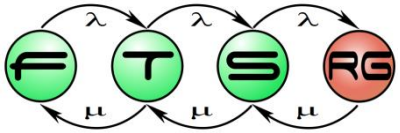
Concrete Syntax Design for Domain-specific Languages

Model Driven Software Development

Lecture 5

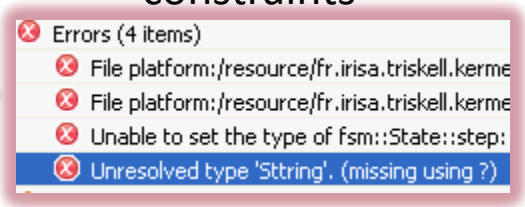


Structure of DSMs

Graphical syntax

Abstract syntax

Well-formedness constraints

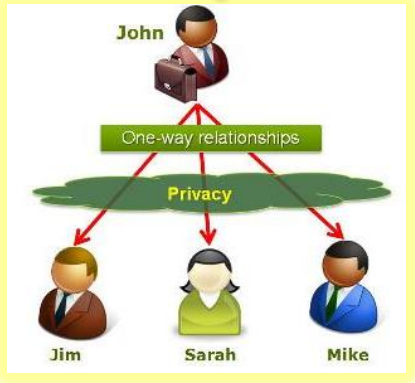


Behavioural semantics, simulation

Code generation

Mapping

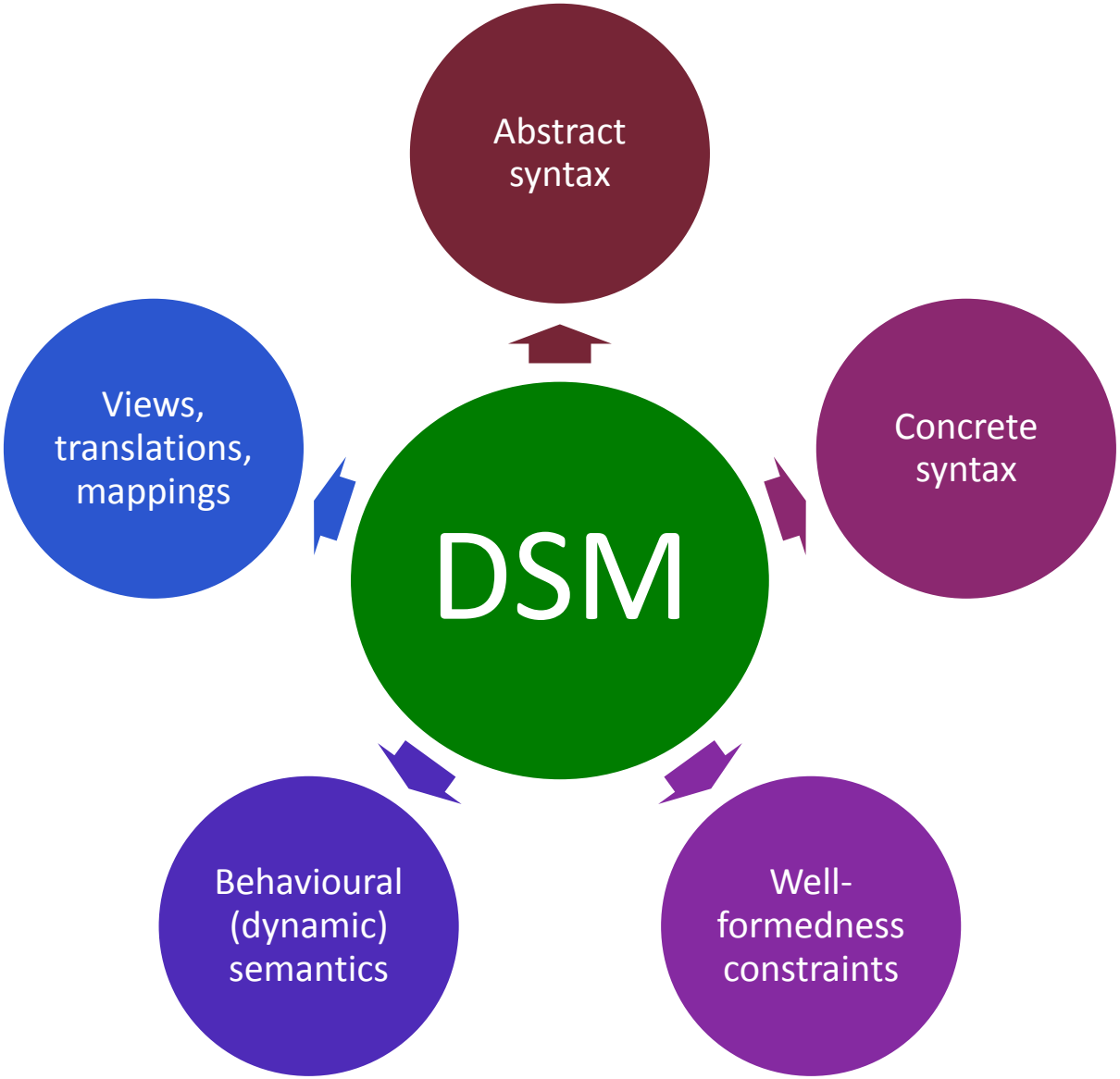
Textual syntax



View

Code (documentation, configuration)

DSM aspects


Abstract syntax
Views, translations, mappings
DSM
Concrete syntax
Behavioural (dynamic) semantics
Well-formedness constraints

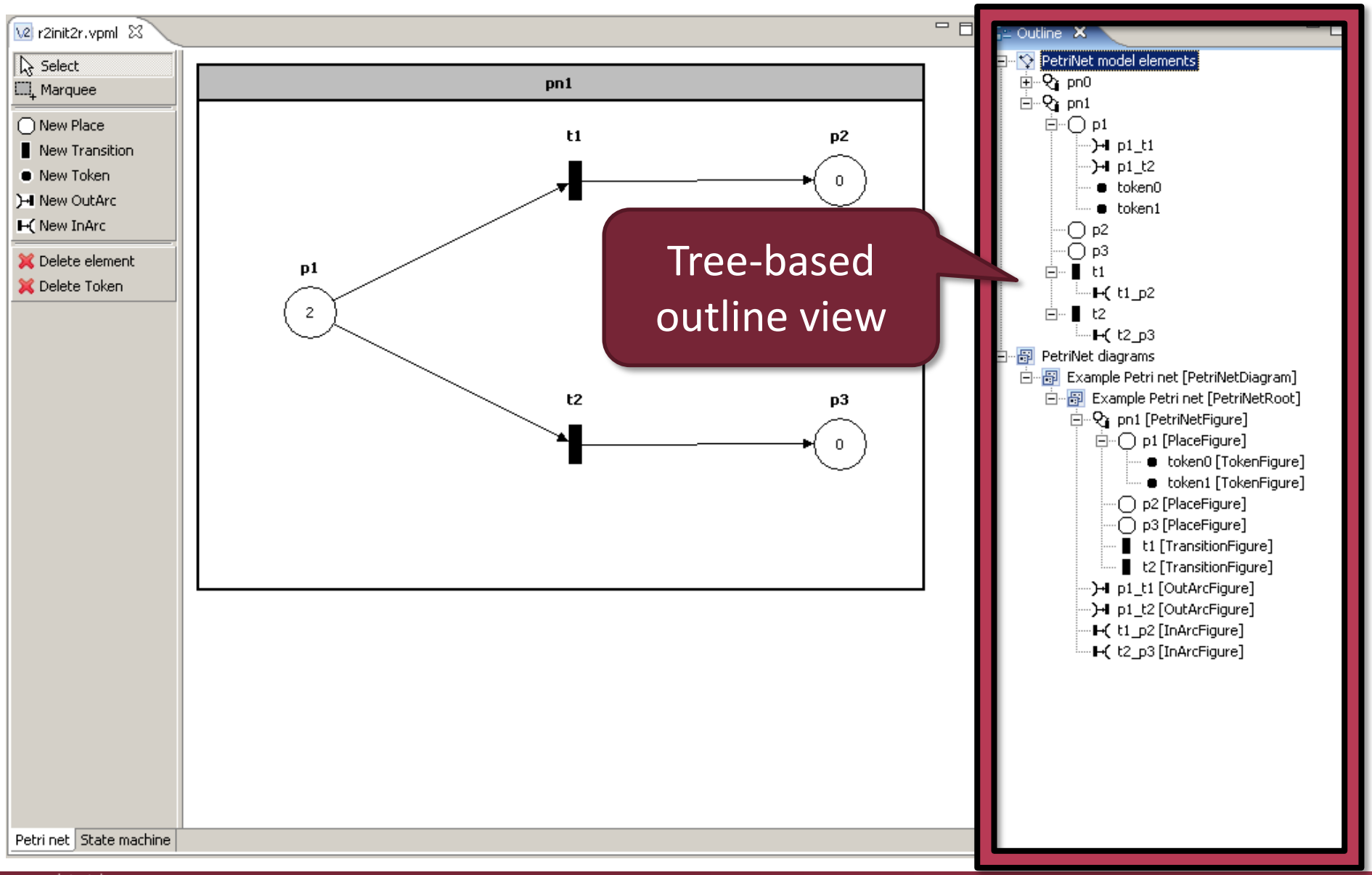
Concrete Syntax Design

- User-facing parts of a modeling language
  - Performance
  - Robustness
  - Usability issues
- Creating model editors
  - Similar problems at programming languages
  - IDE extensions needed
- Viewers are also important!
  - ~read-only editors

