Model-based Software Engineering for/with Petri nets

Behaviour Modelling (and its challenges)

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Motivation

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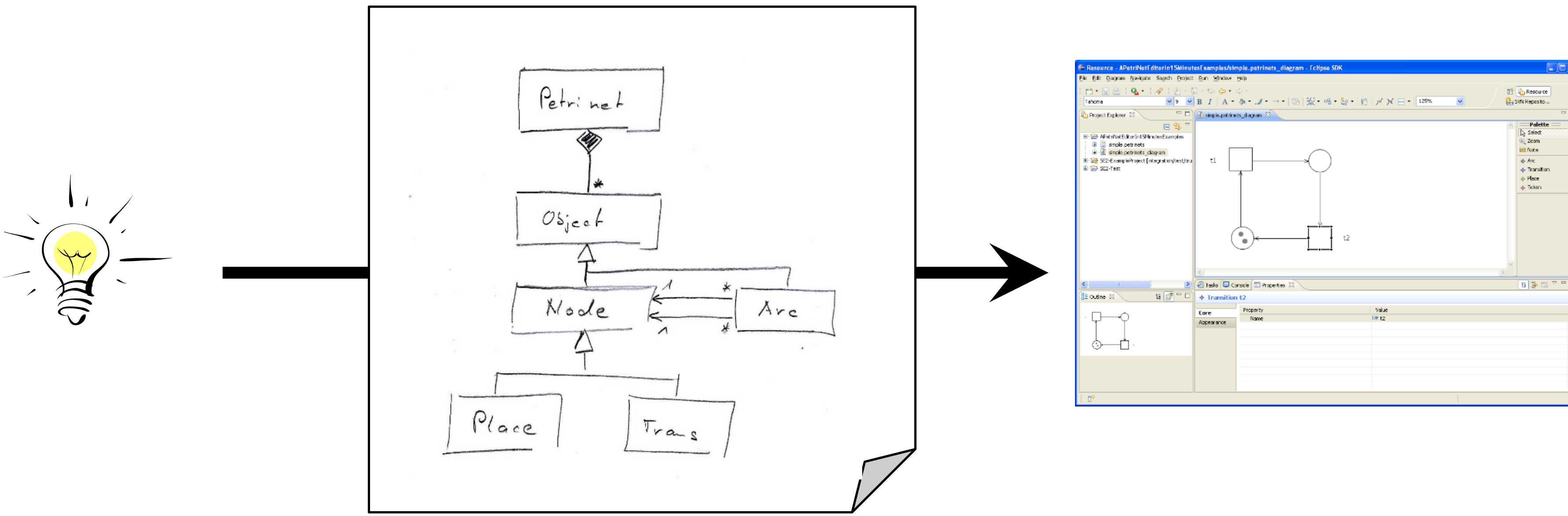

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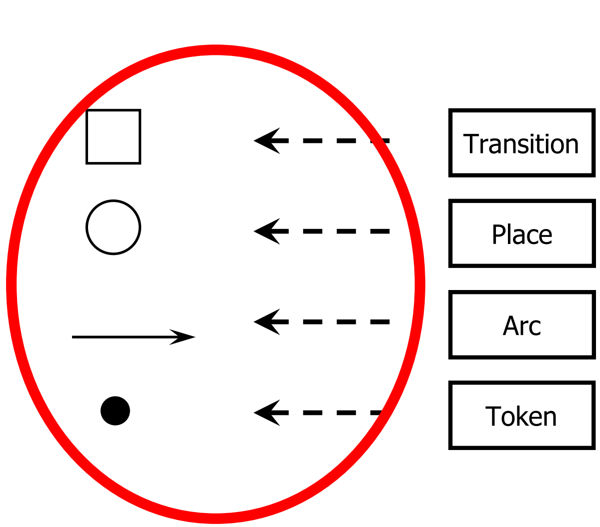
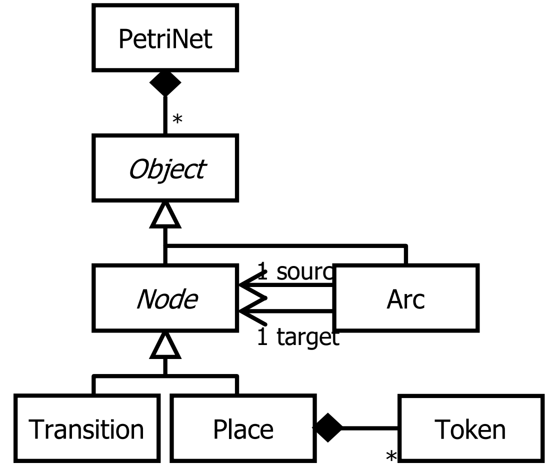
meta model

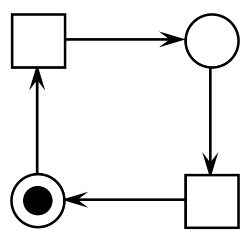


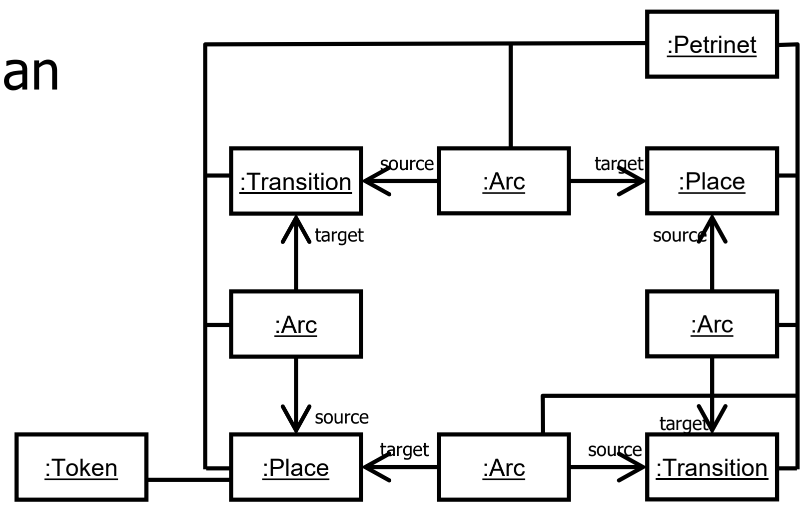


is instance of

generate an editor

model





concrete syntax

abstract syntax

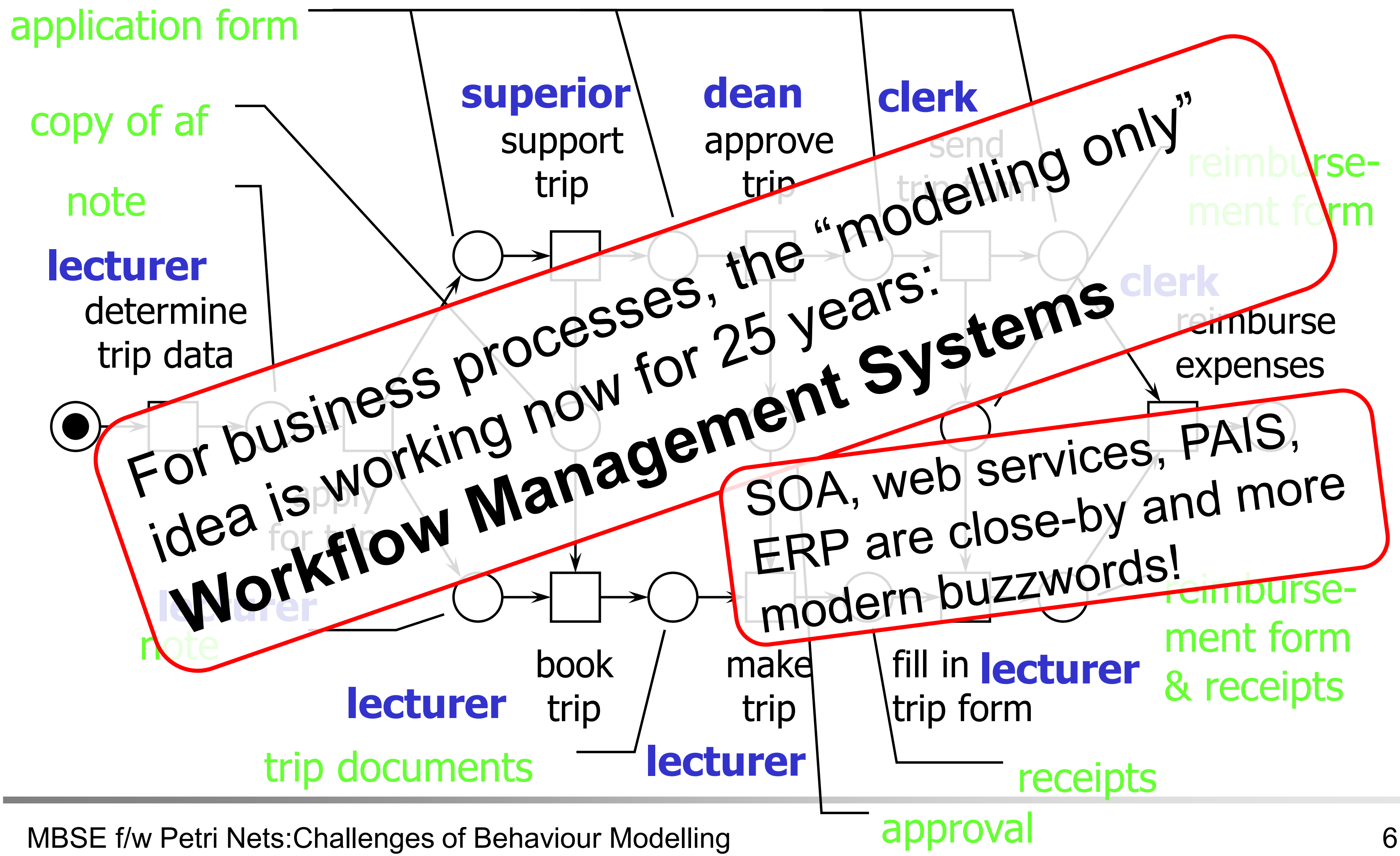
Benefits of Modelling (cntd.)

- Better Understanding
- Mapping of instances to XML syntax (XMI)
- Automatic Code Generation
  - API for creating, deleting and modifying model
  - Methods for loading and saving models (in XMI)
  - Standard mechanisms for keeping track of changes (observers)
  - Editors and GUIs

But, all this is "standard functionality"! Where is "real functionality" or non-standard behaviour?

Table of Contents

Example: Business Trip



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Where does the “modelling only” idea work?

Graphical editors

- graphics only
- standard functions only
- no business logic

Workflow management

- standard GUI only
- business logic explicitly modelled
- dedicated modelling notation

e.g. a Petri net simulator?

