The ePNK: A model bases development project

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Motivation

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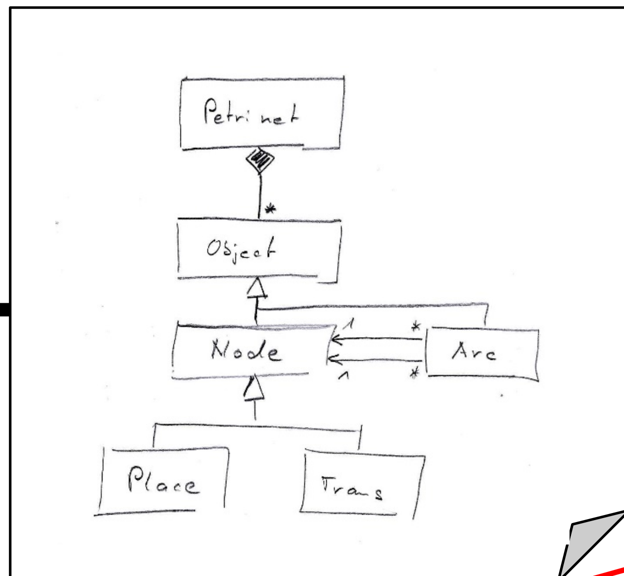
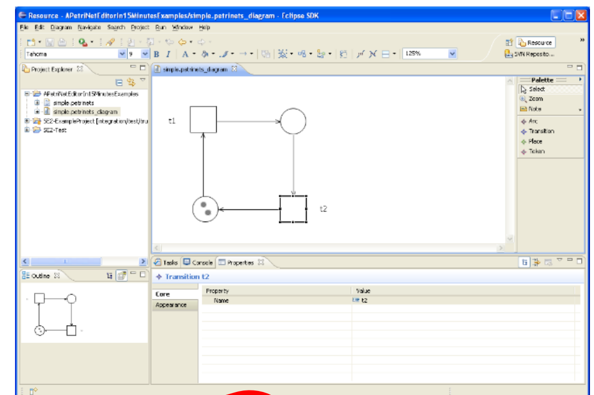
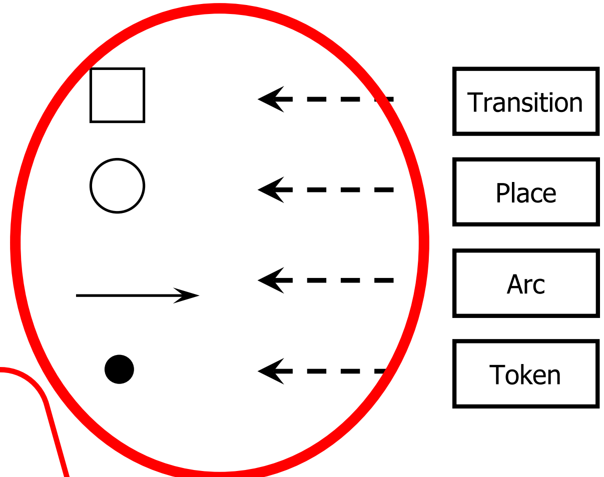
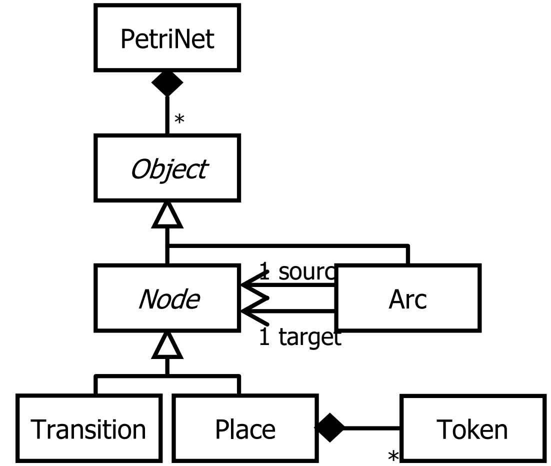




"A Petri net editor in 15 minutes"

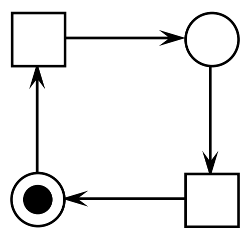
Motivation

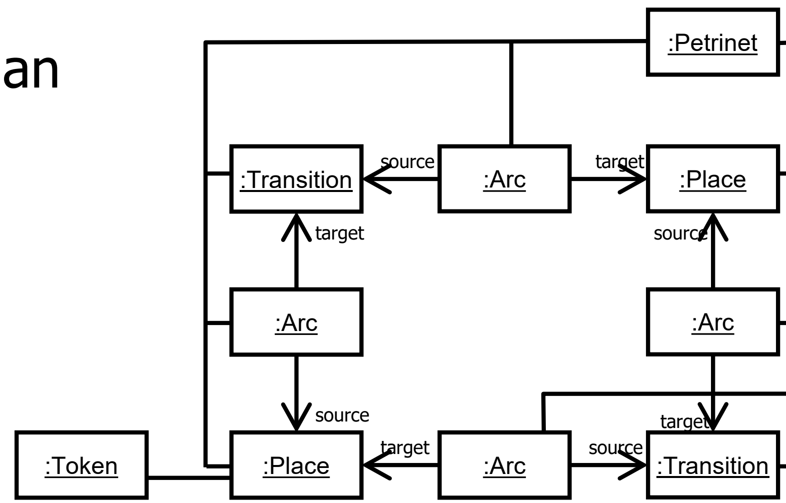




Eclipse EMF and GMF technology

generate an editor





concrete syntax

abstract syntax

Motivation

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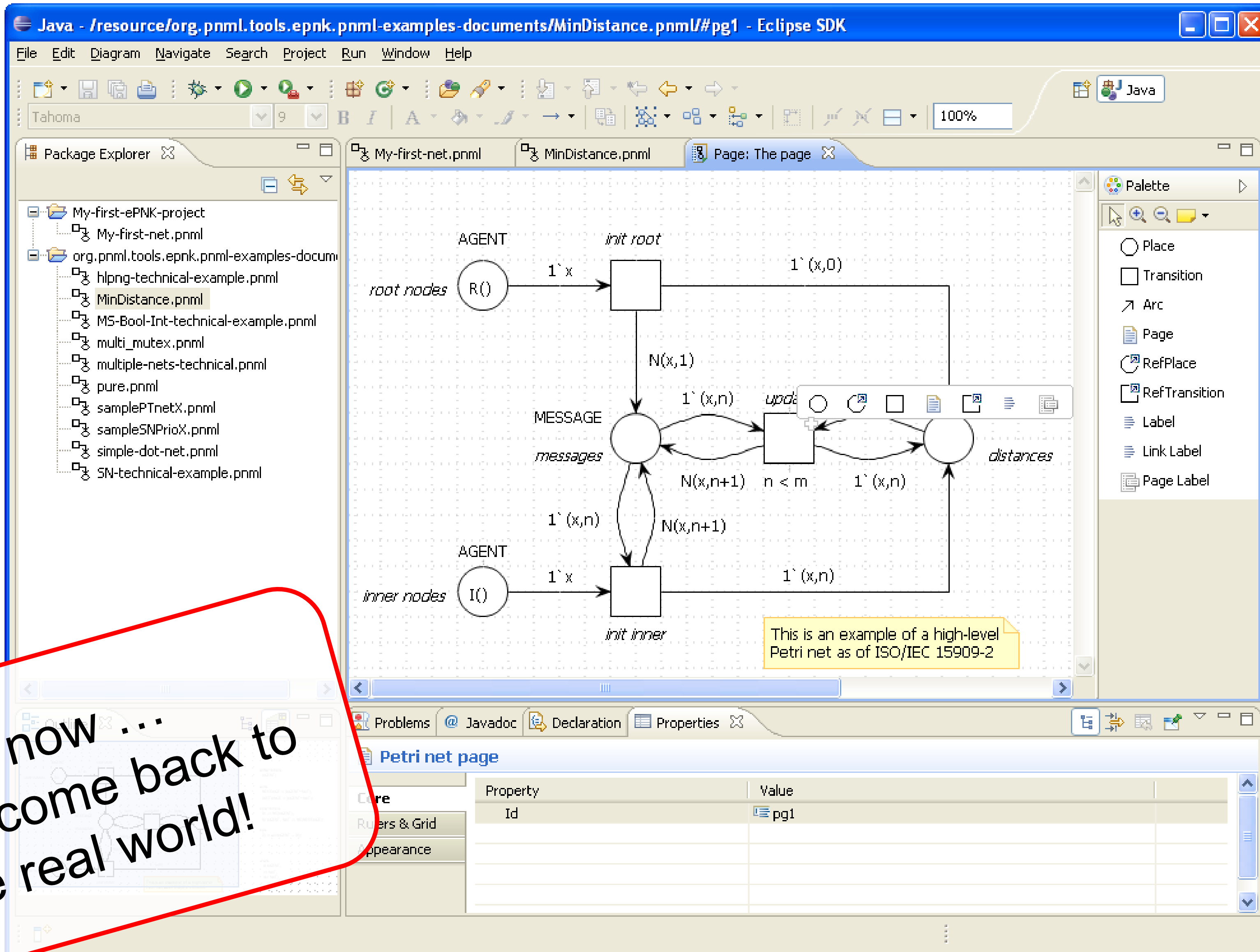

And now … welcome back to the real world!

Real world issues

- Many more features:
  Pages, reference nodes, ...
- Need to define specific XML syntax (PNML)
- Different versions of Petri nets
  (each would need a separate GMF-editor)
- Definition of new versions of Petri net types
  (without touching the existing tool,
  without programming at all?)

as well as some other extensions

Outline

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- Motivation
- PNML
  - Overview
  - Core model
  - Type model
  - Mapping to XML
- Problems and issues
- Concepts for solutions
- Example: YAWL nets and simulator

PNML in a nutshell

- The Petri Net Markup Language (PNML) is an XML-based transfer format for "all kinds" of Petri nets.

- PNML is an International Standard: ISO/IEC-15909-2
  Part 2: focus on high-level nets (under ballot – again)
  Part 3: different extensions
  - modularity
  - type and feature definitions
  - particular versions of Petri nets
  - …

Note that Part 3 is not an international standard yet.

But ...

Isn't XML just soooo boring?

You are sooo right!

That's why the focus is on concepts.

PNML and XML

- The Petri Net Markup Language (PNML) is an XML-based transfer format for "all kinds" of Petri nets.
- For exchanging, PNML between different tools, the XML syntax is important; but that's a technical issue.
- **The interesting stuff are the concepts of PNML.**

Challenges

many versions and variants of Petri nets

- with many common features,
- but also with many variations,
- some fundamental differences,
- and many different combinations of the same or similar features

Petri nets are so simple that everybody thinks he or she can easily change them.

Objective

- PNML should enable the exchange of all kinds of Petri nets, and, ultimately,
- alleviate exchanging between Petri net tools that support different versions of Petri nets without loosing too much information.

A first example

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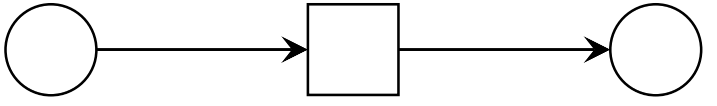
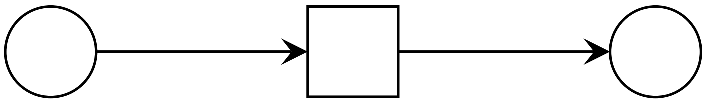
```
<place id="p1"/>
<arc id="a1" source="p1" target="t1"/>
<transition id="t1"/>
<arc id="a2" source="t1" target="p2"/>
<place id="p2"/>
```



A first example

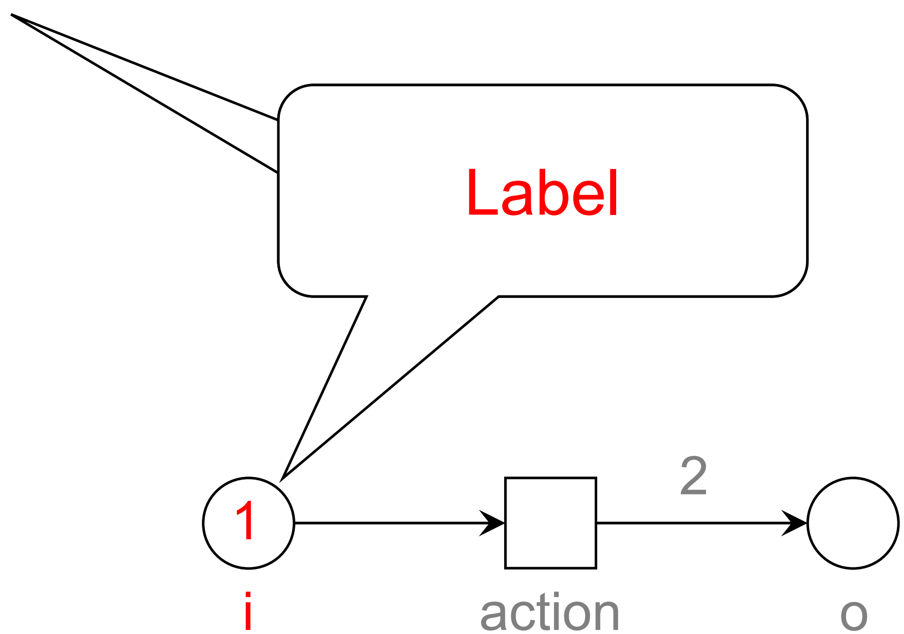

```
<pnml xmlns="http://www.pnml.org/...">
  <net id="n1" type="...">
    ...
    <place id="p1"/>
    <arc id="a1" source="p1" target="t1"/>
    <transition id="t1"/>
    <arc id="a2" source="t1" target="p2"/>
    <place id="p2"/>
    ...
  </net>
</pnml>
```



A first example


```
...
    <place id="p1">
      <name>
        <text>i</text>
      </name>
      <initialMarking>
        <text>1</text>
      </initialMarking>
    </place>
...
```

The particular kind of label depends on the „kind“ of Petri net.



