4SECURail

Designing a Demonstrator of Formal Methods for Railways Infrastructure Managers

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The problem

The railway infrastructure is a complex **System of Systems**

Spreading across many national borders

Managed by many administrative bodies

Developed by many producers

Expensive to develop, maintain and exercise safely

The solution

High Quality Standard Interfaces between components

* to reduce costs and vendors lock-in
* to increase competitivity, dependability and efficiency

The current efforts to advance the state of art
(e.g. EULYNX / ERTMS / SHIFT2RAIL initiatives)

recognize the importance of formal analysis

4SECURail: goals

https://www.4securail.eu/ is a Shift2Rail project

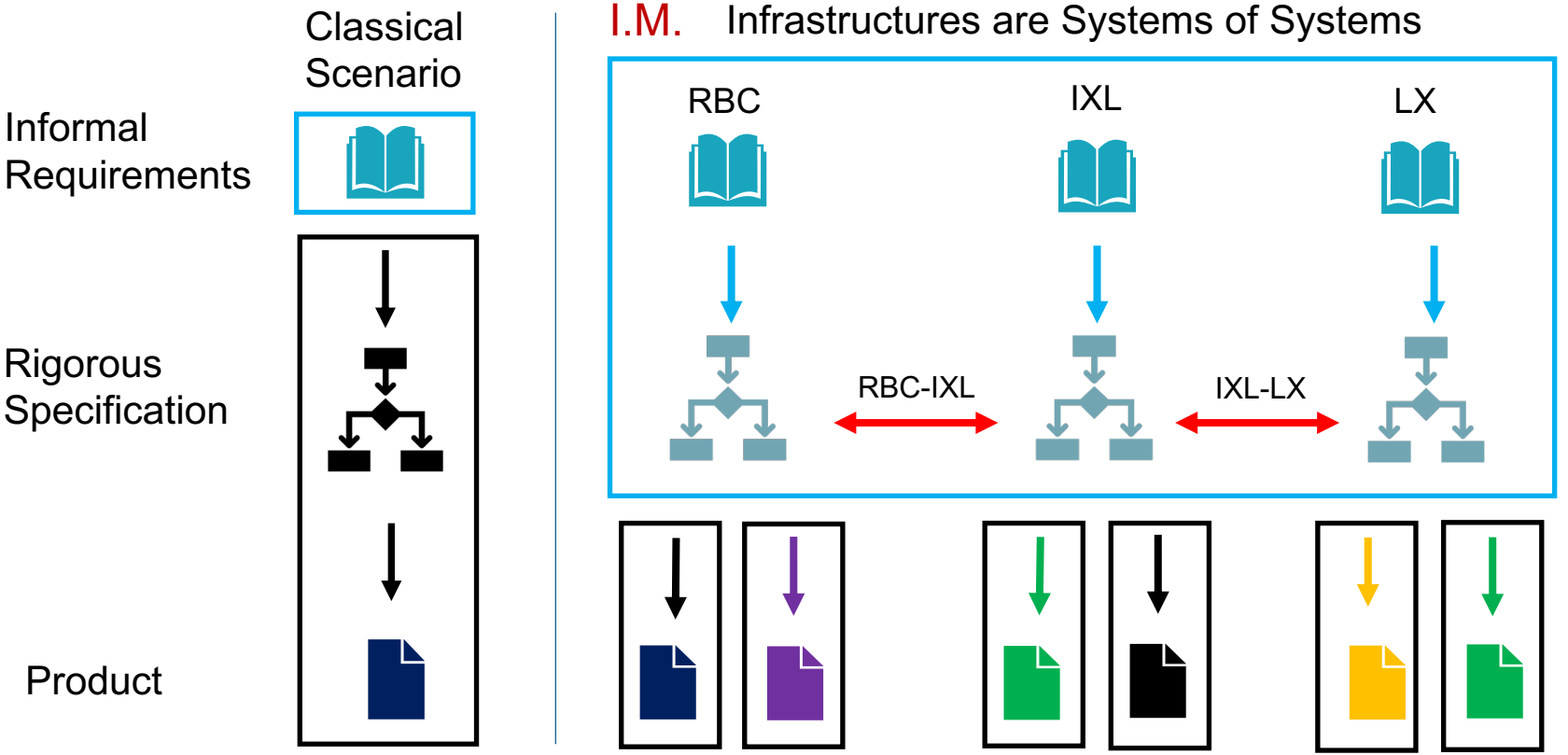
One of its goals is the definition and experimentation of a
Formal Methods Demonstrator:

A controlled experiment in exploiting
formal methods in the requirements definition phase
of a railway signalling system

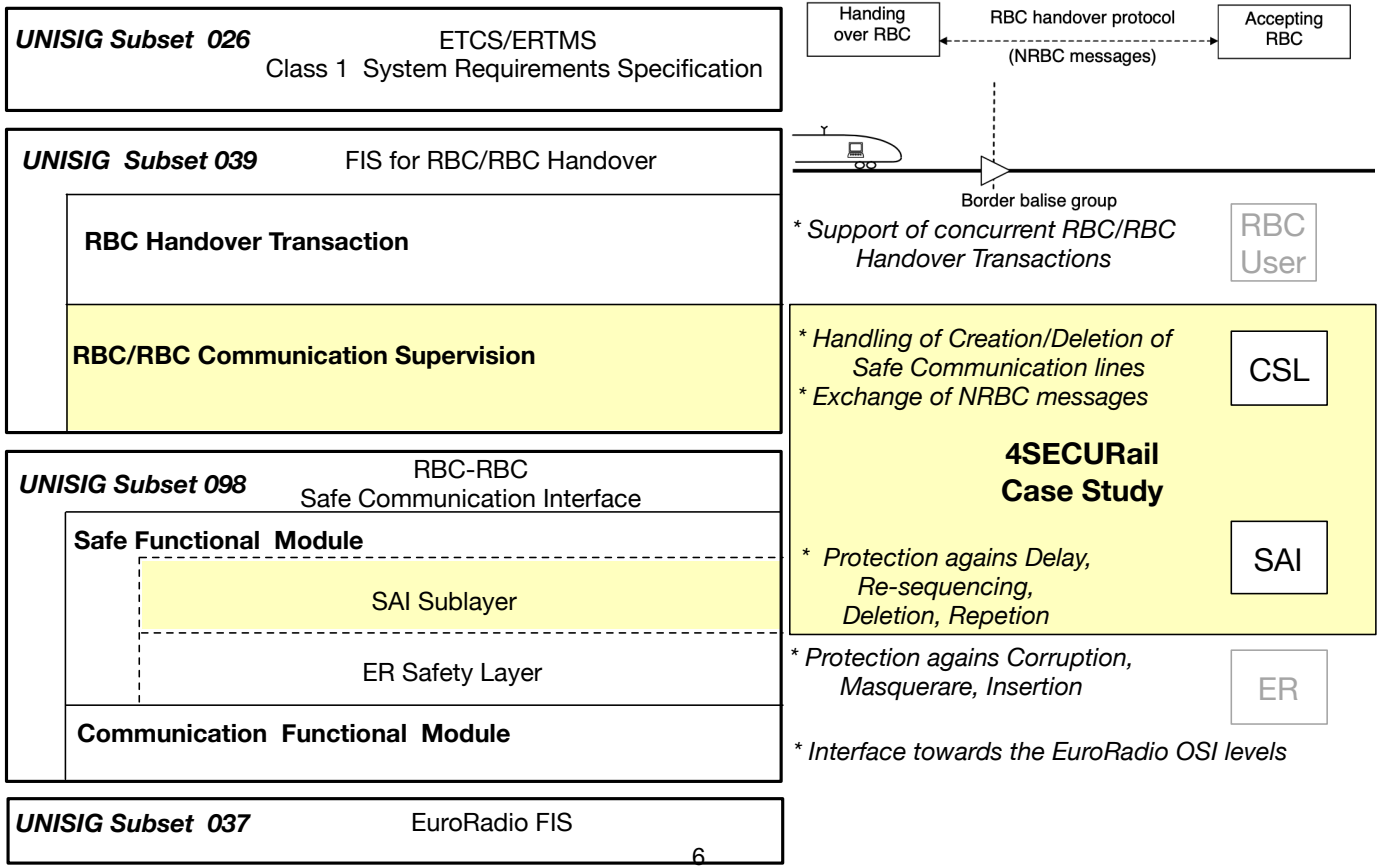
- Can formal methods help improving the quality of requirement specifications (standards)? How?