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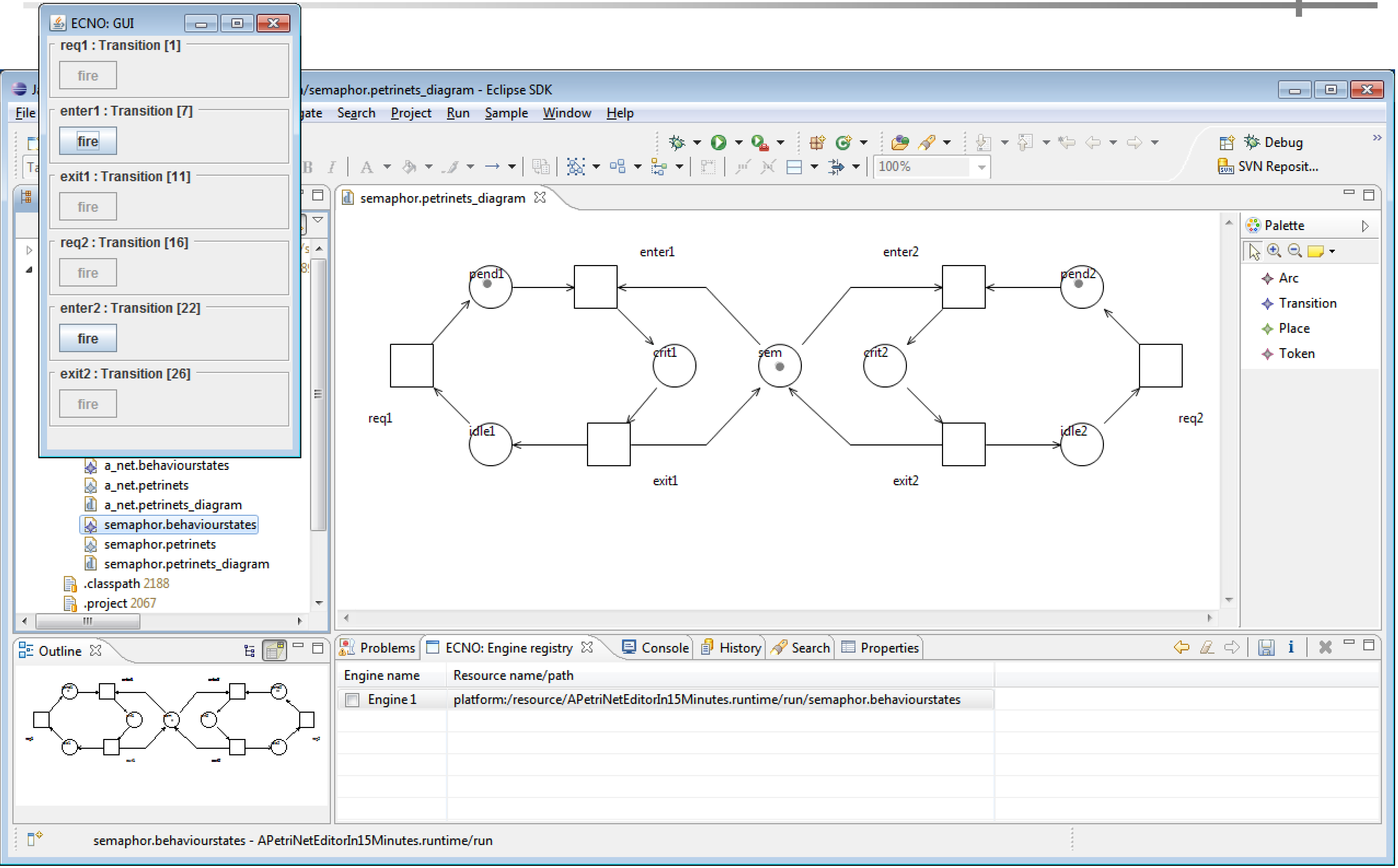

Challenges

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~~"There are no notations for modelling behaviour!"~~

This claim is actually as wrong as it can get!
There are (too?) many such notations!

Challenges

- Adequate modelling methodologies
  - Coarse grain behaviour
  - Fine grain behaviour
- Mechanism for integrating and coordinating behaviour beyond invocation (calls of procedure, function, method, or service)
- Integration with
  - existing software (legacy, manually created, generated)
  - other models (structural & behavioural)
- Change mentality (change culture)
  - Stuck with thread- and invocation-based thinking
  - Software engineering is programming thinking (→ model interpretation vs. code generation)

Moreover: Today's modelling technologies are not very "agile"!

Table of Contents

- Motivation
  - Model-based Software Engineering
  - Business process modelling
- Challenges and Problems
- Some Ideas
  - modelling behaviour
  - integration and coordination of behaviour
    (a vision: Event Coordination NOtation ECNO)
- Discussion

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Motivation

- Given some object oriented software with (or without) explicit domain model,
- model behaviour on top of it – and make these models executable.
- Model behaviour on a high level of abstraction (domain): coordination of behaviour

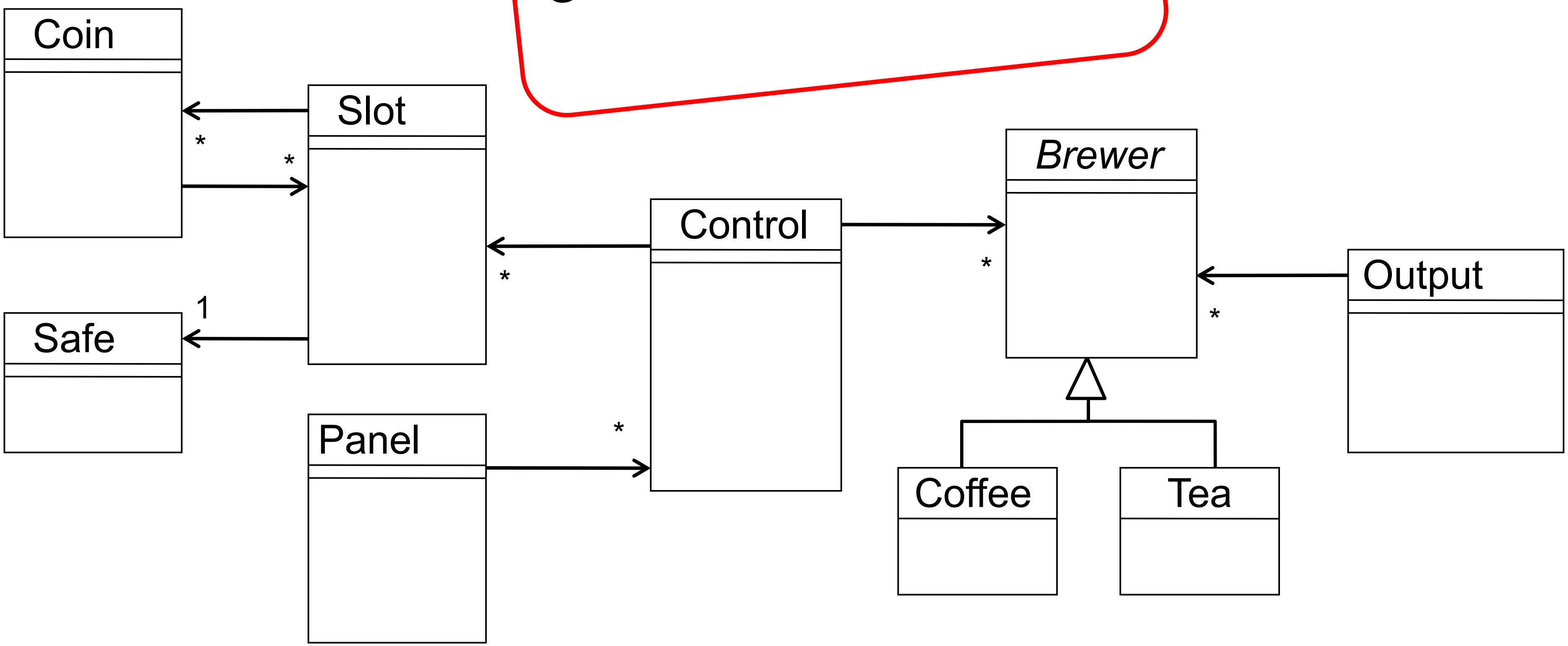
Meta-models / domain models including behaviour!

→ Integrate behaviour models with structural models

→ Integrate different structural models and manually written code (or code generated by different technologies)