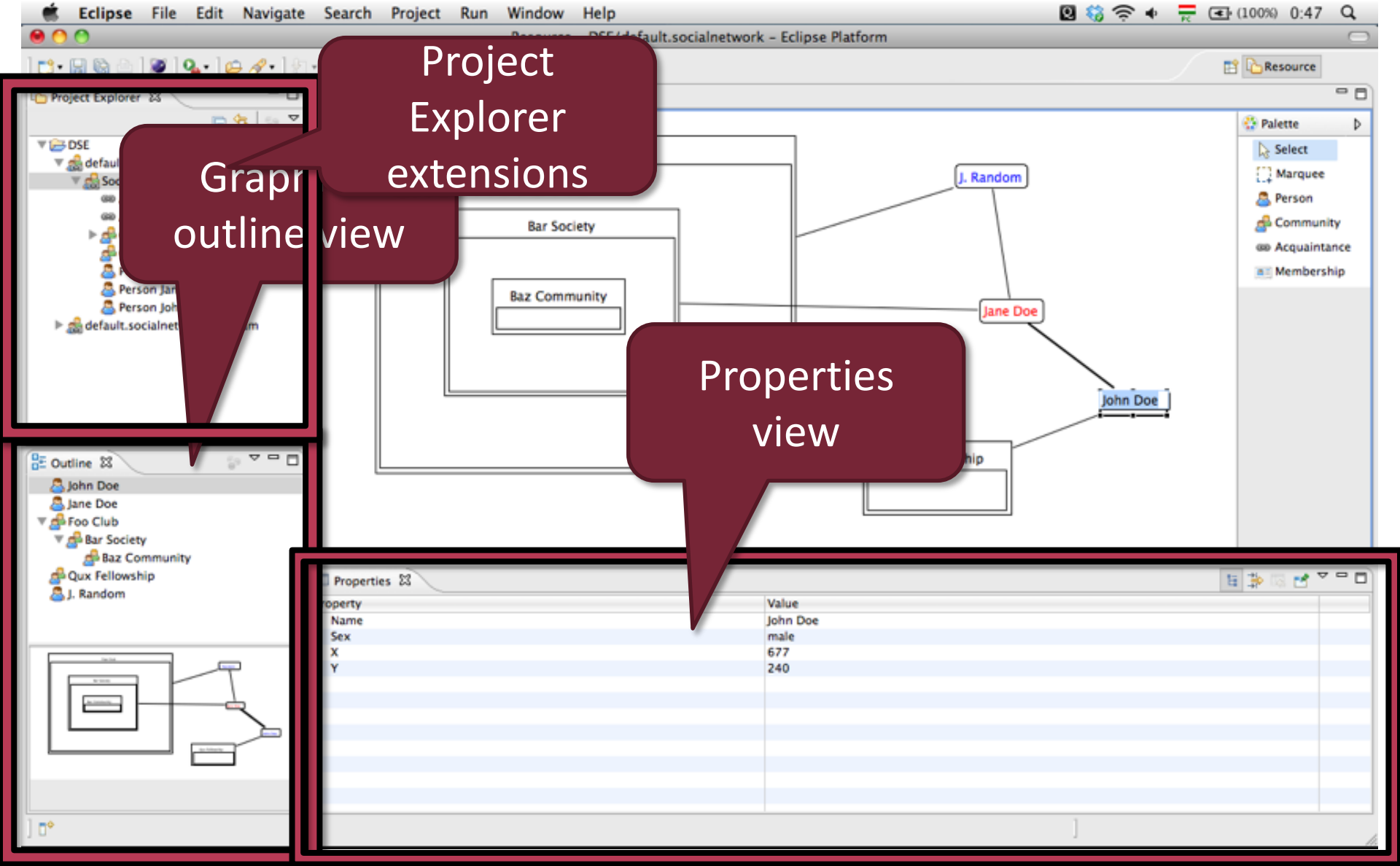
Concrete Syntax Approaches

- Graphical
  - Focus of latter half of today's lecture
  - Typically graph-based modeling (Edges, Nodes)
- Textual
  - More details to come in next lecture
- Form-based
  - Tree views
  - Property sheets, combo / radio /etc.
  - Table/matrix approaches

Example: Petri net editor



Example: Social Network editor



Advanced features

Viewer features

- Outlining / folding / abstraction
- Details / documentation overlay (e.g. Javadoc, „code mining”)
- Validation / task / etc. overlay
- Search, navigability
- Automatic layout/formatting

Editor features

- Templates/snippets/examples
- Guidance (content assist / snap)
- Composite operations/tools/refactorings
- Automatic fixes
- Undo&Redo, Transactionality

Technology

- Eclipse Modeling Tools
  - Several related subprojects
  - Each supports a single aspect
  - Examples of today
- Microsoft Visual Studio 2010 Visualization & Modeling SDK
  - DSL modeling framework from Microsoft
  - Own metamodeling core
  - Focuses on graphical modeling
- JetBrains MPS

Human Aspects

Textual vs. Graphical
Visual Design
Layouting

Question: textual or graphical?

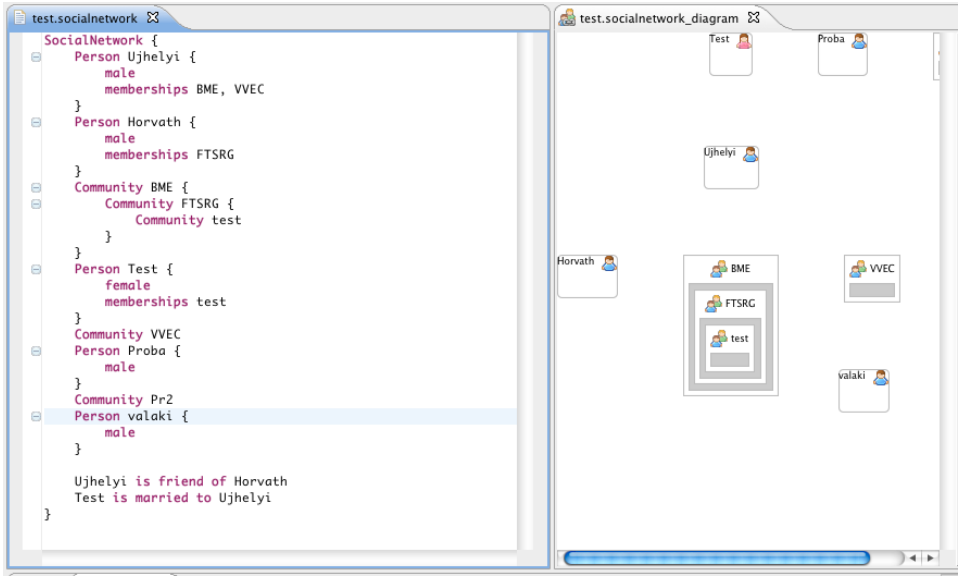
- No clear choice, just rules of thumb

Textual Languages (*raw editing*)	Graphical Languages
Quick and simple editing	More cumbersome editing
References as *string identifiers*	References displayed visually
Inconsistent during editing	Always syntactically correct
Trivial diff&patch, copy&paste, search&replace	Editing services require tool development effort
Typically better for behavior	Typically better for stucture

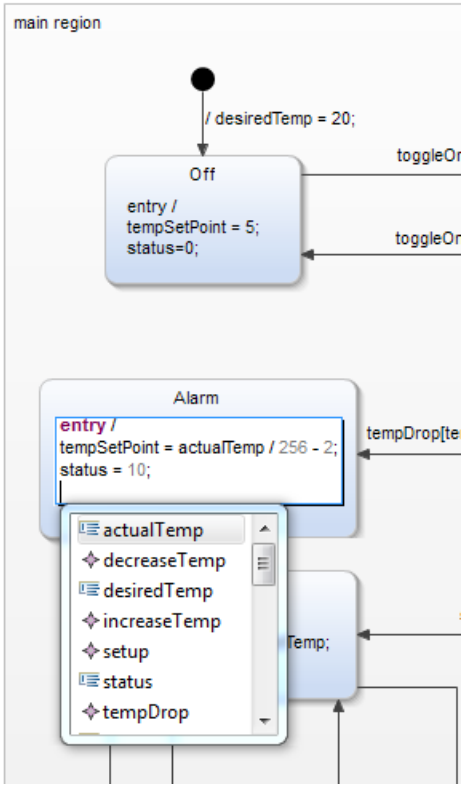
  - Simple languages: consider form-based as well
    - Like graphical, but cross-references poorly supported
- …why not both?

Textual + Graphical

- Same model, two syntaxes
  - Text editor + graphical view
    - Xtext Generic Viewer
  - Textual + graphical editors
    - Xtext + GMF side-by-side

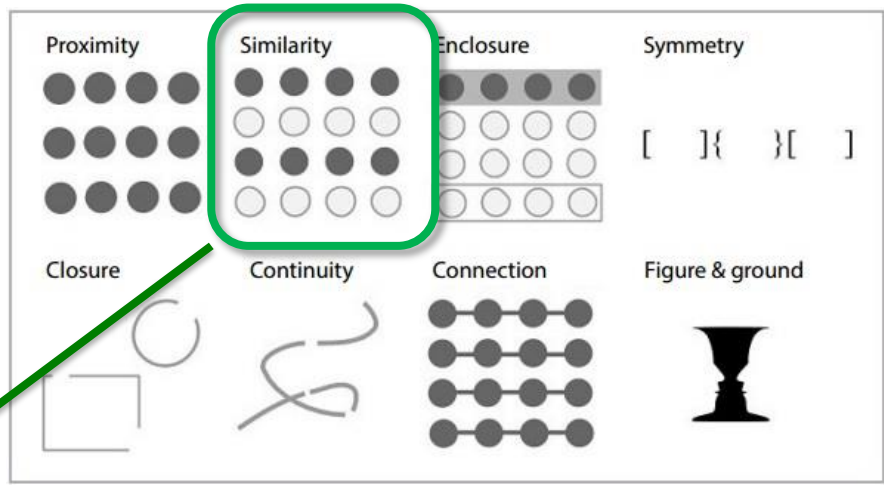


- Different aspects of model
  - Diagram with text fields
    - Embedded Xtext support

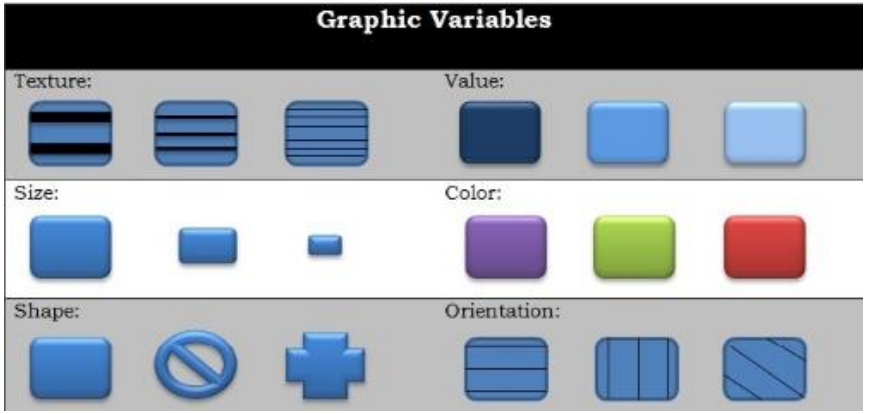


Visual Design 101

- What belongs together? „Gestalt principles of grouping”
  - E.g. which label belongs to which node?



