UML Behavioral Consistency Checking using Instantiable Petri Nets

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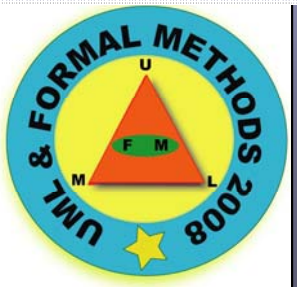
In Conjunction with: 10th Int'l Conf. On Formal Engineering Methods



Context: ModelPlex project

- European IP: *MODELling solution for comPLEX software systems*
  - 2006-2010, 21 partners, 20M€
  - Model centric development
  - Reduce costs, increase quality/productivity
- WP 4: simulation, *verification* & testing (SVT)
  - Model checking is one of many services provided to models
- Develop "Behavioral Consistency Checker" a tool that transparently relies on Model-Checking to offer verification of UML behaviors

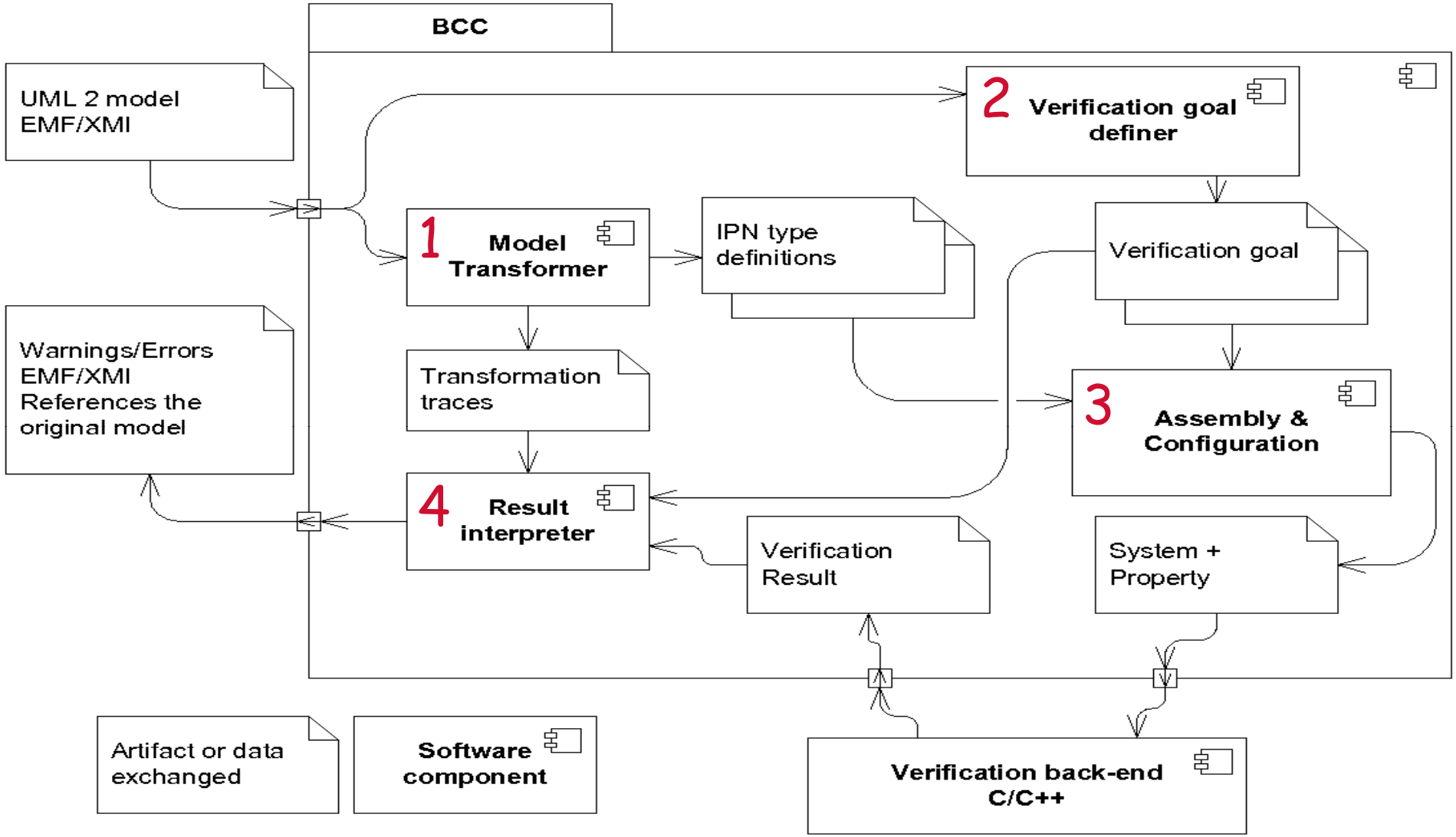
Goals of BCC

- Go beyond syntactic checks:
  - Offered by EVL (Epsilon), OCL
- Transparently use formal verification:
  - Minimal user input
  - Model-checking technology (e.g. Decision diagrams)
- Check that the *behavior* of a system specified in UML2 is *consistent*
  - Integrate execution semantics