- Can their adoption be cost effective? How much?

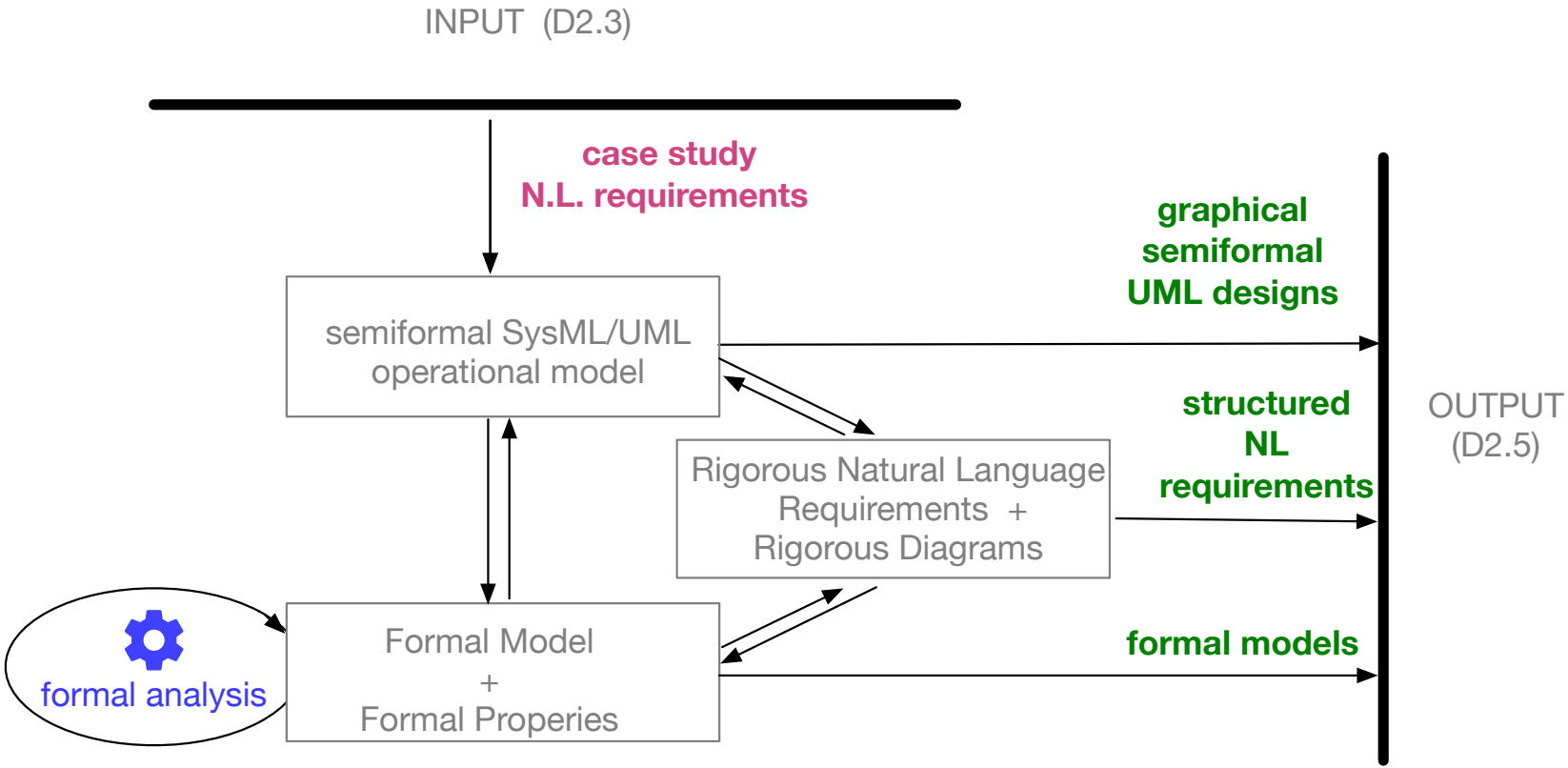
4SECURail: the point of view of Infrastructure Managers