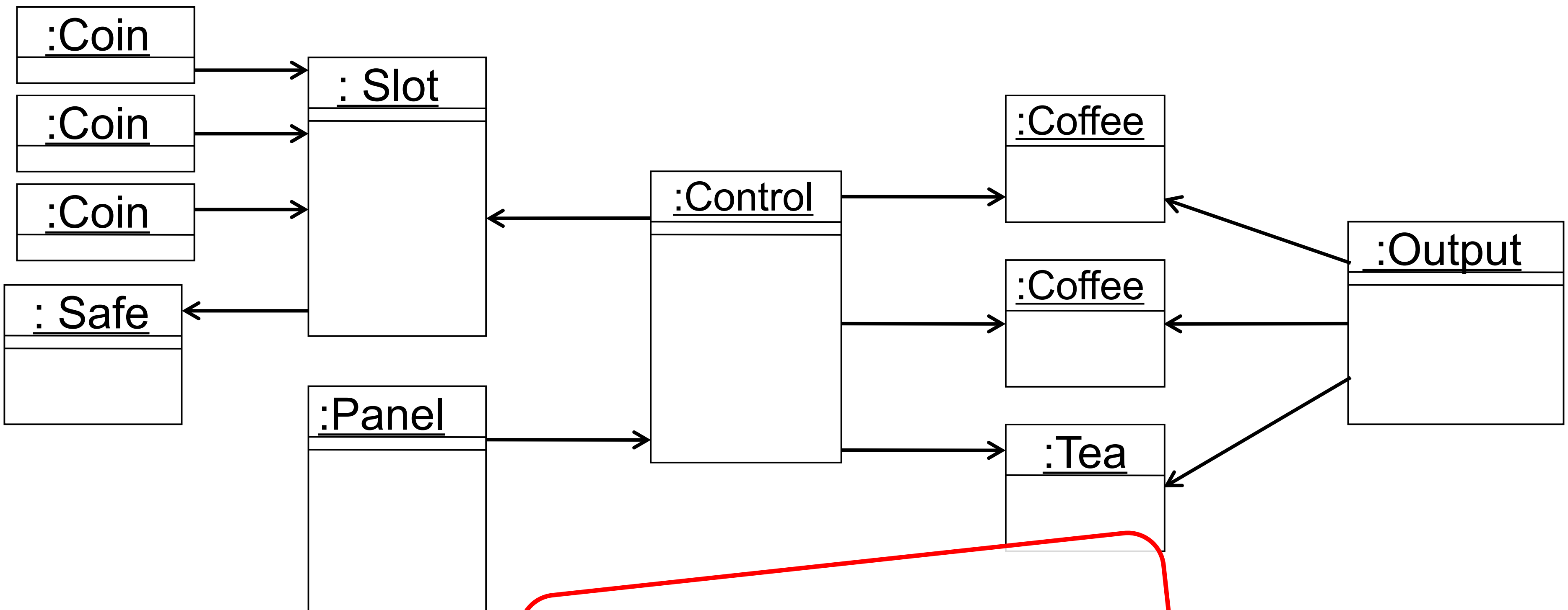
2.1 Example: Vending machine

Class diagram as usual



Instance: Object Diagram

Initial configuration, current situation



Object diagram as usual

Coordination Diagram

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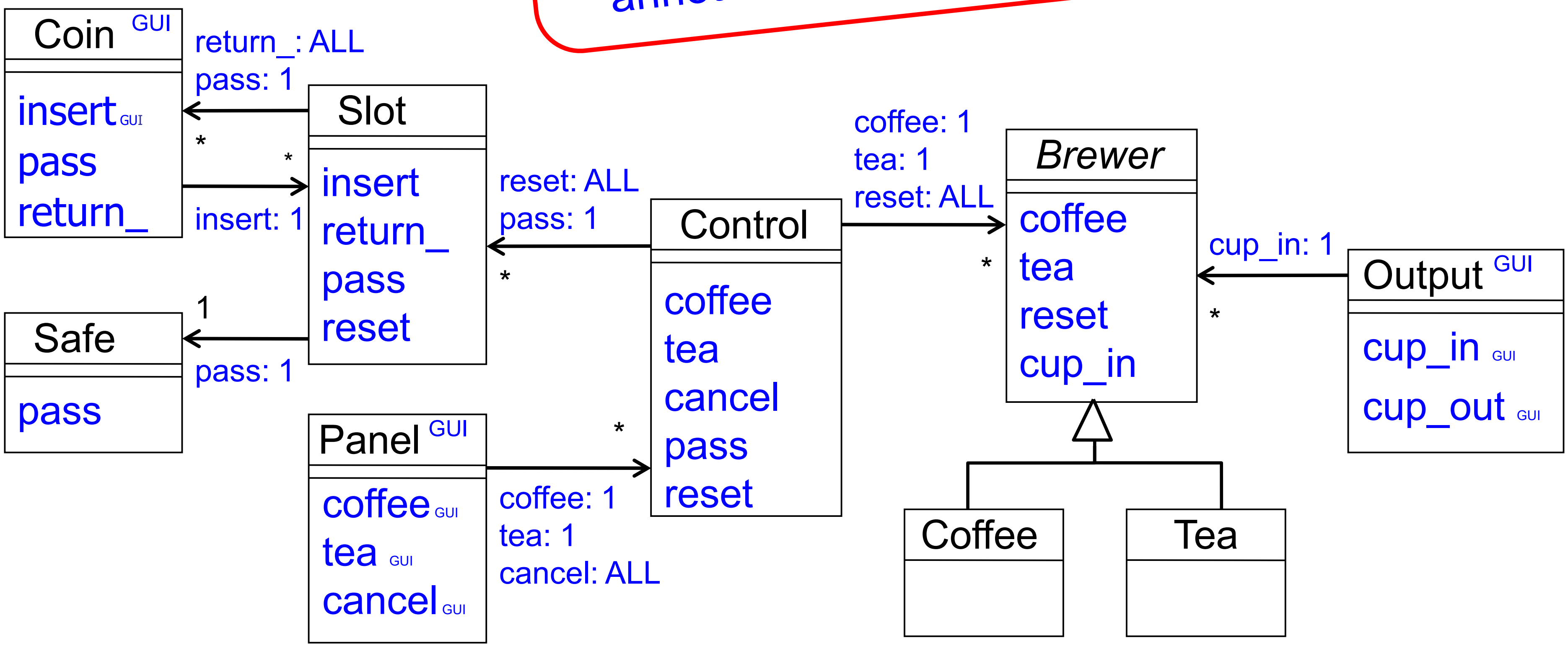
- We call objects elements now!

- Events (event types)
- Coordination annotations: event type + quantification annotation



... + Event declaration

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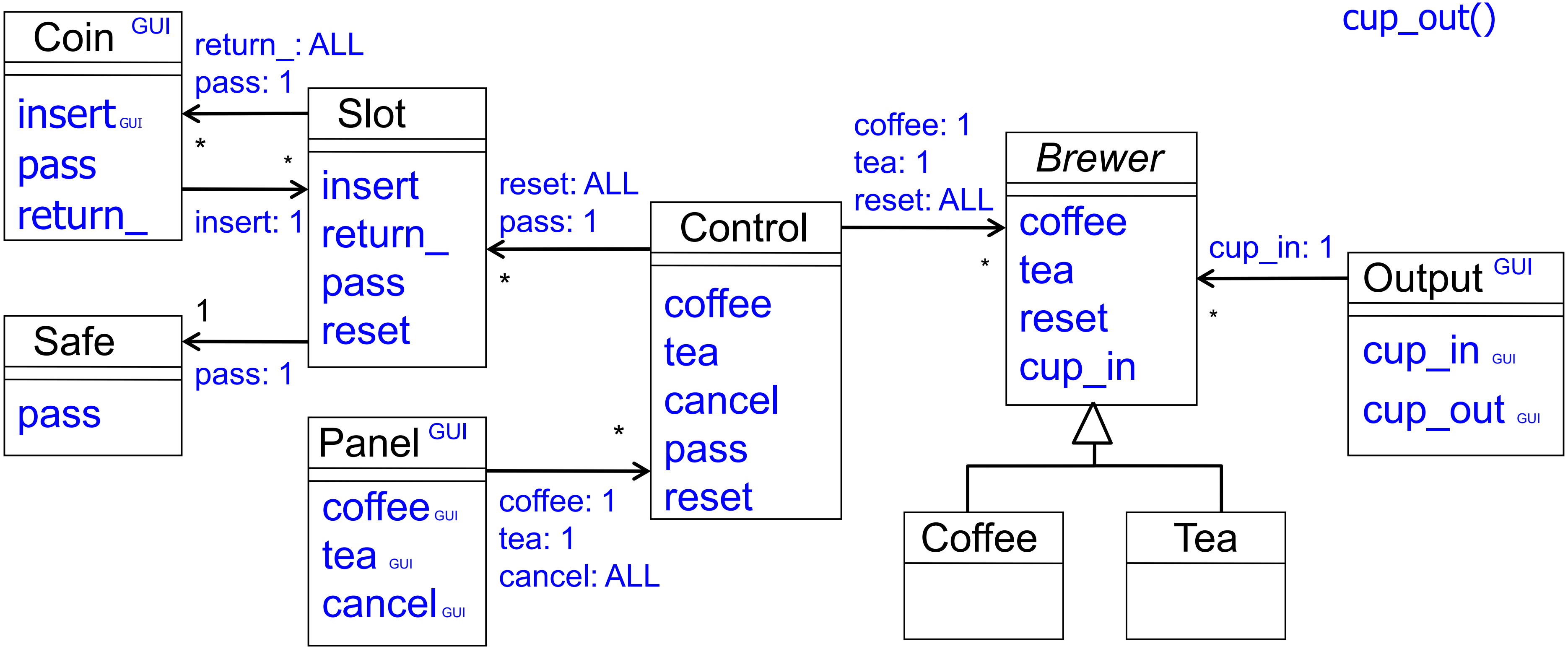
- Event (type) declaration
- Parameters

insert(Coin coin, Slot slot)
pass(Coin coin, Slot slot)
return(Slot slot)
reset_()

coffee()
tea()
cancel()

cup_in()
cup_out()



Interaction

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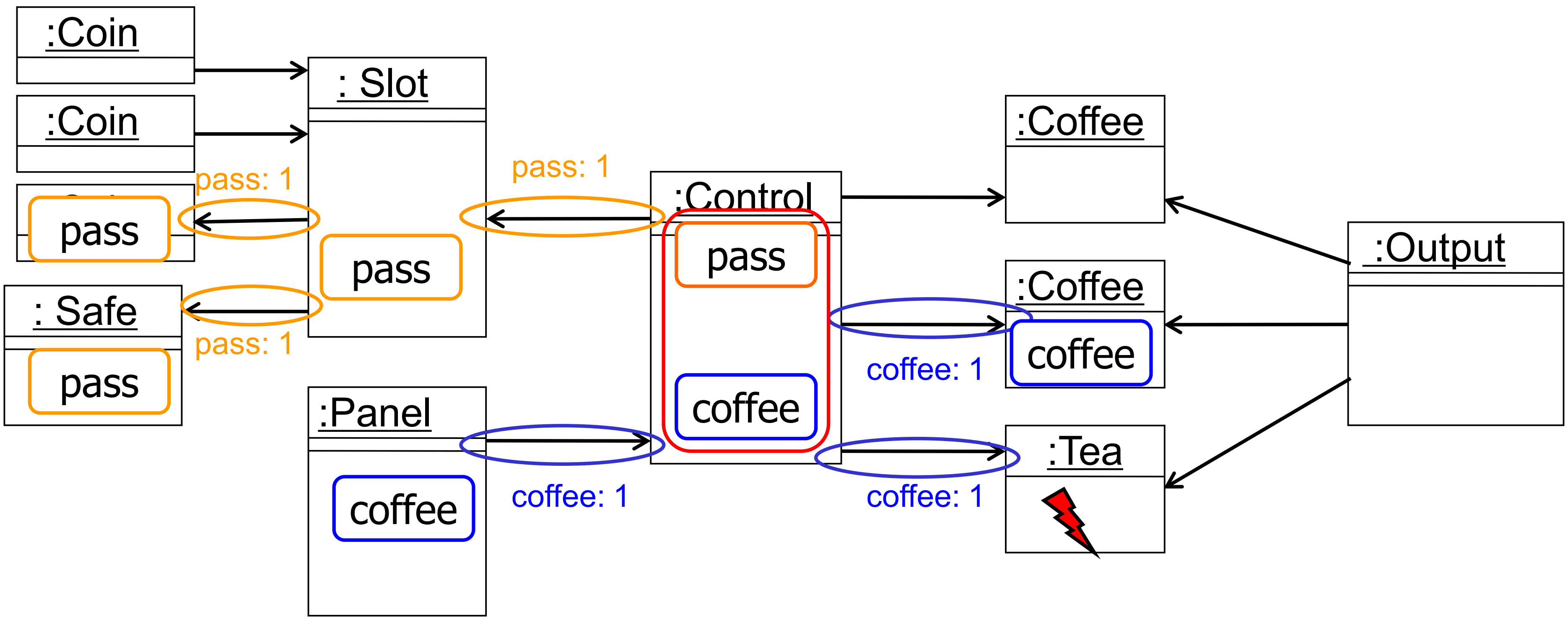
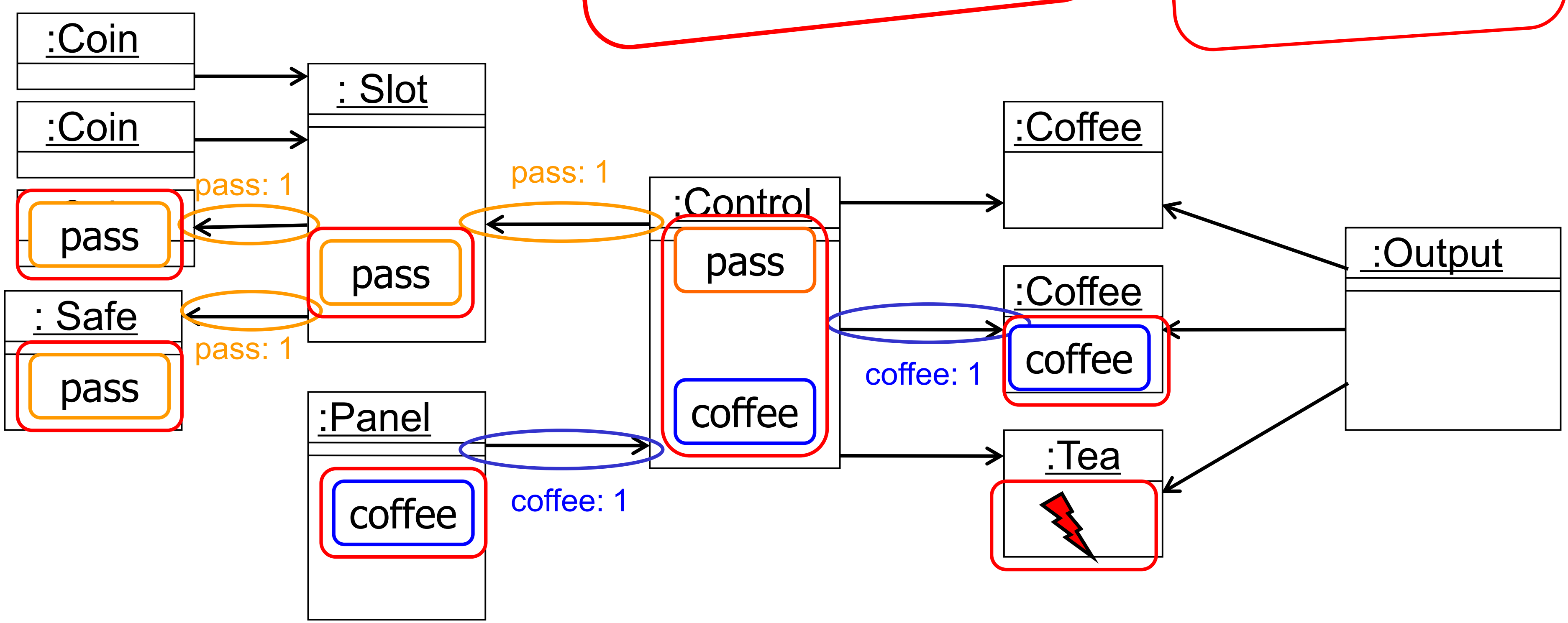


