Model-Based Software Engineering

Lecture 10 – Transformation

Prof. Dr. Joel Greenyer

June 28, 2016

SOFTWARE ENGINEERING

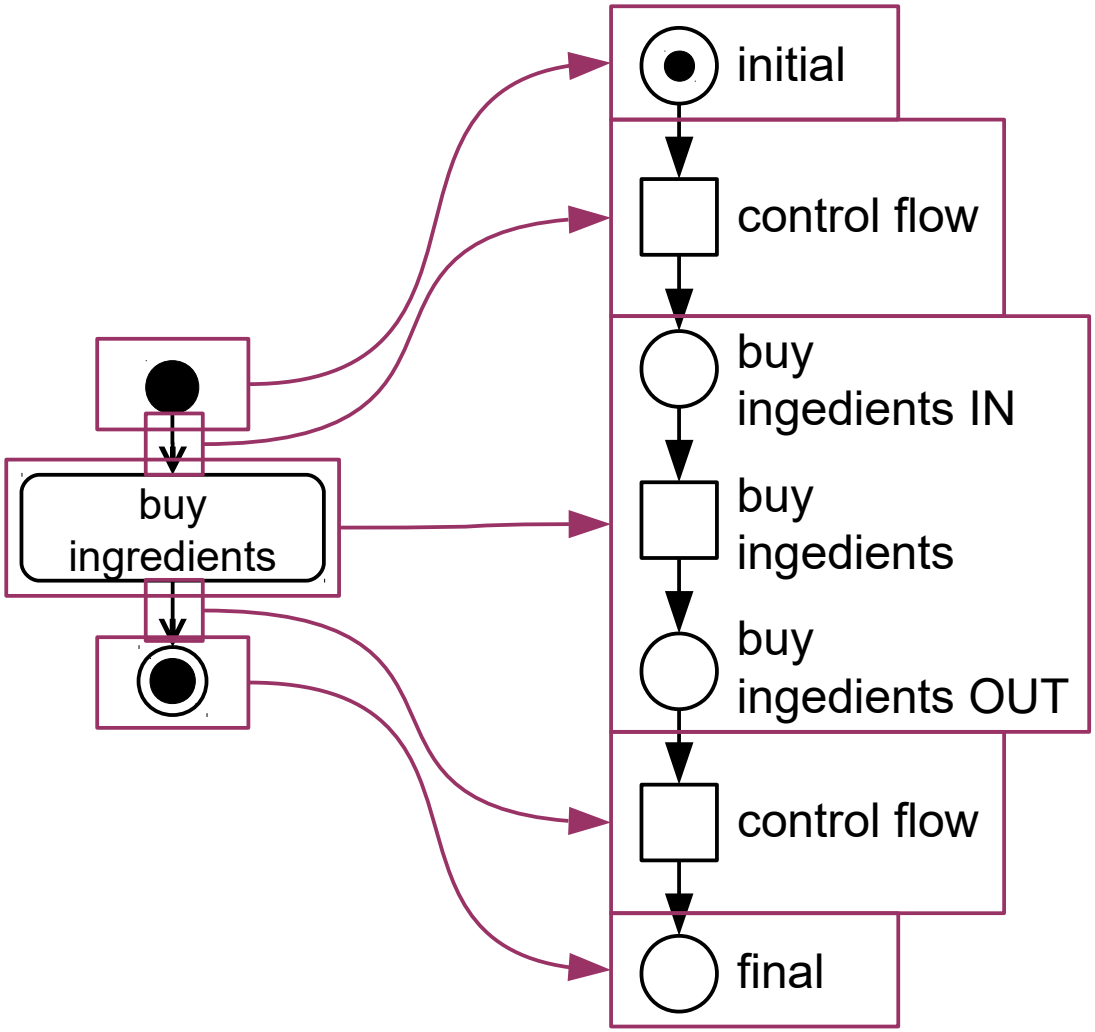
in the last lecture...

5.4. Model-to-model transformation – Triple Graph Grammars

Example:Transform Activity Diagrams to Petri nets

in the last lecture...

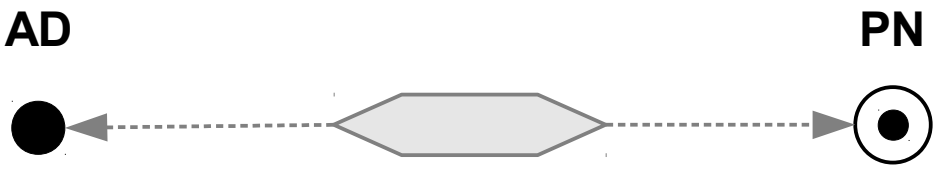
- Let's start simple: How to transform
  - Initial nodes?
  - Final nodes?
  - Action nodes?
  - Control flow edges?



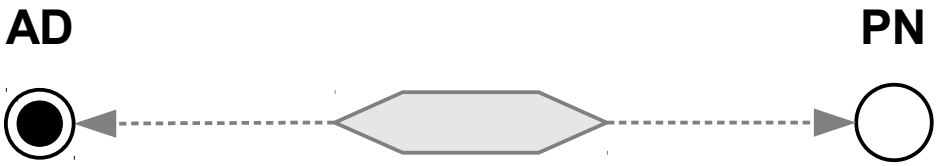
in the last lecture...

Relations Between Model Patterns
Example: Activity to Petri net

- Intial node ↔ Place with intial marking



- Final node ↔ Empty Place



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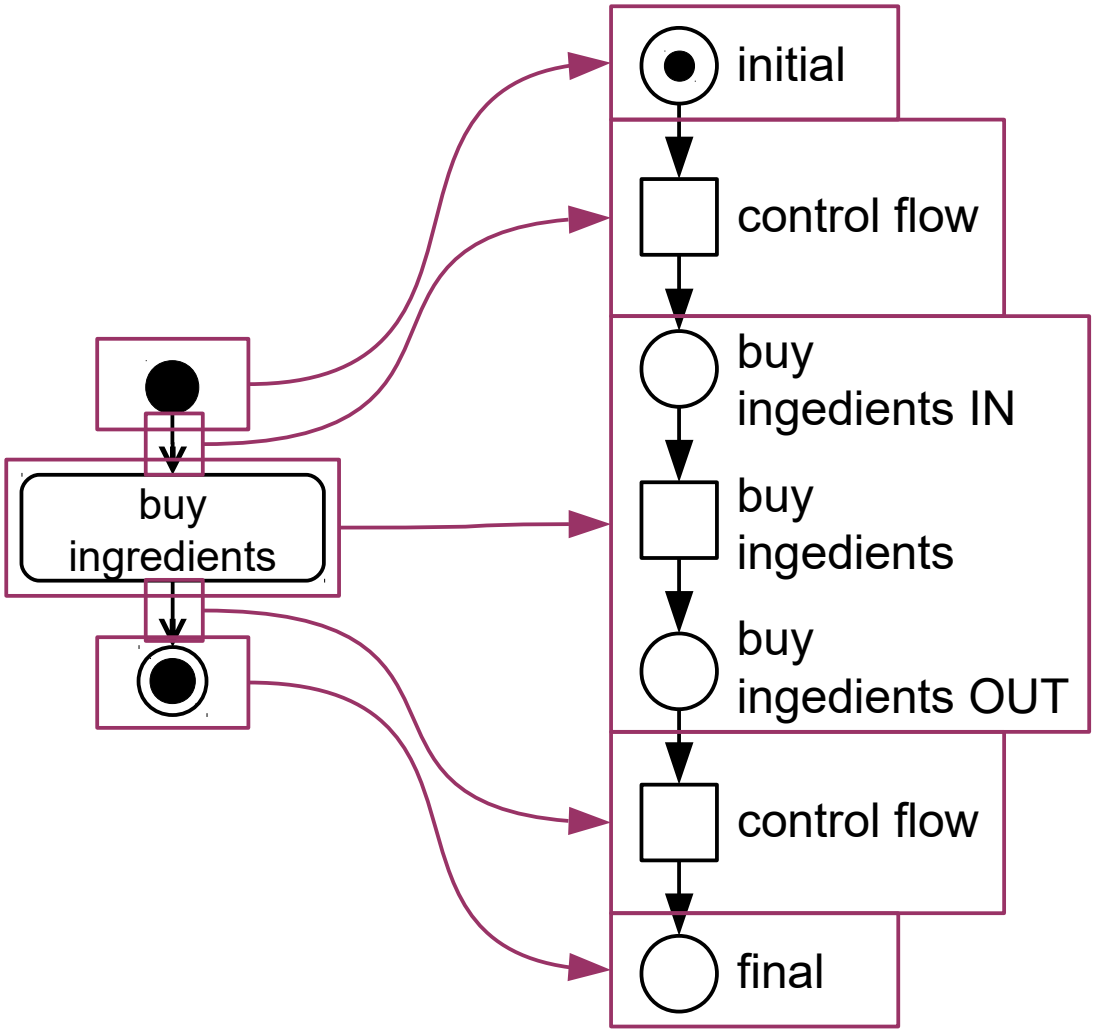
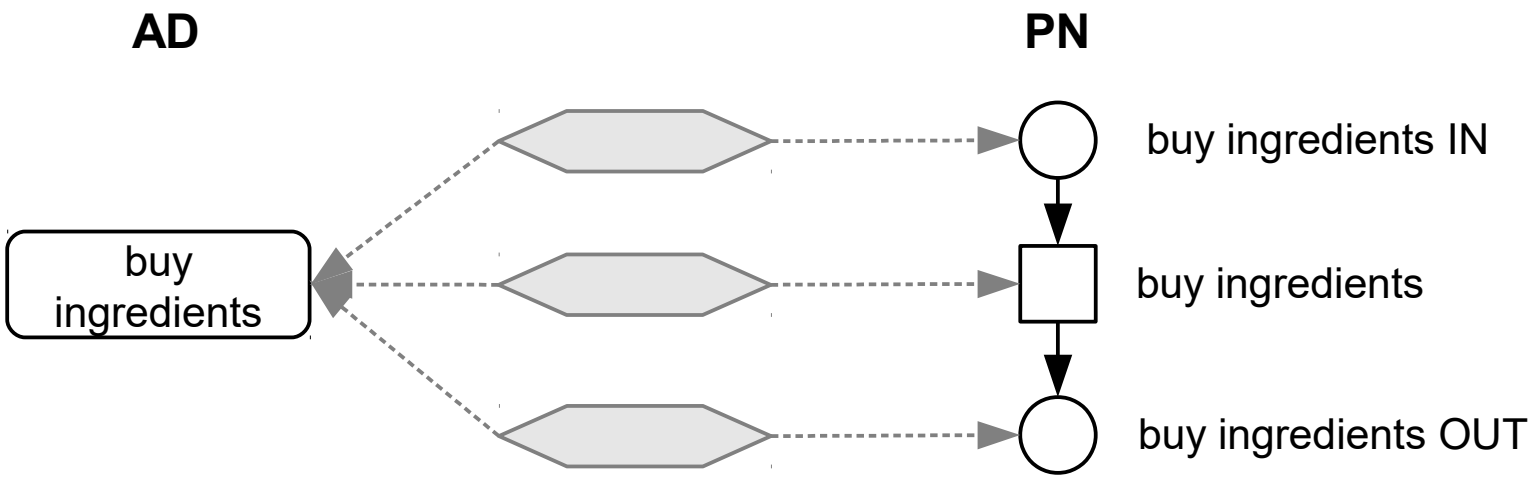


Relations Between Model Patterns
Example: Activity to Petri net

in the last lecture...

