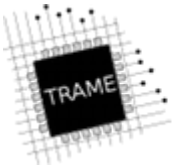
Automatic UML transfo. 4 Context-aware Verification



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Outline

- Context
  - UML
  - Context-based verification & OBP
- Transformation Overview
- UML Subset
- tUML
- ABCD
- Conclusion & Perspectives

Context

- Complex systems with many interacting components
- Verification by Exhaustive Reachability Analysis
  - Automatic
  - Safety and Liveness
  - Counter-example

UML

- A modeling language
  - Graphical, with more than a dozen diagrams
  - Able to model structural and behavioral aspects
  - Semi-formal
- Usable for
  - Requirements
  - Specification
  - Design
- Facilitates dialogue between experts
- Extensible via profiles, notably:
  - MARTE for real-time & embedded systems
  - SysML for systems engineering

Context-aware Verification

- Explicit environment modeling (**contexts**)
  - Operating modes
  - External actors
  - Environmental conditions
- **Requirements** associated to **contexts**

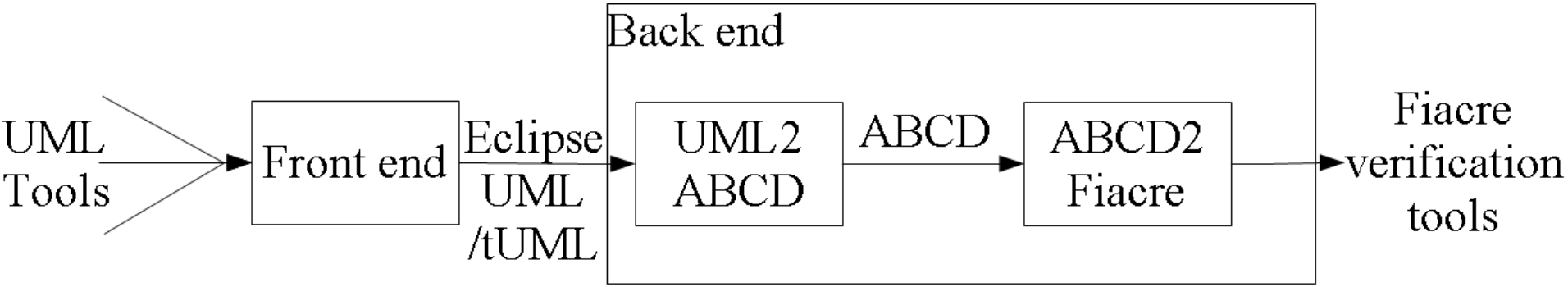
www.obpcdl.org

System-under-study || Context

in Fiacre in CDL

Transformation Overview

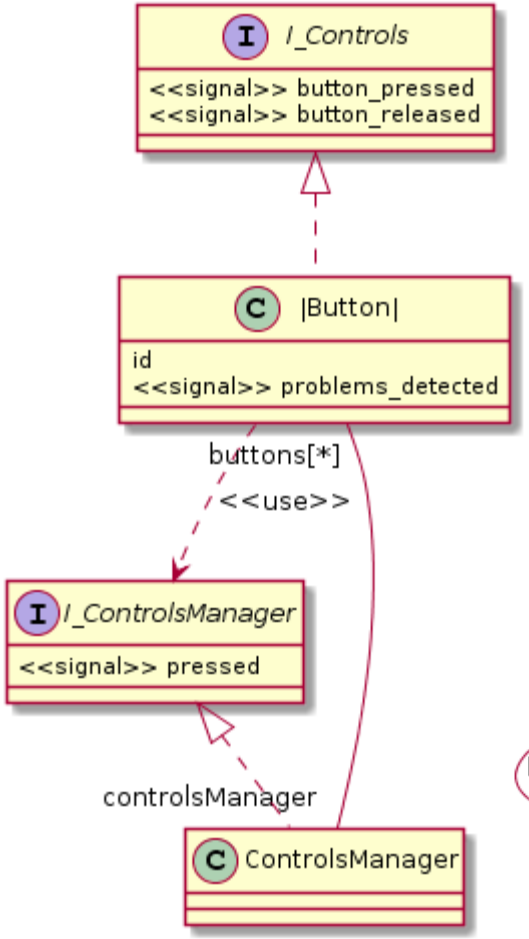
- Model in UML, convert to Fiacre, verify
  - Front end: handles UML tools variability
  - Back end: handles Fiacre model generation
  - Eclipse UML 2.4 metamodel used as reference & pivot abstract syntax