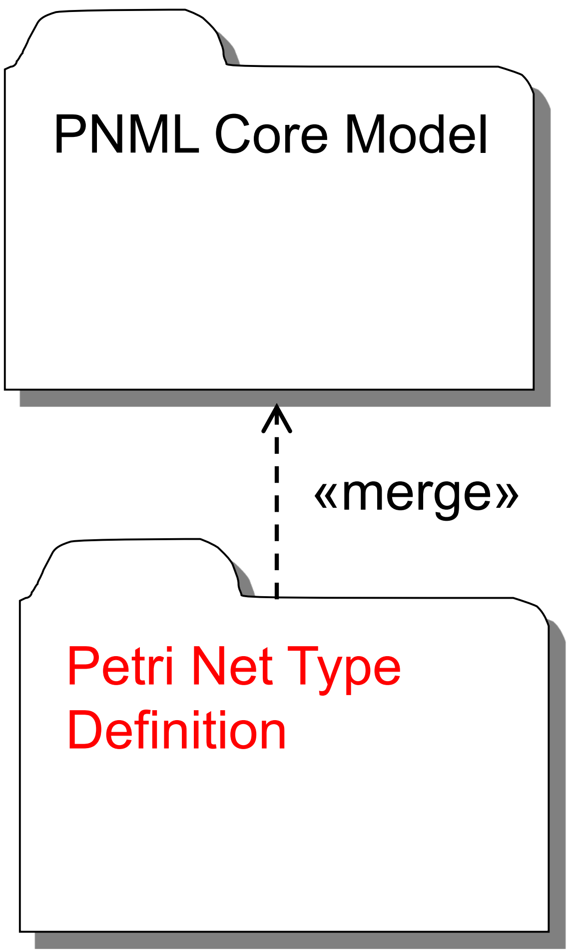
Basic Idea

„All kinds“ of Petri nets can be represented by

- places
- transitions, and
- arcs

along with some

- labels



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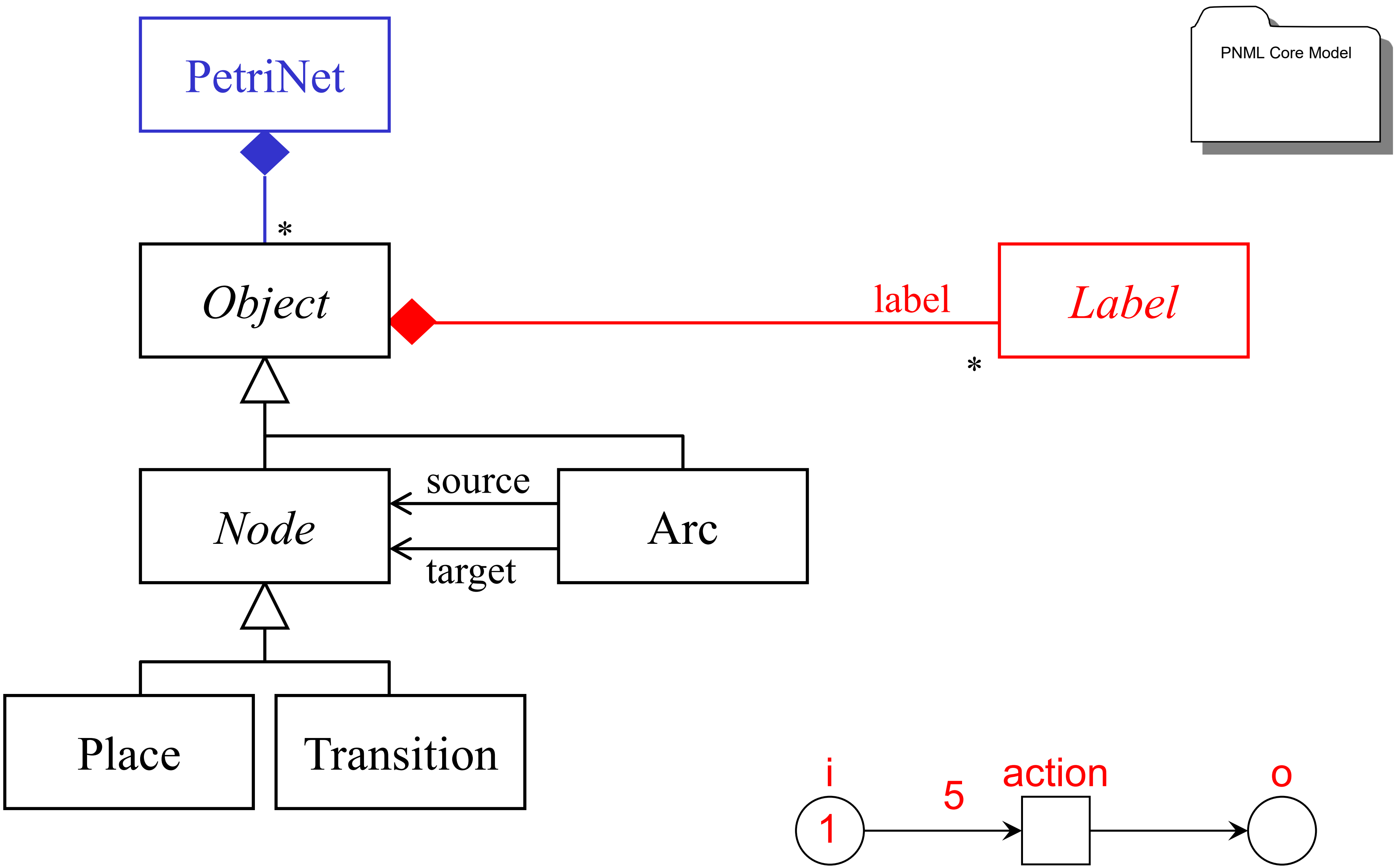
Core Model (overview)



Core Model (overview)

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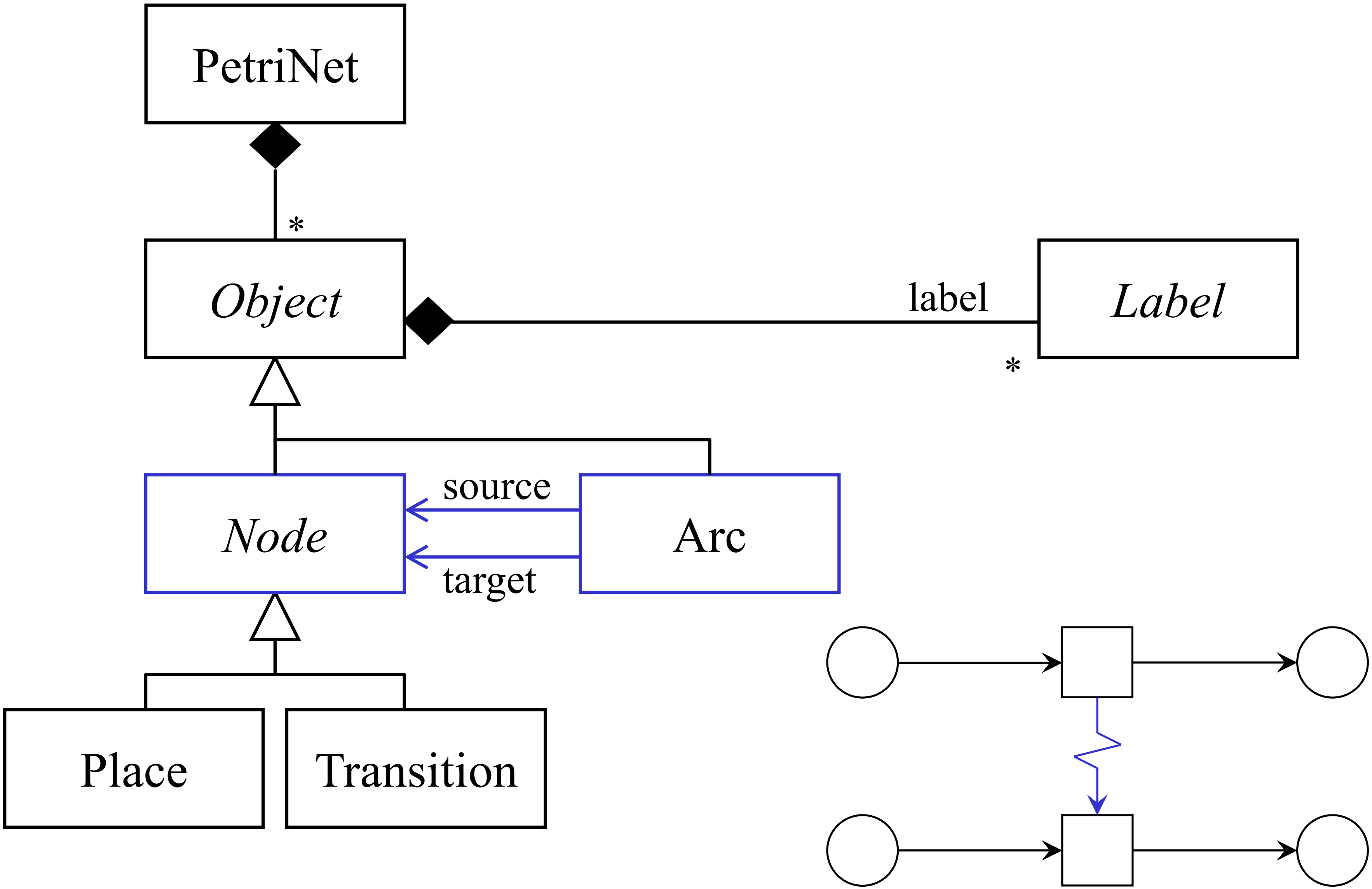
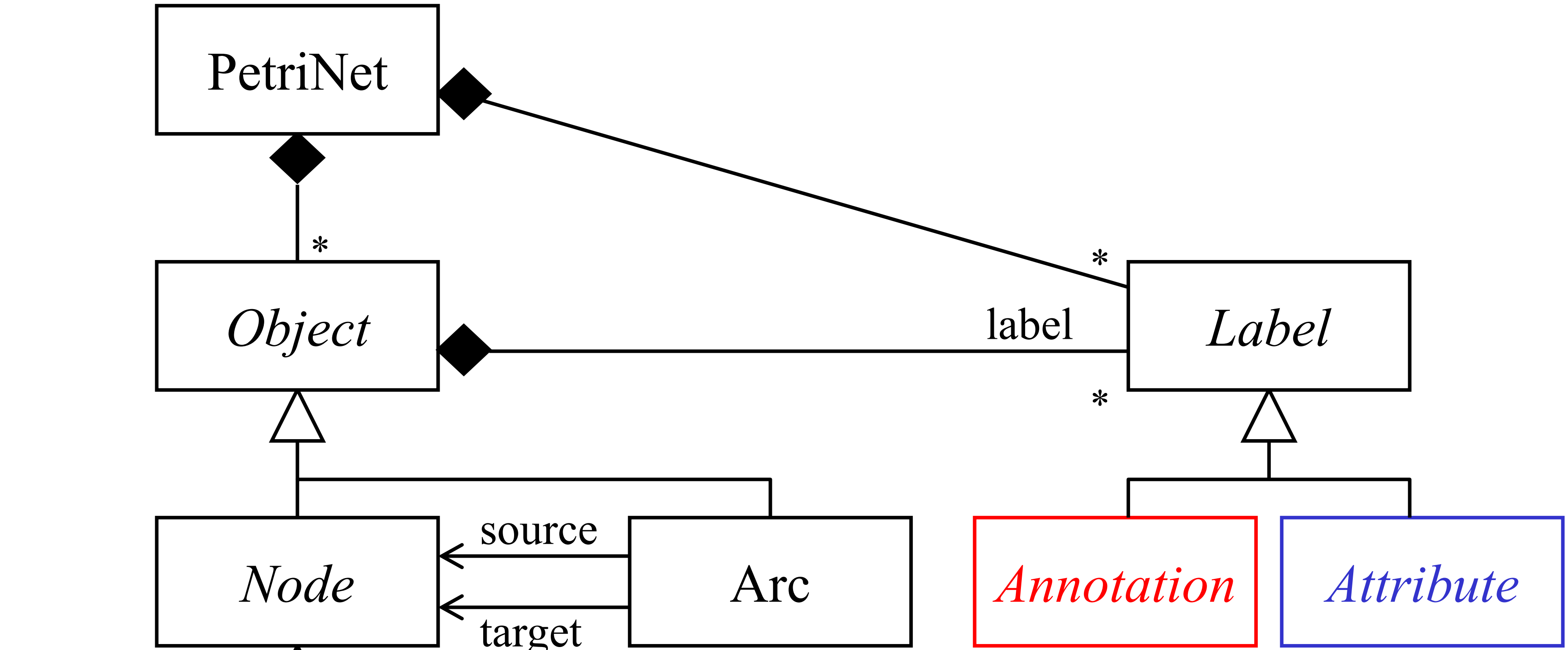
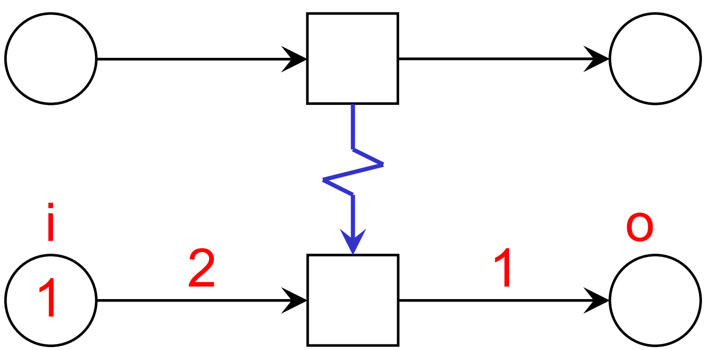


