Towards Fixing Sketchy UML Models by Leveraging Textual Notations

Application to Real-Time Embedded Systems

Frédéric Jouault

frederic.jouault@eseo.fr

Jérôme Delatour

Jerome.delatour@eseo.fr

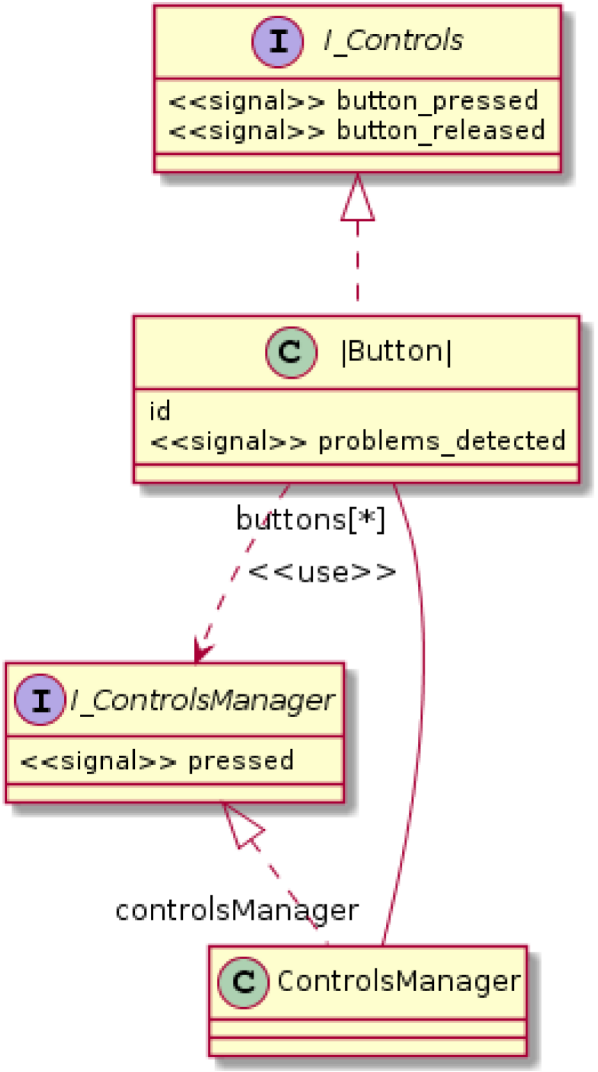
Overall Objective & Problems

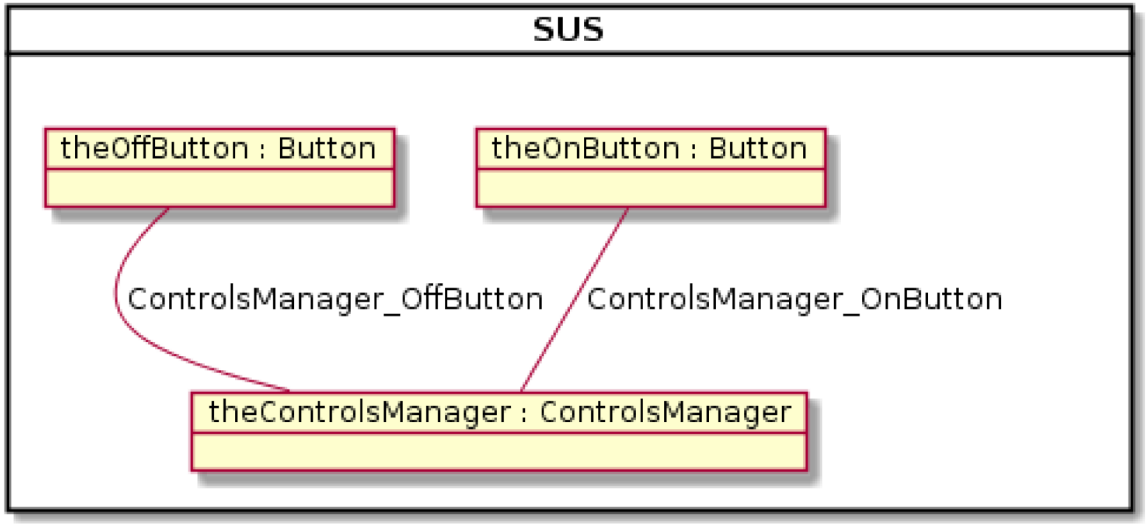
- Our main objective
  - From models created using UML (or SysML) tools such as Papyrus, Rhapsody, etc.
  - Generate verifiable Fiacre specifications
    - Fiacre is a french acronym for “Intermediate Format for the Embedded Distributed Component Architectures”
    - Notably for exhaustive model exploration using tools such as OBP explorer (see: http://www.obpcdl.org/doku.php)
- Notable problems
  - Preciseness & completeness of UML models necessary for formal models generation
  - Semantic mismatches between UML & Fiacre
  - Variability in UML metamodel(s): abstract syntax, concrete syntax, but most importantly semantics