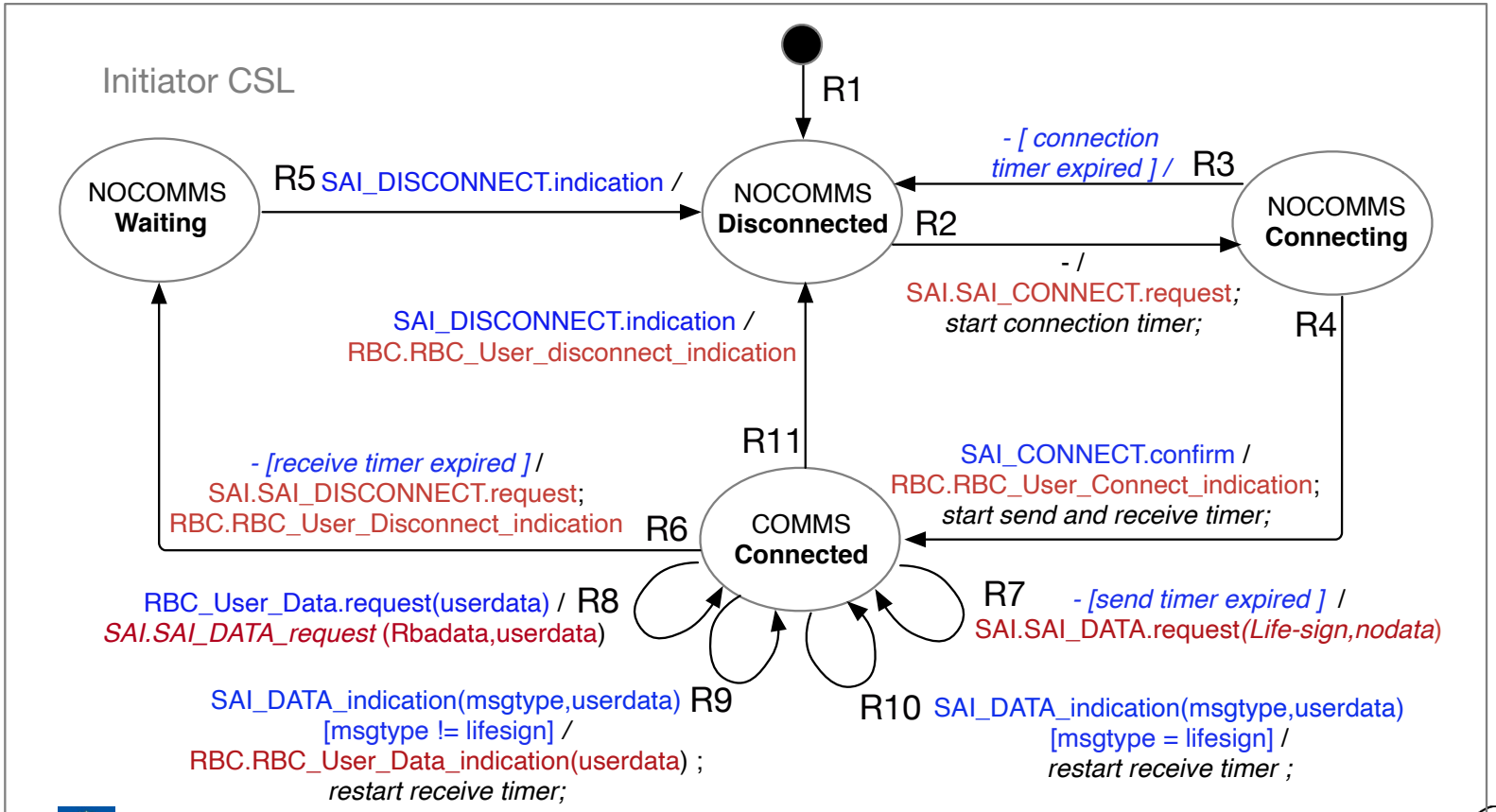
4SECURail: the case study (communications for RBC-RBC handover)