- What is similar? „Bertin’s visual variables”
  - Size, shape
  - Color hue, value, intensity
  - Line style / orientation / texture

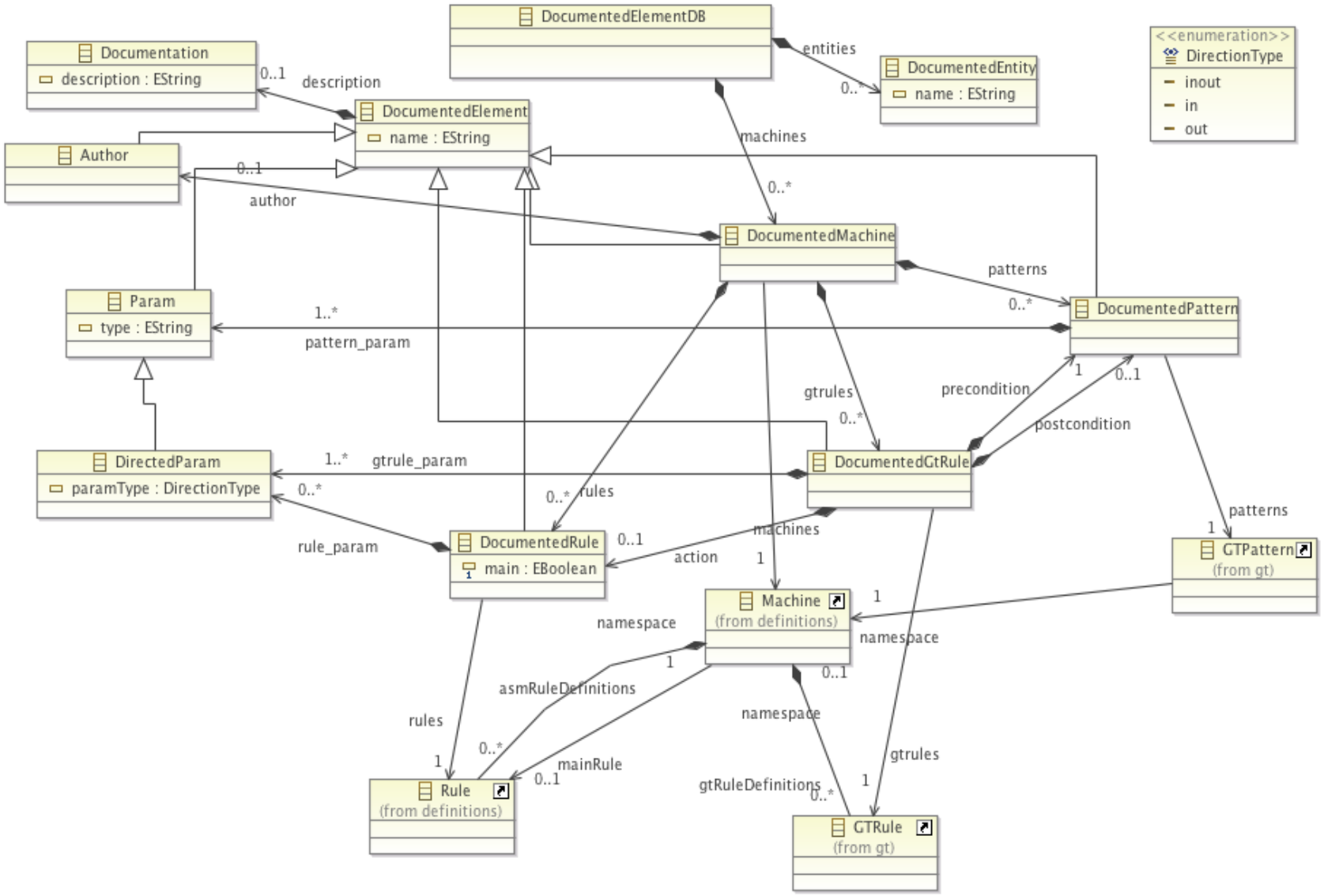


Sources: http://wiki.gis.com/wiki/index.php/Visual_variable
https://www.fusioncharts.com/blog/how-to-use-the-gestalt-principles-for-visual-storytelling-podv/

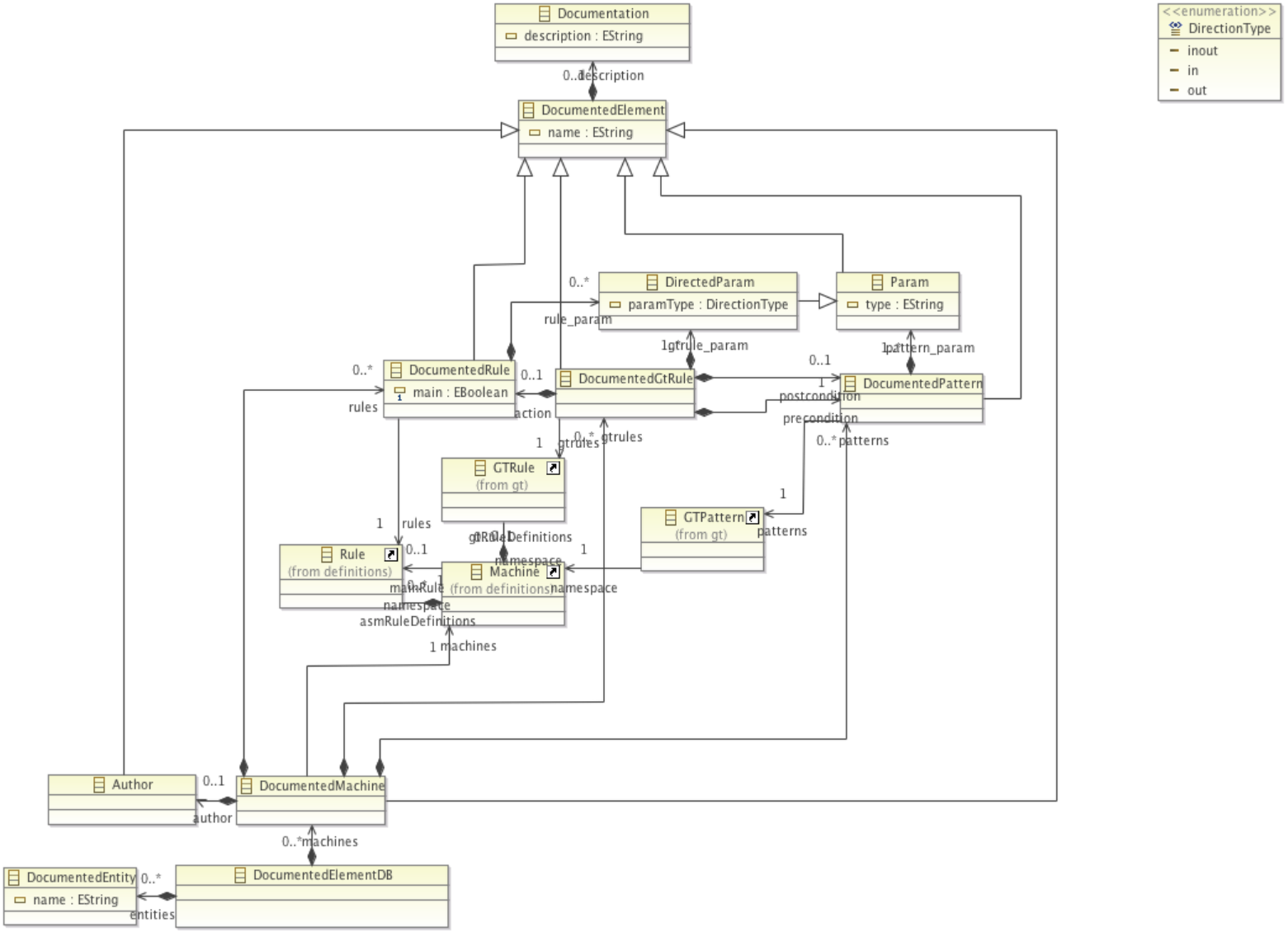
Scaling issues

- Cumbersome editing
  - E.g., automatically reorganize diagram when inserting a node to the middle
- Handling large models
  - 20+ nodes on a diagram:
    - Logical structure, readability possible
    - But needs human support
  - 100-1000+ nodes on a diagram
    - Technological limitations
    - Usability limitations