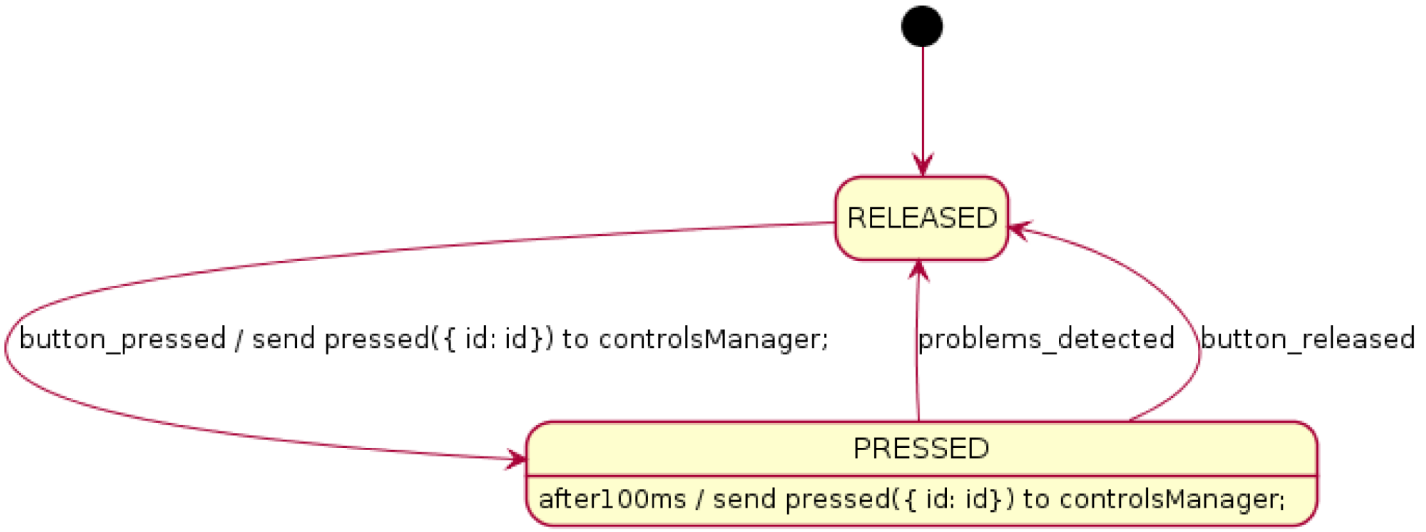
UML Subset

- We model at **general design** level
  - Active objects
    - instances of active classes with state machines
  - Communication via asynchronous signals
    - Interconnections between active objects modeled as composite structure
- Only three diagrams, typical of embedded systems modeling
  - Class
  - Composite structure
  - State
- **Precise** and **unambiguous** semantics

UML Subset Example

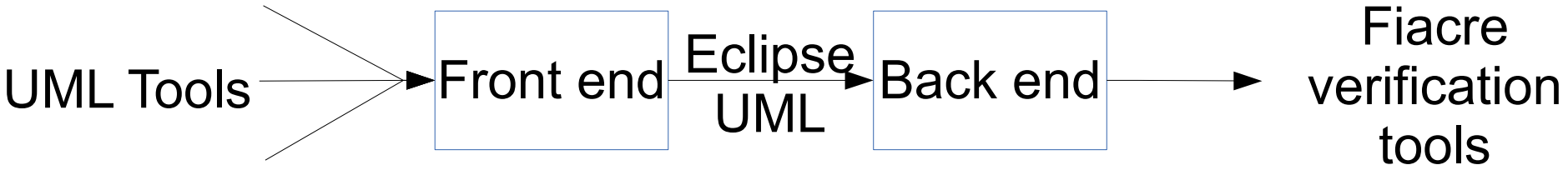






Approach Overview

- Architecture:
  - Front end: handles UML tools variability
  - Back end: handles Fiacre model generation
  - Eclipse UML 2.4 metamodel used as reference & pivot abstract syntax
    - *Native* tools such as Papyrus can be directly supported