4SECURail: the approach of the demonstrator



4SECURail: semiformal modelling (freestyle UML)

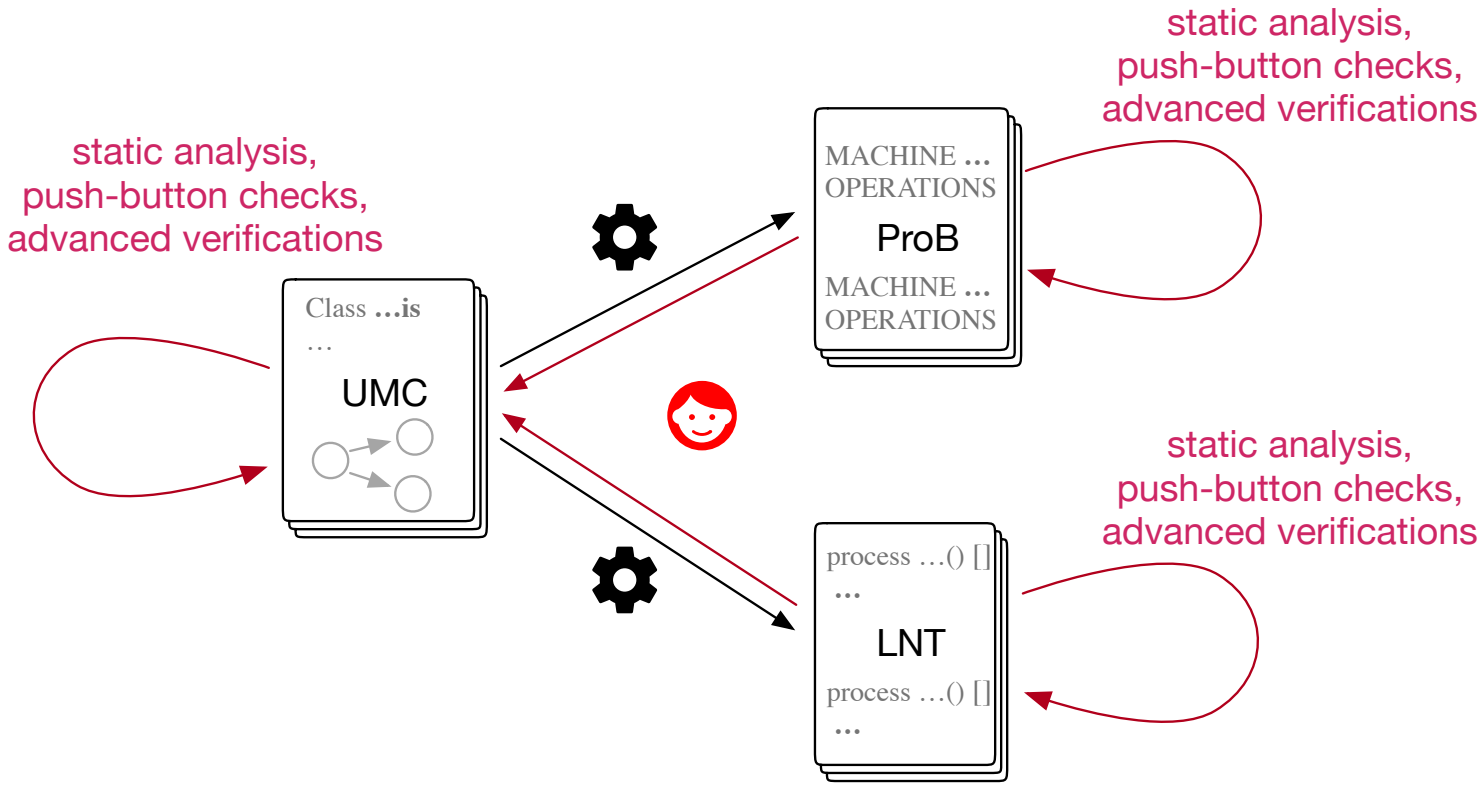


4SECURail: formal modelling and analysis

- Actually implementing freestyle fragments of the semiformal design

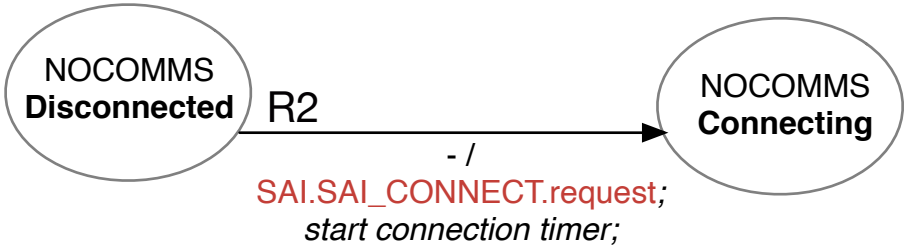
- Model checking of the resulting executable UML models, to detect:
    - introduced implementation errors
    - inconsistencies / missing points of the requirements
    - proofs of properties to be guaranteed

4SECURail: formal modelling and analysis



4SECURail: structured Natural Language requirements

- Based on the semiformal models for the control flow