Example: Layouting

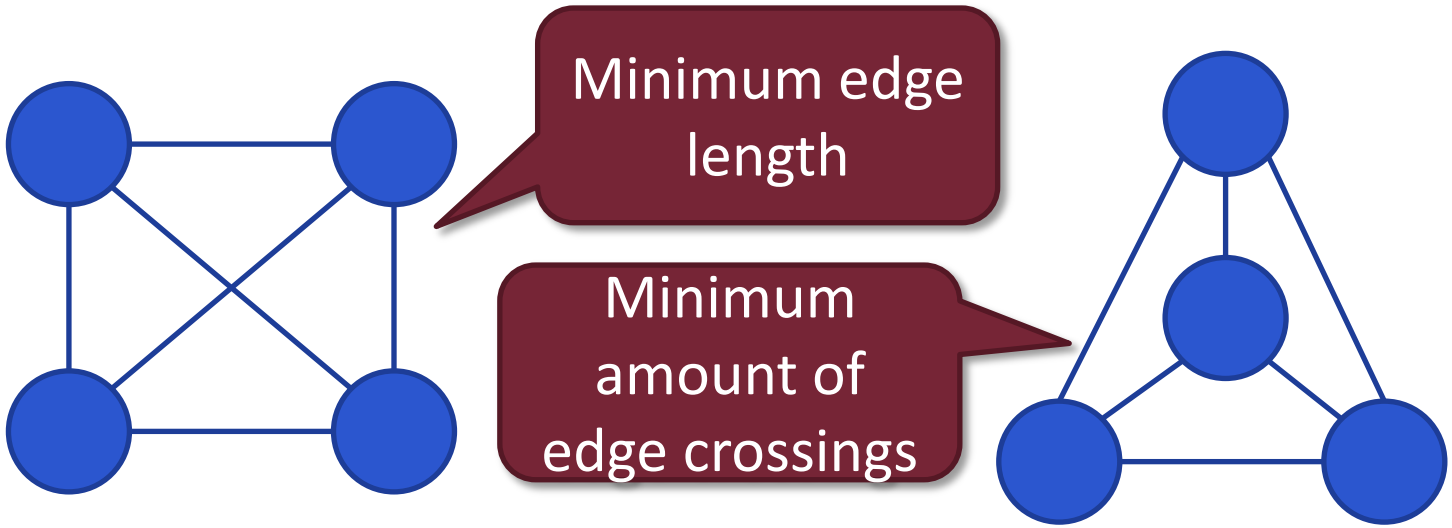


Example: Layouting



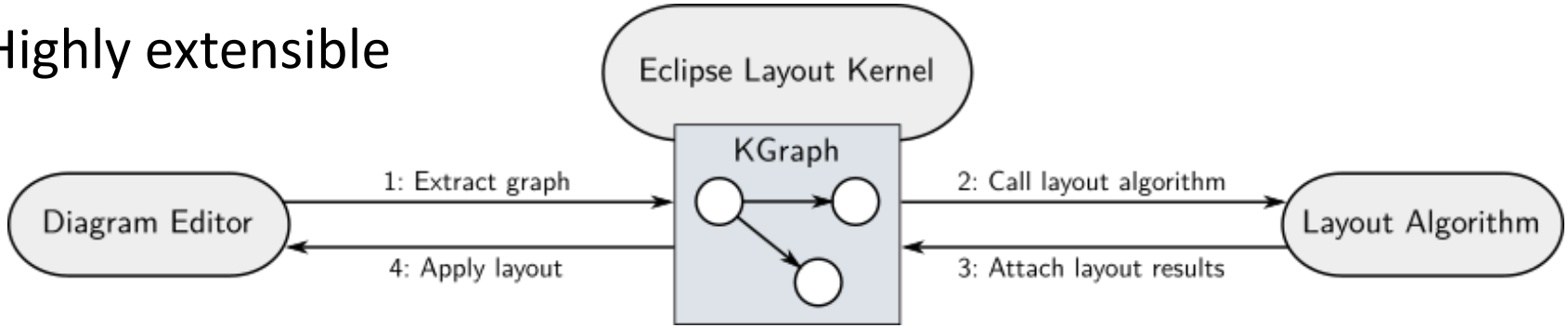
Layouting Support for Graphical Editors

- Computation of the position of nodes
  - Possible to do automatically
  - For a given metamodel
    - No unified visual requirements possible
    - We have to decide what is important to show



Layouting Support for Graphical Editors

- **GraphViz** - http://graphviz.org
  - Layouting project with high quality layout algorithm
  - Hard to integrate into Eclipse applications
- **Zest** - http://wiki.eclipse.org/index.php/Zest
  - Easily Eclipse integration (SWT-based graph widget)
  - So-so layout algorithms
- **ELK** (née ~~KIELER~~) - https://www.eclipse.org/elk/ (relatively new)
  - Eclipse Layout Kernel
  - Some built-in support: GMF, Graphiti
  - Highly extensible

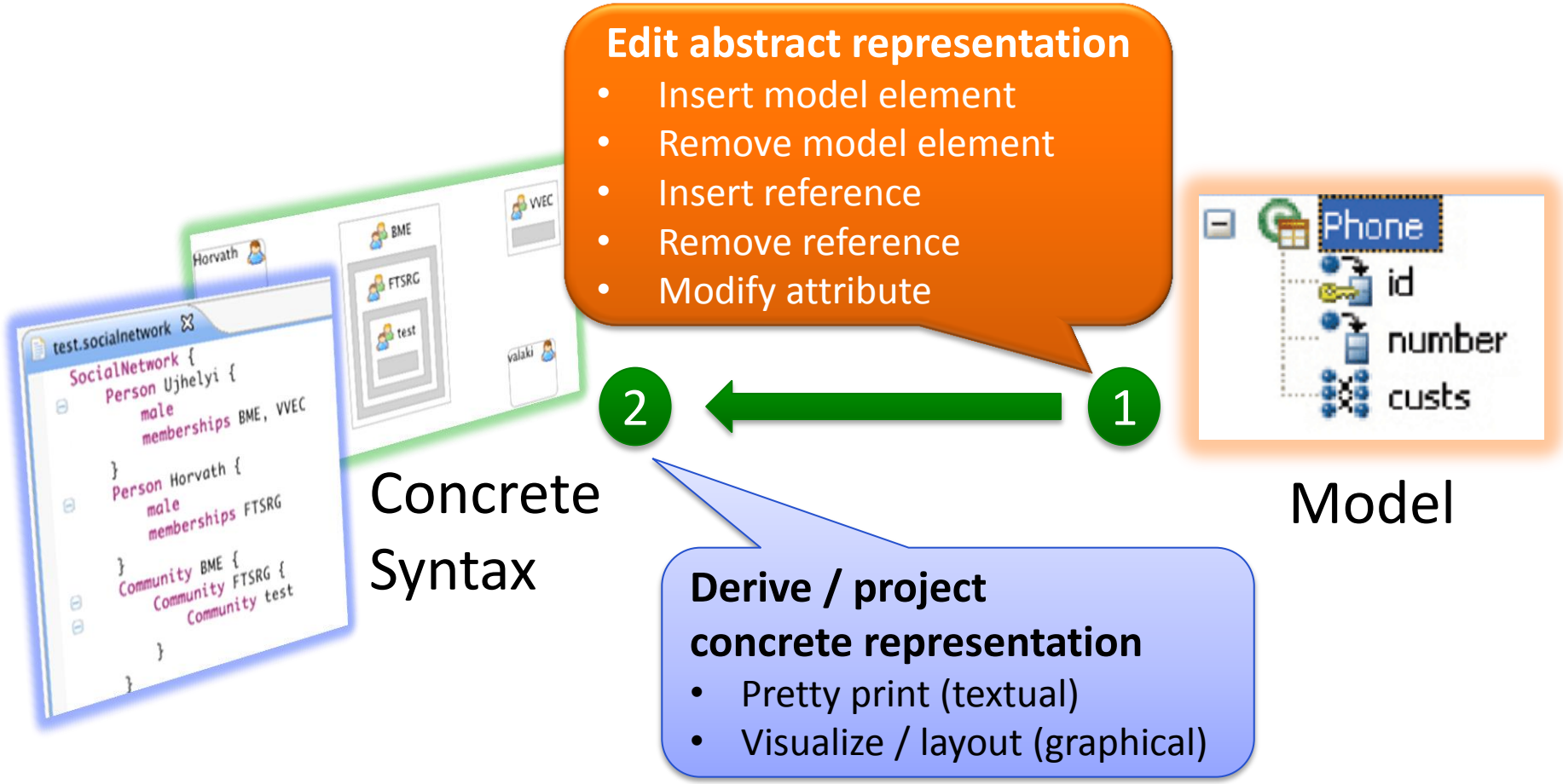


Editor Engineering

Editing Workflows
Transactionality
Notation Models

Projectional vs Raw

- Workflow 1: **projectional editing**
  - AKA syntax-driven editing, structural editing



Projectional vs Raw

- Workflow 2: **raw editing** (w. textual syntax)
  - AKA source editing

Concrete Syntax

Edit concrete representation
- Insert character(s)
- Delete character(s)
- Replace character(s)

1 → 2

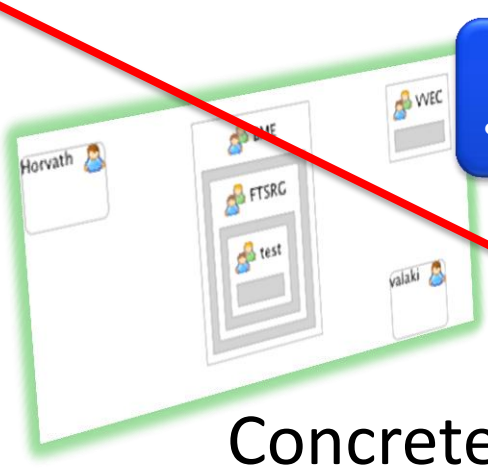
Derive abstract representation
- Parse textual format

Model

Projectional vs Raw

- Workflow 2: **raw editing** (w. graphical syntax)

Highly impractical



Edit concrete representation
- Paint diagram (e.g. PNG)

1

2

Concrete Syntax

Model

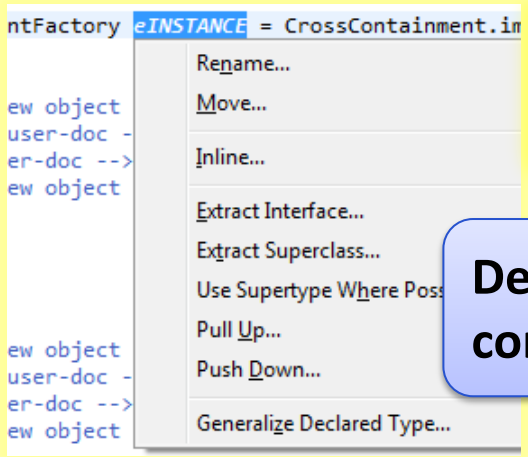
Derive abstract representation
- Image processing with convolutional neural nets
- OCR, etc.