Approach (front end)

- Adapt alternative tools (such as Rhapsody) using transformations
  - Takes care of abstract & concrete syntax variability at relatively low cost
- Evaluate model preciseness & completeness
  - Using extended UML model validation (i.e., more OCL constraints)
  - Rendering UML models in several ways for review by experts
- Model semantic variability
  - Within UML standard
  - Across UML tools (including non-conforming tools, which are unfortunately numerous)

Introducing tUML

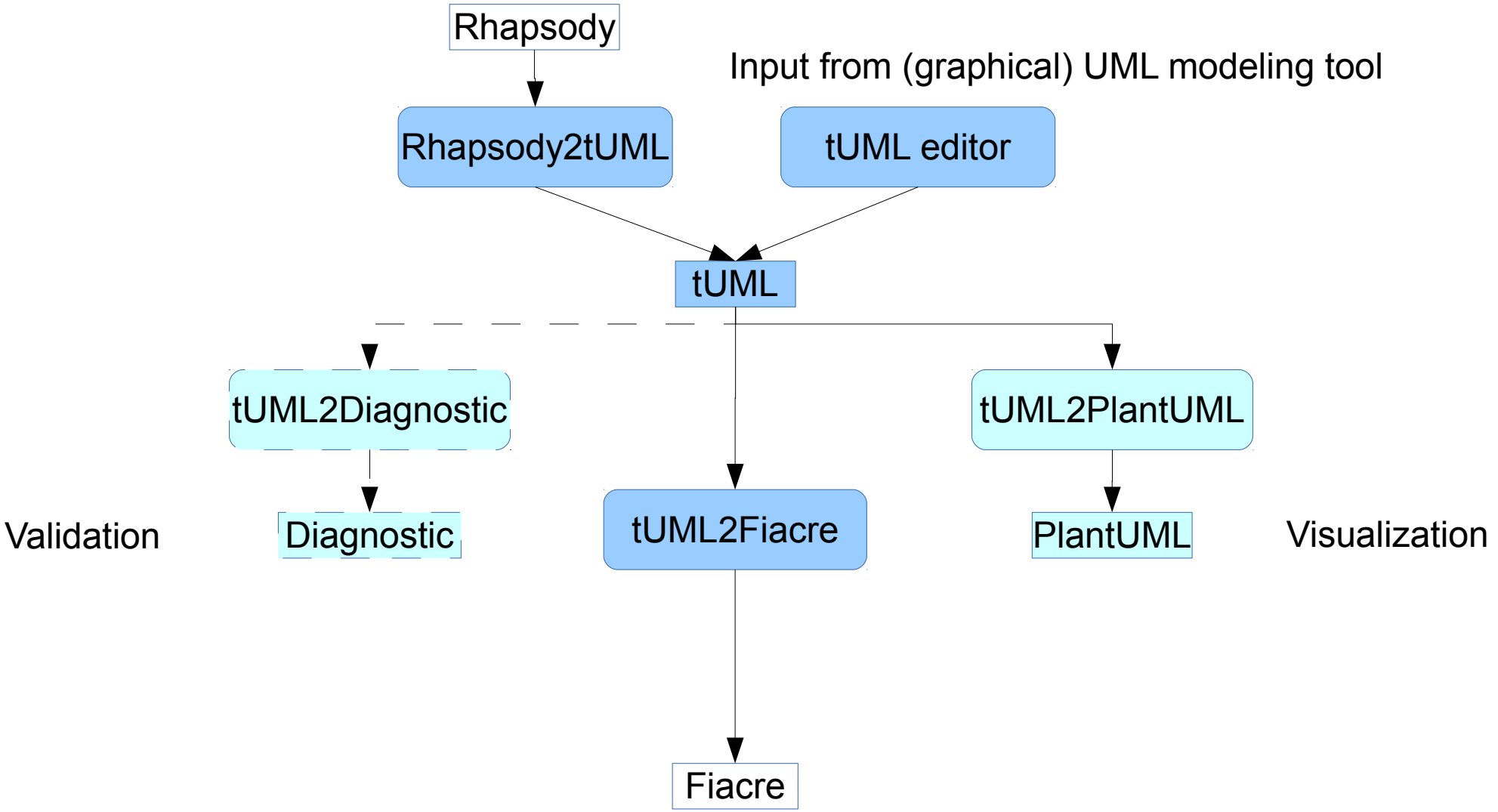
- Problems with graphical UML tools
  - No global model view
  - Hidden “details” (accessible as “properties” via several clicks)
- Approach: a textual syntax for this UML subset
  - A single homogeneous rendering of the complete model
  - Visible “details”
  - Close to UML metamodel
  - Reduced redundancy
  - Full-text search and replace
- tUML is just another view on the model, not intended to replace diagrams