- Abstracting the dataflow from the executable models

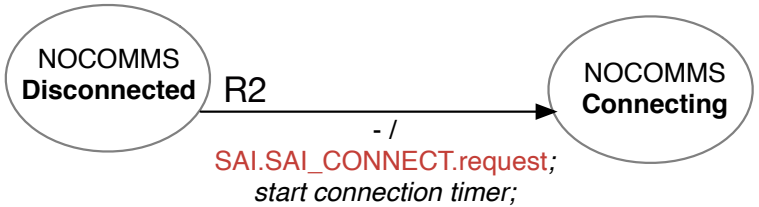


R2: When in *Disconnected* state, the inititor *CSL*
immediately sends a *SAI_CONNECT.request* to the *SAI* component,
starts a connTimer with the specified timeout,
and moves to the *Connecting* state.

4SECURail: more on formal modellling (1/4)

UMC used for the initial formal executable / verifiable system design

UMC is simple, direct textual notation for SysML / UML specification

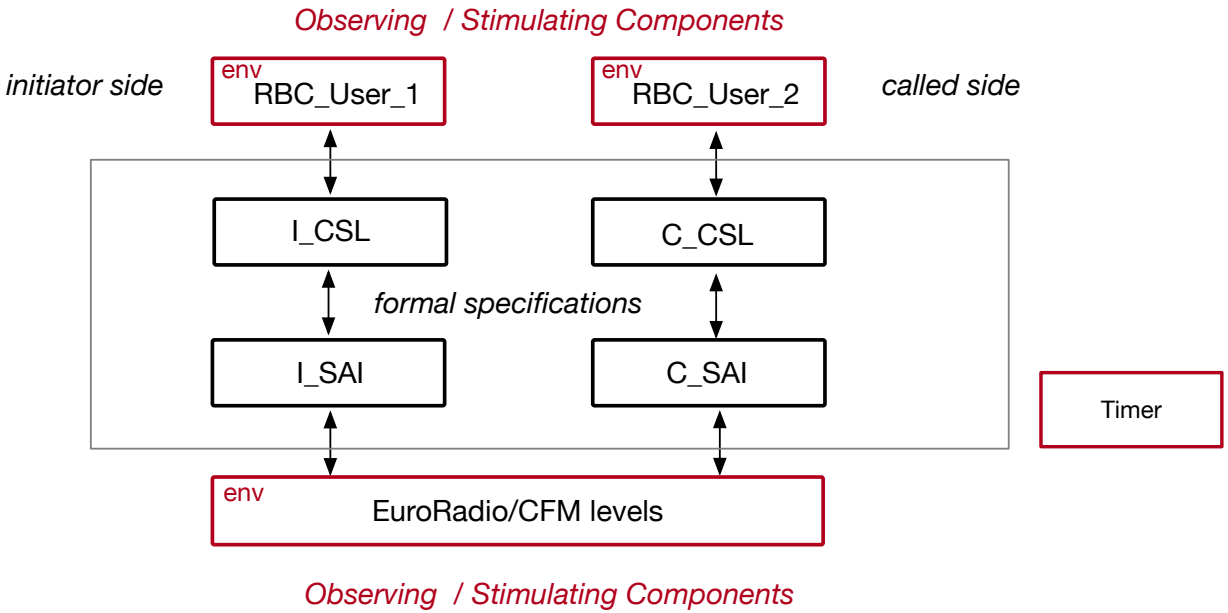



```
NOCOMMSdisconnected -> NOCOMMSconnecting
    { - / SAI.ISAI_CONNECT_request;
      connectTimer := 0; }
```

