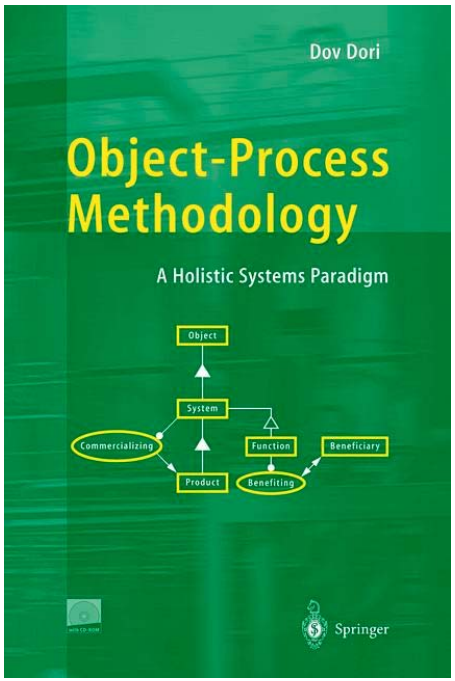
Object-Process Methodology and Its Application to the Visual Semantic Web

Pre-Conference Tutorial PT1
ER-2003, Chicago
October 12, 2003



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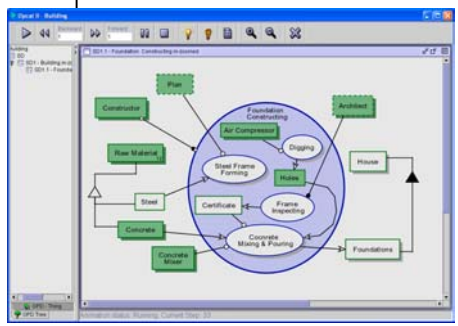
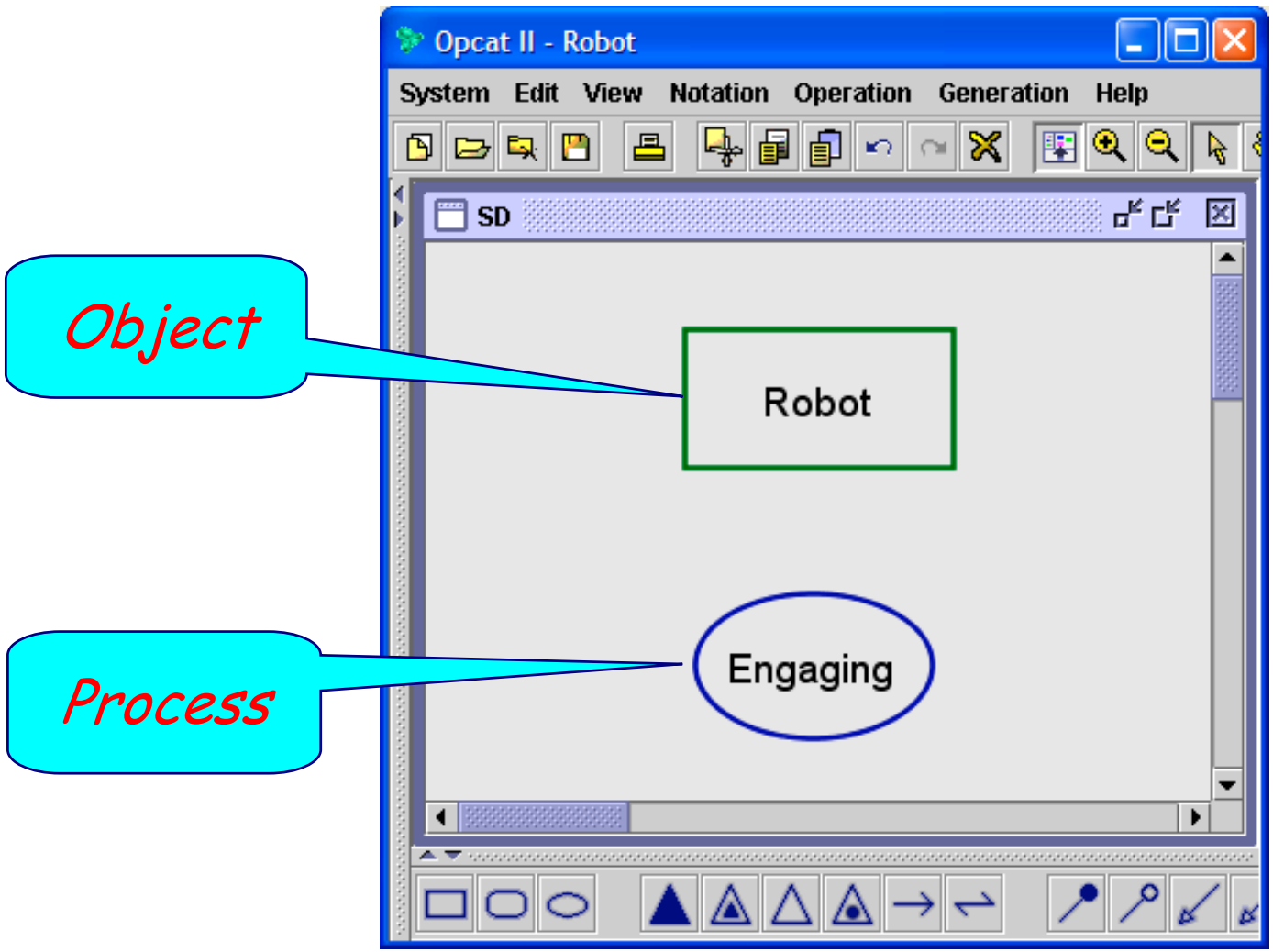
www.ObjectProcess.org



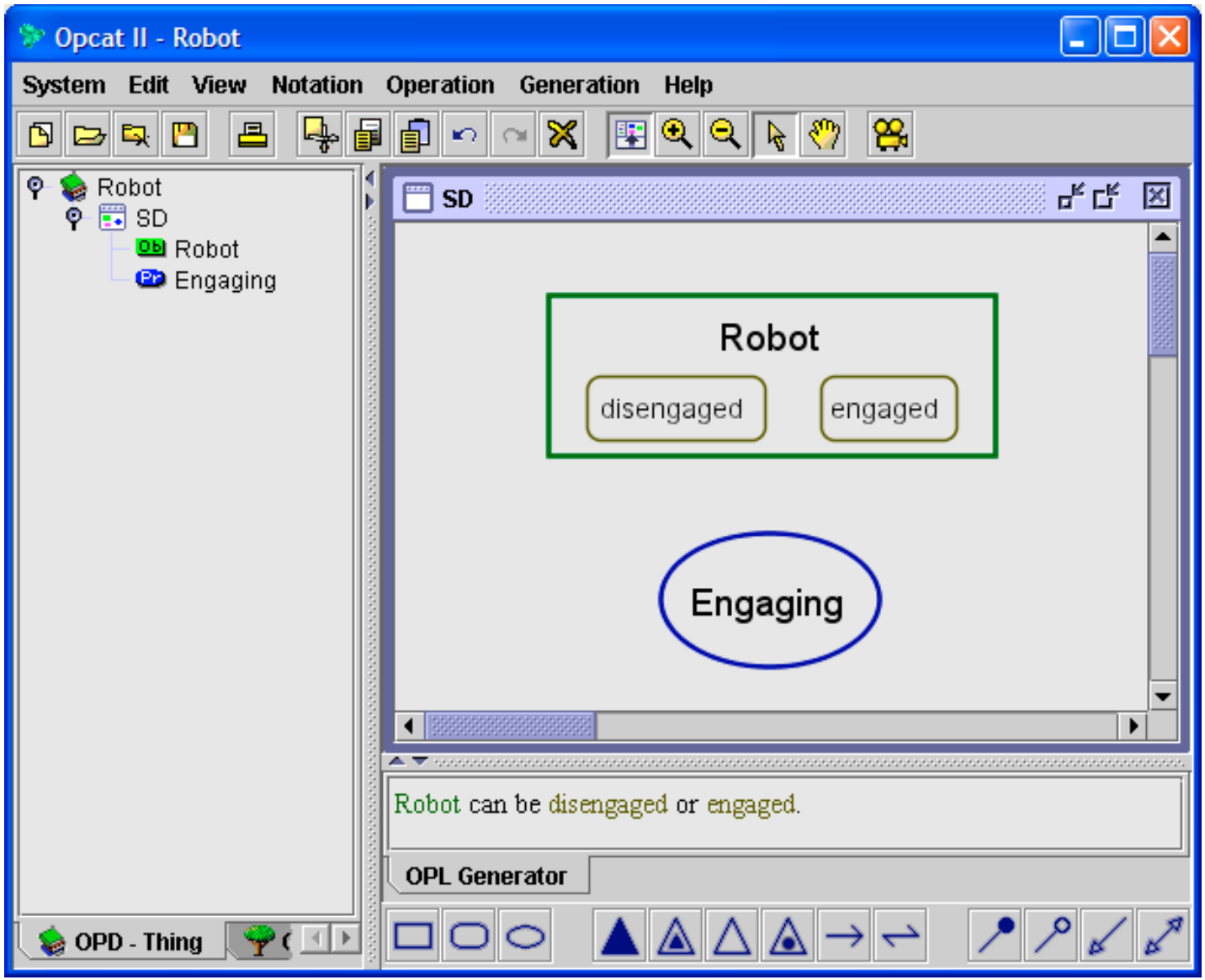
What is Object-Process Methodology (OPM)?

- A comprehensive patented systems modeling, engineering, and lifecycle support paradigm
- Two major features:
  - Unification of function, structure and behavior in a **single** model
  - Bi-modal expression of the model via intuitive yet formal **graphics** and equivalent **natural language**

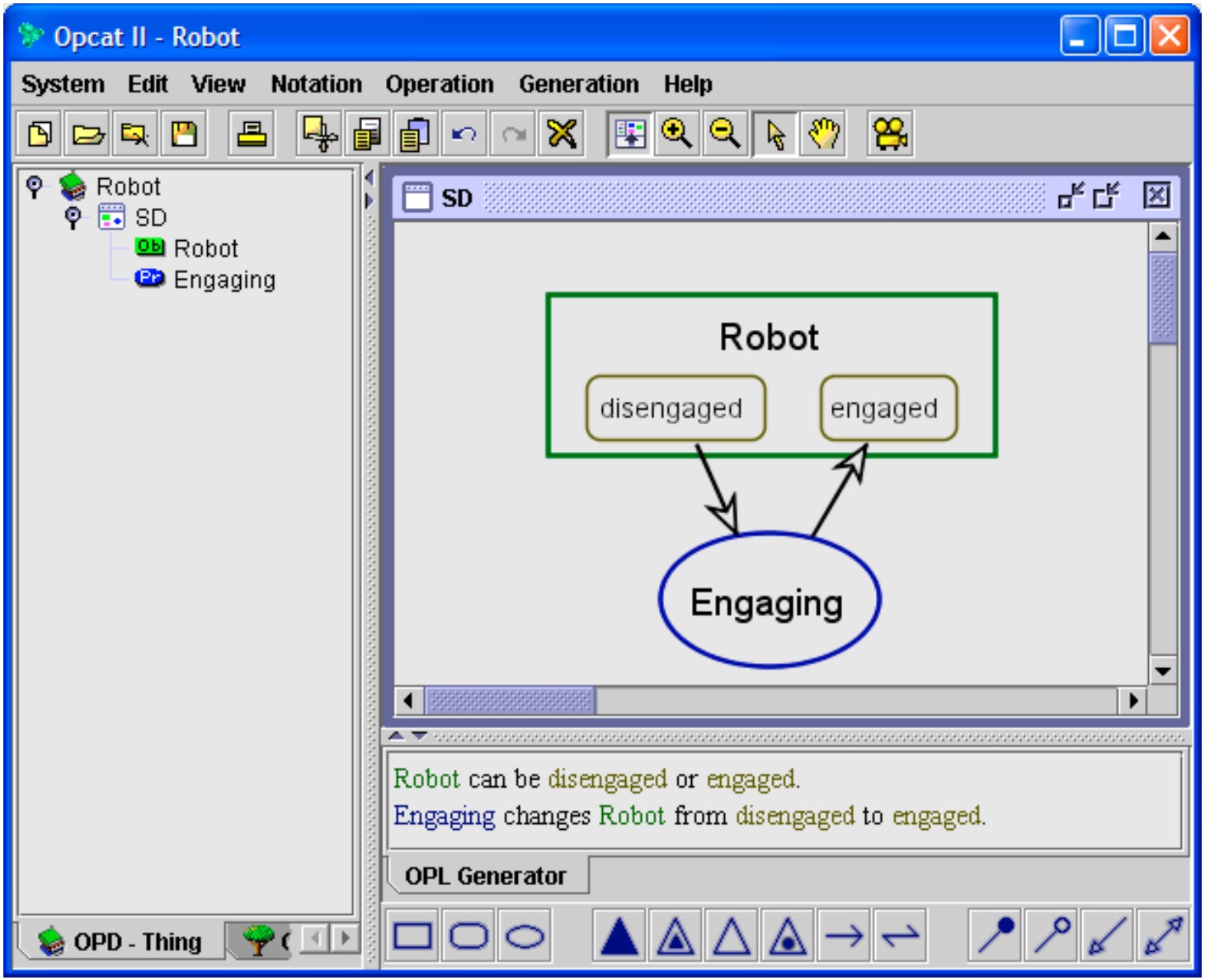
OPM's Building Blocks are Things: Objects and Processes



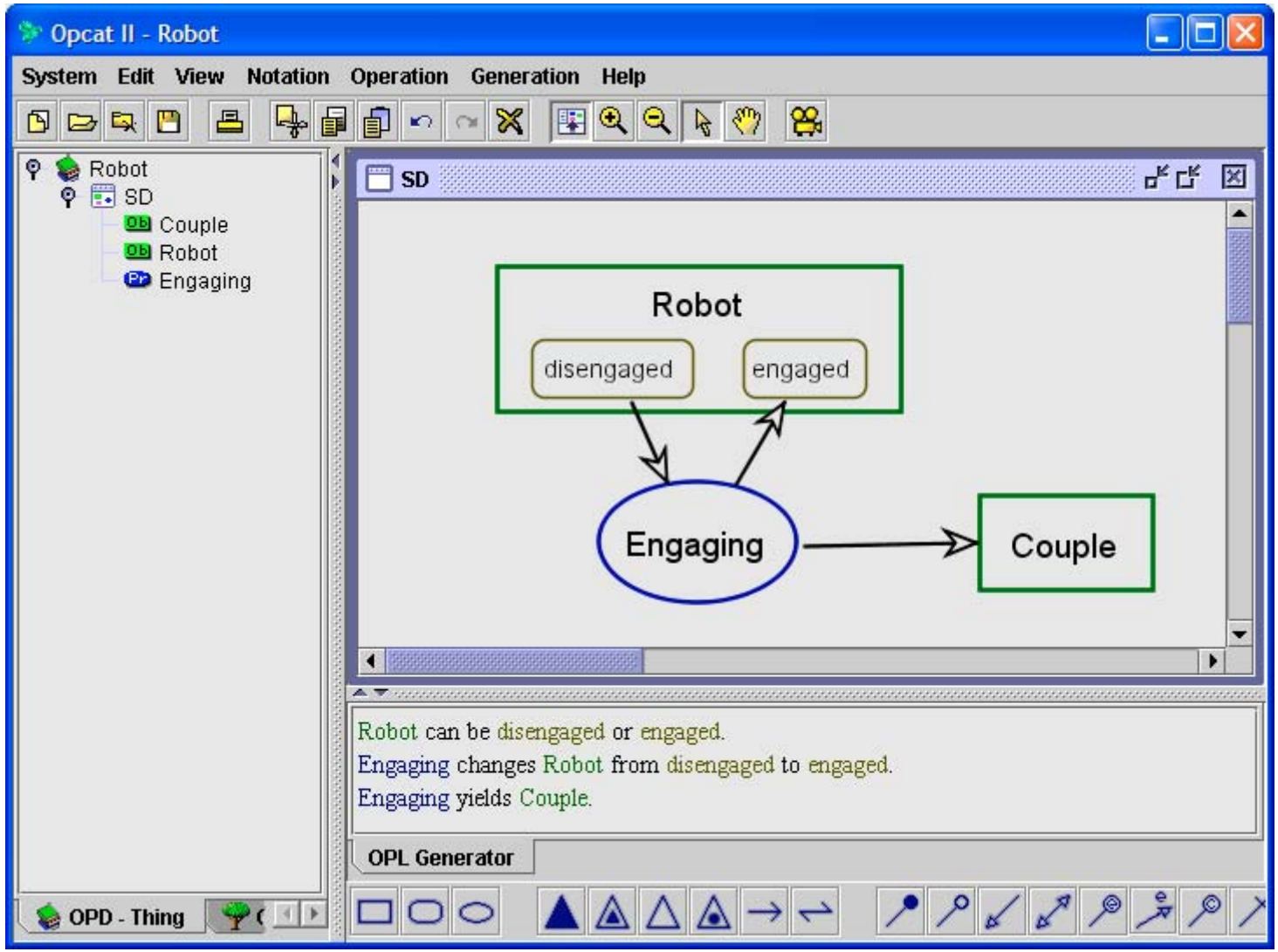
States are situations of objects



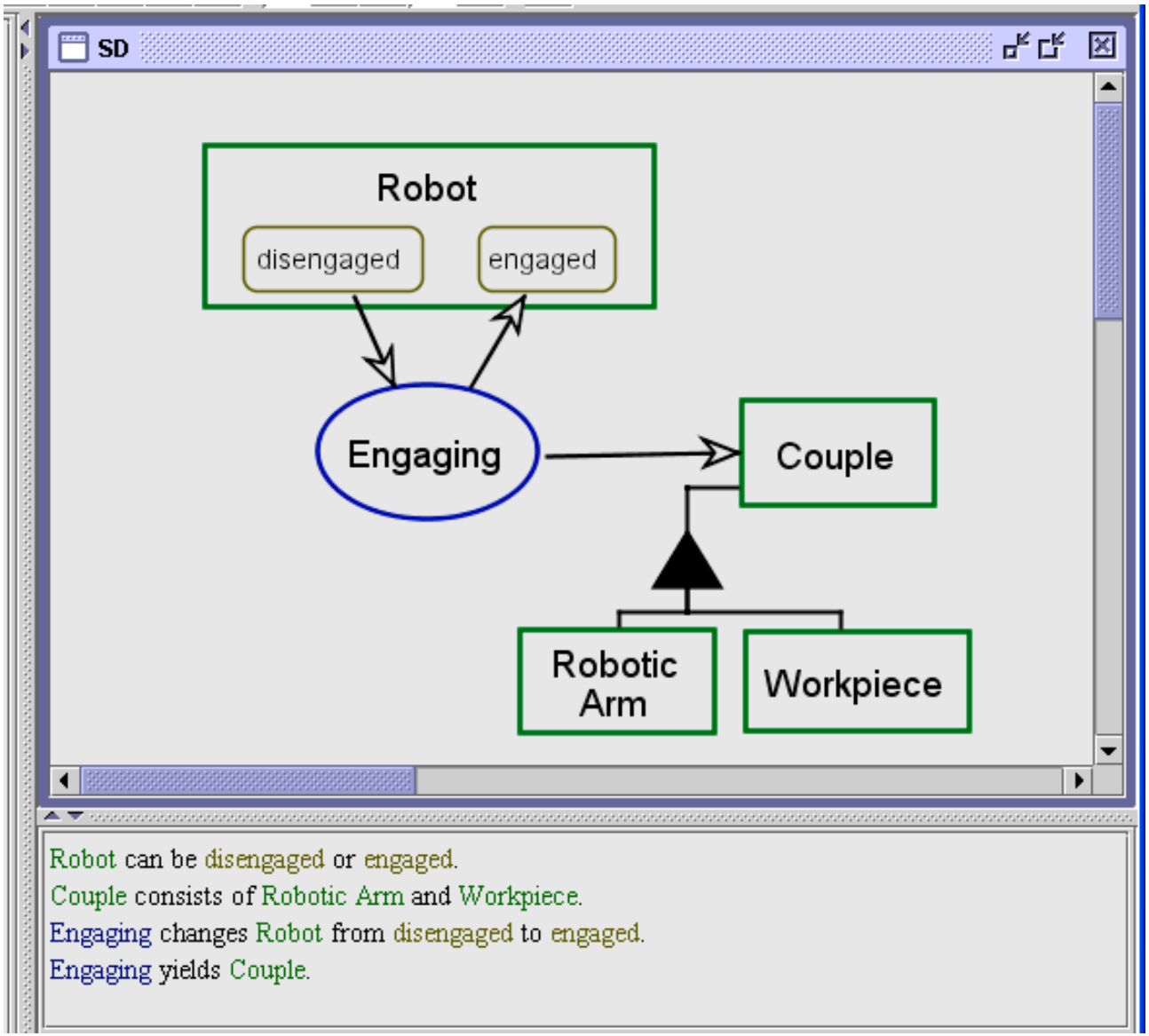
A process changes an object state



A process generates a new object



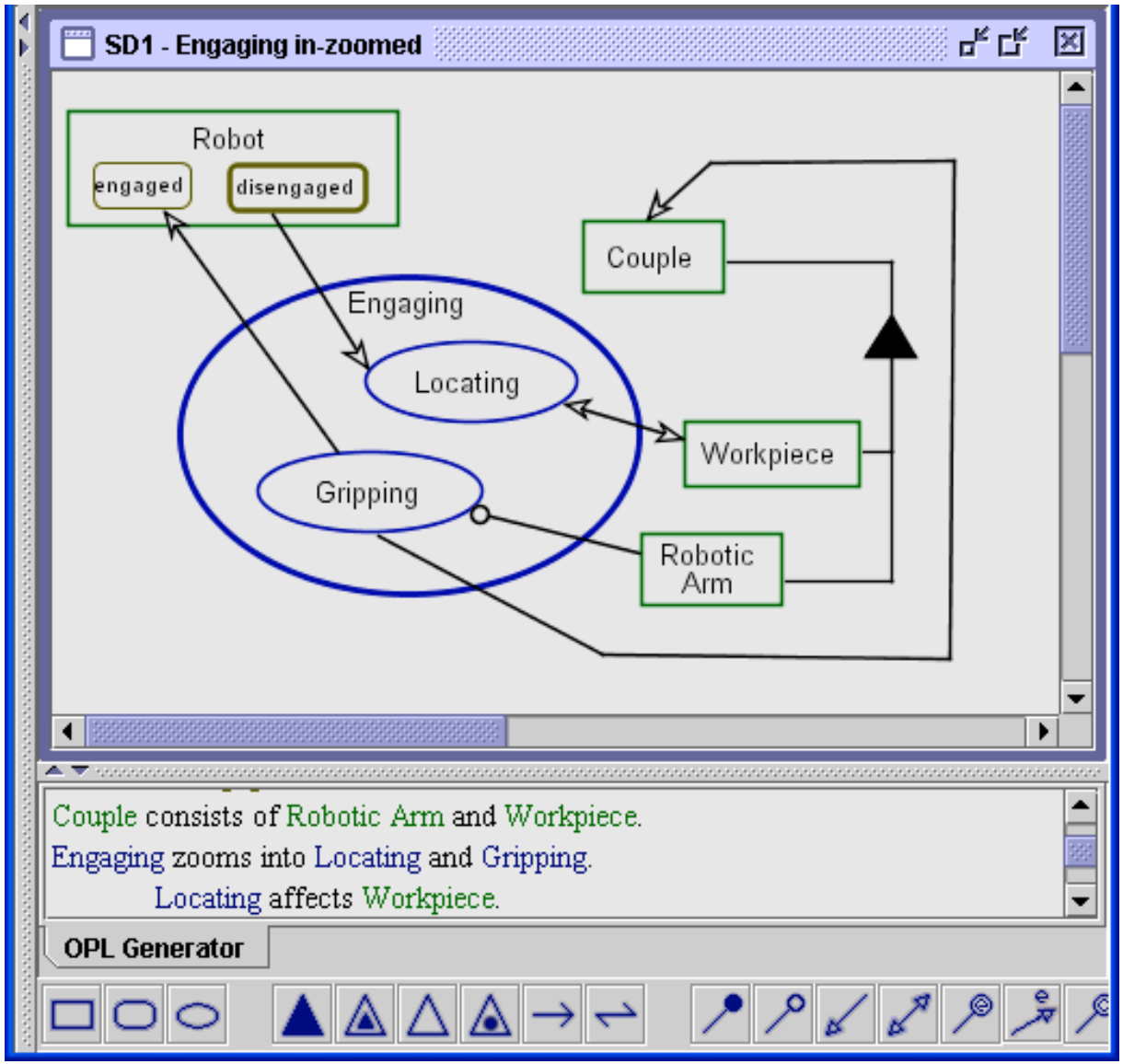
Combining Behavior with Structure



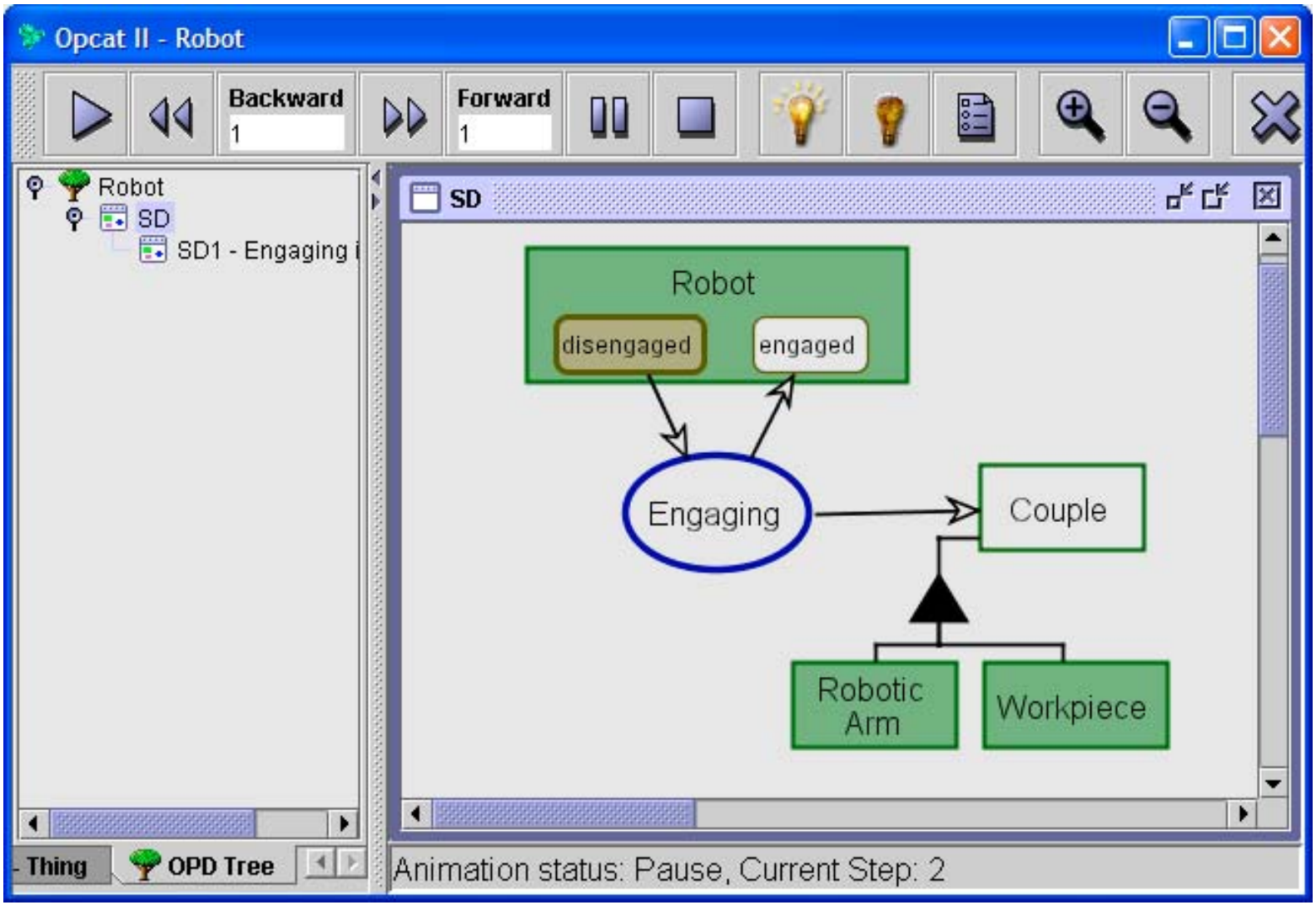
Why Object-Process Methodology?