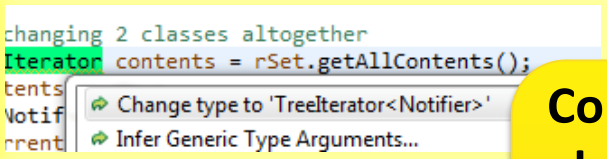
Projectional vs Raw

- „Feature matrix” + examples

	Graphical syntax	Textual syntax
Raw editing		Typical 
Projectional editing	Typical 	Rare 

Mixed workflow





Derive / project concrete representation

Complex manipulation of abstract representation

- Quick fix
- Refactor
- M2M

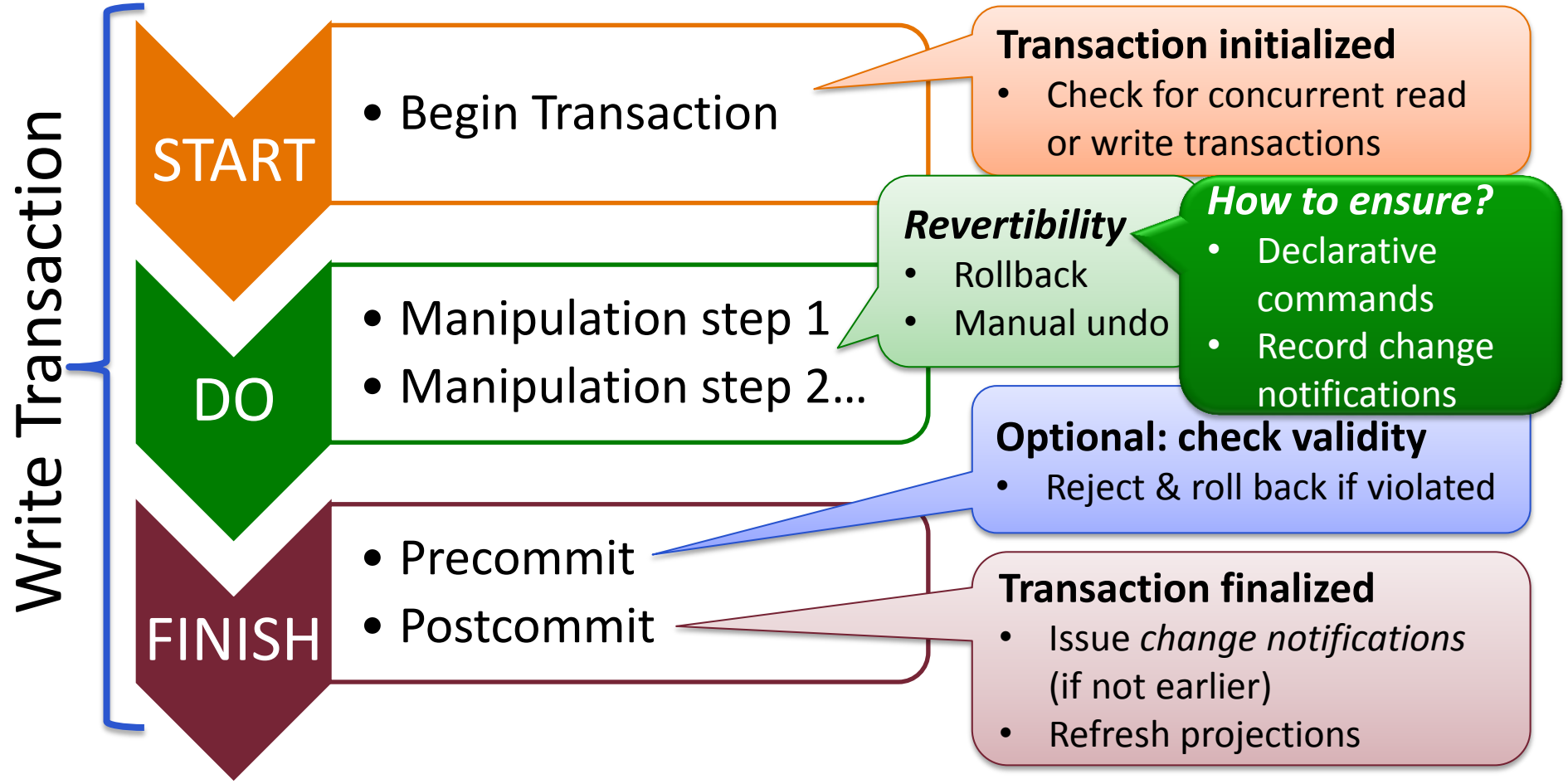
Concrete Syntax

Model

Normal raw editing workflow

Transactions in projectional editing

- Complex manipulation sequence as single action
  - „Extract subprocess”, „Drag&drop attribute” etc.

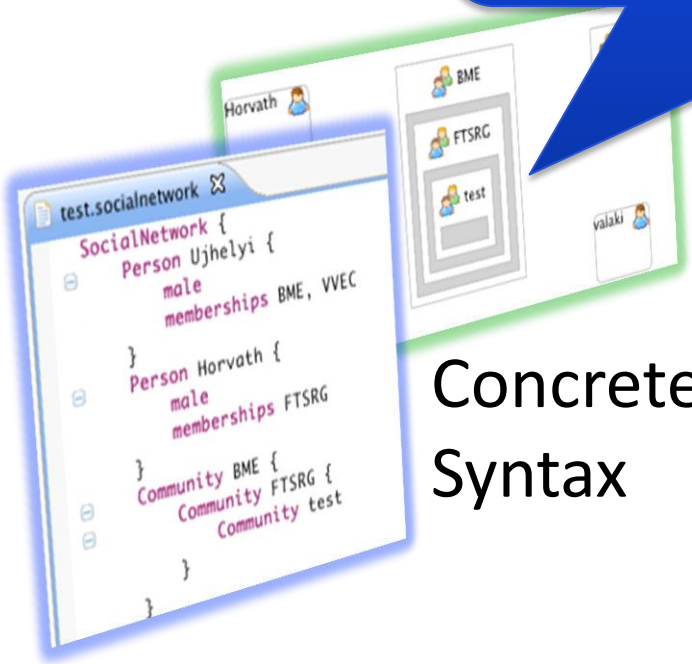


Superfluous notational parameters

- Workflow 1: **projectional editing**

Must include *notational parameters*:
- Whitespace and comments, etc. (textual)
- Layout, edge routing, size, shape, etc. (graphical)

…even though not domain information



Concrete Syntax

2

1

Model

Derive / project concrete representation
- Pretty print (textual)
- Visualize / layout (graphical)

Deriving notational parameters

- Notational parameters can be…
  - …”baked into” projection code
    - e.g. all lines are black, all fonts are 10pt (graphical)
    - e.g. apply this code formatting template (textual)
  - …derived from domain information
    - e.g. shape determined by type, color by visibility

Problem 1:	**Problem 2**:
Editable parameters cannot be a function of the domain model, must be stored	Providing sane values is difficult for some parameters e.g. position in diagram