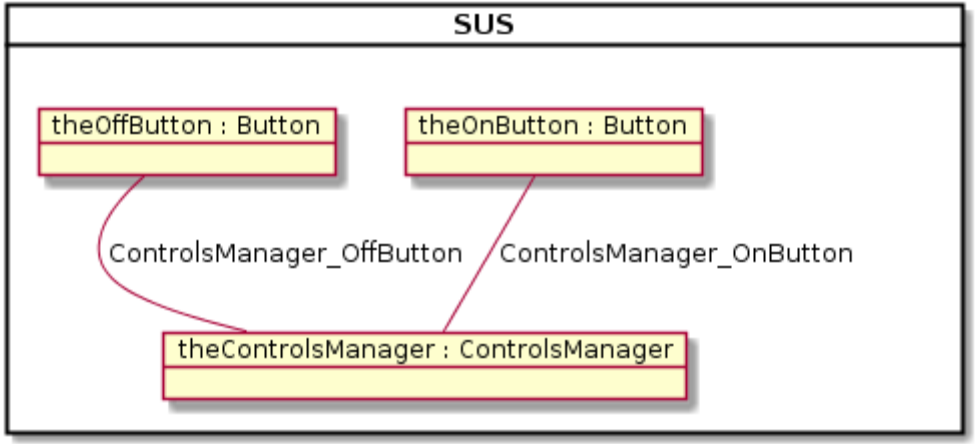


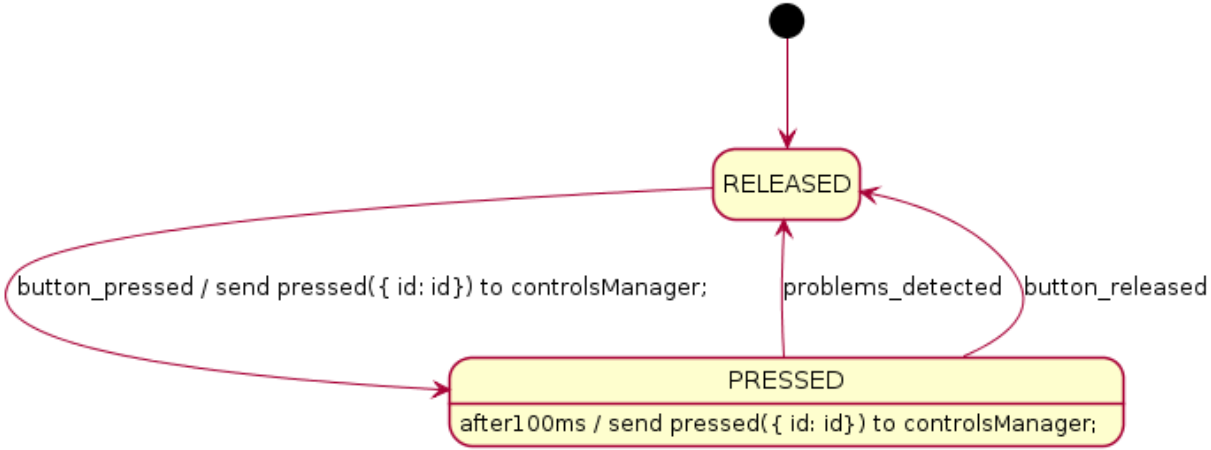
UML Subset

- Only three diagrams, typical of embedded systems modeling
  - Class
  - Composite structure
  - State
- **Precise** and **unambiguous** semantics
- We model at **general design** level
  - Active objects
  - Communication via asynchronous signals