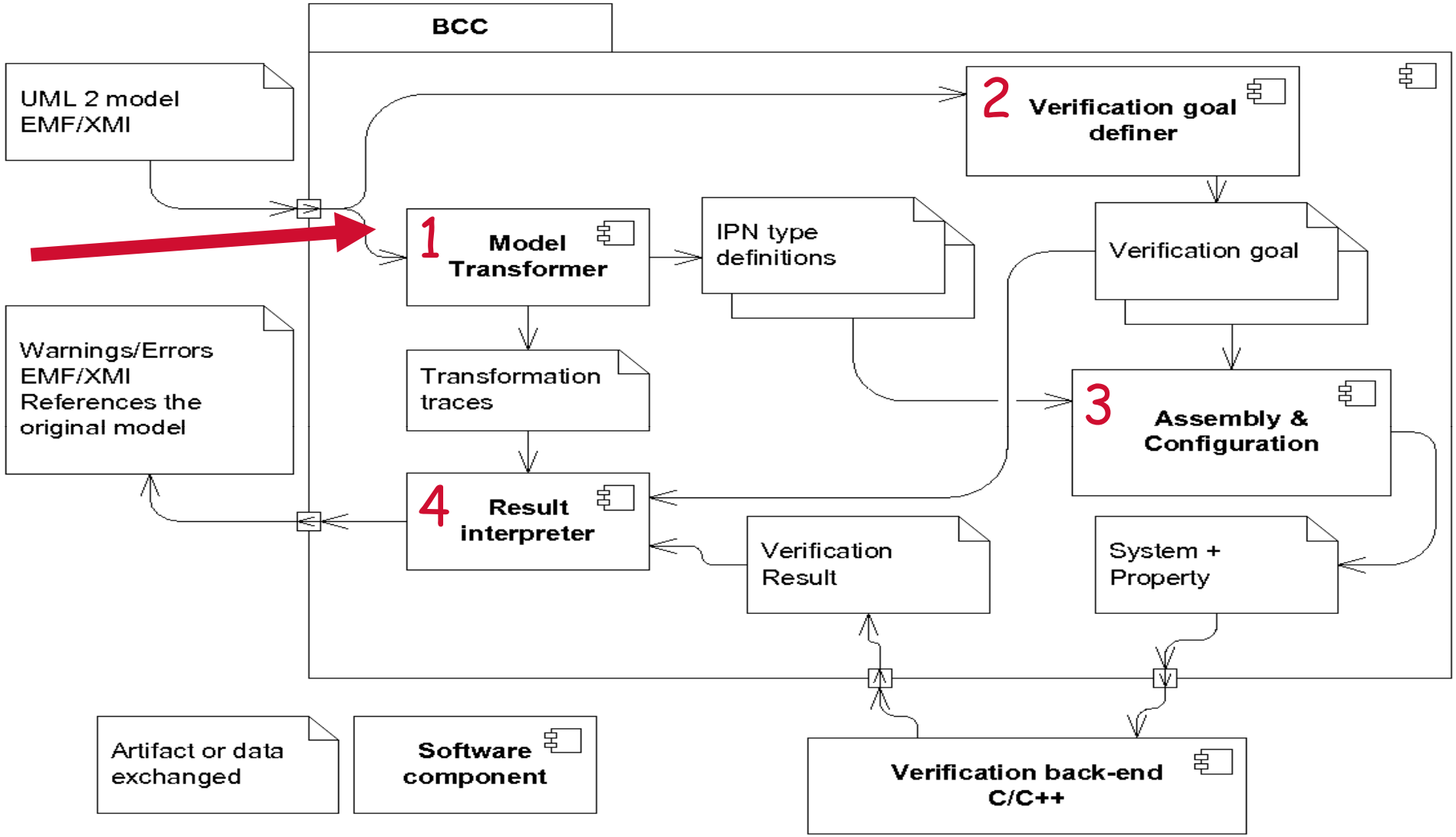
Means of BCC

- Translate UML to a formal notation
  - Consistent with MDA approach: a PSM for verification
- A generic description of "UML Behavior" semantics
  - Notion of type and instance
  - Use of an interface = public transitions
  - Composition through synchronizations:
    - *CallBehavior/EndBehavior*
    - *Send/Receive Event*
- Petri nets as an elementary component
  - Allow reuse of existing verification technology/tools

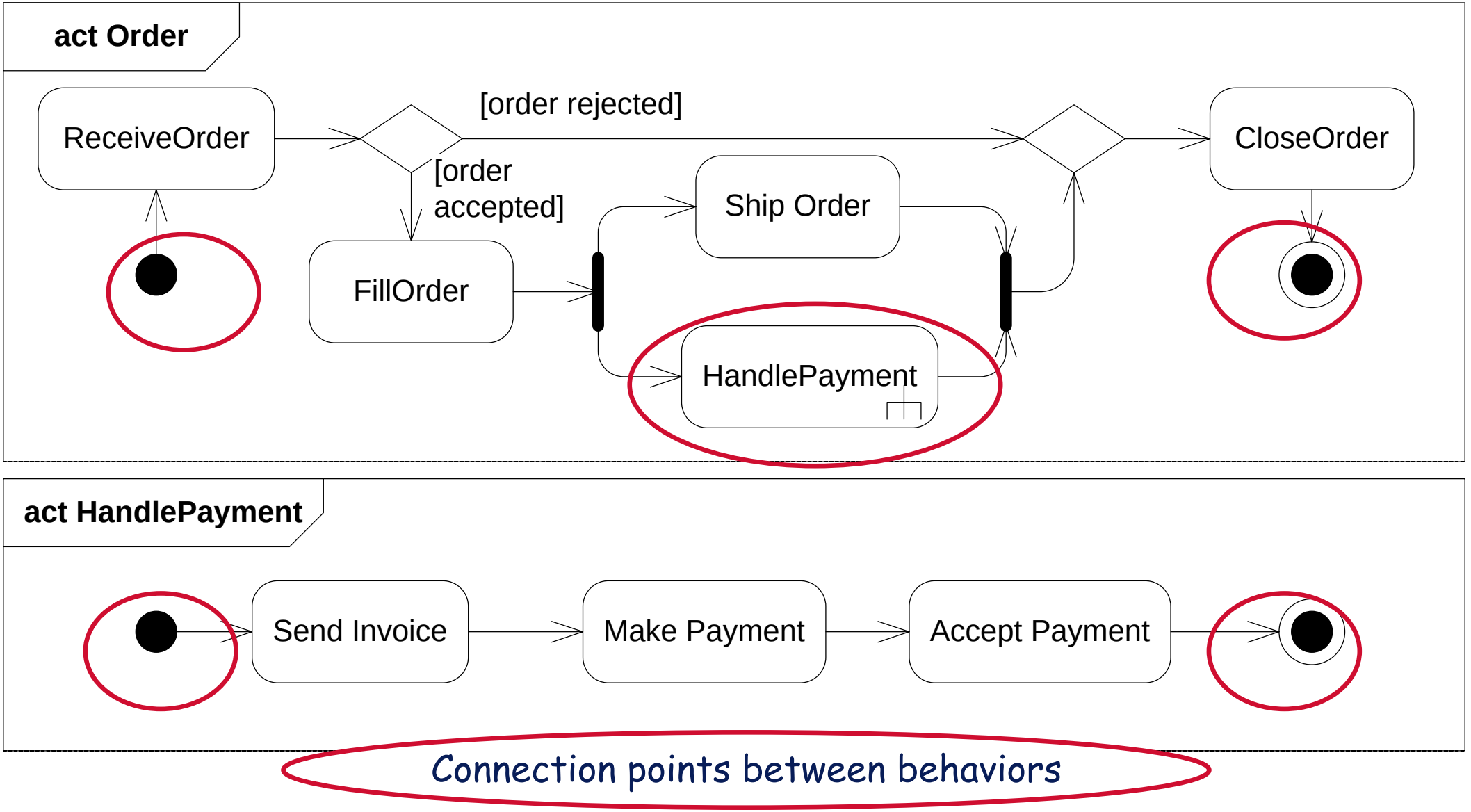
Behavioral Consistency Checker: Internal Architecture



