Model-based Software Engineering
(02341, spring 2016)

Ekkart Kindler

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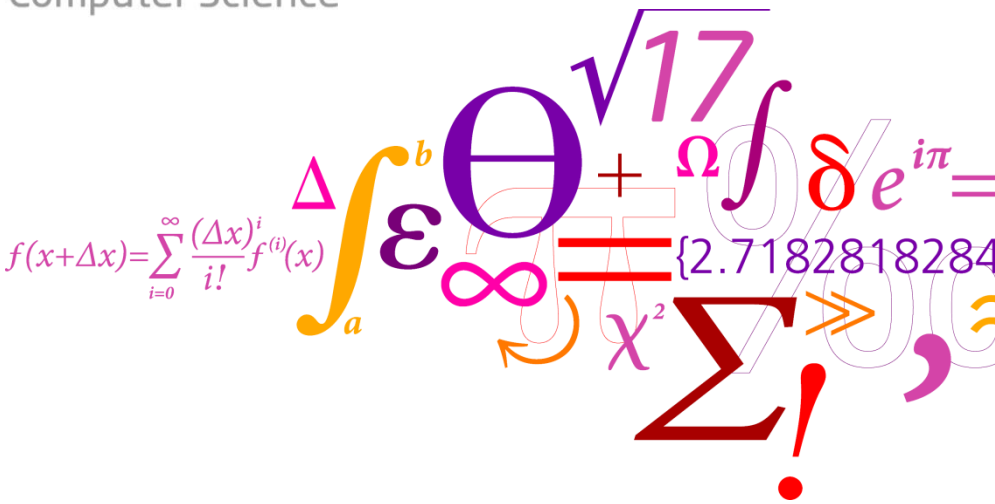

V. The ePNK & PNML

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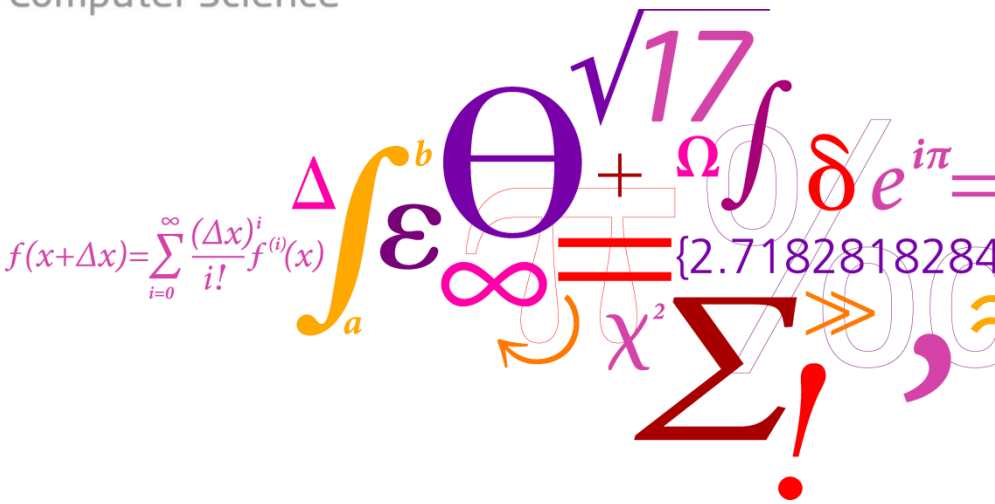

1. Motivation

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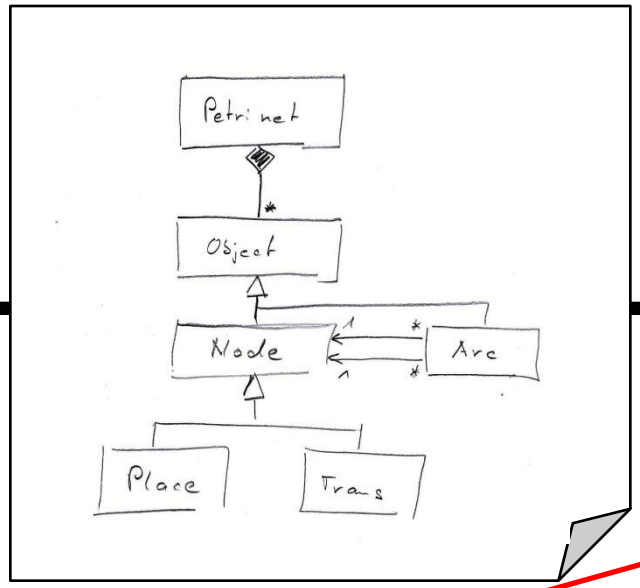

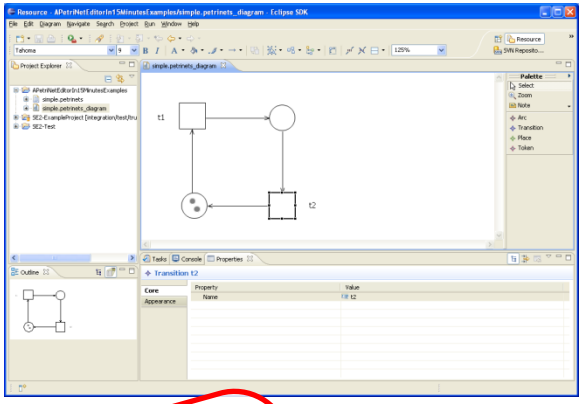

"A Petri net editor in 15 minutes" (once you know how to do it)

Motivation

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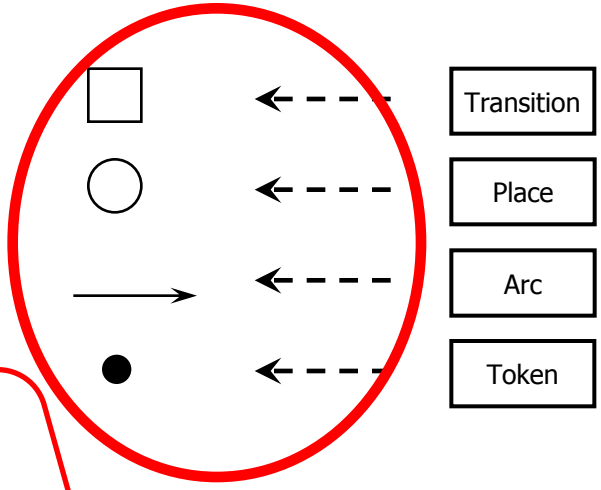
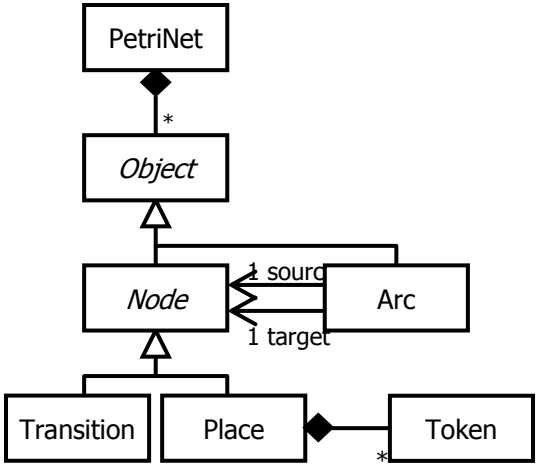
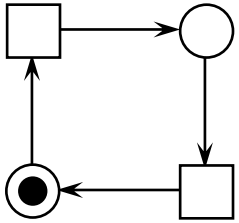
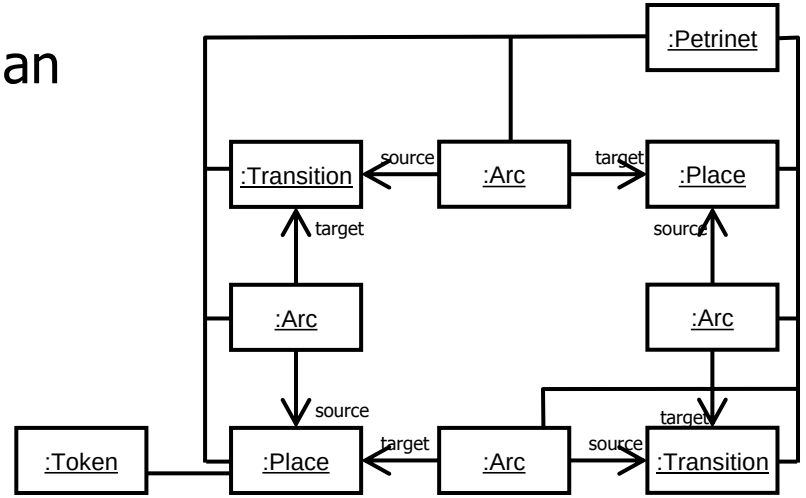




Eclipse EMF and GMF technology

generate an editor





concrete syntax

abstract syntax

Motivation

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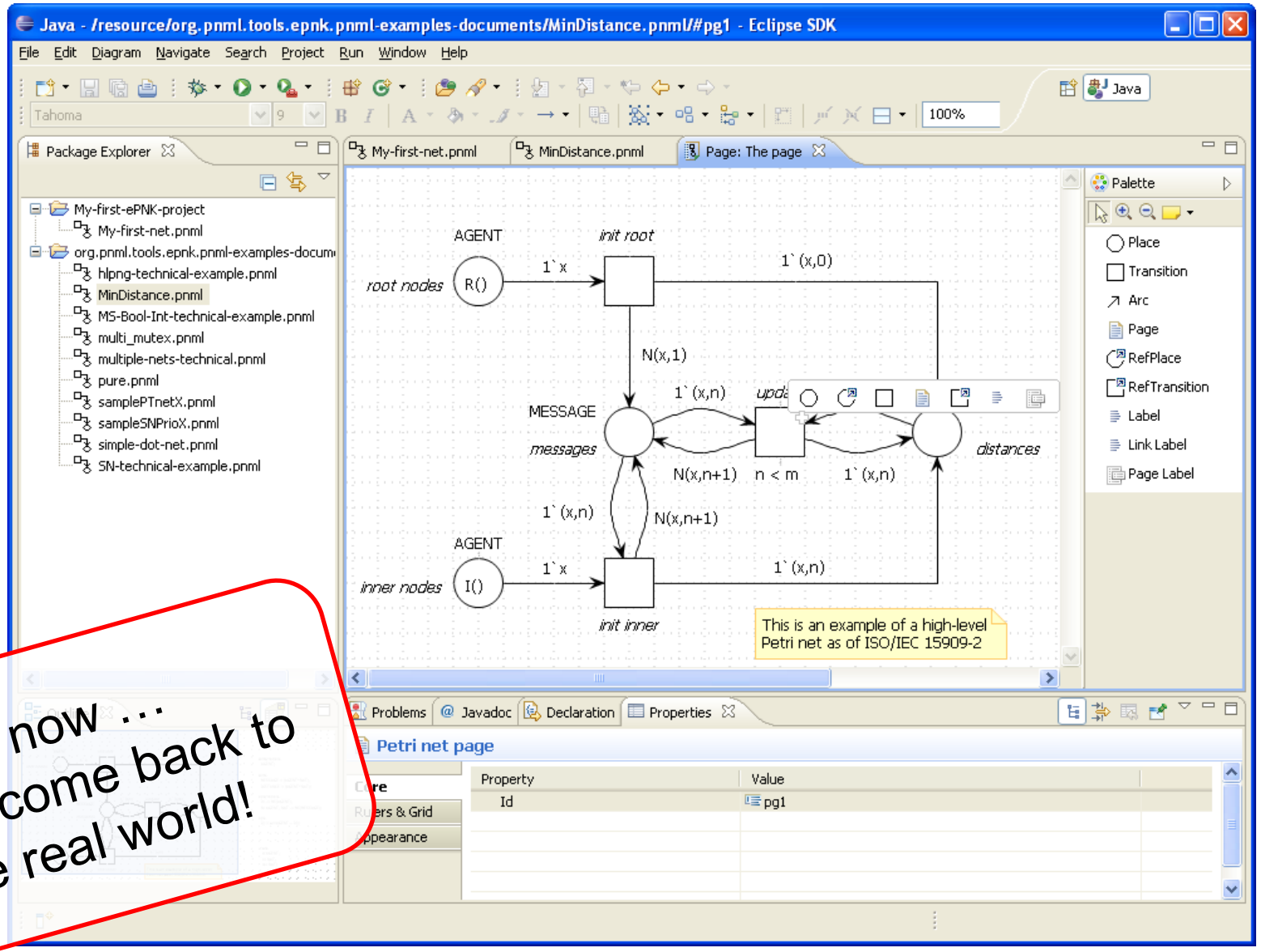