- Action node ↔ Transition with input and output place



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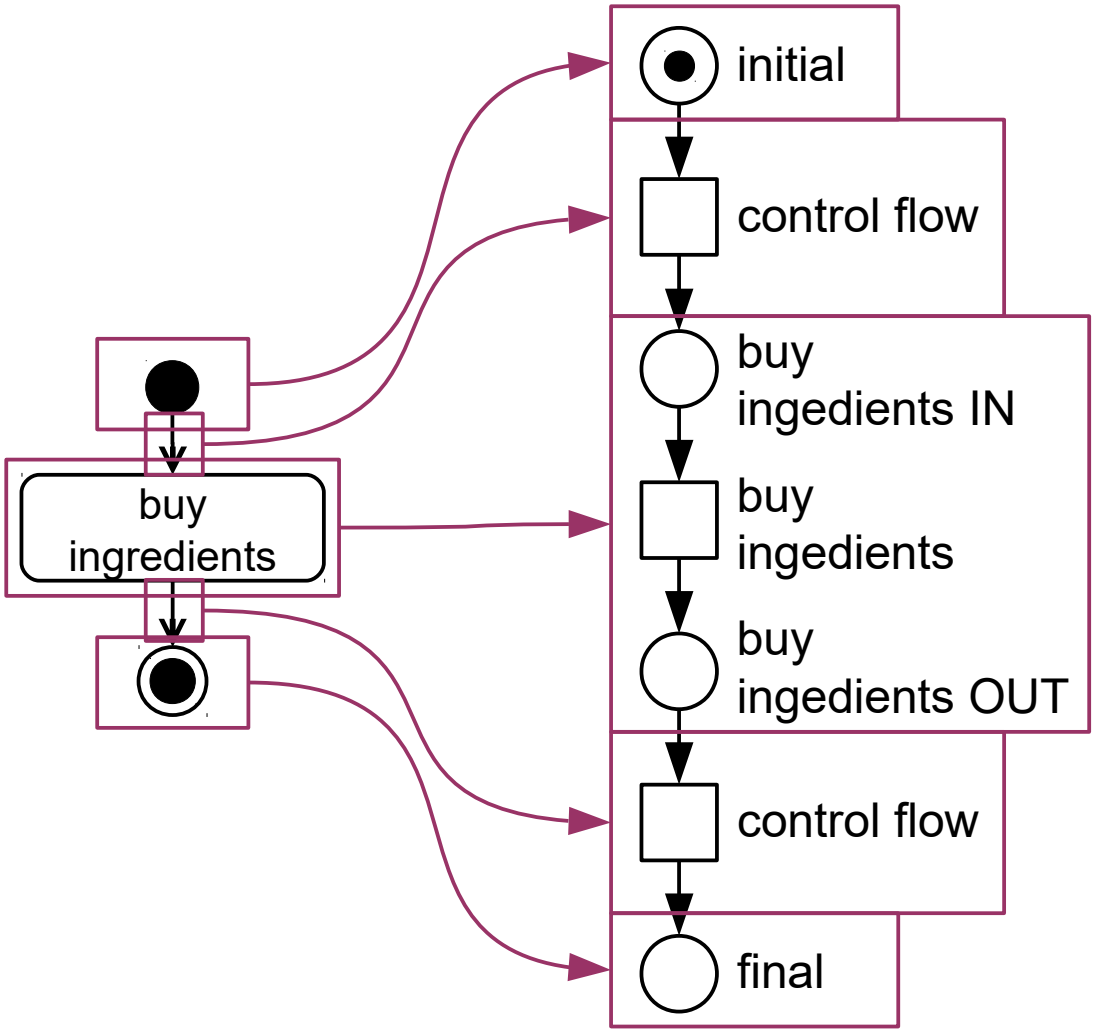
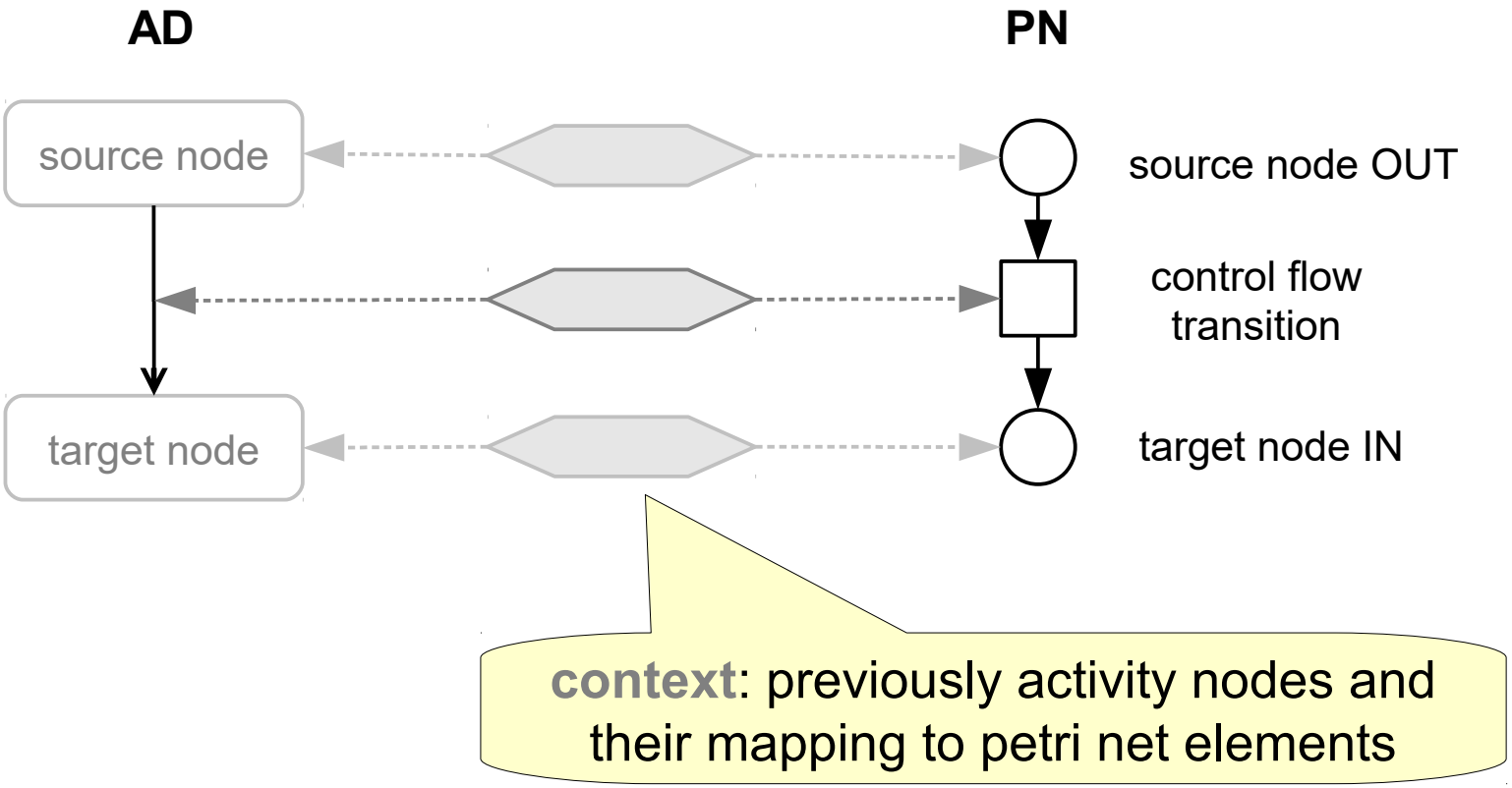


Relations Between Model Patterns
Example: Activity to Petri net

in the last lecture...

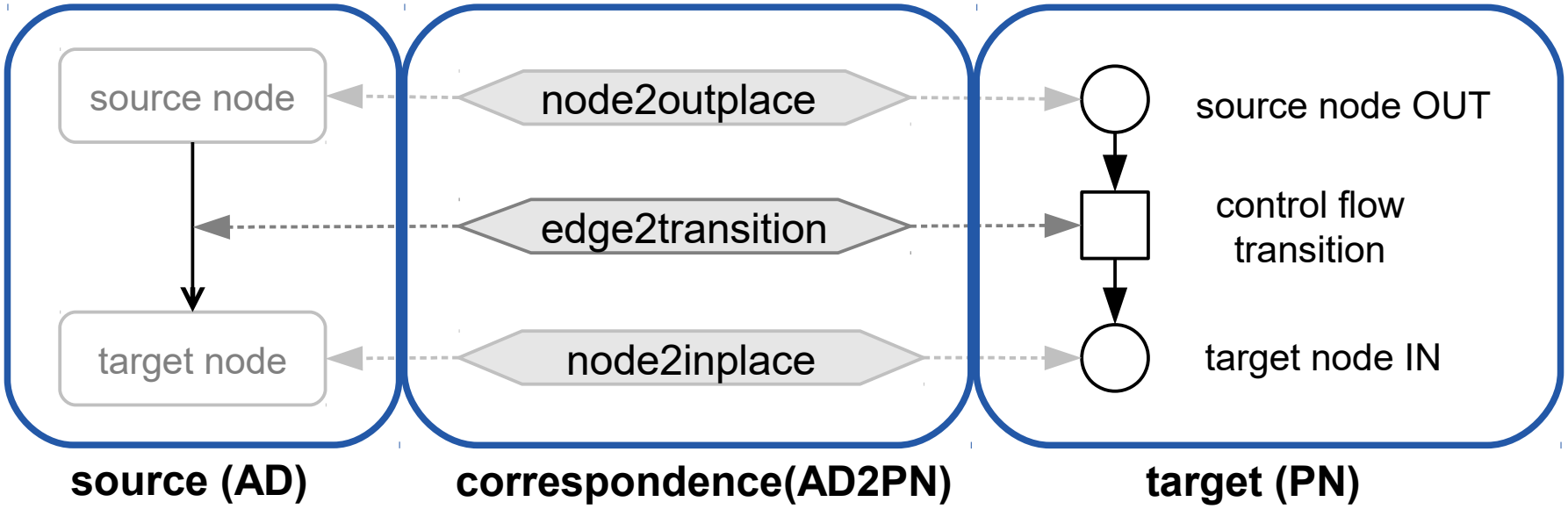
- Control flow edge ↔ Transition connecting in- and out places that correspond to the edge's source and target nodes



Triple Graphs

in the last lecture...

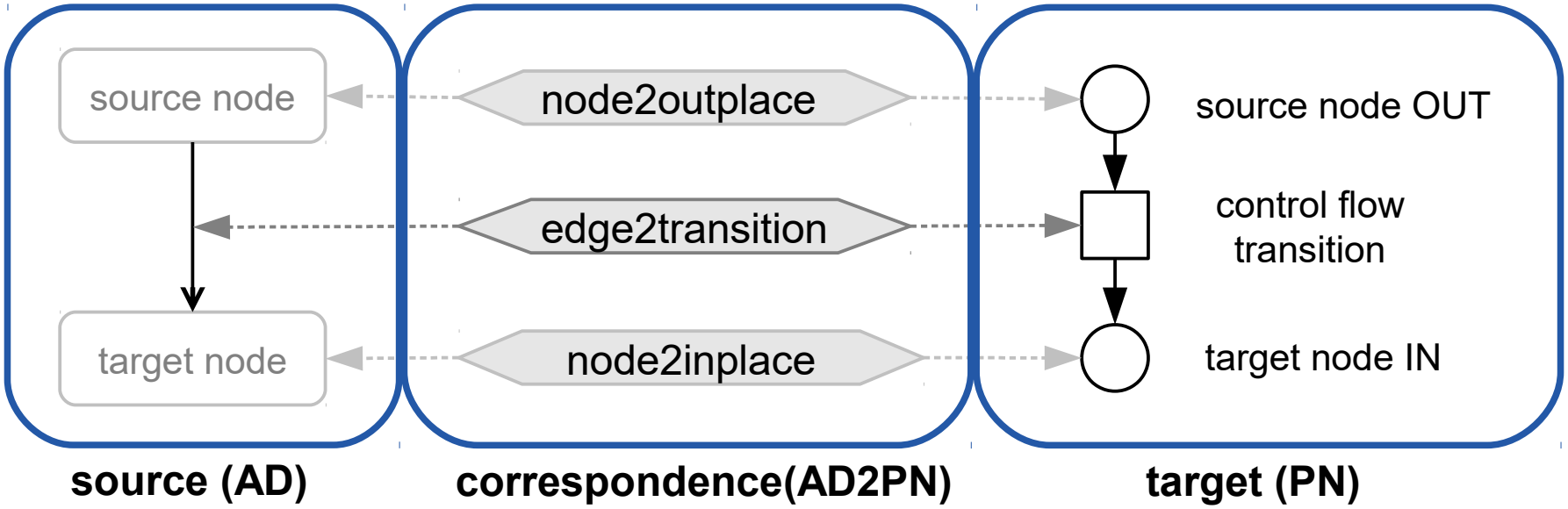
- **Idea 1**: describe the mapping of models as a **triple graph**
- What does a **triple graph** consist of?
  - **source** graph (model)
  - **target** graph (model)
  - **correspondence** graph (model) that connects the source and target graphs (models)



Triple Graphs

in the last lecture...

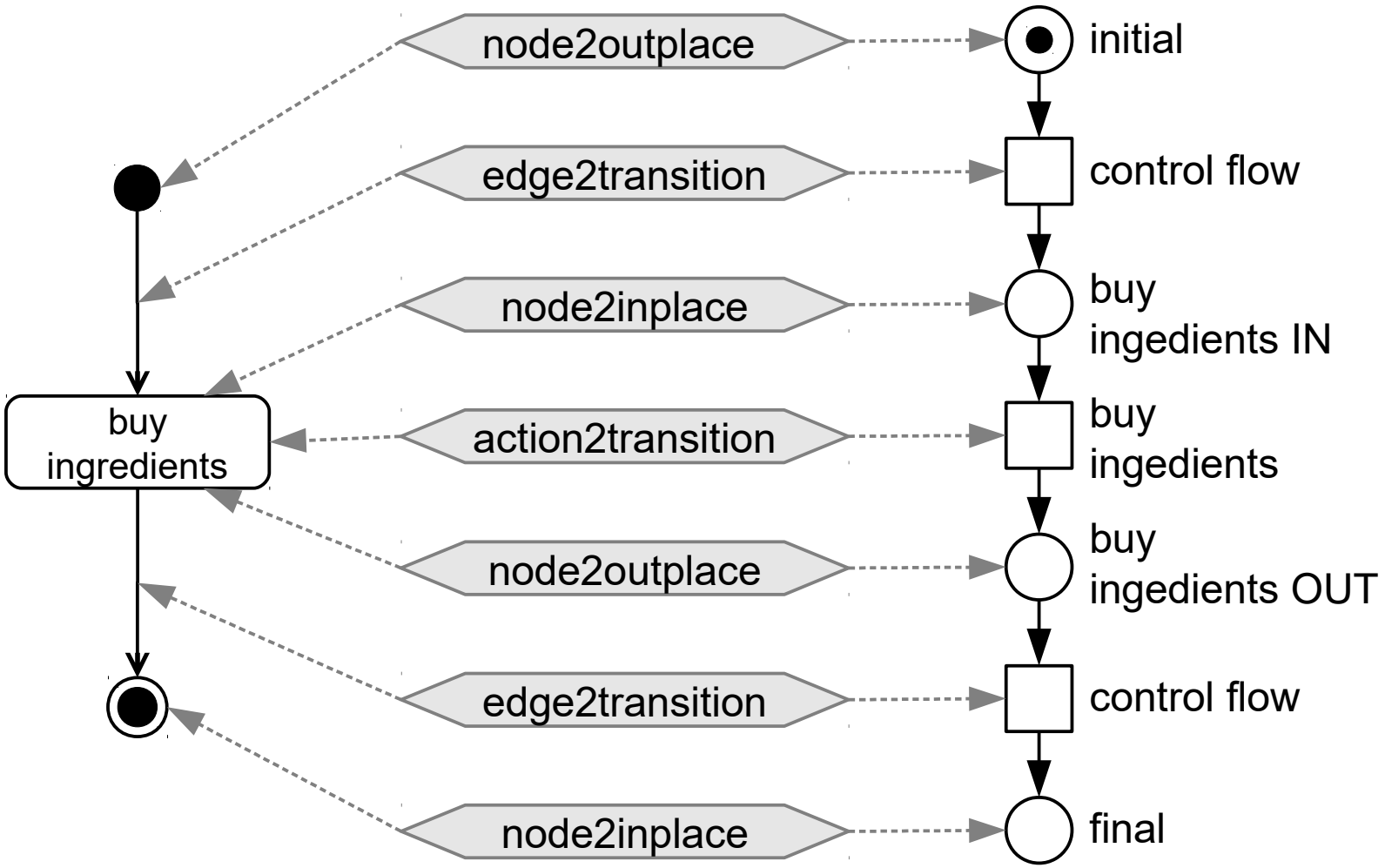
- The three different graphs (source, target, correspondence) are typed over (usually different) type graphs (metamodels)
- Also called source-, target-, and correspondence- **domain**
  - **source domain:** Activity Diagrams
  - **target domain:** Petri net
  - **correspondence domain:** AD2PN



Triple Graphs

in the last lecture...