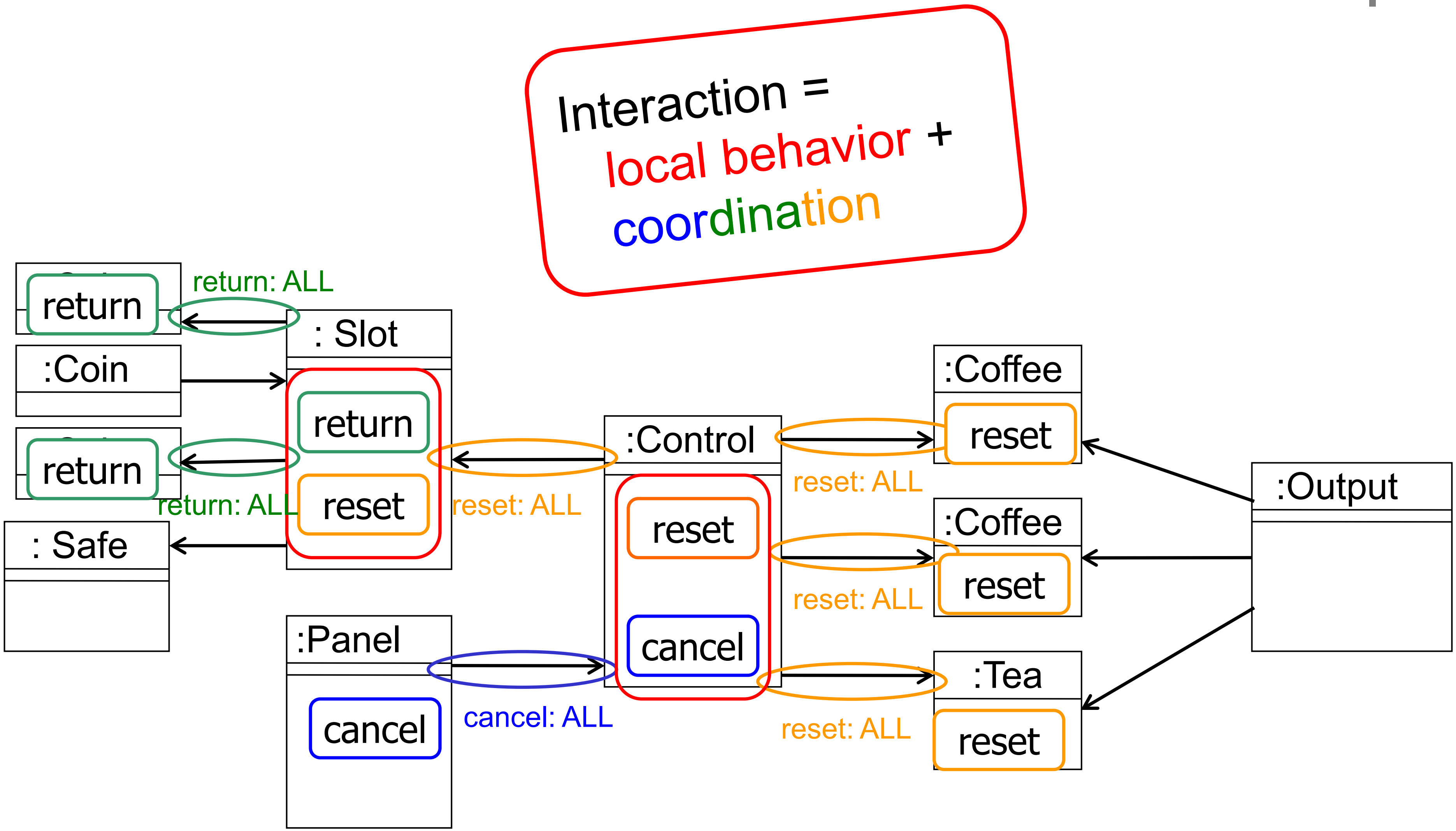
Interaction

Interaction =
local behavior +
coordination

We come back to
local behaviour!
→ slide 20



Another Interaction



Local behaviour: Coffee

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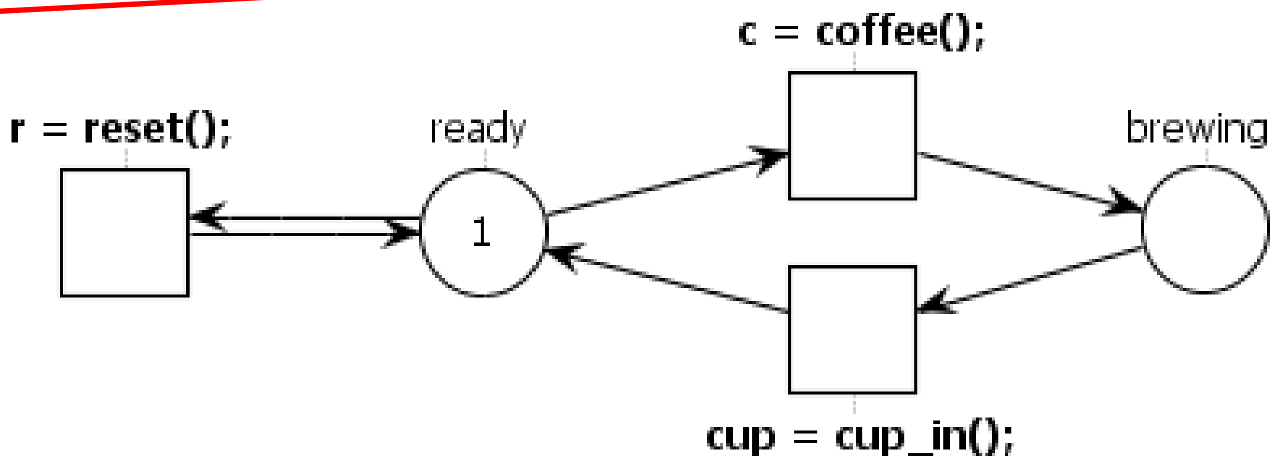
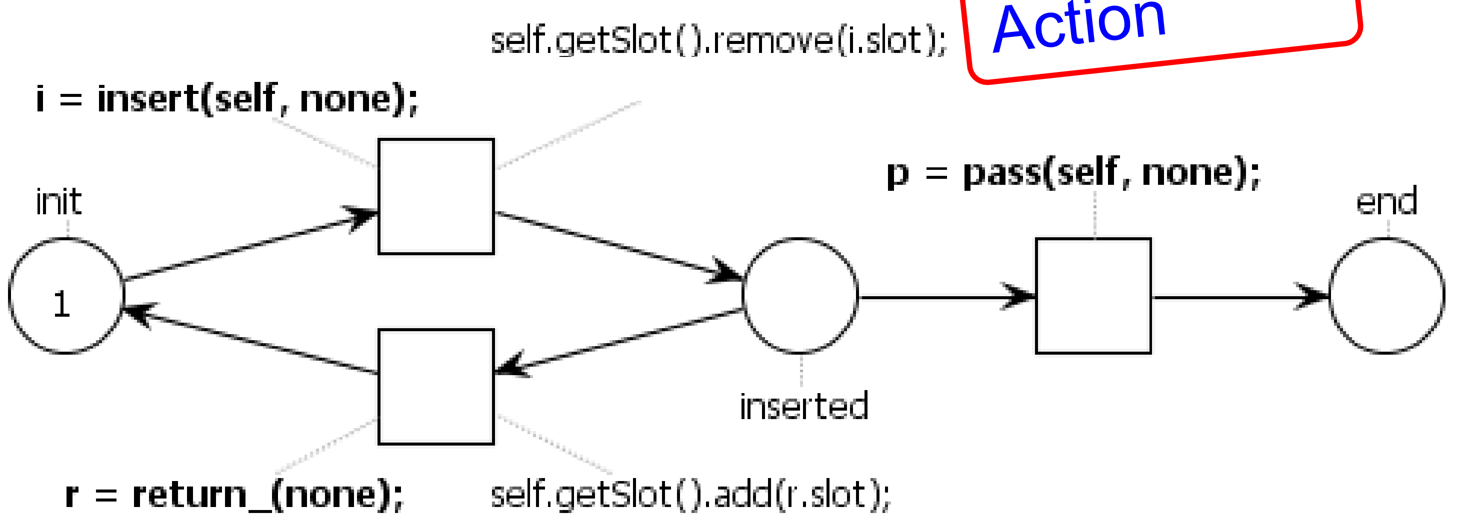
Elements are objects with an explicitly modelled **life-cycle**

Event binding



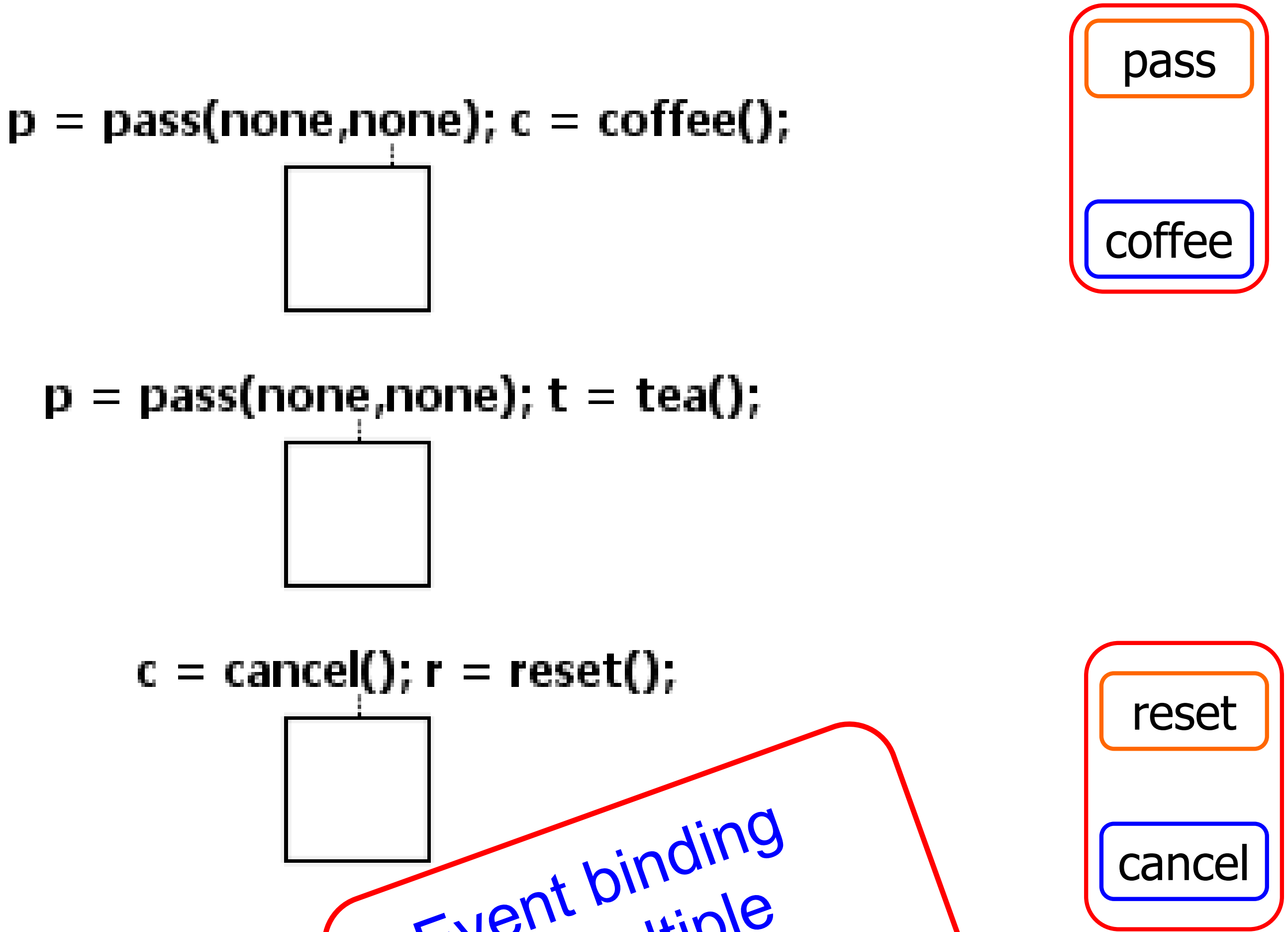
Local behaviour: Coin

Action



- Event binding
- Parameter assignment

Local behaviour: Control



- Event binding with multiple event types!