  - …**stored in the model**

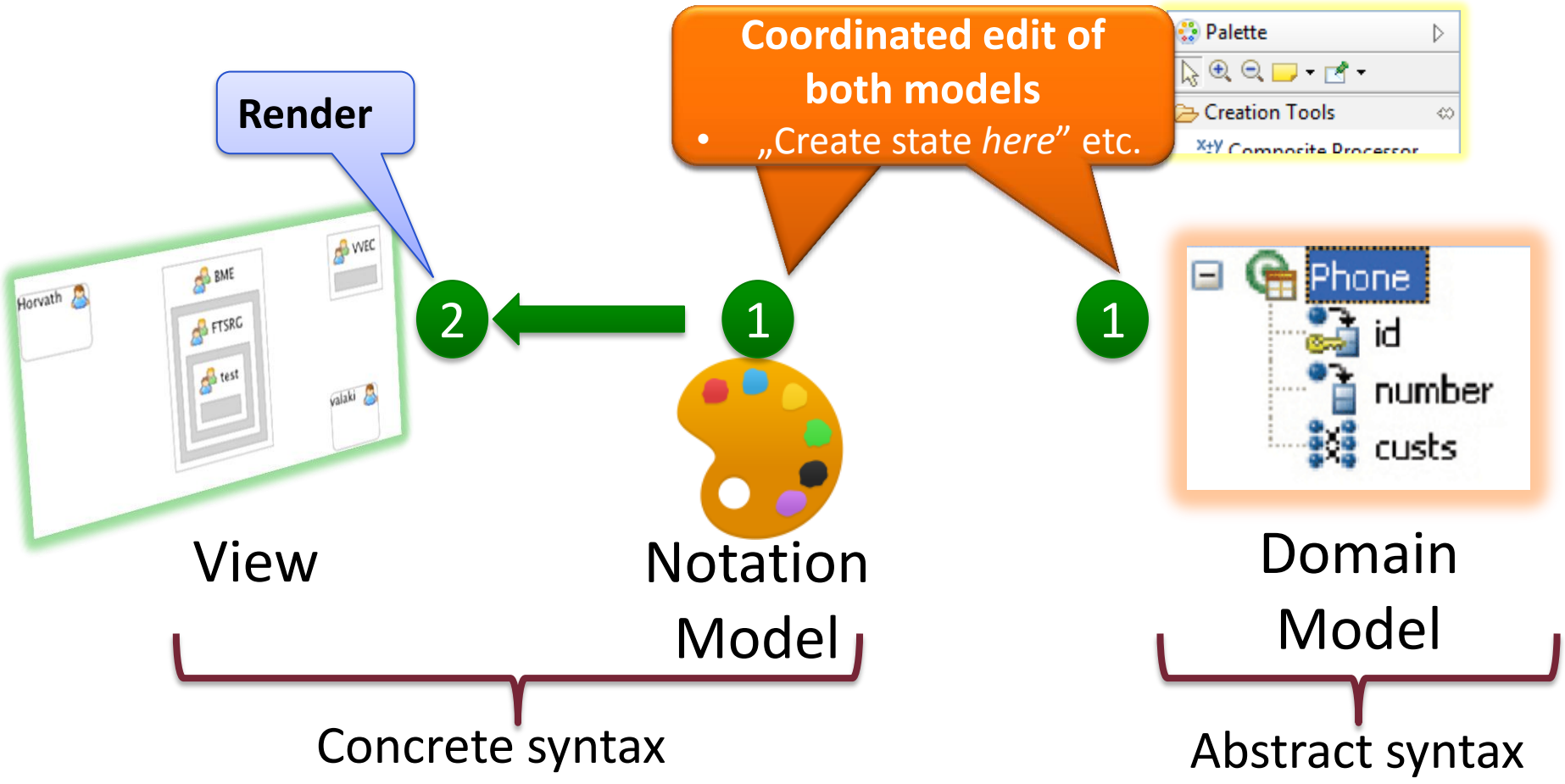
Notation/view models

M.Fowler's „Presentation Model" architectural pattern

- Decompose model:
  - Domain / Semantic model (abstract syntax)
  - **Notation model** (view model): presentation state
    - may be editable by user
    - but still needs derivable defaults → see layouting
- Generic implementation in GMF and Graphiti
  - Based on EMF, in fact
- Often stored in external files
  - Separation of concerns
  - E.g. code generator not interested in view information

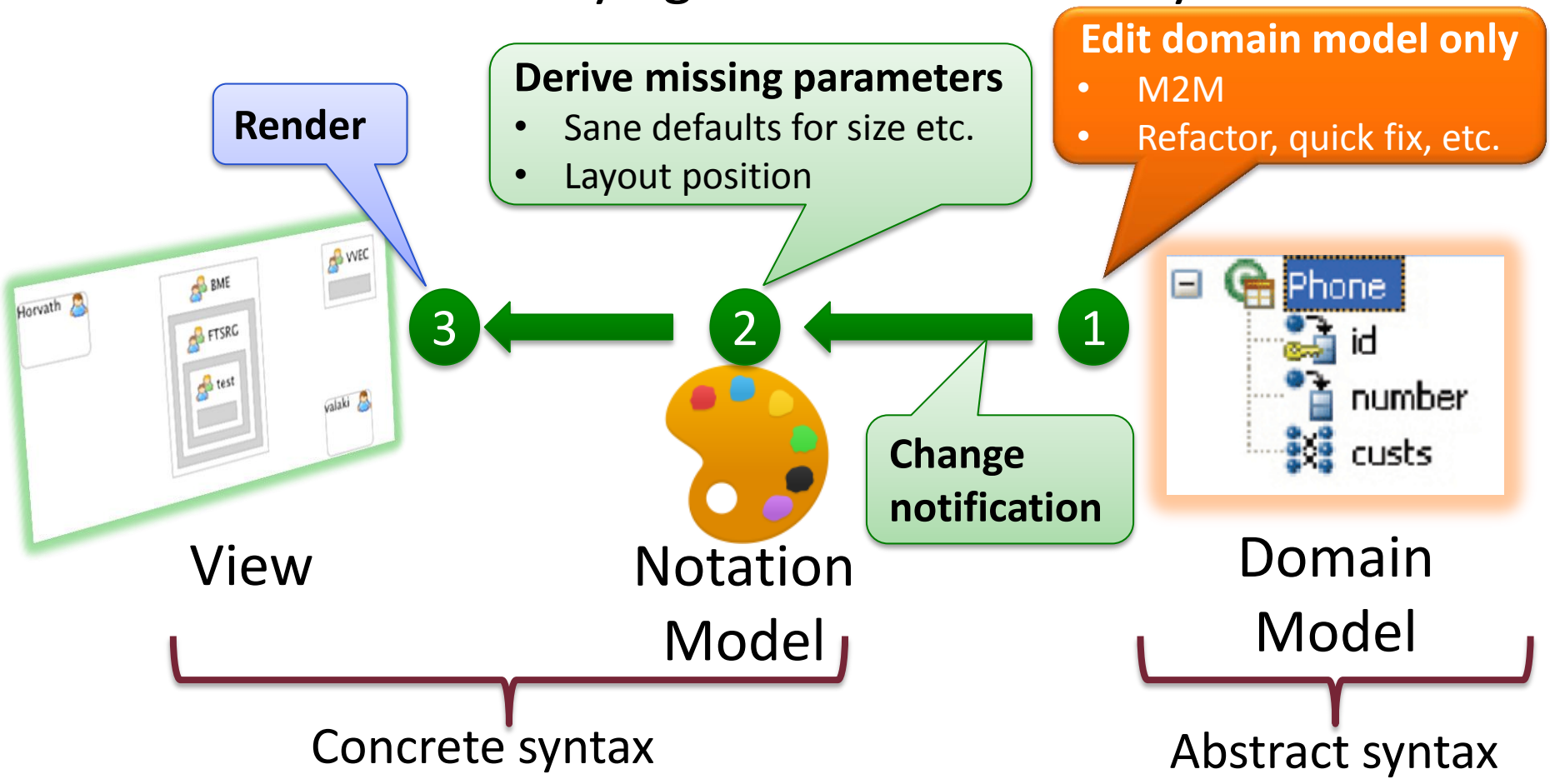
Editing workflow with notation models

- Workflow 1: **projectional editing**
  - Scenario A: co-modifying domain&notation models



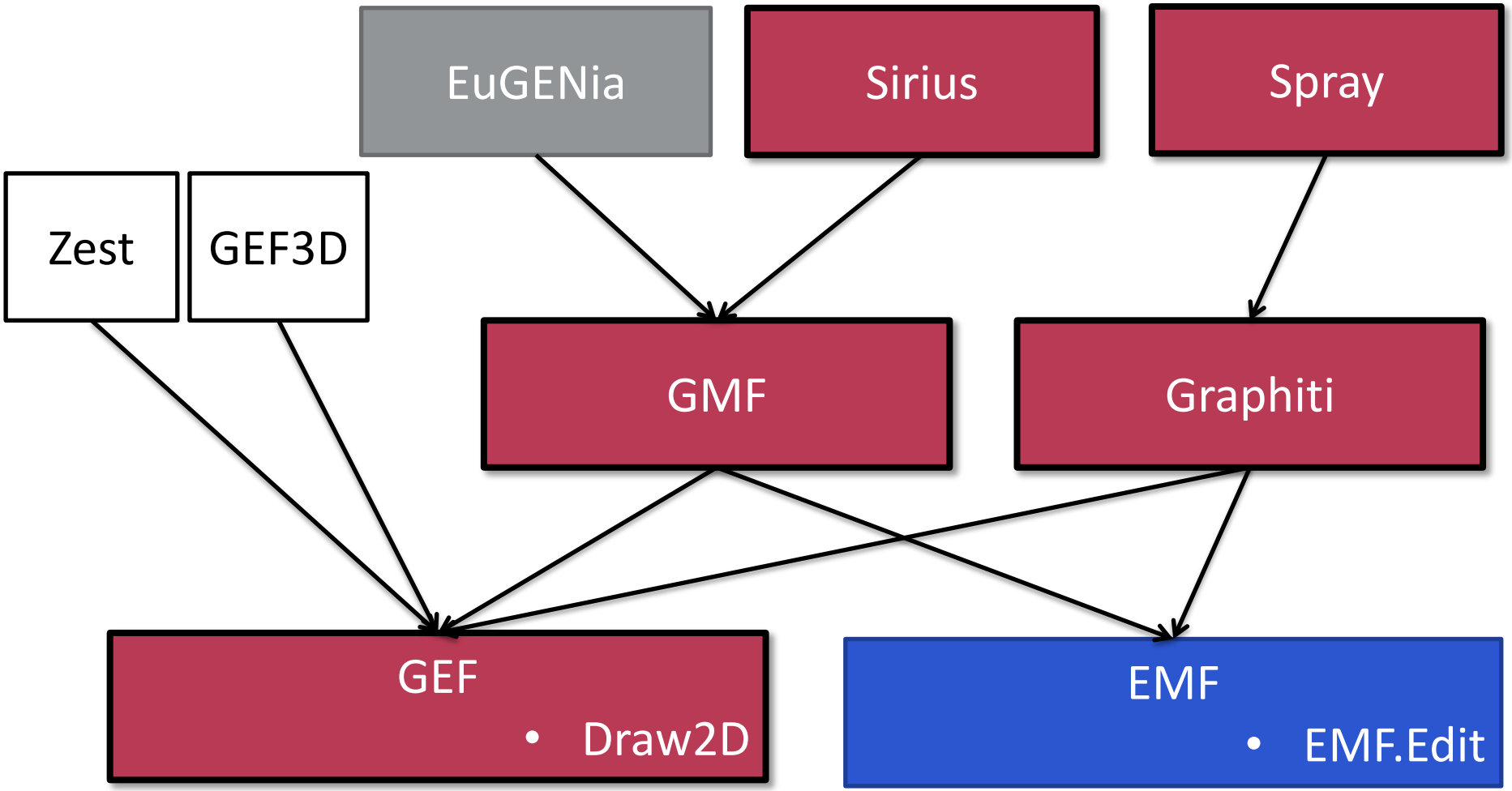
Editing workflow with notation models

- Workflow 1: **projectional editing**
  - Scenario B: modifying domain model only