Rea world issues

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- 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,
  (almost)without programming

as well as some other extensions

Outline

- Motivation
- PNML
  - Overview
  - Core model
  - Type model
  - Mapping to XML
- Experience and statistics
- ePNK: Tutorial

2. 1. PNML in a nutshell

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- 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. Part 1 is under revision.

But ...

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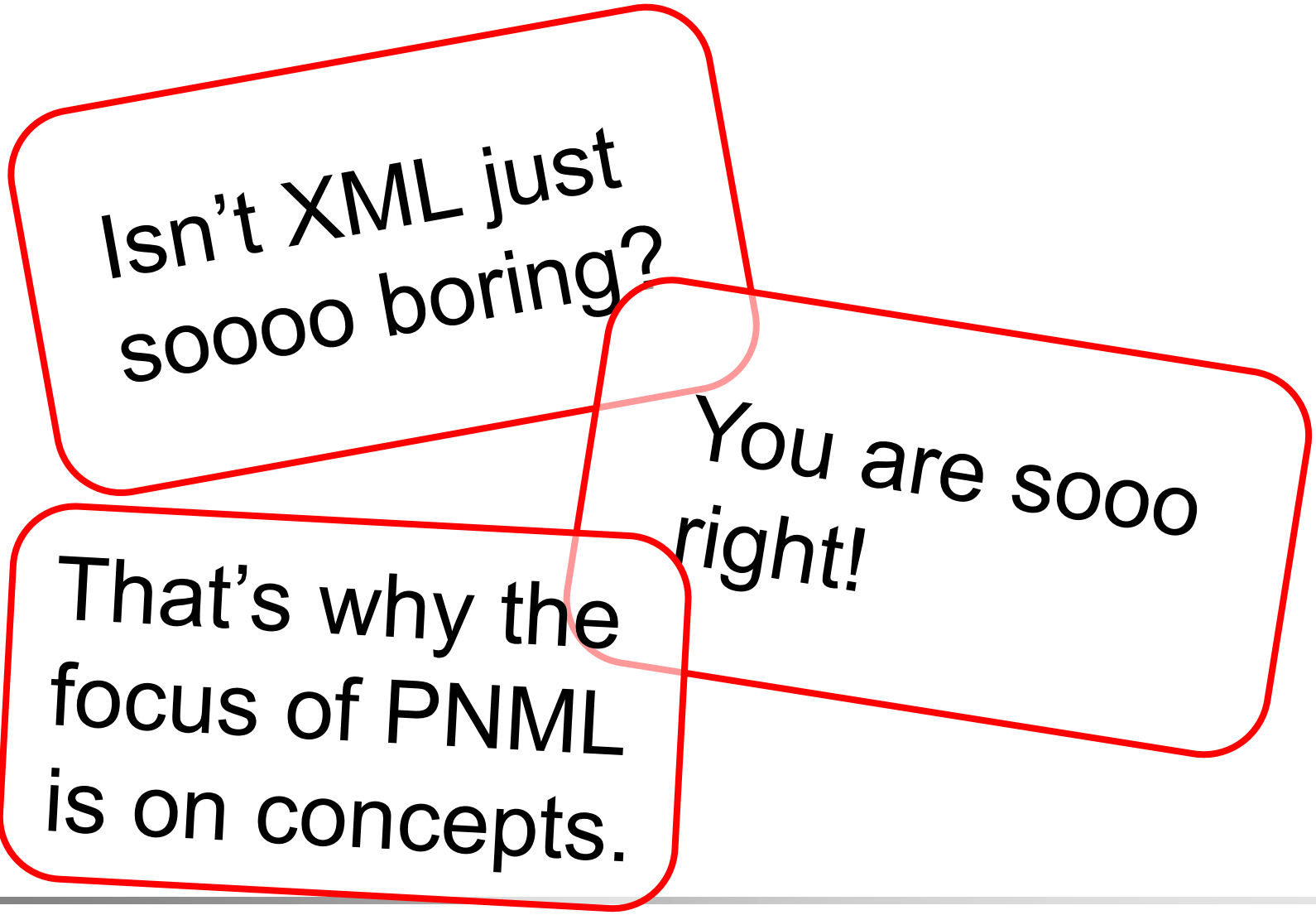

PNML and XML

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- 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

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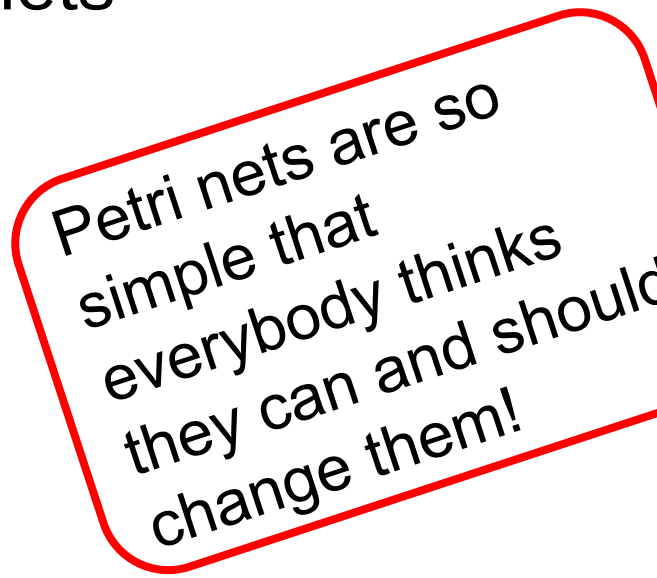
many versions and variants of Petri nets

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



Objective

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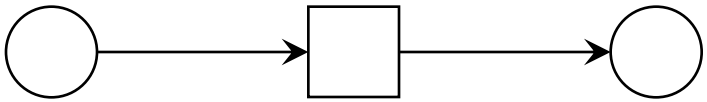
```
<place id="p1"/>
<arc id="a1" source="p1" target="t1"/>
<transition id="t1"/>
<arc id="a2" source="t1" target="p2"/>
<place id="p2"/>
```



A first example

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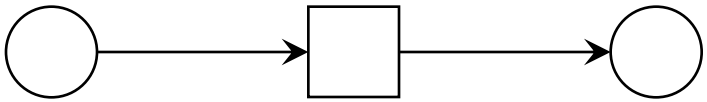
```
<pnml xmlns="http://www.pnml.org/..."> 
  <net id="n1" type="..."> 
    ... 
    <place id="p1"/> 
    <arc id="a1" source="p1" target="t1"/> 
    <transition id="t1"/> 
    <arc id="a2" source="t1" target="p2"/> 
    <place id="p2"/> 
    ... 
  </net> 
</pnml>
```



A first example

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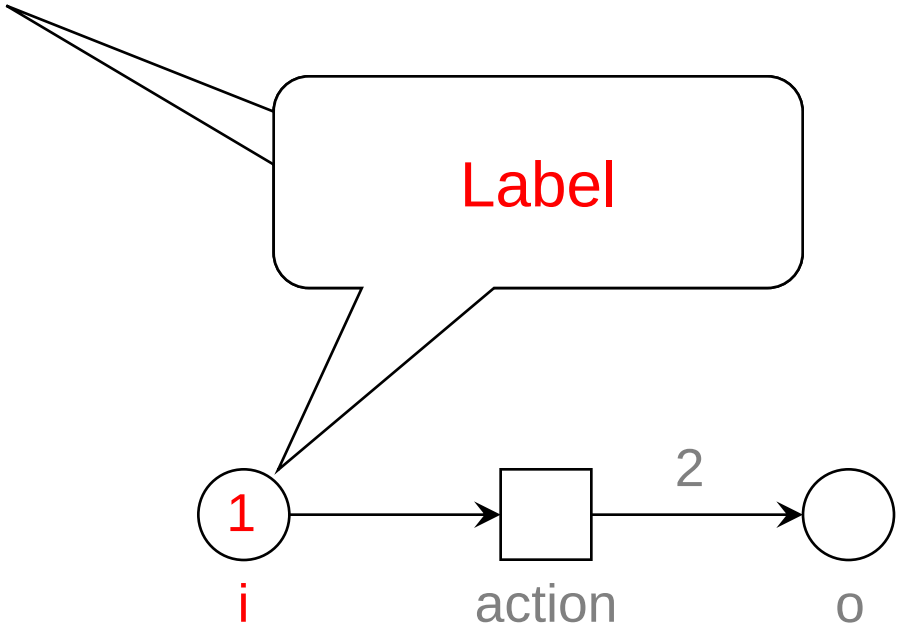
```
...
    <place id="p1">
      <name>
        <text>i</text>
      </name>
      <initialMarking>
        <text>1</text>
      </initialMarking>
    </place>
...
```

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



Basic Idea

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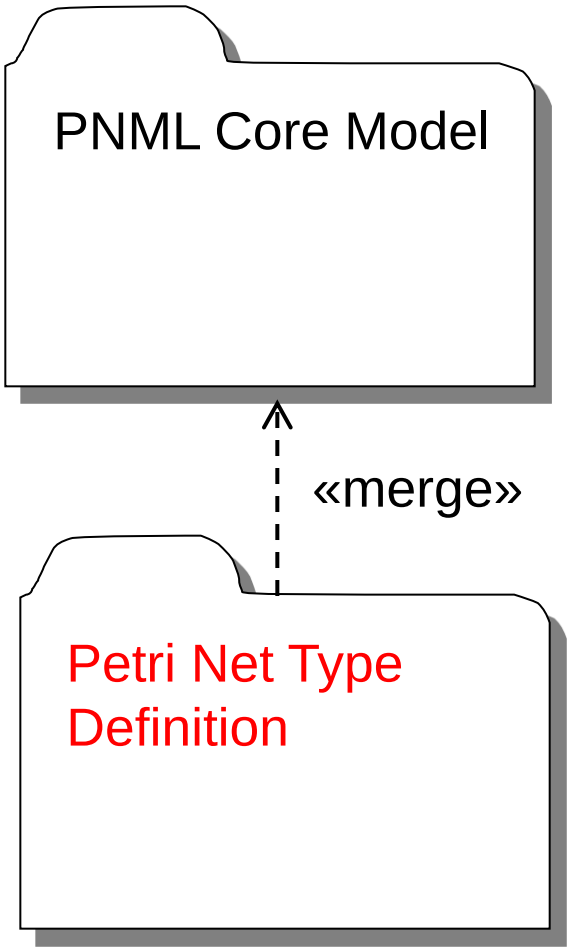
„All kinds“ of Petri nets can be represented by