Local behaviour: Slot

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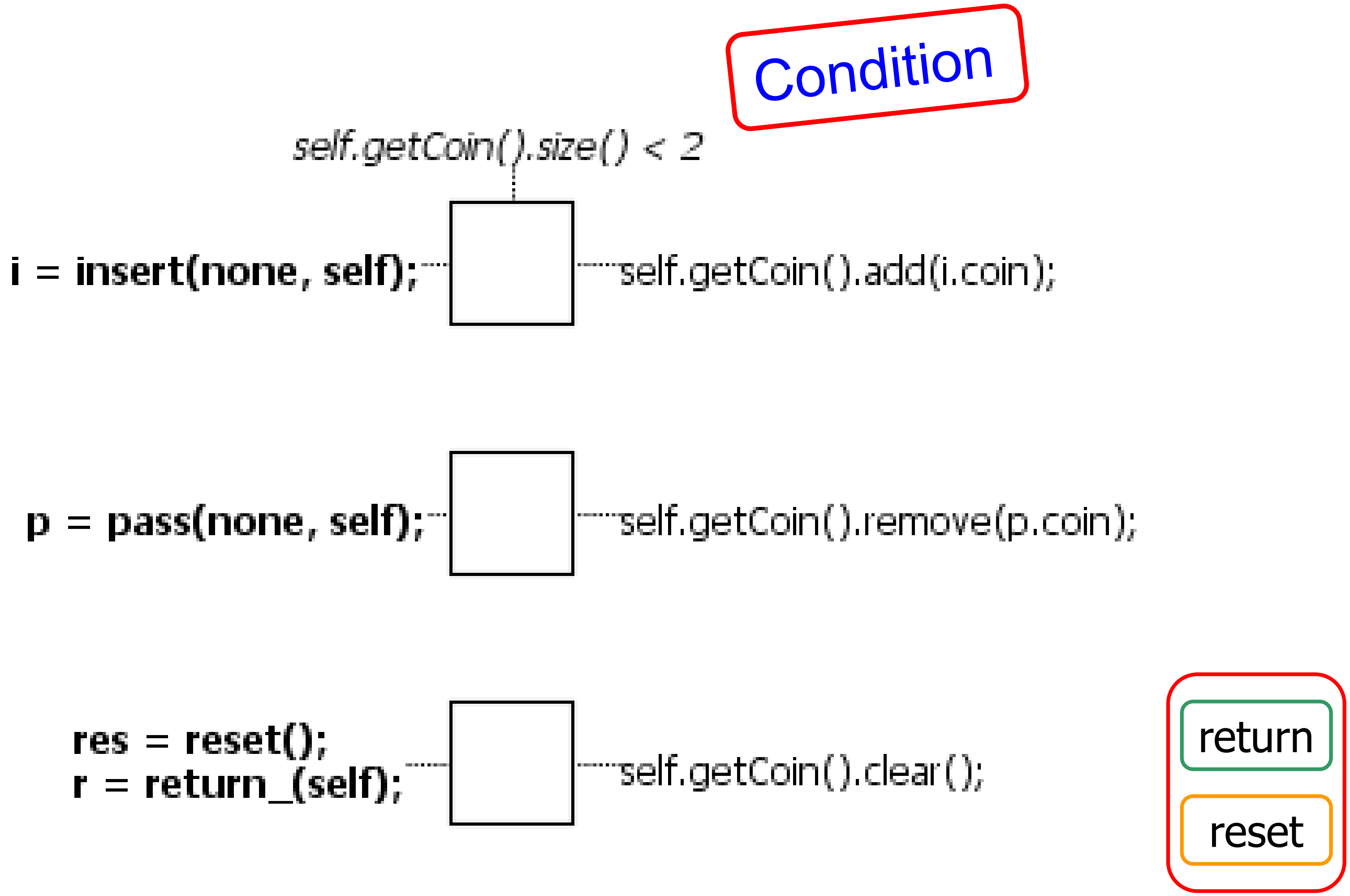

Interaction

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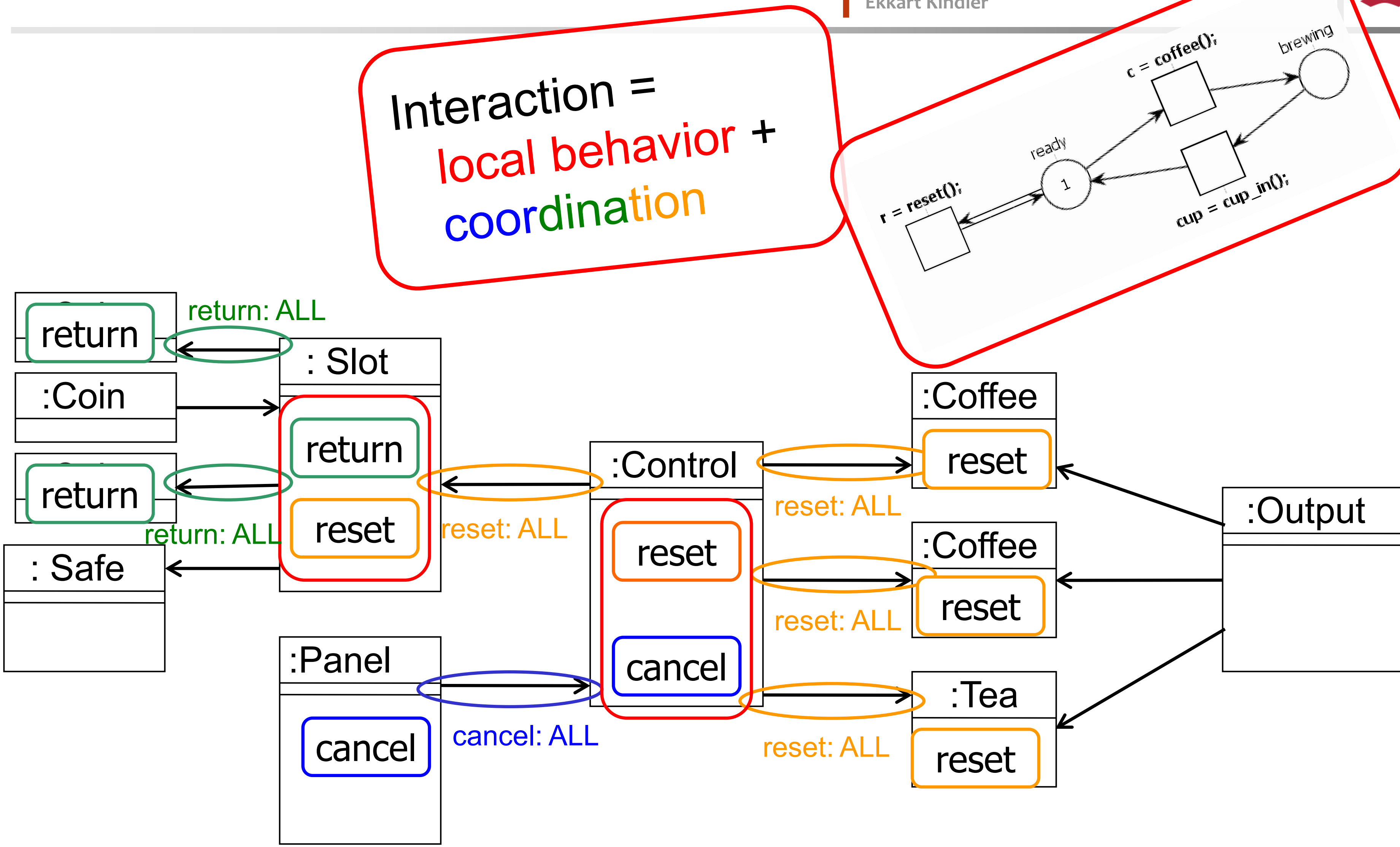
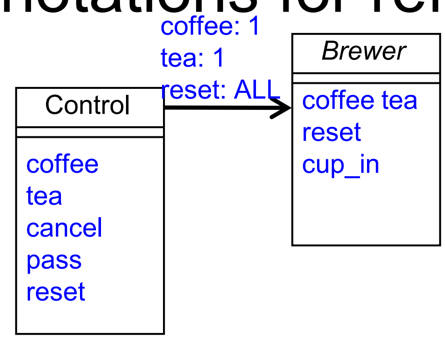


2.2 ECNO: Basic Concepts

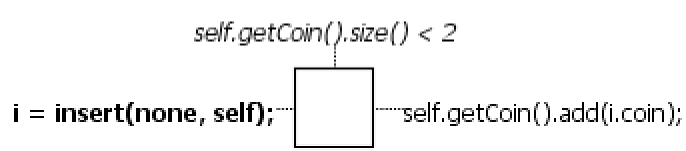
- ElementTypes (Classes)
- EventTypes with
  - parameters

insert(Coin coin, Slot slot)

- Global Behaviour: Coordination annotations for references
  - Event type
  - Quantification (1 or ALL)



- Local behaviour (life-cycle): ECNO nets (or something else)
  - Event binding (with parameter assignment)
  - Condition
  - Action



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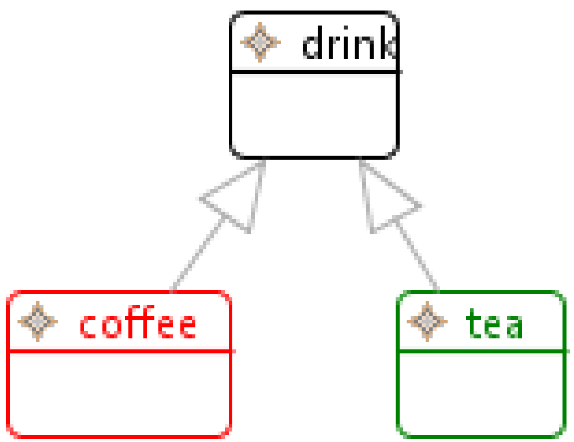
ECNO with its basic concepts has some limitations, which makes modelling things **in an adequate way** a bit painful. ECNO has some additional concepts to make modelling more convenient. E.g.