UML Subset Example







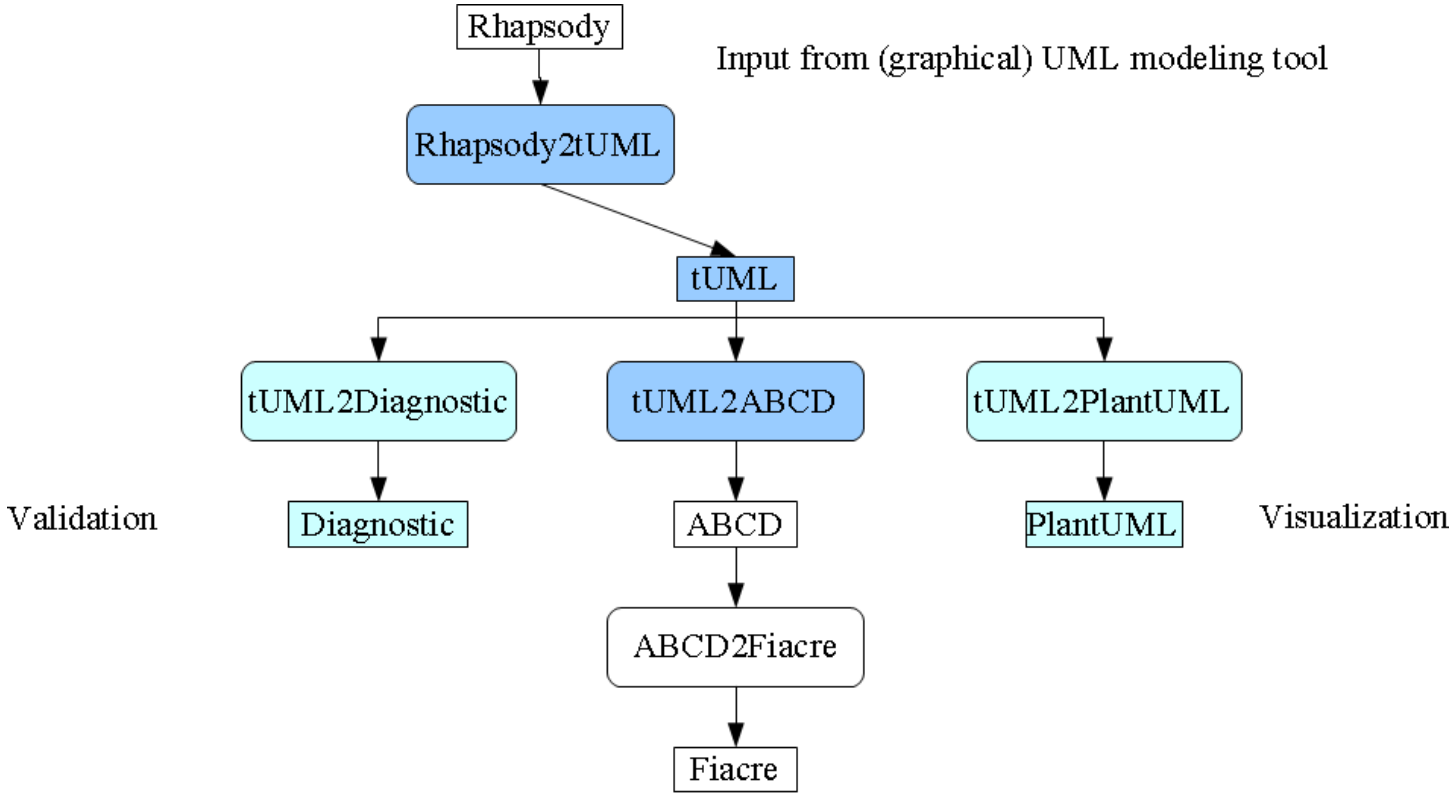
tUML

- Problem 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

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 Tools


Rhapsody
Input from (graphical) UML modeling tool
Rhapsody2tUML
tUML
tUML2Diagnostic
tUML2ABCD
tUML2PlantUML
Validation
Diagnostic
ABCD
PlantUML
Visualization
ABCD2Fiacre
Fiacre

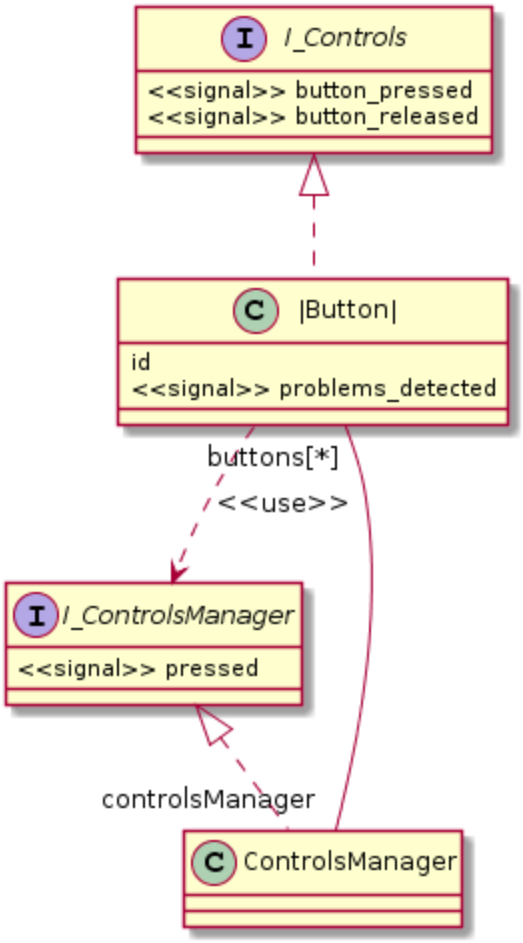
ABCD

- Intermediate format
- Halfway between UML & Fiacre
  - Reuses Fiacre syntax, but notably adds UML-like event-pool

- **A**rchitecture
- **B**ehaviors
- **C**ommunications
- **D**ata

ABCD Example

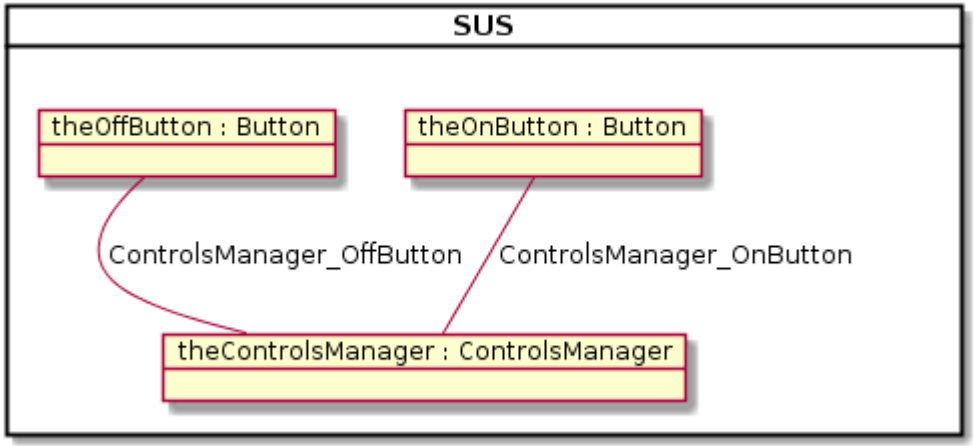
Class Diagram




```
type ButtonEvents is union
        problems_detected   //localy defined event
|       button_pressed
|       button_released
end union

type ControlsManagerEvents is union
        pressed of int
end union

channeltype ToControlsManager is eventpool buffersize: 2 of ControlsManagerEvents
channeltype ToButton is eventpool buffersize: 2 of ButtonEvents
```