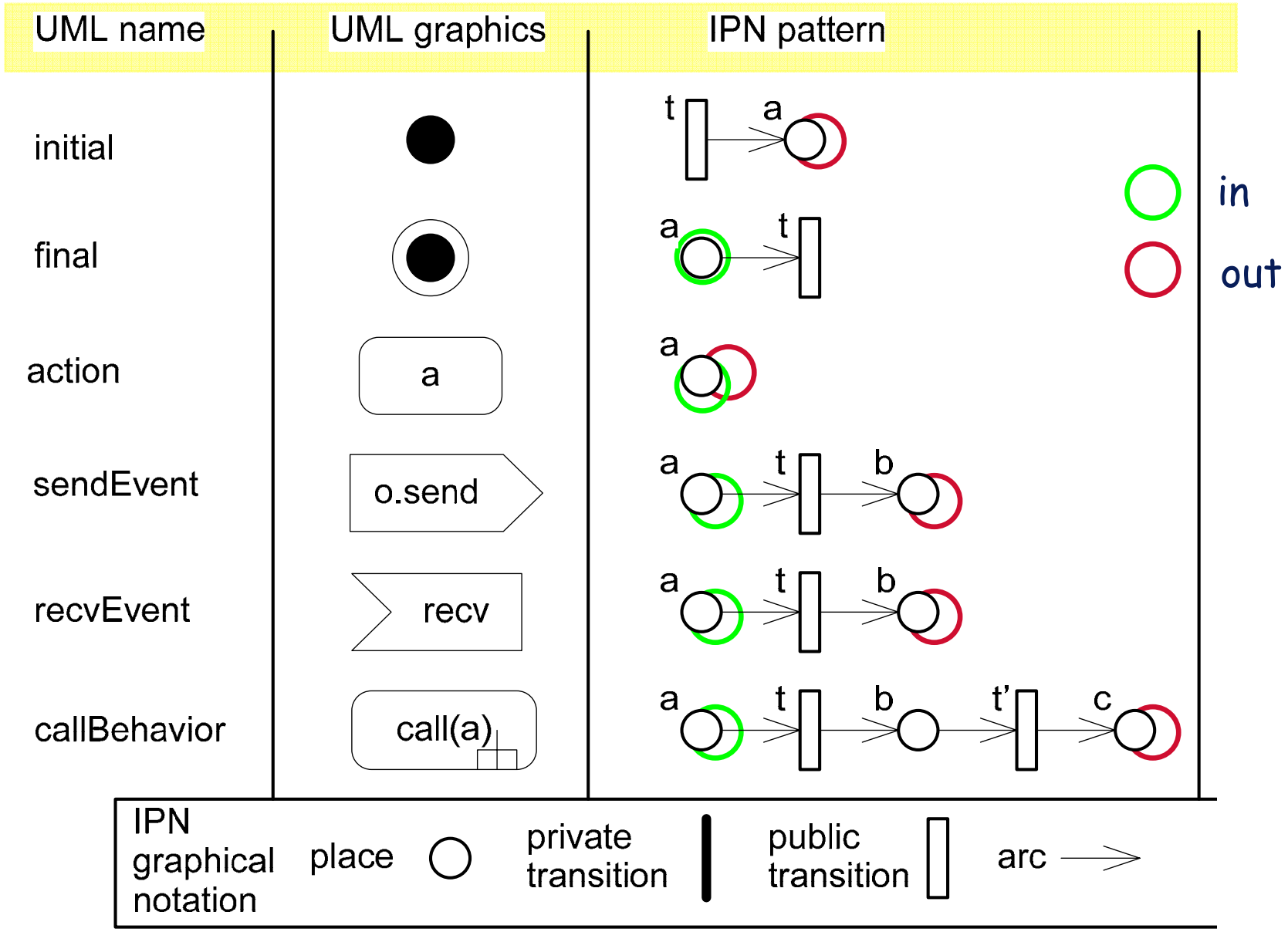
Step 1: Transformation



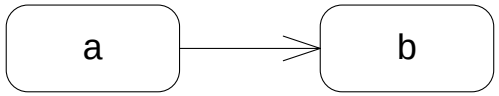
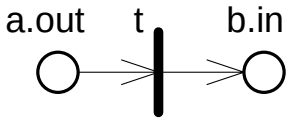
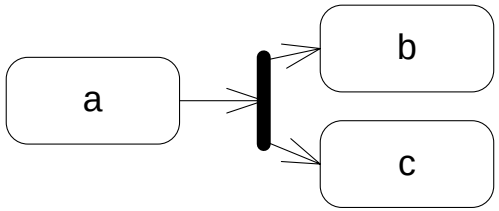
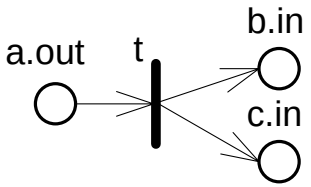
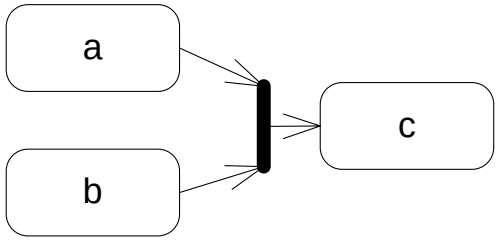
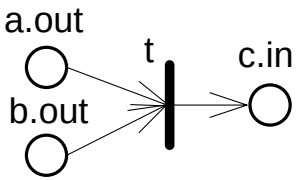
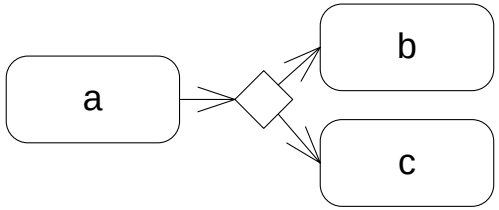
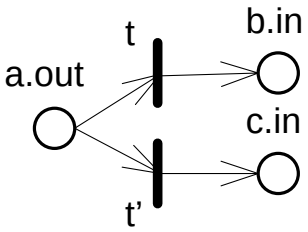
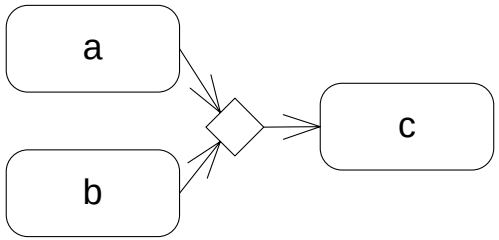
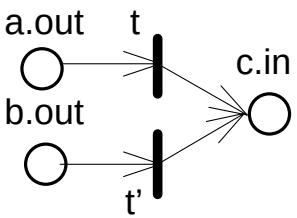
An example translation (Activity diagram)



