OMEGA2

Profile & tools for system modelling and verification with UML 2.x & SysML

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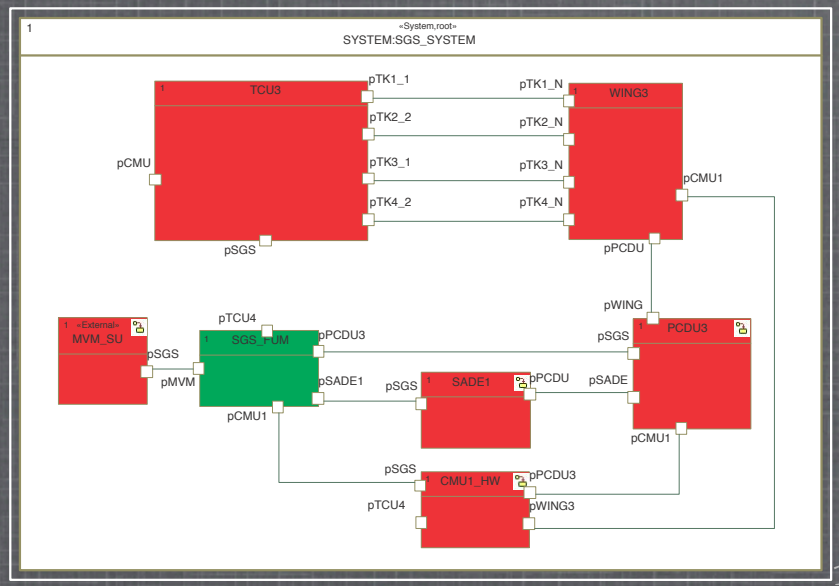
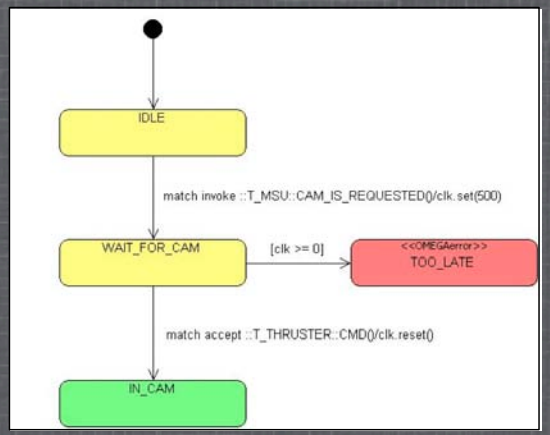
Tools developed in partnership with
Work supported by





Outline

- Overview of OMEGA v1 - profile and tools
- OMEGA v2 language extensions
  - composite structures
  - concurrency model
- Implementation in IFx2
- Conclusions

OMEGA v1 language

A large subset of UML 1.5 (1)

+

(More) model coherence constraints

+

A formal operational semantics (2)

+

RT & Verification extensions (3)

(1) Structure (object-oriented), behaviour (SM, actions)

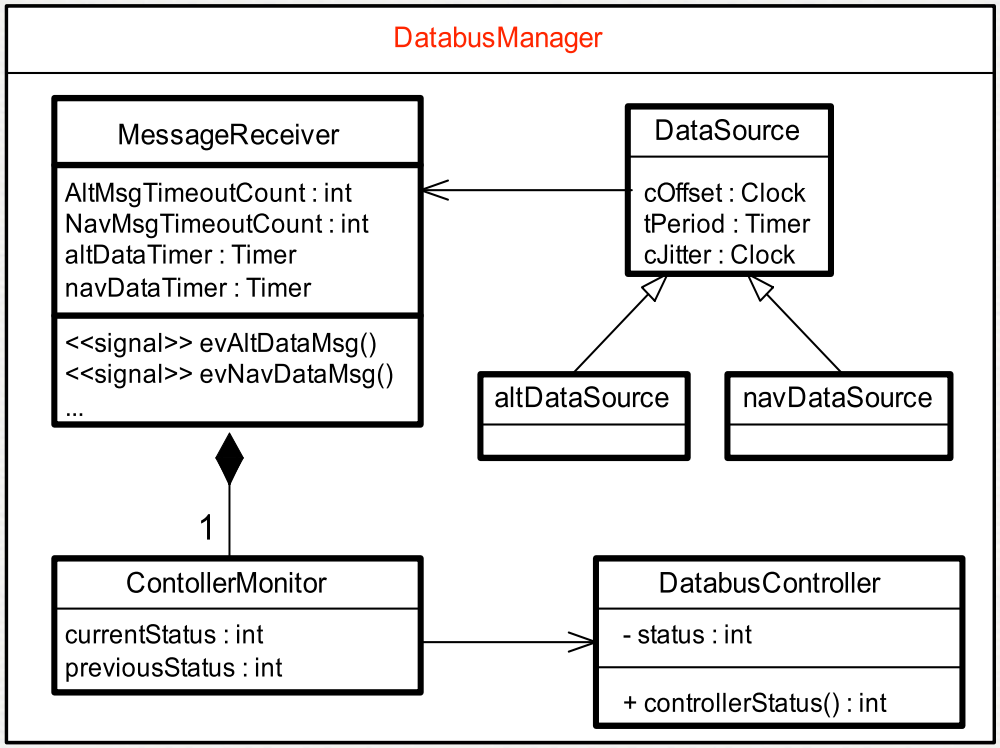
(2) Based on the Rhapsody tool semantics and defined in [Damm, Josko, Pnueli, Votintseva 2002 & Hooman, Zwaag 2003]

(3) Timing constraints, timed behaviour (semantic projection to timed automata), property observers