- places
- transitions, and
- arcs

along with some

- labels



Outline

- Motivation
- PNML
  - Overview
  - Core model
  - Type model
  - Mapping to XML
- Experiences and statistics
- ePNK: Tutorial

2.2 Core Model (overview)

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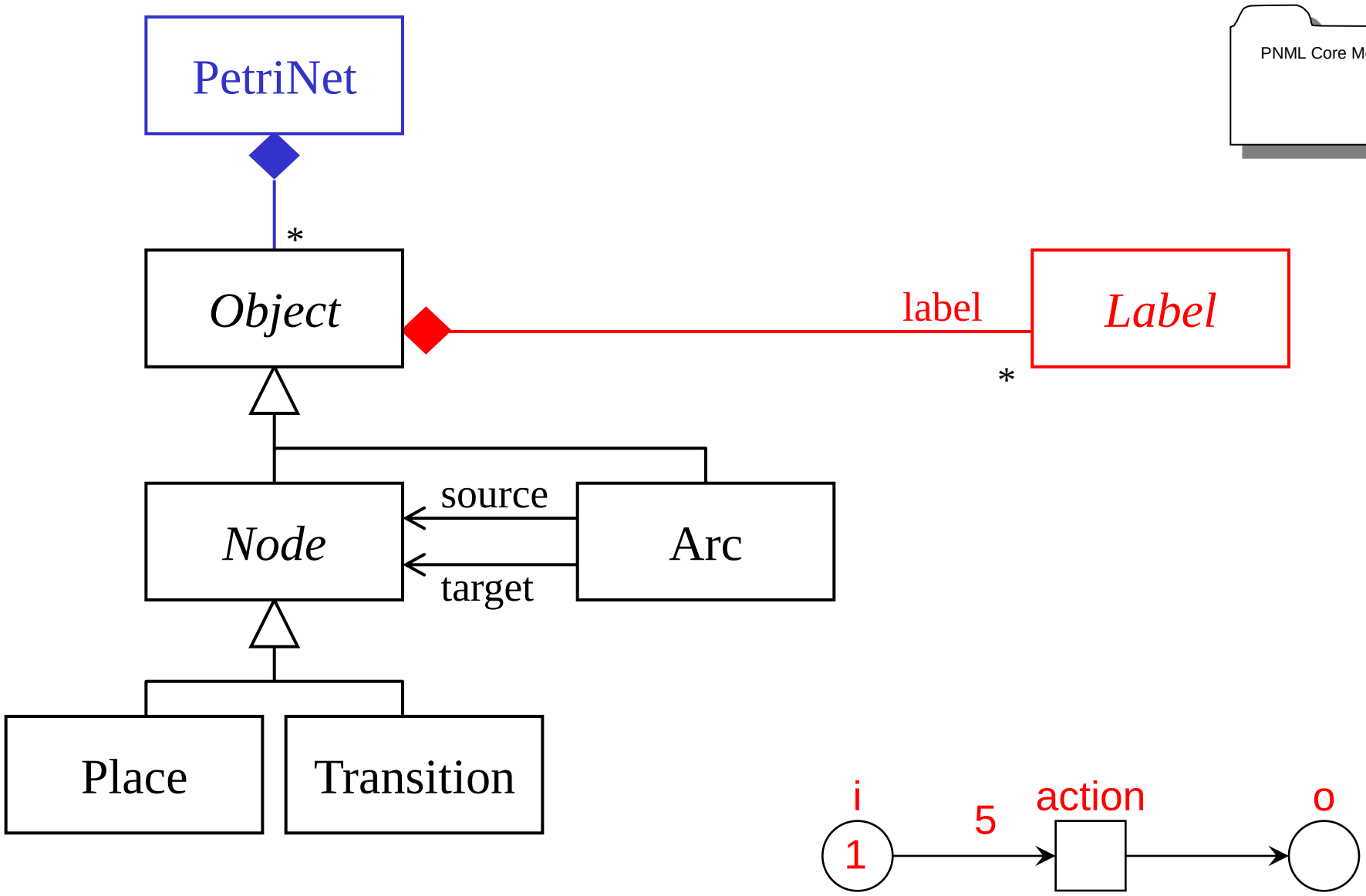

Core Model (overview)

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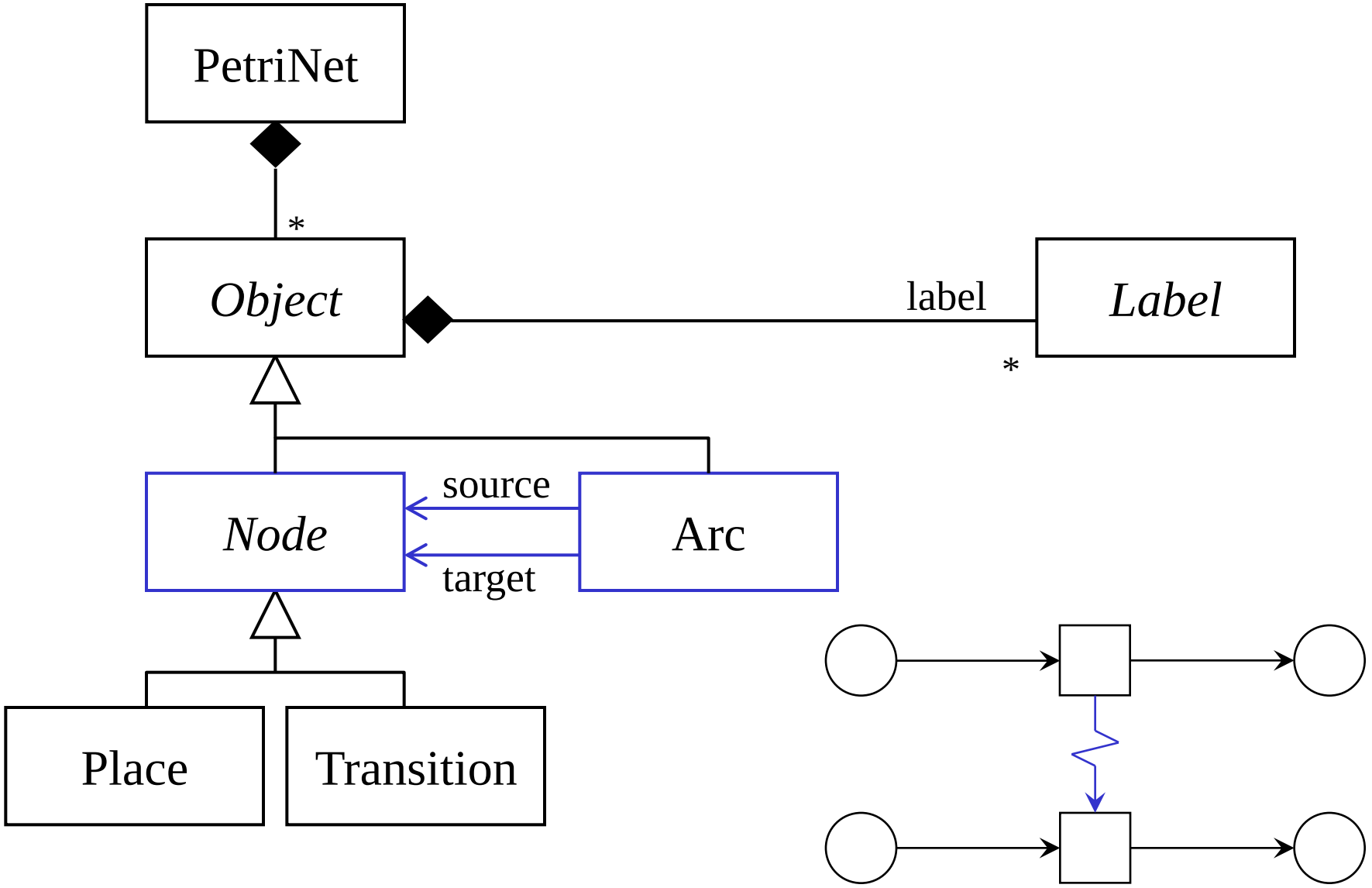

Core Model (overview)

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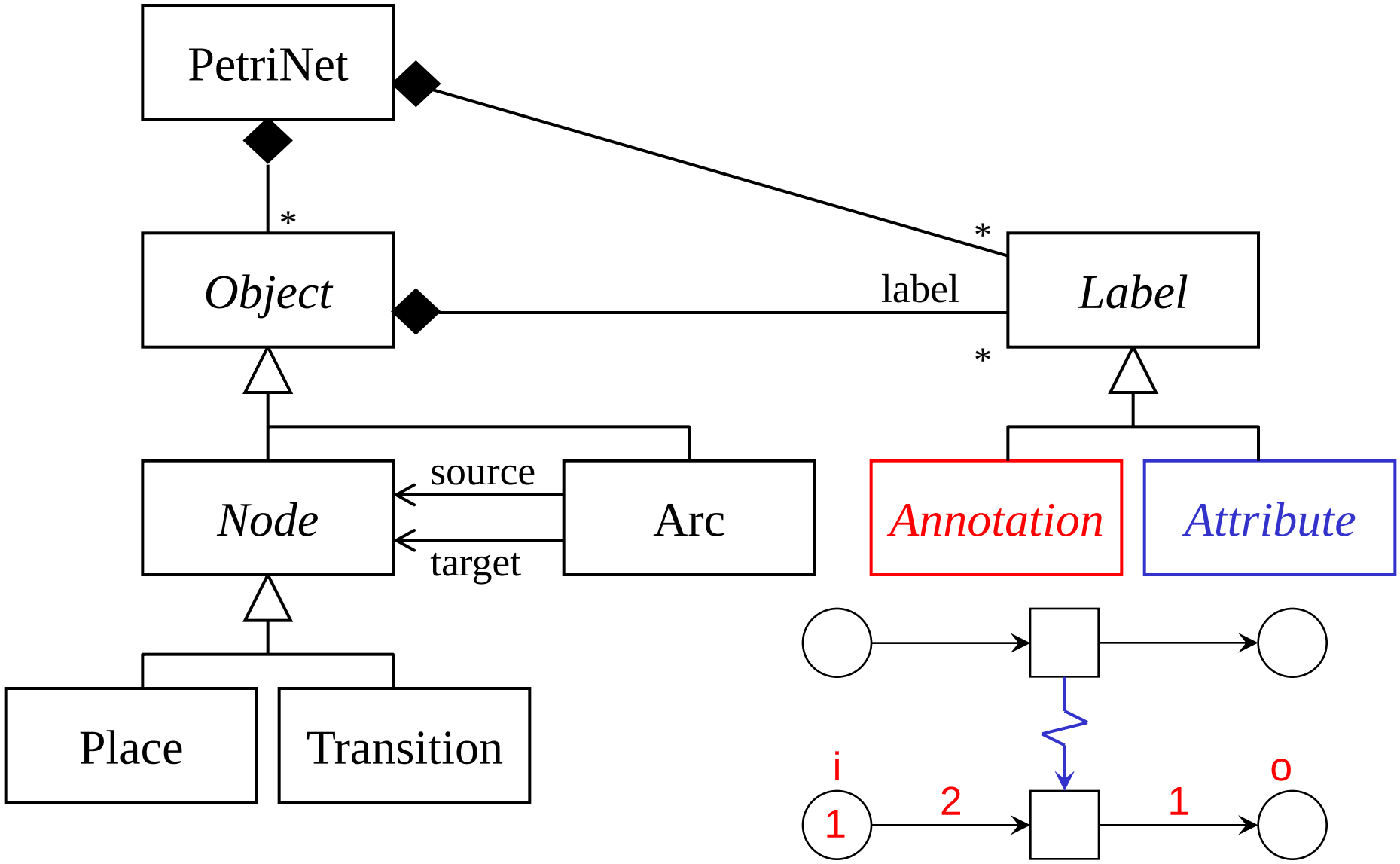