Core Model (overview)





Core Model (overview)

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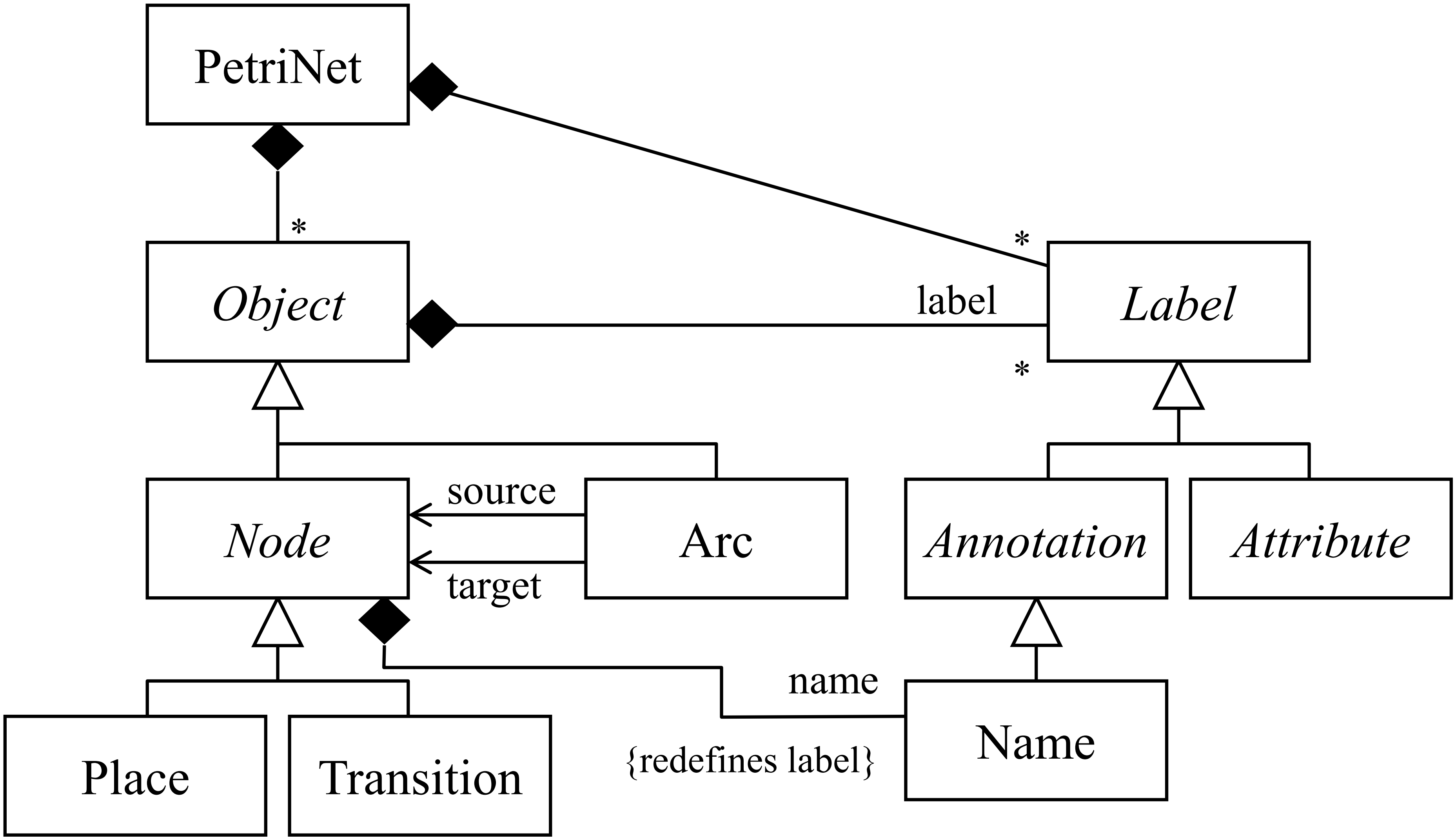
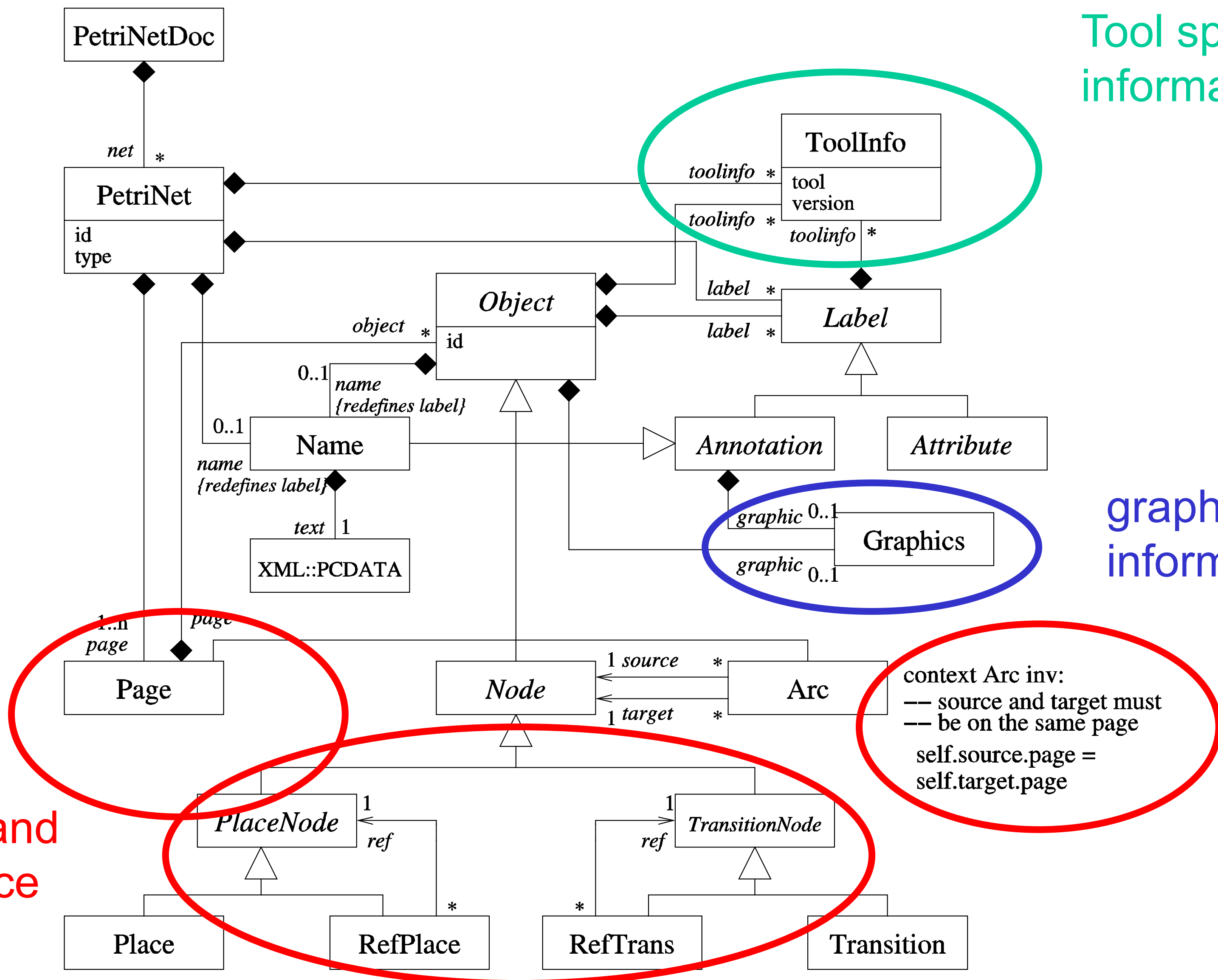


PNML Core Model



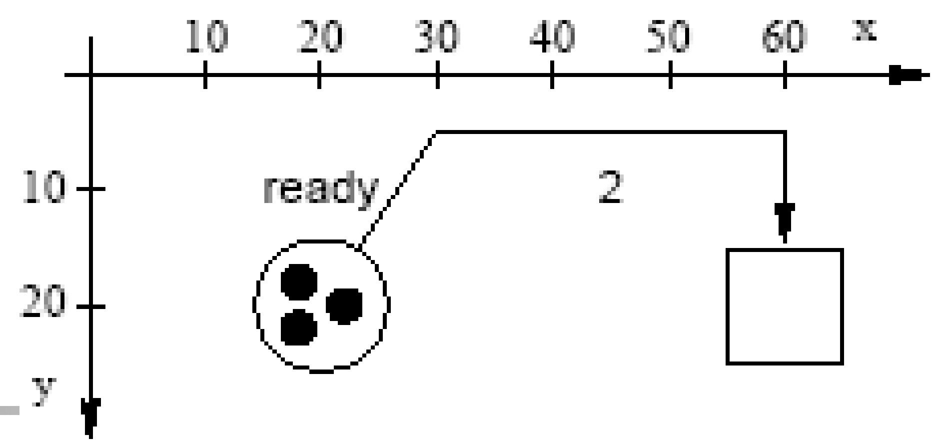
Tool specific information

graphical information

pages and reference nodes

Tool specific information

```
<initialMarking>
  <text>3</text>
  <toolspecific tool="org.pnml.tool"
                version="1.0">
    <tokengraphics>
      <tokenposition x="-2" y="-2" />
      <tokenposition x="2" y="0" />
      <tokenposition x="-2" y="2" />
    </tokengraphics>
  </toolspecific>
</initialMarking>
```



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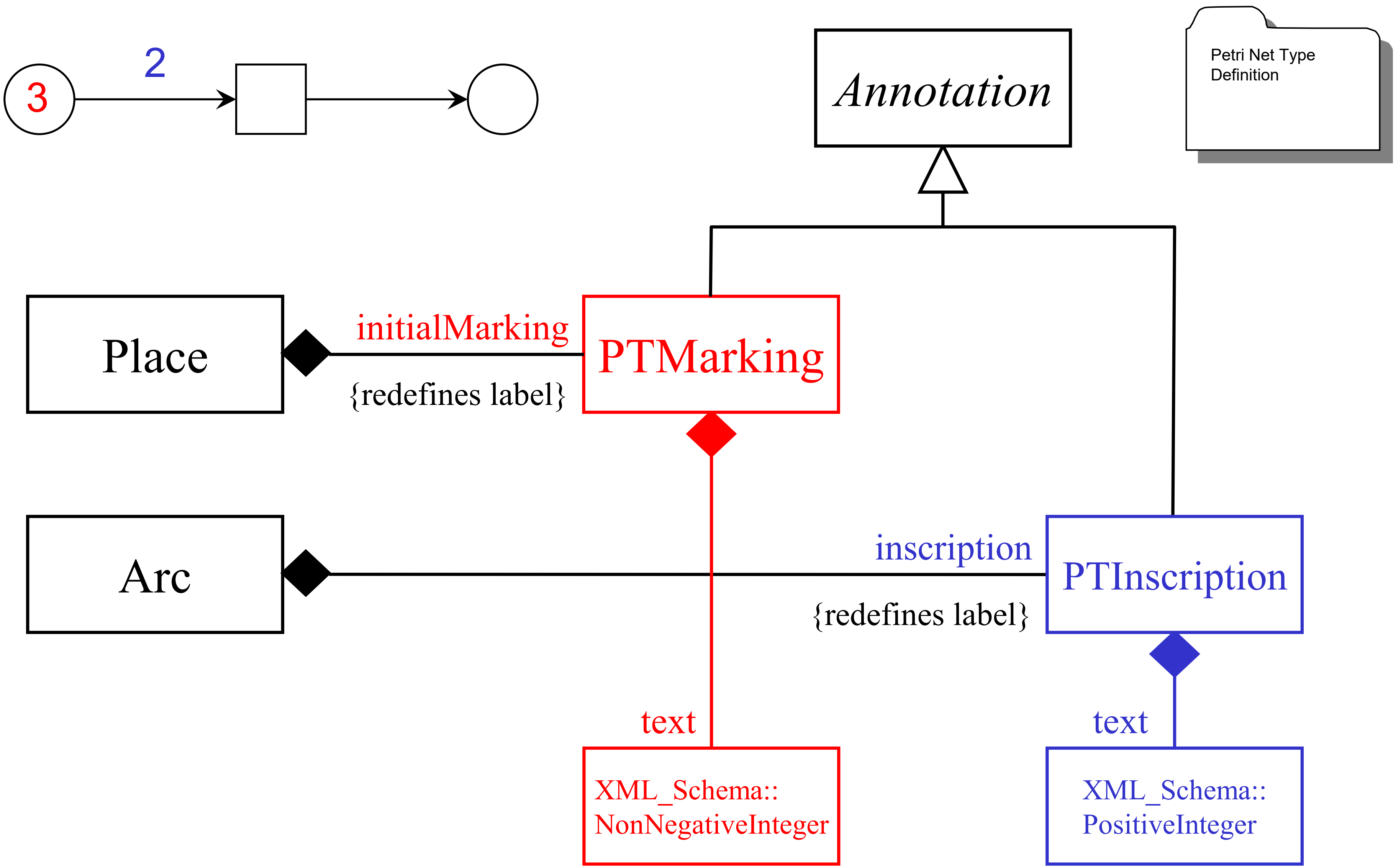
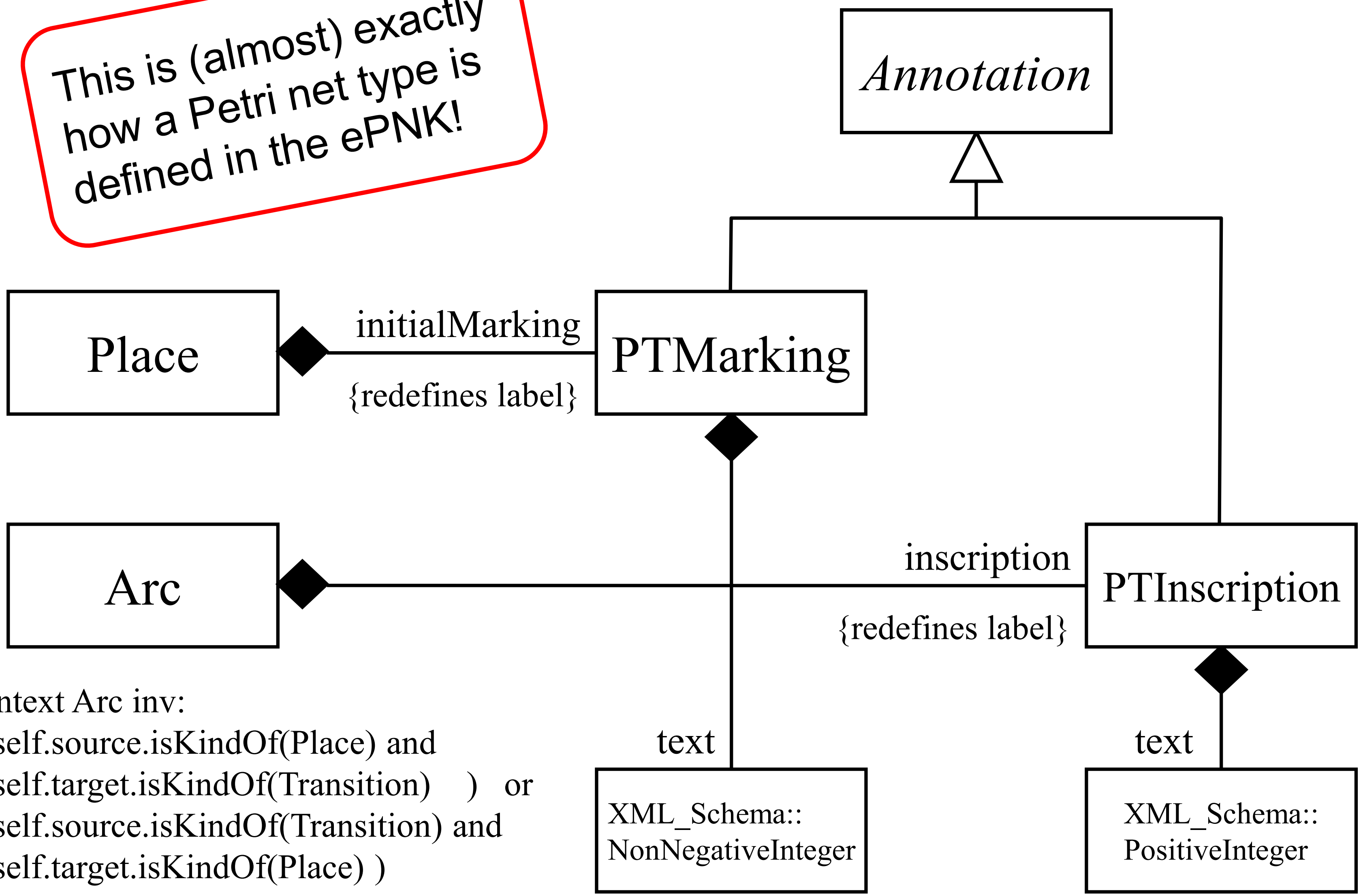
Type Definition: PT-Net