Translation rules from UML-AD to IPN: nodes

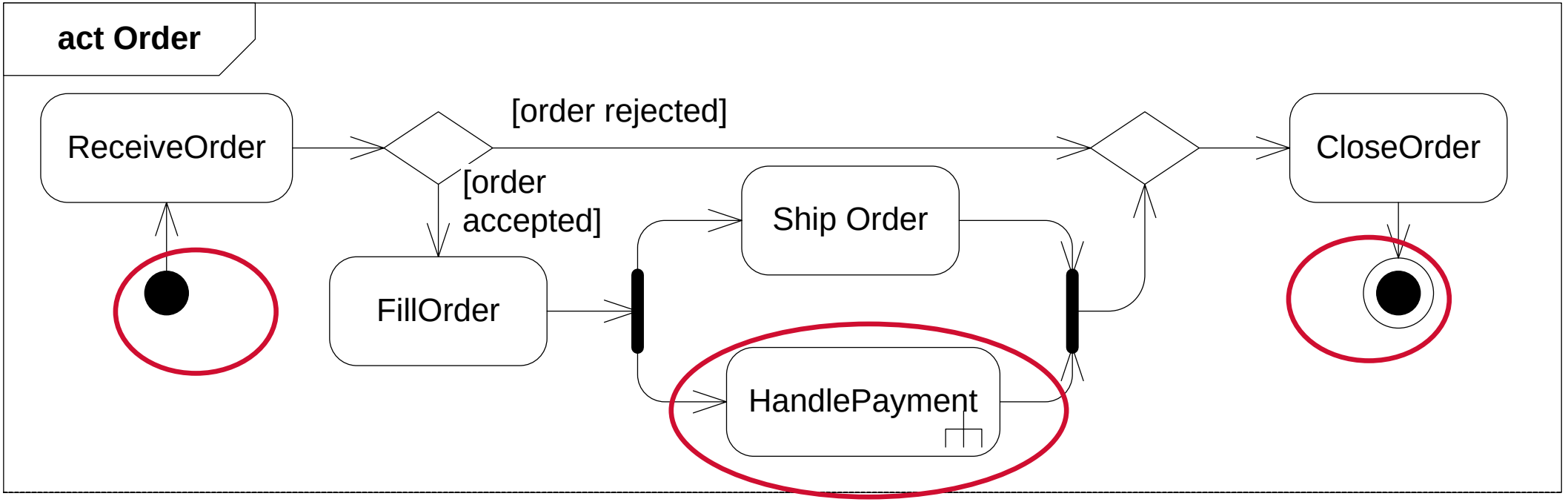


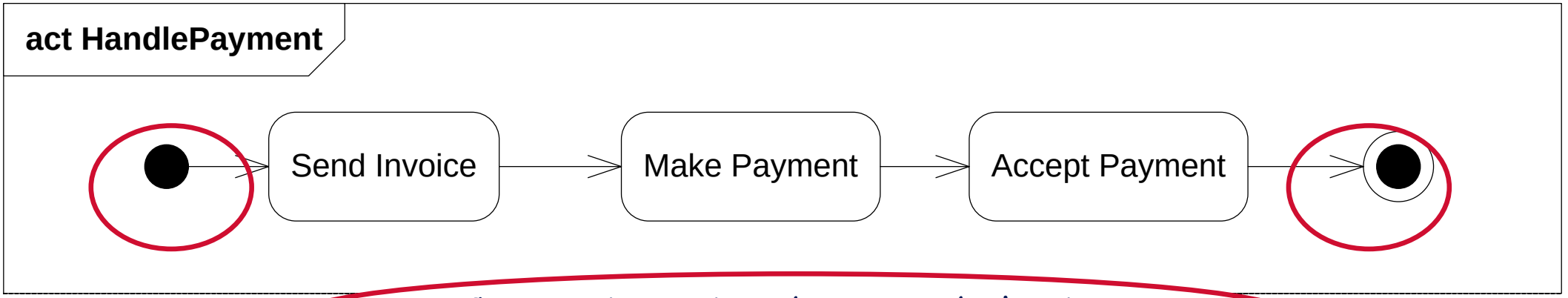
Translation rules from UML-AD to IPN: edges

UML name	UML graphics	IPN pattern
Control Flow		
Fork		
Join		
Decision		
Merge		

Only private transitions

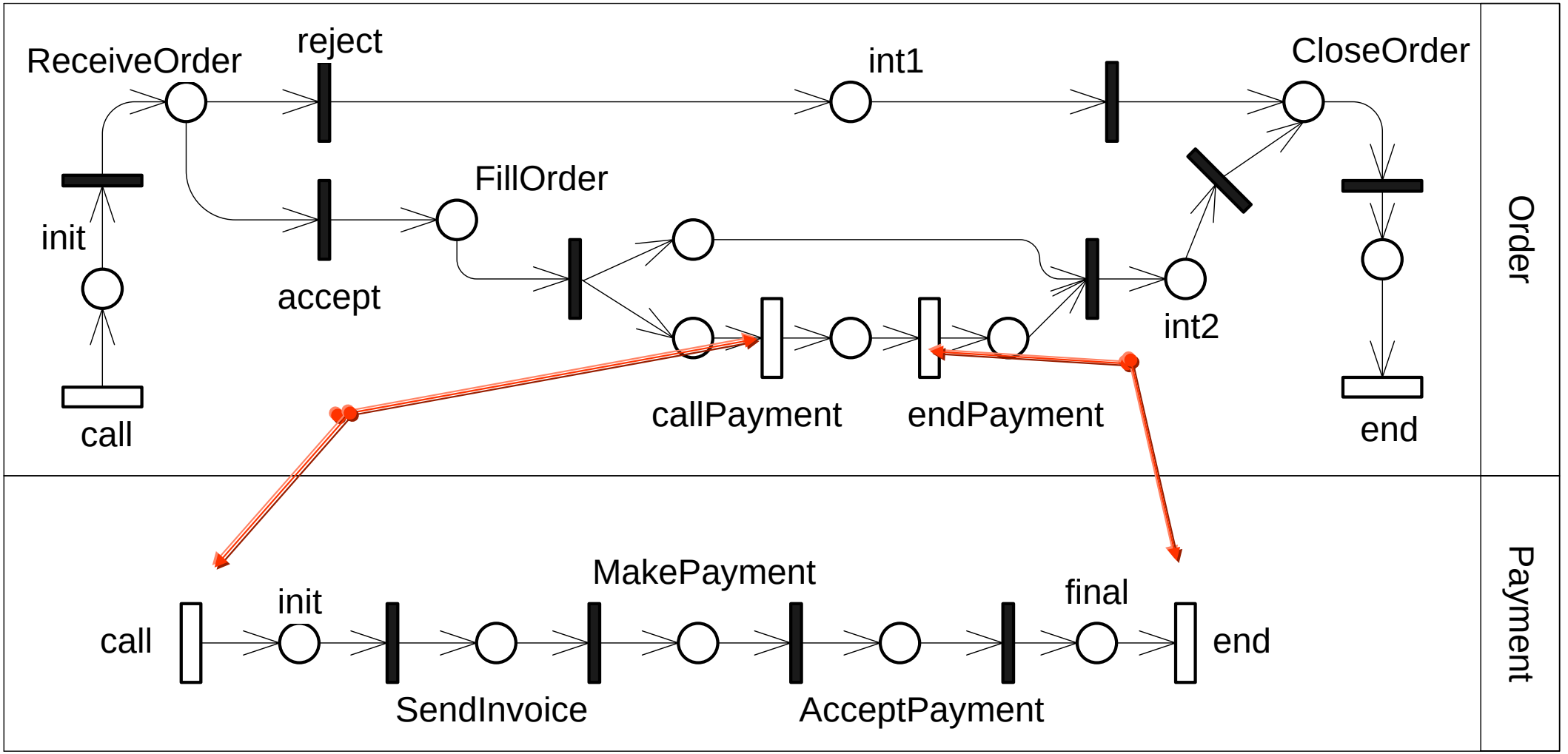
An example translation (Activity diagram)