Graphical Editor Technologies

Graphical Editor Technologies



Implementation

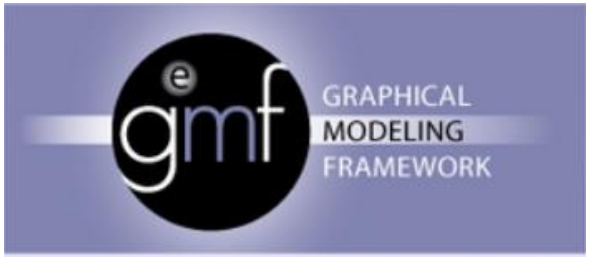
- Presentation
  - Based on a Canvas
  - Using vector-graphic libraries (GEF/Draw2d)
- Model manipulation
  - *EMF Edit* model manipulation commands
    - Atomic operations: create/modify/remove node/edge
  - Transactional modifications with *EMF Transactions*
    - Undo/redo support
- Notation/view model
  - Domain-independent implementation in GMF, Graphiti

Technologies 1. - GEF

- Graphical Editing Framework (GEF)
  - “Low level” editor framework
  - Not EMF-specific
- Model-View-Controller approach
- Generic graph-based editor framework
  - Including undo/redo support
  - Graphical outlines
- Manual coding for every possible element
- GEF4 FX – JavaFX-based replacement of the core

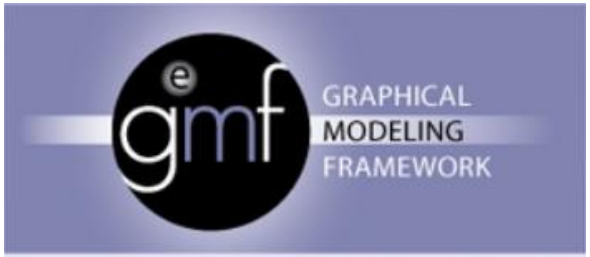
Technologies 2. – GMF

- Graphical Modeling Framework
- Based on GEF and EMF
- Well-separated view and domain models
  - Generic view model
  - Synchronization provided by GMF framework
- Relatively old technology
  - Widely used
  - Very complex to start



Technologies 2. – GMF

- Model-driven development environment
  - Common model for graphical editors, using
    - Figure definition model
      - Basic symbol definition of the graphical language
    - Tooling model
      - Defining model manipulation commands
    - Mapping model
      - Mapping figures and tools to domain model
  - Fully functional editor can be generated
    - Problematic manual modifications
- Or a high-level editor framework
  - Manual coding



Technologies 3. - Graphiti

- Newer high level graphical editor framework
  - Based on EMF and GEF
  - But: different approach then GMF
    - Simplified programmatic API
    - Manual coding
  - Idea
    - All Graphiti based editors should
      - Look similar
      - Behave similar

Technologies 3. - Graphiti

- Development methodology
  - Coding over a high-level Java framework
    - Much simpler then GMF
    - Repetitive code needed
- Spray project
  - Textual modeling environment for graphical editors
  - Generates code over the Graphiti framework

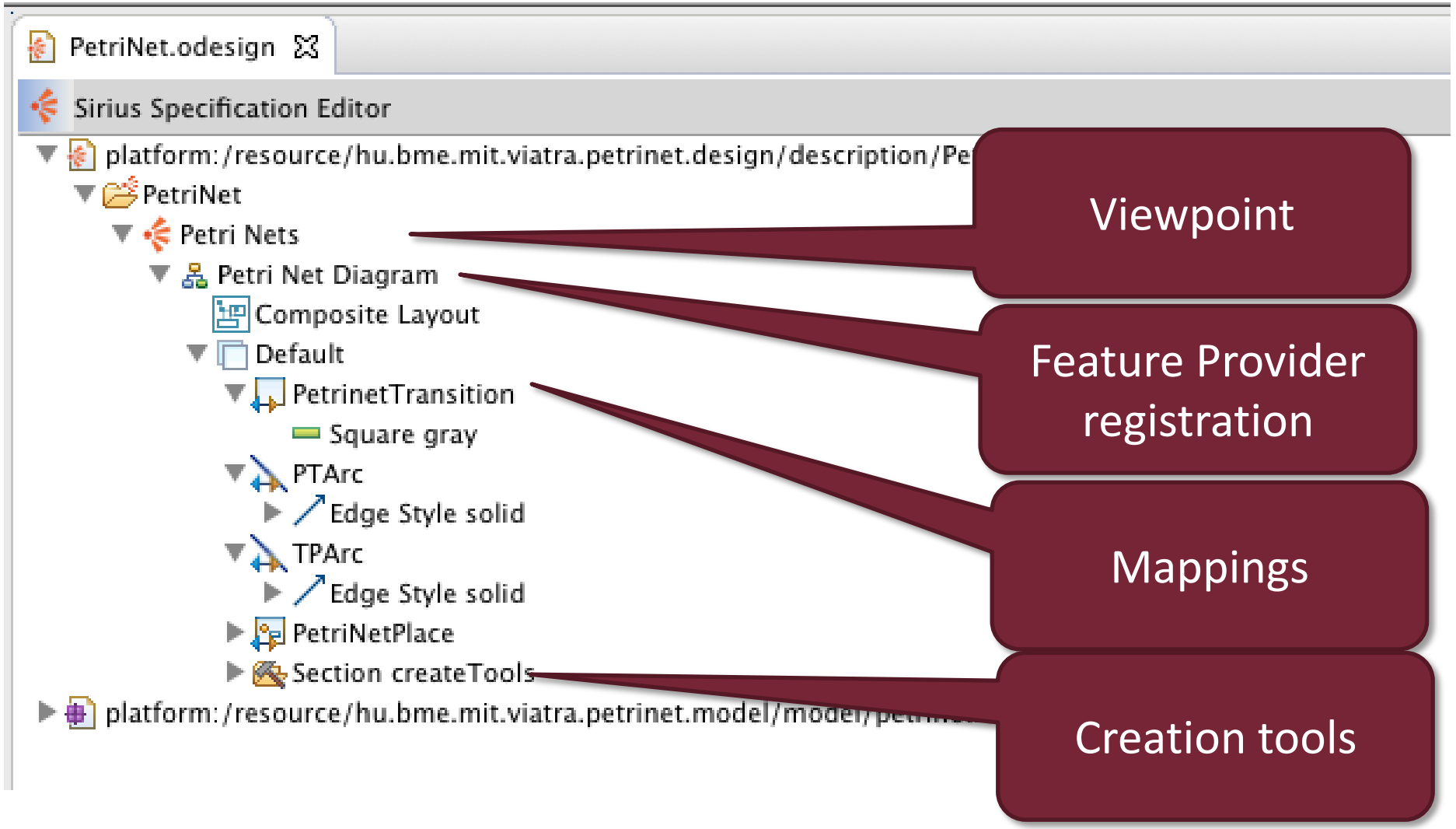
Technologies 4. - Sirius

- New modeling project
  - Since 2013 on eclipse.org
  - Previously Obeo Designer – commercial tool
- How stable is it?
  - Old projects are to be migrated
  - Version history
    - 0.9: 2013-12-10
    - 1.0: 2014-06-25 (Kepler release train)
    - …
    - 5.1: 2017-10-26
    - …

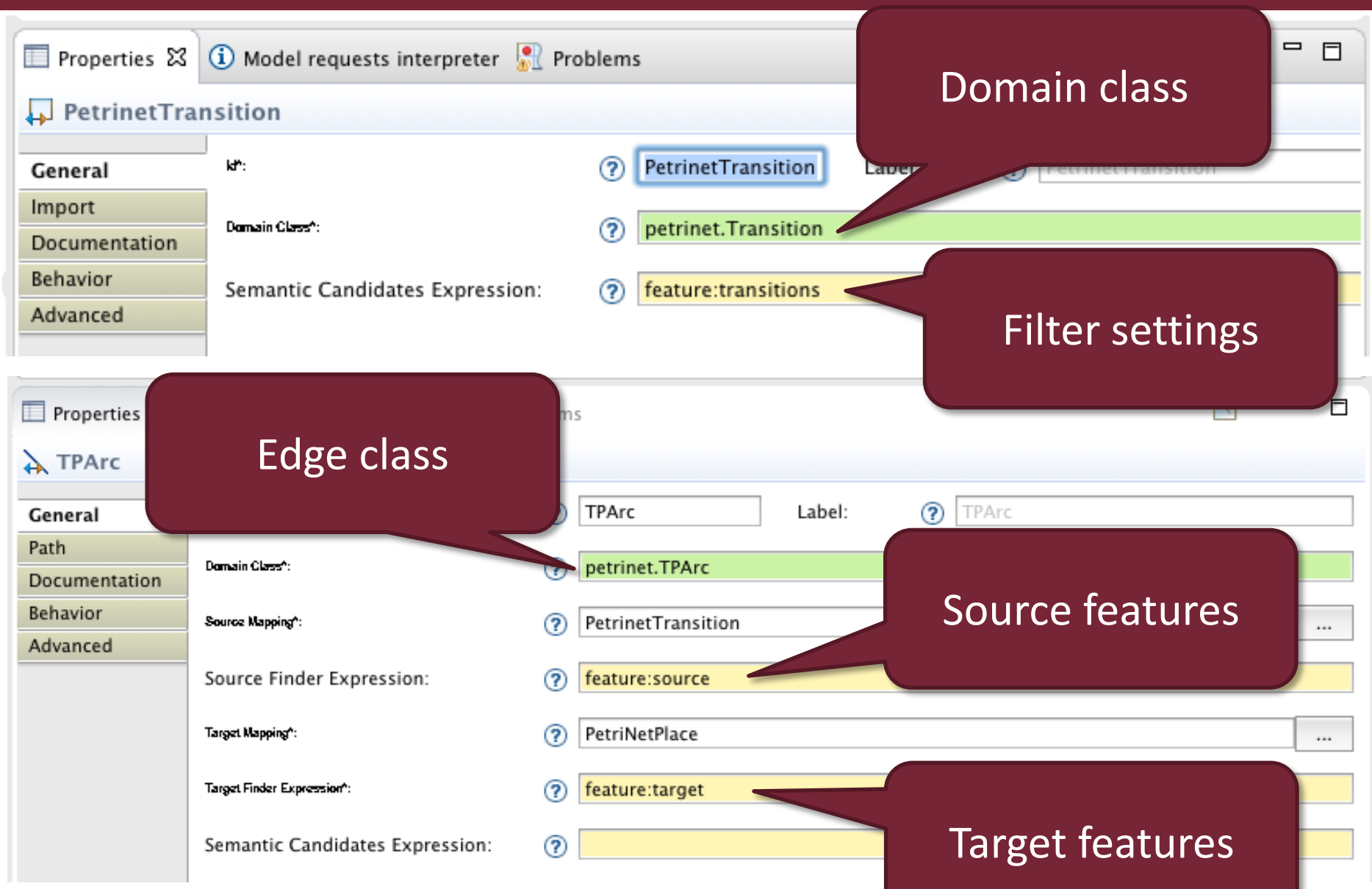
Sirius Viewpoints

- Base concept:
  - Every diagram is a view of the model
  - With a defined syntax
    - **Graphical**
    - Table/Tree syntax
    - Xtext-based textual syntax
- Viewpoint definition
  - Viewpoint specification model