Core Model (overview)

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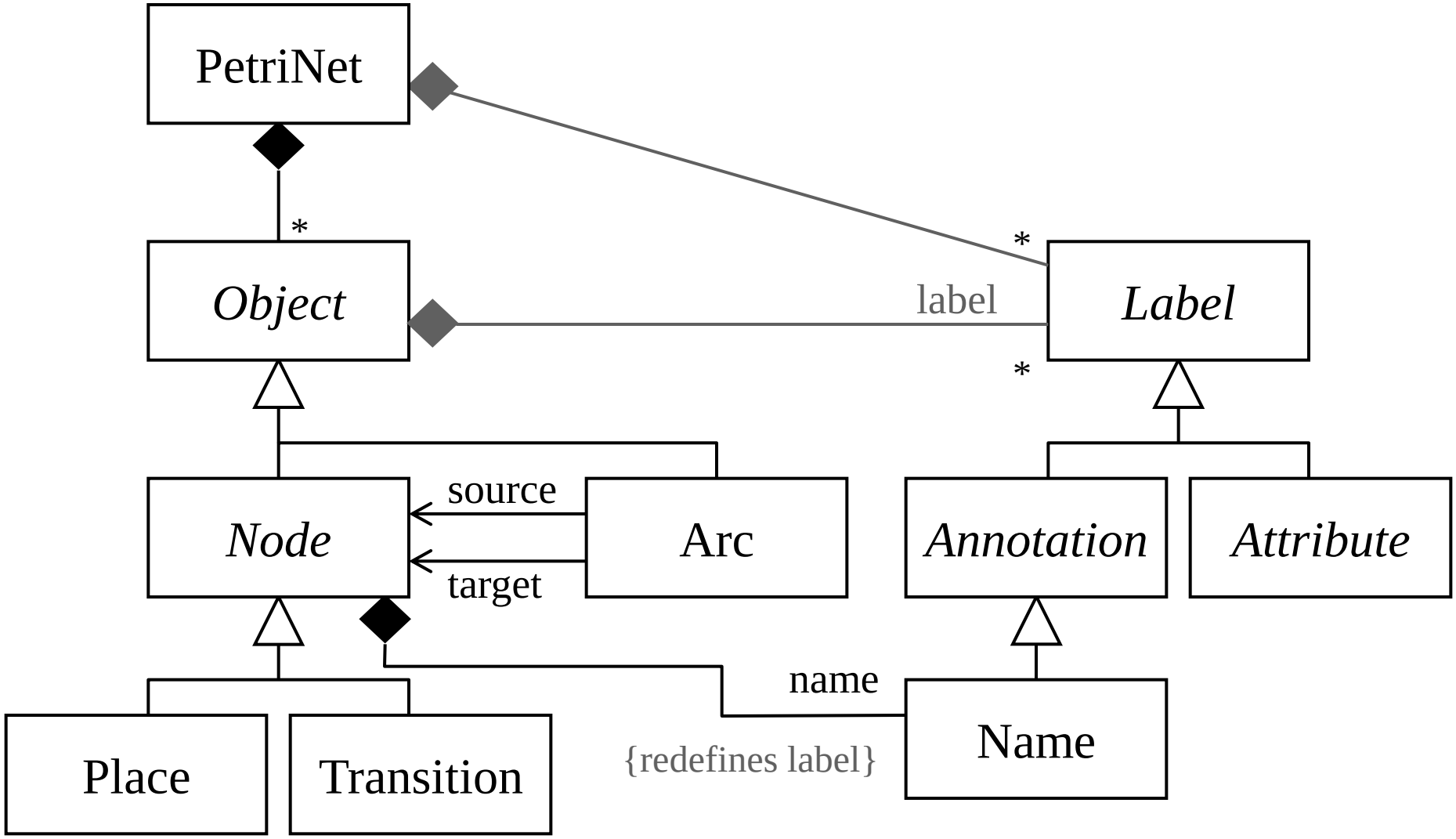

PNML Core Model

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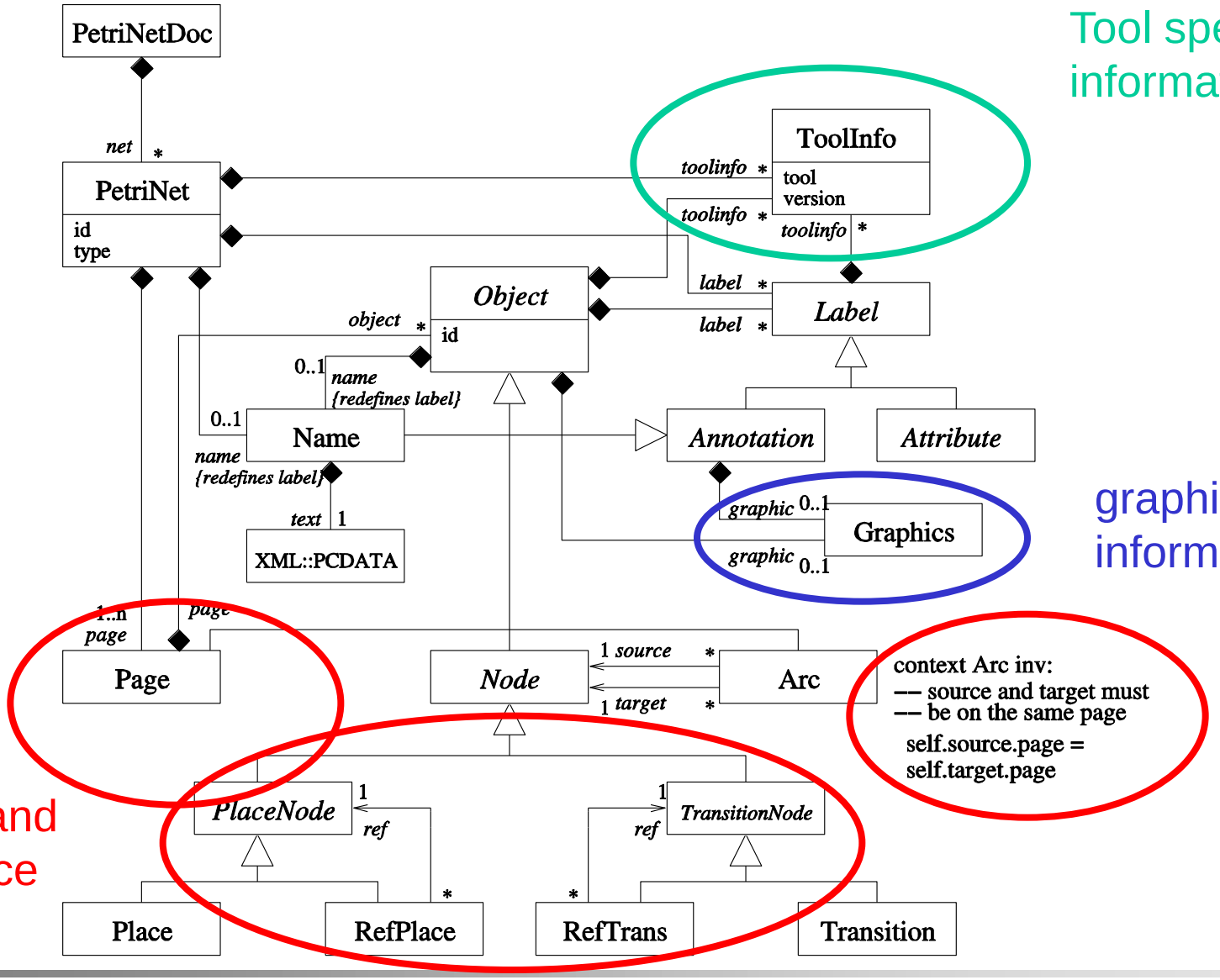

Tool specific information

graphical information

pages and reference nodes

Tool specific information

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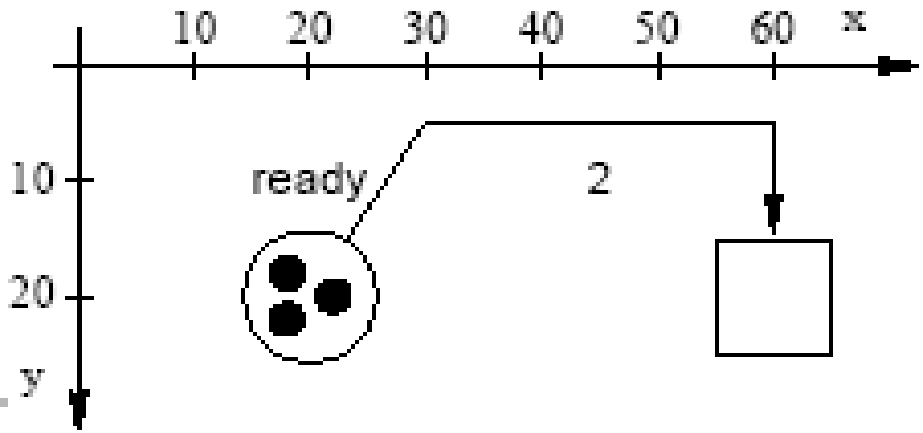
```
<initialMarking>
  <text>3</text>
  <toolspecific tool="org.pnml.tool"
                version="1.0">
    <tokengraphics>
      <tokenposition x="-2" y="-2" />
      <tokenposition x="2" y="0" />
      <tokenposition x="-2" y="2" />
    </tokengraphics>
  </toolspecific>
</initialMarking>
```