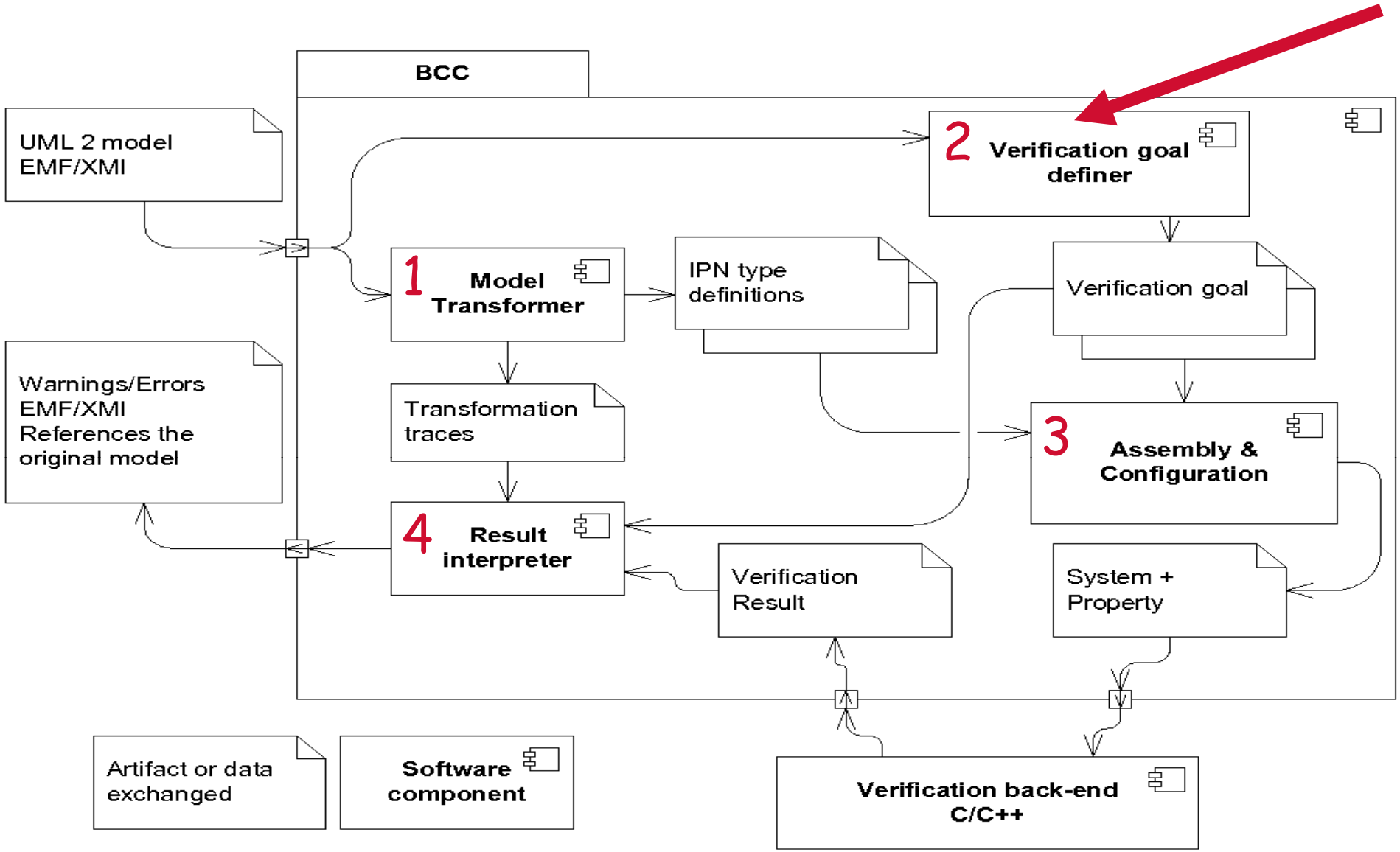


Connection points between behaviors

An example translation (IPN): 1 Diagram <-> 1 IPN Type



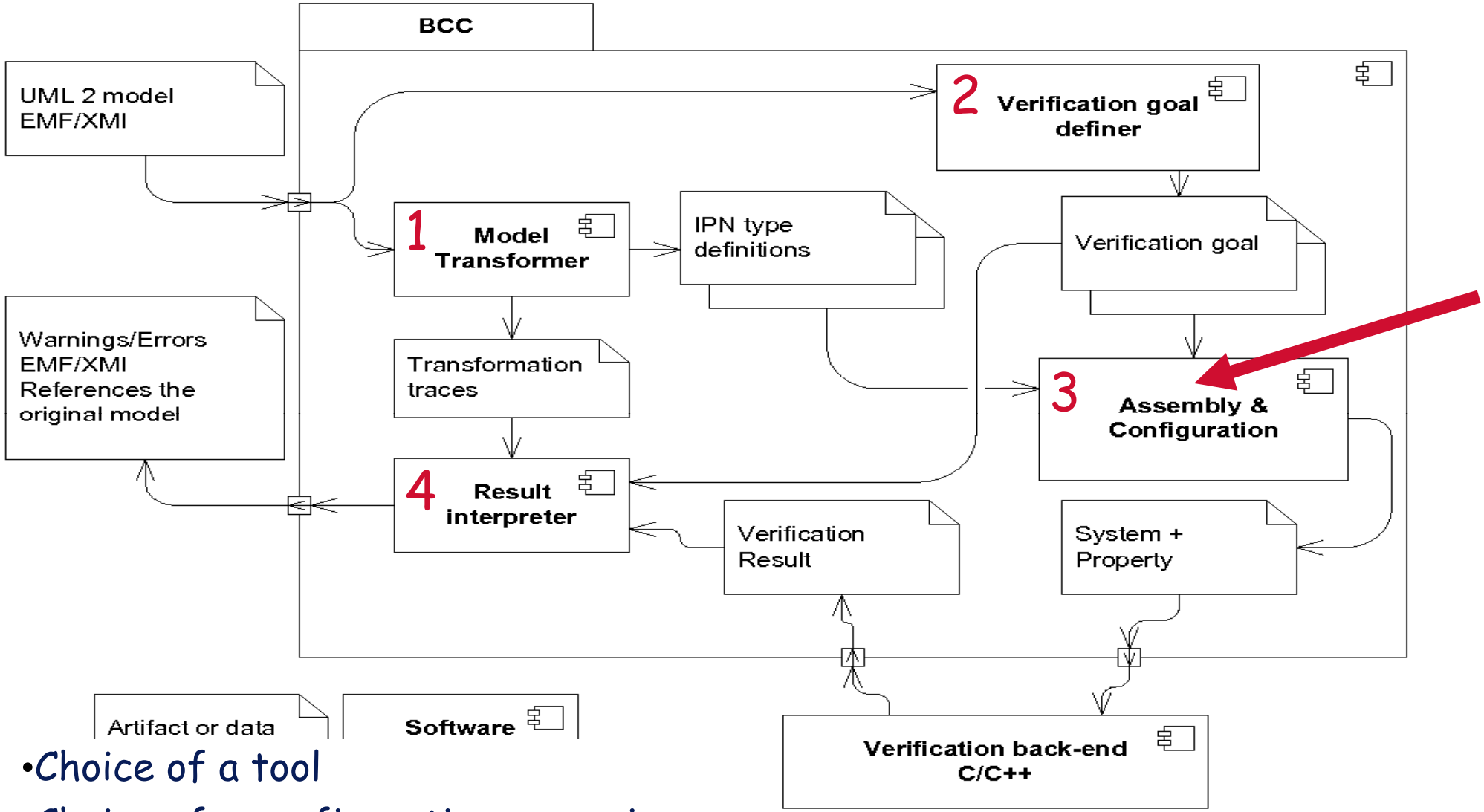
Step 2 : verification goals



Classification of properties

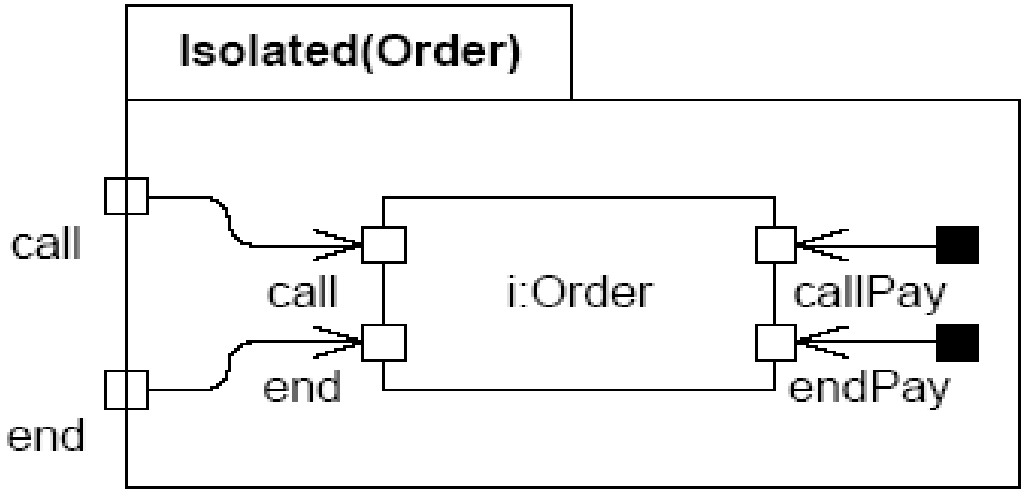
- Model independent: (No user input !!)
  - Deadlocks, Livelocks
  - Unbounded behavior (bad specification)
  - Unreachable behavior (dead code)