OMEGA v1 language

UML class diagrams

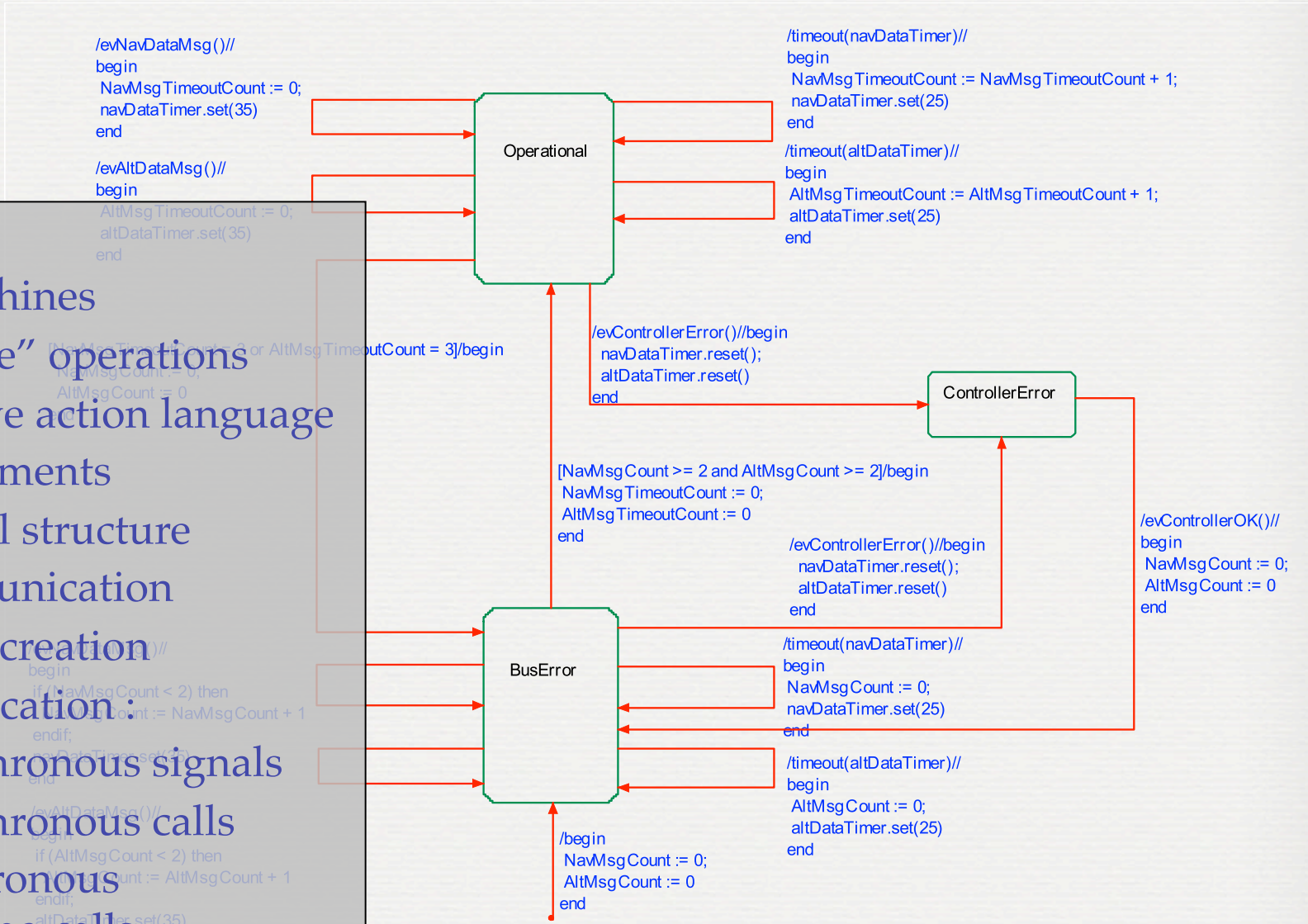
- active / passive classes
- associations
- composition
- generalization