Outline

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2.3 Type Definition

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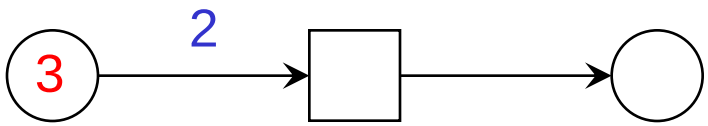

Type Definition: PT-Net

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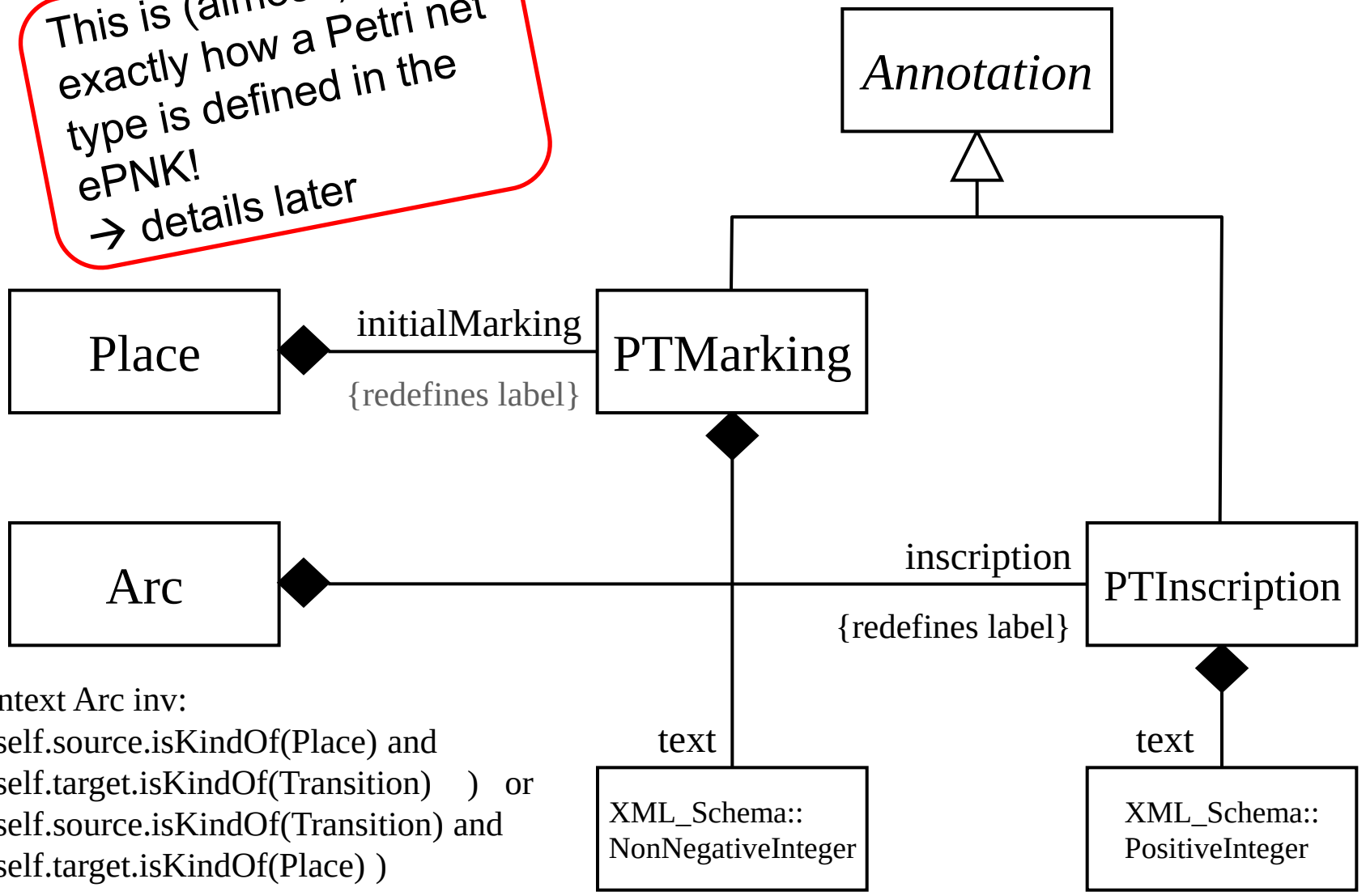
This is (almost!) exactly how a Petri net type is defined in the ePNK!
→ details later



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)

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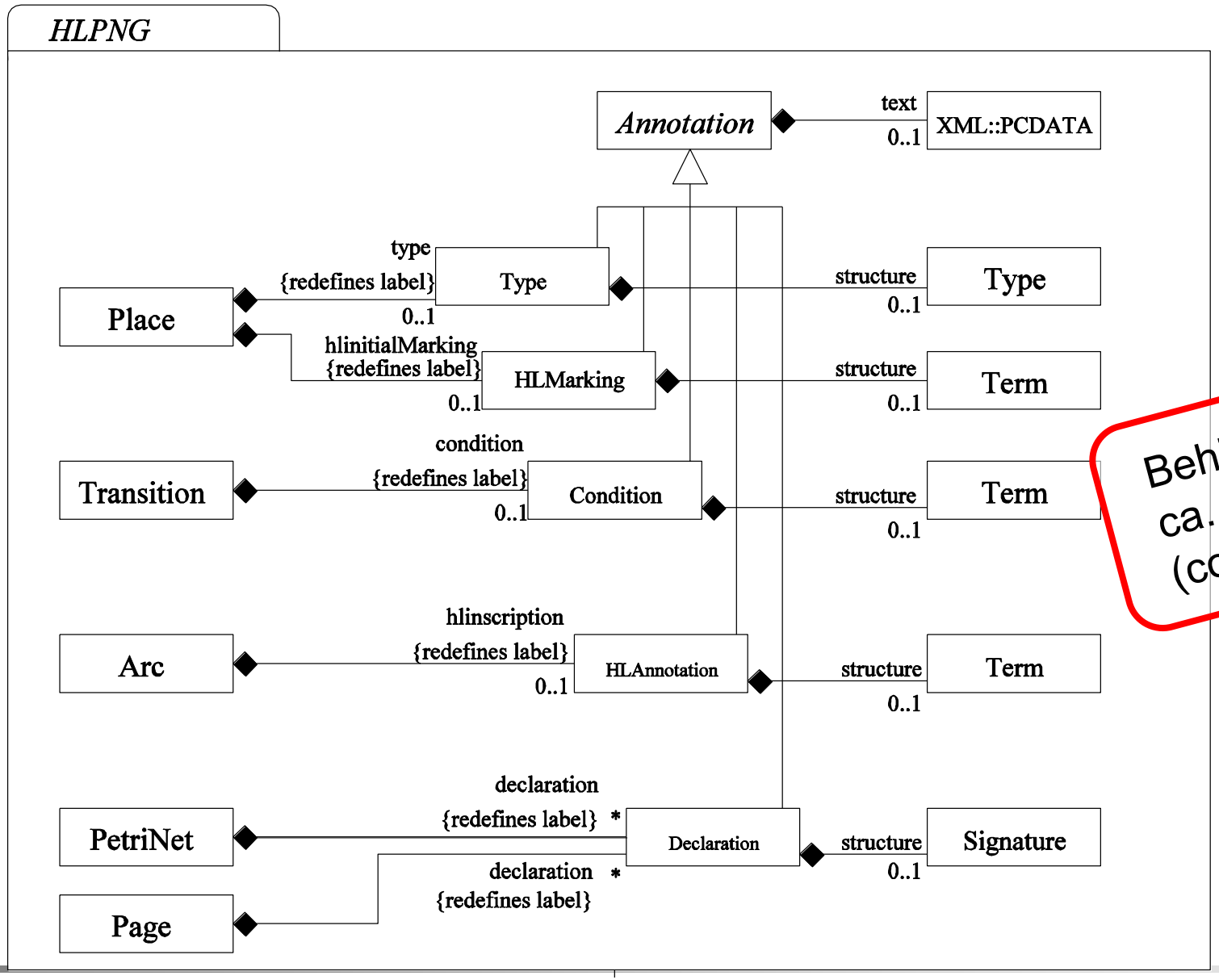

Behind this part ca. 80 classes (constructs).

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2.4 Core Model in XML

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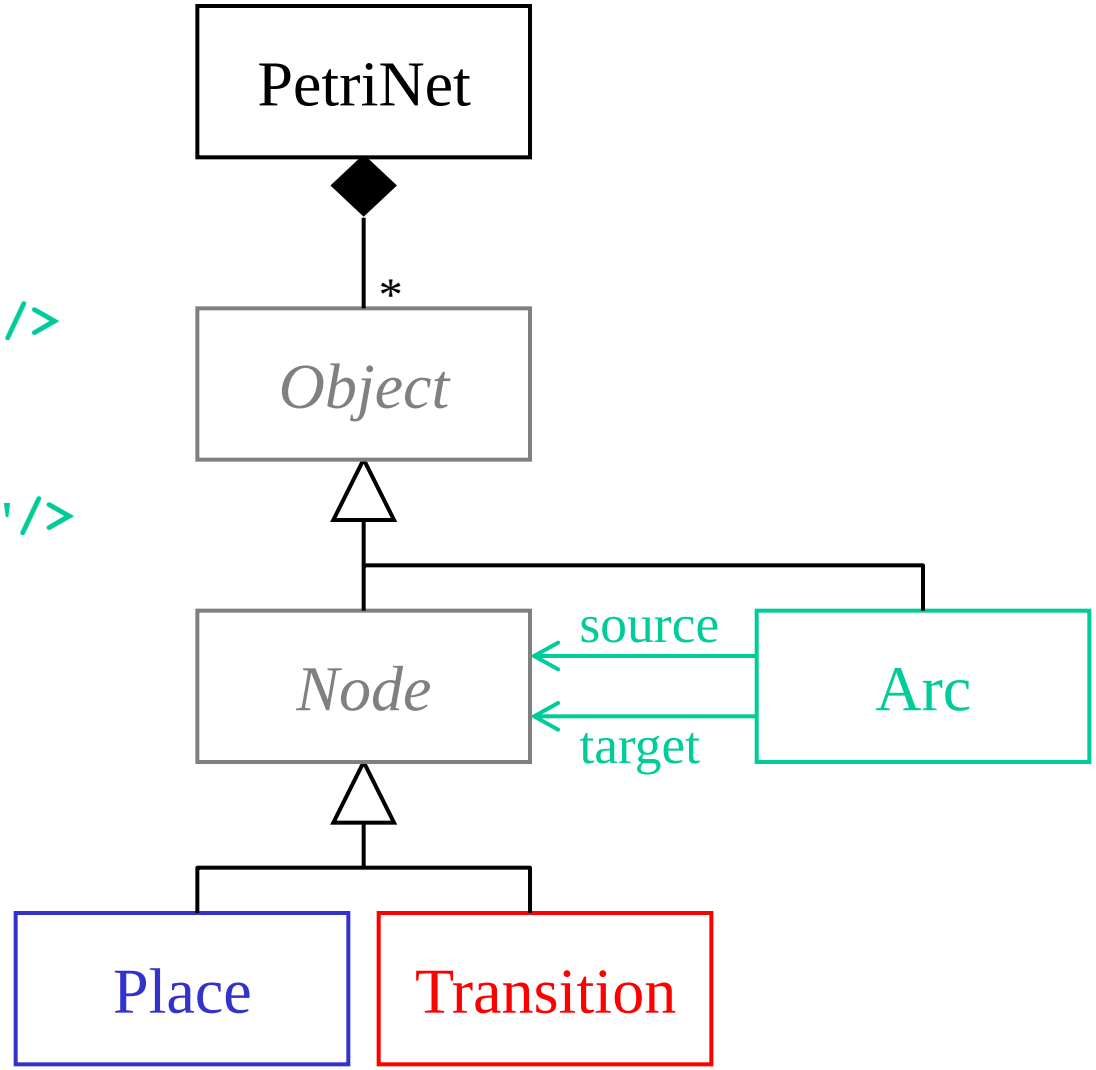
```
<pnml xmlns="http:...">
 <net id="n1" type="...">
  <place id="p1"/>
  <arc id="a1" source="p1"
               target="t1"/>
  <transition id="t1"/>
  <arc id="a2" source="t1"
               target="p2"/>
  <place id="p2"/>
 </net>
</pnml>
```