  - UML specific, model dependent: e.g. Reachability of final state from initial configuration
- Model instance dependent:
  - Reachability of a state: invariants, (un)desired states
    - *Would require a mapping from OCL to IPN*
  - Temporal logic (CTL, LTL…)
    - *Use stereotyped sequence diagrams ?*

Step 3 : Assembly and Verification Tool configuration

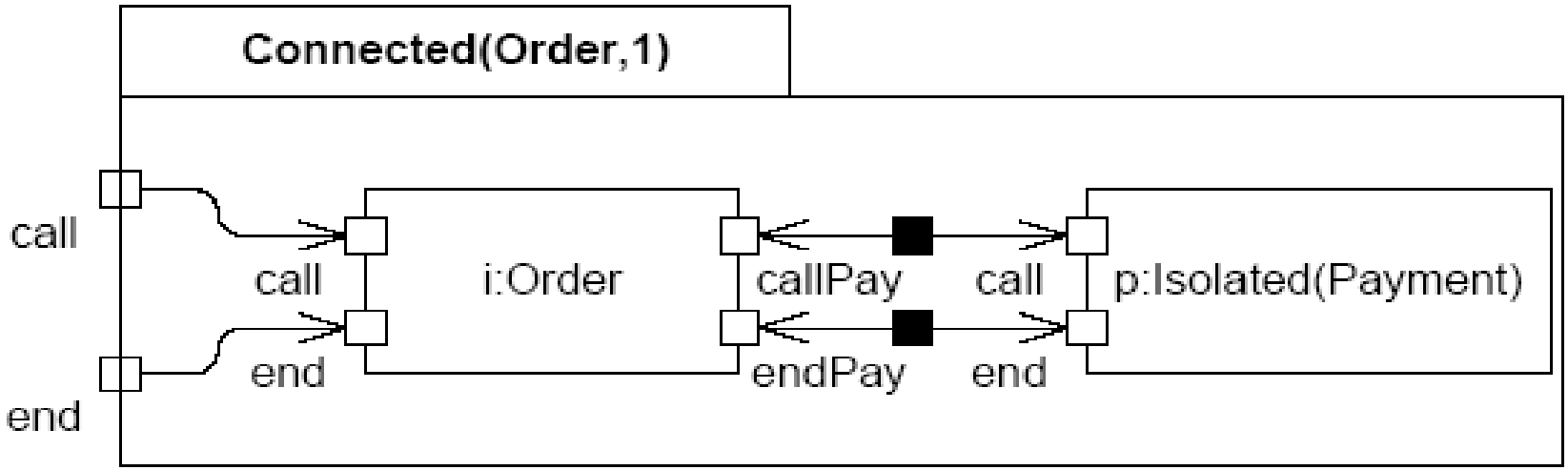


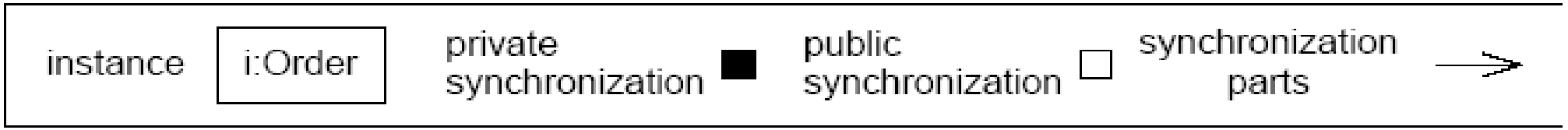
- Choice of a tool
- Choice of a configuration scenario