OMEGA v1 language

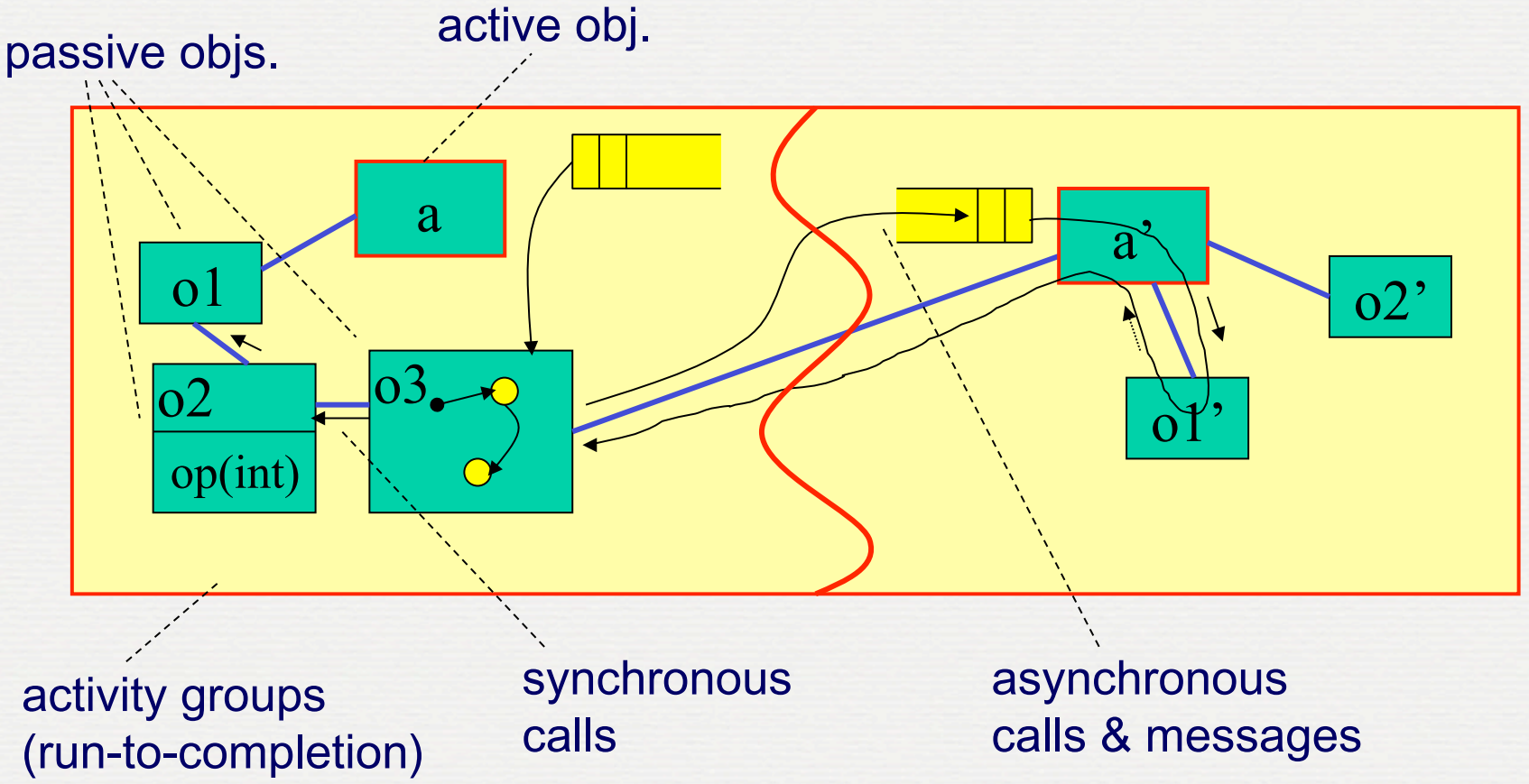
Behaviour

- state machines
- “primitive” operations
- imperative action language
  - assignments
  - control structure
  - communication
  - object creation
- communication :
  - asynchronous signals
  - asynchronous calls
  - synchronous blocking calls