Labels in XML

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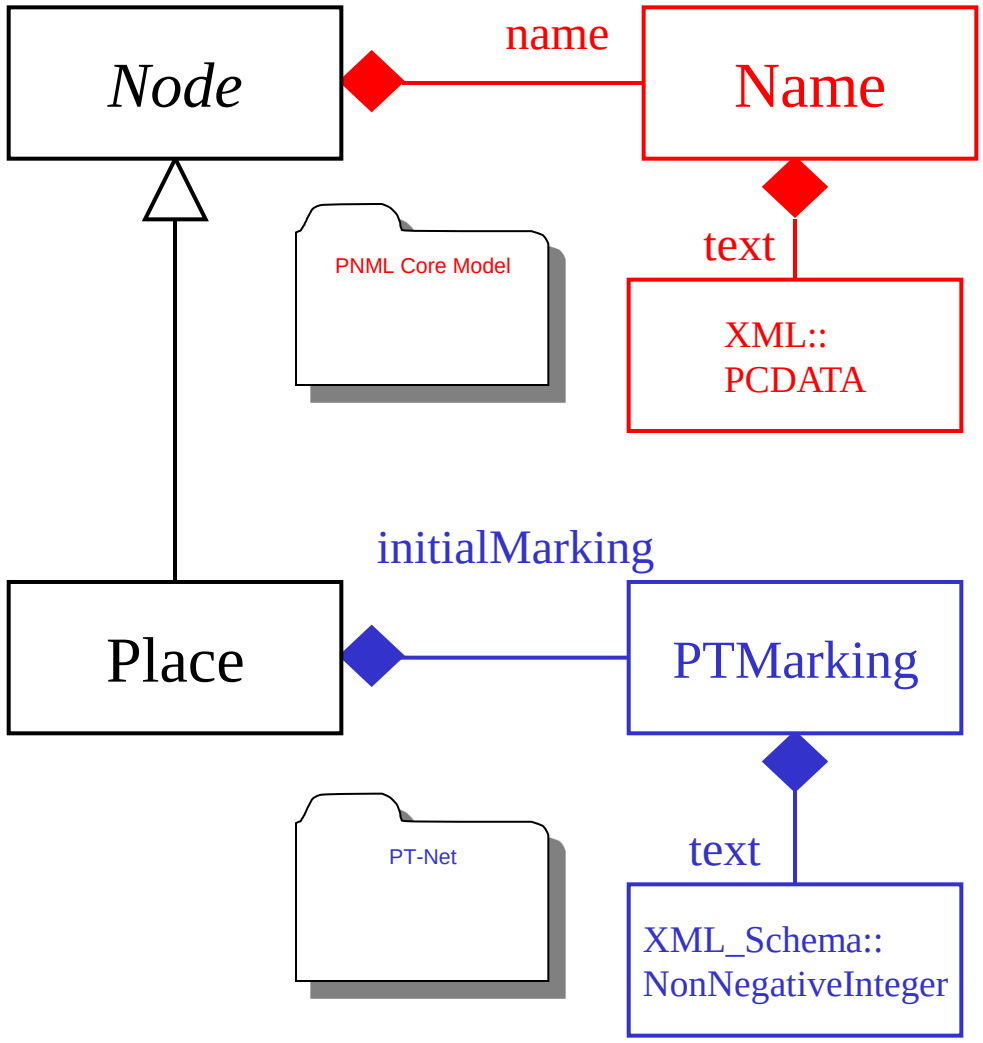
```
...
  <place id="p1">
    <name>
      <text>i</text>
    </name>
    <initialMarking>
      <text>1</text>
    </initialMarking>
  </place>
...
```



In general

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- How can this mapping 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) + some additional ePNK specific mechanisms.

Not discussed in this course, you do not need to define mappings to XML (use the default mapping).

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3. Experience

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- 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 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 statistics

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- Petri Net Type: P/T-Net plugin
  - Ecore 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 type for inhibitor nets type took *me* 33 minutes!

- 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 statistics

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- 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

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- 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!

Outline

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4. The ePNK: Tutorial

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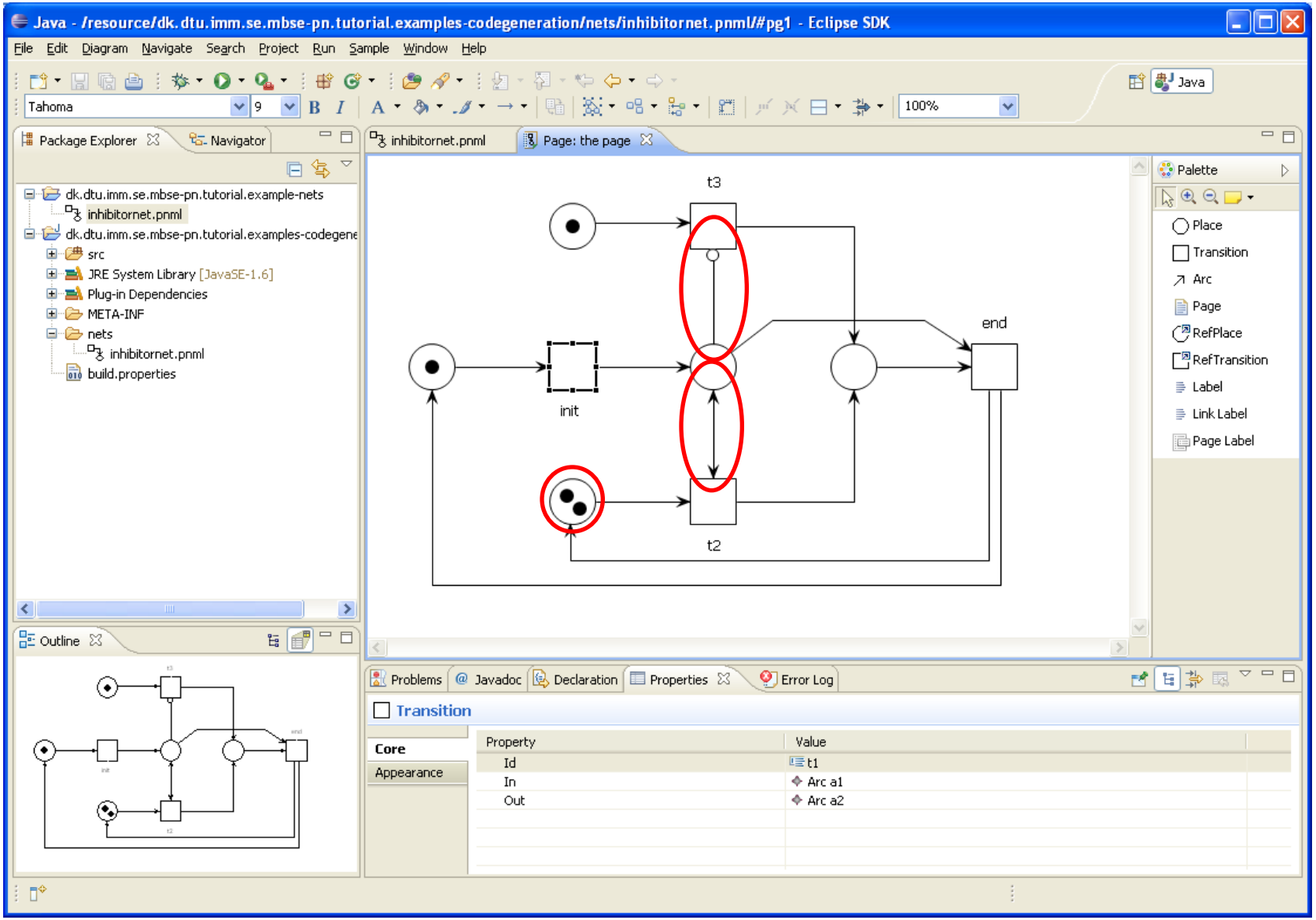

Define a Petri Net Type

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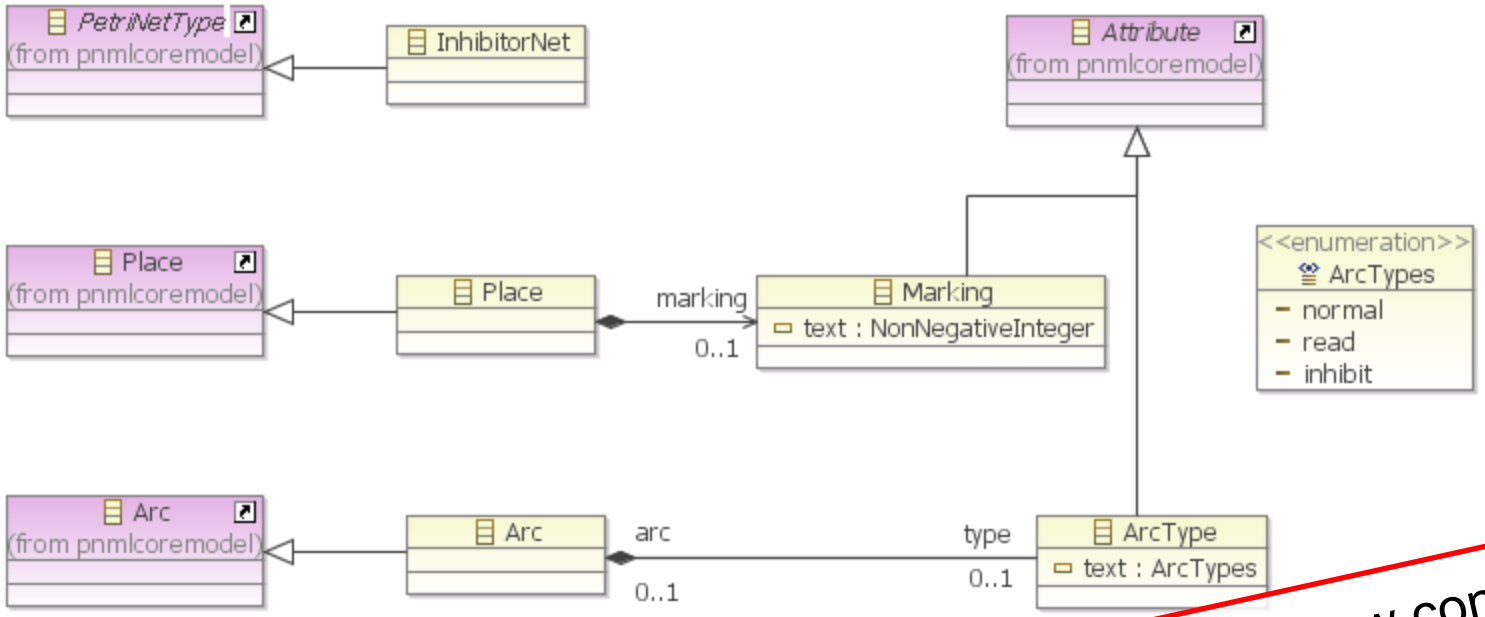
What should it take to define this new Petri Net type conceptually?