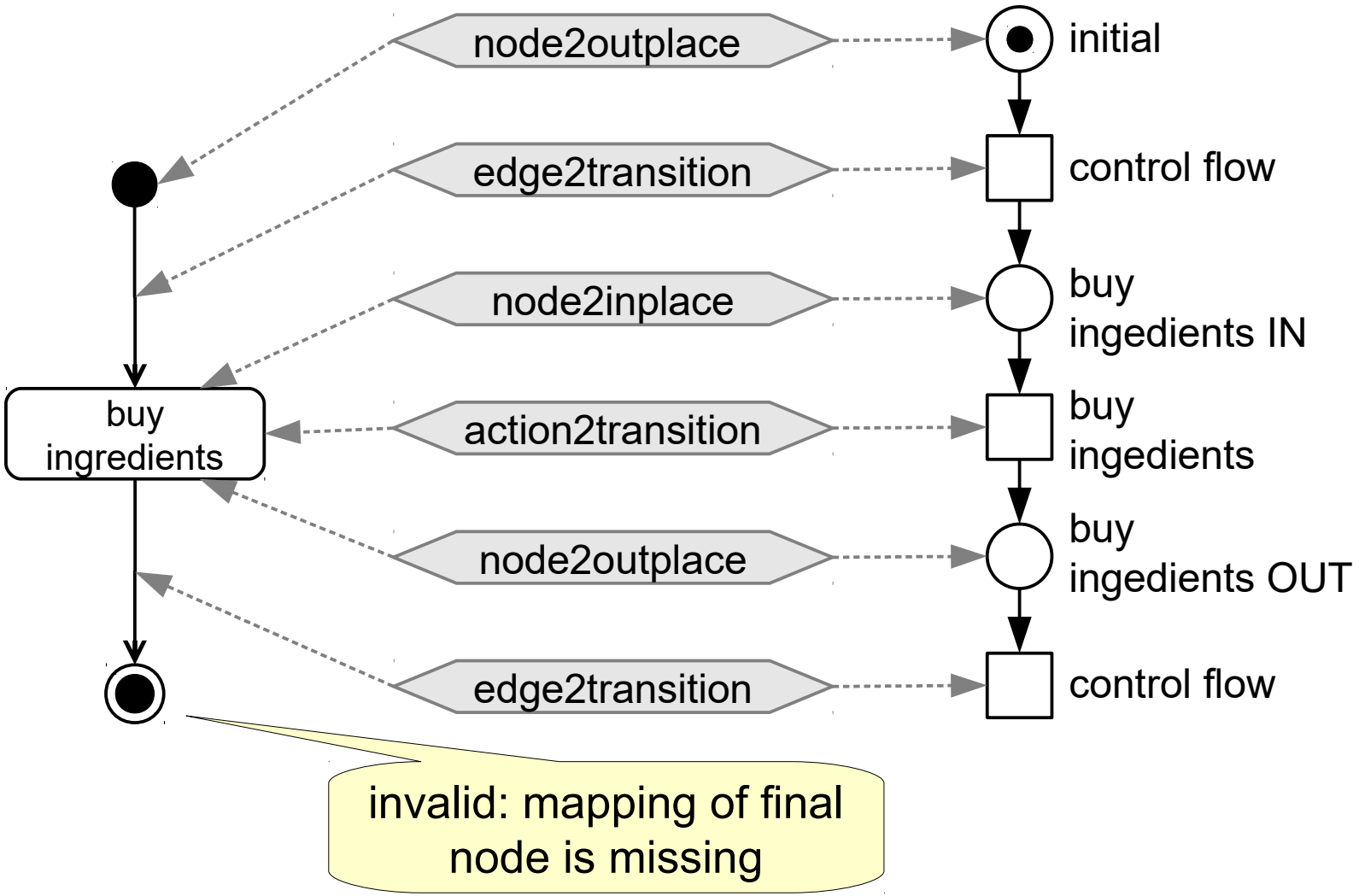
- Example of a bigger triple graph



Triple Graphs

in the last lecture...

- An “invalid” triple graph



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Triple Graph Grammar (TGG)

in the last lecture...

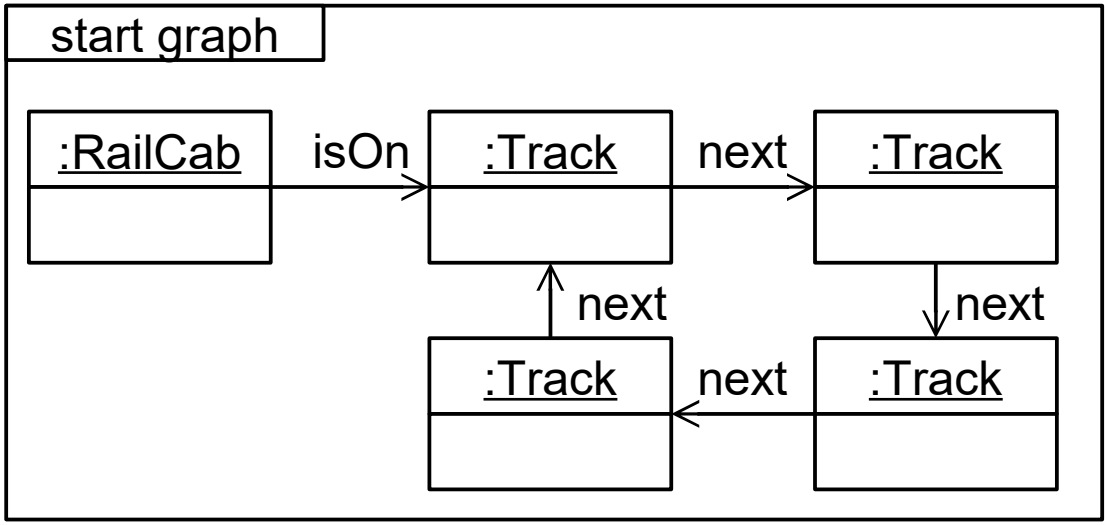
- How to describe which triple graphs are valid in which ones are not?
  - i.e., express which mappings are valid and which ones are not

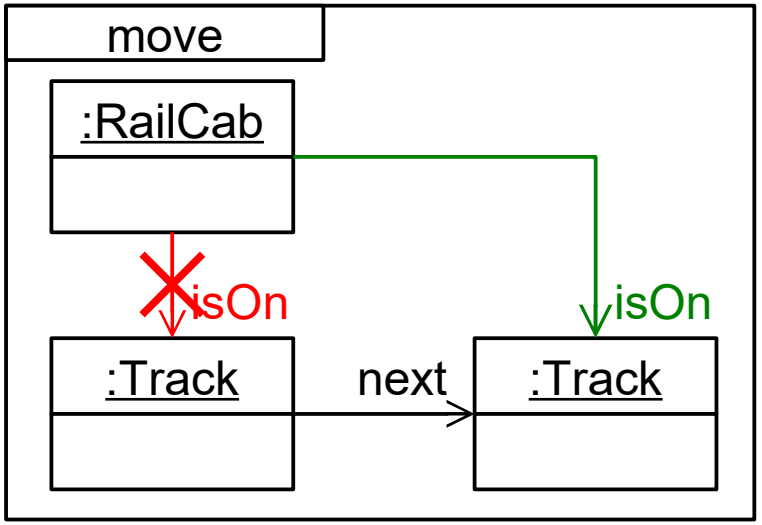
- **Idea 2**: Use a **graph grammar** that describes the production of valid triple graphs
  - → Triple Graph Grammar (TGG)

Graph Grammars

in lecture 8...

- A **graph grammar** consists of
  - a set of **graph grammar rules**
  - a **start graph** (also called **host graph**)
  - a **type graph**
- A graph grammar describes a (possibly infinite) set of graphs
  - those that can be constructed from the start graph by applying the graph grammar rules in all possible orders
- Graph grammars are also called **Graph Transformation Systems**





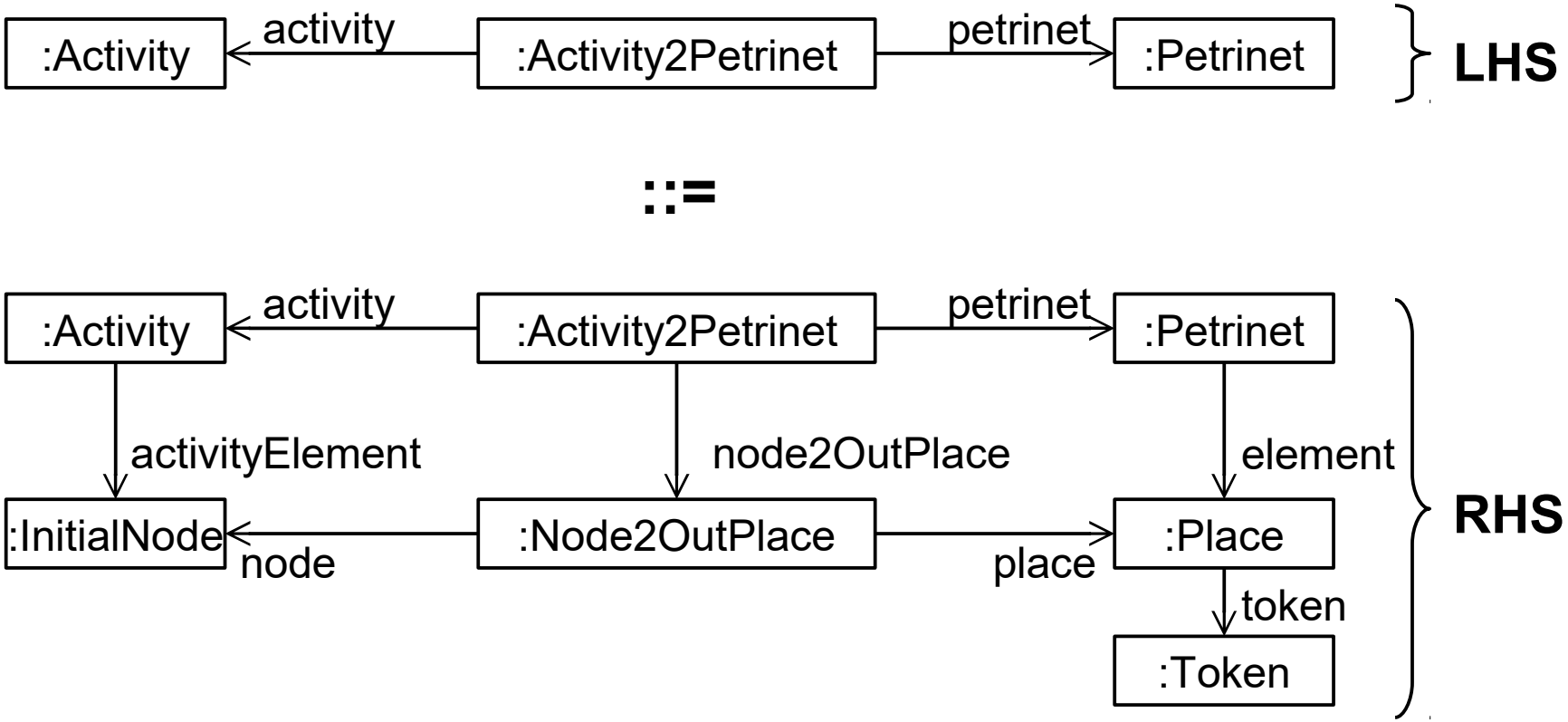
Triple Graph Grammar (TGG) Example

- **TGGs are also regular graph grammars**
  - hence, they also define a **start graph** or **axiom**
    (often a mapping of two model's root nodes)

- The axiom is the smallest valid triple graph
  - as we will see, TGG rules are non-deleting

Triple Graph Grammar (TGG) Example

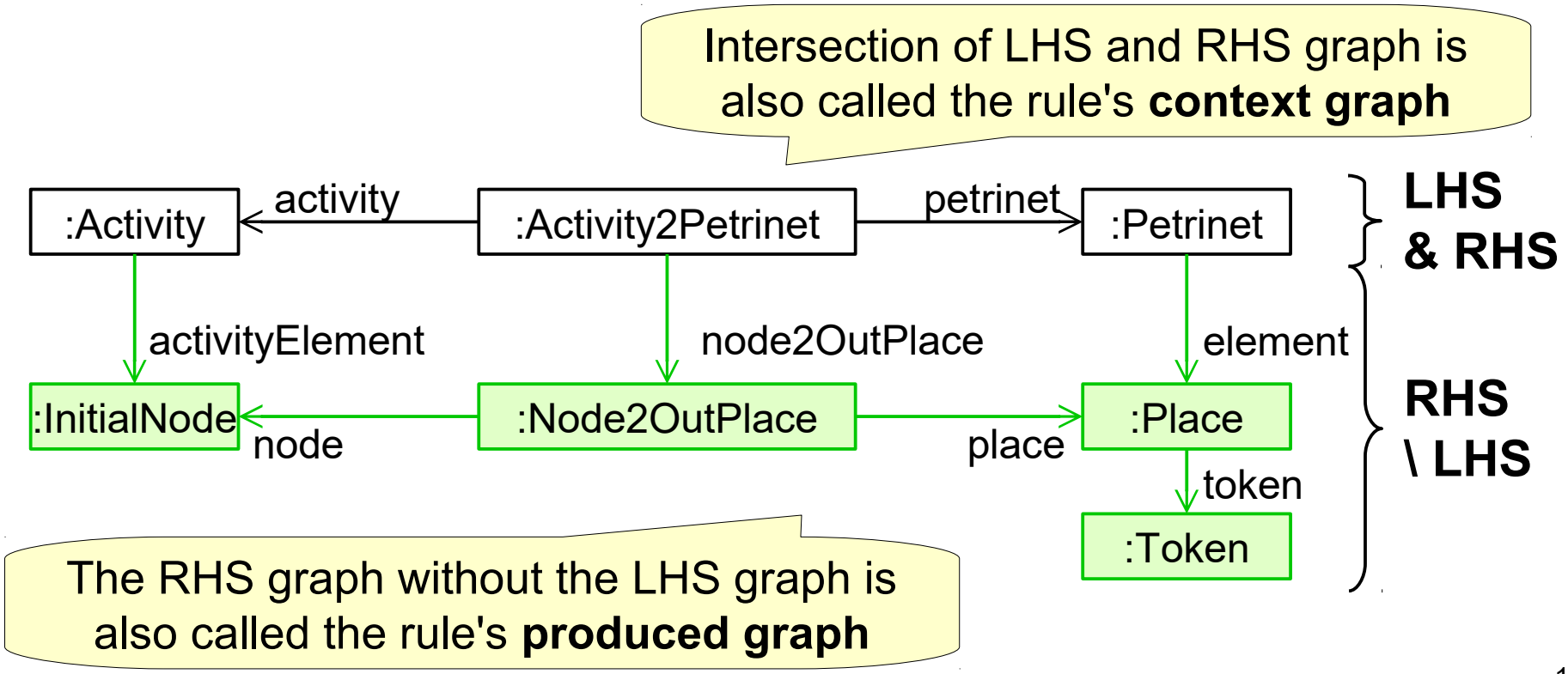
- A TGG rule for extending a valid triple graph