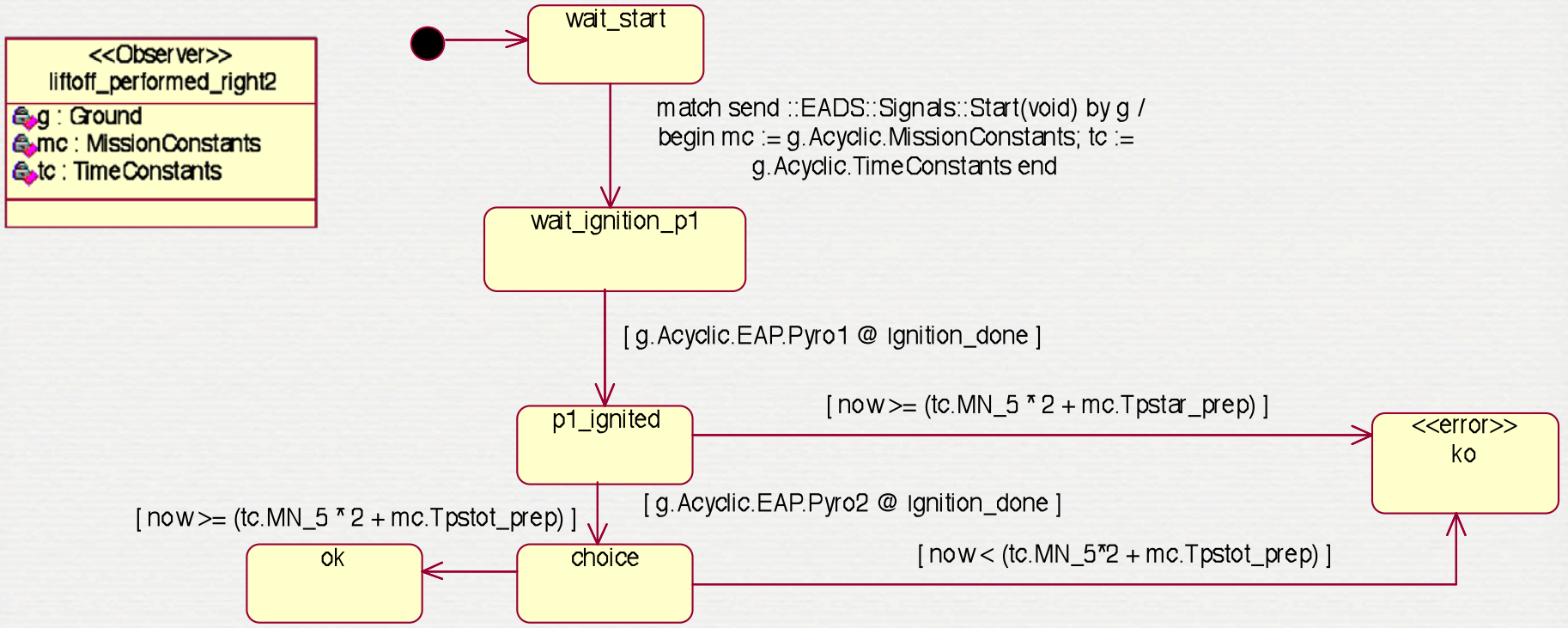
OMEGA v1 language

Composition & communication semantics



OMEGA v1 language

Observers: objects monitoring the system state & events and giving verdicts



IFx toolset

Principle: translation to a formal timed automata model

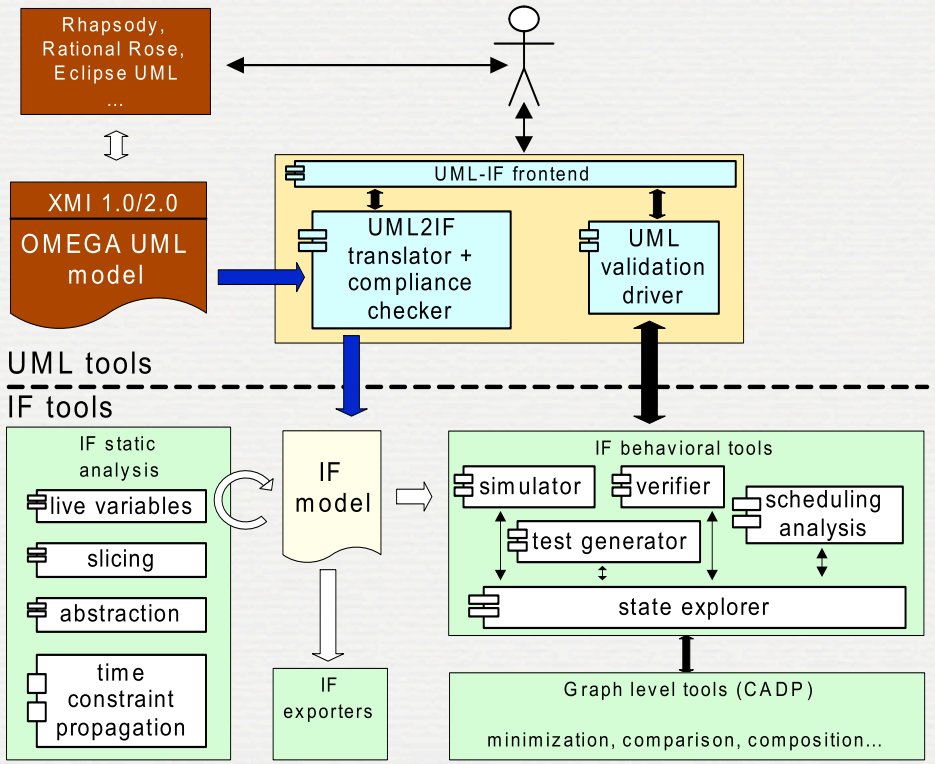
Functionality

simulation
interactive, random, replay/
analyze diagnostics…

verification
observers,μ-calculus,
state graph minimisation
(bisimulation),…

static analysis
dead variable/code elimination,
slicing,…

Architecture



Use of OMEGA

Case studies:

- EADS Astrium Space Transportation:
  Verification of functional & scheduling properties of the Ariane-5 flight software [FMOODS06]
- Nationaal Lucht- en Ruimtevaartlaboratorium (NLR):
  Timing verification of airborne data acquisition module [UML&FM08]
- ESA / EADS Astrium:
  Simulation and verification of ATV Solar Wing Management

Tool development partially financed by ESA

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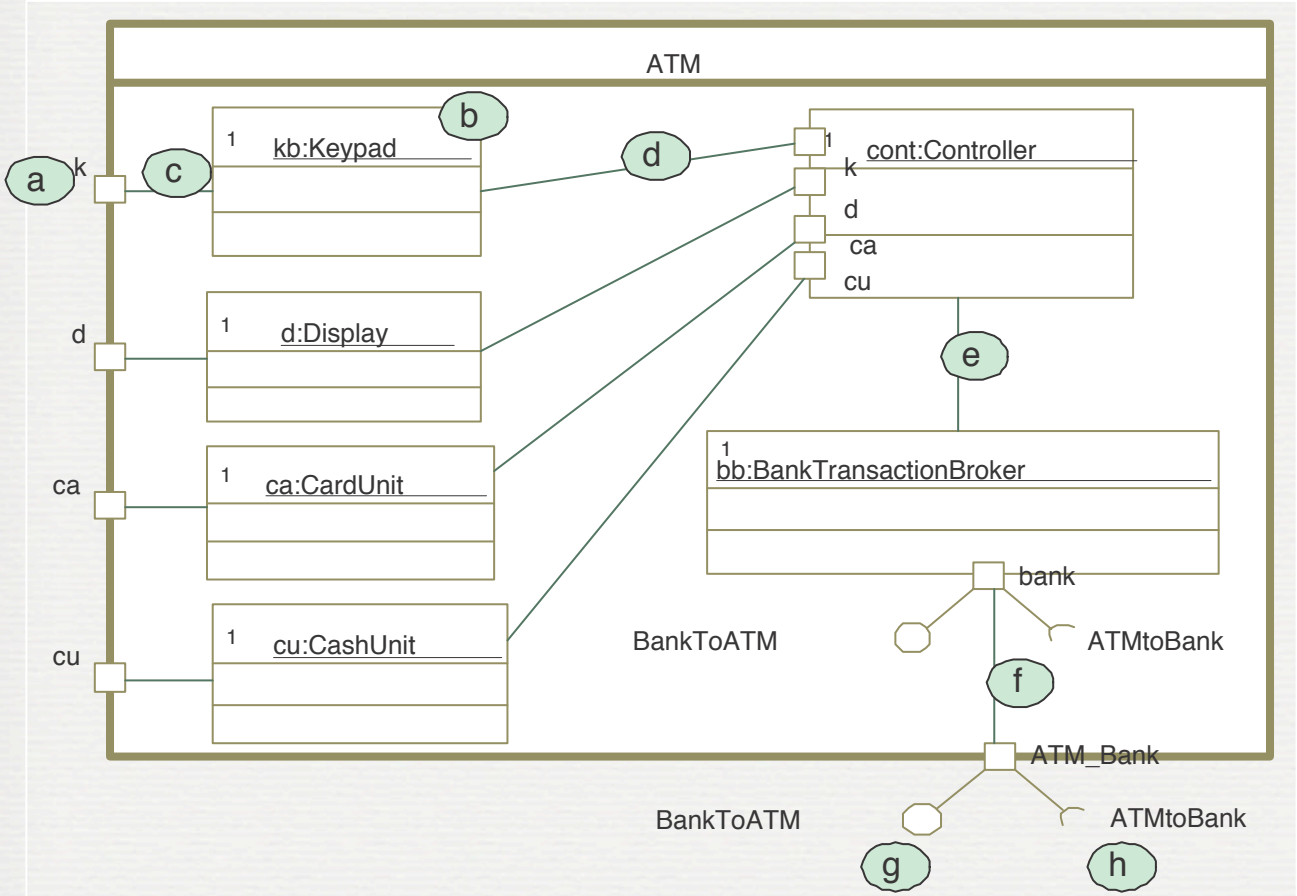
Motivation - missing features