Define the new concepts:
As a software engineer,
we do that with a class
diagram

Define a Petri Net Type

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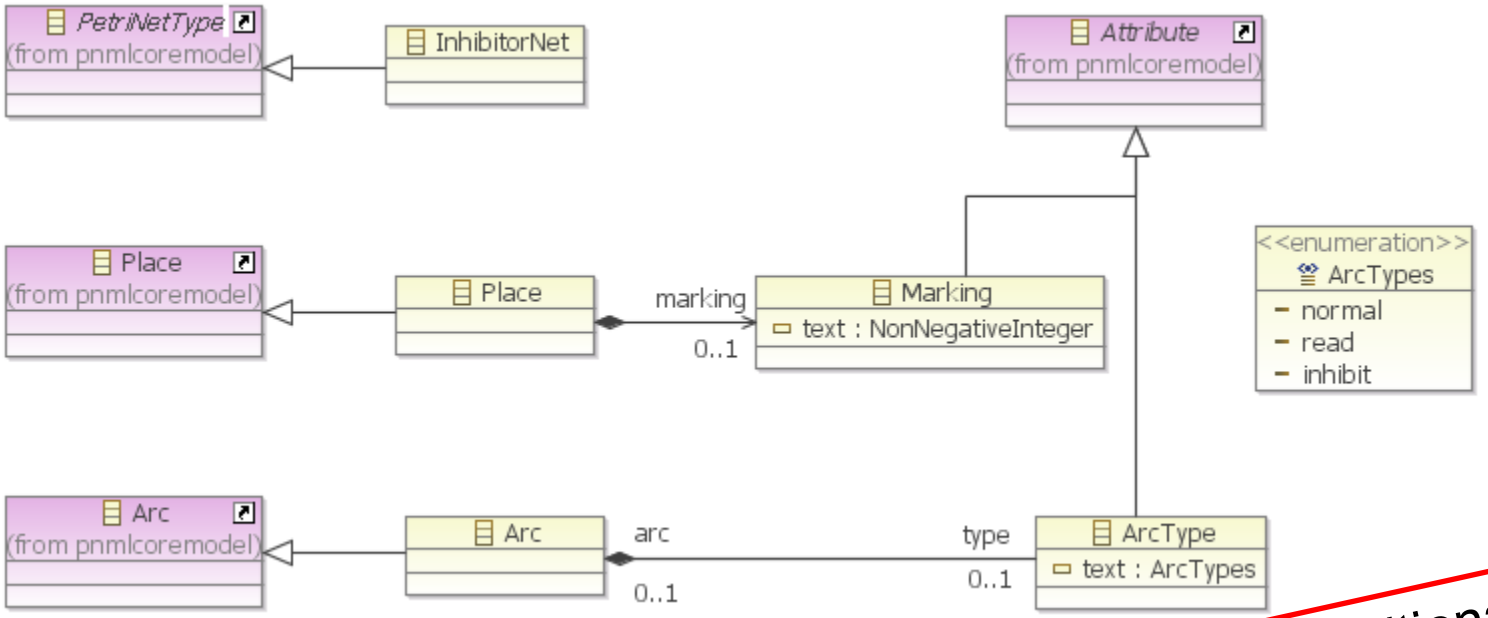

Define the additional constraint:
As a software engineer we do it with OCL (see Tutorial 7)

```
( self.source.oclIsKindOf(pnmlcoremodel::PlaceNode) and
  self.target.oclIsKindOf(pnmlcoremodel::TransitionNode) )
or
( self.source.oclIsKindOf(pnmlcoremodel::TransitionNode) and
  self.target.oclIsKindOf(pnmlcoremodel::PlaceNode) and
  not ( self.type.text = ArcTypes::inhibit ) )
```

Define a Petri Net Type

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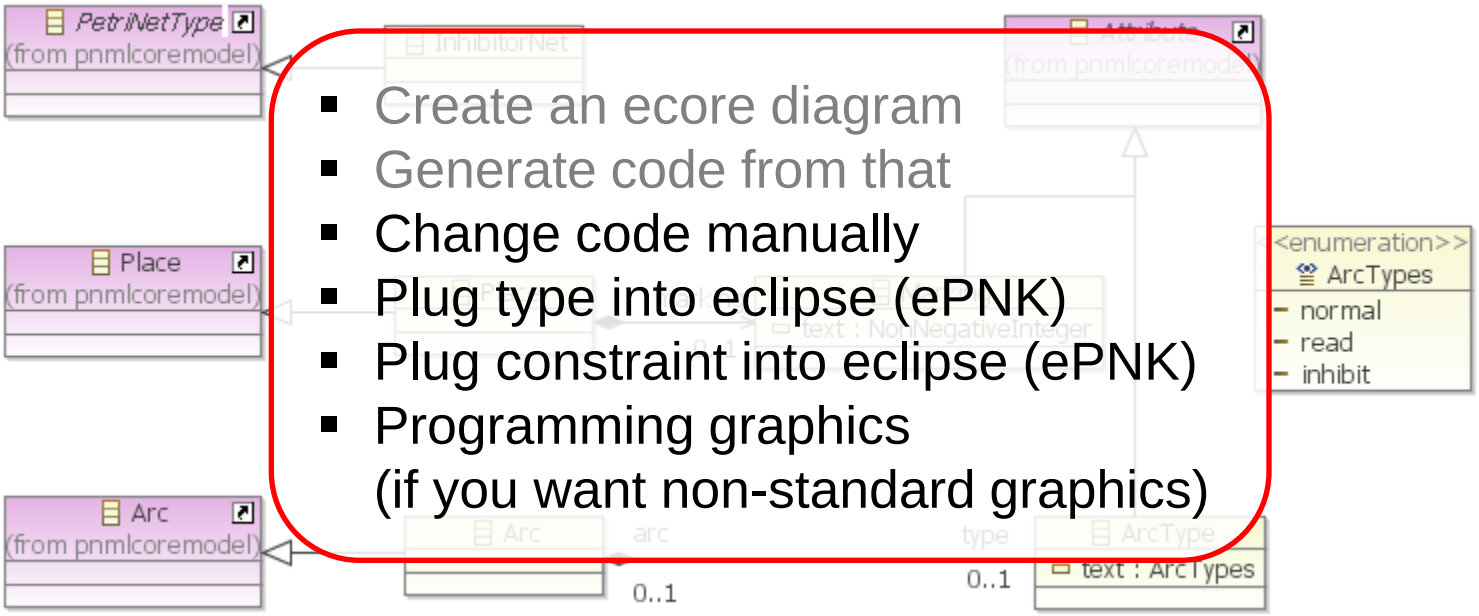
What does it take to implement it now?



- Create an ecore diagram
- Generate code from that
- Change code manually
- Plug type into eclipse (ePNK)
- Plug constraint into eclipse (ePNK)
- Programming graphics
  (if you want non-standard graphics)

```
( self.source.oclIsKindOf(pnmlcoremodel::PlaceNode) and
  self.target.oclIsKindOf(pnmlcoremodel::TransitionNode) )
or
( self.source.oclIsKindOf(pnmlcoremodel::TransitionNode) and
  self.target.oclIsKindOf(pnmlcoremodel::PlaceNode) and
  not ( self.type.text = ArcTypes::inhibit ) )
```

Change code manually

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```
package inhibitornets.impl;

[…]

public class InhibitorNetImpl extends PetriNetTypeImpl implements
   InhibitorNet {

   public InhibitorNetImpl() {
        super();
   }

   protected EClass eStaticClass() {
        return InhibitornetsPackage.Literals.INHIBITOR_NET;
   }

   public String toString() {
        return "http://dk.dtu.imm.se.mbse-pn.tutorial.inhibitornet";

   }

}
```

Plug in net type

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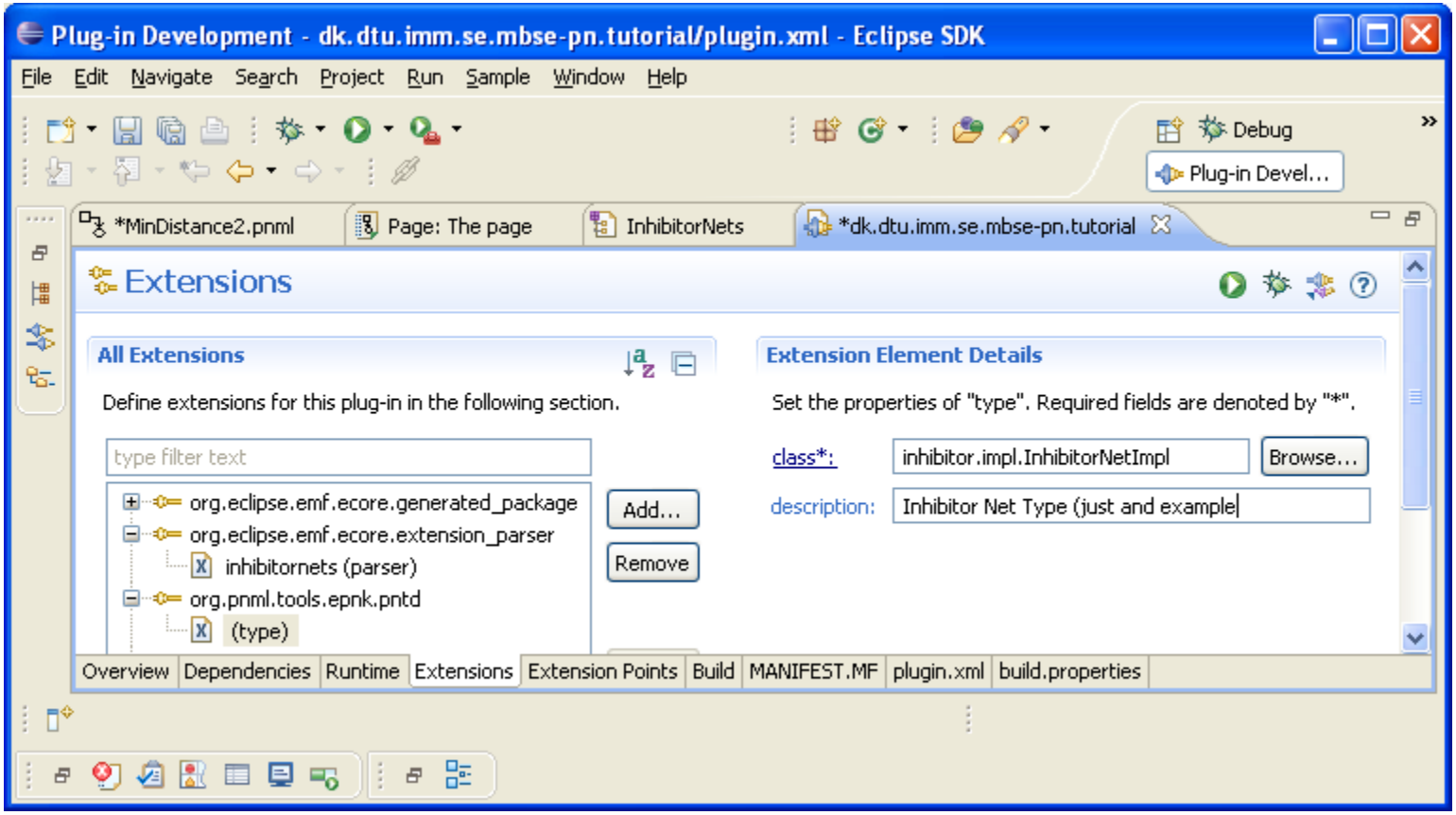

Plug in net type

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```
<extension
    id="inhibitornets"
    name="Inhibitor Nets"
    point="org.pnml.tools.epnk.pntd">
    <type
        class=" inhibitornets.InhibitorNetImpl"
        description="Inhibitor nets">
    </type>
</extension>
```