Triple Graph Grammar (TGG) Example

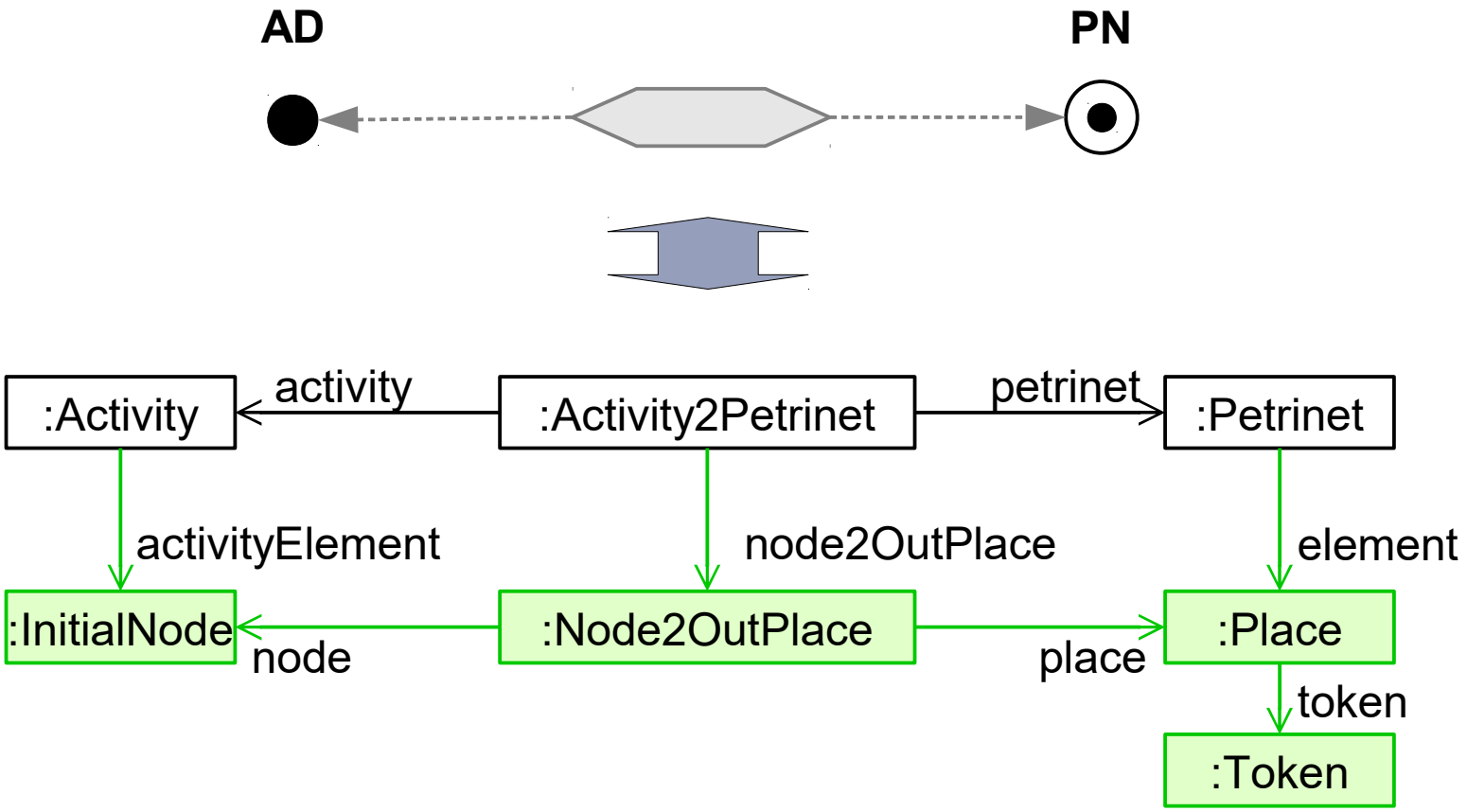
- A TGG rule for extending a valid triple graph

- in shorthand notation:



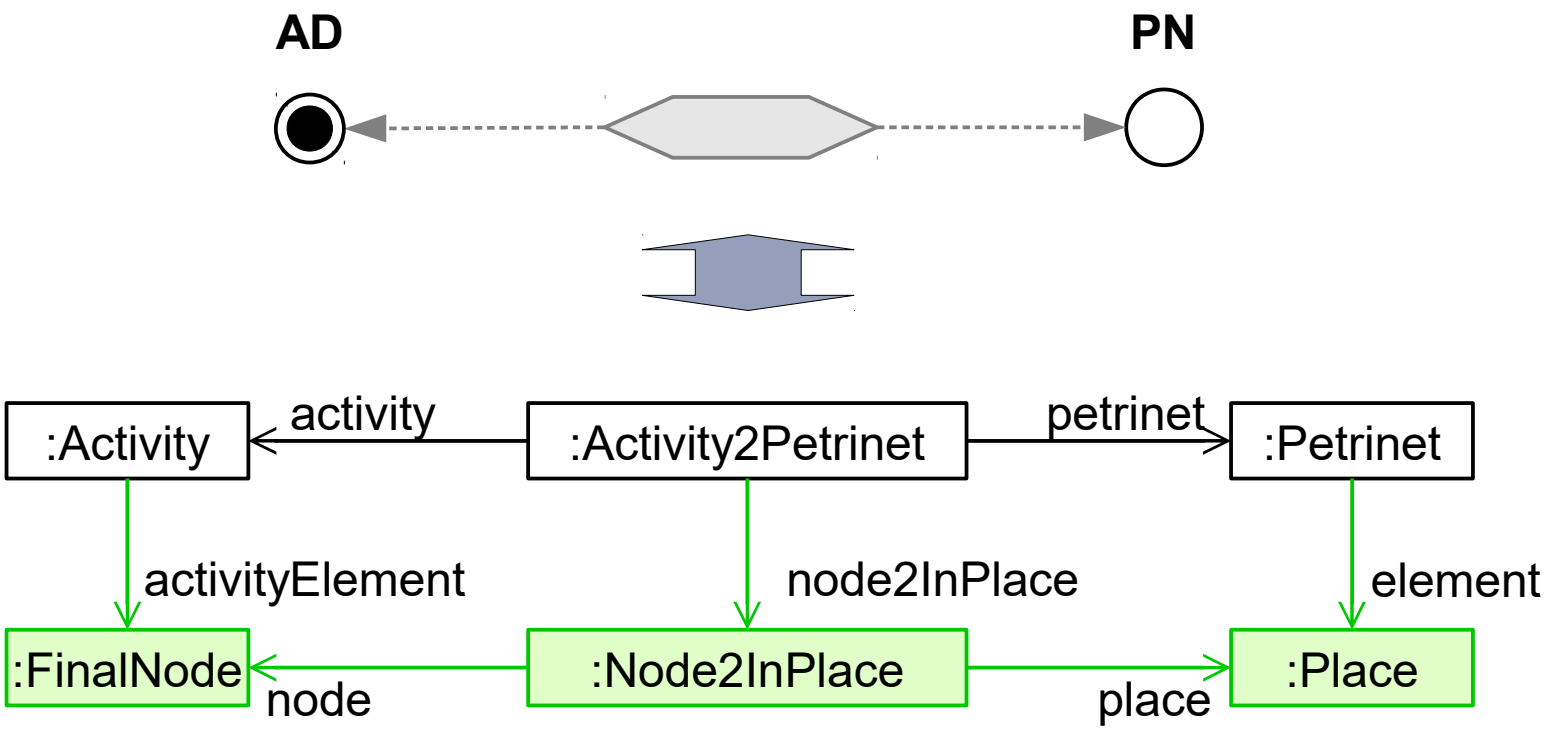
Intuitive Relation vs TGG Rule

- TGG rules are very close to the intuitive relation we described before



Intuitive Relation vs TGG Rule

- Final node ↔ Empty Place (similar to the rule before)