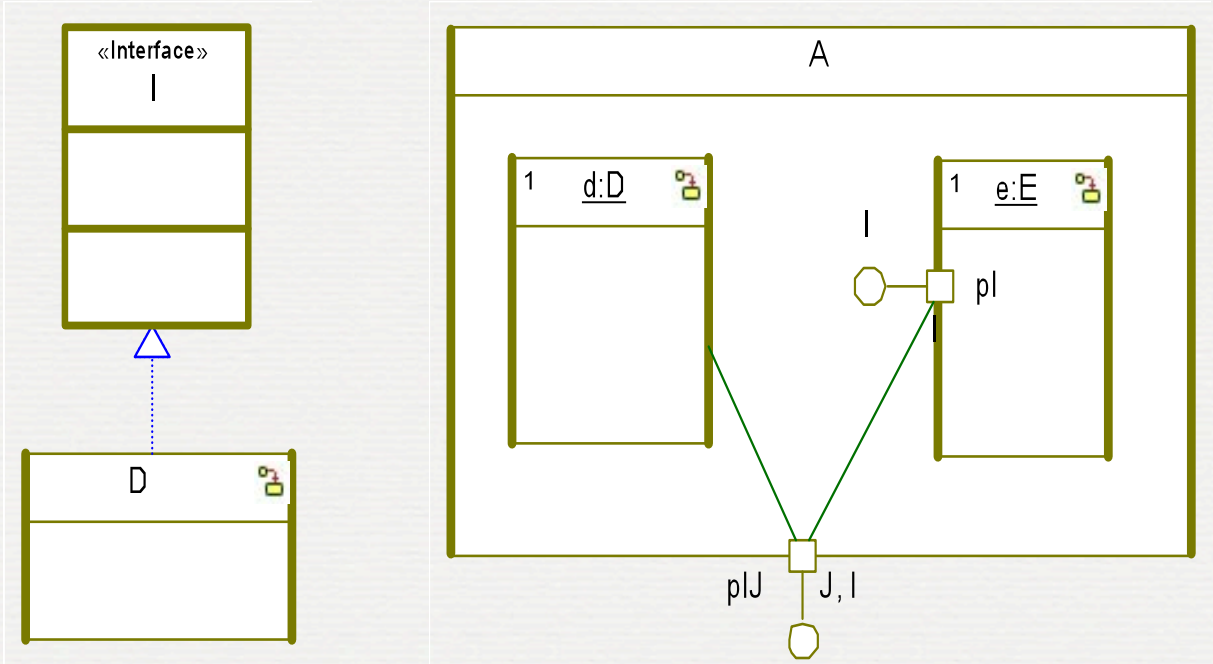
- **Language**
  - Structure: *hierarchical architecture modelling*
    - ⇒ UML 2.x composite structures
    - ⇒ SysML internal block diagrams
  - Concurrency model: *better synchronisation constructs*
  - Behaviour: parallel regions, other minor updates
- **Tool**
  - Compatibility with recent UML/SysML editors (Rhapsody 7.x) -- support for XMI 2.x

UML composite structures

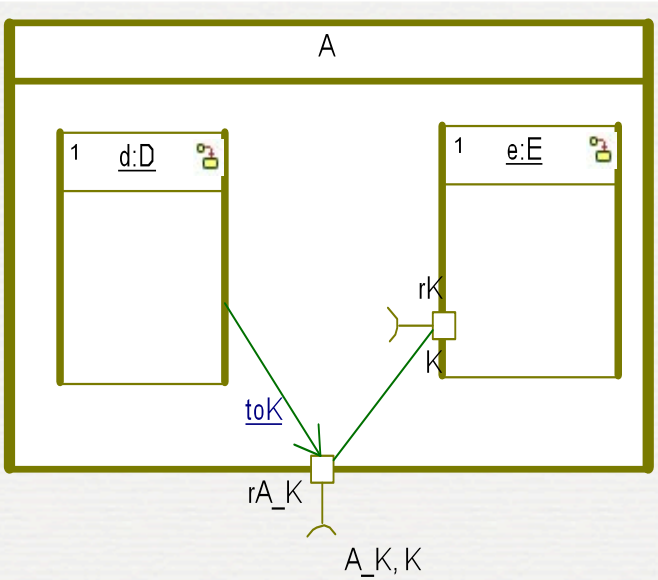


Elements :
(a) port
(b) part
(c) delegation connector
(port-to-instance)
(d) assembly connector
(port-to-instance)
(e) assembly connector
(instance-to-instance)
(f) delegation connector
(port-to-port)
(g) provided interface
(h) required interface