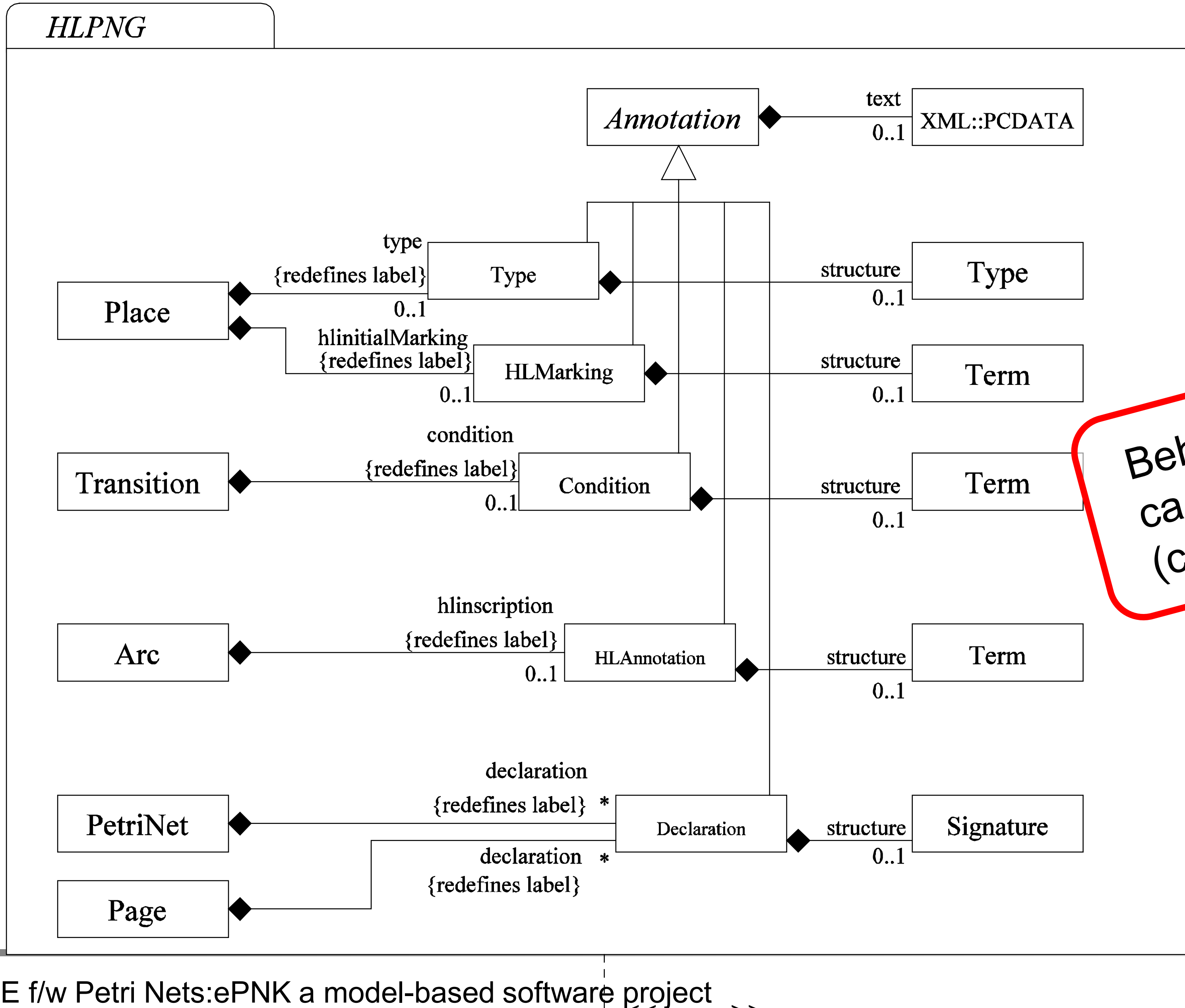
Type Definition: PT-Net

This is (almost) exactly how a Petri net type is defined in the ePNK!



context Arc inv:
(self.source.isKindOf(Place) and
self.target.isKindOf(Transition)) or
(self.source.isKindOf(Transition) and
self.target.isKindOf(Place))

Type Definition: HLPNG (overview)



Behind this part ca. 80 classes (constructs).

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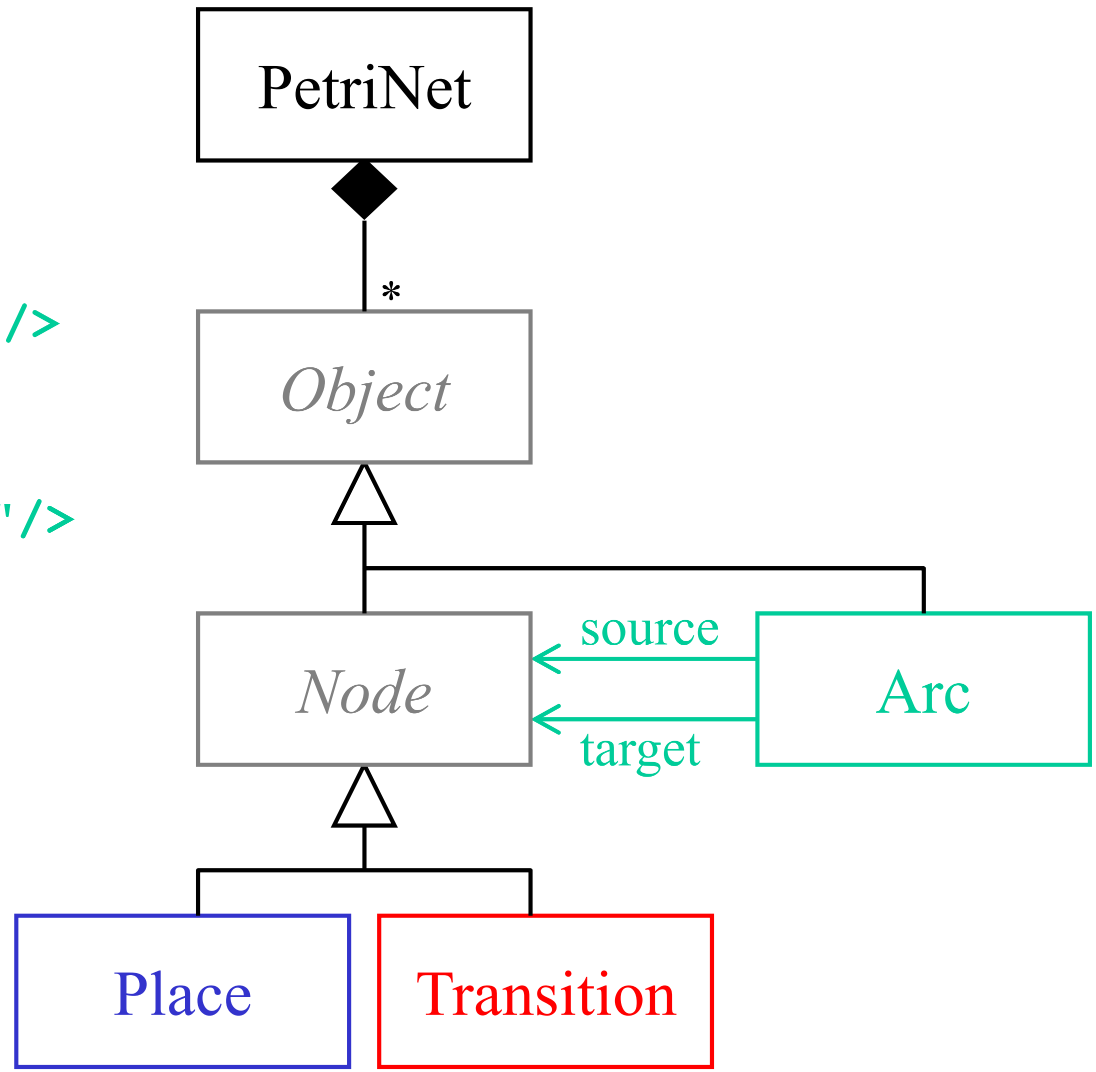
- Concepts for solutions
- Experience and statistics

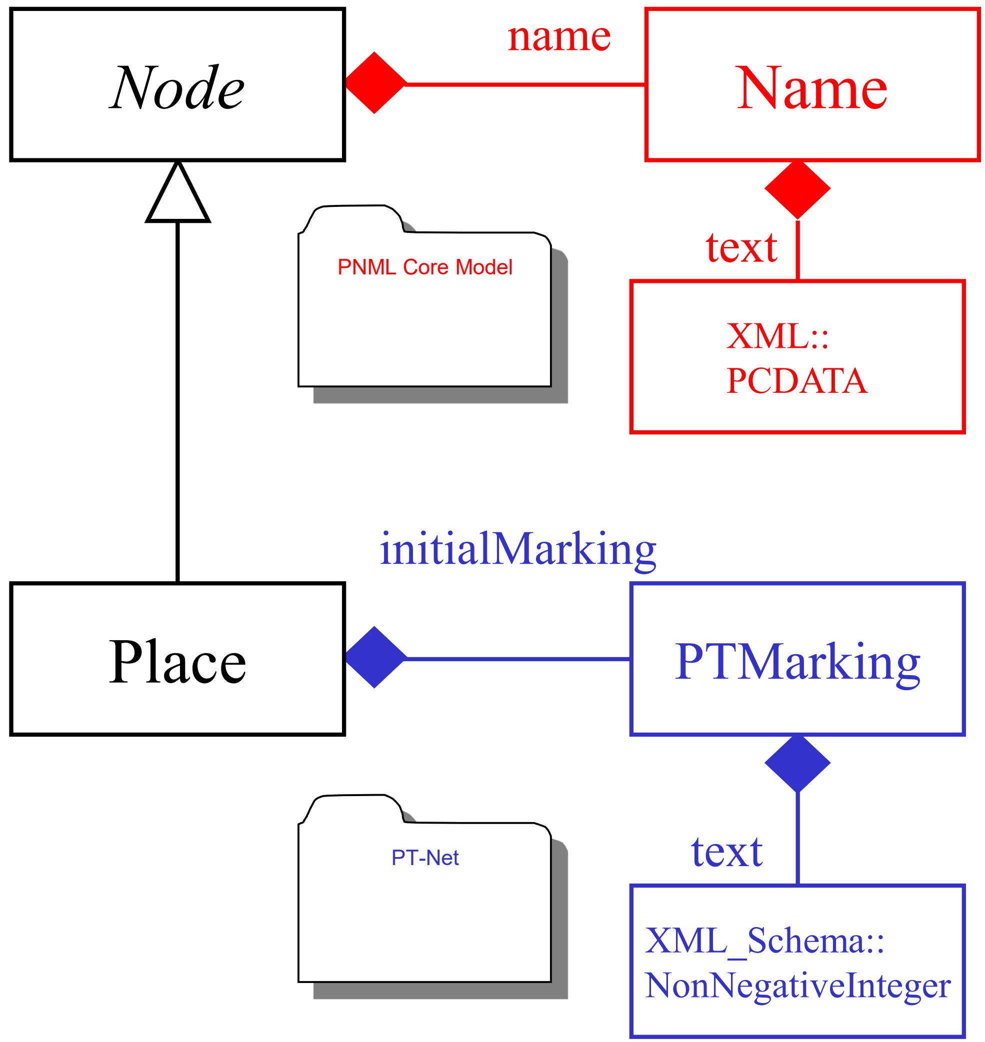
Core Model in XML

```
<pnml xmlns="http:...">
 <net id="n1" type="...">
  <place id="p1"/>
  <arc id="a1" source="p1"
               target="t1"/>
  <transition id="t1"/>
  <arc id="a2" source="t1"
                target="p2"/>
  <place id="p2"/>
 </net>
</pnml>
```



Labels in XML


```
...
  <place id="p1">
    <name>
      <text>i</text>
    </name>
    <initialMarking>
      <text>1</text>
    </initialMarking>
  </place>
...
```



In general

- How can this be defined in general?
  - Core model:
    Just implement it
  - Petri net type:
    Just implement it
    - code it for every new type!
    - interface with rest?