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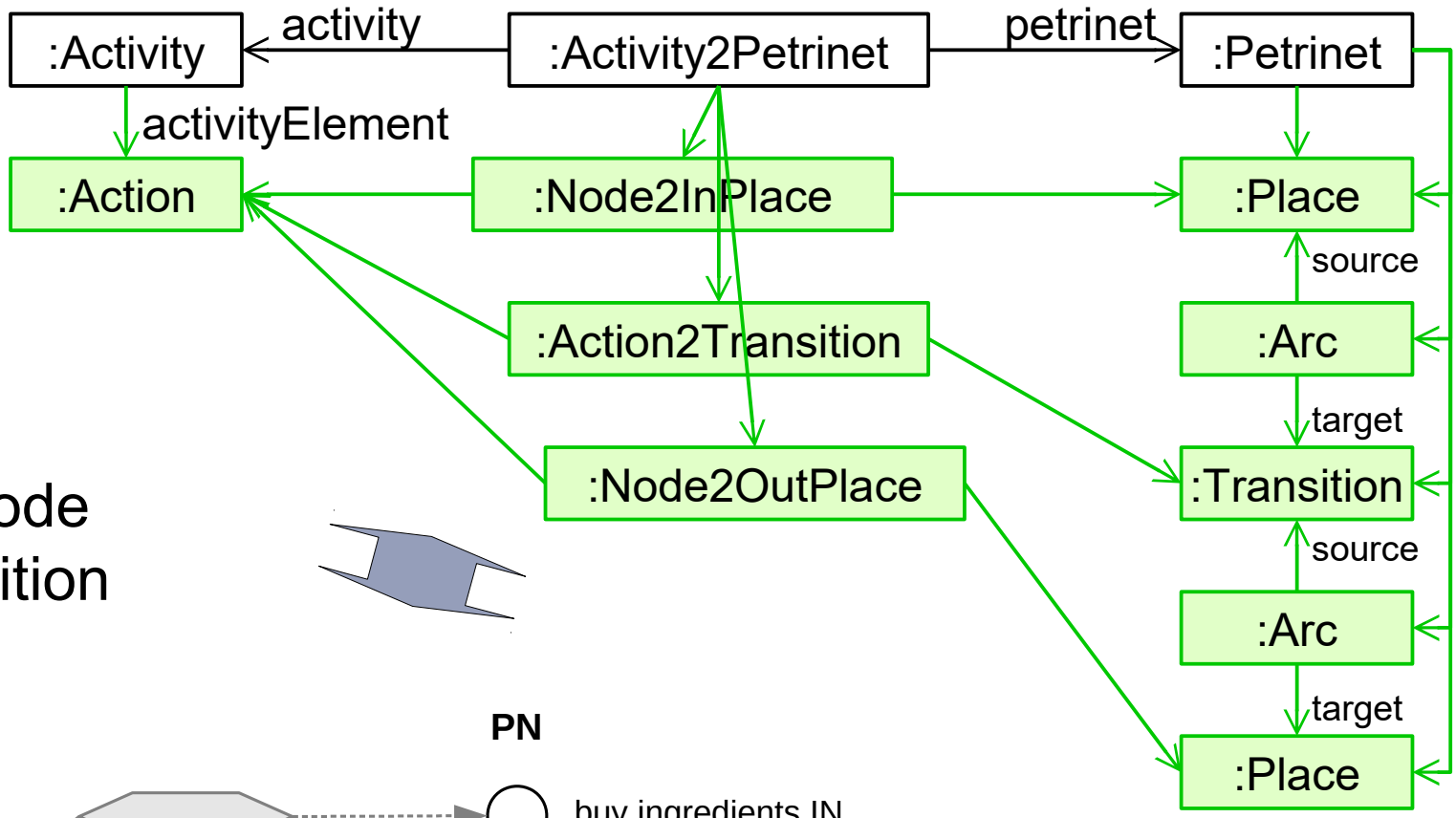
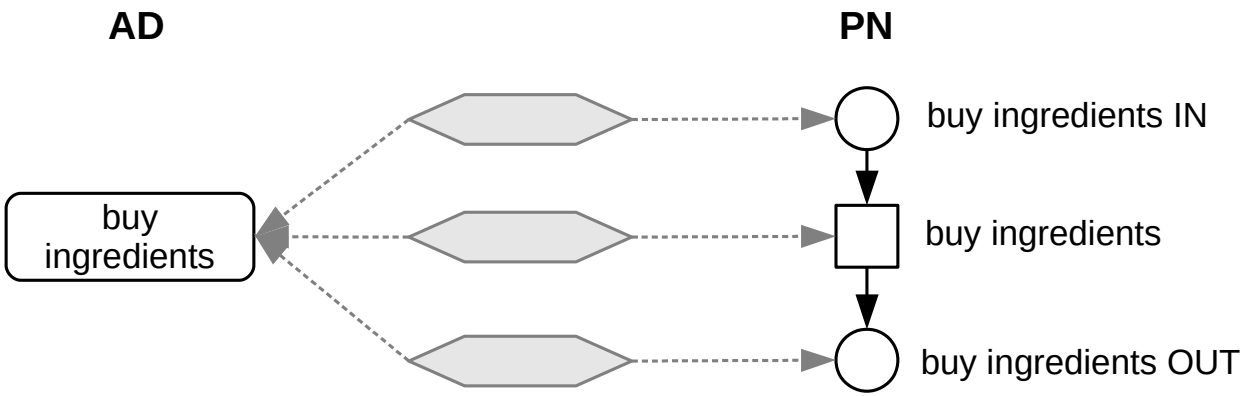
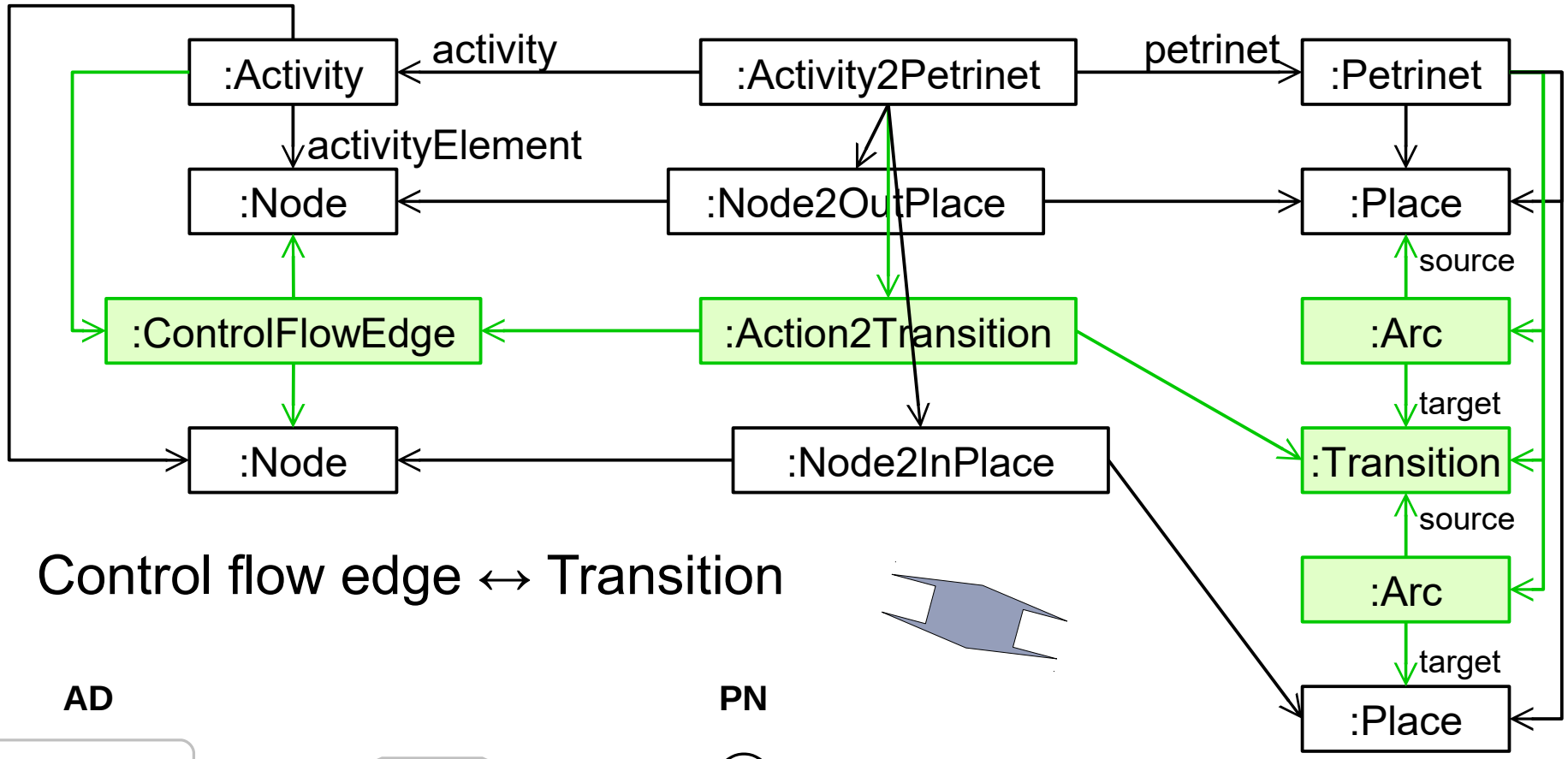


- Action node ↔ Transition

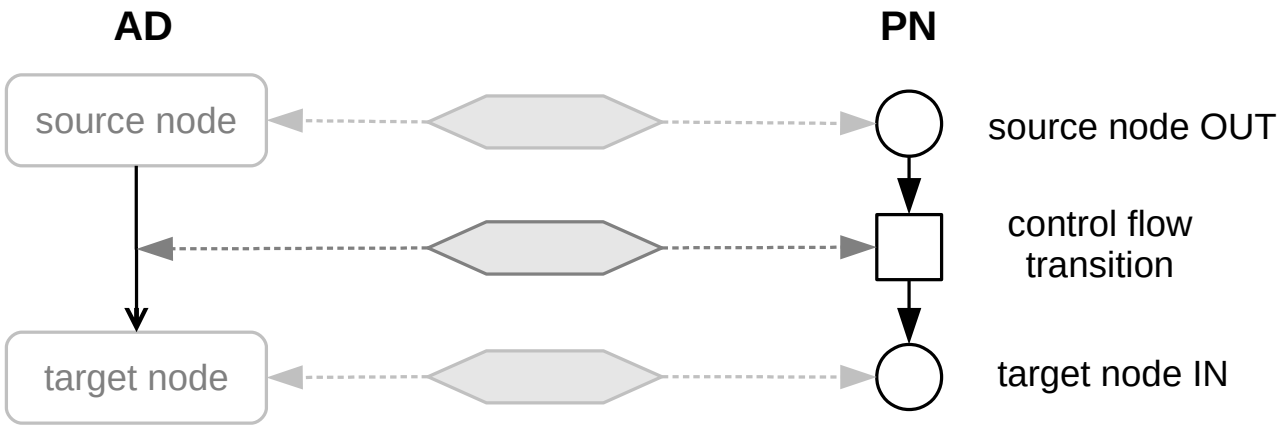


(ommitting some edge labels for space reasons)

Intuitive Relation vs TGG Rule



- Control flow edge ↔ Transition



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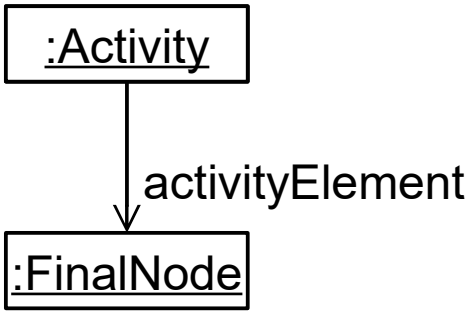
Application Scenarios

- TGGs can be used to produce valid triple graphs
  - but that alone is not very useful...
- But, we can **operationalize** them for different useful purposes (**application scenarios**)
  - transforming a given source model into a target model
  - transforming a given target model back into a source model
  - given a source and a target model, create the correspondence model to check whether they are valid corresponding models
  - synchronize given source and target models as changes happen in the source or target model

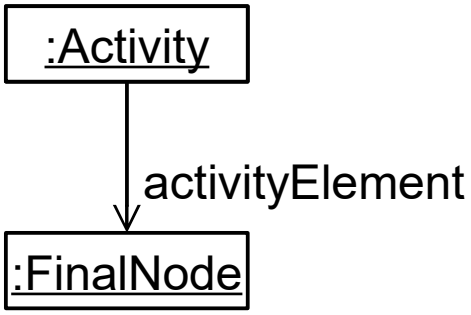
Forward Transformation Scenario

- Given is a source model



Forward Transformation Scenario

- Given is a source model
- First, we *apply* the axiom:



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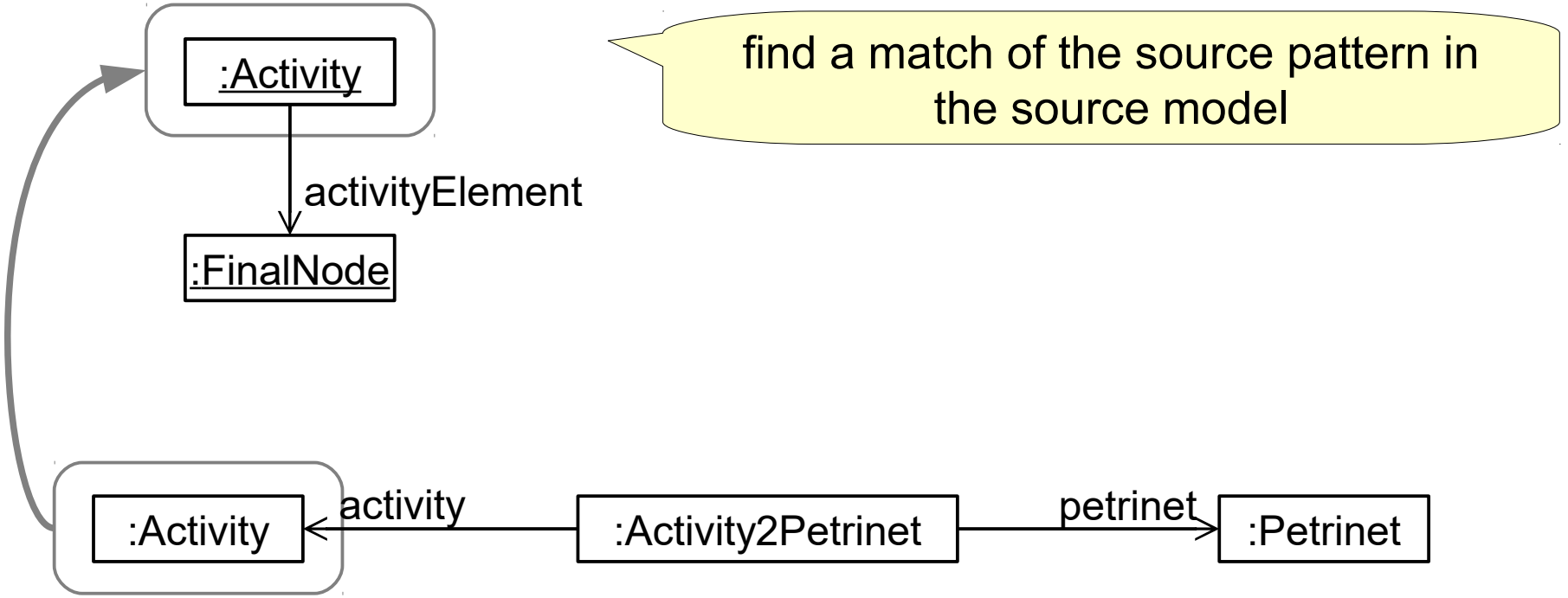

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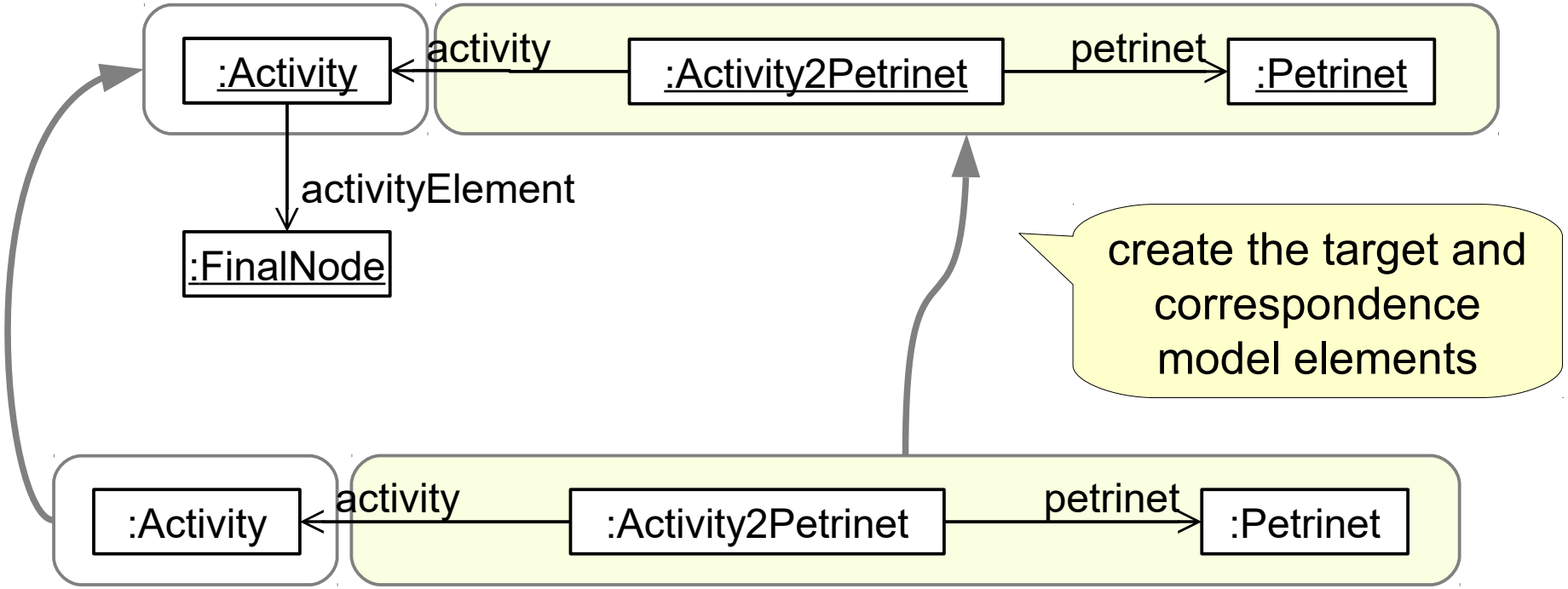