- Used an **extremely** limited UML subset,
  - with a very clear semantics
  - easy to translate into other formal notations

4SECURail: more on formal modellling (2/4)

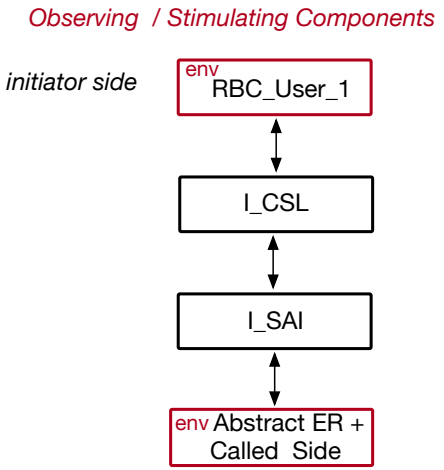
Specified CSL and SAI components to be complemented by necessary environment components



- Environment components still modelled as state machines

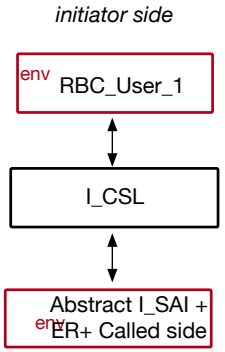
4SECURail: more on formal modellling (3/4)

Property-driven constructions of analysis scenarios (varying the environment)



All messages sent by the RBC are forwarded to the ER

connection_timeout = ..
send_timeout = ...
receive_timeout =..
...
...
...



The initiator CSL, when connected, continuously sends RBC messages or Lifesign messages

4SECURail: more on formal modellling (4/4)

Formal frameworks

- Not just UMC (academic research / teaching oriented tool)
  But also ProB and LNT + CADP (mature, industry ready)

- ProB / LNT models mechanically generated from UML / UMC

- Achieving formal methods diversity
  (robustness of the modelling)

- More complete static analysis,
  different verification techniques expoitable

4SECURail: results

Demonstrator results:

Artefacts: Better documentation for the developers
Semiformal designs, formal designs, natural language requirements
(more clear and rigorous than the initial ones)

Feedback: Detection of dangerous ambiguities in the initial requirements
(especially in the form of missing requirements and
hidden assumptions on the environment components)

4SECURail: Cost / Benefit analysis

Detailed, financial, economic Cost / Benefit analysis still in progress

Observed demonstrator Costs: licenses, training, effort

Observed demonstrator Benefits:

higher quality specs:

- easier to implement
- less prone to raise interoperability problems

4SECURail: references

- 4SECURail website: https://4securail.eu
- Final event (free registration!): https://www.4securail.eu/news-and-events.html

- D2.1 Rationale for demonstrator structure
- D2.3 Initial case study requirements definition
- D2.5 The Formal Methods demonstrator experiment

- D2.4 Preliminary CBA structure
- D2.6 Final CBA (due end of November 2021)

10.5281/zenodo.5541217 revised case study requirements
10.5281/zenodo.5541307 formal models and scenarios
10.5281/zenodo.5541350 model transformation tools

4SECURail

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Topic: S2R-OC-IP2-01-2019 - Demonstrator development for the use of Formal Methods in railway environment and Support to implementation of CSIRT to the railway sector

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