tUML
or {tvtUML} ?
(**t**extual, **v**erifiable by **t**ranslation)

tUML Example

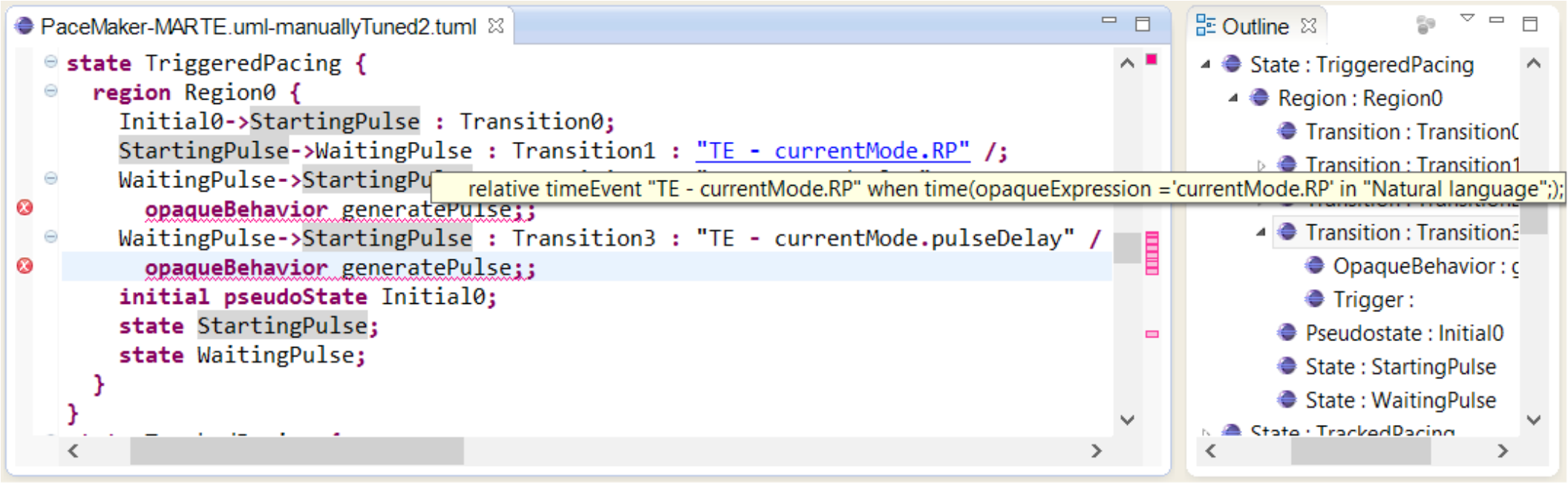
```
class |Button| behavesAs SM implements I_Controls
    receives
        problems_detected_R(problems_detected) {
    private controlsManager[1-1] : ControlsManager in ControlsManager_Button;
    private id[1-1] : Integer;

    stateMachine SM {
        region MainRegion {
            Initial -> RELEASED;
            RELEASED -> PRESSED : button_pressed_SE /
                opaqueBehavior = 'send pressed(id) to controlsManager;' in ABCD;;
            PRESSED -> PRESSED : after100ms /
                opaqueBehavior = 'send pressed(id) to controlsManager;' in ABCD;;
            PRESSED -> RELEASED : problems_detected_SE /;
            PRESSED -> RELEASED : button_released_SE /;
            initial pseudoState Initial;
        }
    }
}
```