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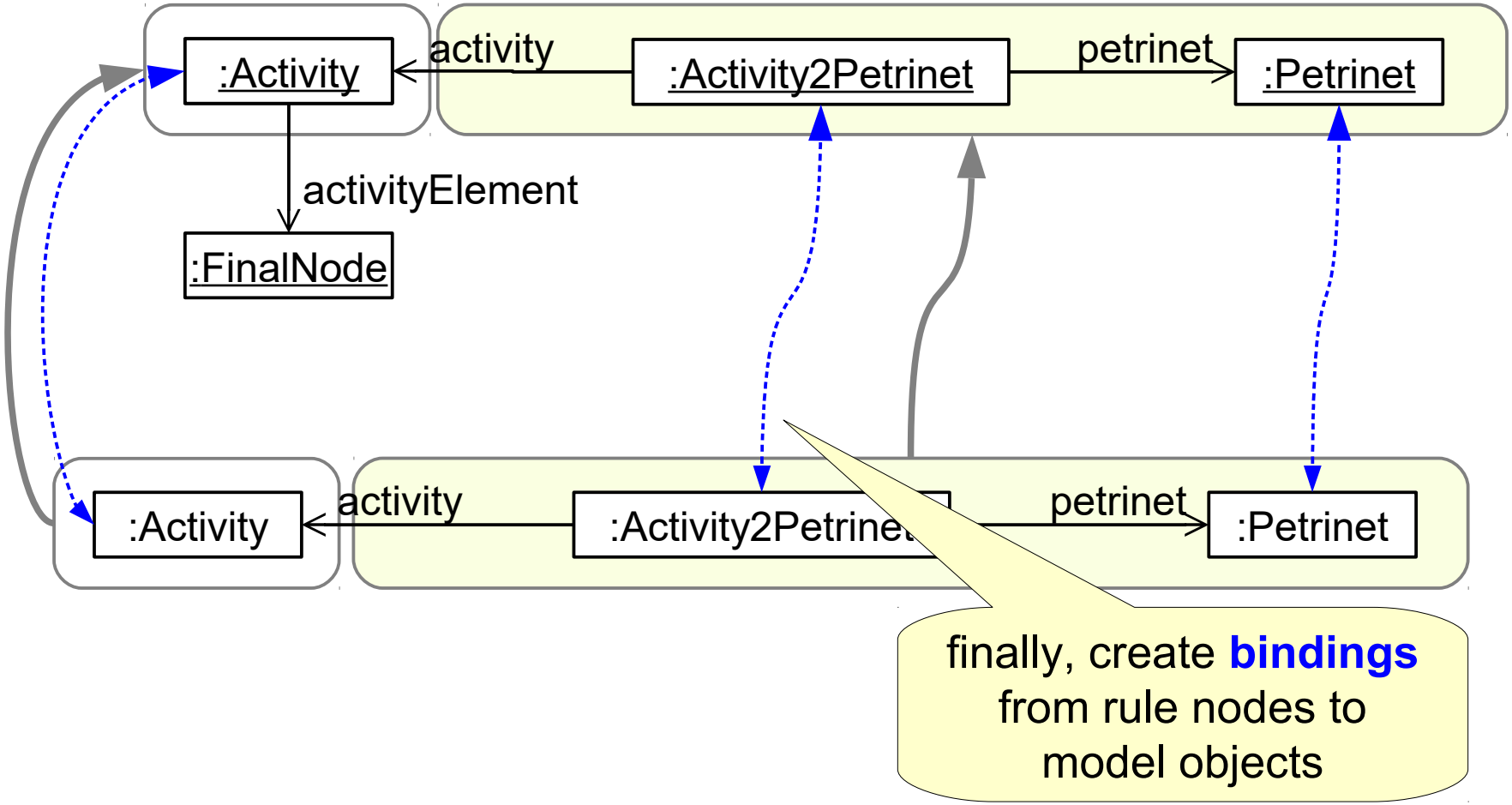
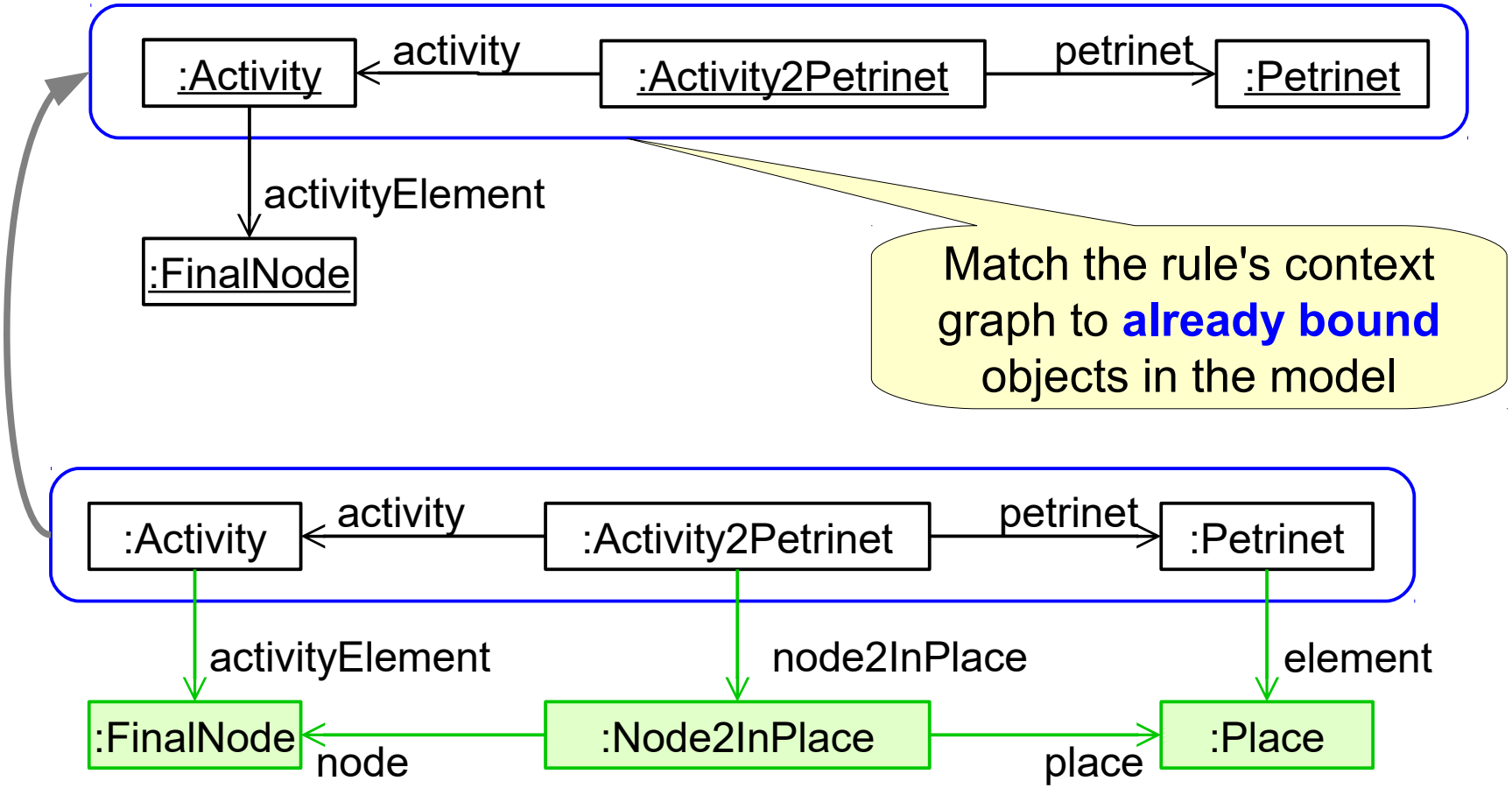


Forward Transformation Scenario

- Then, find TGG rule that can be applied as follows:



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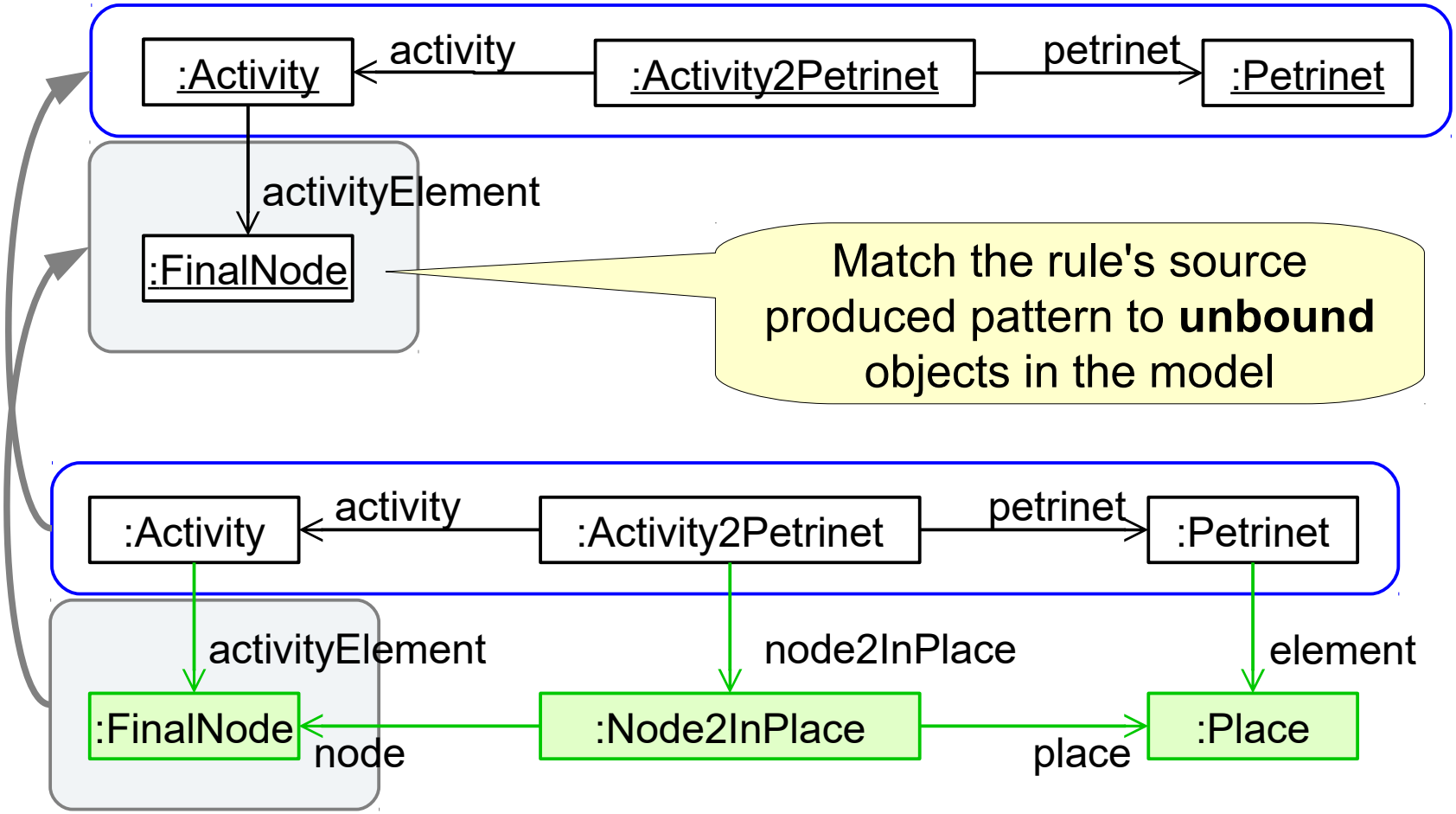

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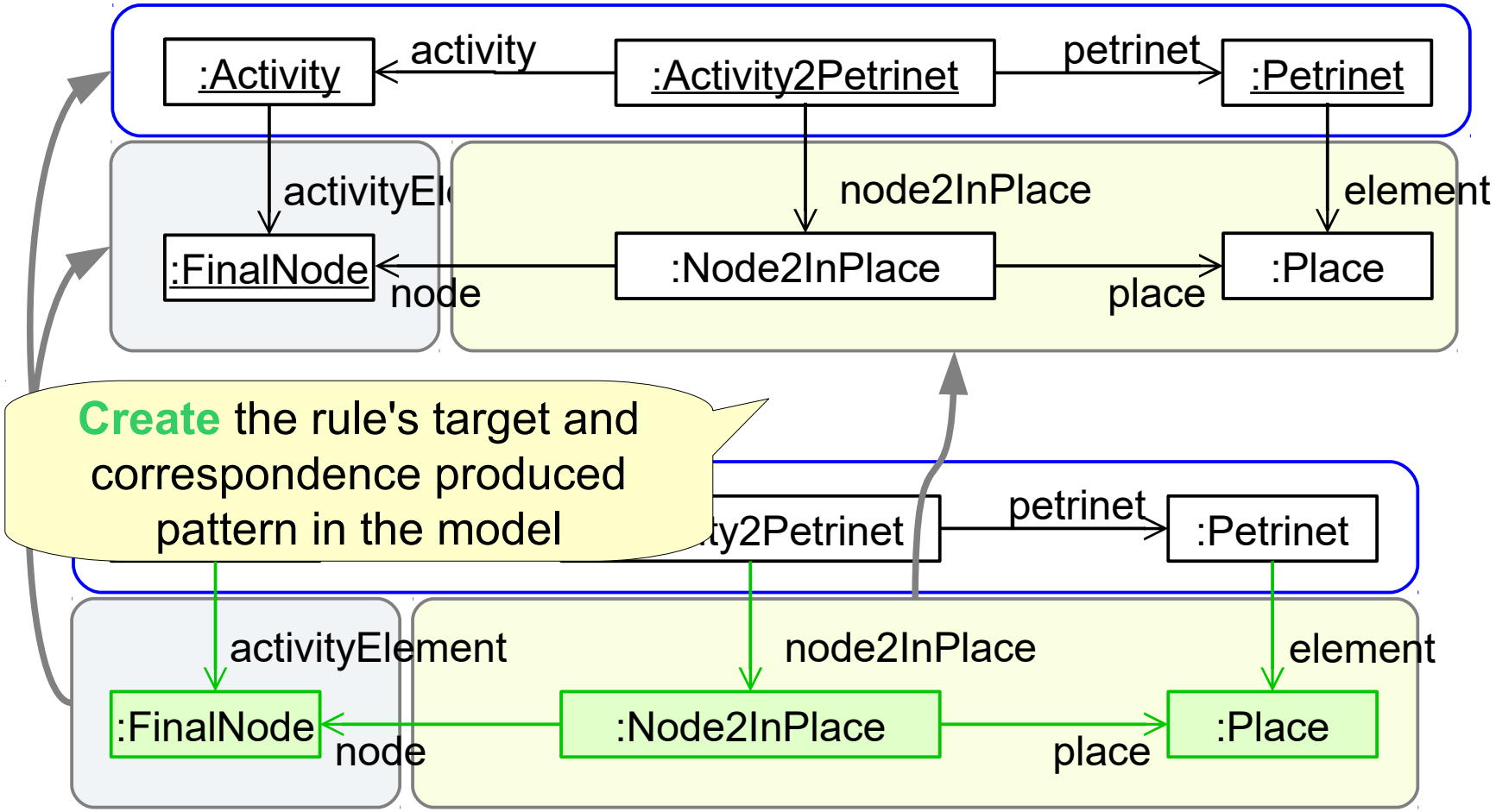