Just a glimpse …

- Inheritants on events



”Nicer Vendingmachine”

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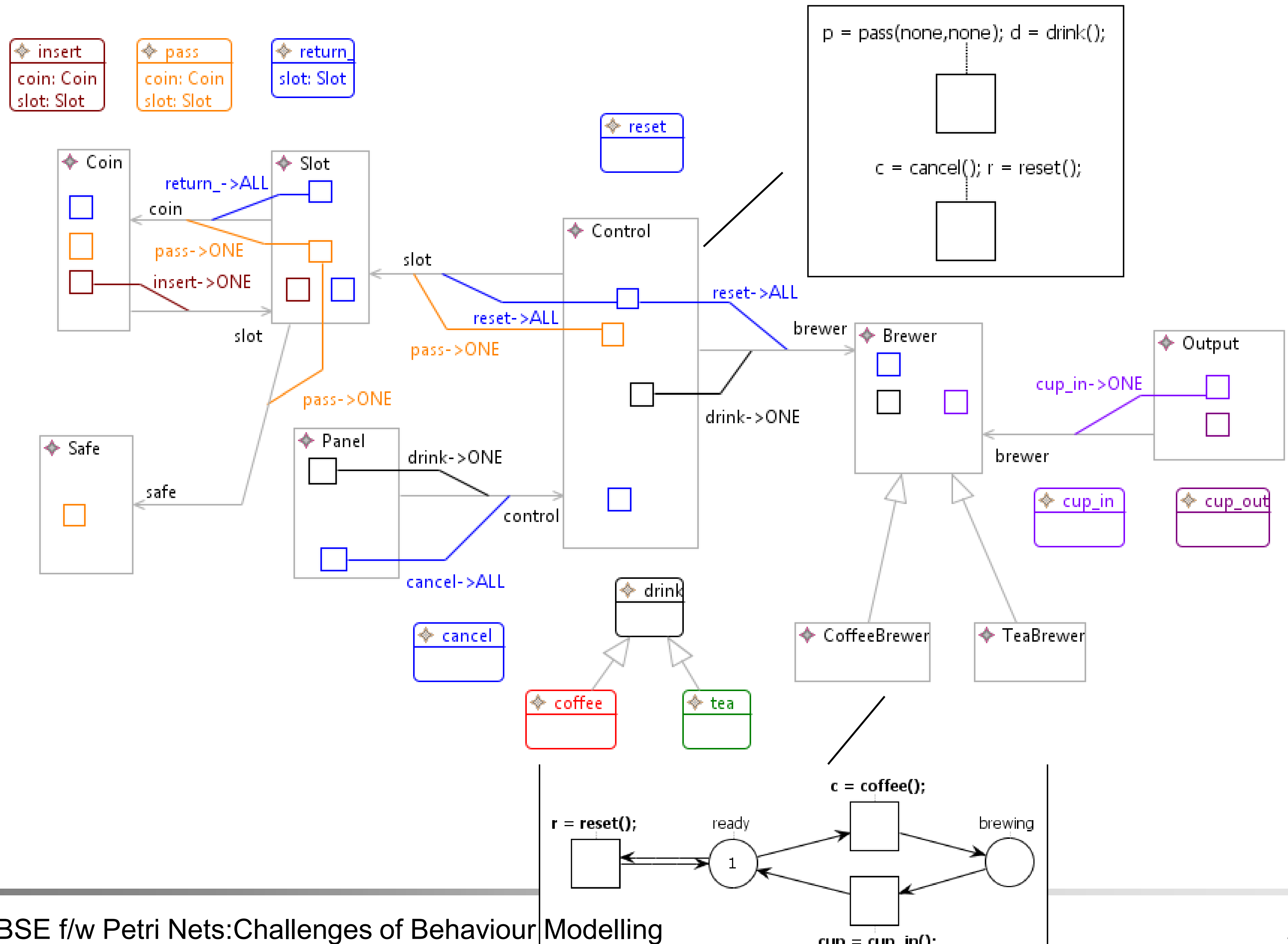

Behaviour inheritance

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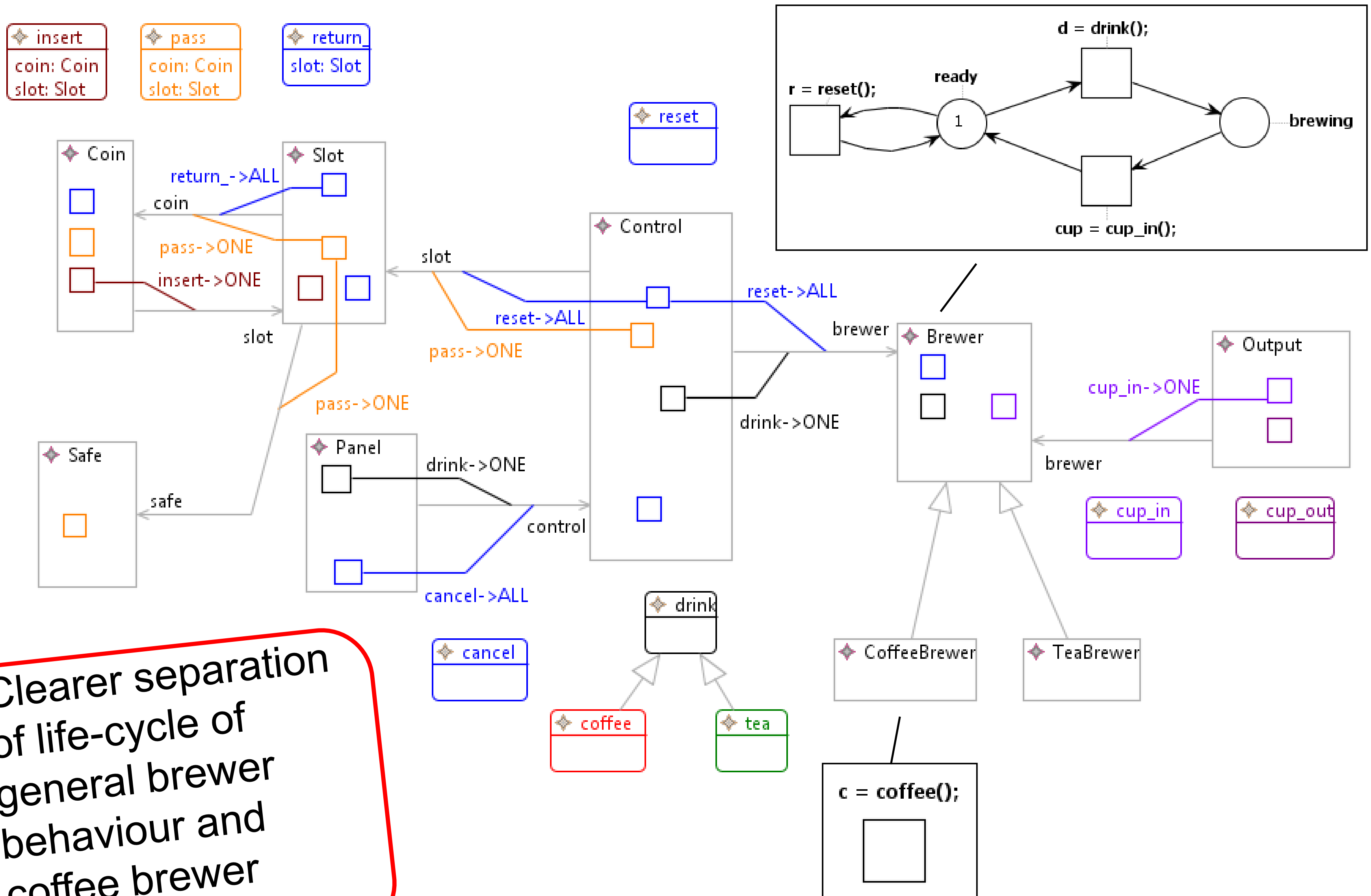
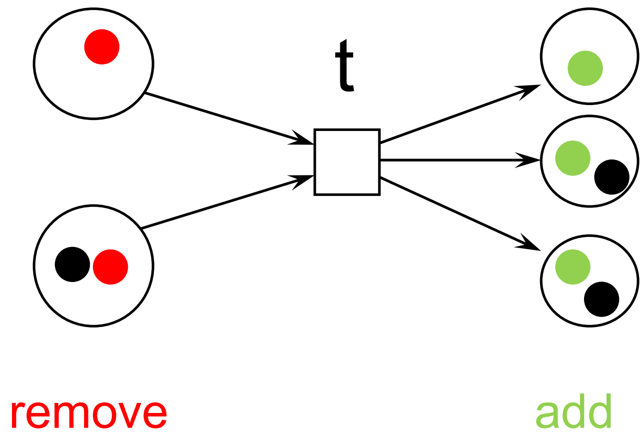


Clearer separation of life-cycle of general brewer behaviour and coffee brewer specifics.

2.4 Example 2: Petri nets



How can we model that behaviour in ECNO nets?

Transition t **enabled**:
  for ALL incoming Arcs a:
    for ONE source Place p of Arc a:
      find a token

Fire Transition t:
  for ALL incoming Arcs a:
    for ONE source Place p of Arc a:
      find a token and remove it

  for ALL outgoing arcs a:
    for ONE target Place p of Arc a:
      add a new Token

Petri net: Abstract Syntax

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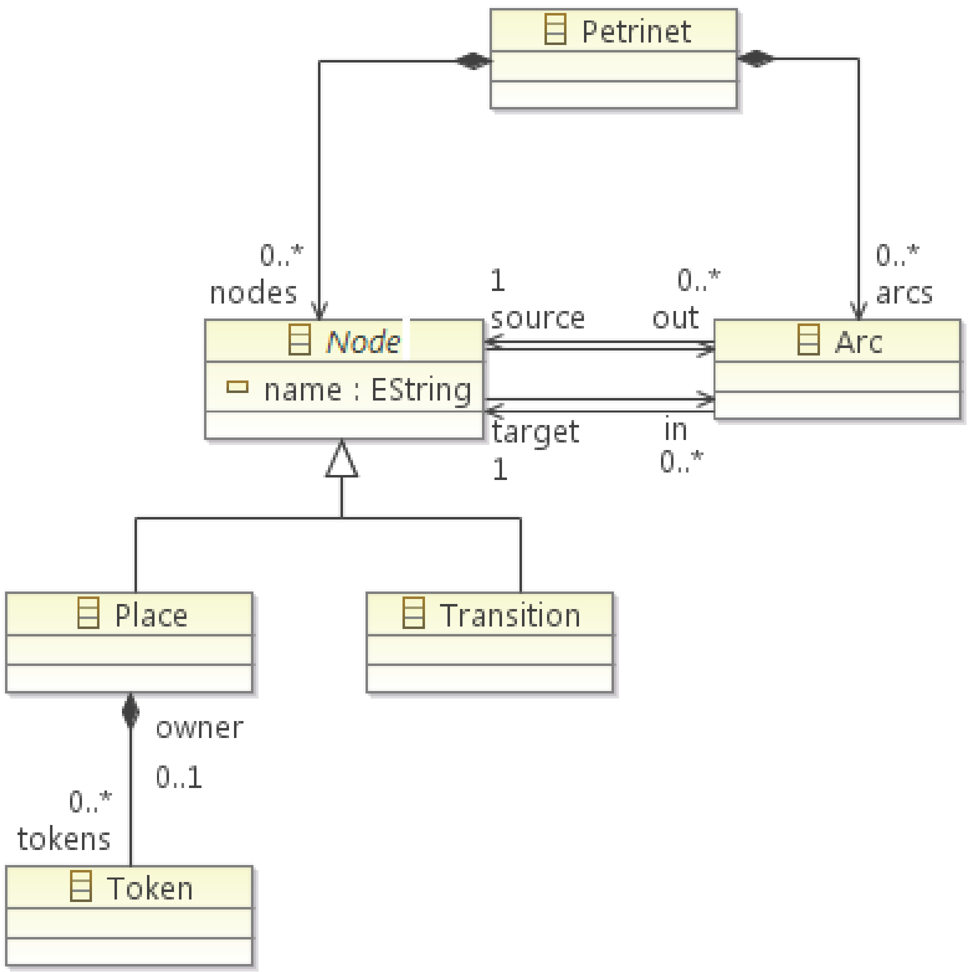
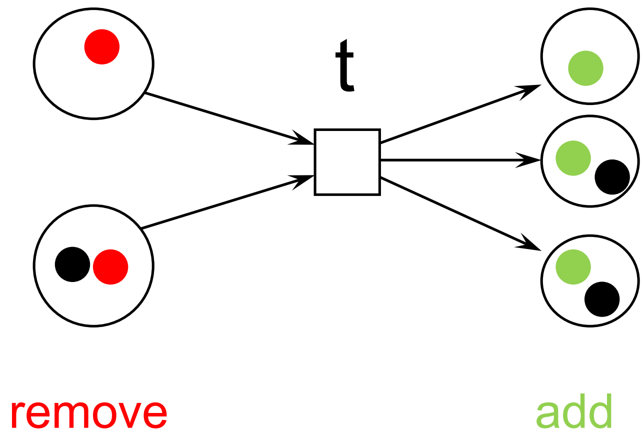