tUML Transformations

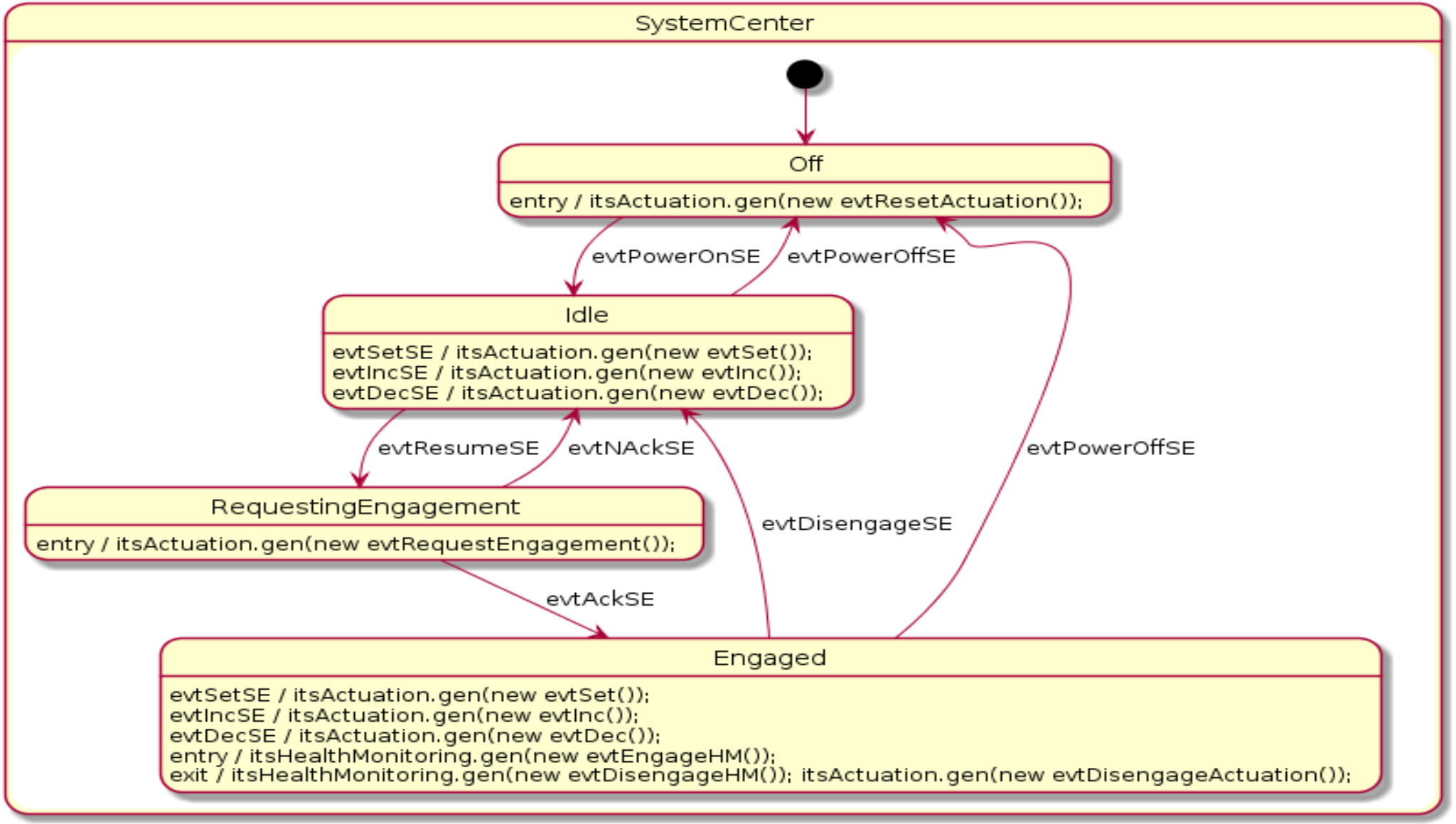


tUML Editor

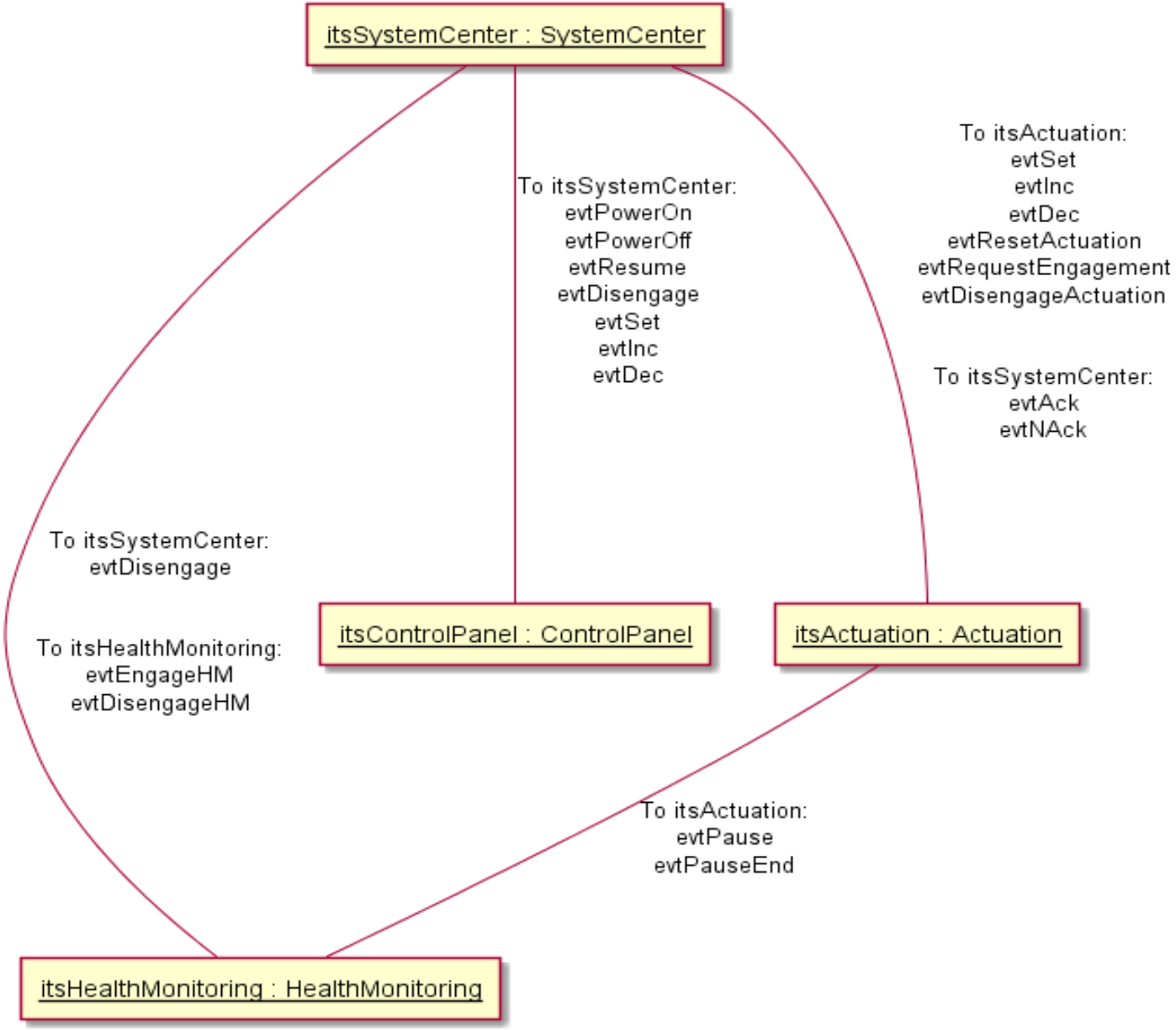
- Defined with TCS (xText-like)



Visualization Example: Cruise Control System



Visualization Example: Context Diagram



Profiles/Stereotypes Example

```
model ProfilesTest {
    <<pathmap://SysML_PROFILES/SysML.profile.uml#
        //Blocks/Block>>
    class A {}
    <<pathmap://Papyrus_PROFILES/MARTE.profile.uml#
        //MARTE_DesignModel/HLAM/RtUnit(
            isDynamic=false,
            srPoolSize=5,
            operationalMode=m,main=o)>>
    class B extends A implements I {
        operation o();
    }
    interface I {}
    <<pathmap://Papyrus_PROFILES/MARTE.profile.uml#
        //MARTE_DesignModel/HLAM/RtUnit(
            isDynamic=false,
            srPoolSize=5,
            main=B::o)>>
    <<pathmap://SysML_PROFILES/SysML.profile.uml#
        //Blocks/Block>>
    class C extends B {}
    class D {}
    activity m {}
}
```