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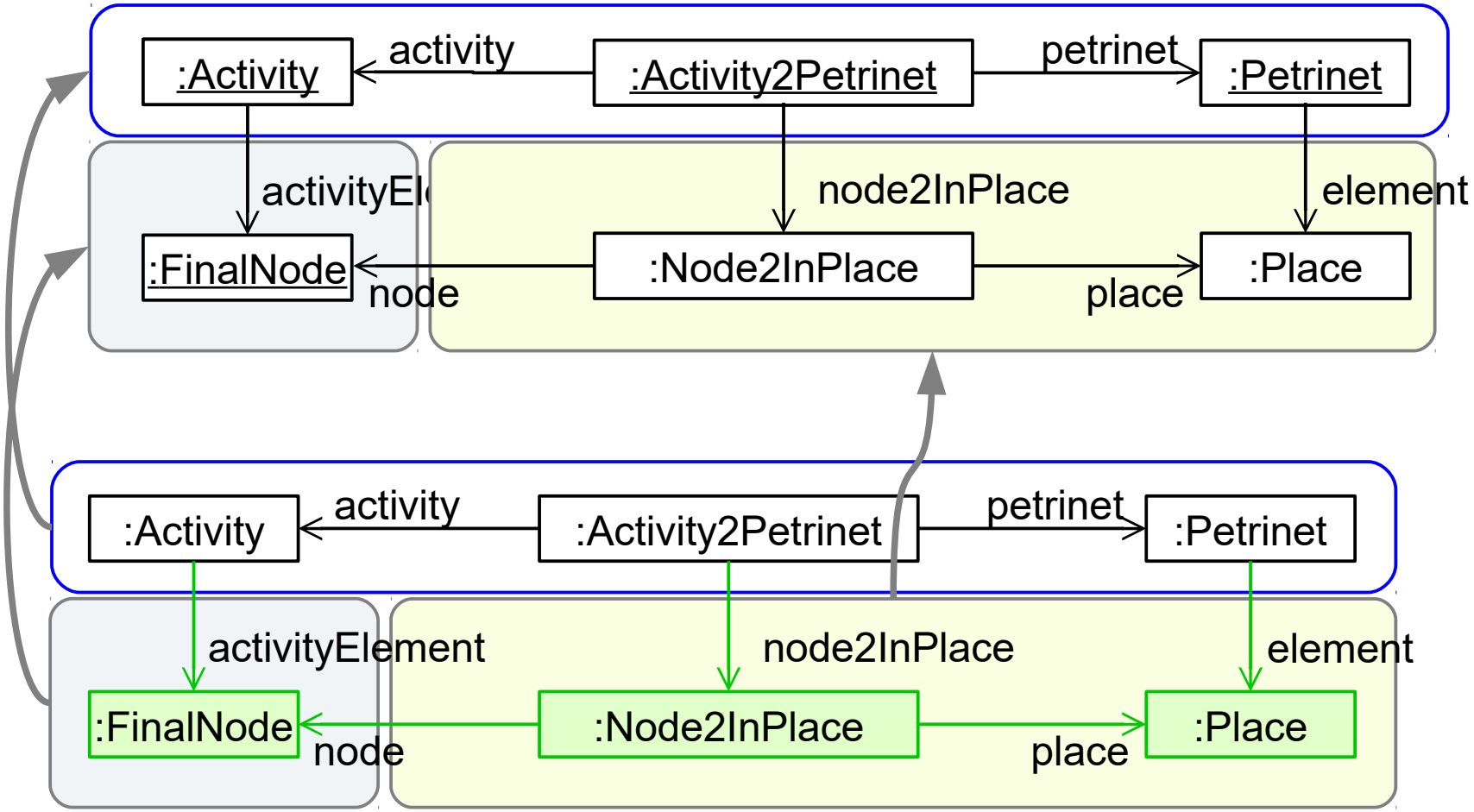

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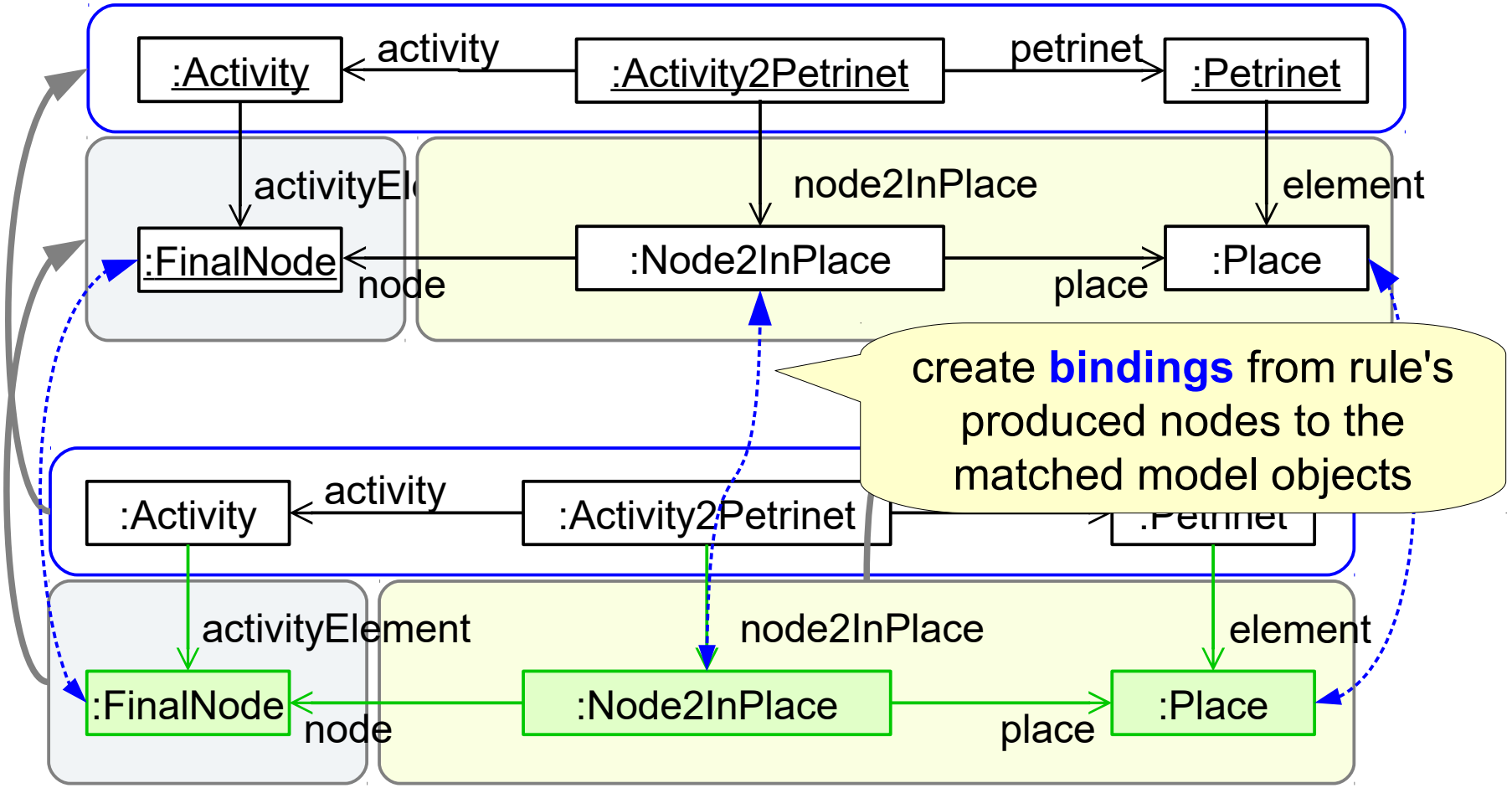
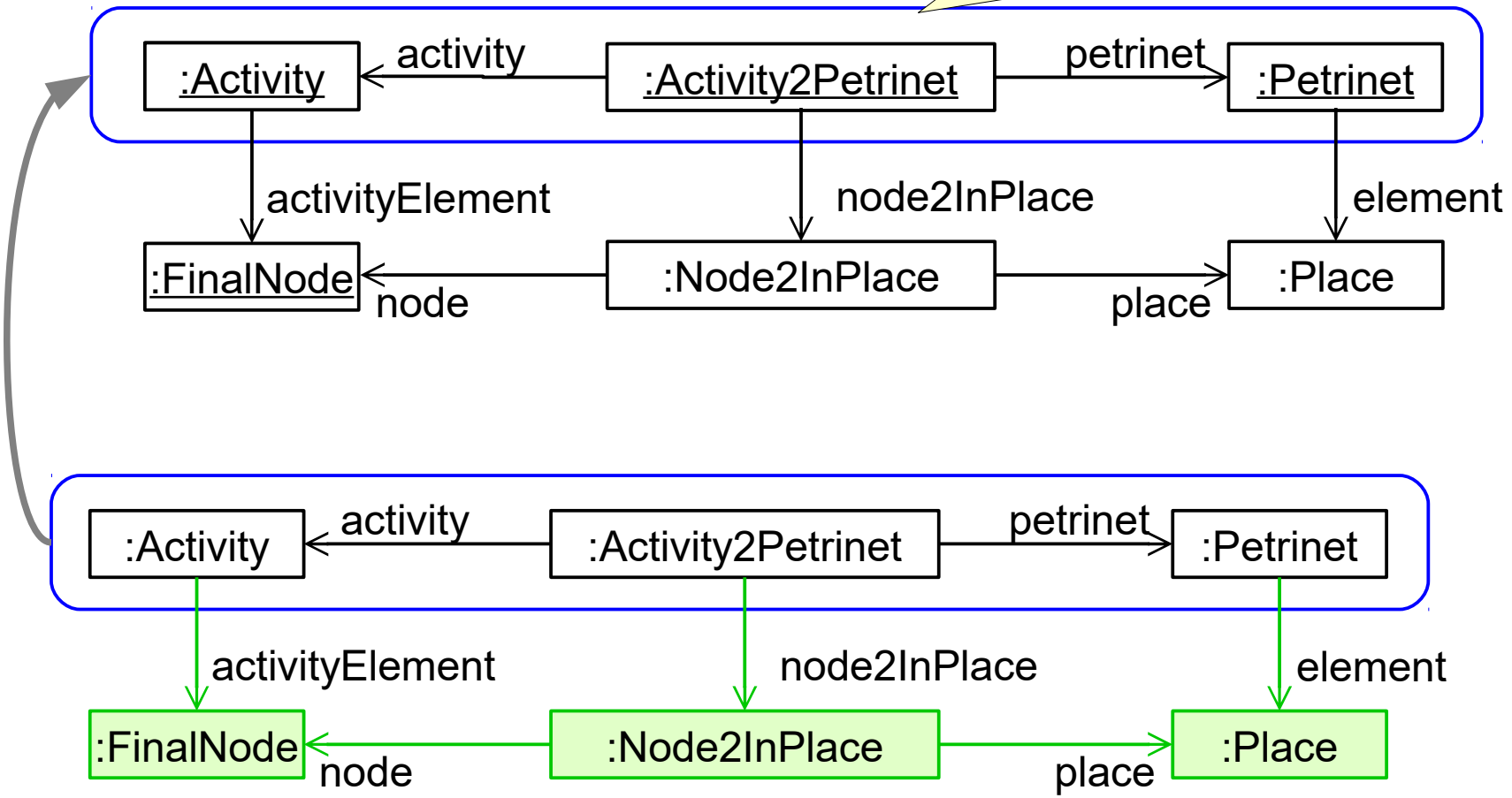


Forward Transformation Scenario

- Can we apply the rule again?

We can match the context graph pattern to already bound model elements, but...