Incremental verification

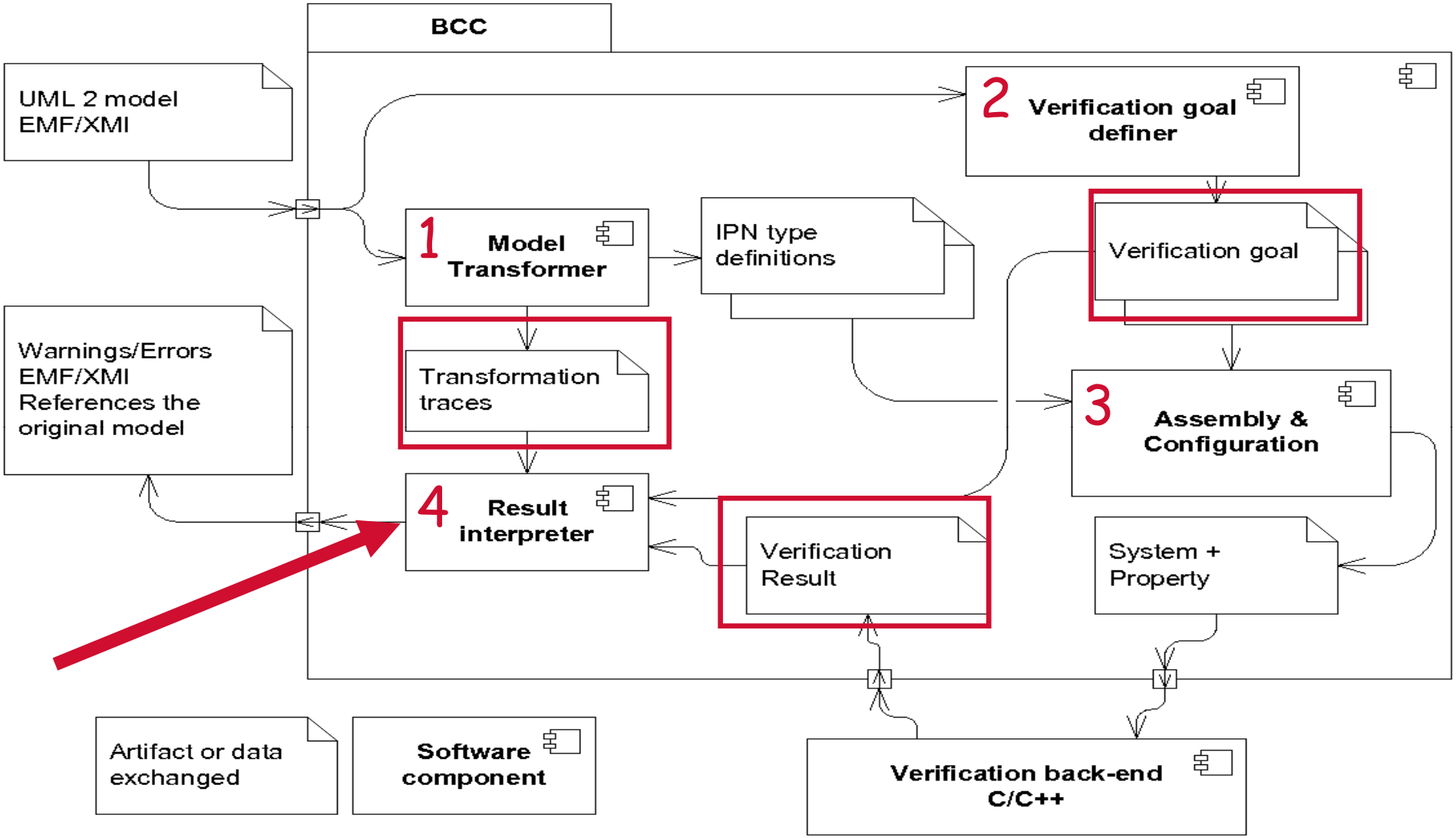


- Limit complexity of simple checks
- Optimize w.r.t. property.
- Reuse IPN type declarations





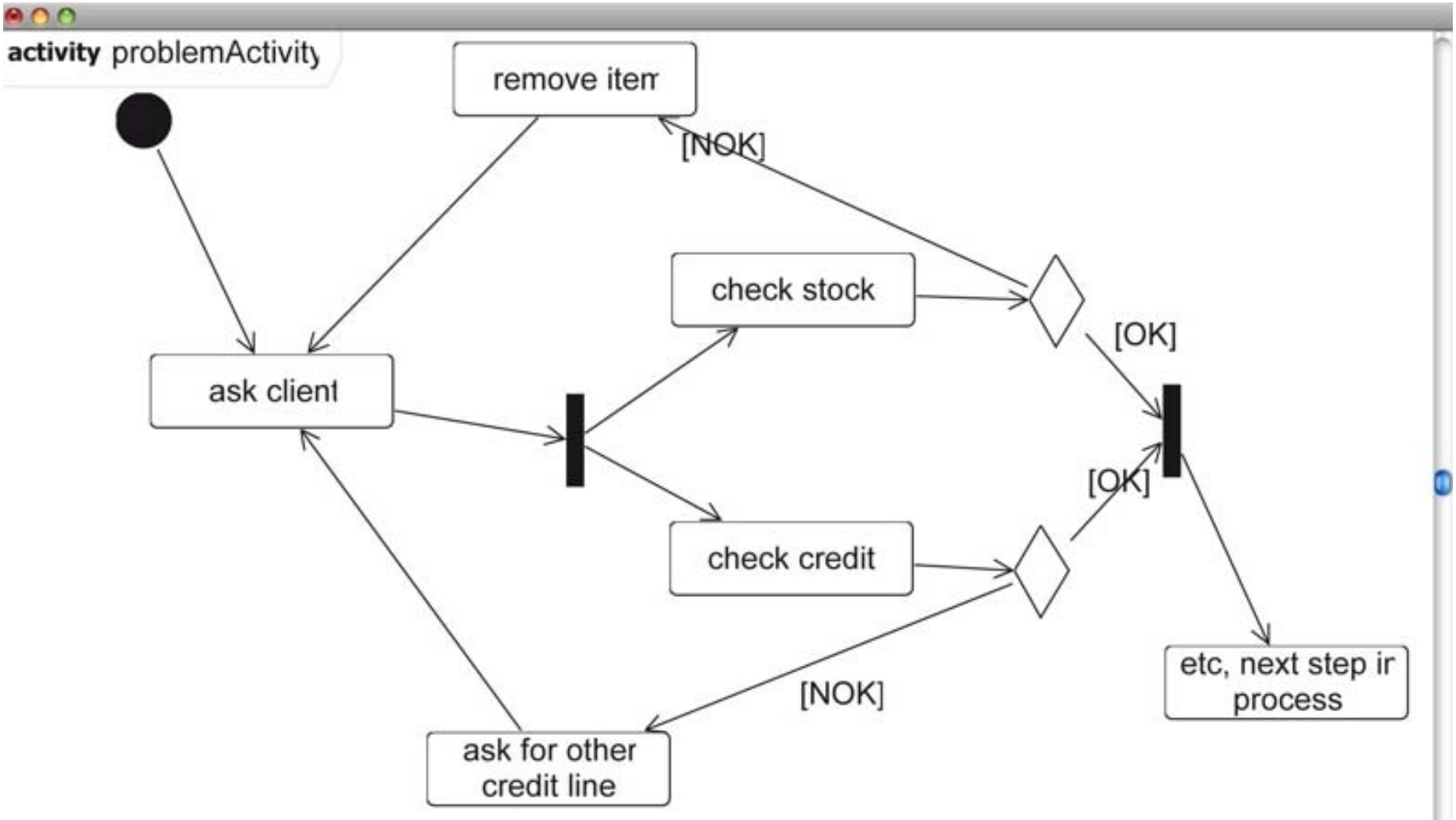
Step 4 : Result Interpretation
Keep it simple !