Viewpoint Specification Model



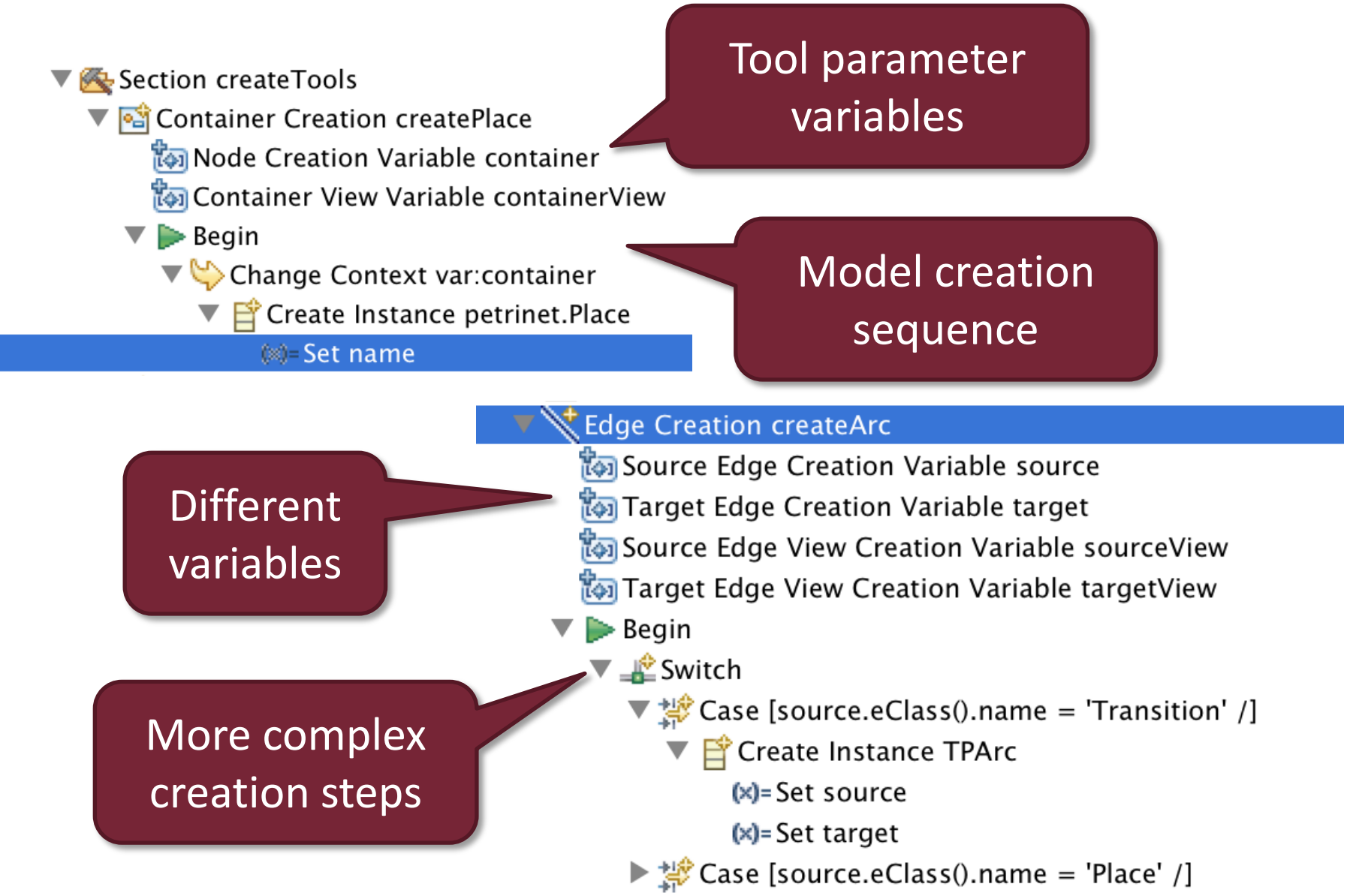
Node & Edge Mapping



Feature Selection

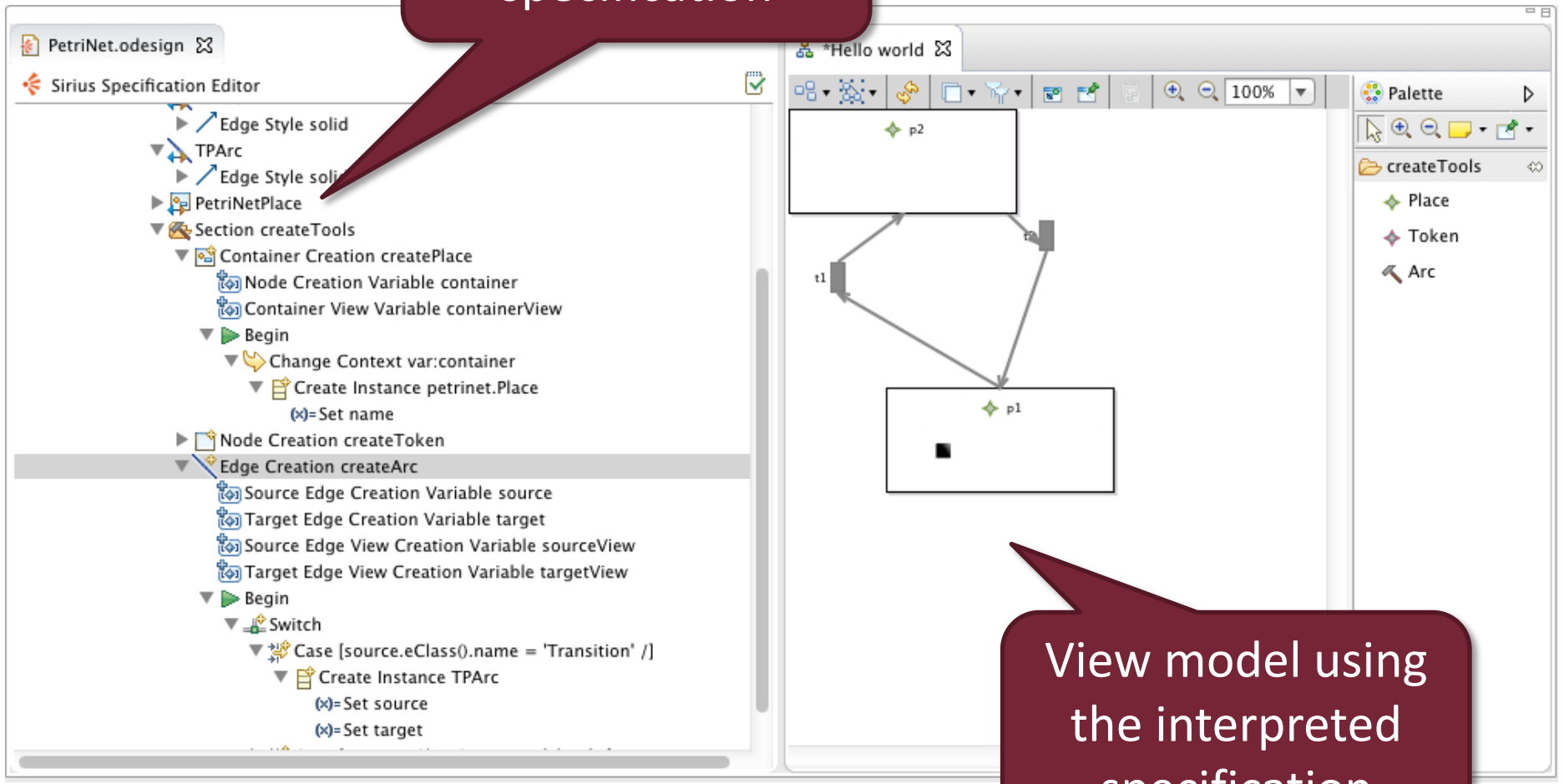
- Interpreted **model query** expressions
  - Special interpreters
    - **var**: accessing specification model variables
    - **feature**: accessing EMF model features
    - **service**: accessing service methods
  - Acceleo
    - Acceleo expressions
      - Basic operations
      - Comparison with single ‘=‘ symbols
    - Syntax: **[theExpression/]**
  - Raw OCL
    - Not recommended, Acceleo provides superset features
  - Custom interpreter

Node & Edge Tool



Interpreted Modeler Development

Viewpoint specification



View model using the interpreted specification

Technology Comparison

	GEF	GMF	Graphiti	Sirius
Model	Arbitrary	EMF	EMF	EMF
Non graph-based presentation	Manageable	Large amount of customization needed	Not supported	Tree, Table
Code size	Large, repetitive code	Mostly modeling, some coding	Smaller amount, but repetitive code	Negligible
Development workflow	Only coding	Modeling and coding	Coding	Modeling

Concrete Syntax Design

Conclusion

Concrete Syntax Design

- Multiple approaches
  - Textual and/or graphical syntaxes
  - Combinable
- Large amount of development work needed
  - Directly used by users
  - Usability issues
- Not everything is coded in an editor
  - Editor + corresponding views form the interface