- As the inherent complexity and interdisciplinary nature of systems increases, the need for a universal modeling, engineering, and lifecycle support approach becomes ever more essential.
- The unnecessary complexity and software orientation of UML – the current standard language – calls for a simpler, formal, generic paradigm for systems development.

Complexity Management

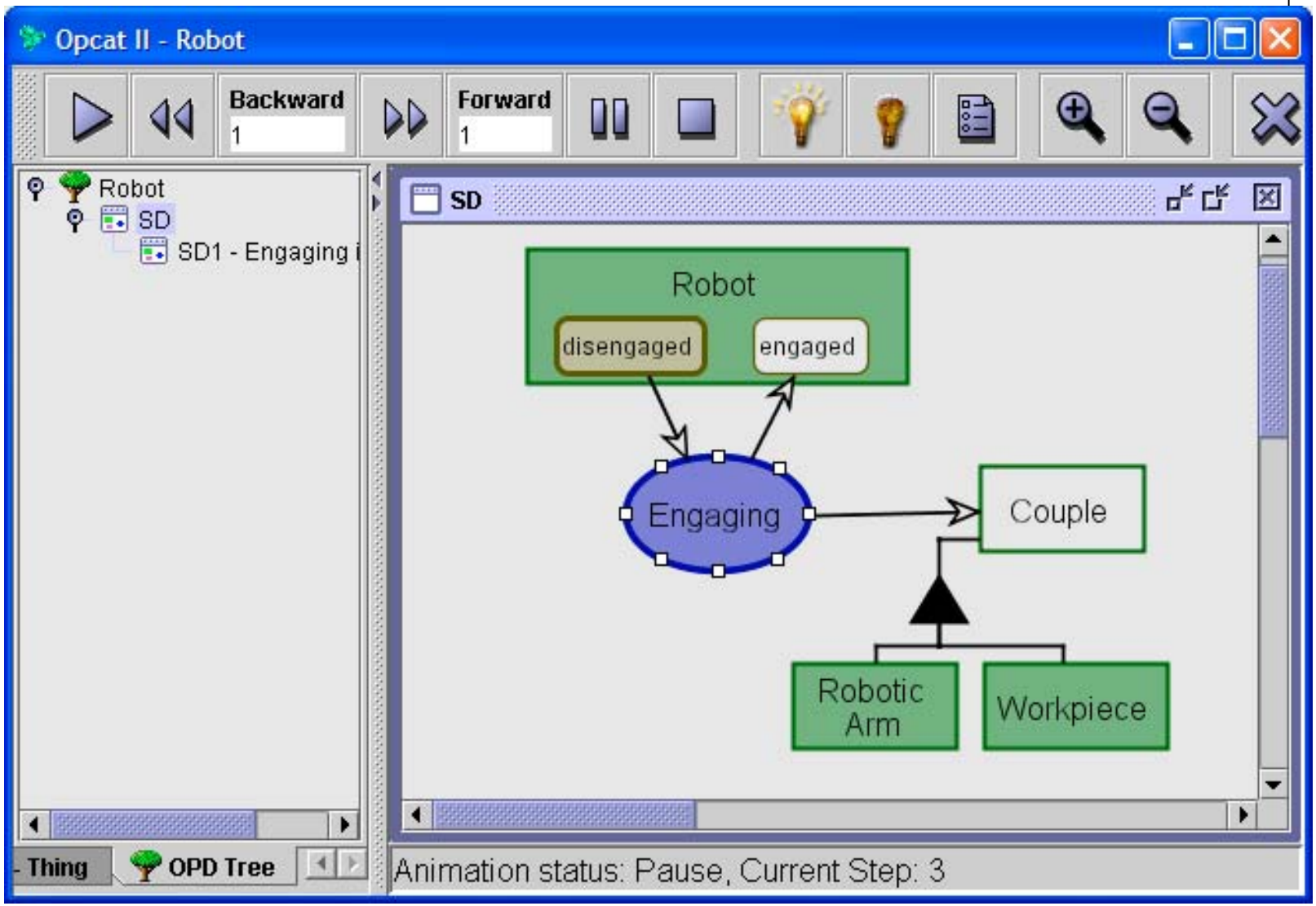


Animated Simulation: Starting



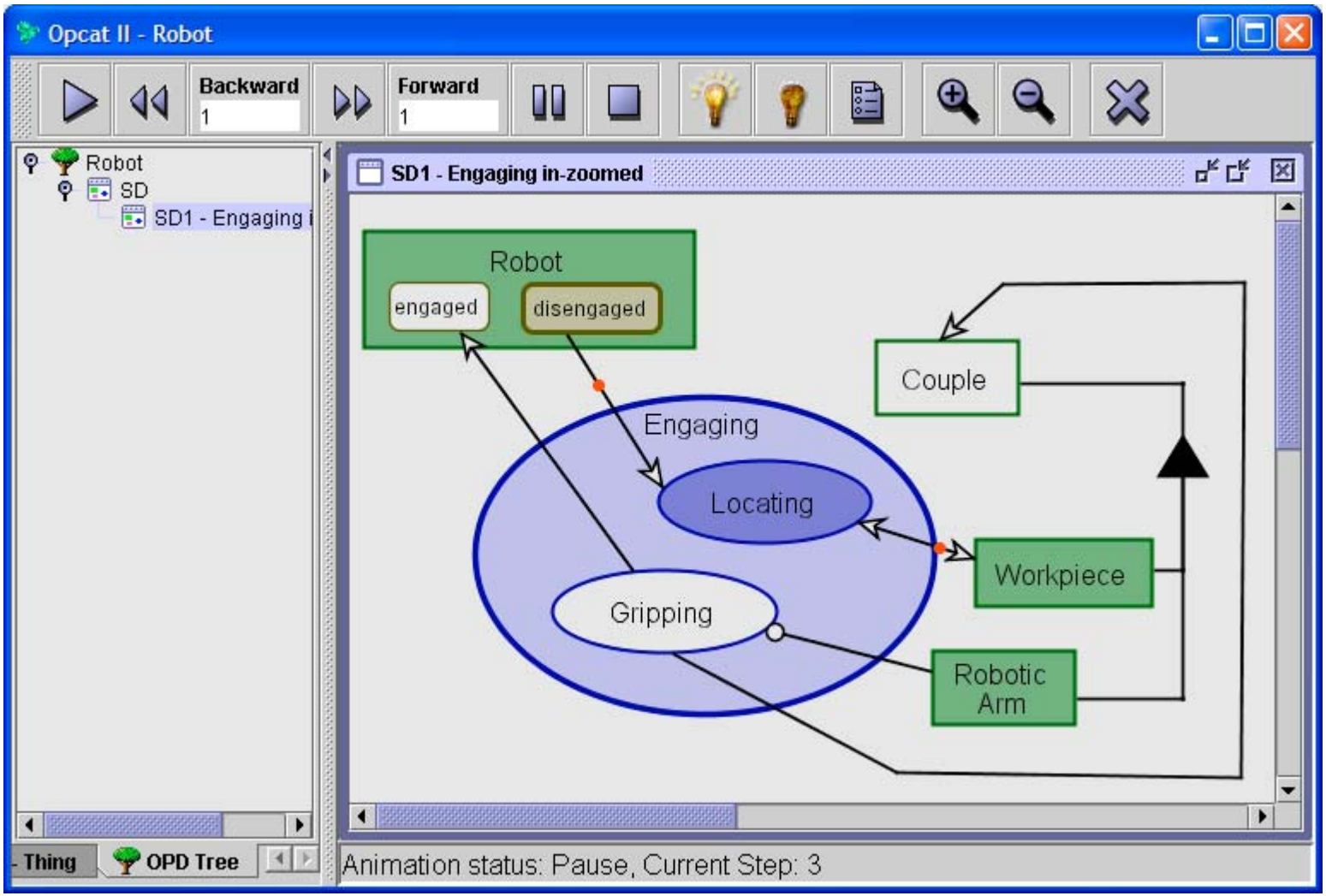
Animated Simulation:

Engaging activated



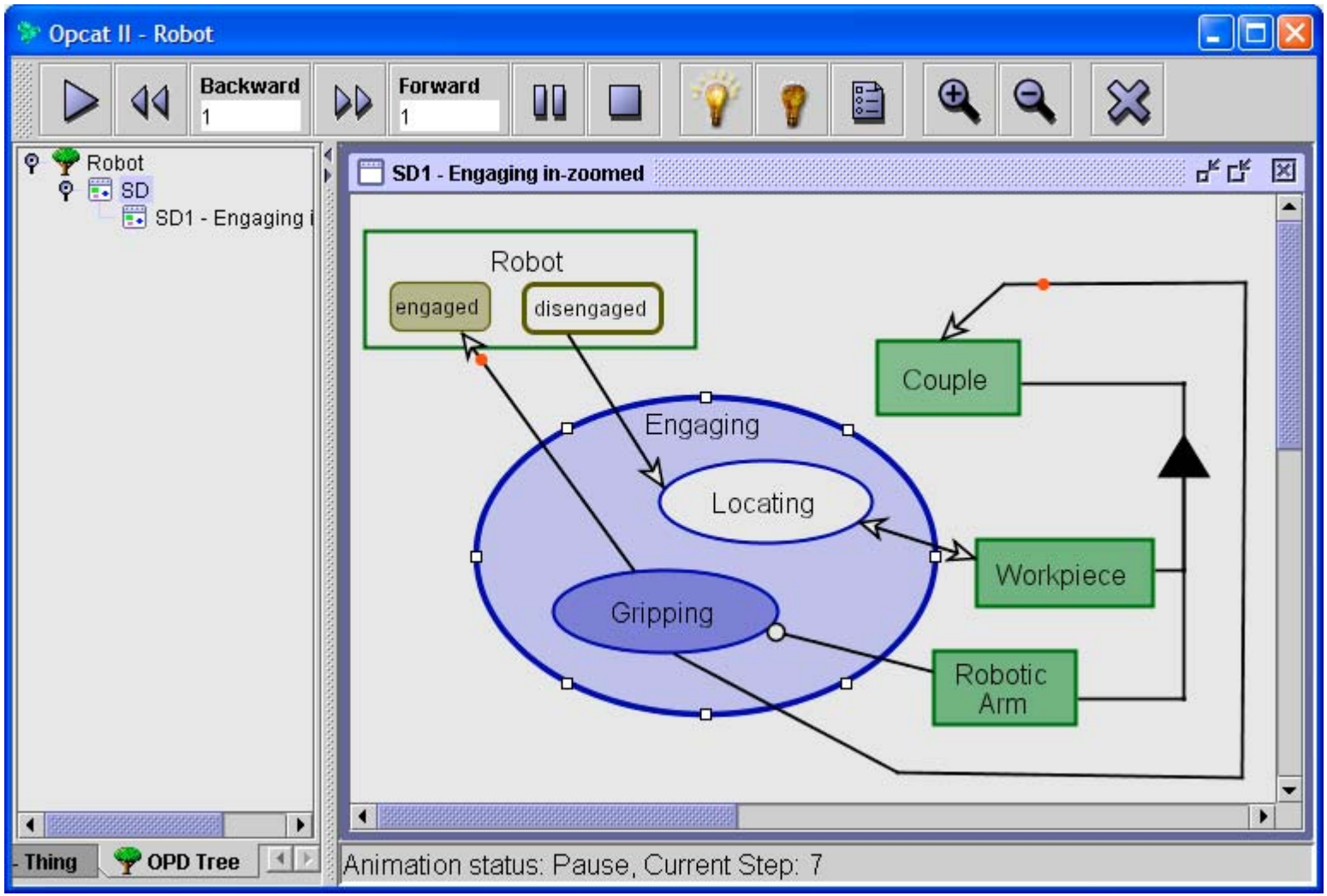
Animated Simulation:

Locating occurs, Workpiece affected

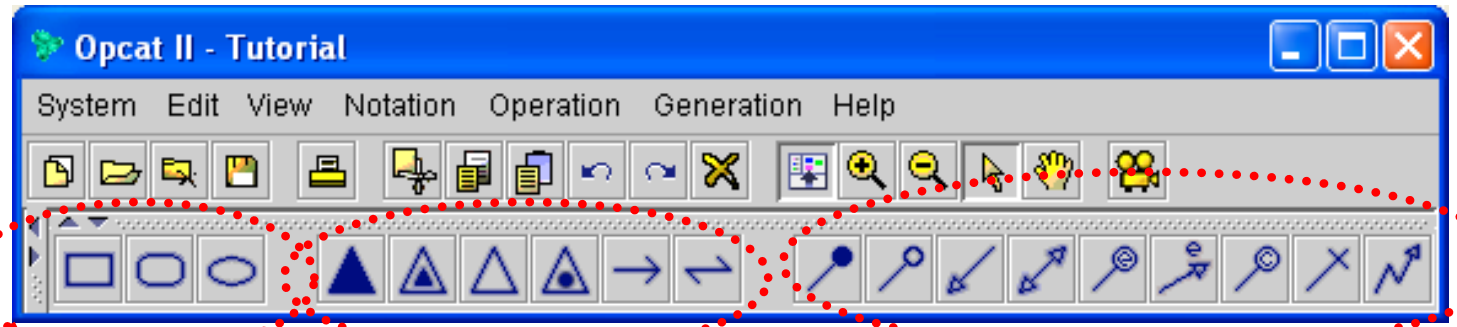


Animated Simulation:

Gripping occurs, Couple generated

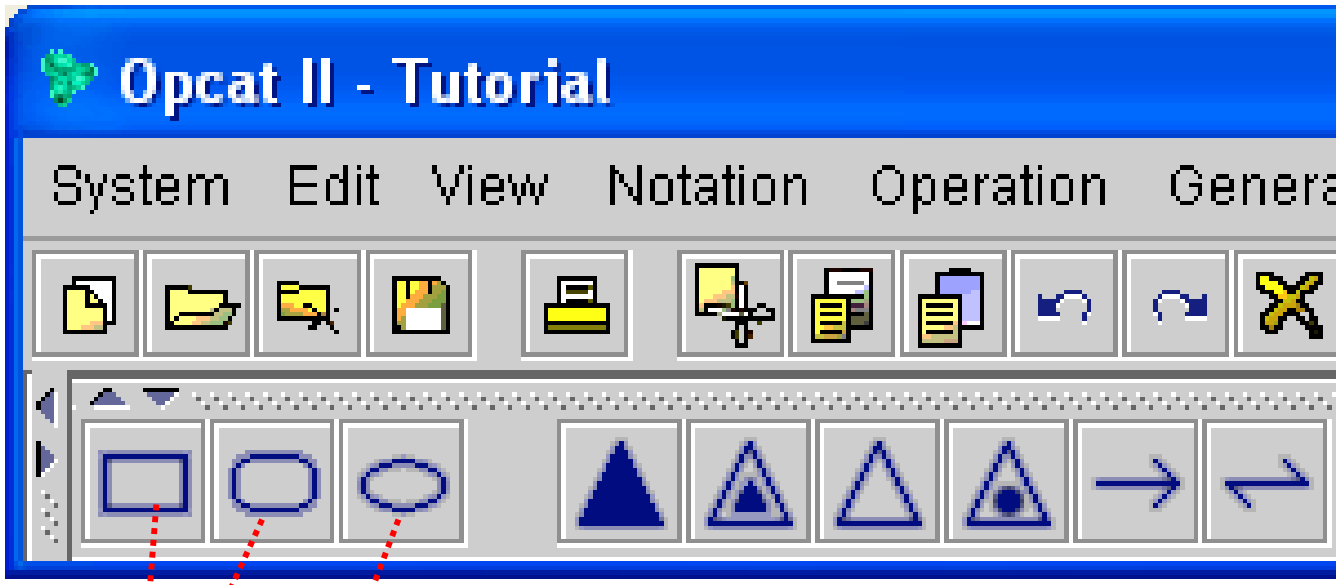


OPM Elements: Entities and Links



- Entities:
  - **Object**
  - **State**
  - **Process**
- Links:
  - **Structural link**
  - **Procedural link**

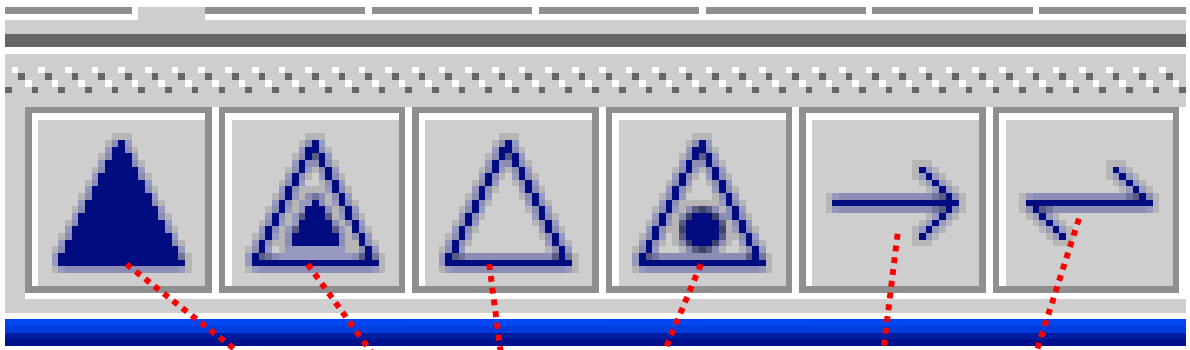
OPM Entities



- **Object:** A thing that exists for some time
- **State:** A situation at which an object can be
- **Process:** A thing that transforms an object

OPM Structural Links

Links denoting persistent relations between objects



Fundamental:

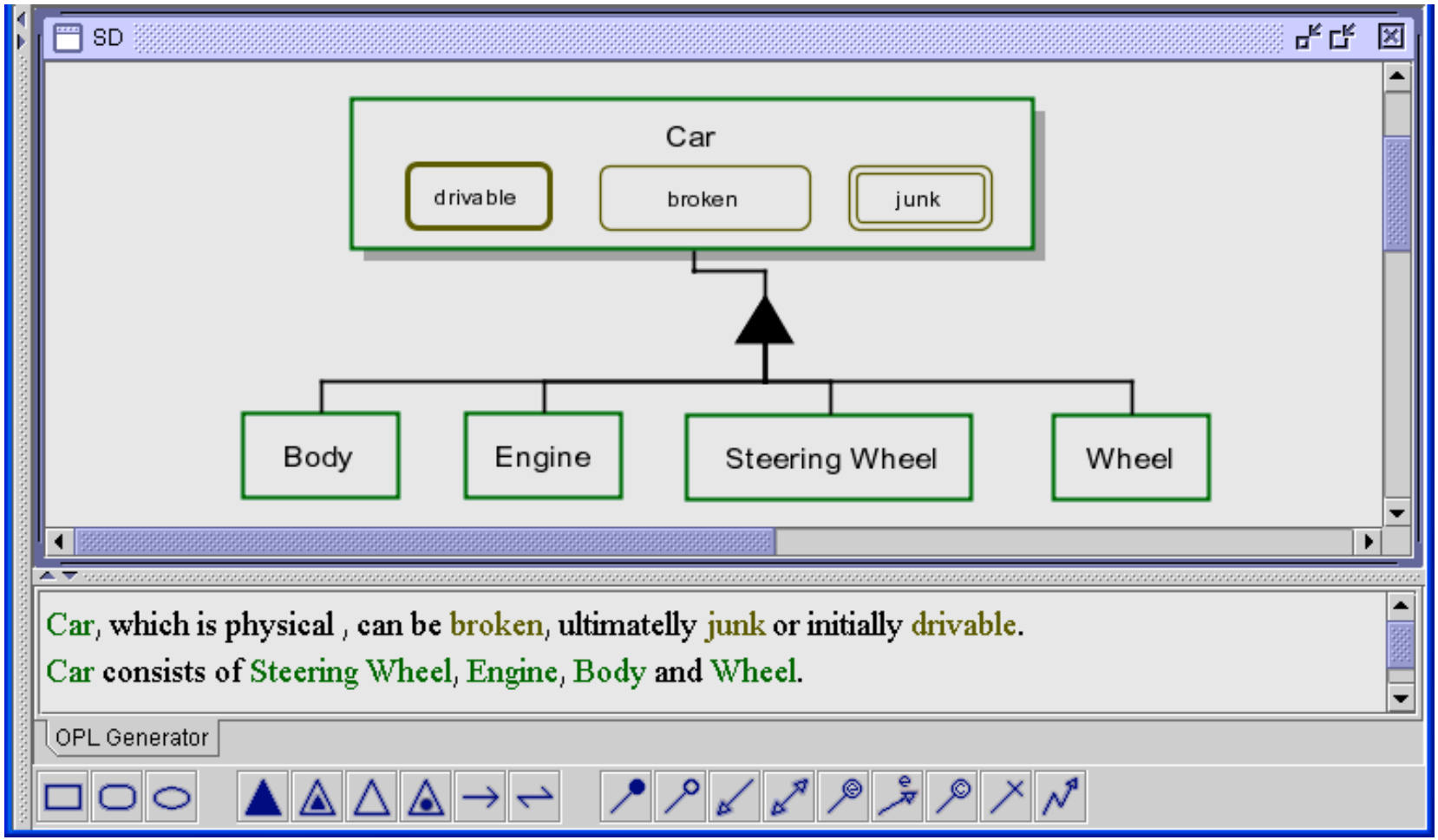
- Aggregation-participation
- Exhibition-characterization
- Generalization-specialization
- Classification-instantiation

General:

- Unidirectional tagged structural relation
- Bidirectional tagged structural relation