Possible tUML Extensions

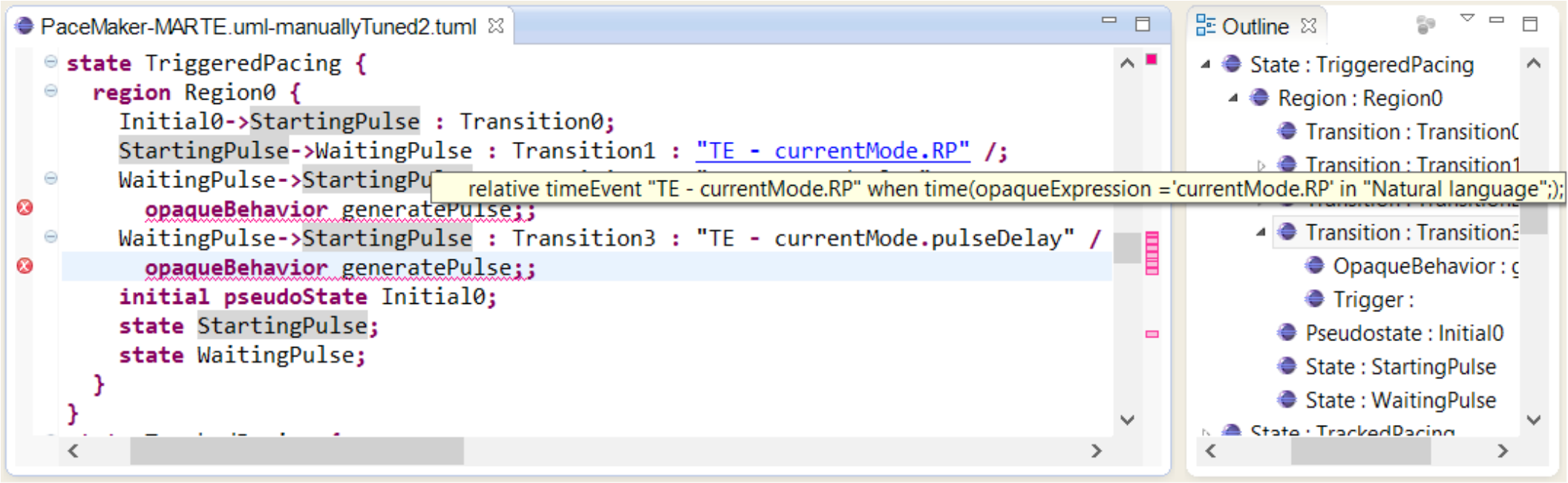
- Extend supported UML subset
  - Improved State Machines support: composite states
  - Activities
  - Improved communications: operations (asynchronous calls, synchronous calls), ports (lightweight)
  - Non-opaque guards & effects → Activity and Actions subset (fUML, Alf, etc.)
  - Alternative semantics for UML variation points
- But we must make sure we can verify models using these additional features.

Conclusion

- In a UML model verification context
- For critical embedded systems
- Leveraging a specific textual syntax
- Applied to a PaceMaker Case Study
  - Originally as a contemplative model (i.e., nice pictures)
  - That we tried to verify
  - That we tried to “fix” using graphical editors
  - For which tUML simplifies the fixing work