Better idea: use infrastructure to map model concepts to XML (ExtendedMetadata)!?

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- **Problems and issues**
- Concepts for solutions
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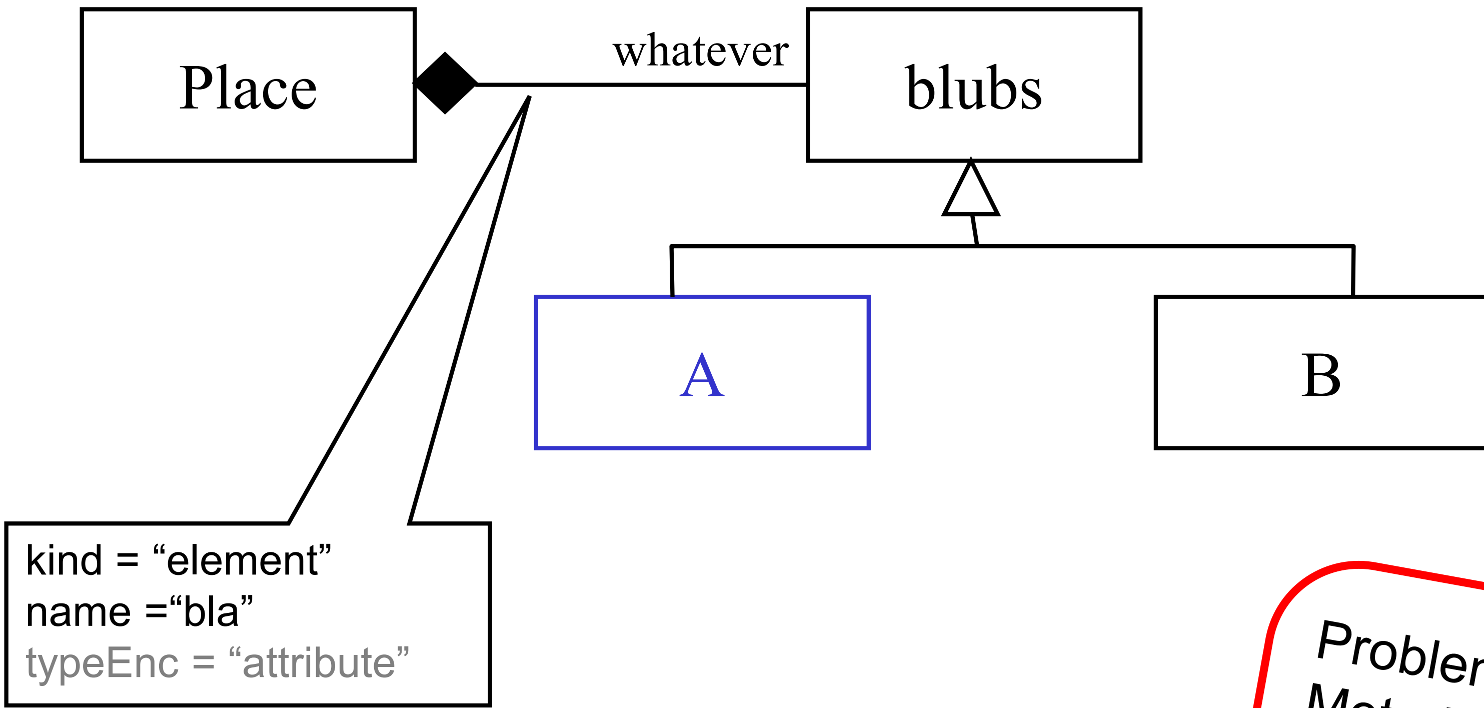
Idea: Extended Metadata




```
<place ...>
  <bla type="...ptnets.A">
    <text>... </text>
  </bla>
</place>
```

Problem: Extended Metadata is not powerful enough to express all mappings necessary for PNML. ePNK implements its own mapping mechanism.

Problems

- Mapping from concepts (model) to XML (and vice versa)

- How to plug in net type models and their XML mapping
- Implement a complex type (>= 80 classes) and a complex concrete syntax in a simple way – and complex conditions

- How to plug in tool-specific features and use standard XMI mapping along with PNML-serialization
- How to deal with unknown tool-specific extensions (ignore them without deleting them)

- One graphical editor for all (also future) Petri net types (generic graphical editor)

→ using Model-based Software Engineering technologies (reusing as much as possible from EMF, GMF, Xtext, Validation)

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Solutions

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- PNML-Mapping:
  - extended mapping that is flexible enough for all our needs (and some more)
  - hooked into the existing XMI-serialization (→ when there is no mapping defined in the ePNK, XMI is used as default, XMI deals with cross-references even when no id's exist)

- Net-types plug-in:
  - A EMF-model plus a factory for producing all the extended elements
  - PNML-Mapping for new elements (if necessary)
  - Separate constraints for syntactical constraints (batch and live)

  - For structured net types: Interface for parsing and linking (in concrete type used Xtext → worked surprisingly smooth for parsing and surprisingly bad for serialization)

Solutions

- Tool-specific extensions:
  - Plug-in for tool-specific extensions
  - “magic” AnyType hooked into XMI-Mapping/PNML-Mapping (keeps XML structure which you do not care for and writes it again)

- Graphical editor:
  - Integrated EMF/GMF-Editor (worked surprisingly simple; but many nasty little but time-consuming issues)
  - ProxyLabels that, below the surface, can be any Petri Net Type specific label (using a reflective API to get the right ones)

  - Explicit generation of GMF diagram from PNML graphical information
  - Update of PNML graphical information via listeners to GMF-diagram

→ all this required many manual changes in the GMF-generated editor

Outcome

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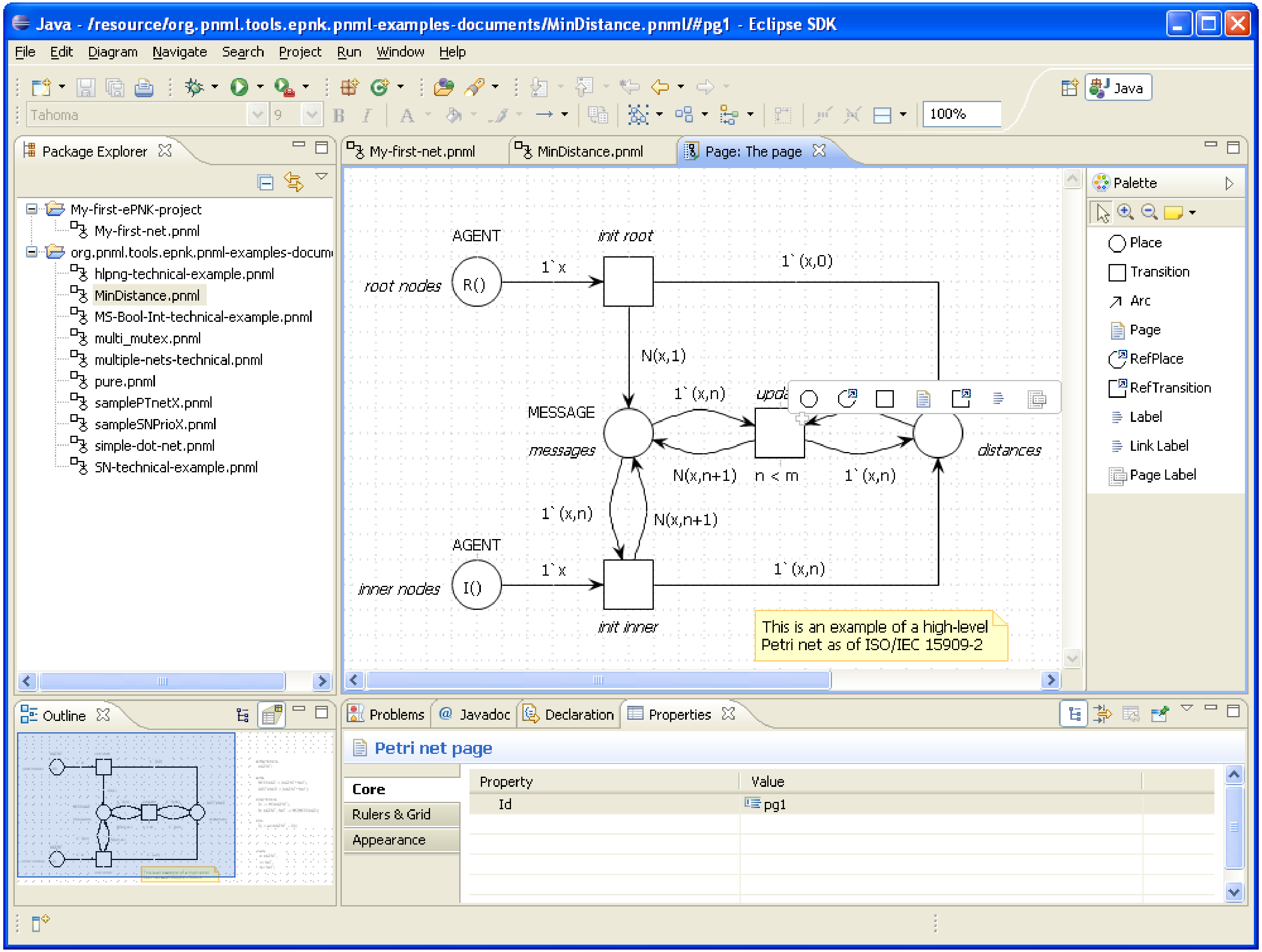

ePNK: Features

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- Generic graphical editor for all kinds of Petri nets
- Supporting PNML, PT-Nets, HLPNGs, SN
(some graphical information still ignored)
- Problem reporting mechanism
- Some basic functionality (mostly for demo purposes)
  - simple simulator for PT-Nets
  - simple codegenerator for PT-Nets
  - simple model checker for PT-Nets
  - serialiser for HLPNG labels
(in case PNML nets come without textual labels)

ePNK: Features

- Extension mechanisms
  - defining new net types (basically, making a model) (with or without dedicated mapping to XML for new concepts)
  - constraints for net types (OCL or programmed constraints)
  - graphical appearance of nets and their elements (depending on attributes: inhibitor arcs, read arcs, tokens)
  - tool specific information (basically, making a model)

  - adding new functions (mostly the eclipse plugin mechanism)
  - define ePNK applications, with user interactions