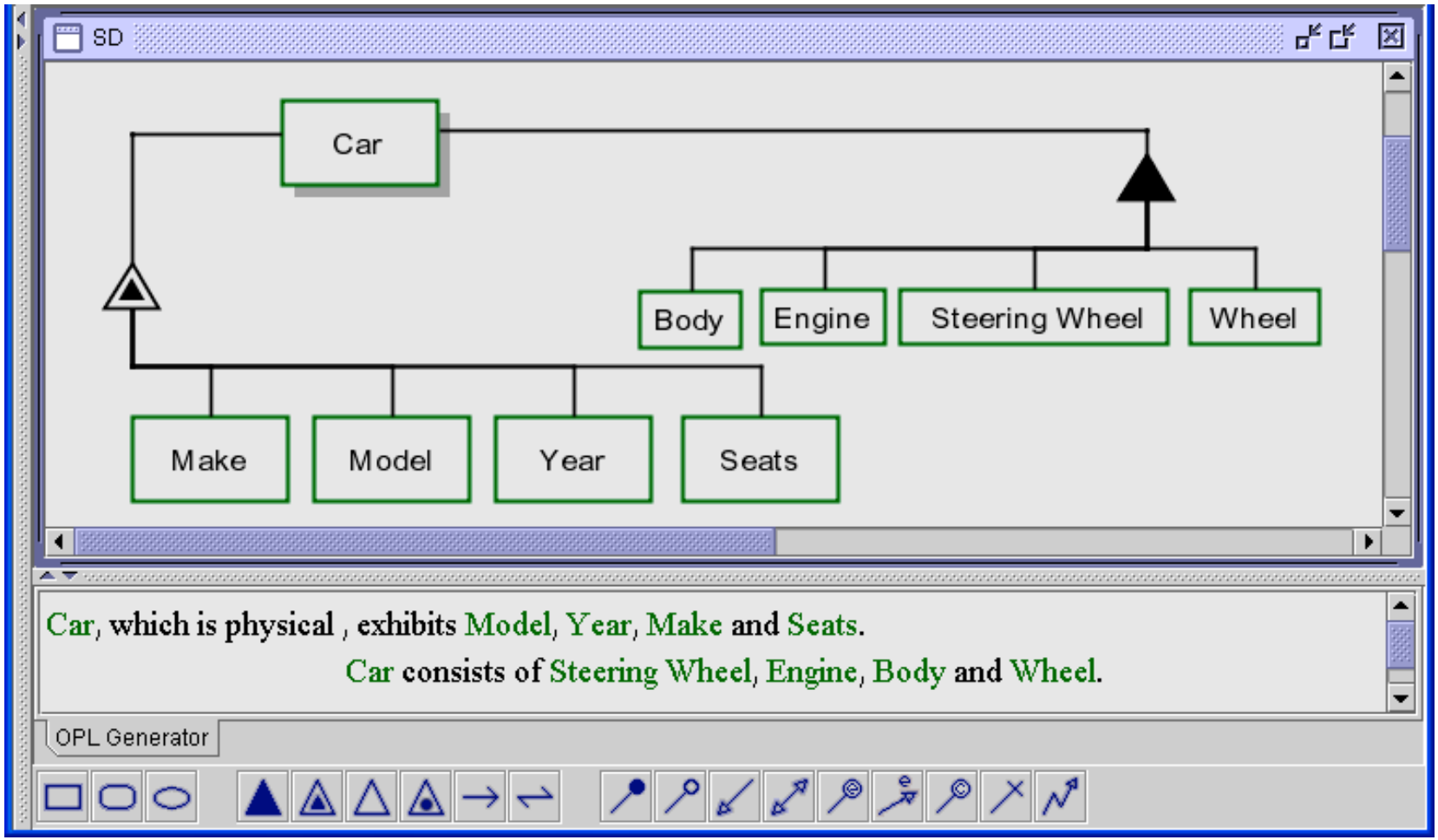
Aggregation-participation

A structural relation between the whole and its parts



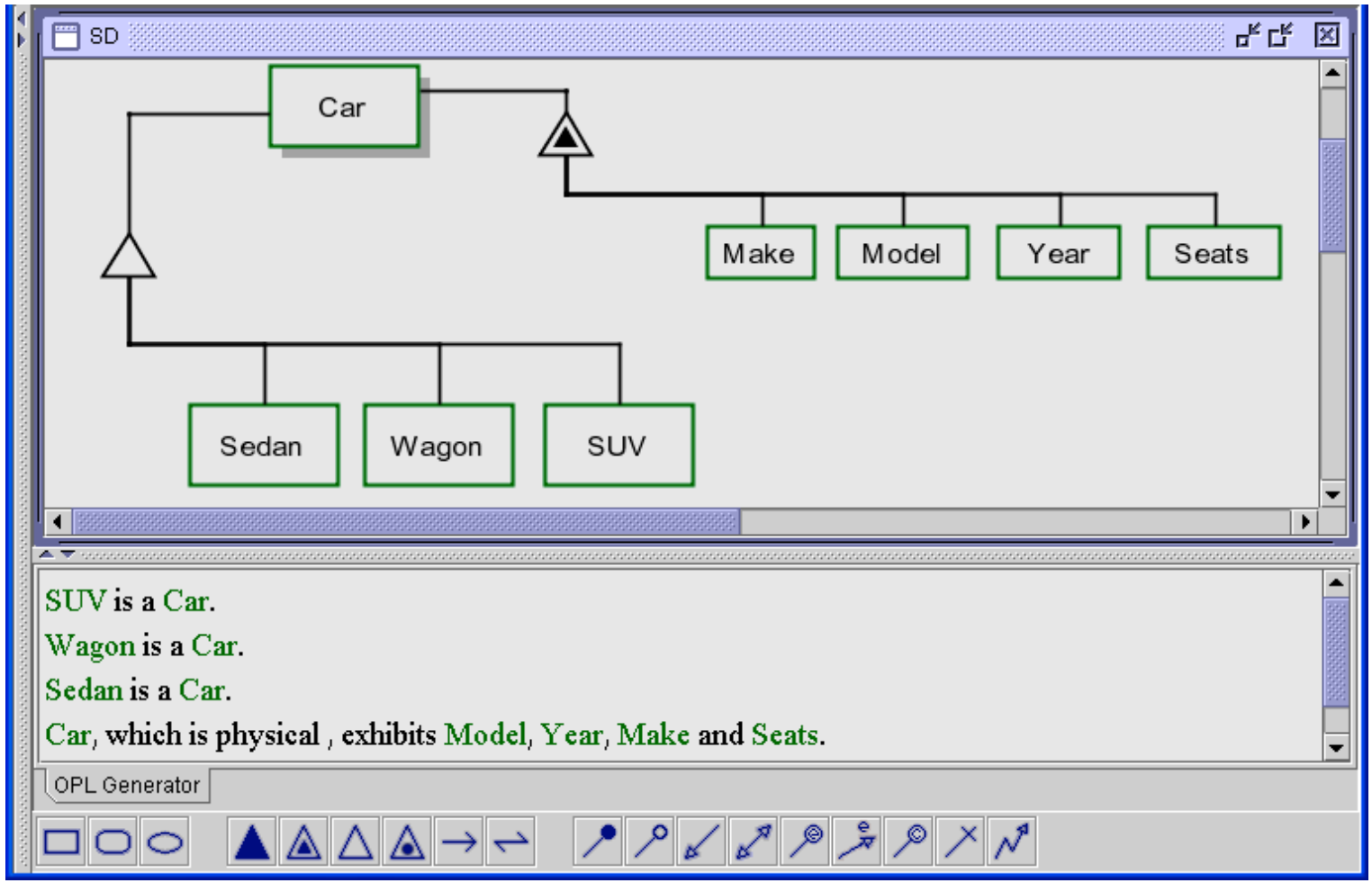
Exhibition-characterization

A structural relation between a thing and its features



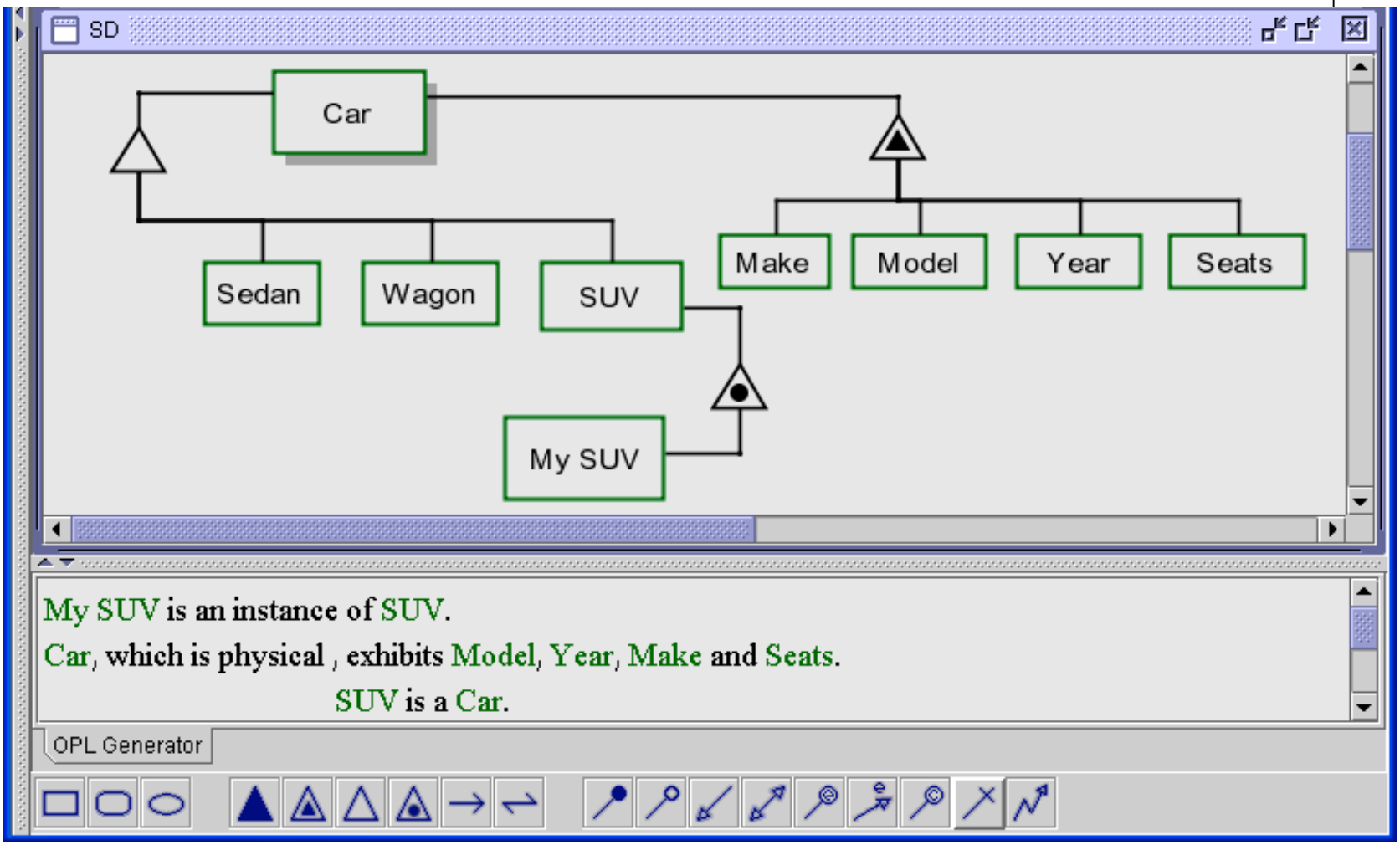
Generalization-specialization

A structural relation between a thing and its specializations (known as the “is-a” relation)



Classification-instantiation

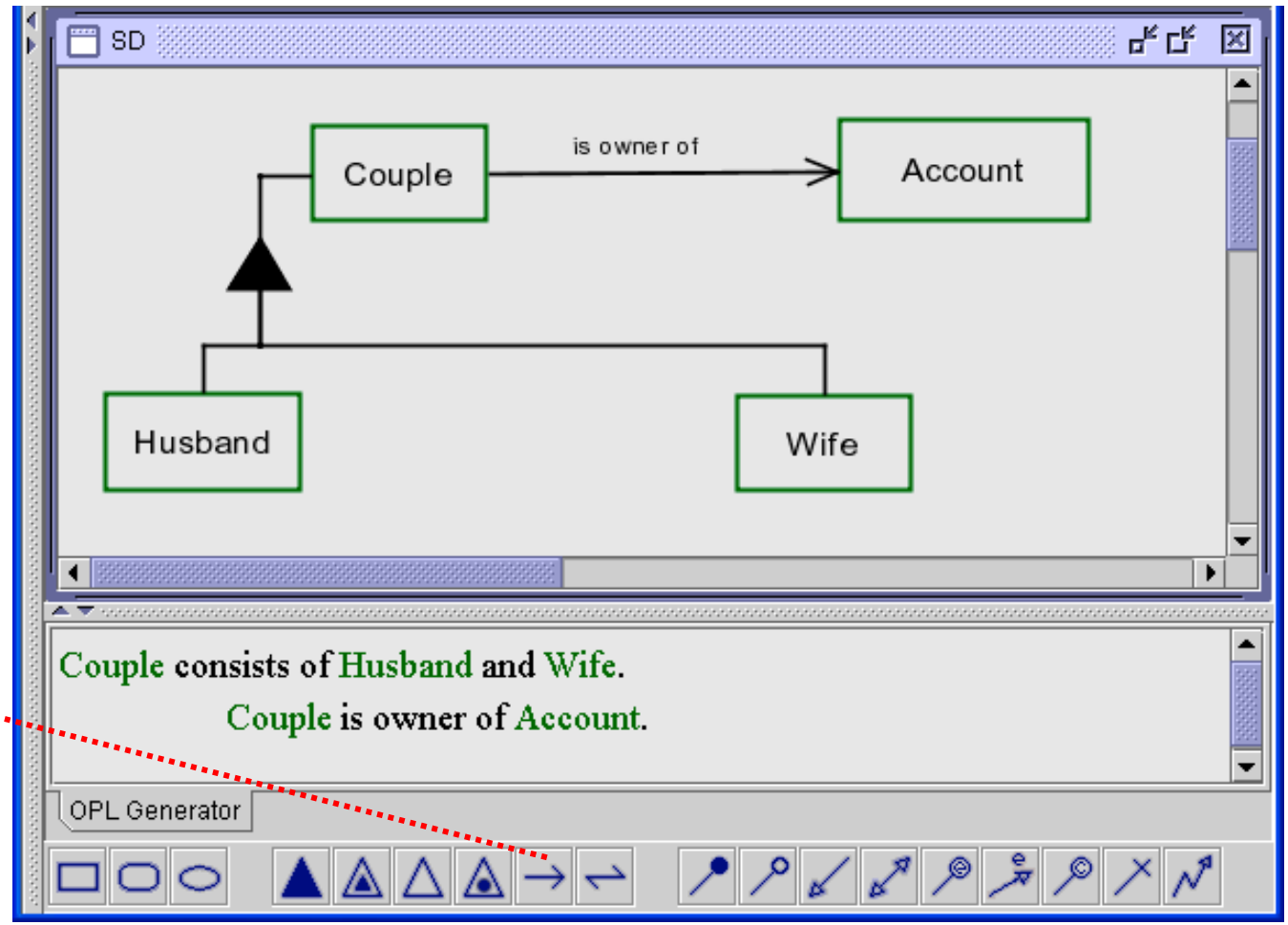
A structural relation between a thing and its instances



General tagged structural link

A structural relation between two things whose semantics is expressed through its tag

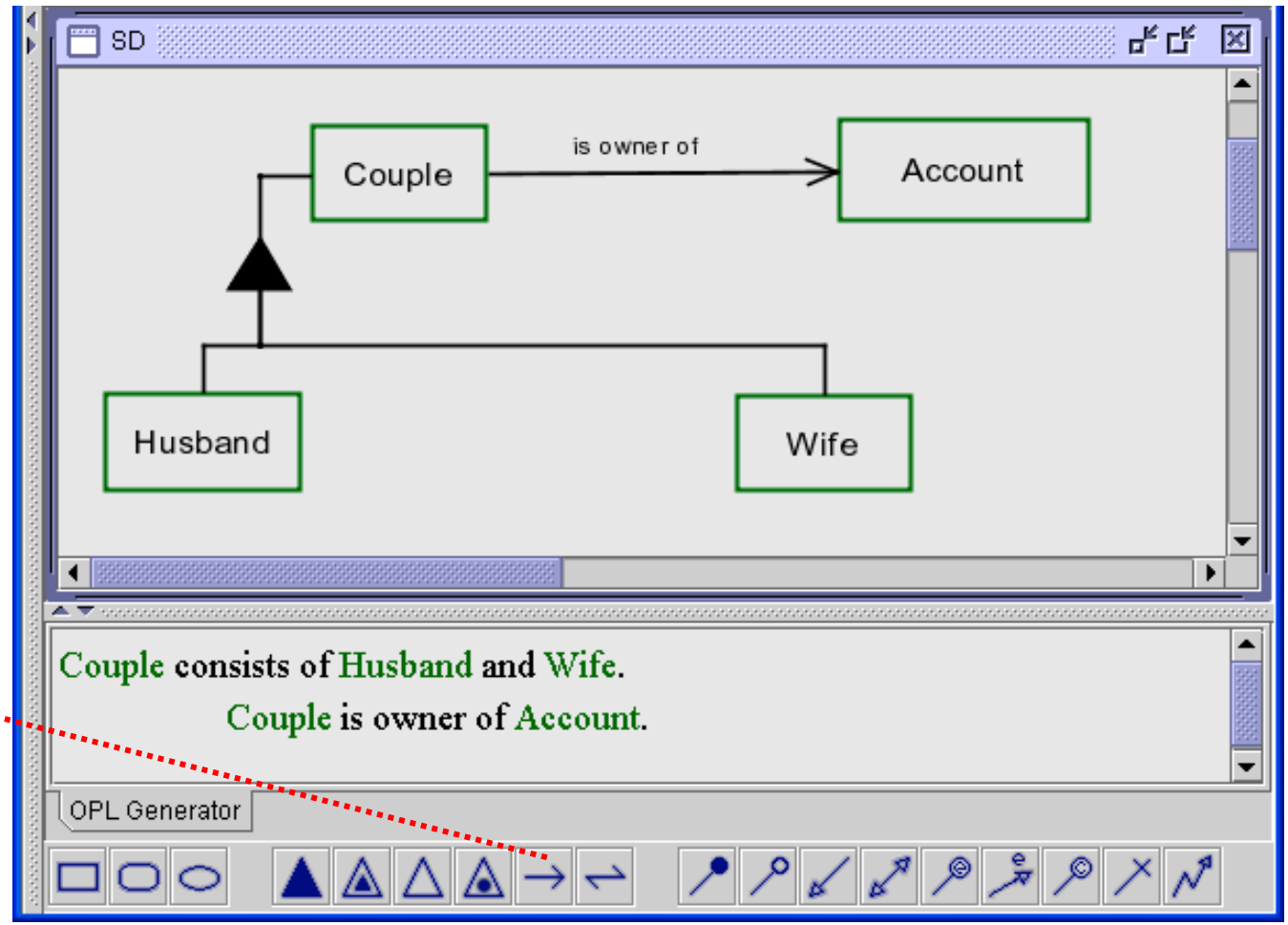
Unidirectional tagged structural link



General tagged structural link

A structural relation between two things whose semantics is expressed through its tag

Unidirectional tagged structural link

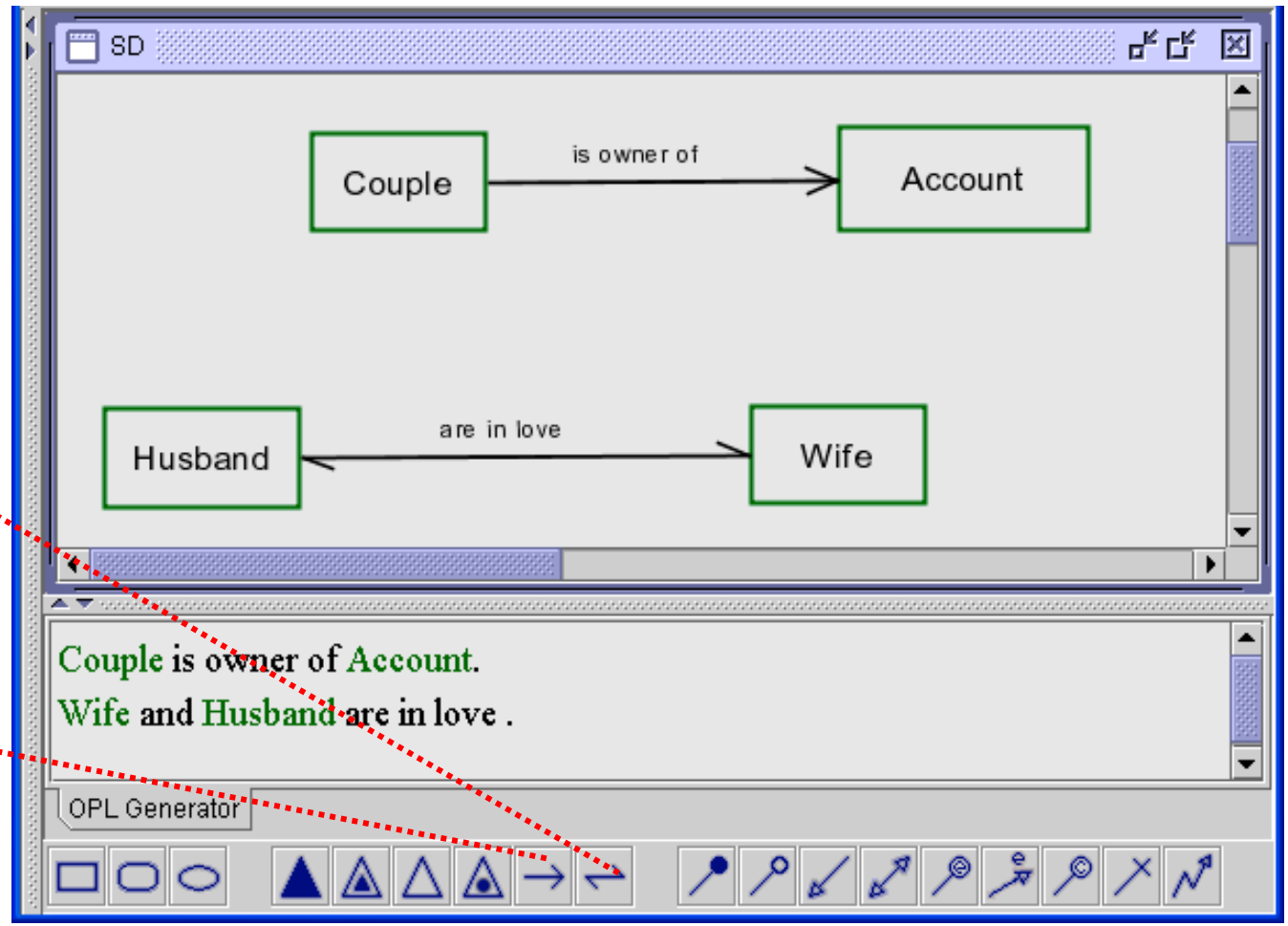


General tagged structural link

A structural relation between two things whose semantics is expressed through its tag

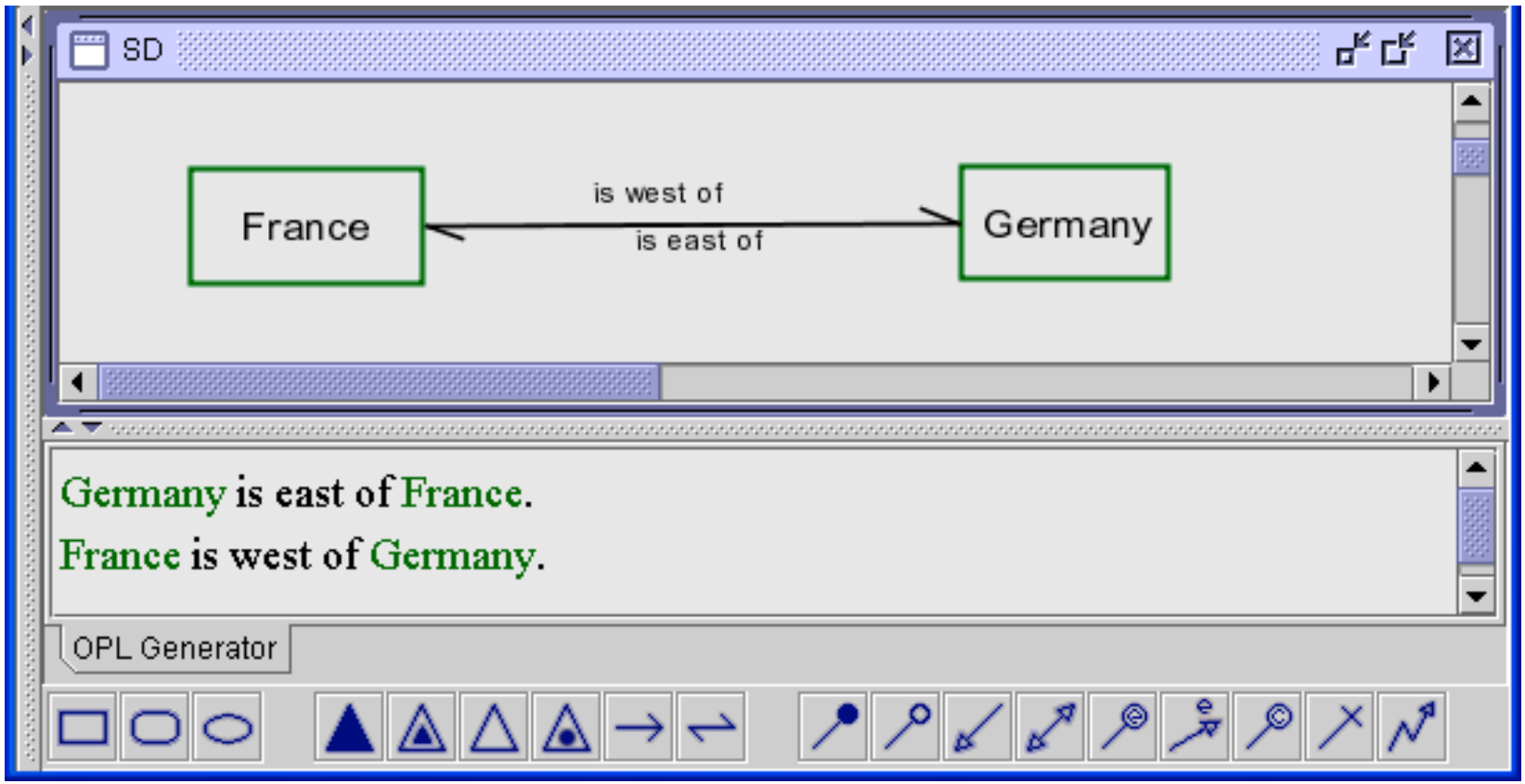
Bidirectional tagged structural link

Unidirectional tagged structural link



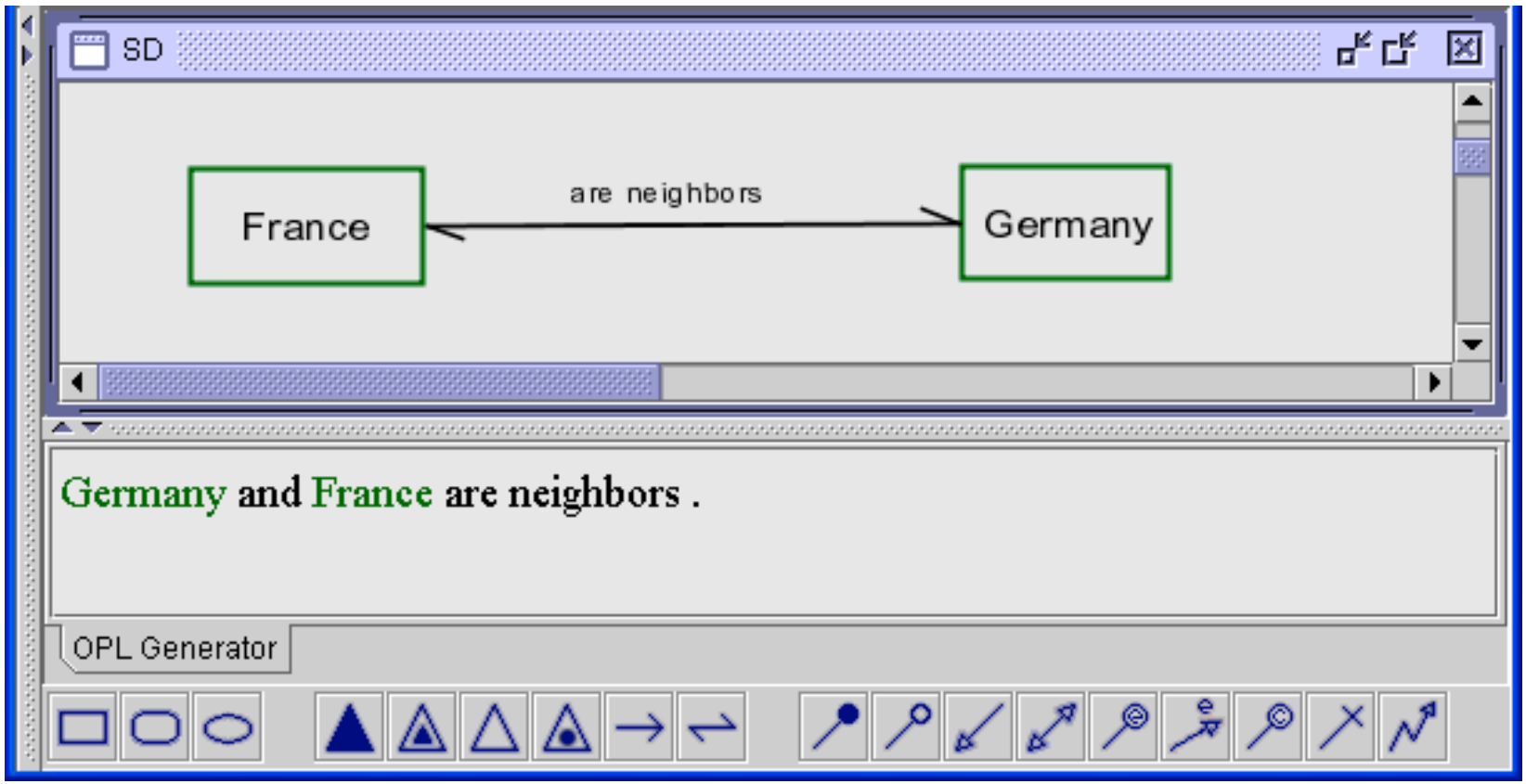
Bi-directional tagged structural link with two tags

Each tag results in a separate sentence.