ABCD Example

Composite Structure Diagram

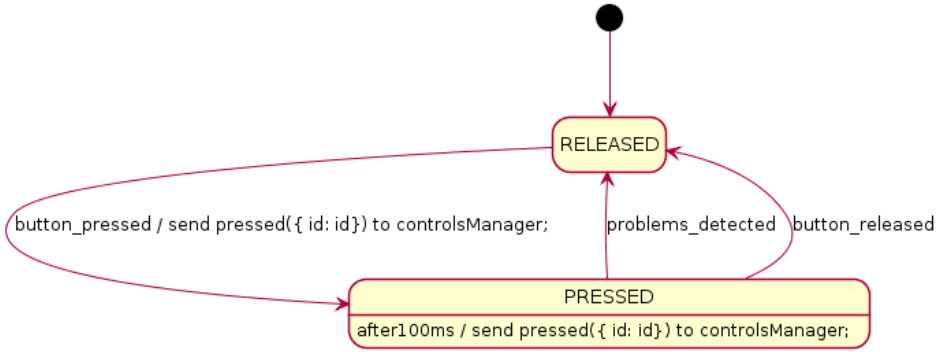



```
channel itsOnButton : ToButton
channel itsOffButton : ToButton
channel itsControlsManager : ToControlsManager
par
        [itsOnButton]          theOnButton:Button(1)        [itsControlsManager]
||      [itsOffButton]         theOffButton:Button(2)       [itsControlsManager]
||      [itsControlsManager]   theControlsManager:ControlsManager
end par
```

ABCD Example

State Diagram

```
process Button
        port
                myEventPool : in ButtonEvents;
                itsControlsManager : out ControlsManagerEvents;
        param
                id : int
is
init to RELEASED
from RELEASED
        receive ButtonEvents:button_pressed from myEventPool;
        send ControlsManagerEvents:pressed(id) to itsControlsManager;
        to PRESSED
from PRESSED
        select
                wait[100,100];
                send ControlsManagerEvents:pressed(id) to itsControlsManager;
                to PRESSED
        []      receive ButtonEvents:problems_detected from myEventPool;
                to RELEASED
        []      receive ButtonEvents:button_released from myEventPool;
                to RELEASED
        end select
```



ABCD vs. Fiacre

```
from UnsetSetting
  defer = {evtRequestEngagement}
select
...
[] receive evtSpeedA(speed) from eP;
...
end select;
```

```
from UnsetSetting
select
...
[] case (not (empty myEventPool)) of
   true ->
      myEventPool :=
            preprocessDeferred_ToActuation(
                  myEventPool, [true, false, false, ...]);
      case (first myEventPool) of
            evtSpeedA (speed) ->
            myEventPool := (dequeue myEventPool)
            end case
   end case;
 ...
end select;
```