The ePNK

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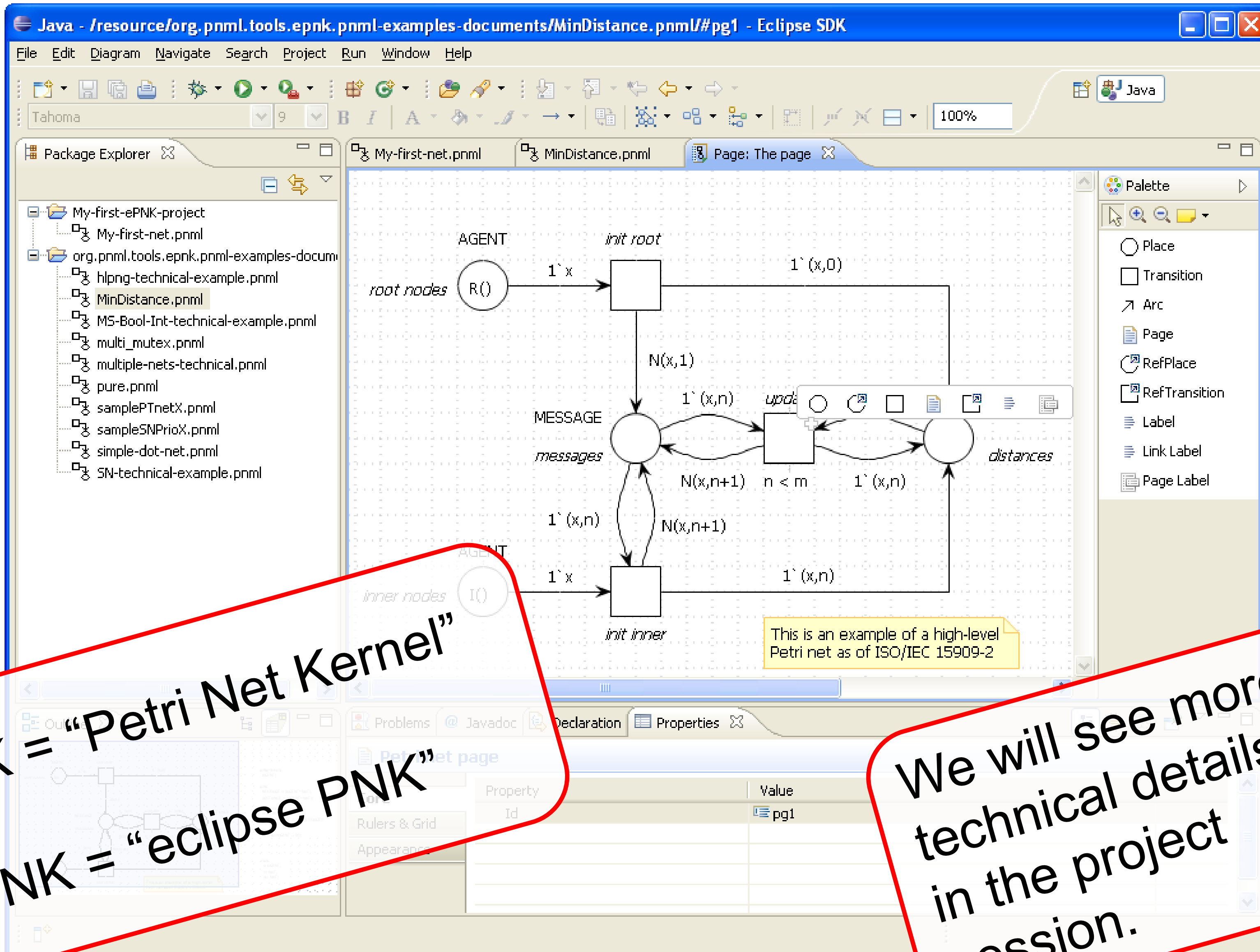

PNK = "Petri Net Kernel"
ePNK = "eclipse PNK"

We will see more technical details in the project session.

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The ePNK:
An Example: YAWL nets and Simulator

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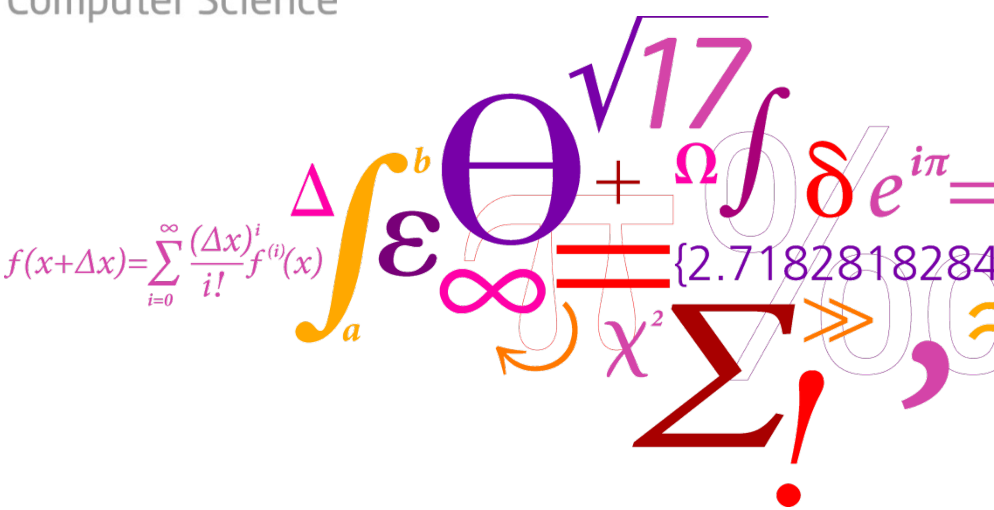
This example is deployed with the ePNK! We can have a look into that in the hands-on part.



ePNK

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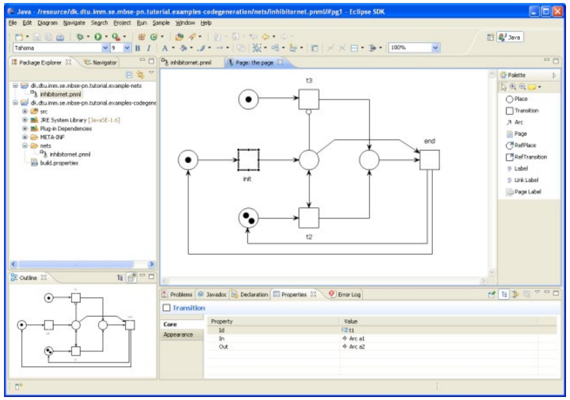
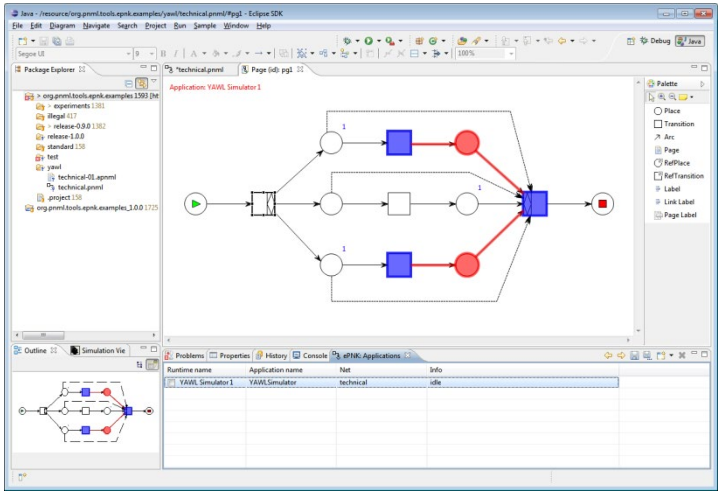
- Platform for developing Petri net tools based on the PNML transfer format
- With PNML (core model) at its heart
- Pluggable architecture:
  - any new type of Petri net (PNTD)
  - new of application with visual feedback and user interaction





ePNK: Core Paradigm

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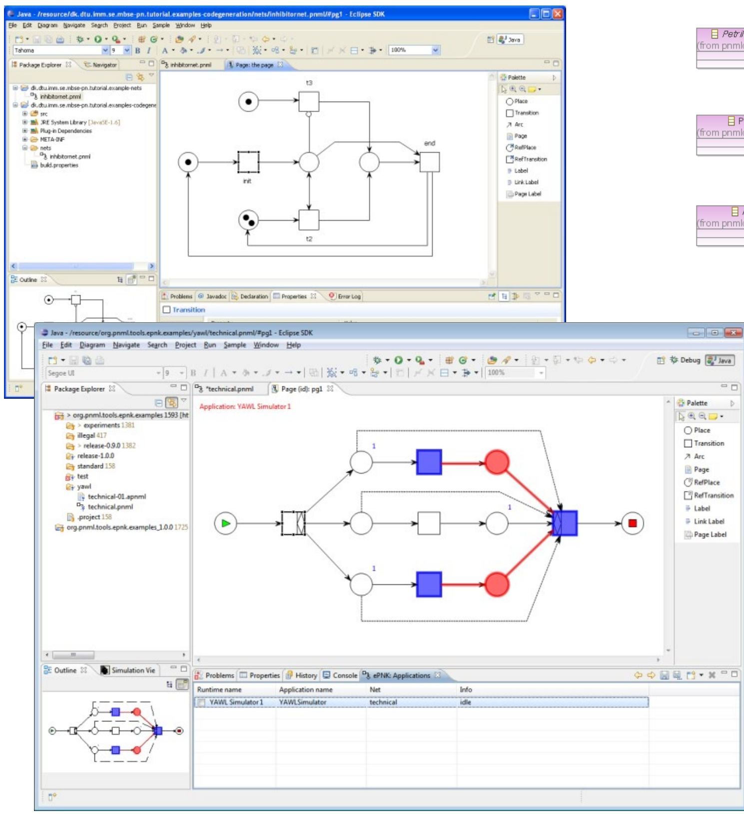
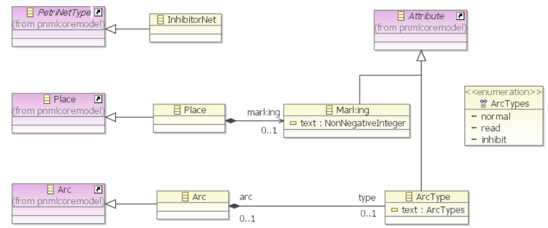
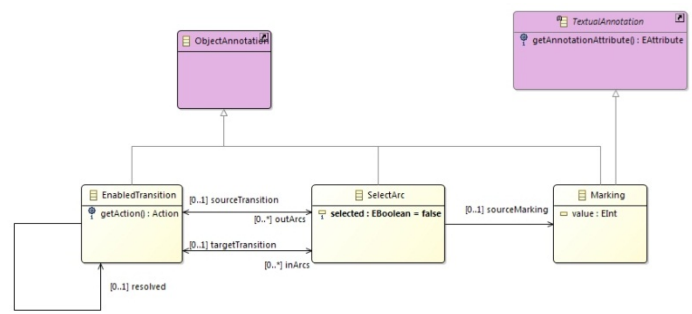
- Core paradigm: Model-based Software Enigneering







Example: YAWL nets

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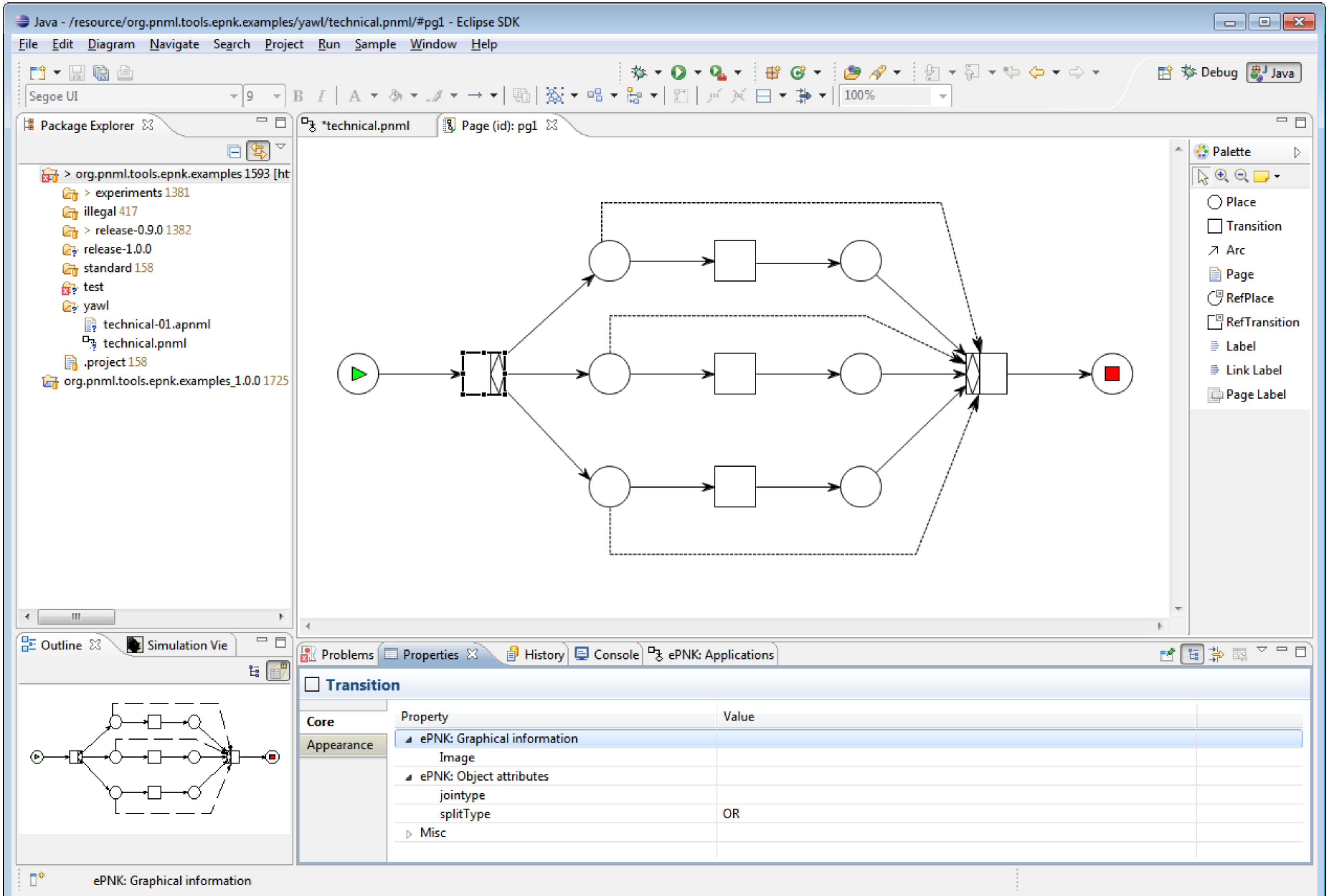