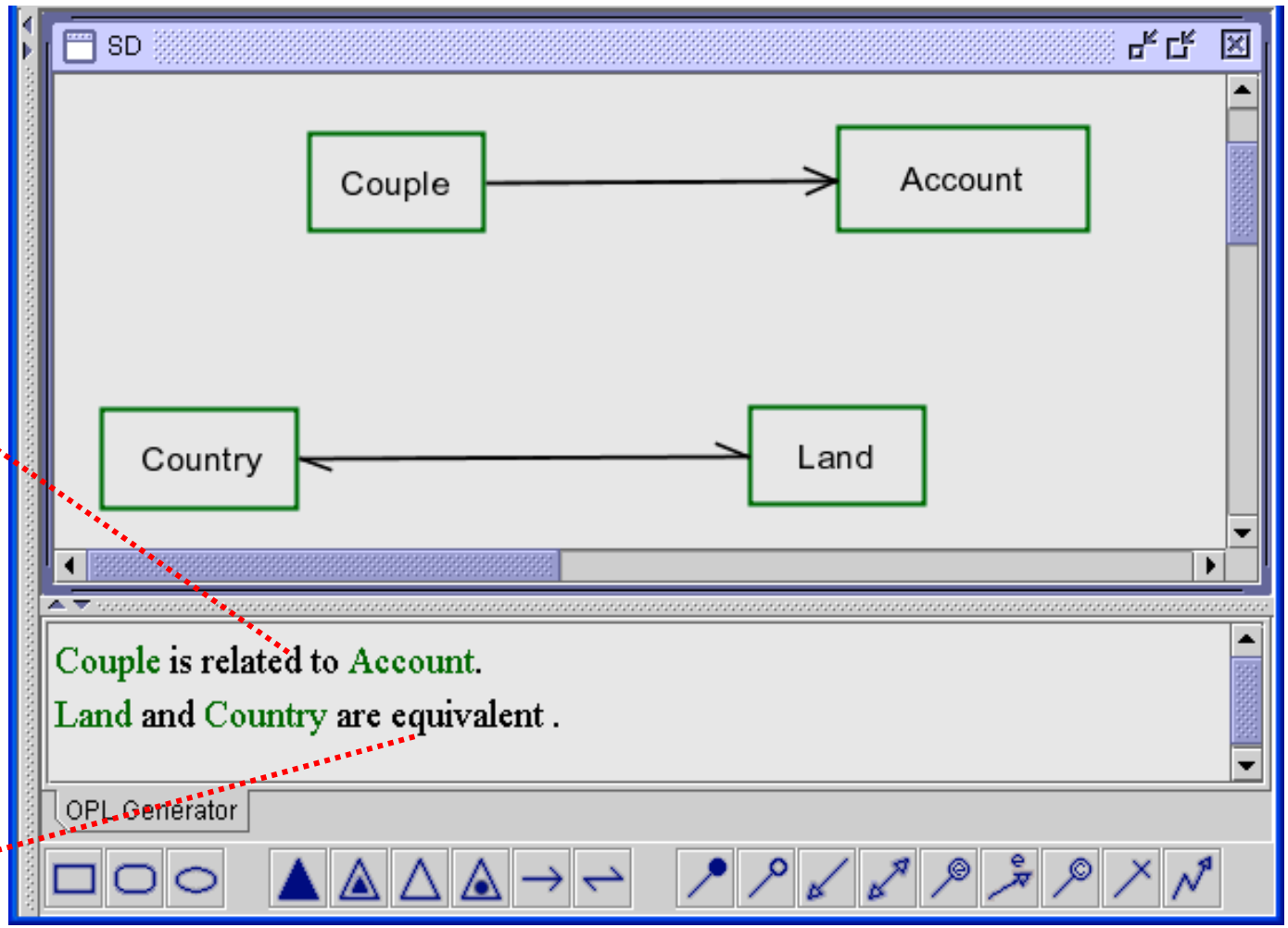
Bi-directional tagged structural link with one tag

A structural relation between two things whose semantics is expressed through its tag



Null tag structural link

A structural relation between two things with an empty tag

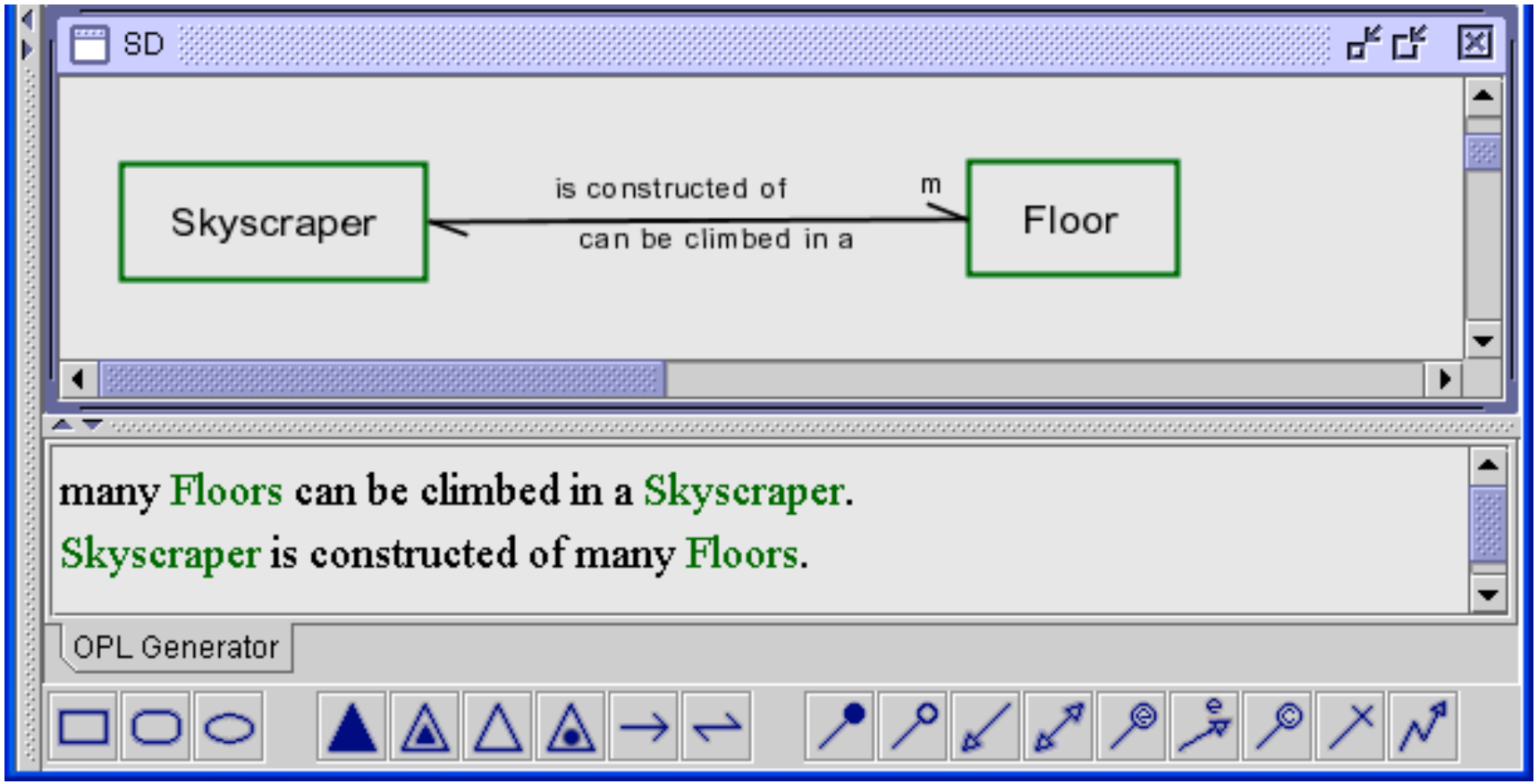


Unidirectional null tag OPL

Bidirectional null tag OPL

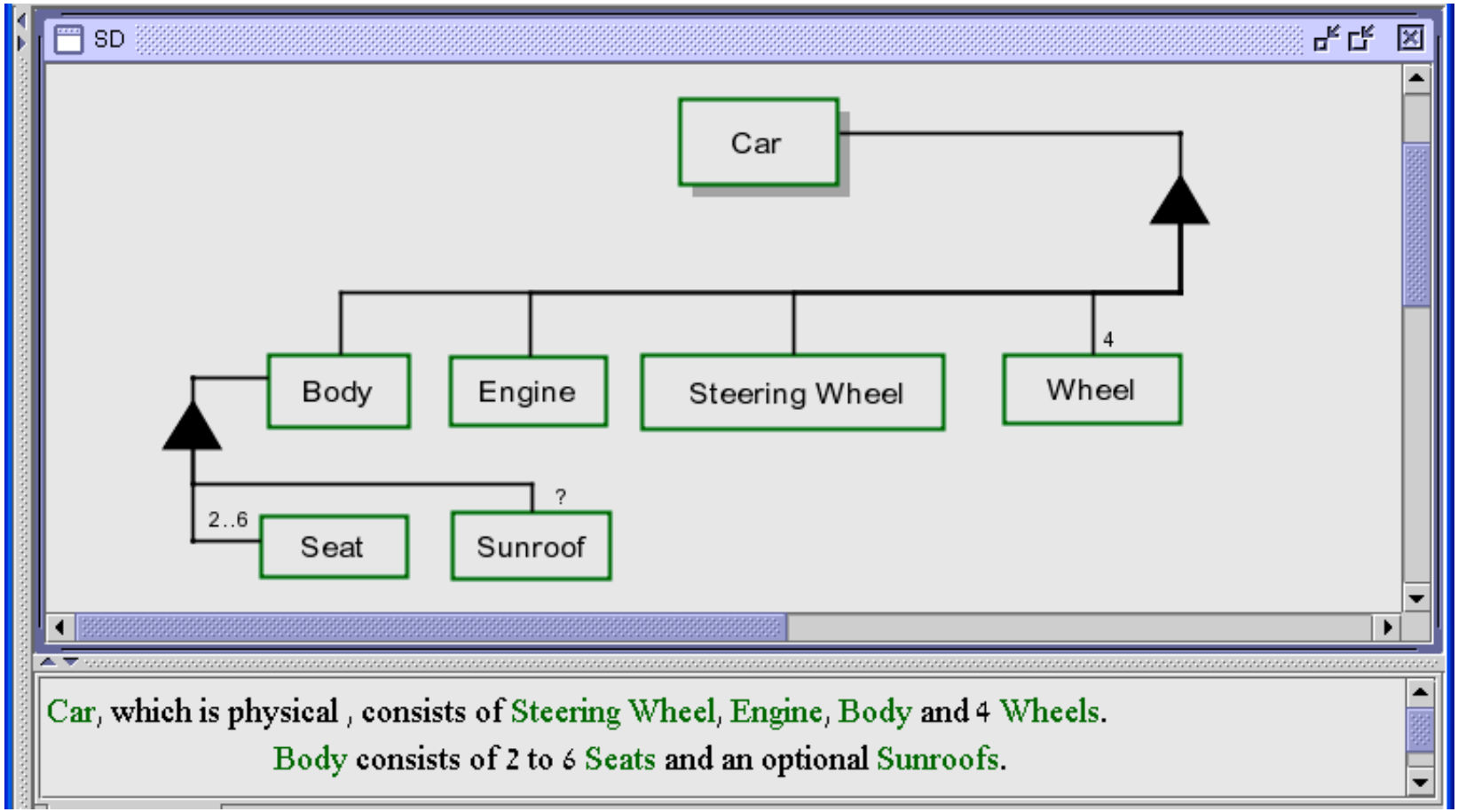
Participation constraints

Structural relation can be associated with various quantities



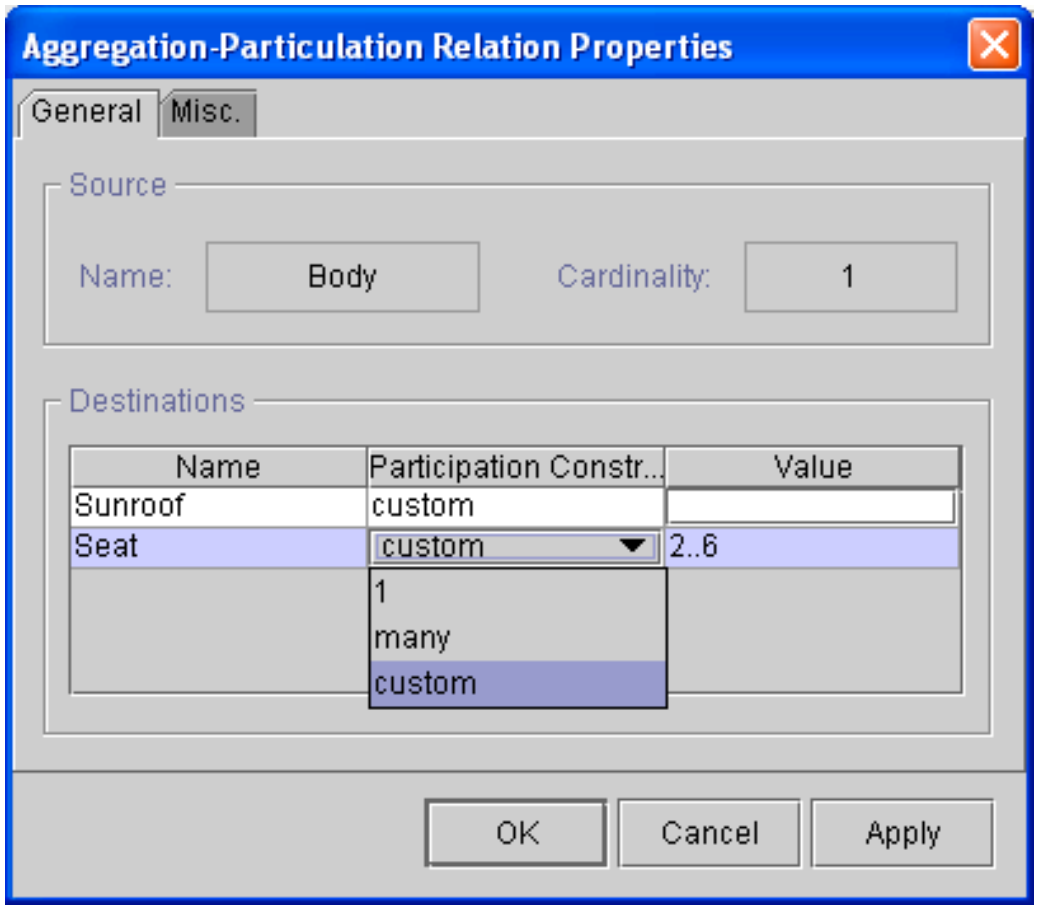
Participation constraints

The aggregation-participation link can have participation constraints on the parts



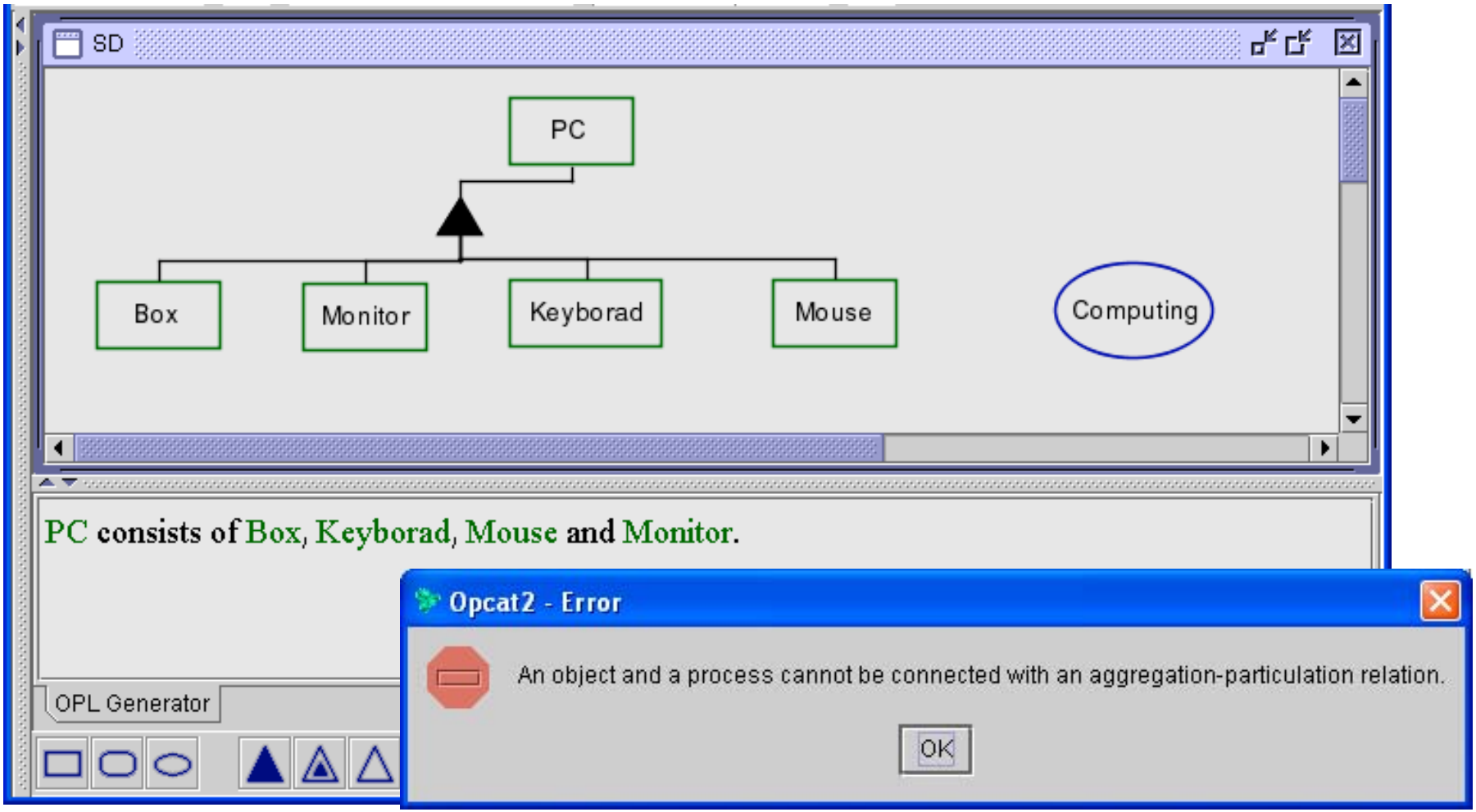
Setting participation constraints

Each part in the aggregation-participation link can be set separately



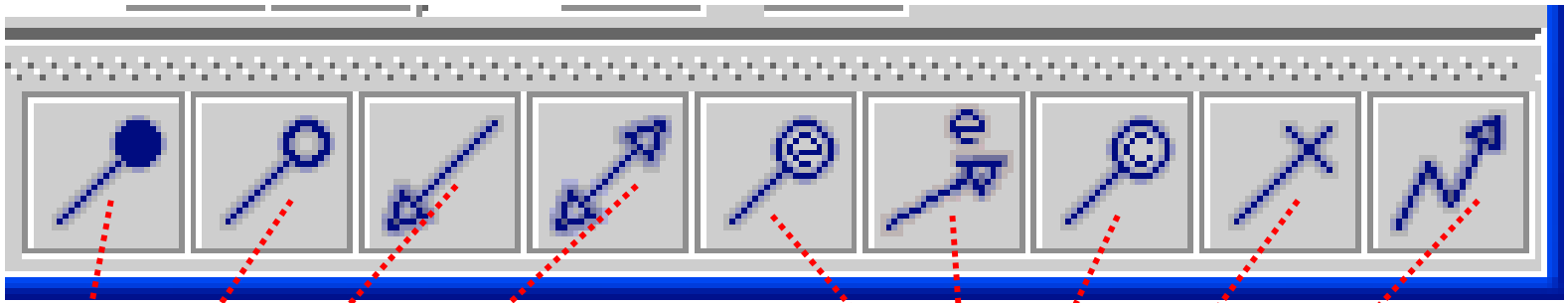
Syntax and Semantics Consistency Checking

Trying to make a process part of an object results:



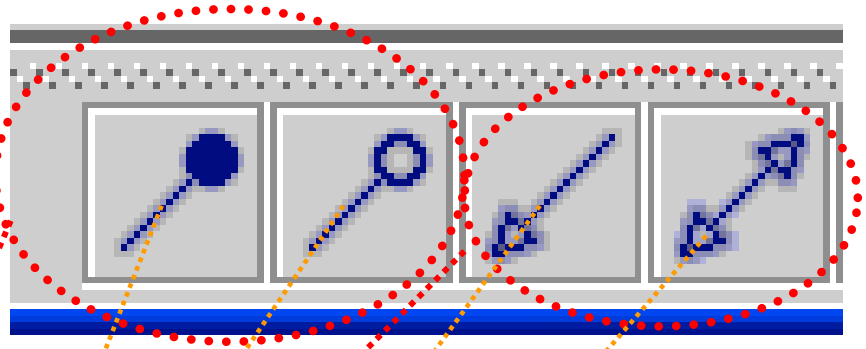
OPM Procedural Links

Links between a process and the object it transforms or a state of that object



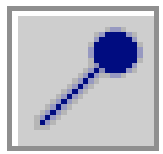
- Agent link
- Instrument link
- Consumption/result link
- Effect link
- Event links
- Condition link
- Exception link
- Invocation link

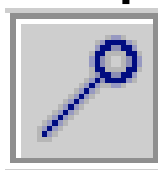
Two Procedural Link Types



- Enabling Links
  - Agent link
  - Instrument link
- Transforming Links
  - result/consumption/input/output link
  - Effect link… more

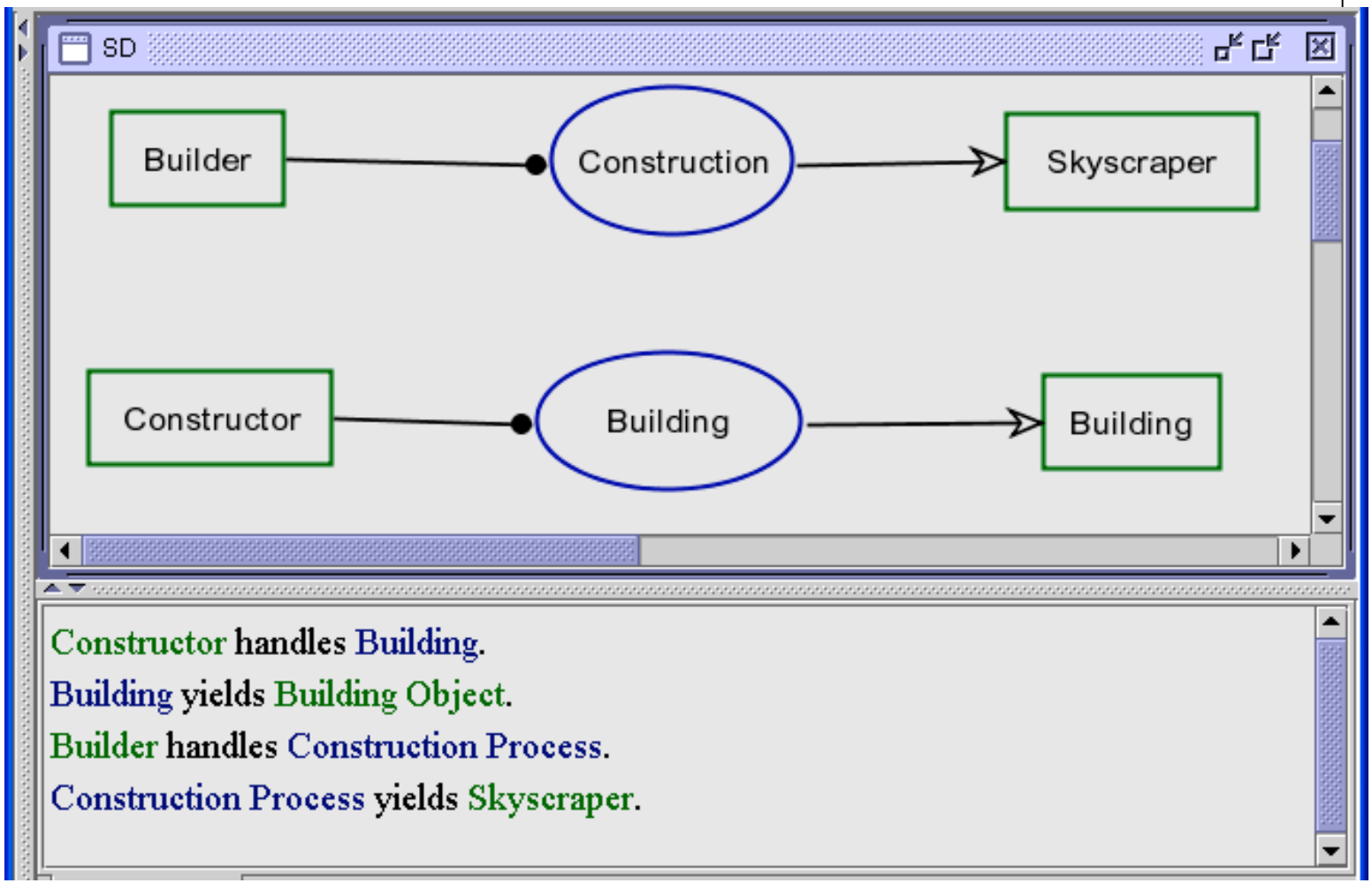
Enabling Links

- Link objects that enable the process but are not transformed by it
  - Agent link 

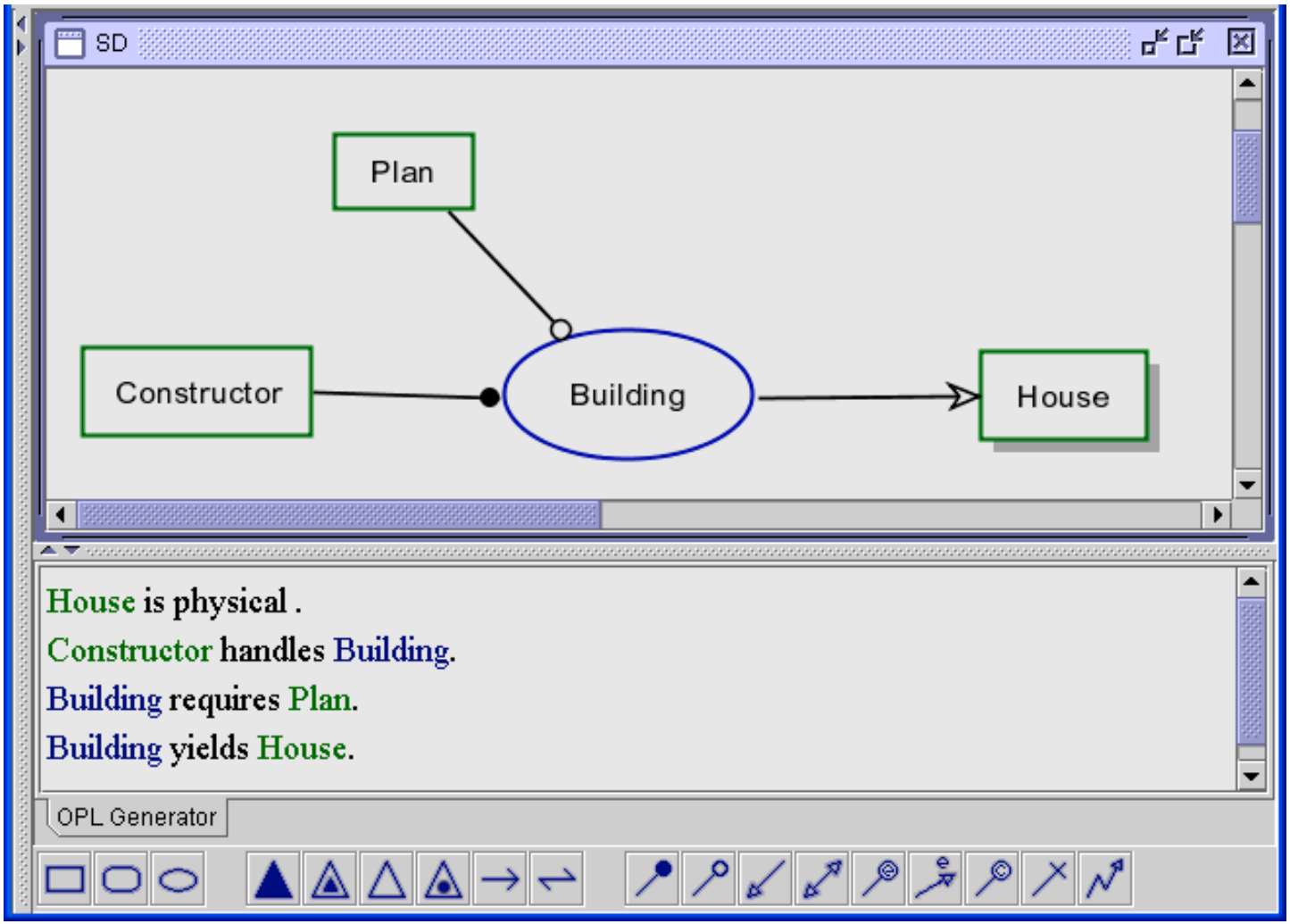
  Links a human or a group of humans that trigger the process or participate in it
  - Instrument link 

  Links a non-human object that the process requires in order for it to occur or execute

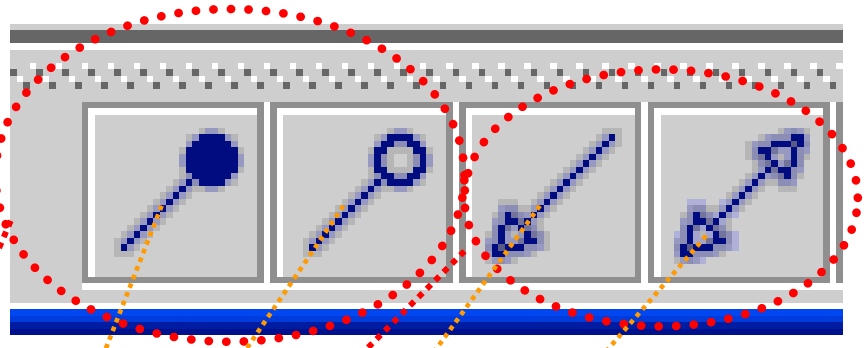
Agent Link


SD
Builder
Construction
Skyscraper
Constructor
Building
Building
Constructor handles Building.
Building yields Building Object.
Builder handles Construction Process.
Construction Process yields Skyscraper.