preprocessDeferred_ToActuation

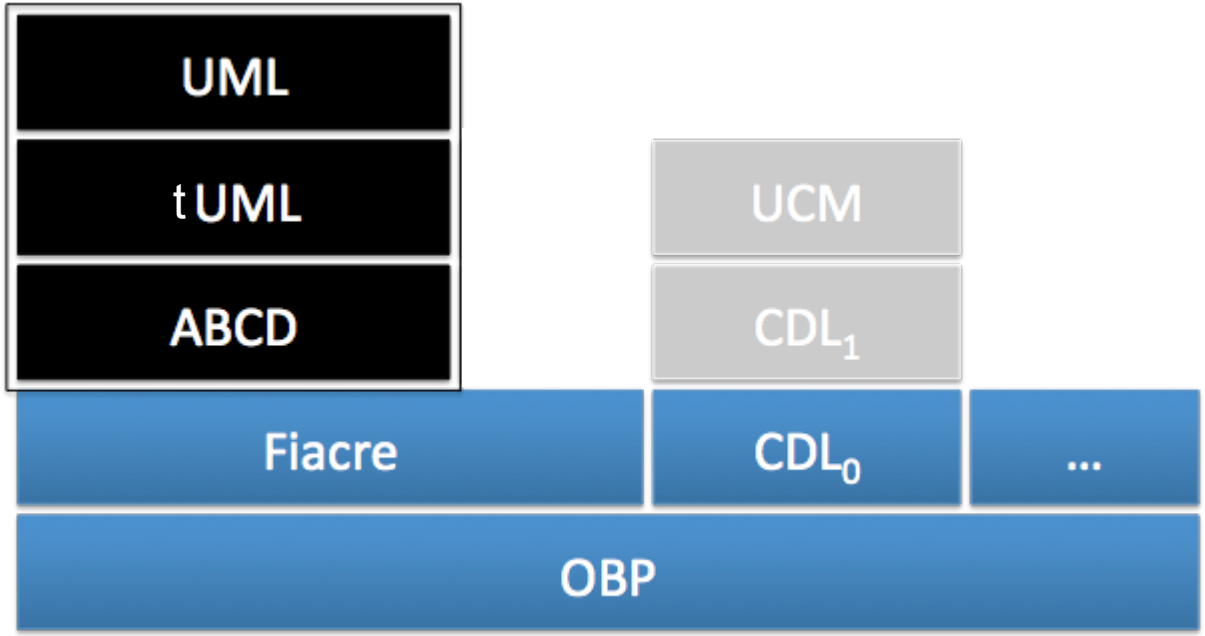
```
function preprocessDeferred_ToActuation
(eventPool: ToActuation, deferMask:
deferMask_ToActuation) : ToActuation is
var
deferred: ToActuation := {| | },
result: ToActuation := {| |},
continue: bool := true
begin
while ((not (empty eventPool)) and continue) do
                case (first eventPool) of
                evtRequestEngagment -> if deferMask[1] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtChangeActuation -> if deferMask[1] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtResetActuation -> if deferMask[2] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtPause -> if deferMask[3] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtPauseEnd -> if deferMask[4] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtSetA -> if deferMask[5] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtIncA -> if deferMask[6] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtDecA -> if deferMask[7] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                | evtSpeedA (any) -> if deferMask[8] then