Example 2: Petri nets

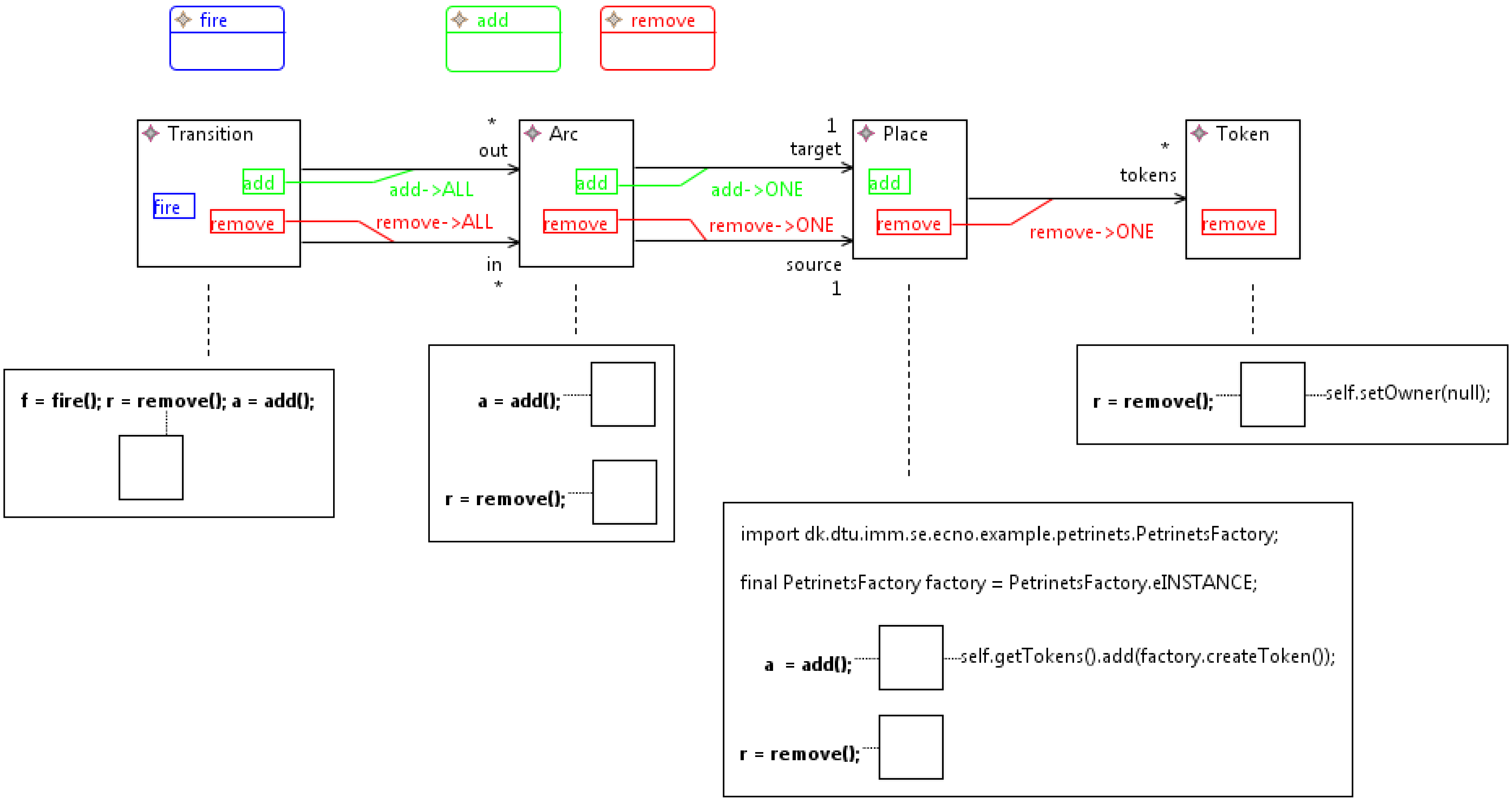


Transition t **enabled**:
  for **ALL** incoming Arcs a:
    for **ONE** source Place p of Arc a:
      find a token

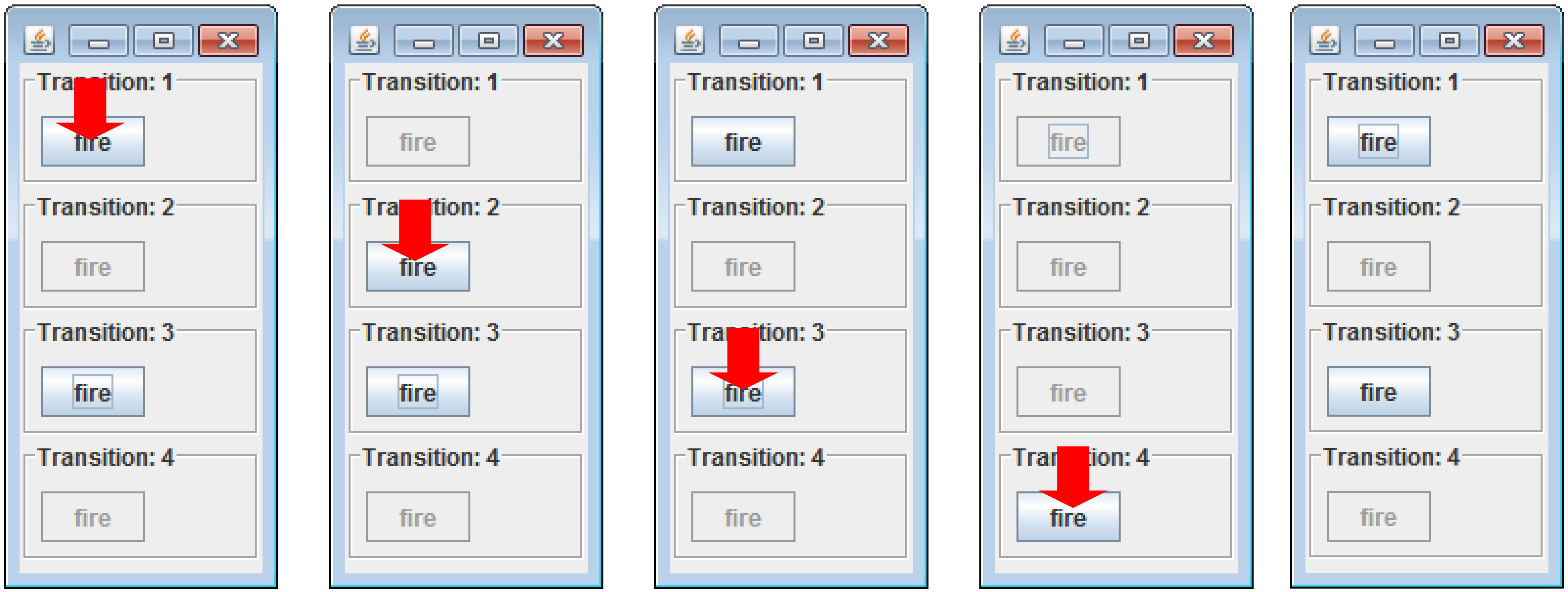
Fire Transition t:
  for **ALL** incoming Arcs a:
    for **ONE** source Place p of Arc a:
      find a token and remove it

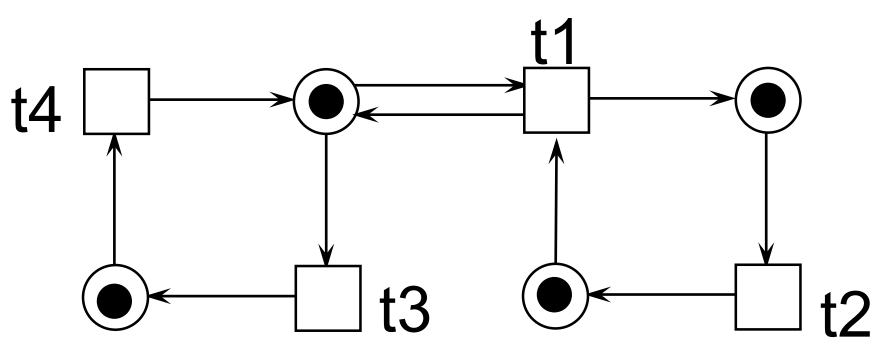
  for **ALL** outgoing arcs a:
    for **ONE** target Place p of Arc a:
      add a **new** Token

ECNO Semantics of PN



Result


Transition: 1
fire
Transition: 2
fire
Transition: 3
fire
Transition: 4
fire


t1
t4
t3
t2

Petri net simulator

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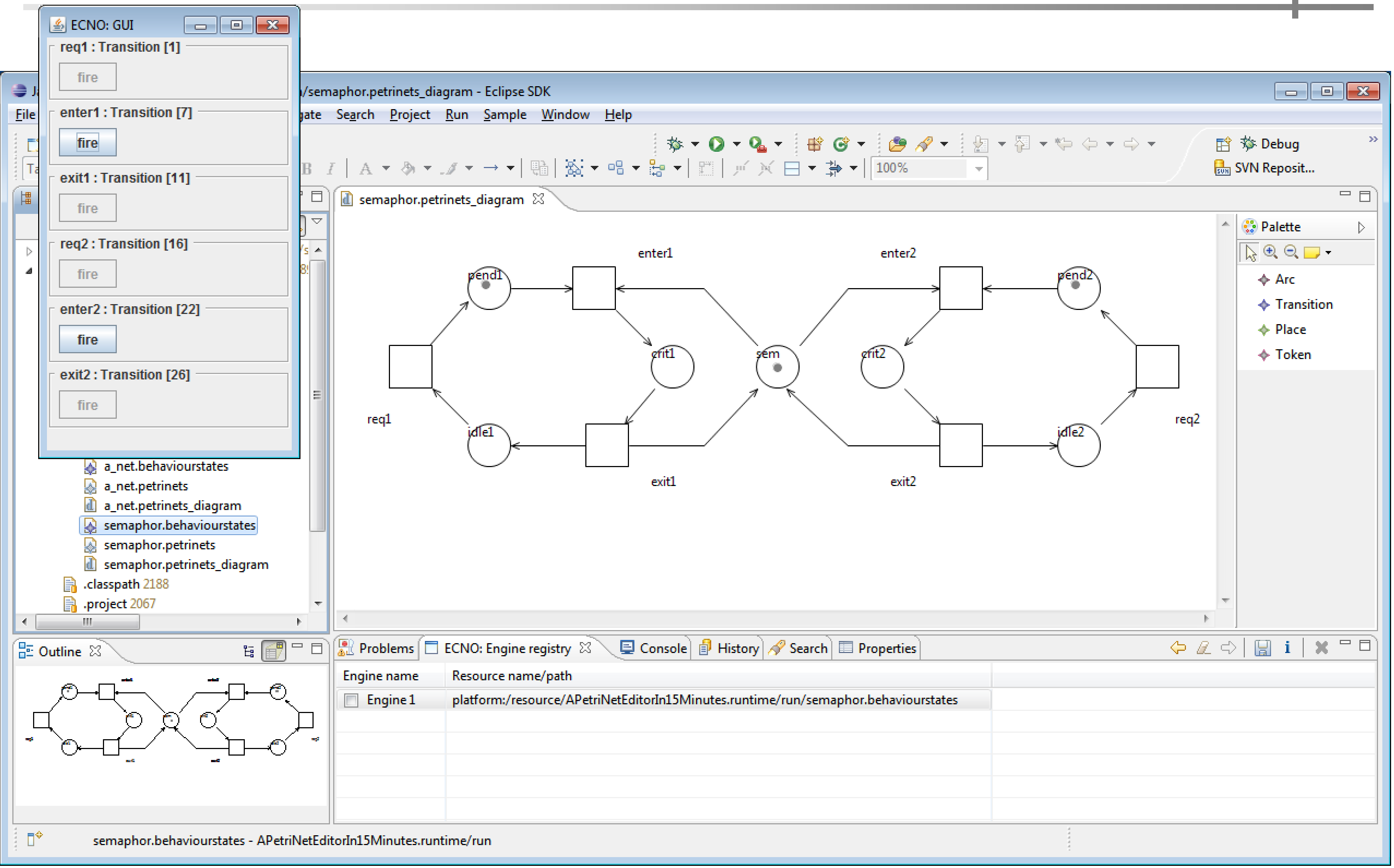