Instrument Link

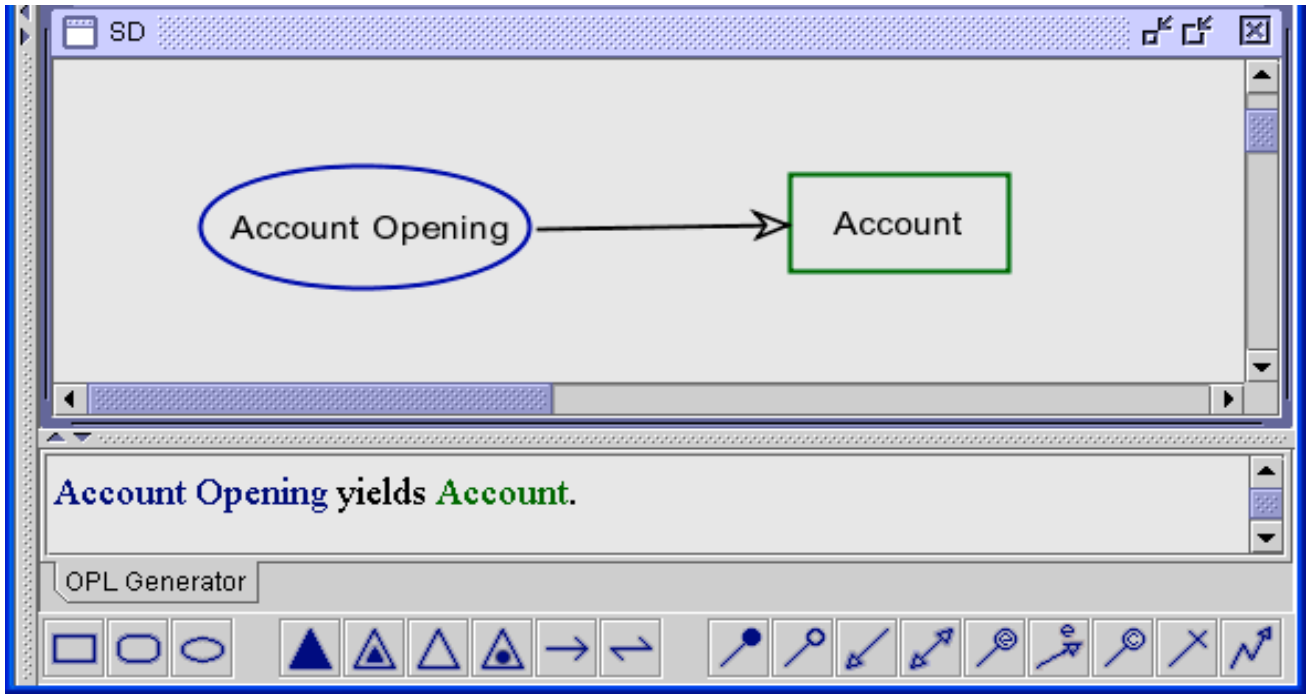


Procedural Links

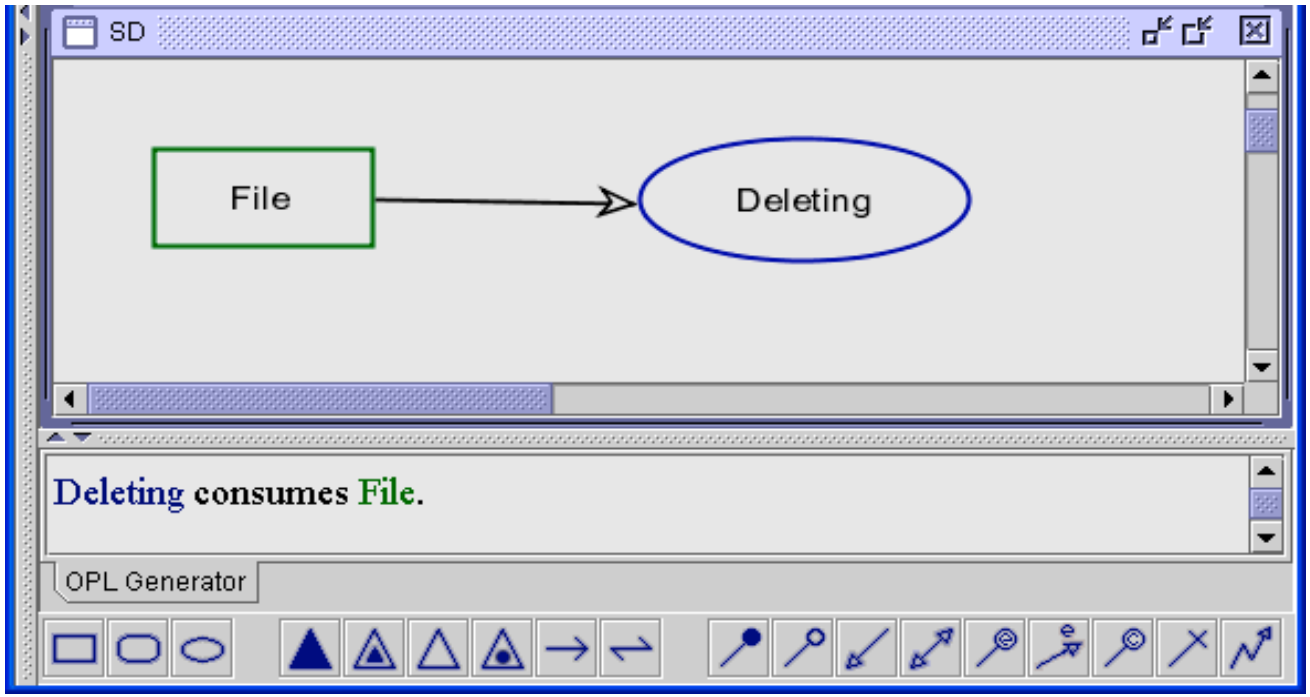


- Enabling Links
  - Agent link
  - Instrument link
- Transforming Links
  - result/consumption/input/output link
  - Effect link

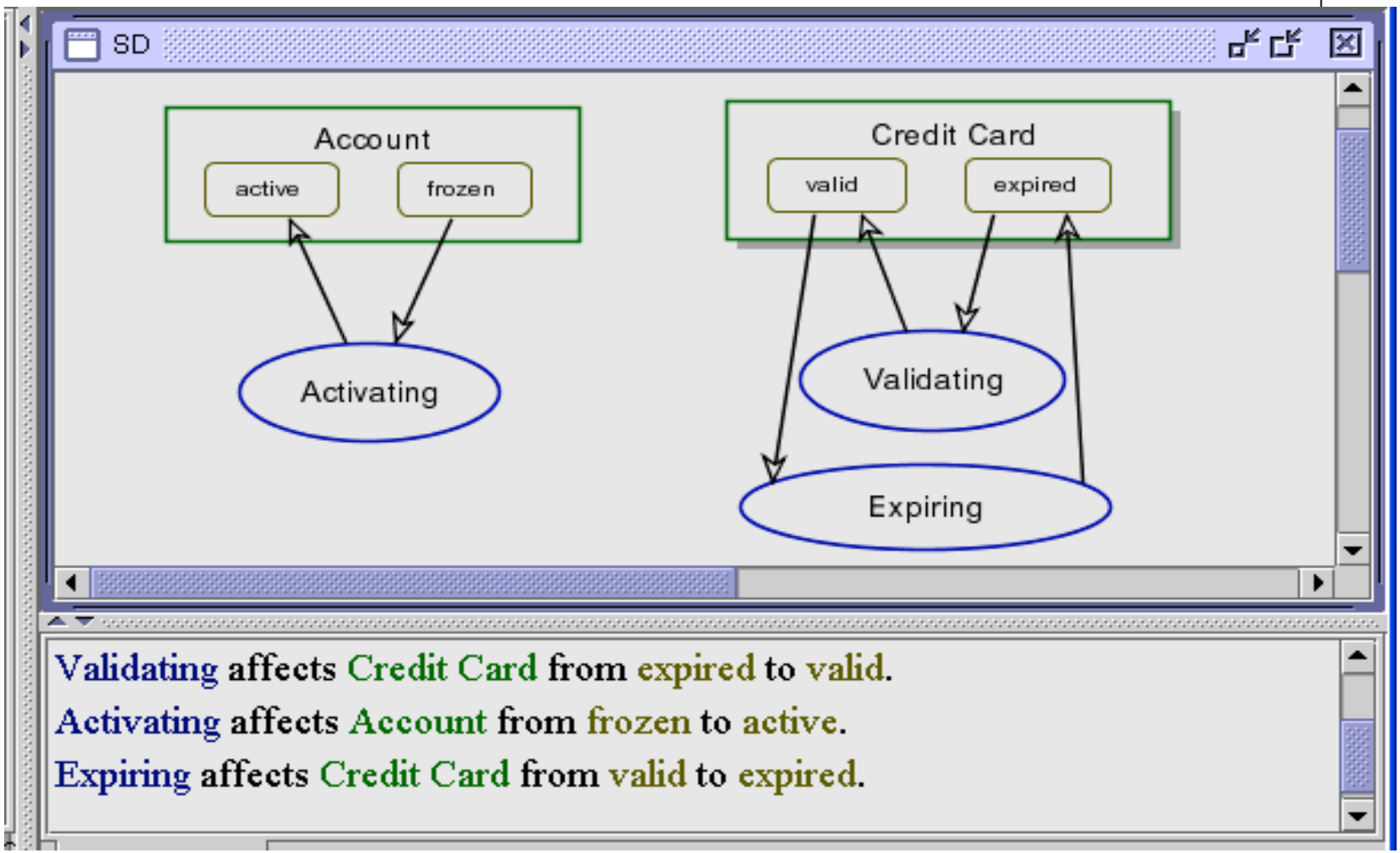
Creating a new object: Result link



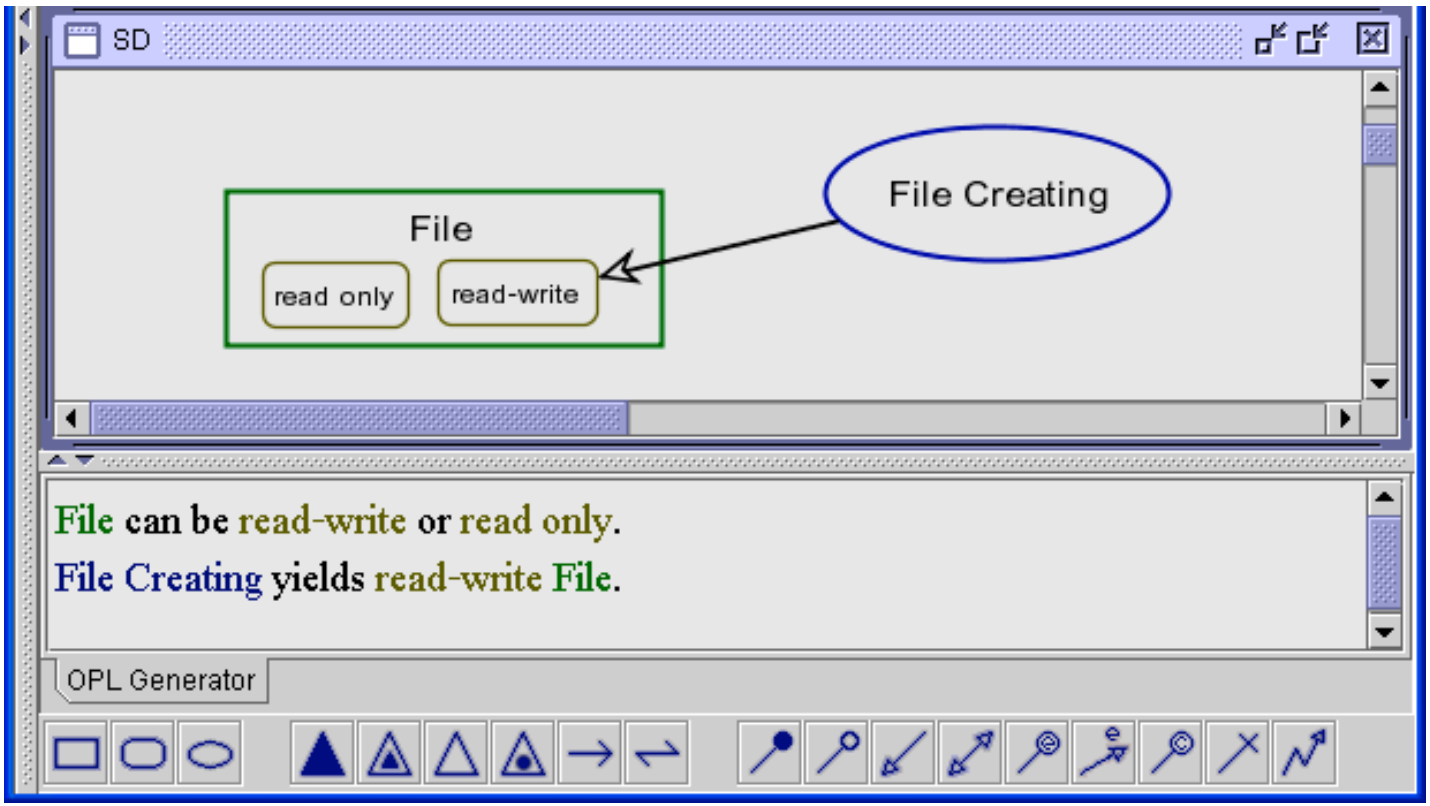
Consuming an existing object: Consumption link



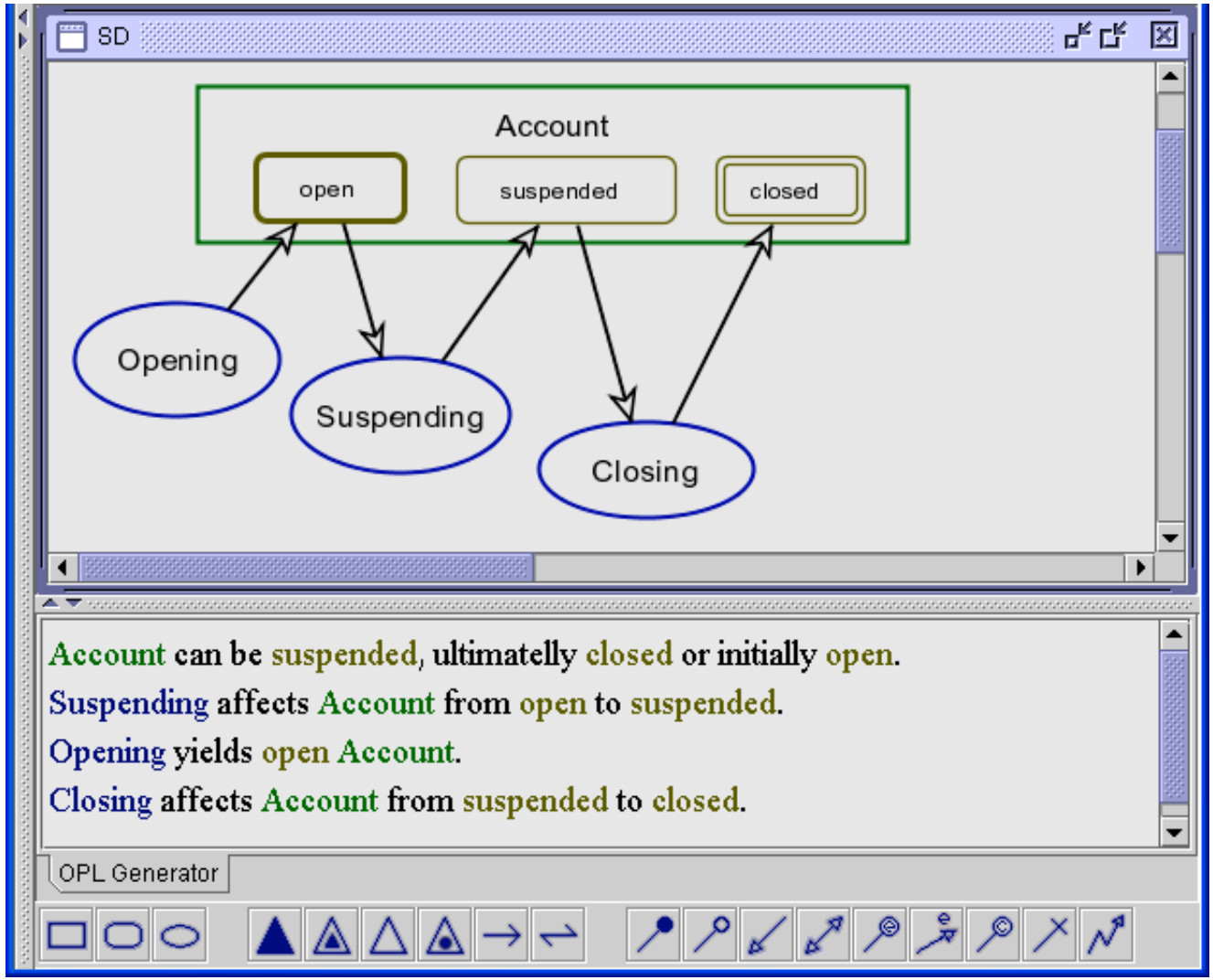
Changing object state



State-specified object generation

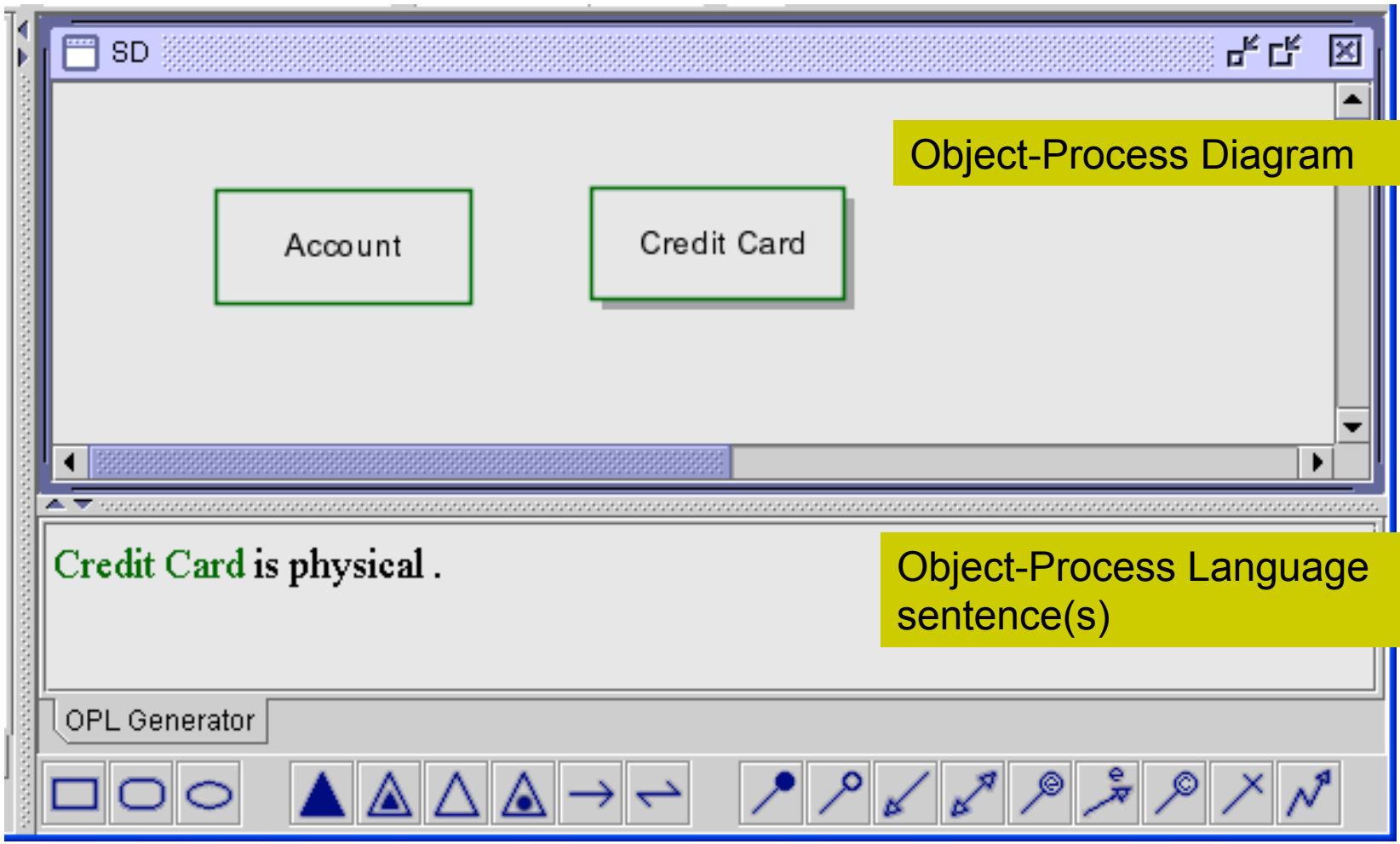


States can be initial or final

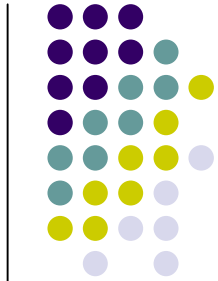


Object Essence

Can be informatical (default) or physical

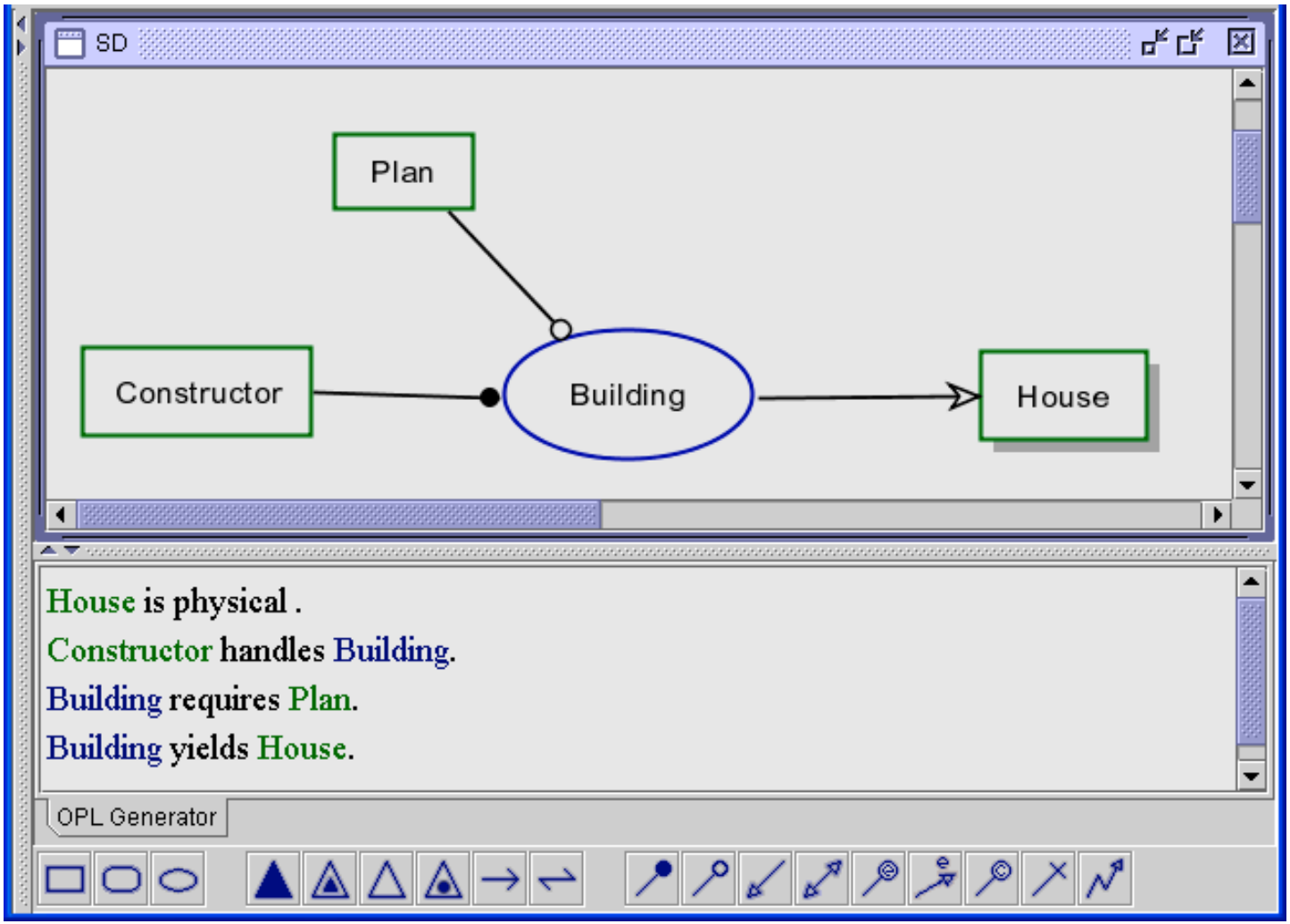


Processes transform objects

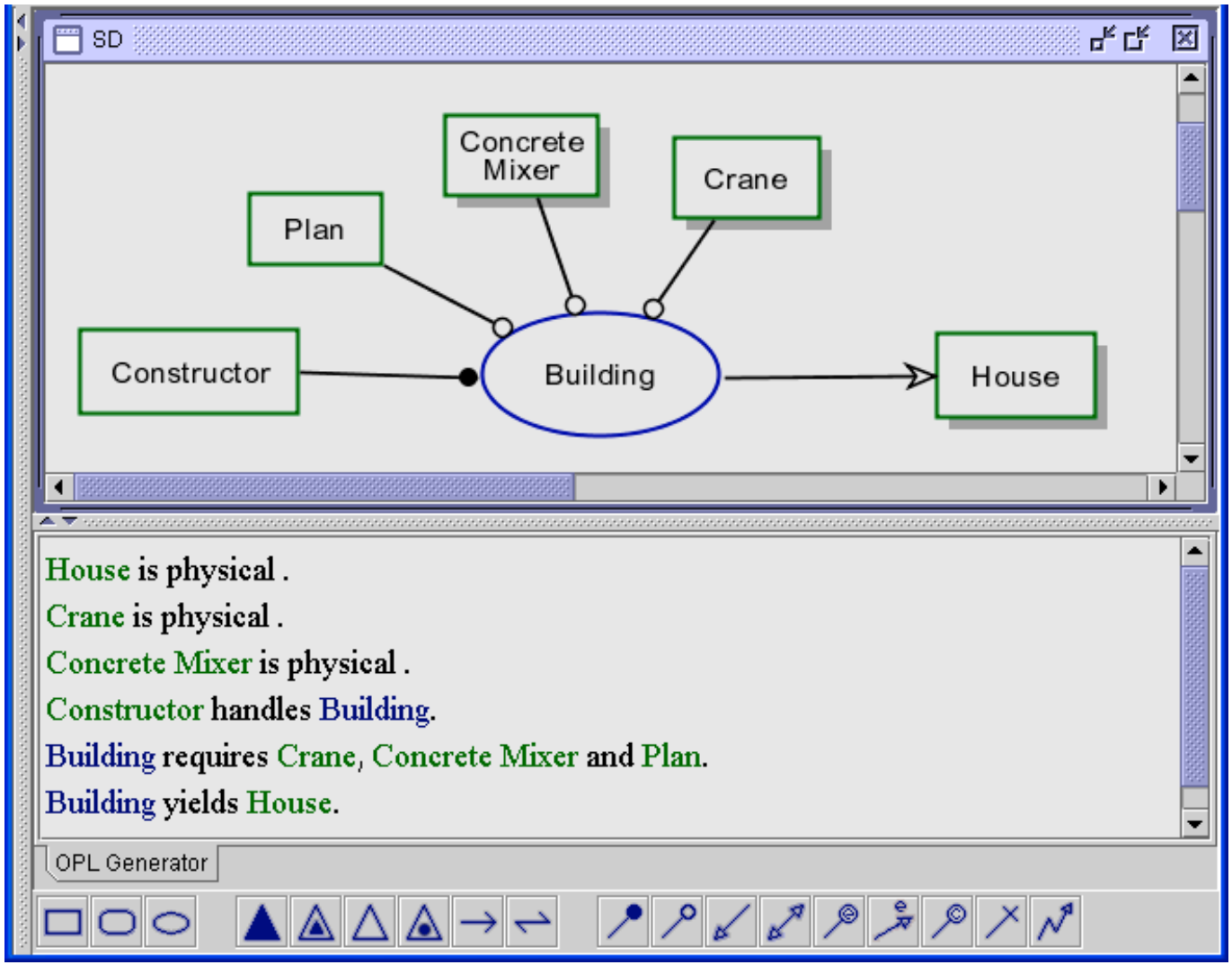


- Three transformation options:
  - Change an object state
  - Create (generate) a new object
  - Consume (destroy) an existing object