Identifying Issues in tUML Editor

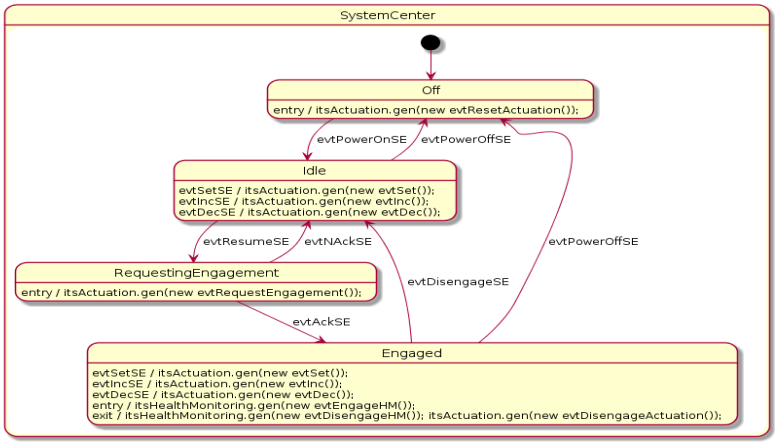
- Problem markers

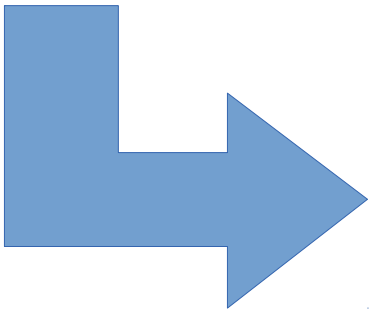


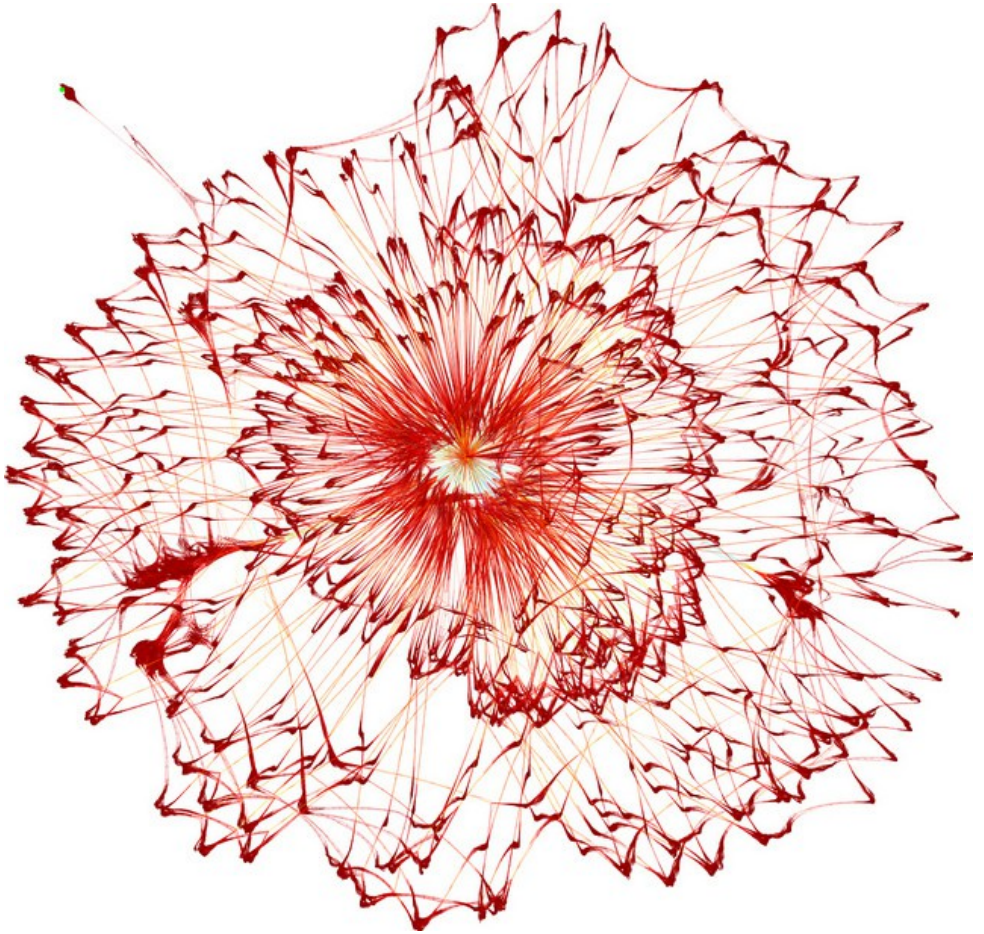
Possible Extensions of this Work

- Systematic study of problems that can be fixed more easily by using tUML
- Partial textual view instead of whole-model view
- Abstract-Concrete syntaxes synchronization
- Comparing to other ways to address the problem of graphical UML editors, e.g.:
  - Leveraging the new Papyrus customization features (hiding elements in the palette, selecting which property show up in property views, etc.)

Thanks for listening!







Non contractual pictures.