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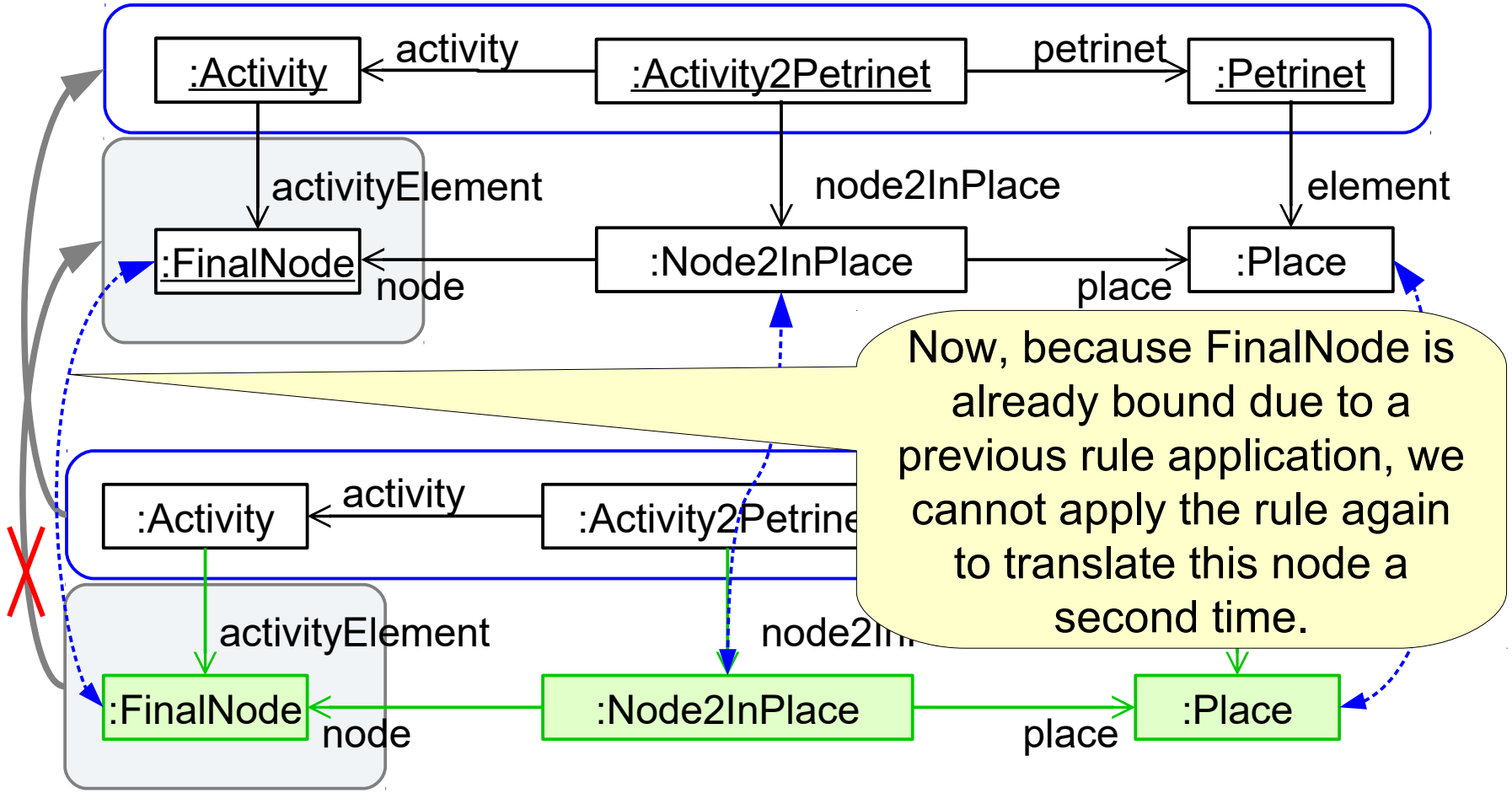
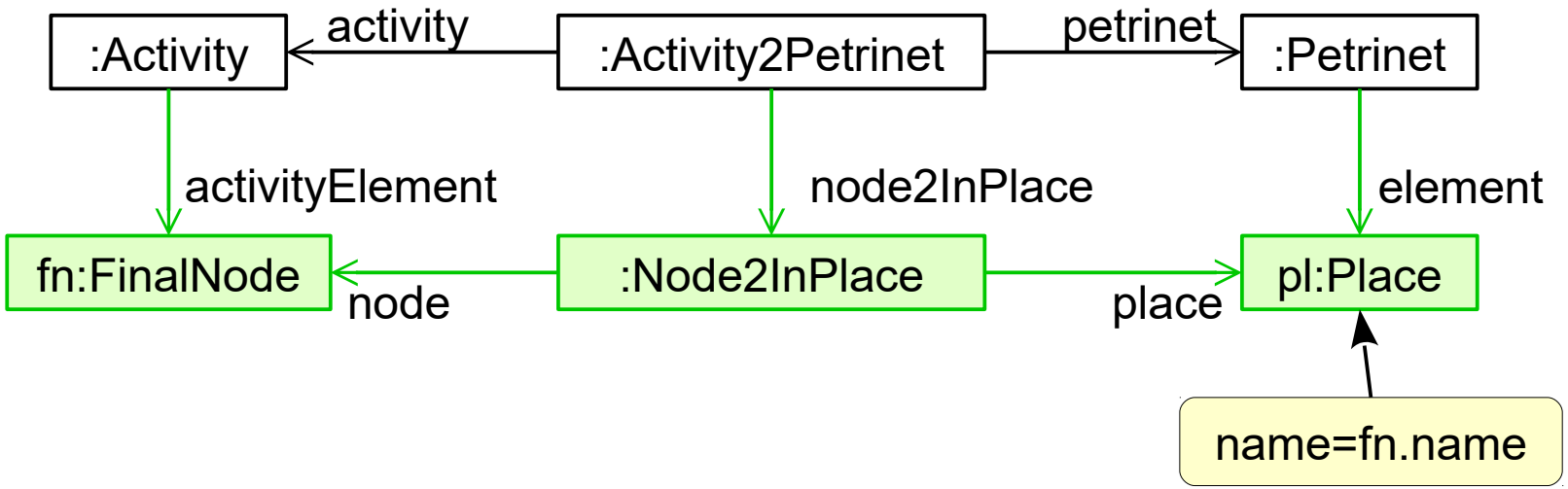


TGG Extensions

- Extensions of TGGs include:
  - support for reuse in rules: rule inheritance
  - support for attribute constraints
- Example: Attribute constraints



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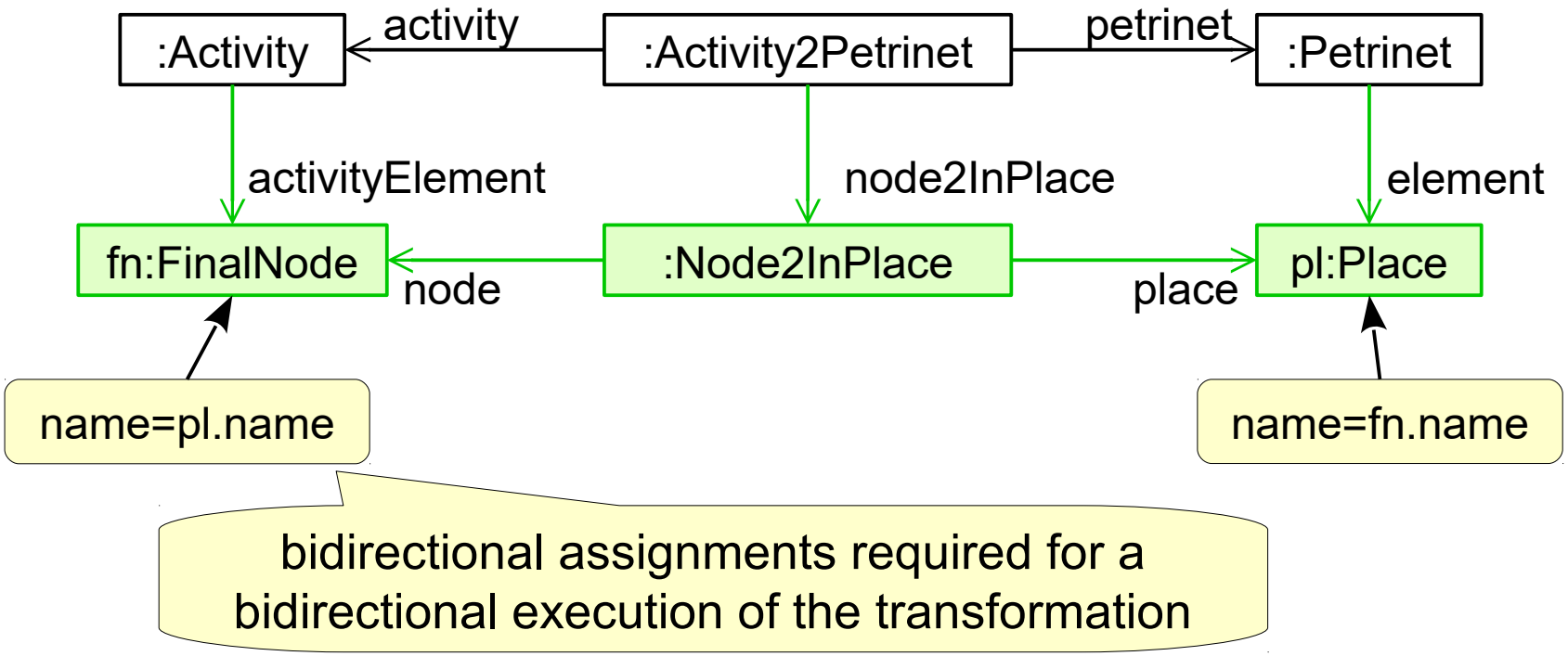
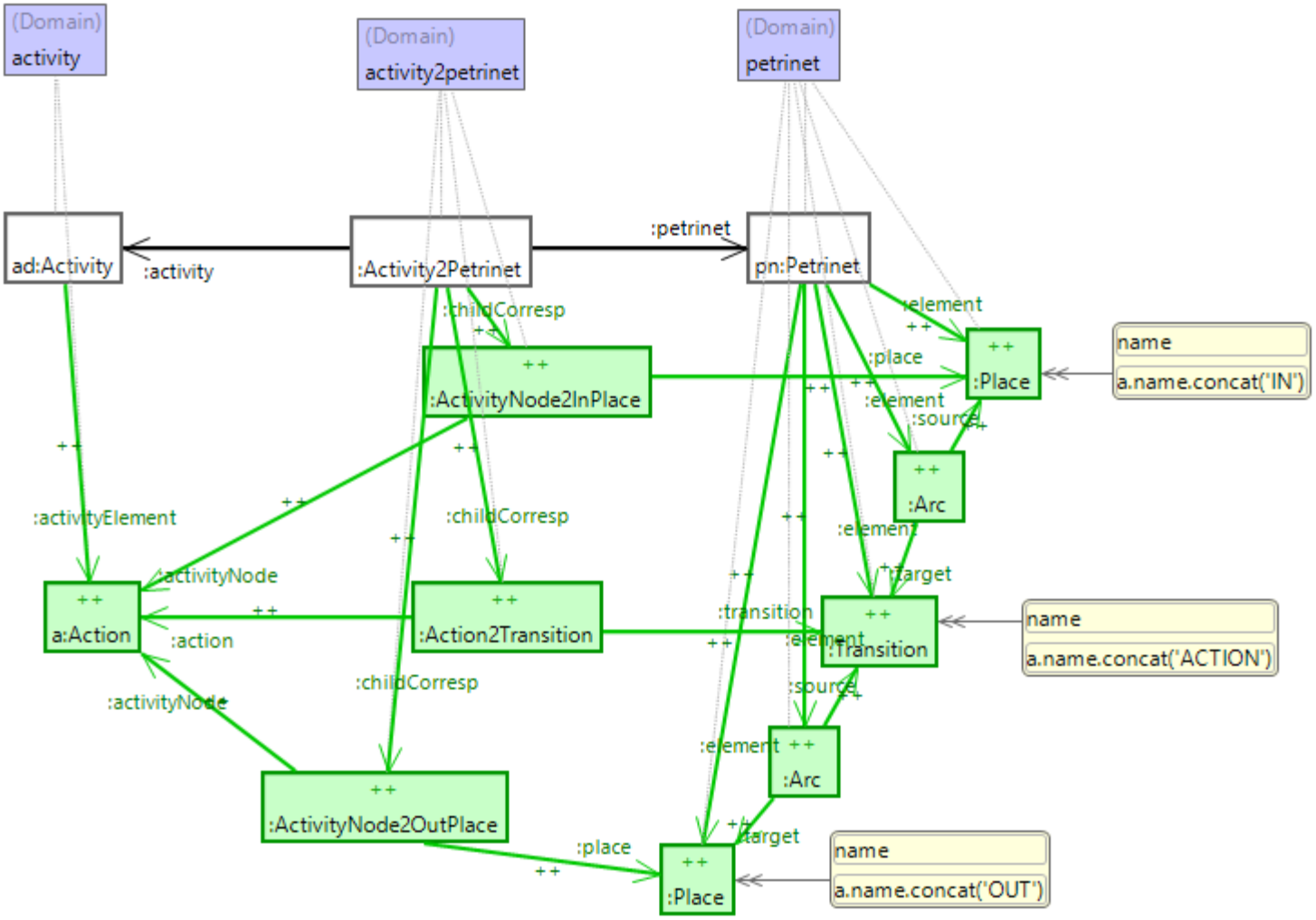


Tool Support

- Different academic and industrial tools exist:
  - TGG-Interpreter
  - eMOFLON
  - Fujaba
  - MDELab
  - EMorF

TGG Interpreter

- Screenshot of a TGG rule diagram in the editor of the TGG Interpreter tool:



TGG Transformations

- **Advantages**
  - **declarative**: model corresponding patterns instead of programming the exact transformation procedure
    - Equivalent imperative program often **significantly** more complex!
  - **visual representation** of the corresponding graph structures
    - enhances comprehension of the transformation
- **Disadvantages**
  - visual rules are nice as long as rules are not bigger than screen
  - **Debugging** is difficult
    - Approaches exist, but still hard to find problems, especially when rule application is non-deterministic
  - **Performance**: optimized engines exist, but rule matching is always potentially slower than an imperative program
  - Only works well if source and target models have a similar structure

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5.5. Model-to-model transformation – Query/View/Transformation

QVT (Query/View/Transformations)

- QVT is an OMG standard for model transformations
  - see http://www.omg.org/spec/QVT/1.1/PDF/
- Defines different languages
  - **QVT-Relations** (QVT-R), declarative language, similar to TGGs
  - **QVT-Core**: declarative language, more simple than QVT-R, something that QVT-R can be compiled to for execution
  - **QVT-Operational**: An imperative language
  - **Black-Box Operations**: Ability to integrate other model transformation or programming languages