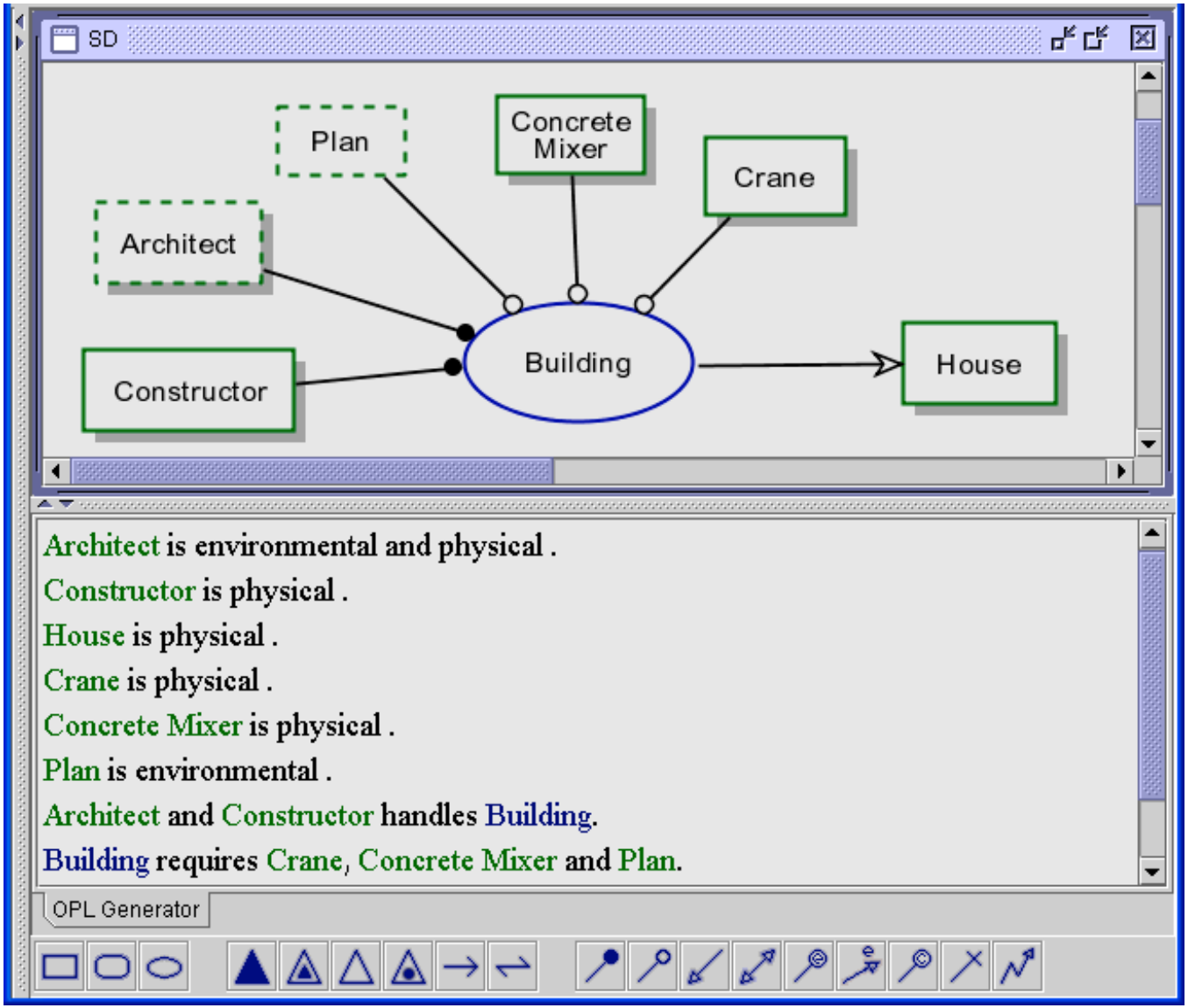
Enabling Links: Agent and Instrument



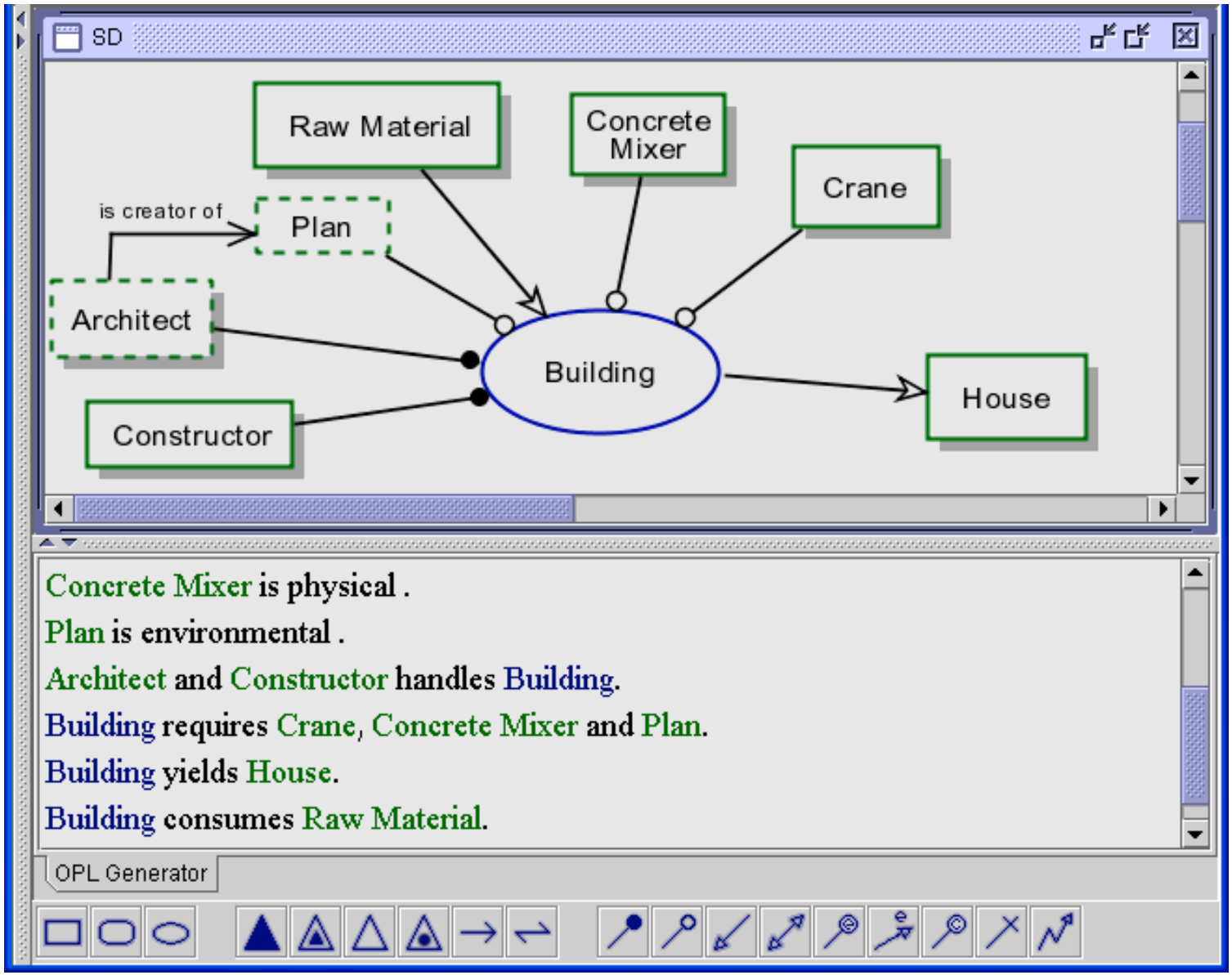
Adding physical Instruments



Systemic vs. environmental objects



Raw Material is consumed, House created



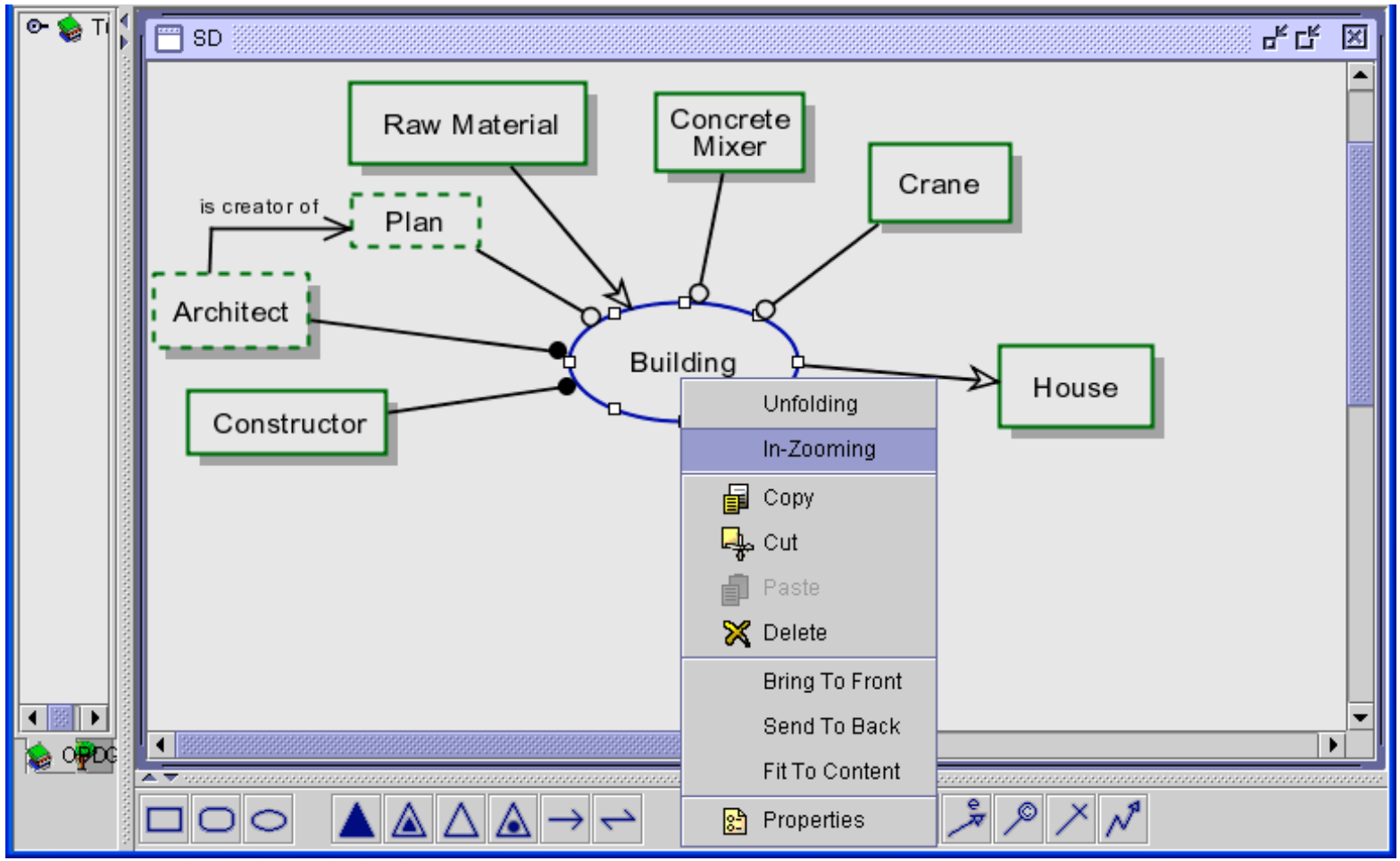
Complexity Management in OPM

Three refinement/abstraction mechanisms:

- In-zooming/out-zooming
- Unfolding/folding
- State expression/state suppression

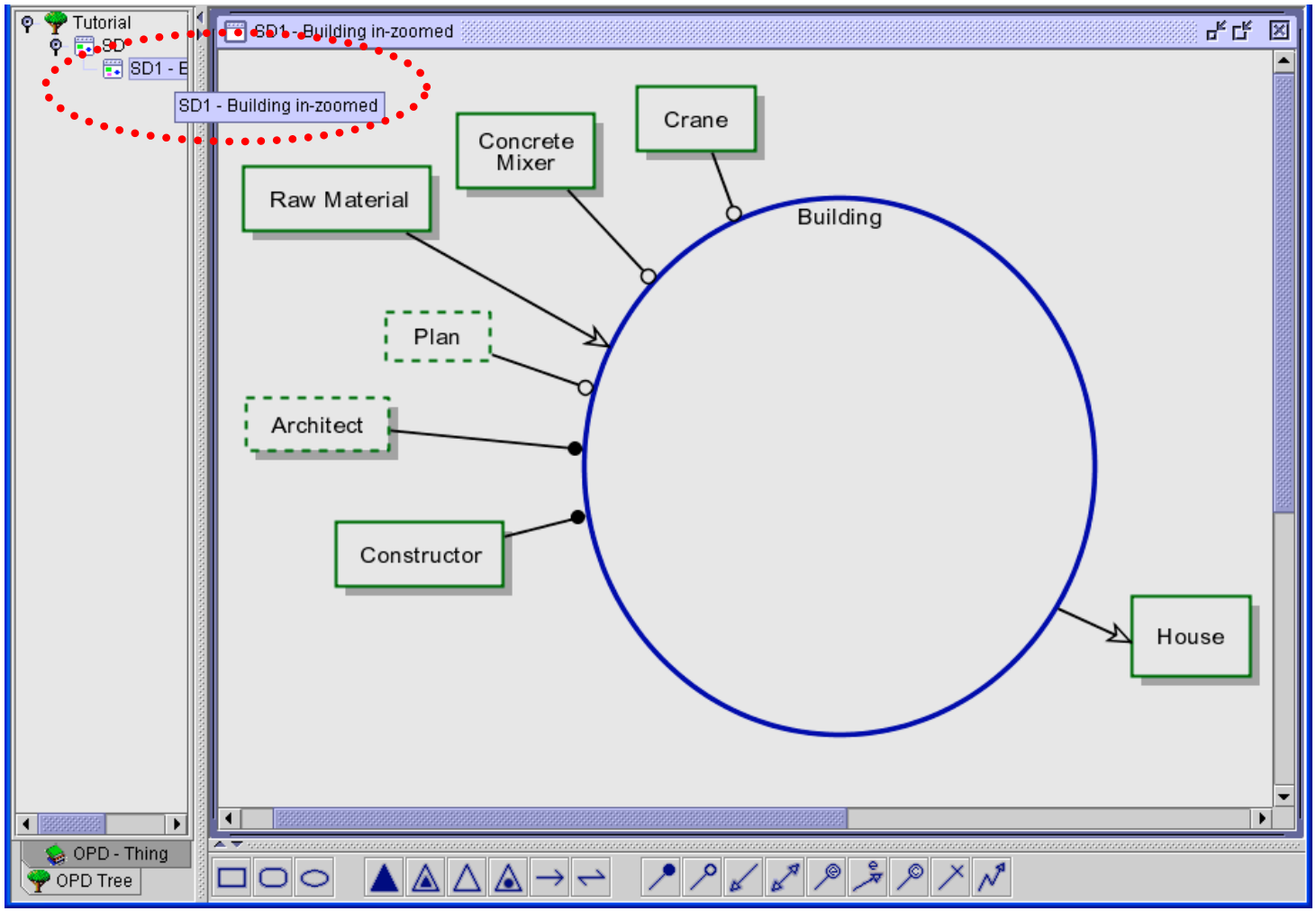
In-zooming

Exposing the details inside a complex process



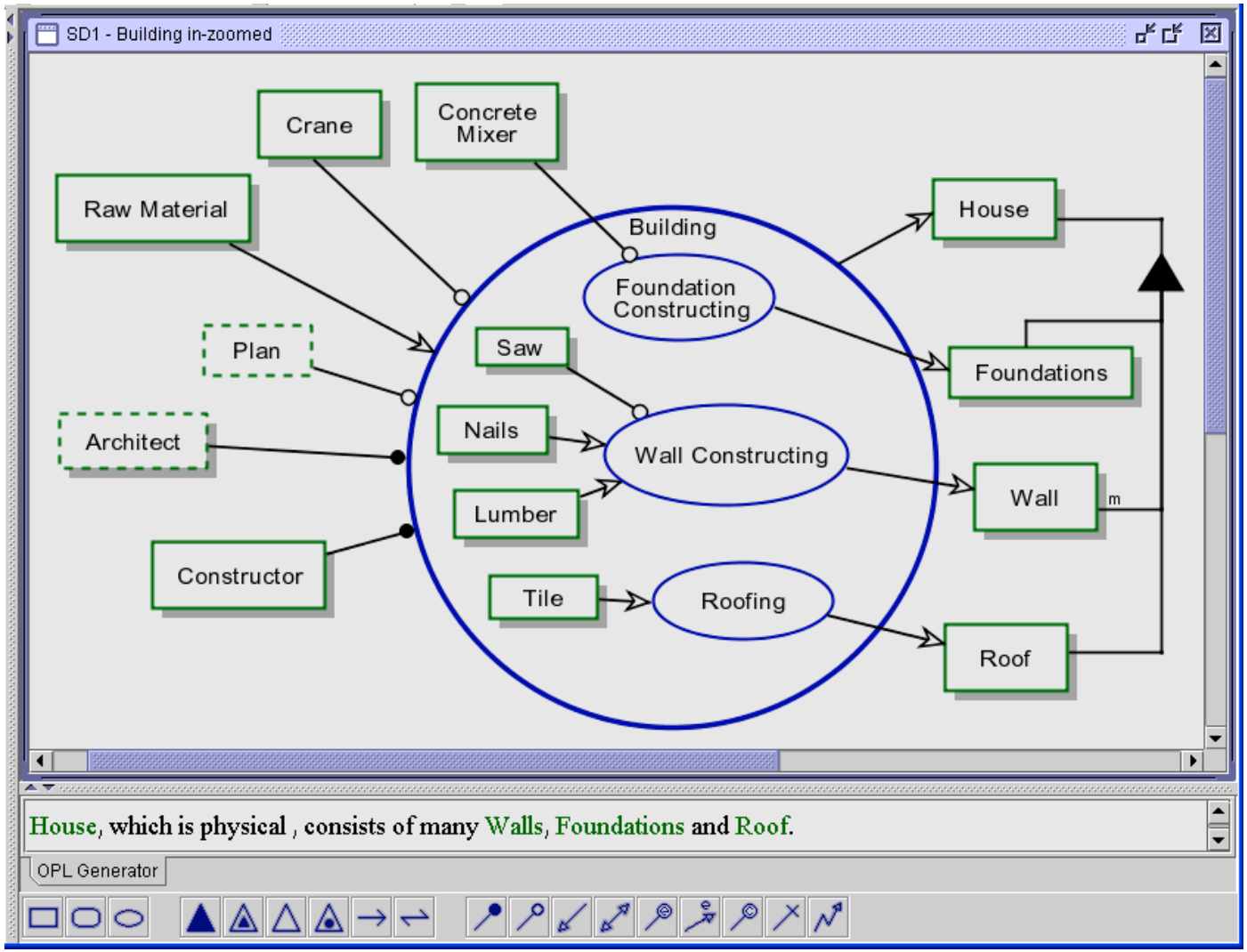
In-zooming

A new OPD is created with Building enlarged

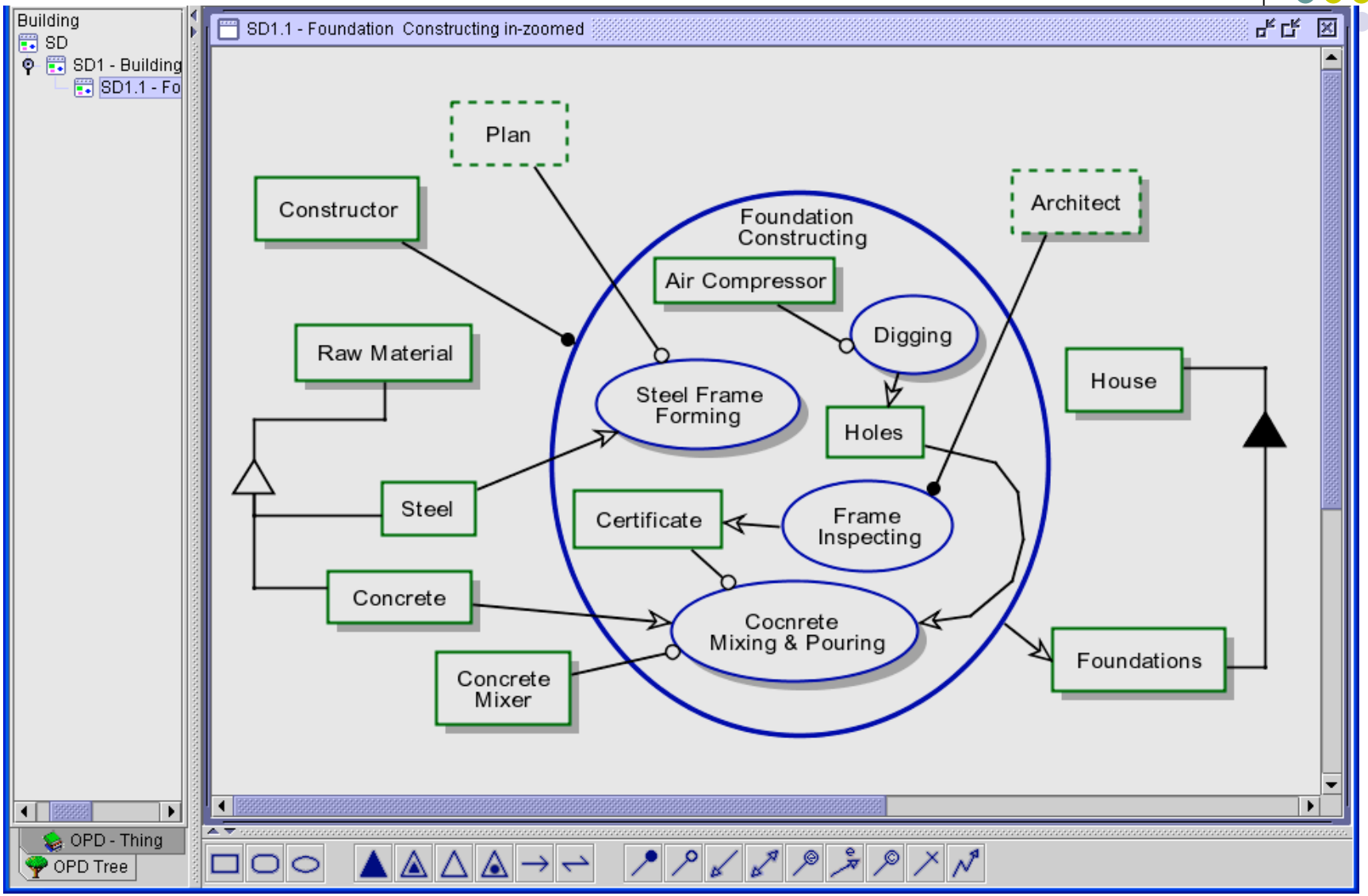


In-zooming

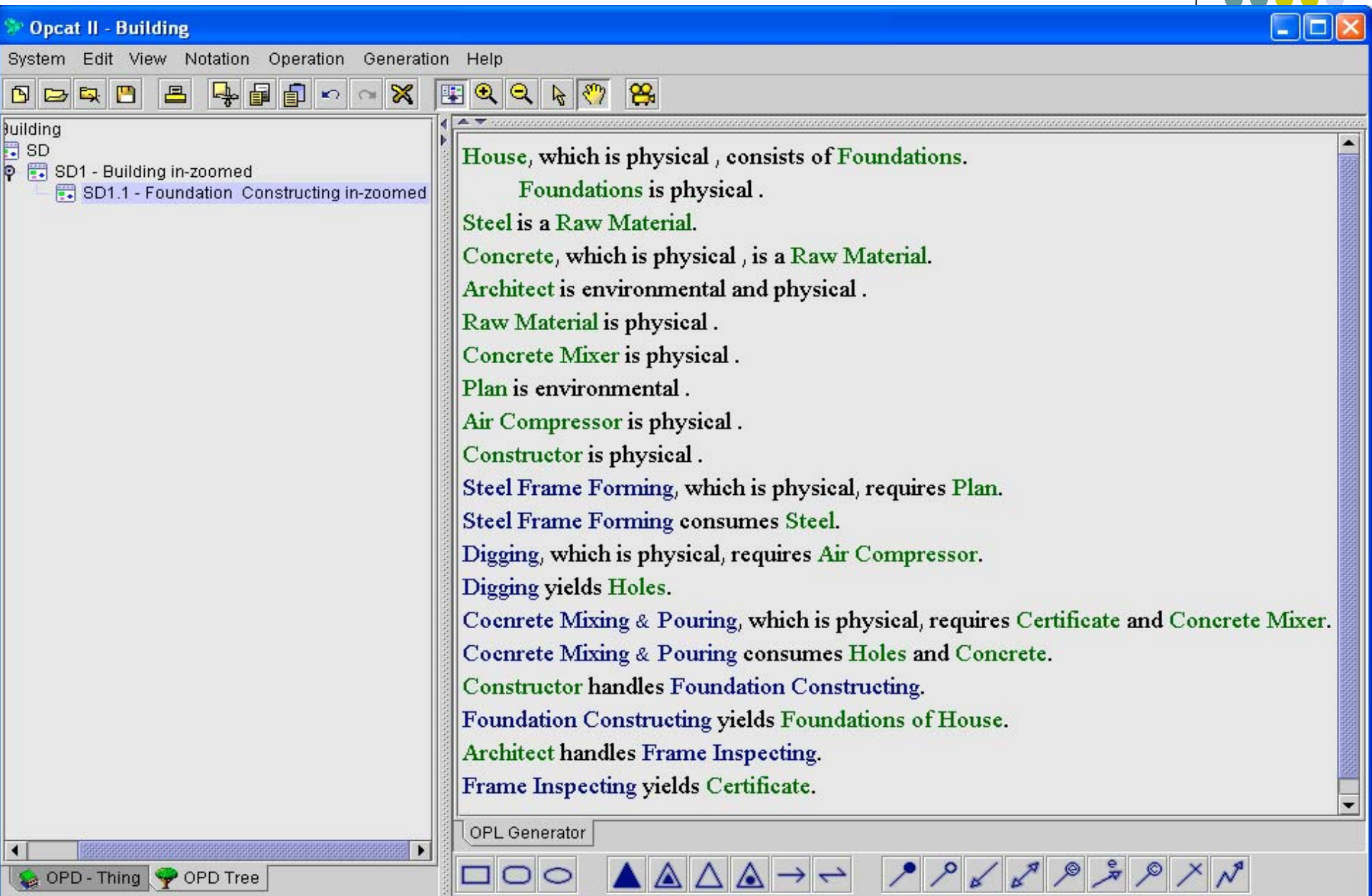
The sub-processes of the Building process are depicted inside the in-zoomed process ellipse