2.5 ECNO: Summary

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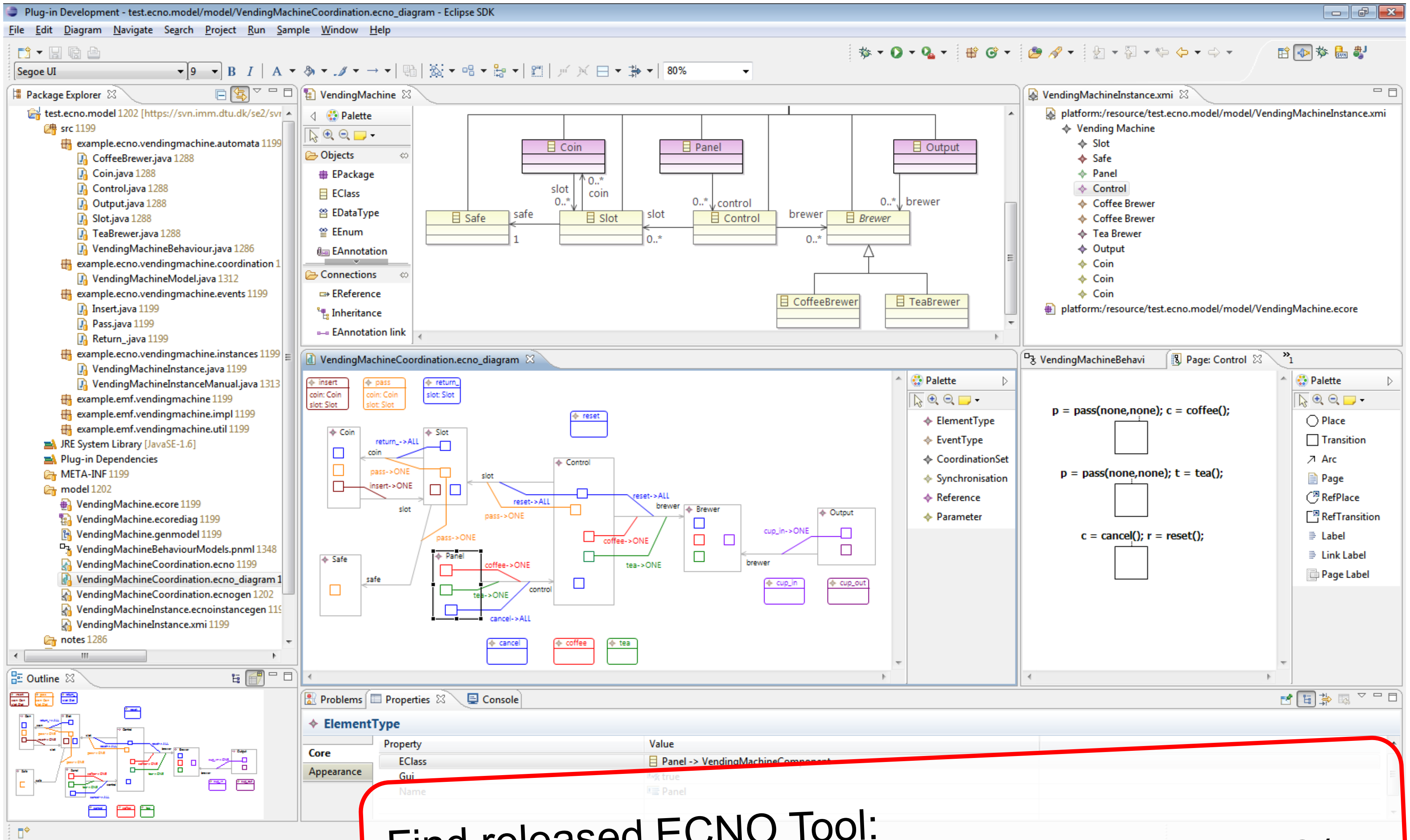

Find released ECNO Tool:
http://www2.compute.dtu.dk/~ekki/projects/ECNO/

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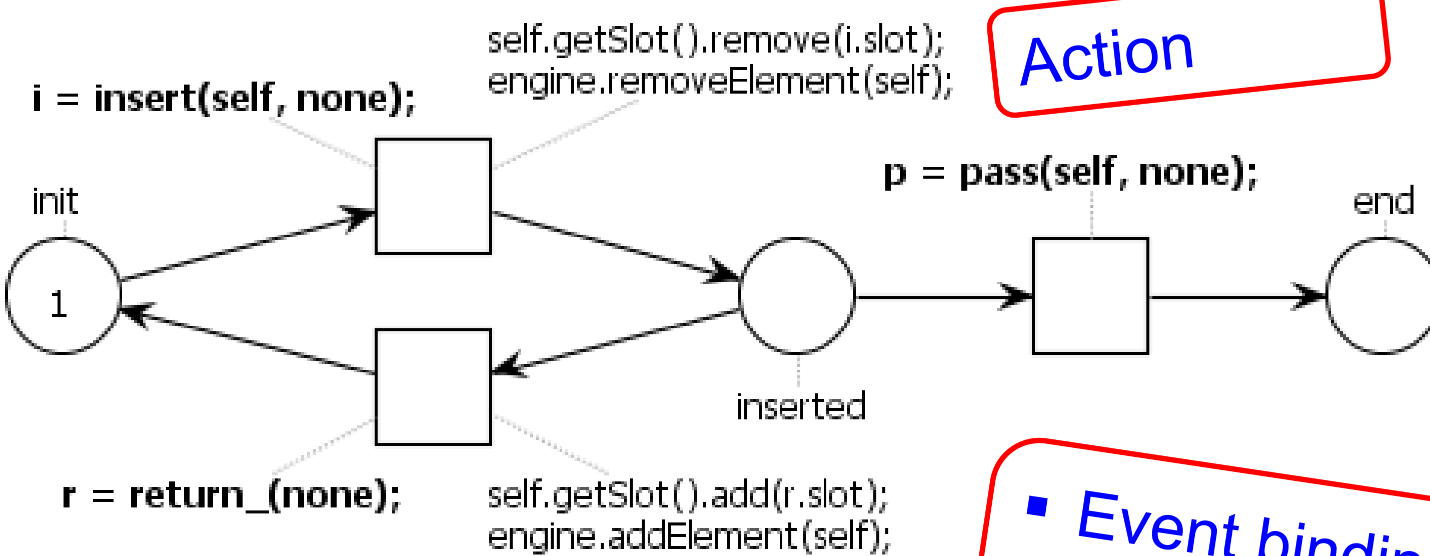
- ECNO nets and the code generator are probably the largest application of the ePNK!

Declarations and imports

```
import dk.dtu.imm.se.ecno.engine.ExecutionEngine;

final ExecutionEngine engine = ExecutionEngine.getInstance();
```



Action

- Event binding
- Parameter assignment

Beyond Mickey Mouse

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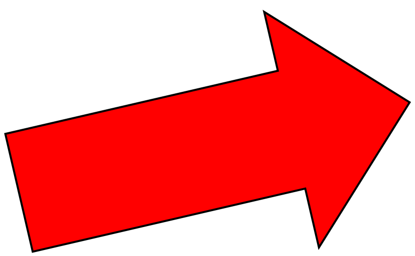

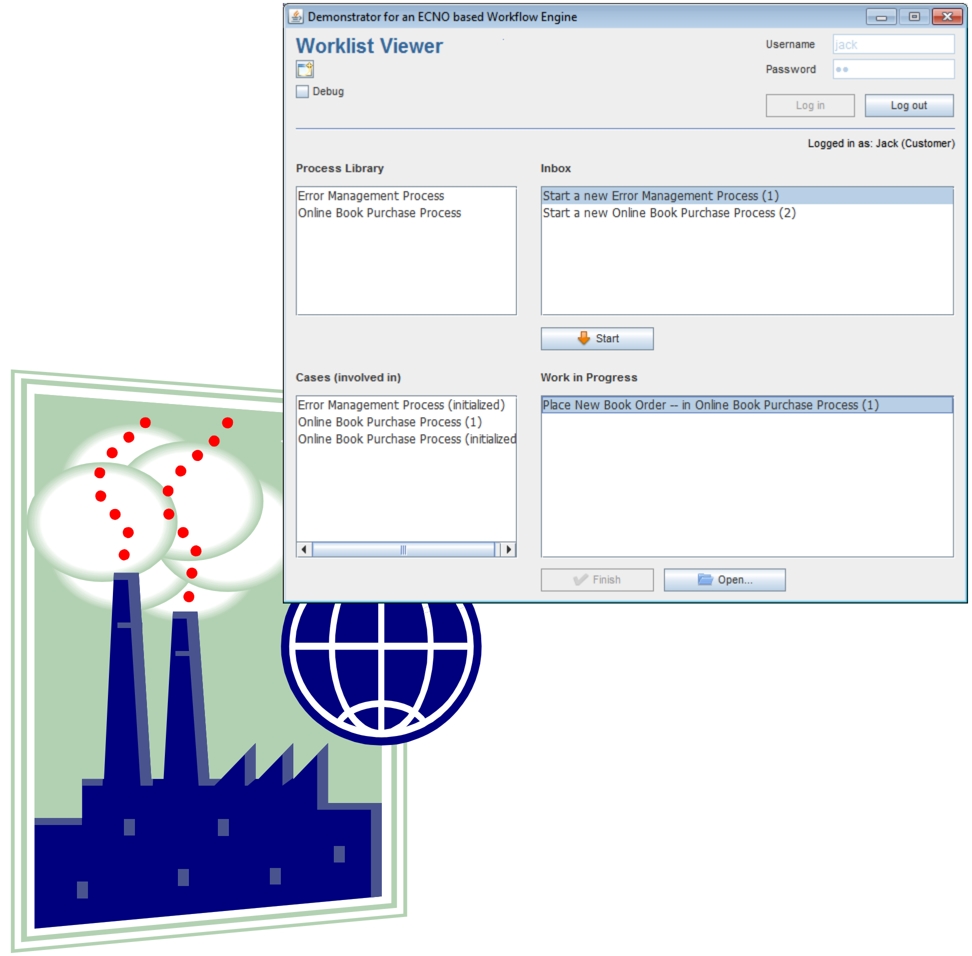

Discussion

- Models of software on higher level of abstraction
  → concise / adequate
- Domain model including semantics
- Coordination! Not invocation!

UML is too invocation oriented!

- Idea: Define semantics of ECNO in ECNO itself (truely "meta")

UML does that (→ MOF)
– but for structure only!
How about behaviour?

ECNO: Focus

- Software Engineers
  (vs. end-users)
- Domain level
  (vs. low-level programming)
- Coordination
  (vs. algorithmics/invocation/sequential flow)
- Behaviour
  (vs. GUI)

But, there is a project were standard GUI generators could be coupled with ECNO, to model the complete software including behaviour and GUI!

Comment of a non-IT friend

”Oh, that’s great. Then I can also develop my own software now.”

My first reaction:
Nooo?!

ECNO is for software engineers, helping them focussing on the domain and not on technical details!

On second thought:

Can’t we help end-users develop their own programs? At least in simple cases.