                deferred := (enqueue(deferred, (first eventPool)))

                eventPool := (dequeue eventPool)
                                else

                continue := false
                                end if
                end case
                end while;
if (not (empty eventPool)) then
                result := (enqueue(result, (first eventPool)));
                eventPool := (dequeue eventPool)
end if;
while (not (empty deferred)) do
                result := (enqueue(result, (first deferred)));
                deferred := (dequeue deferred)
                end while;
while (not (empty eventPool)) do
                result := (enqueue(result, (first eventPool)));
                eventPool := (dequeue eventPool)
                end while;
return result
end
```

Conclusion

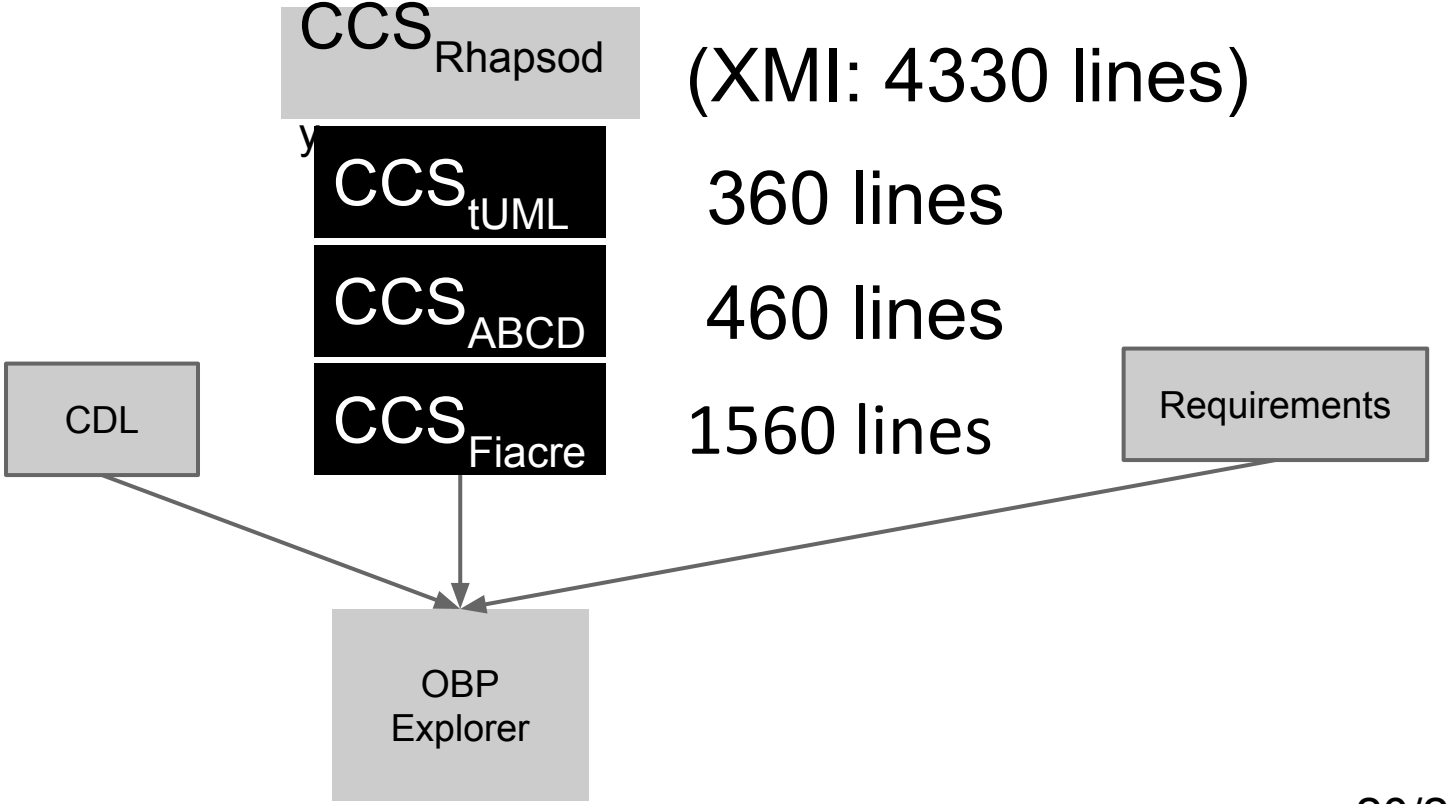
- Our tool
  - helps creating correct models
  - enables verification of UML models
    - By transformation to Fiacre
    - Supporting contexts by using OBP
  - can be extended to additional input formalisms
    - By targeting either UML/tUML or ABCD