Example: YAWL simulator

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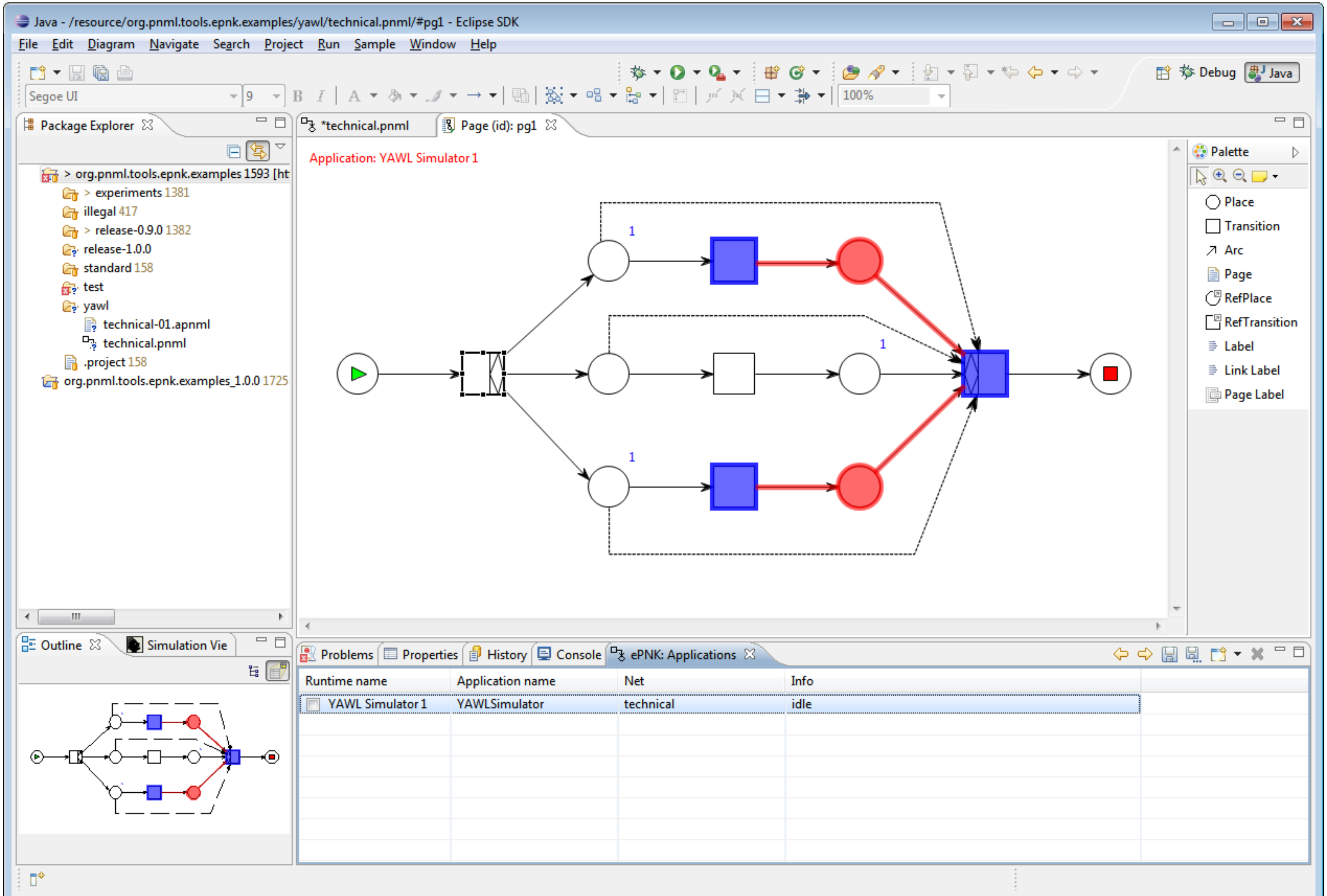

YAWL net: What to do

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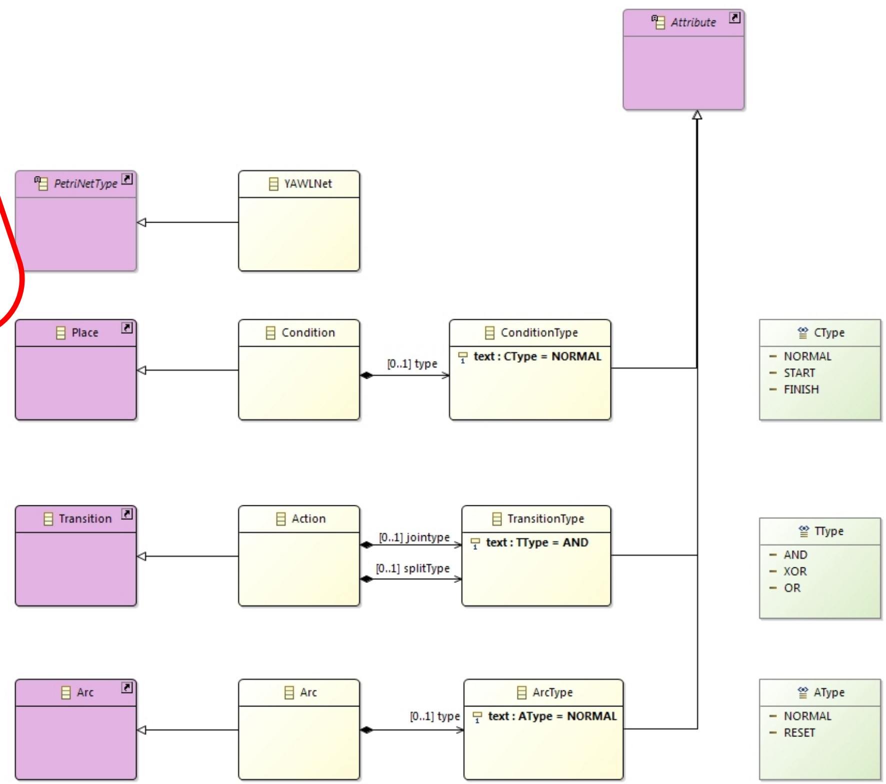
Step 1:

- Define the Petri net type by a class diagram (Ecore diagram)

Concepts:
- Conditions with start / finish attribute
- Actions with join and split types
- Arcs with RESET type



YAWL net: What to do

Step 2:

- Define additional constraints

```
( self.source.oclIsKindOf(pnmlcoremodel::PlaceNode) and
  self.target.oclIsKindOf(pnmlcoremodel::TransitionNode) )
  or
( self.source.oclIsKindOf(pnmlcoremodel::TransitionNode) and
  self.target.oclIsKindOf(pnmlcoremodel::PlaceNode) and
  self.type->size() = 0 )
```

Example (here OCL):

- Out-going arcs cannot have the type attribute set (cannot be RESET arcs)

YAWL net: What to do

Example:
- RESET arcs dashed with double arrow head

Step 3:

- Define dedicated graphics

```
public void update() {
    boolean oldIsReadArc = isResetArc;
    isResetArc = YAWLFunctions.isResetArc(arc);
    if (isResetArc != oldIsReadArc) {
        setGraphics();
}   }

private void setGraphics() {
    if (isResetArc) {
        this.setTargetDecoration(
            new DoubleArrowHeadDecoration());
        this.setLineStyle(SWT.LINE_DASH);
    } else {
        this.setTargetDecoration(new ArrowHeadDecoration());
        this.setLineStyle(SWT.LINE_SOLID);
}   }
```

You get

- Graphical editor for YAWL (with dedicated graphic representation of special YAWL features)
- A PNML compatible file format for YAWL along with a save and load operation for that format
- Consistency check for all constraints (live or batch)

Example: YAWL simulator

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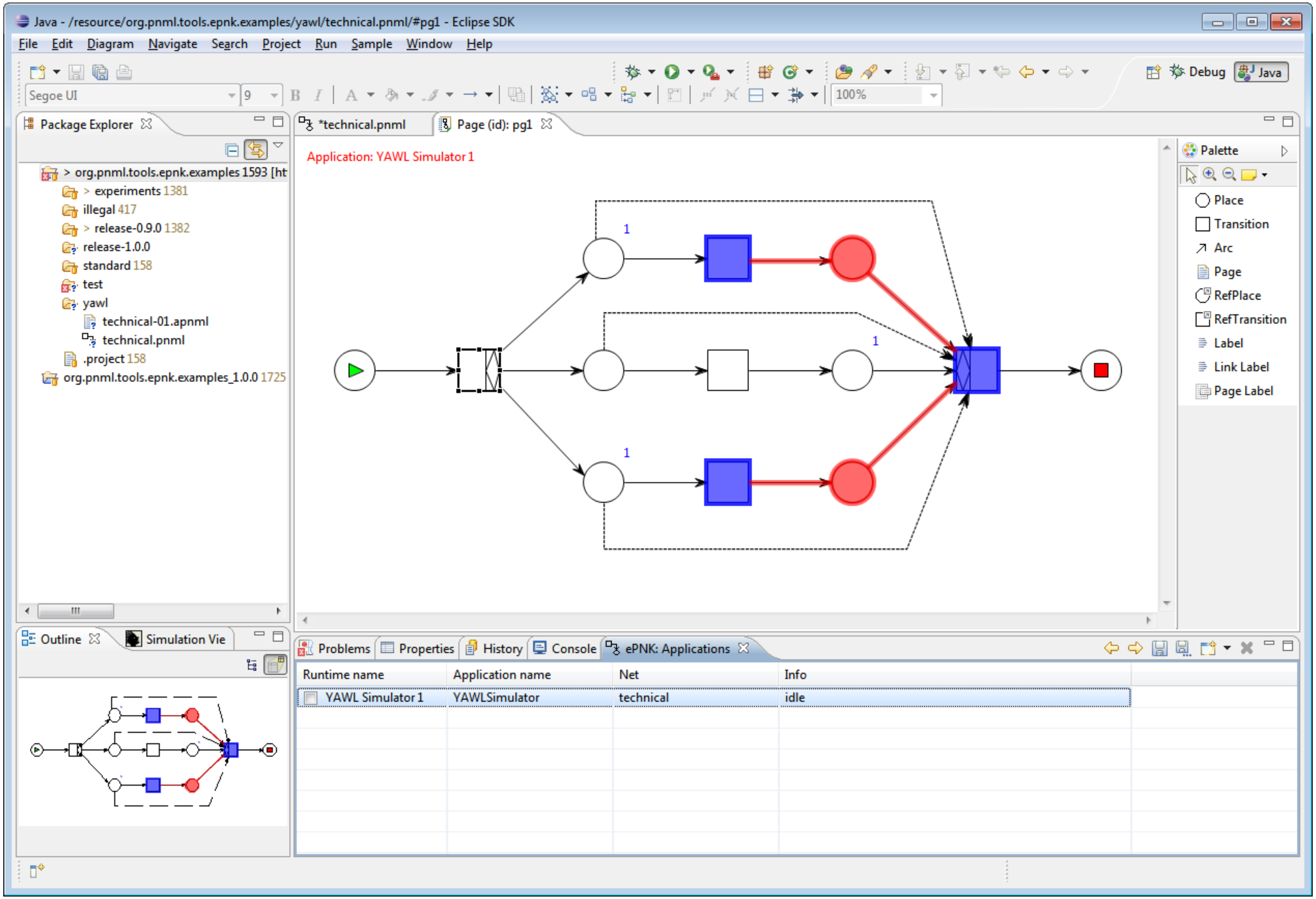
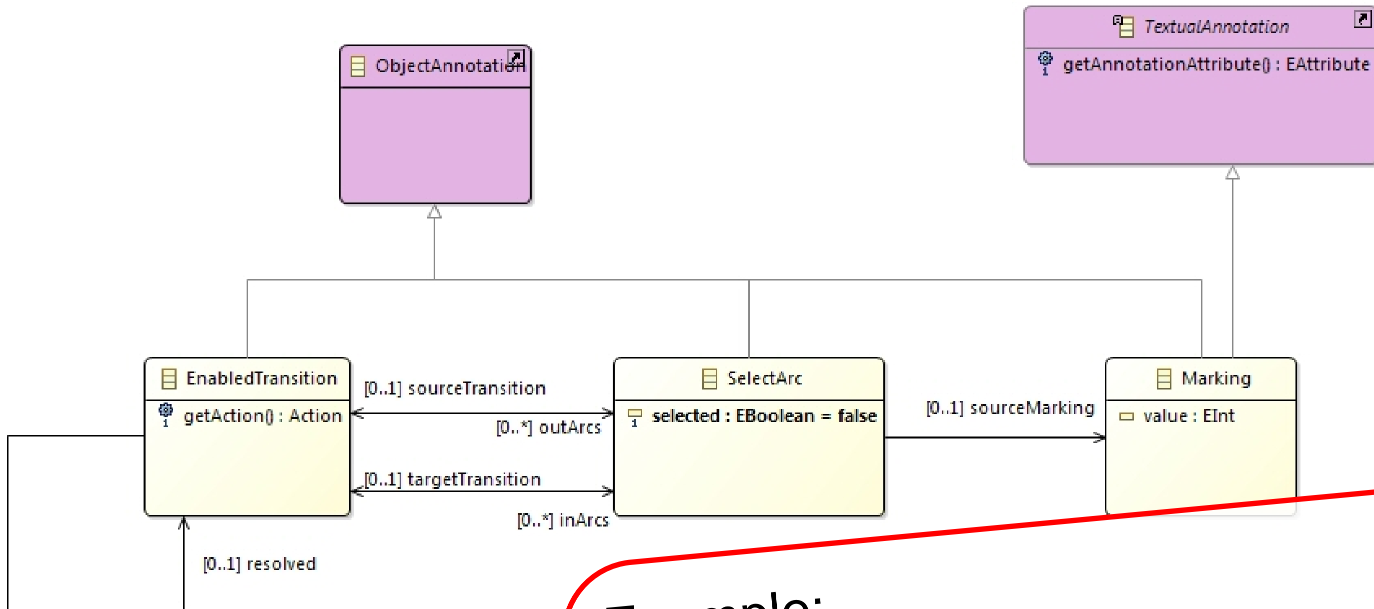


Simulator: What to do

Step 1:

- Define annotations you need



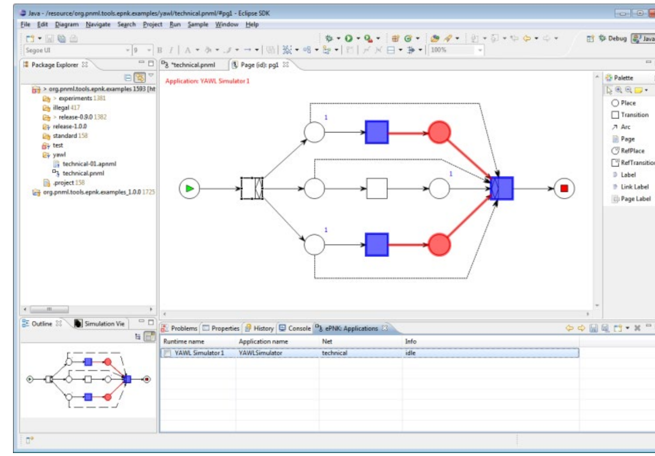
Example:
- Enabled transitions
- Arcs (to be selected)
- Marking of place
- “red marks” for backward cone of OR-joins (standard Object Annotations)

Simulator: What to do

Example:
- Select arcs for XOR-join and for OR- and XOR-splits
- Firing transitions

Step 2:

- Define how annotations should look: Presentation handler(s)



```
if (annotation instanceof SelectArc) {
  SelectArc selectArc = (SelectArc) annotation;
  if (editPart instanceof ConnectionNodeEditPart) {
    ConnectionNodeEditPart connectionEditPart =
      (ConnectionNodeEditPart) editPart;
    Object modelObject =
      connectionEditPart.resolveSemanticElement();
    if (modelObject instanceof Arc) {
    PolylineOverlay overlay = new PolylineOverlay(connectionEditPart);
    if (!selectArc.isSelected()) {
      overlay.setForegroundColor(ColorConstants.lightGray);
      overlay.setBackgroundColor(ColorConstants.lightGray);
    } else {
      overlay.setForegroundColor(ColorConstants.blue);
      overlay.setBackgroundColor(ColorConstants.blue);
   }
   return overlay;
```

Example: YAWL simulator

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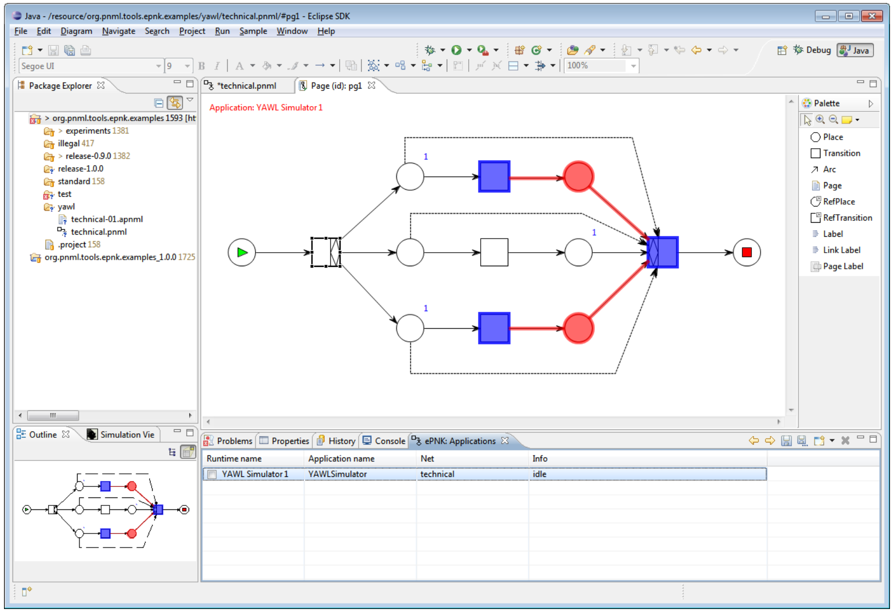
Step 3:

- Define what should happen when user clicks / double clicks on an annotation: Action handler(s)



You get:

- Graphical overlays on top of the graphical editor
- The user can interact with the overlays (selecting arcs, firing transitions)
- The user can save the annotations and load them again (in the YAWL example, a firing trace)

Example: YAWL simulator

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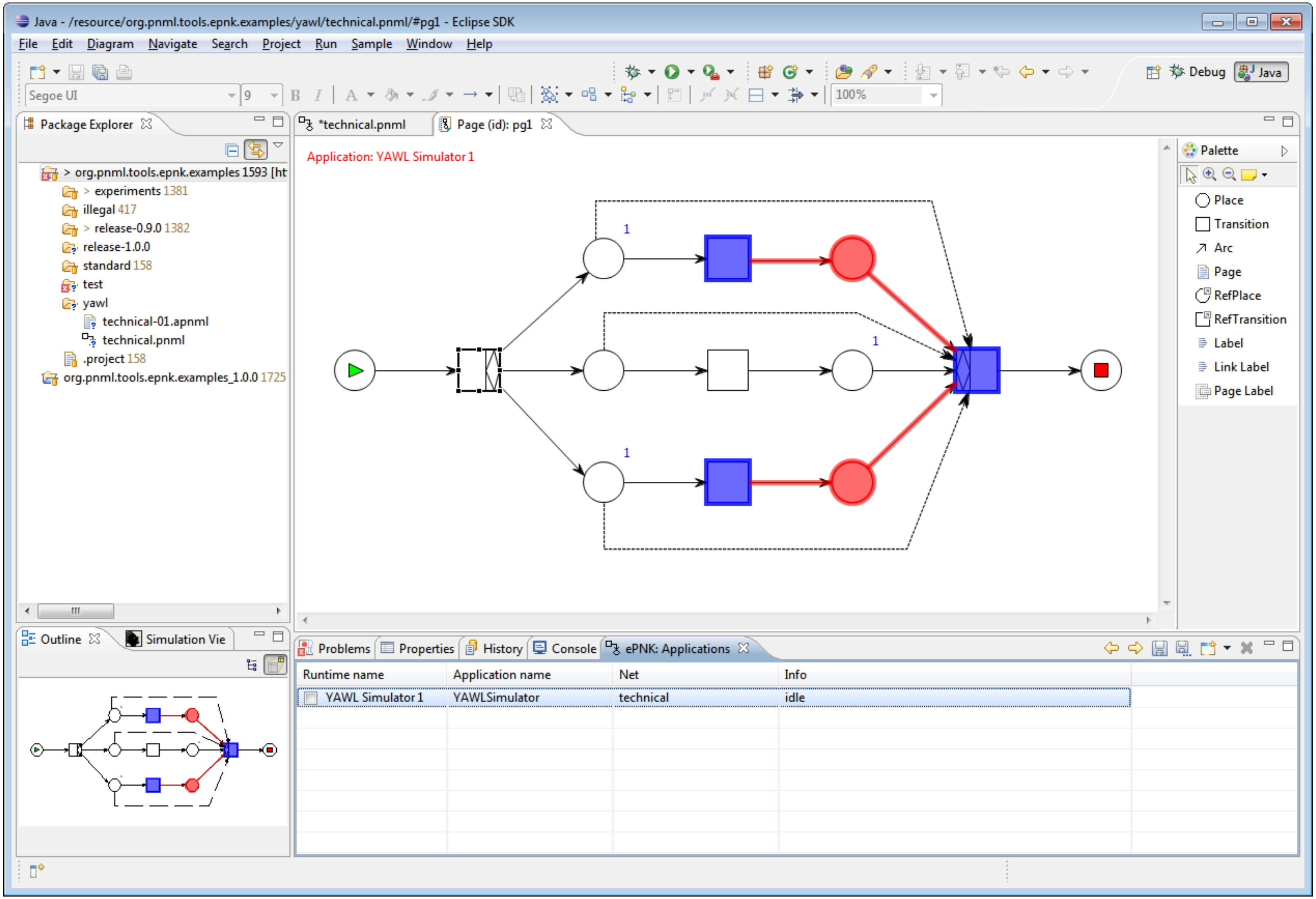

The ePNK: Material

- More information in private demo
- **ePNK: Home page**
  http://www2.compute.dtu.dk/~ekki/projects/ePNK
- Ekkart Kindler: The ePNK: A generic PNML tool - **Users' and Developers' Guide for Version** 1.0.0. IMM-Technical Report-2012-14, DTU Informatics, Kgs. Lyngby, Denmark, December 2012 (available online via ePNK home page).
- **Eclipse update site** (Indigo – Photon – 4.11): ePNK 1.2
  http://www2.compute.dtu.dk/~ekki/projects/ePNK/1.2/update/

A draft for version 1.2 is available at this course's home page (updated half way through ☹)

ePNK in MOF

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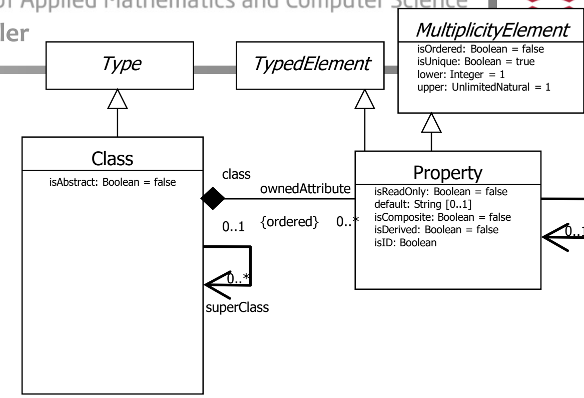
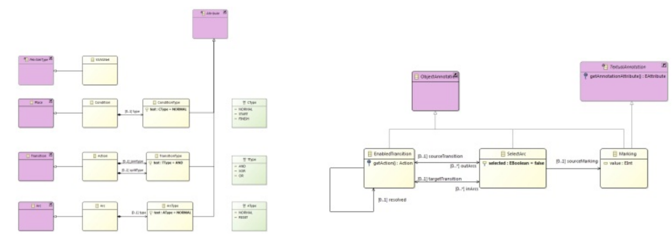
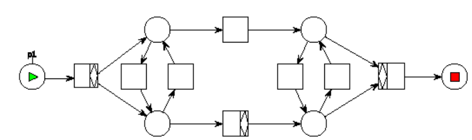
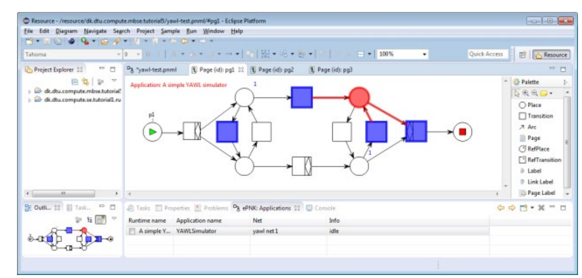


M3	Ecore (~ EMOF)
M2	ePNK and YAWL meta models + Annotation model (runtime simulator)
M1	YAWL model
M0	YAWL case (instance of a simulation – execution trace)

↑ = conforms to / is instance of







Appendix

Experience

- Agile development approach (no major design in advance)
  - In principle possible. But, you
  - need to know pitfalls of technology (unexpected implementations) well
  - manual changes must be made with good understanding of technology in order to achieve maintainability
    - this is more tricky for GMF than for EMF (but possible)

This is not in principle a problem for MBSE, but a problem with current tool support.

- Documentation missing
  - Many cool and important features of EMF/GMF are not documented
    - Guess what could be supported
    - Understand philosophy behind
    - Debug to find out details

- EMF/GMF is solid technology
  - if you know how to use and understand the philosophy behind
  - some parts are made for a very specific purpose and are not as general as suggested (ExtendedMetaData) ,

Experience

- Time effort: Altogether (up to version 0.9.0) < 5weeks
  - ca. **1 week** for making the core model and implementing core infrastructure (only EMF, generic Petri net types, XML mapping mechanism)
  - ca. **1 week** for HLPNG Petri net type, the model, its PNML-mappings and the parser for labels (Xtext)
  - ca. **½ week** for extending the PNML-mapping infrastructure so that all HLPNG features can be mapped to XML
  - ca. **½ week** for implementing the validation constraints for HLPNG (correct typing of expressions, resolution of types, …)
  - ca. **1 week** for graphical for graphical editor
  - ca. **½ week** for brushing up the graphical editor (and cleaning a bit up behind the scenes)

Part of that 1 week of debugging! 2 days my own bugs; 3 days replacing missing documentation!

As of version 0.9.2 with some extra features: 8 weeks!

Code inspection

- Petri Net Type: P/T-Net plugin
  - model for P/T-nets
  - XML-mapping: 2 lines
  - manual changes in one generated class (4 lines, 2 of them for the above XML-mapping)
  - 1 OCL constraint

Implementing the complete PNTD for the hands-on project takes me about half an hour.

- Tool-specific extension: Token position plug-in
  - model for token positions
  - no XML-/PNML mapping
  - manual creation of one class (25 lines, making the “pieces” know to Eclipse)

- GMF/EMF-editor integration
  - 45 @generated NOTs

These figures refer to ePNK version 0.9.0!

Code inspection

- Petri Net Type: HLPNG plug-in
  - model for HLPNG-nets
  - Xtext grammar for concrete syntax
  - PNML-mapping: ca. 70 entries (+ Factory)
  - manual changes in generated classes: ca. 130 (mostly functionality implementing type and sort resolution functions and helpers)
  - 1 OCL constraint, and 11 constraint classes (complex constraints)

These figures refer to ePNK version 0.9.0!

Statistics

- Project contains
  - 20 eclipse plug-in projects (11 automatically generated)
  - 10 models (+ 1 grammar)
  - 125 model classes (and interfaces)
  - ca. 800 code classes
  - ca. 36.000 MLOC (> 50.000 TLOC)
  - ca. 220 “@generated NOT” tags
  - (guess < 2000 manual lines of code)

These figures refer to ePNK version 0.9.0!