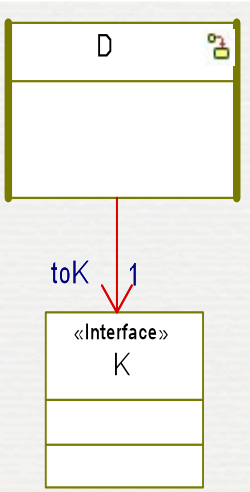
Ambiguous structures



Ambiguous structures



should imply



Unambiguous structures

OMEGA objective: clear & coherent semantics

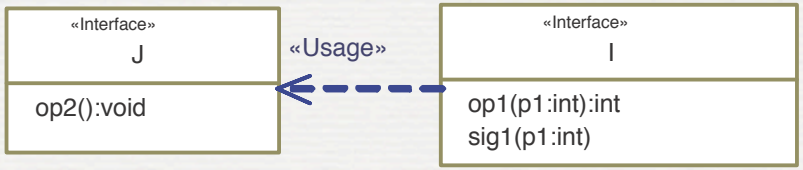
Rules for well-formed structures

Static type safety

Operational semantics

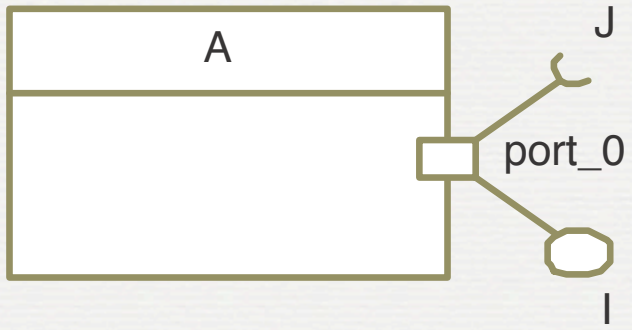
Bidirectional vs. unidirectional ports

Bidirectional ports lead to typing problems:



- example of action in A:

```
port_0.op2()        // port_0 complies to J
```

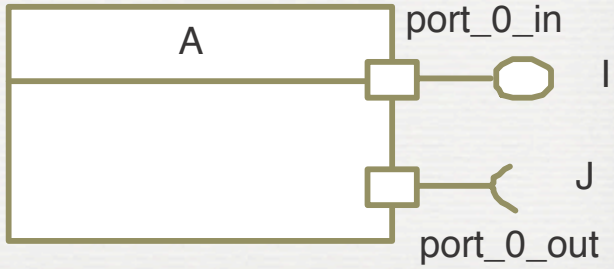


- behaviour specification of port_0:

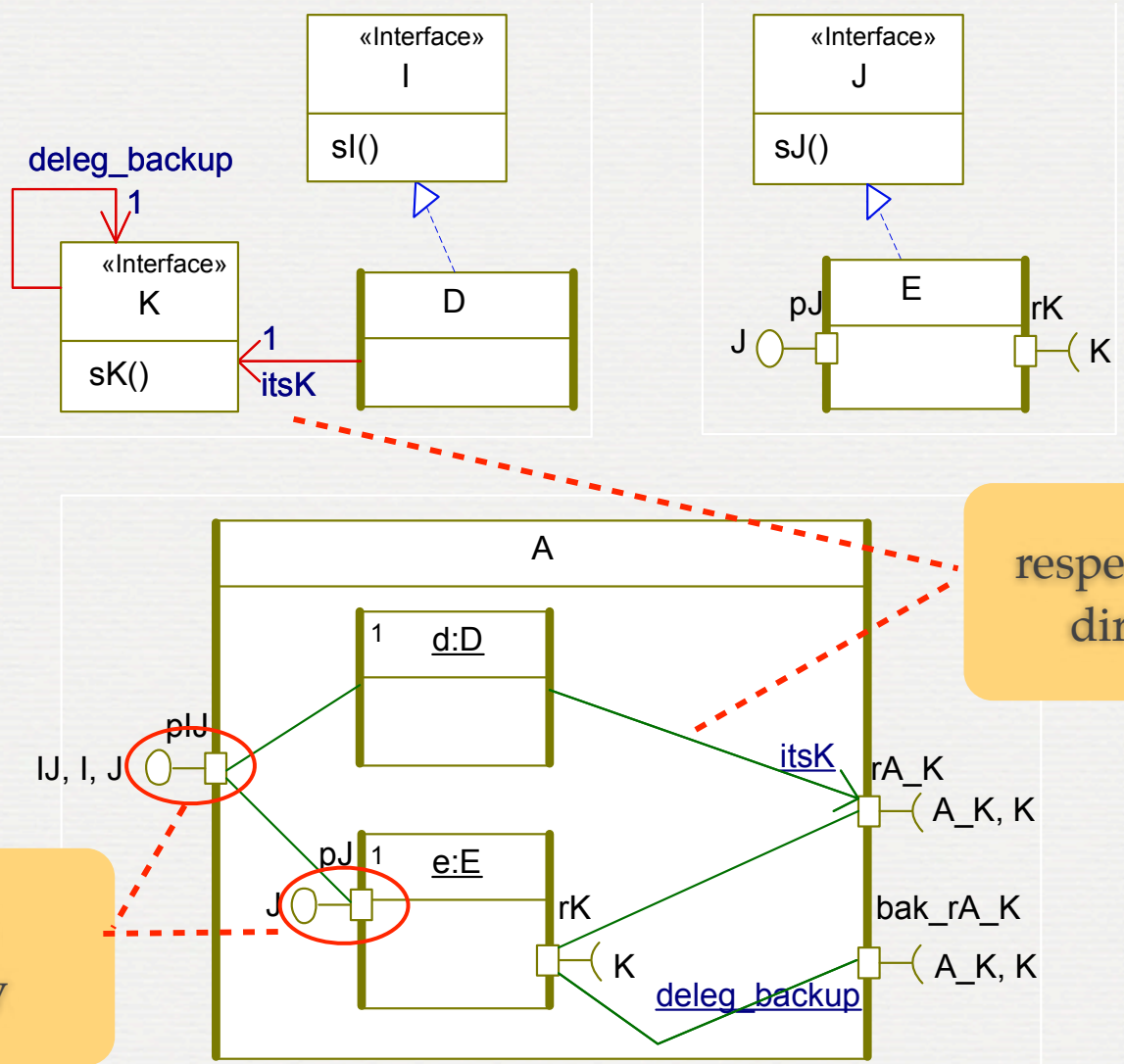
```
input op2() :       // port_0 complies to J and I
   ...
input op1(x) :      // port_0 complies to J and I
   ...
input sig1(x) :     // port_0 complies to J and I
   ...
```

OMEGA: no bidirectional ports !