Fully qualified (Java) class name

Plug in constraint

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```
<extension
    point="org.eclipse.emf.validation.constraintProviders">

      [about 40 other boring but technically important lines]


  <![CDATA[
  ( self.source.oclIsKindOf(pnmlcoremodel::PlaceNode) and
    self.target.oclIsKindOf(pnmlcoremodel::TransitionNode) )
  or
  ( self.source.oclIsKindOf(pnmlcoremodel::TransitionNode) and
    self.target.oclIsKindOf(pnmlcoremodel::PlaceNode) and
    not ( self.type.text = ArcTypes::inhibit ) )
  ]]>
     </constraint>
    </constraints>
  </constraintProvider>
</extension>
```

Unfortunately, this is a bit technical

Constraints can also be programmed

→ Tutorial 7

Programm Graphics

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```
public class InhibitornetsArcFigure extends ArcFigure {
[...]
  private void setGraphics() {
    RotatableDecoration targetDecorator = null;
    RotatableDecoration sourceDecorator = null;

    if (type.equals(ArcTypes.NORMAL)) {
      targetDecorator = new ReisigsArrowHeadDecoration();

    } else if (type.equals(ArcTypes.INHIBIT)) {
      CircleDecoration circleDecoration =
        new CircleDecoration();
      circleDecoration.setLineWidth(this.getLineWidth());
      targetDecorator = circleDecoration;

    } else if (type.equals(ArcTypes.READ)) {
      targetDecorator = new ReisigsArrowHeadDecoration();
      sourceDecorator = new ReisigsArrowHeadDecoration();
[...]
```

Just a glimpse!

→ details Tutorial

Result

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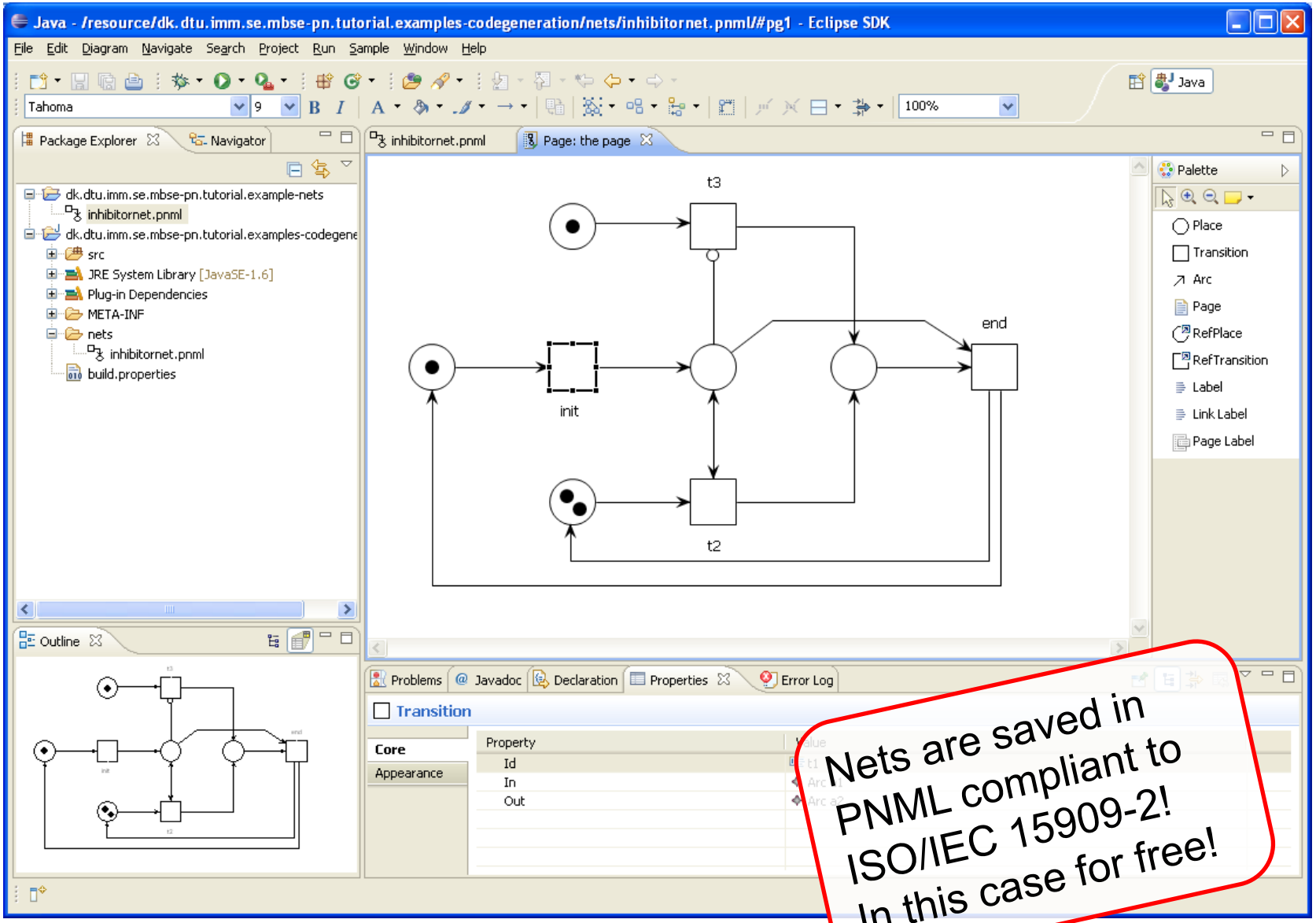

Applications (on nets)

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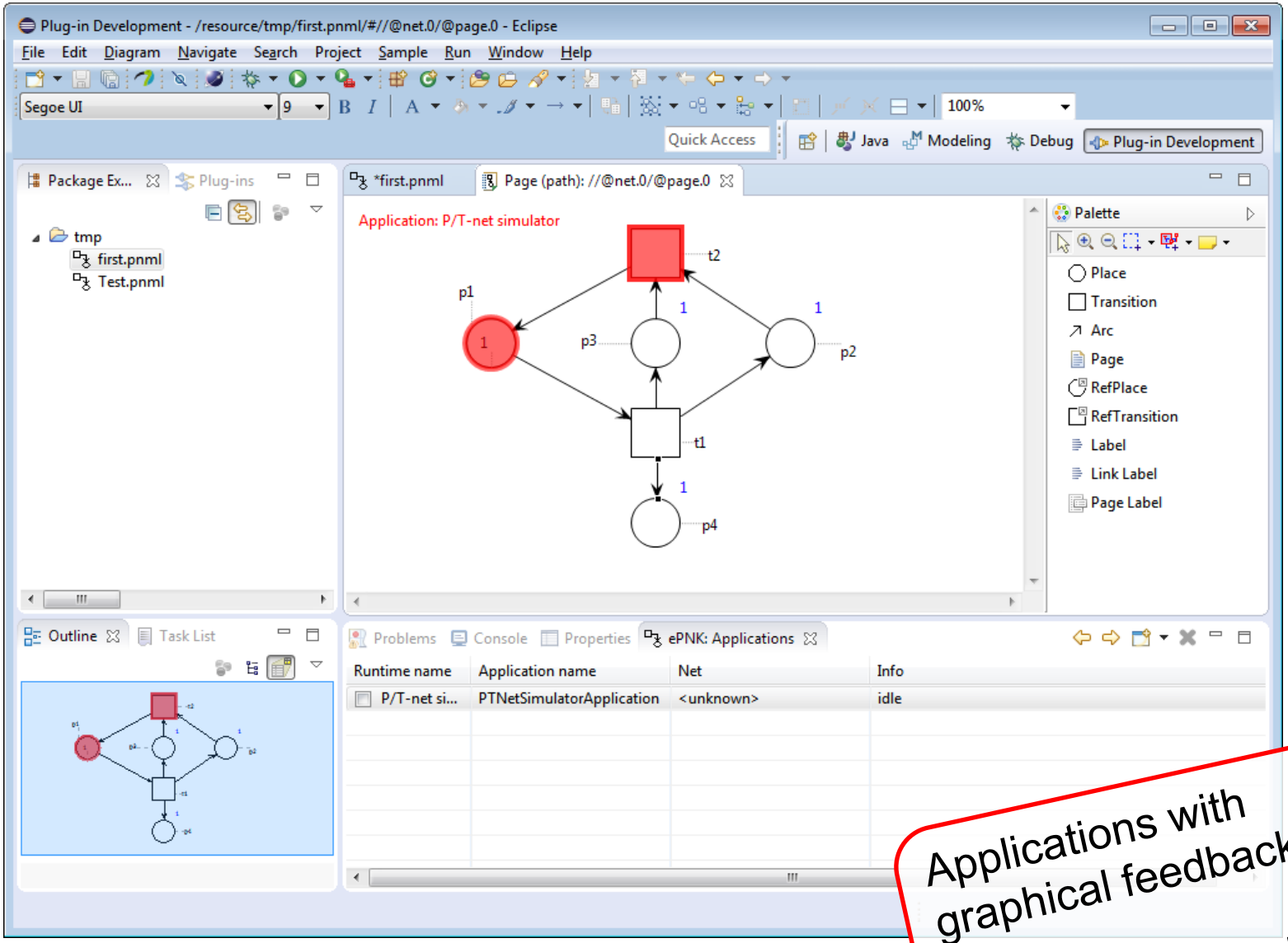

Applications with graphical feedback

→ Details Tutorial 7 & 8