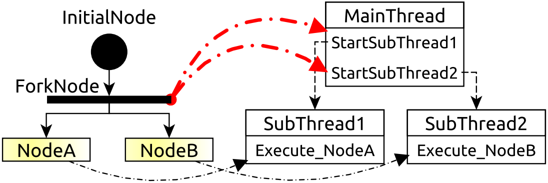
…obtained after manual "translation" of the fUML specification.

Illustration on fUML



Language Specifications

- MoCMapping: Model transformation from $\mathcal{L}_{\text{Domain}}$ to $\mathcal{L}_{\text{MoC}}$.
- ⚠ Used to capture *exclusively* the concurrency aspects. The source and the target are thus *not semantically equivalent*.
- **Projections**: part of the metamodel of the trace of the MoCMapping. Used to compensate the $1 \rightarrow n$ nature of the MoCMapping.



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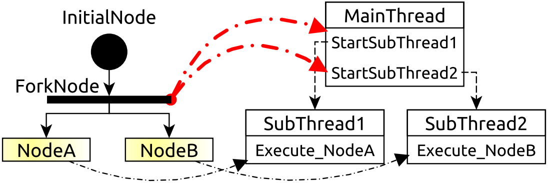
  e.g., ForkNode is transformed into many "start thread" instructions.



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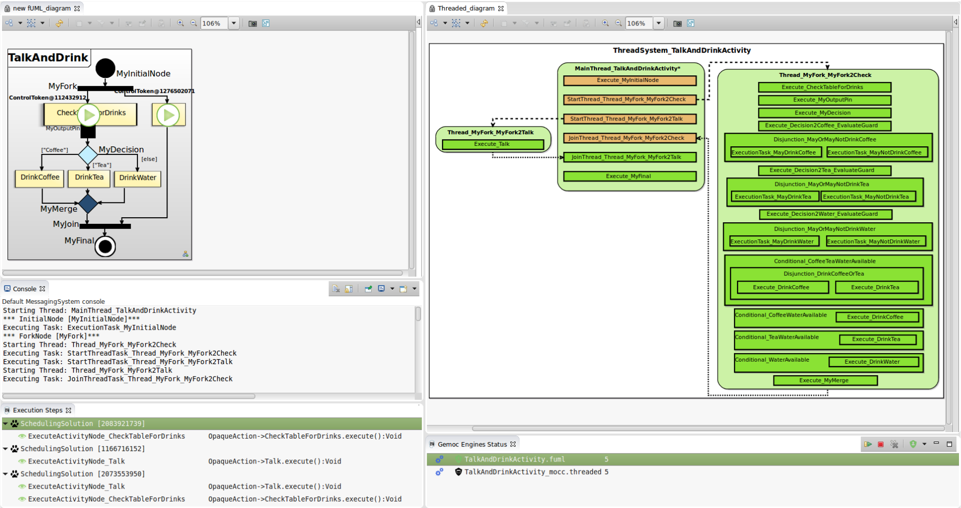
Validation on fUML



Implementation

The GEMOC Studio:

- Based on the Eclipse Modeling Framework (EMF).
- Dedicated metalanguage for the different aspects of a language specification.
- Generic execution, animation and debugging facilities.

Implementation of the contribution in the GEMOC Studio

- MoCMapping: any model transformation language can be used.
- Projections: small dedicated metalanguage (using Ecore + Xtext).
- Communication Protocol: dedicated metalanguage, the GEMOC Events Language (GEL) [5], extended with the use of the Projections.

Conclusion

Recursive definition of the concurrency-aware xDSML approach:

- Seamless integration into the approach.
- No MoC-specific MoCMapping metalanguage.
- Common interface for MoCs (*i.e.*, as concurrency-aware xDSMLs).
- Verification of behavioral properties can be performed based on the selected MoC.

⚠ Additional overhead to the runtime performance.

Perspectives

- Standard library of Models of Concurrency
  including a bootstrapping of Event Structures.
- Integration of existing verification tools for standard MoCs.
  e.g., for Petri nets, Actors, etc.
- Verification of domain properties through higher-order transformations.
  i.e., translating the verification results back into the original domain .
- Generating efficient implementations of the xDSMLs.

Acknowledgement

This work is partially supported by the ANR INS Project GEMOC (ANR-12-INSE-0011).
More information at : `http://www.gemoc.org`

Artefacts and Questions

@see: `http://gemoc.org/exe16/`

contains:

- Videos illustrating:
  - the **Language Workbench** (Concurrency-aware specification of the Threading xDSML and of fUML using Threading as its MoC);
  - the **Modeling Workbench** (Execution of the example fUML Activity).
- The **GEMOC Studio** with:
  - our Threading xDSML implementation;
  - our fUML implementation;
  - the example fUML Activity.

Thank you for your attention.
Questions?

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