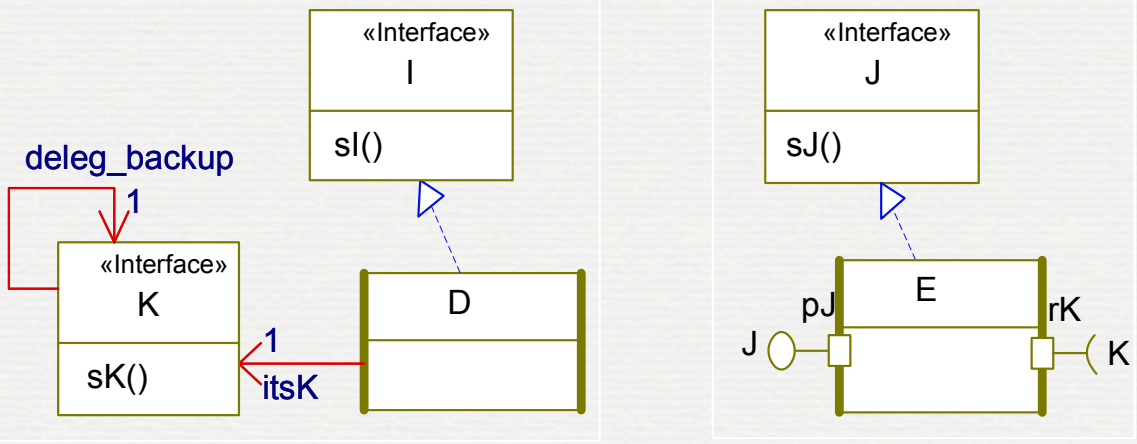
Replace with:

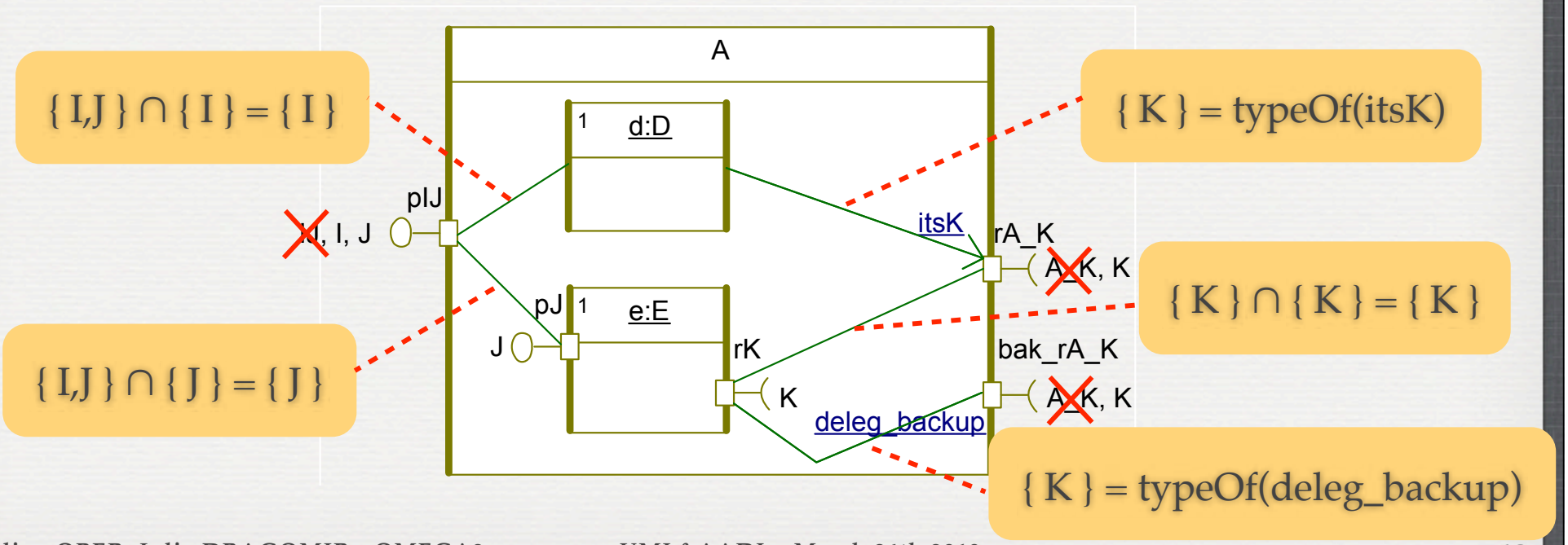


Connector directionality



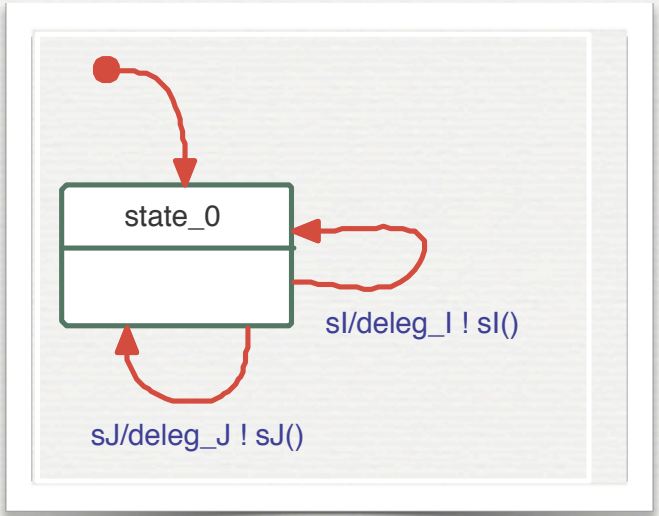
Connector typing

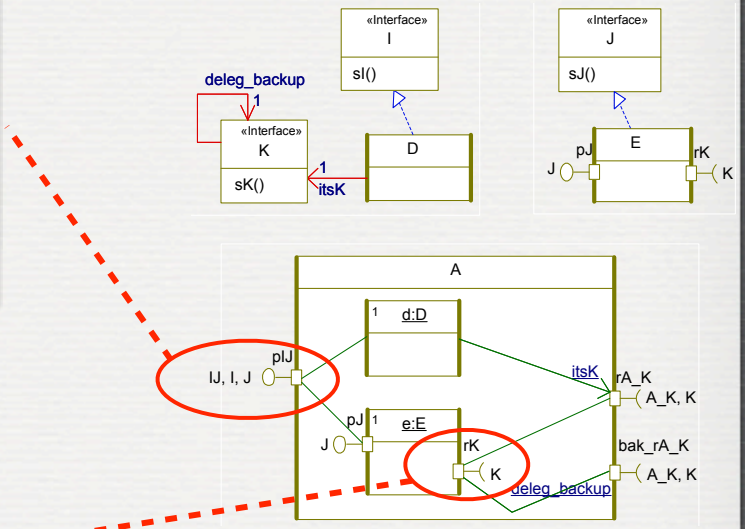




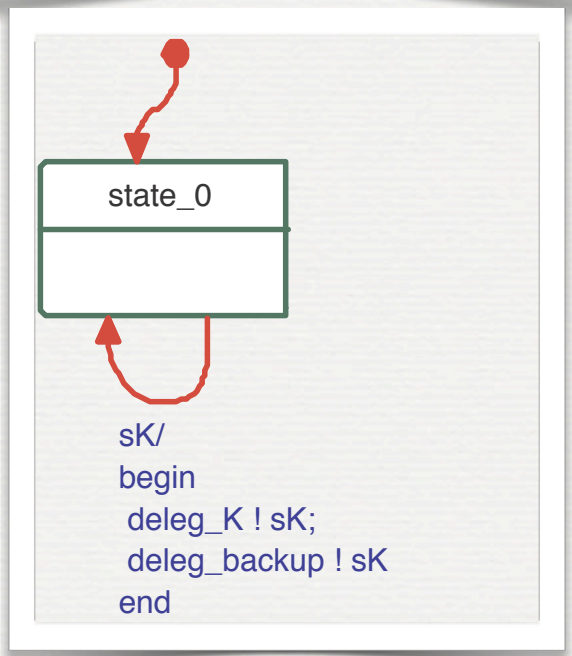
Port behaviour

Default port behaviour:





Explicit port behaviour:



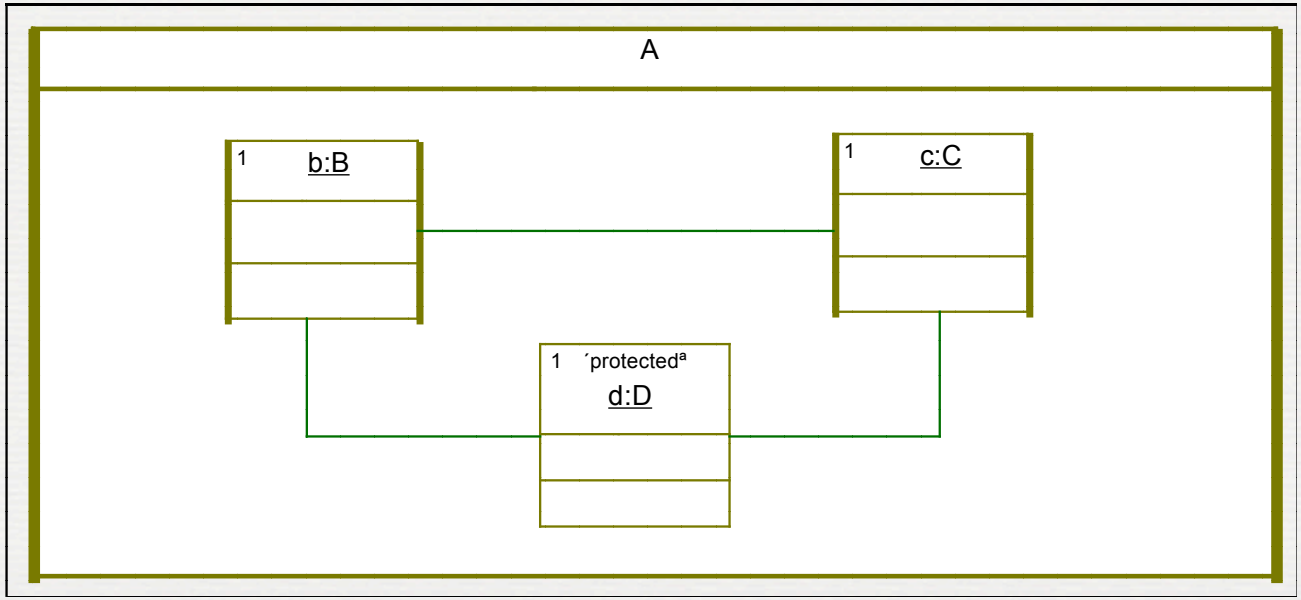
Concurrency model

- Lack of sharing & synchronization mechanisms

  ⇒ Ada-like protected objects (with *functions* and *guarded entries*)

  ⇒ Coherent with the activity group semantics

  ⇒ Rules to make them *coherent with composite structures*



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IFx2

- Same overall architecture
  - translation of models (XMI 2.x) to IF using Eclipse/UML
- Principles and evaluation
  - ports and connectors handled as *first class* elements
    ⇒ dynamic routing for requests
    ⇒ allows for dynamically reconfiguring composite structures
  - offline partial-order reduction to reduce impact of routing actions on the size of the state space
    ⇒ state space explosion is not aggravated by new features

Conclusions and future work

- Simple but not simplistic profile for real-time software & systems modelling
  - fully defined operational semantics
  - simulation & verification toolset

  ⇒ complementary to broader approaches such as MARTE
- Tool & profile currently evaluated by ESA on realistic models
- Current and future work
  - formalize composite structures type system & prove type safety
  - improve profile & tool: SysML adaptations, improved integration and user experience, advanced diagnostics features, etc.