Conclusion

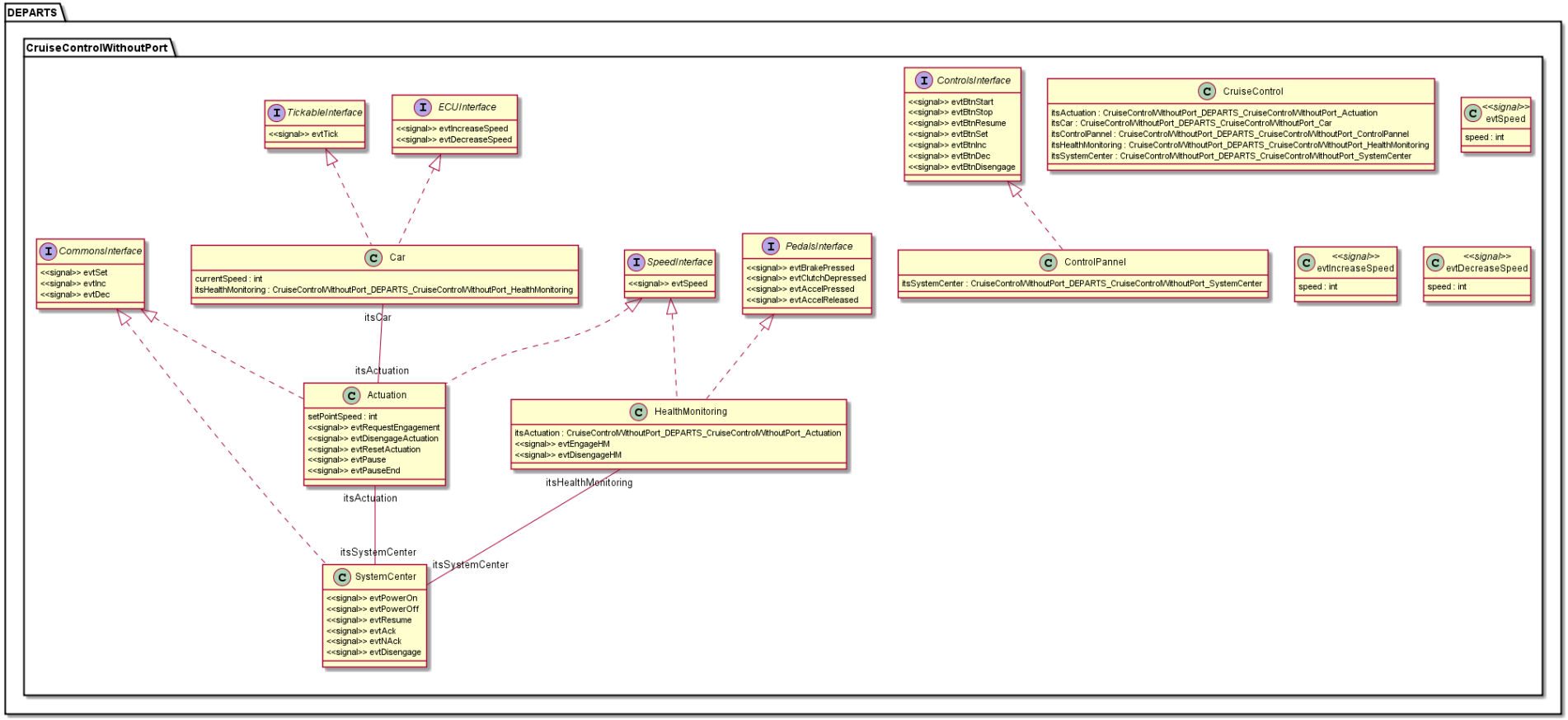
UML 2 Fiacre



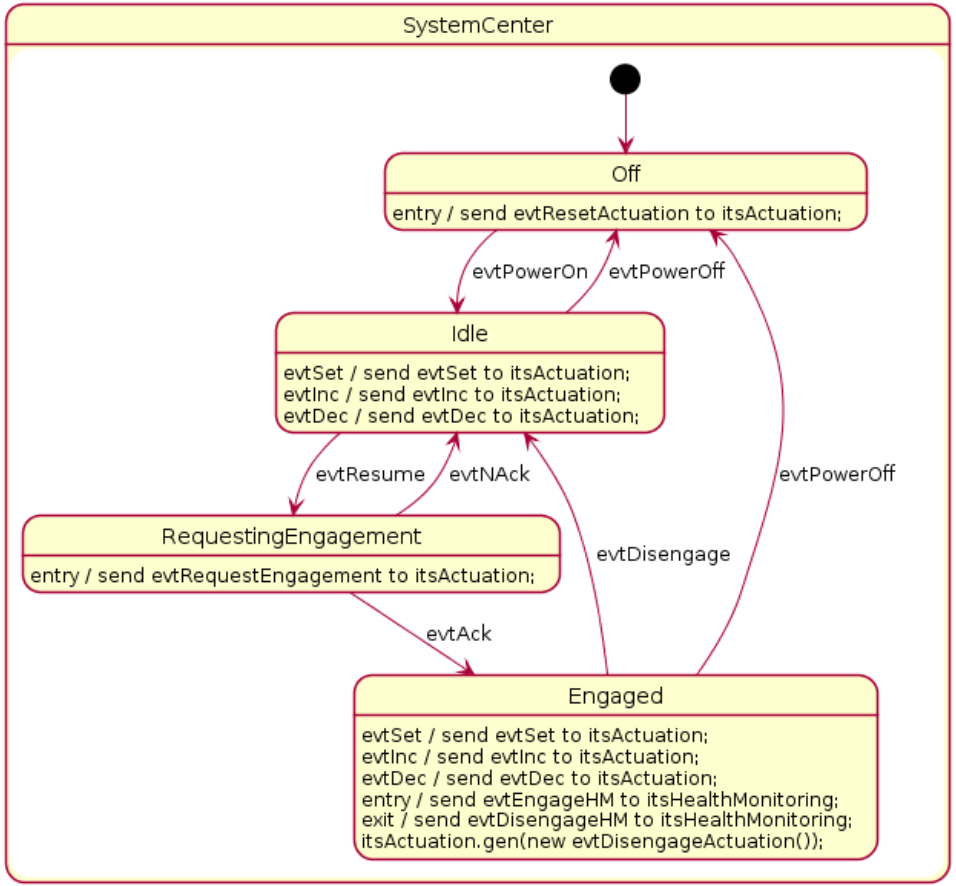
Application to
Cruise-Control System (CCS)