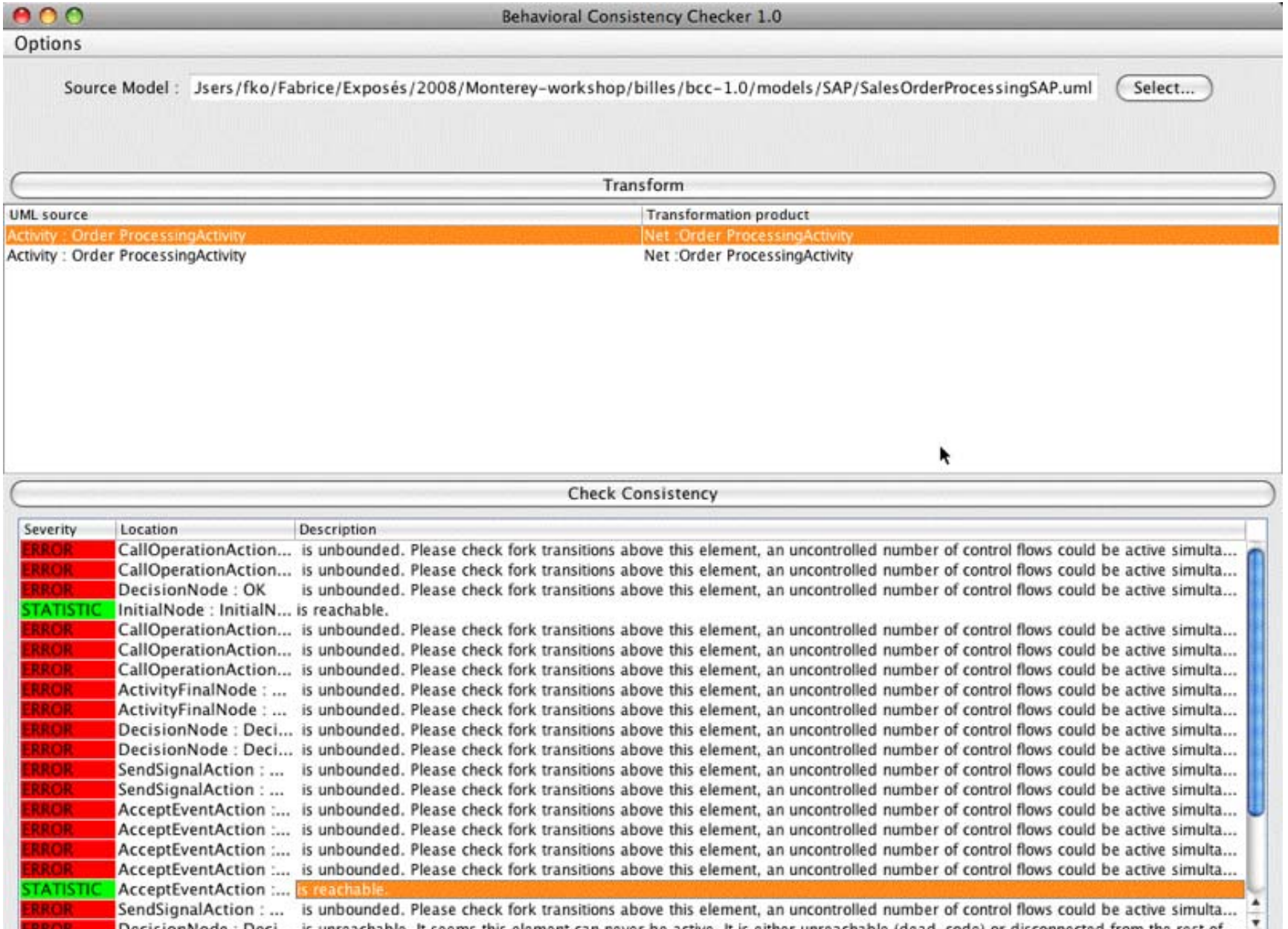
The SAP specification

Activity diagram from SAP

- Any of the two checks can fail and trigger the fork again…

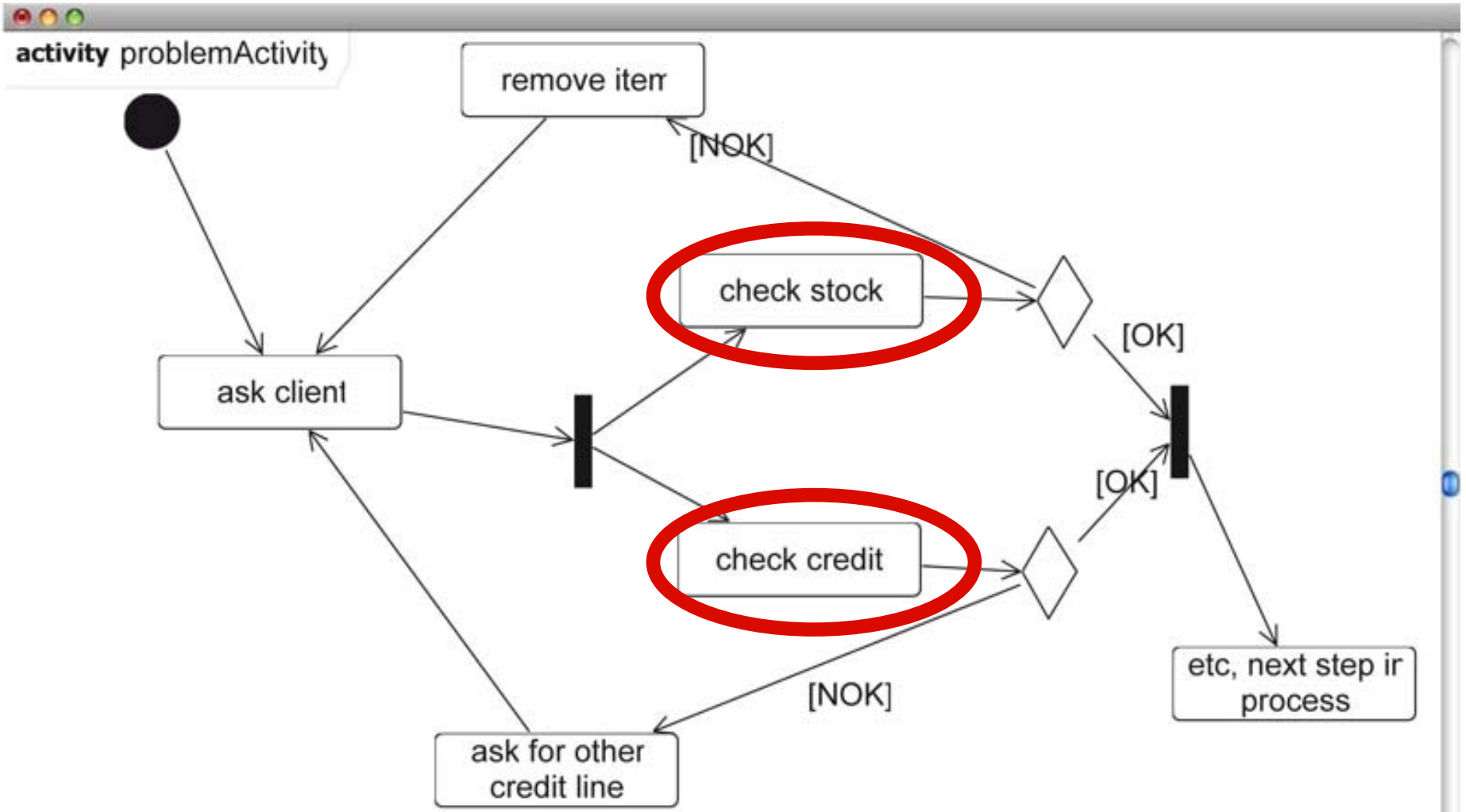


Working on the SAP model with BCC



Meanings of red errors

- From simulation, more CPU is needed due to important activity
- From verification: the spec's structure is unbounded by construction



Conclusions

- Still work in progress
  - Define additional consistency rules
  - Use profiled models for model specific properties
  - Eclipse problem view integration
- Experience learned:
  - Use of default properties already useful
  - Fully automated chain necessary
- Need for structure and hierarchy in target formalism
  - Applicability of compositional approach to other elementary bricks than Petri nets
- We also develop an efficient decision diagram based model-checking solution see ddd.lip6.fr
  - Hierarchy allows more efficient verification algorithms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BCC 1.0 (current)
User guide 0.3 (current)
Behavioral Consistency Checker
BCC is a model checking based tool to check consistency of UML diagrams. It is developed within the ModelPlex project.
BCC is produced as LIP6 contribution within task 4.3, Model-Based Verification:
Software property description metamodel with domain specific property description dialects.
Techniques for hierarchical composition of verification models.
Verification engines that integrate multiple, concern-specific technologies with different applicability and scope, with heuristics for choosing the most appropriate technology depending on context.
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