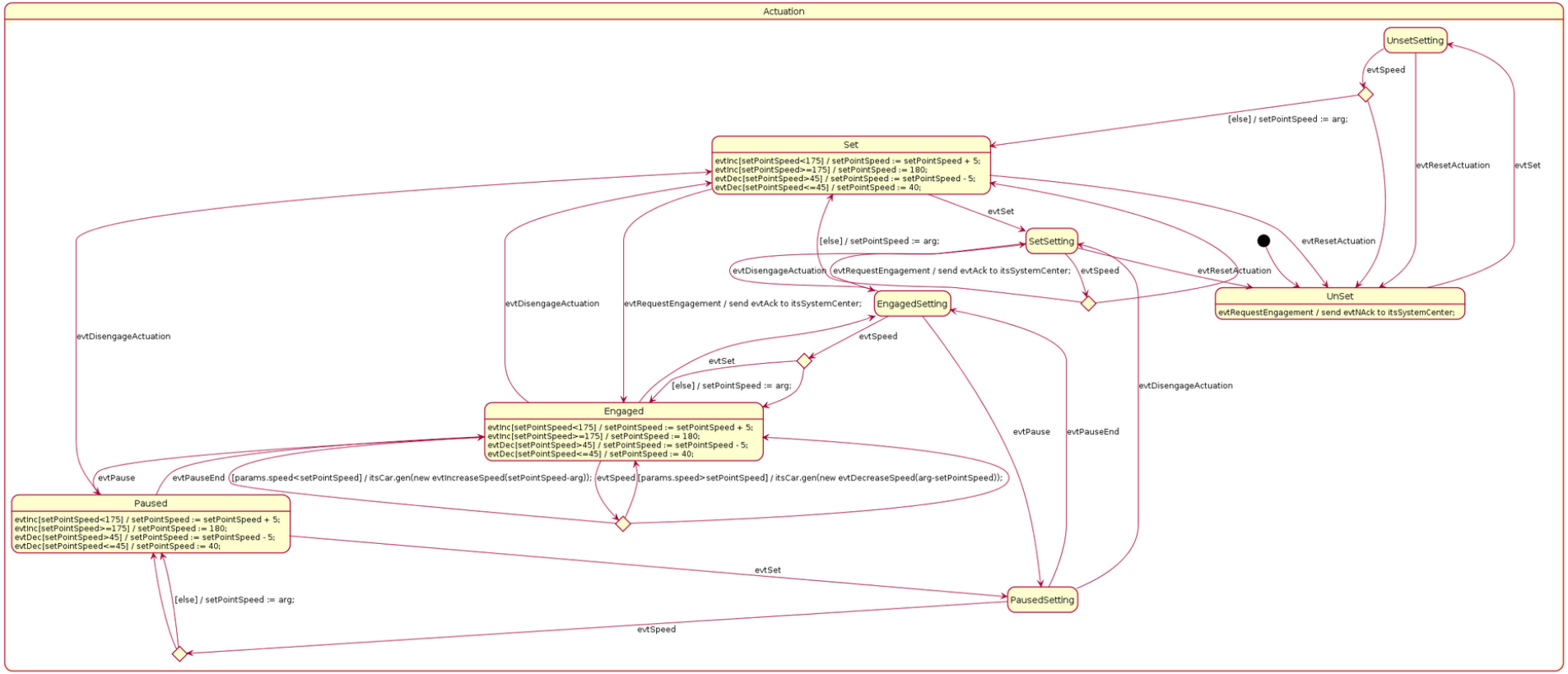
Application to CCS - Class Diagram

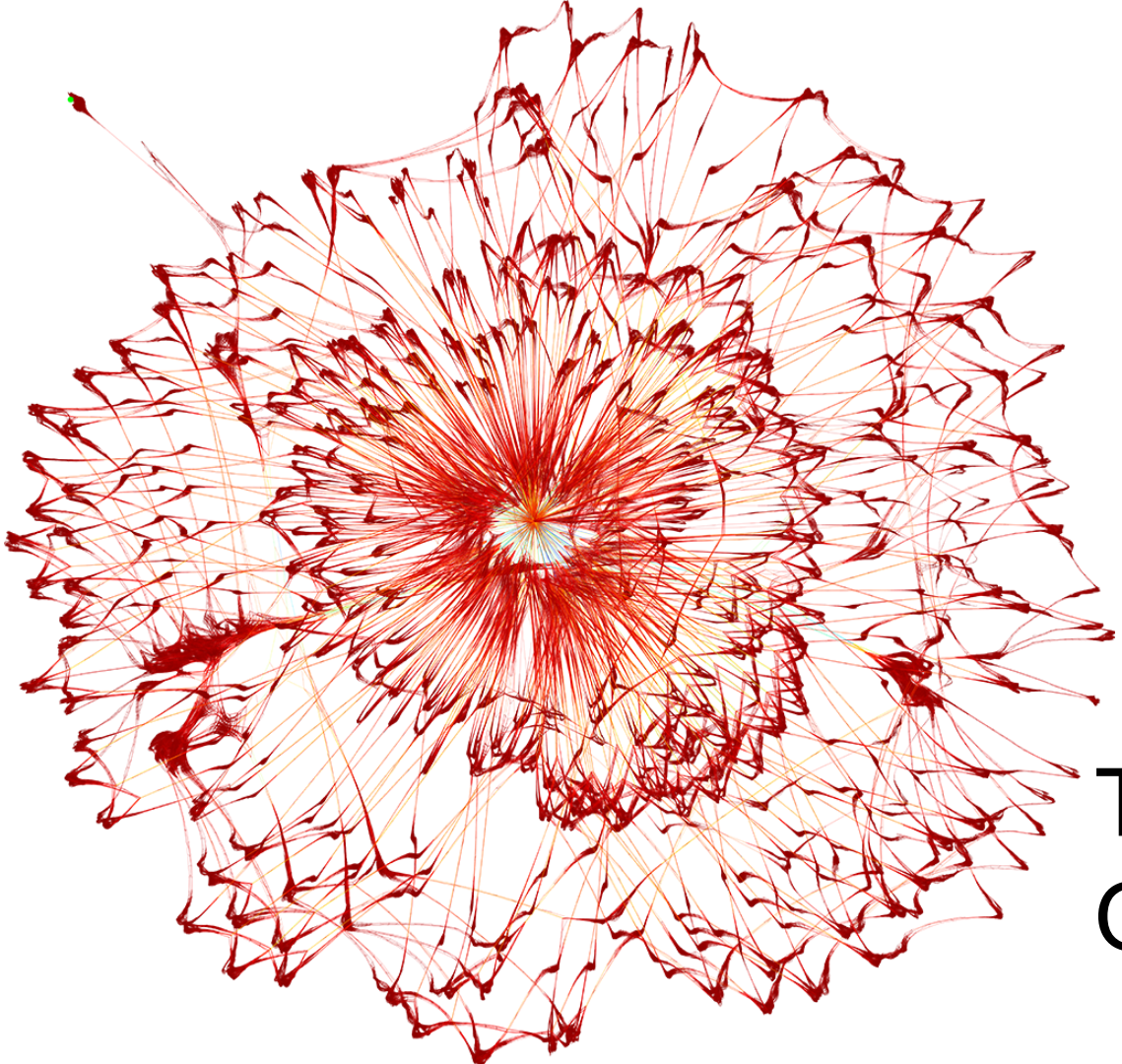


Application to CCS - State Diagram



Application to CCS - State Diagram





Thanks!
Questions?

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