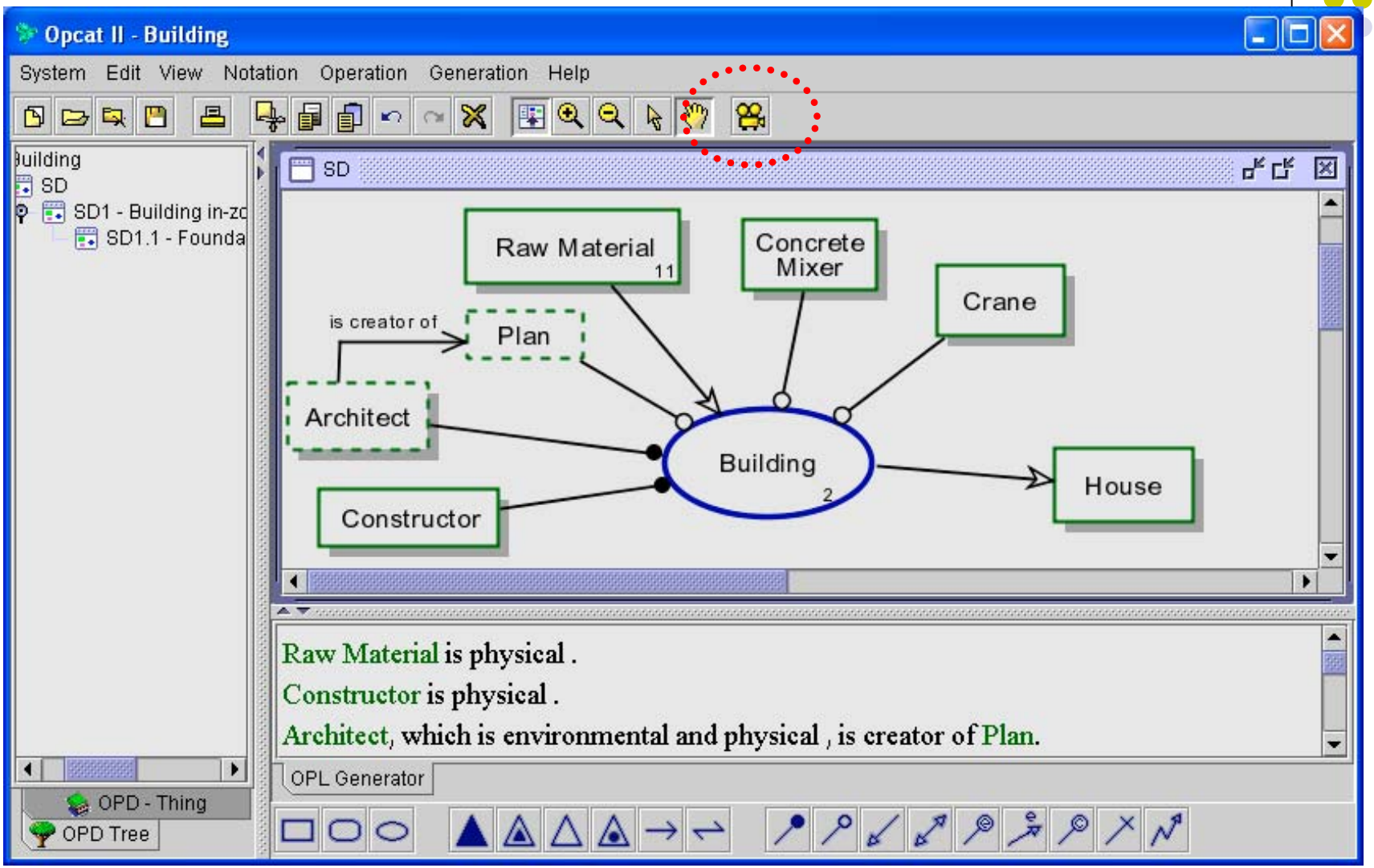
In-zooming is recursive



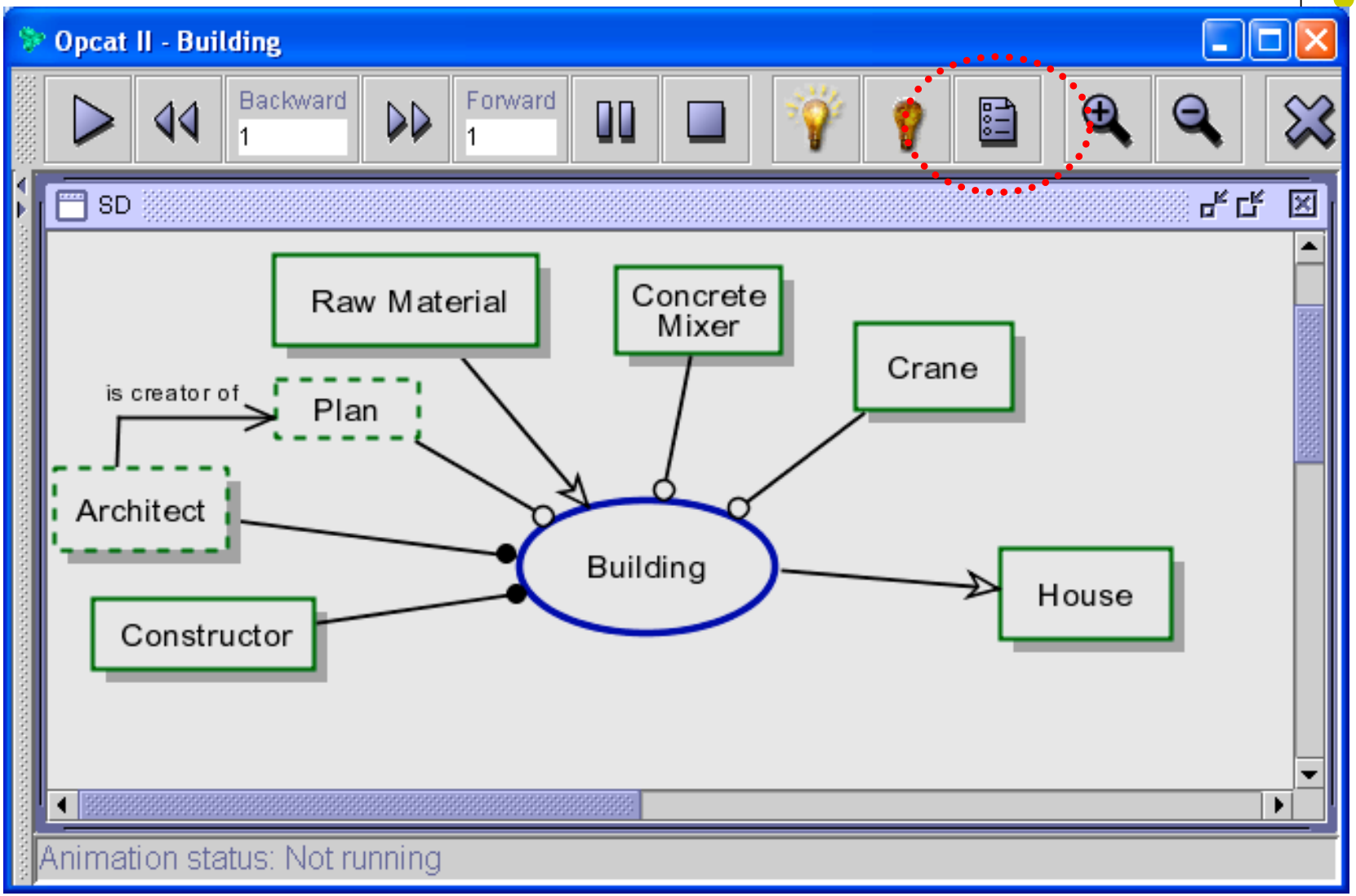
The OPL paragraph:



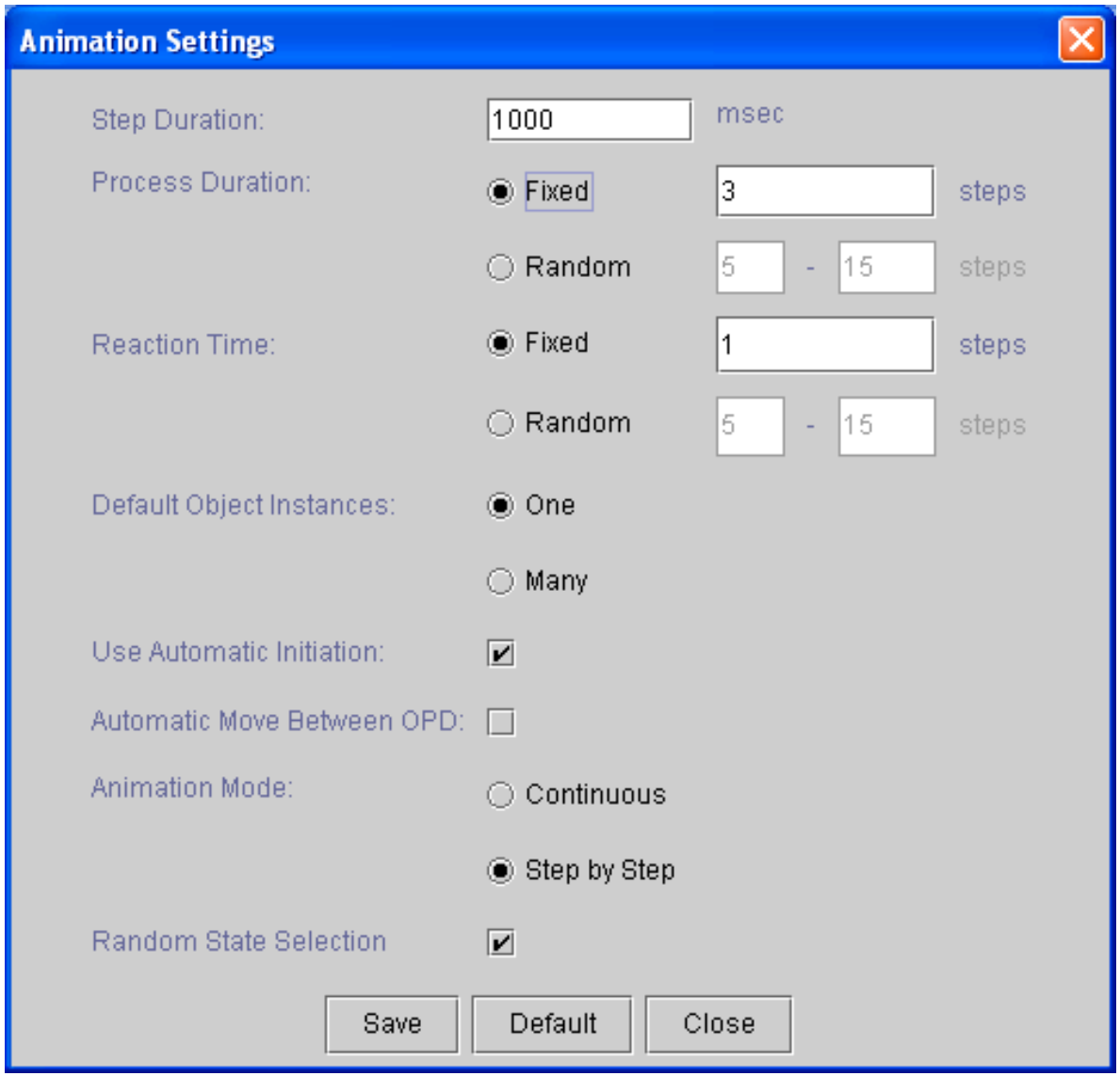
Simulation by animation



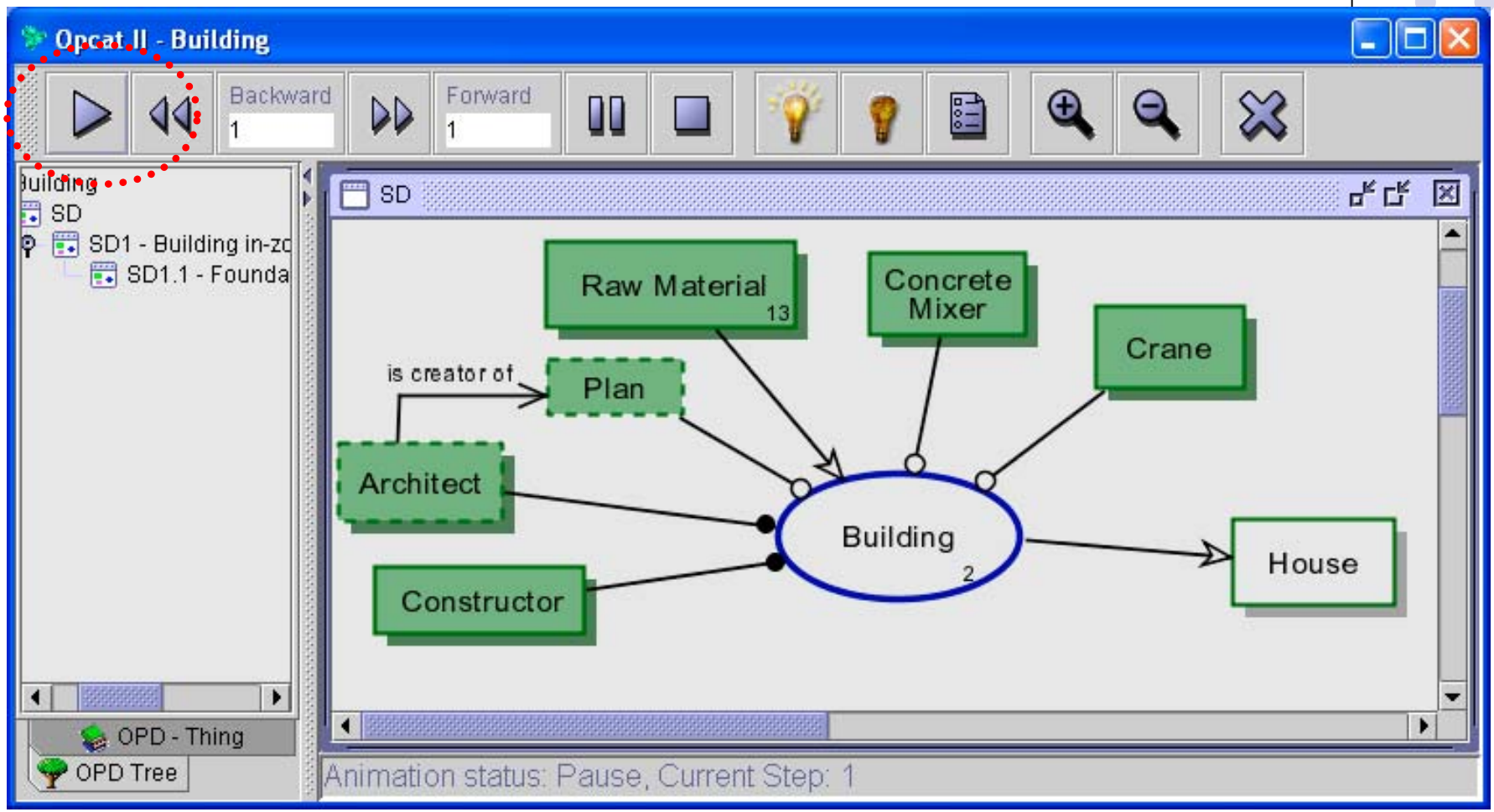
Simulation setup



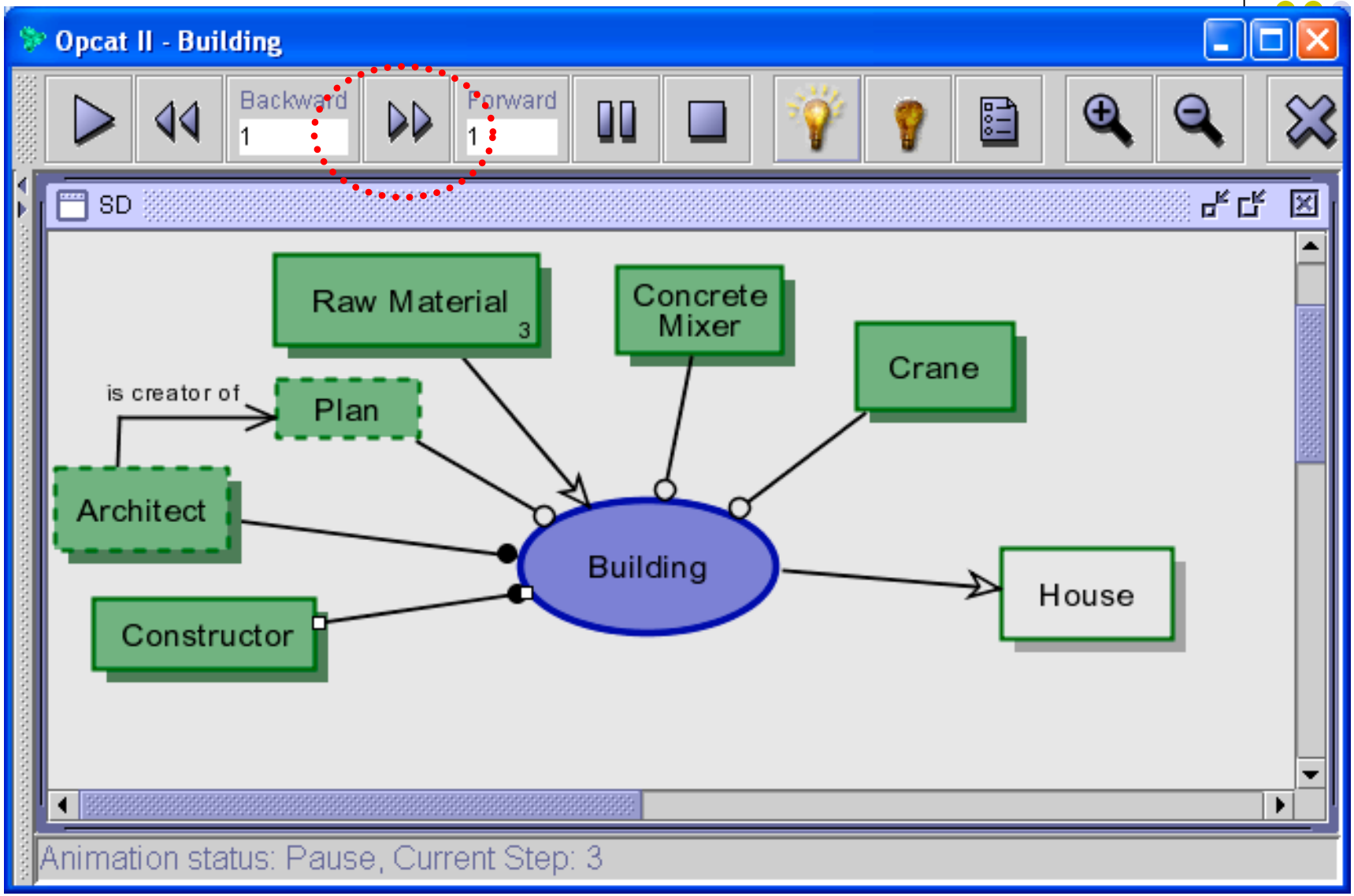
Animation parameter setup



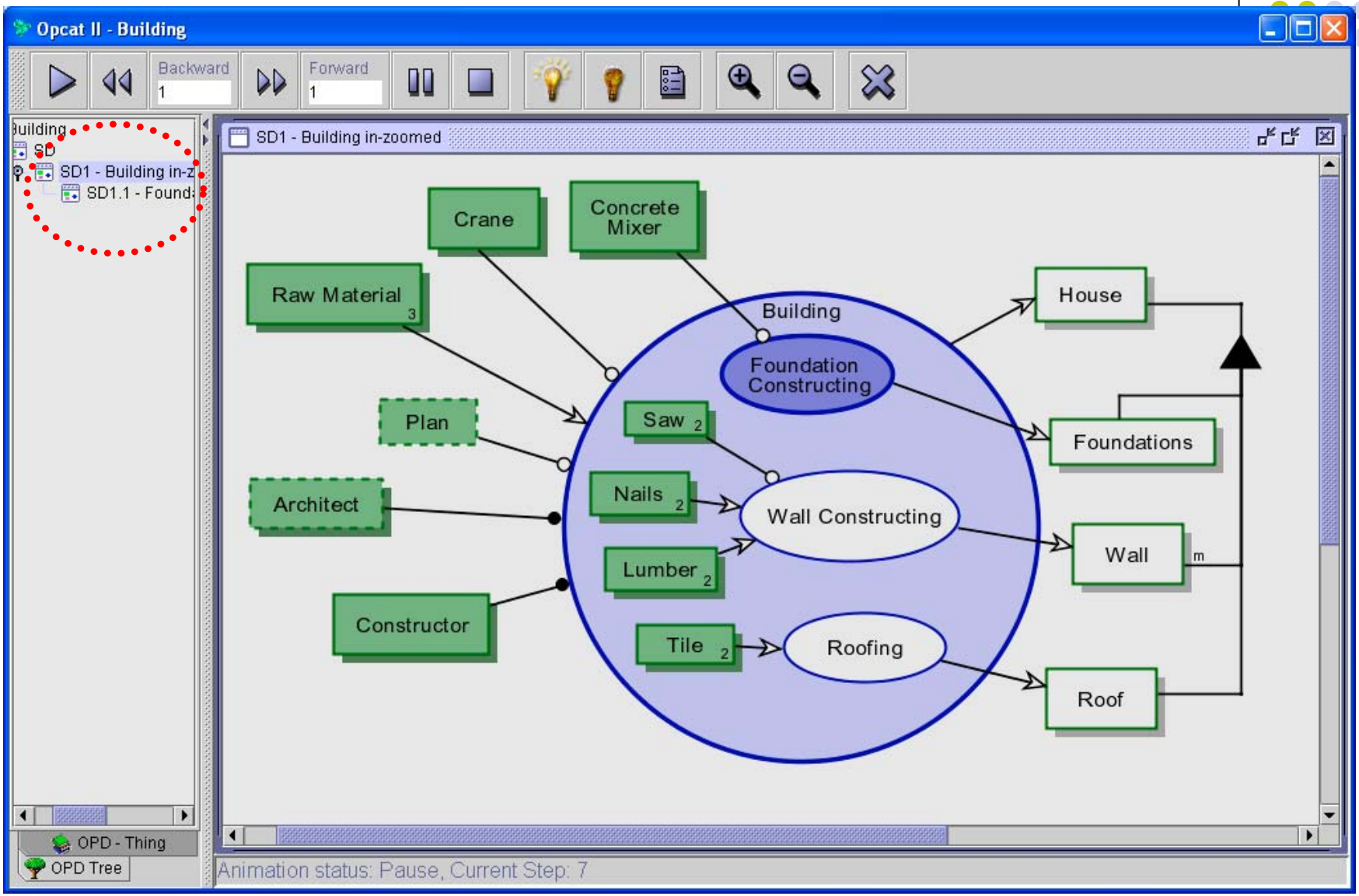
Green objects already exist



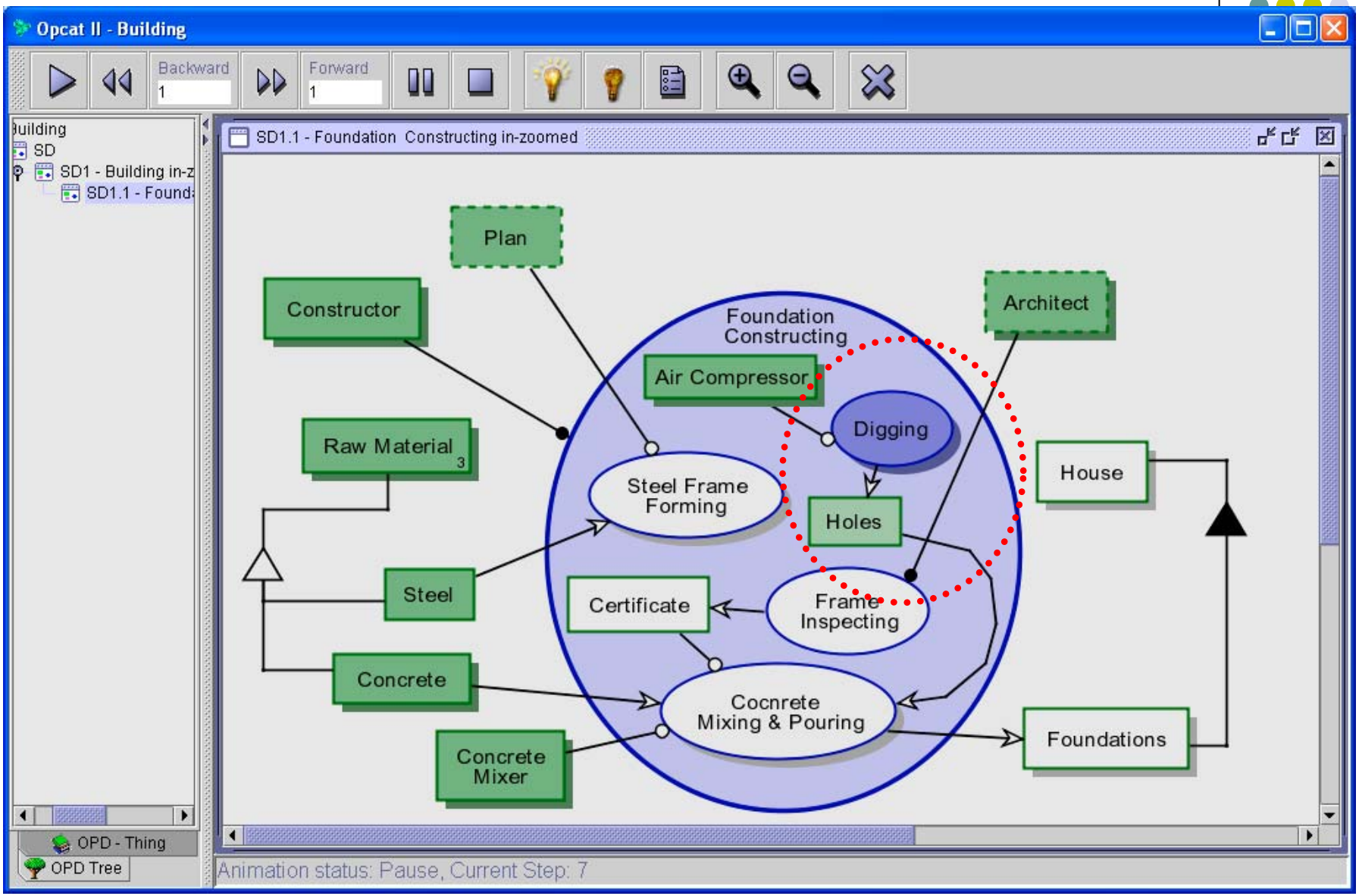
Building started



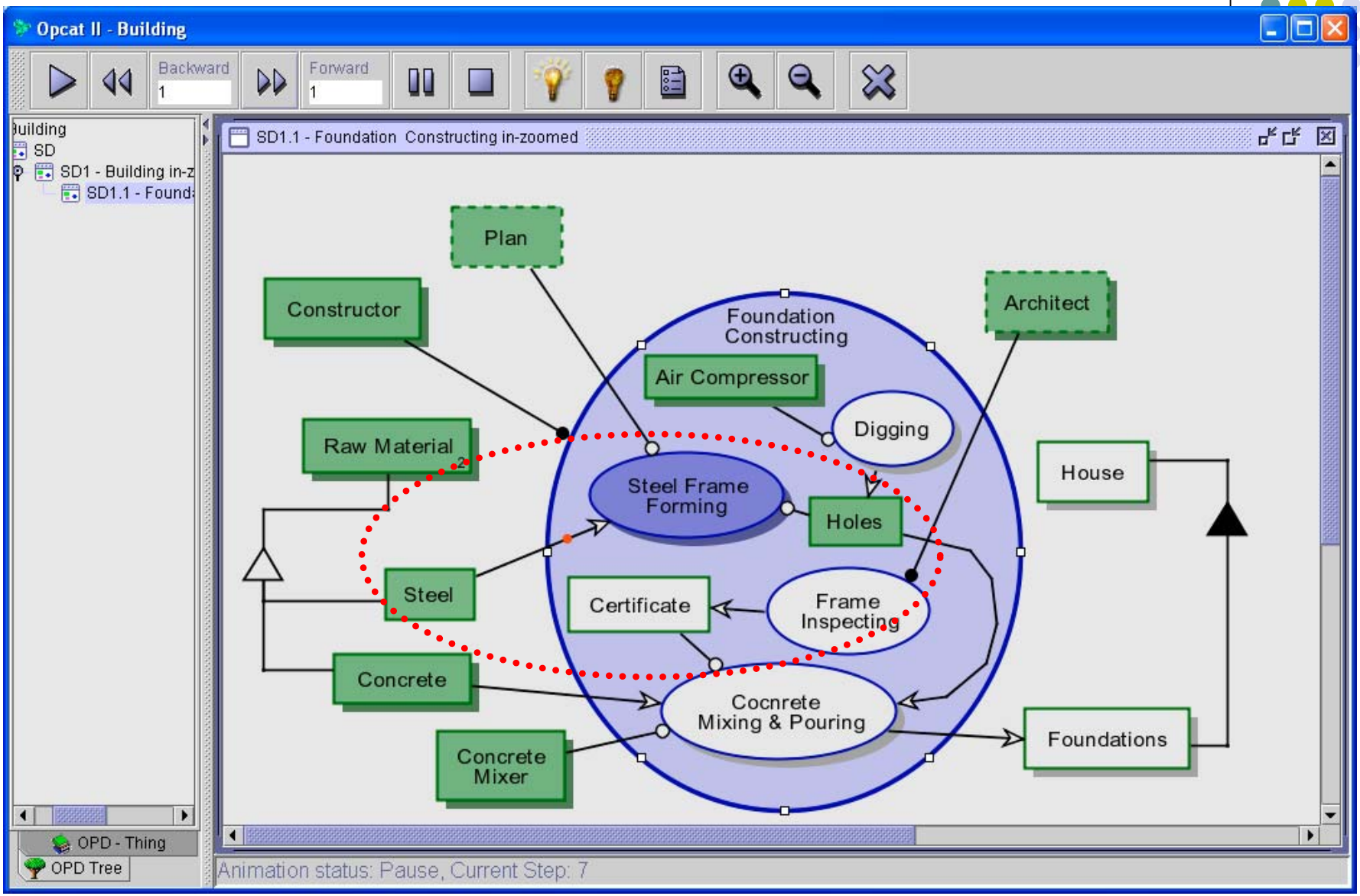
Building in-zoomed



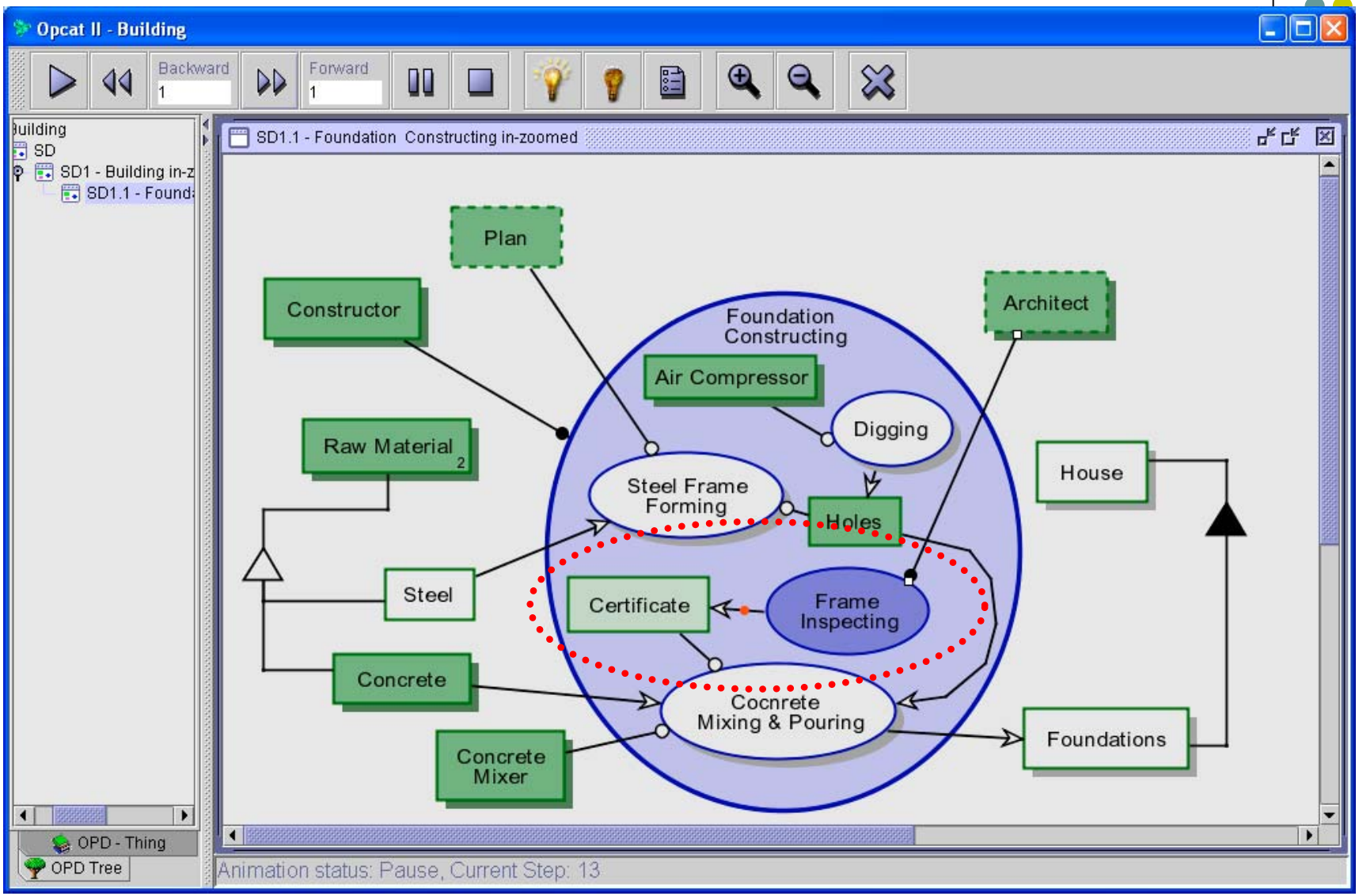
Foundation Constructing in-zoomed



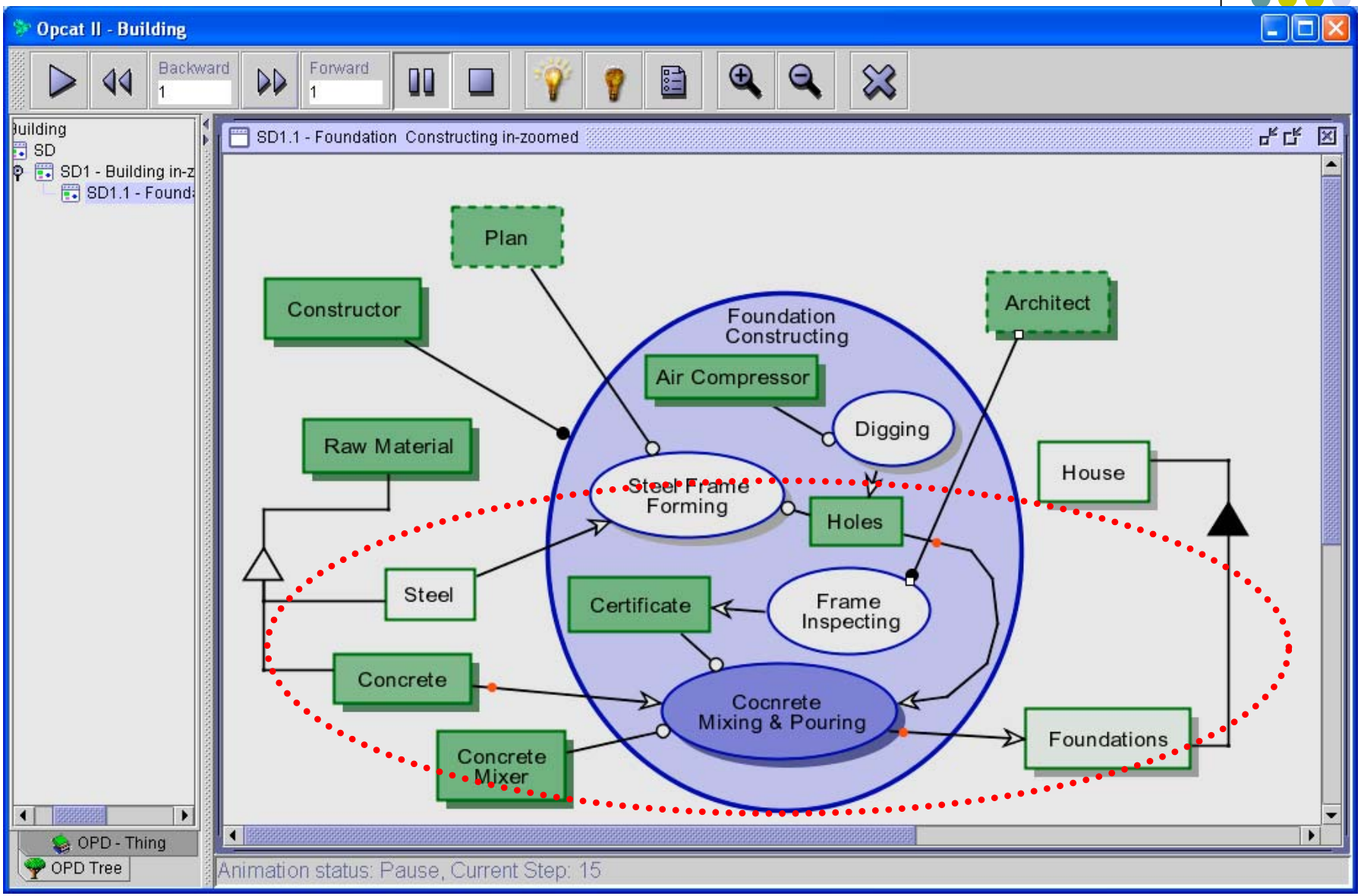
Foundation Constructing in-zoomed



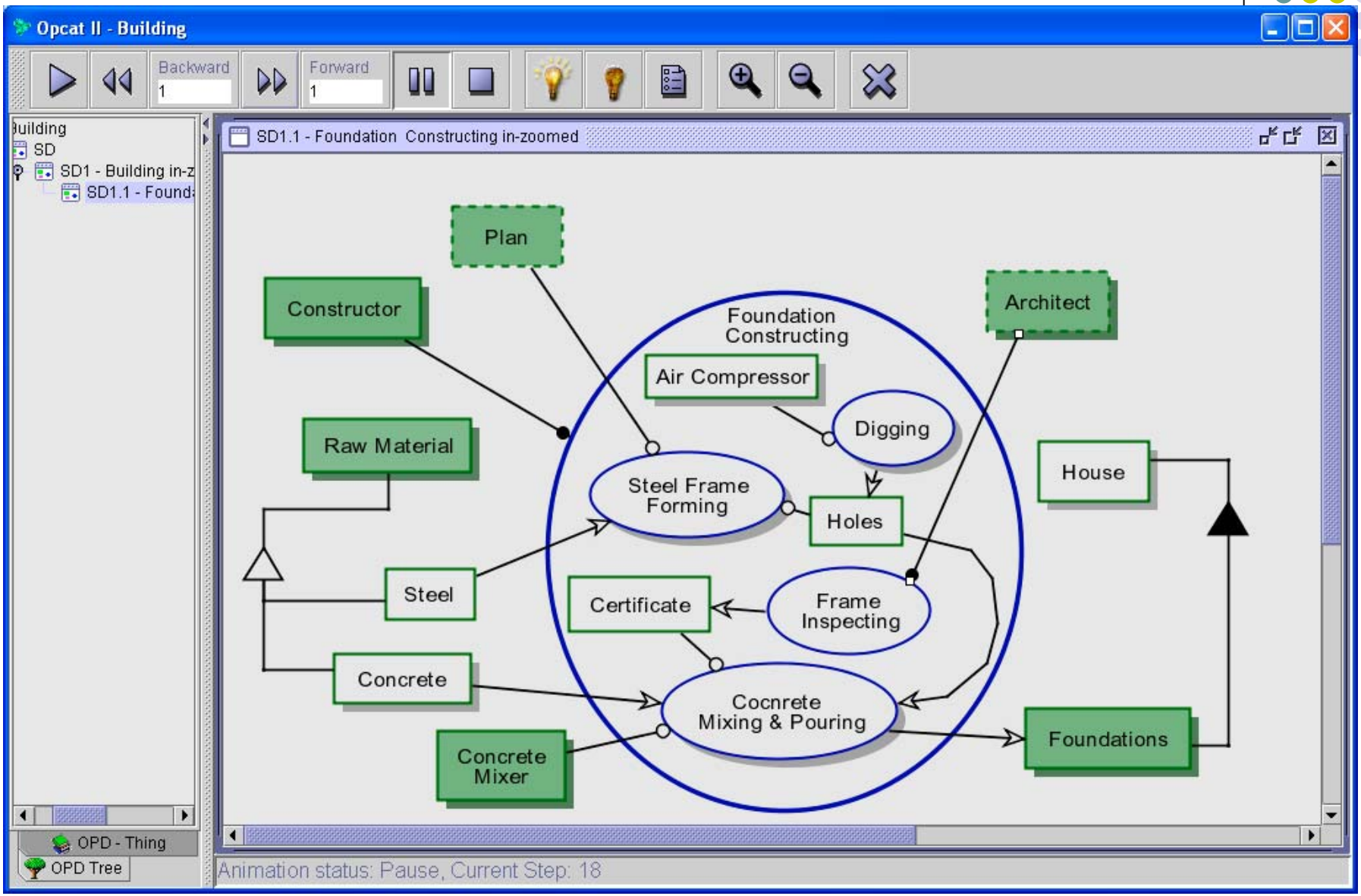
Certificate is being created



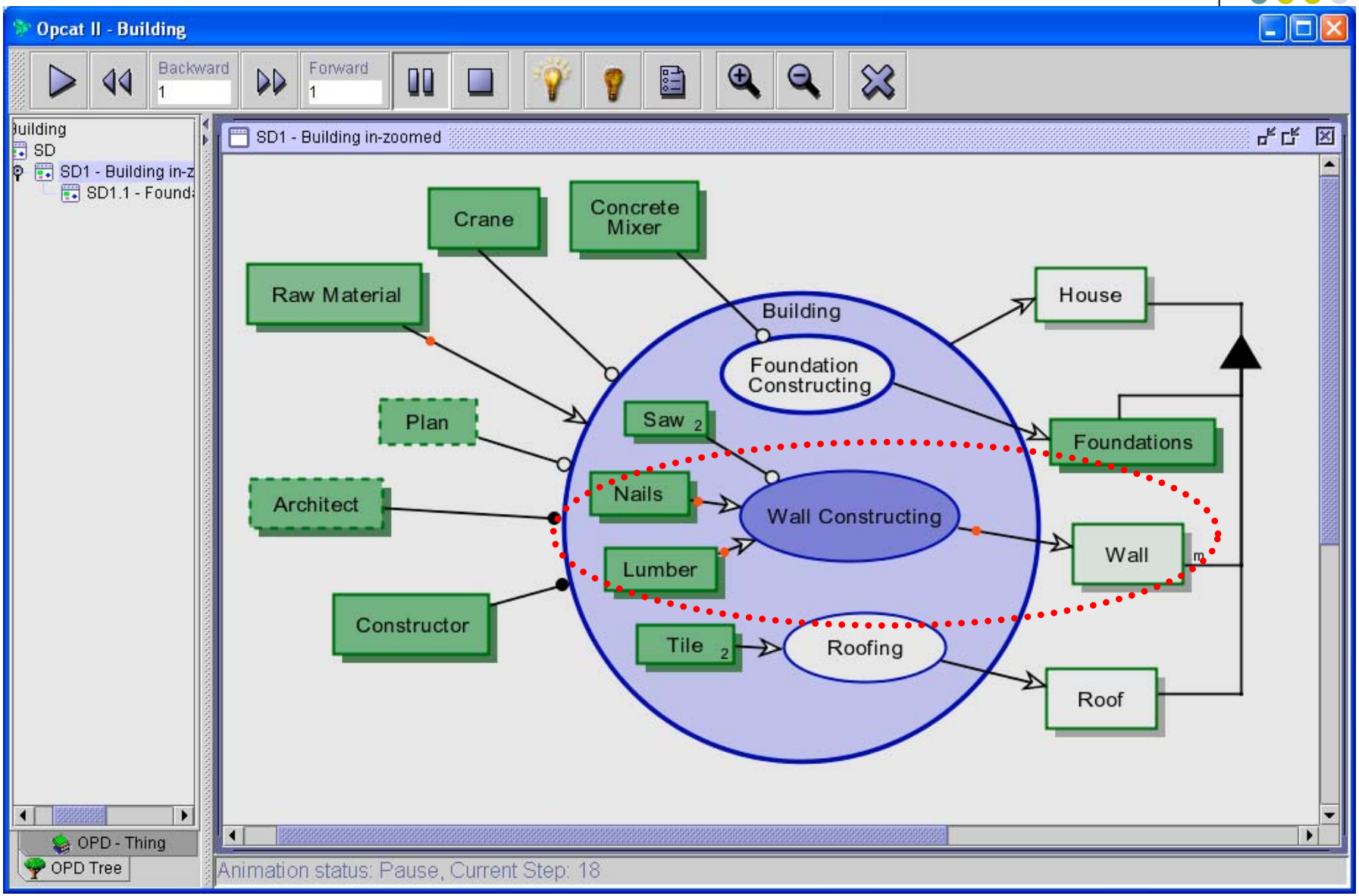
Foundations are being created, Holes and Concrete consumed



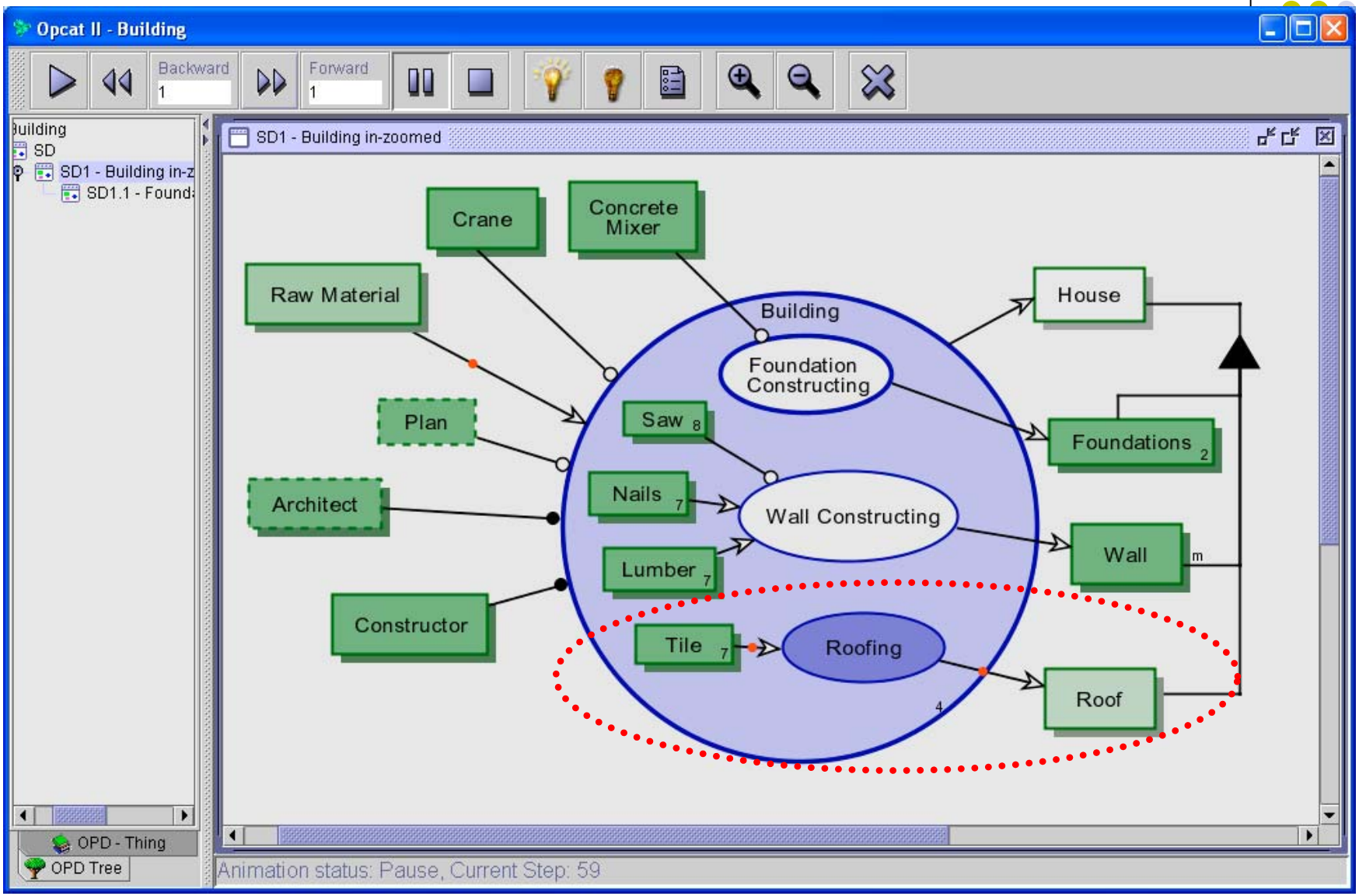
Foundations are ready, Steel and Concrete consumed



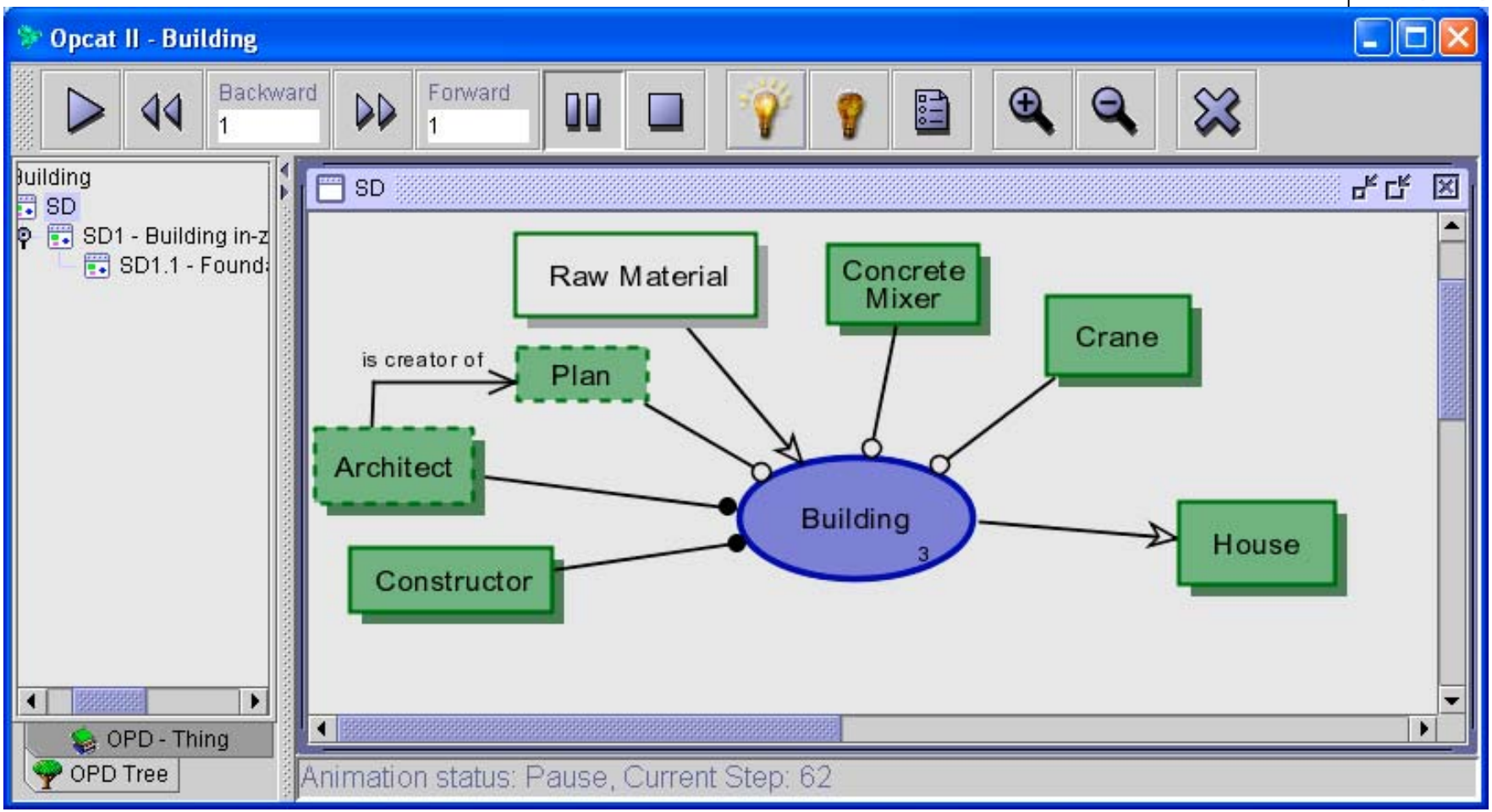
Walls are being constructed, Nails and Lumber consumed



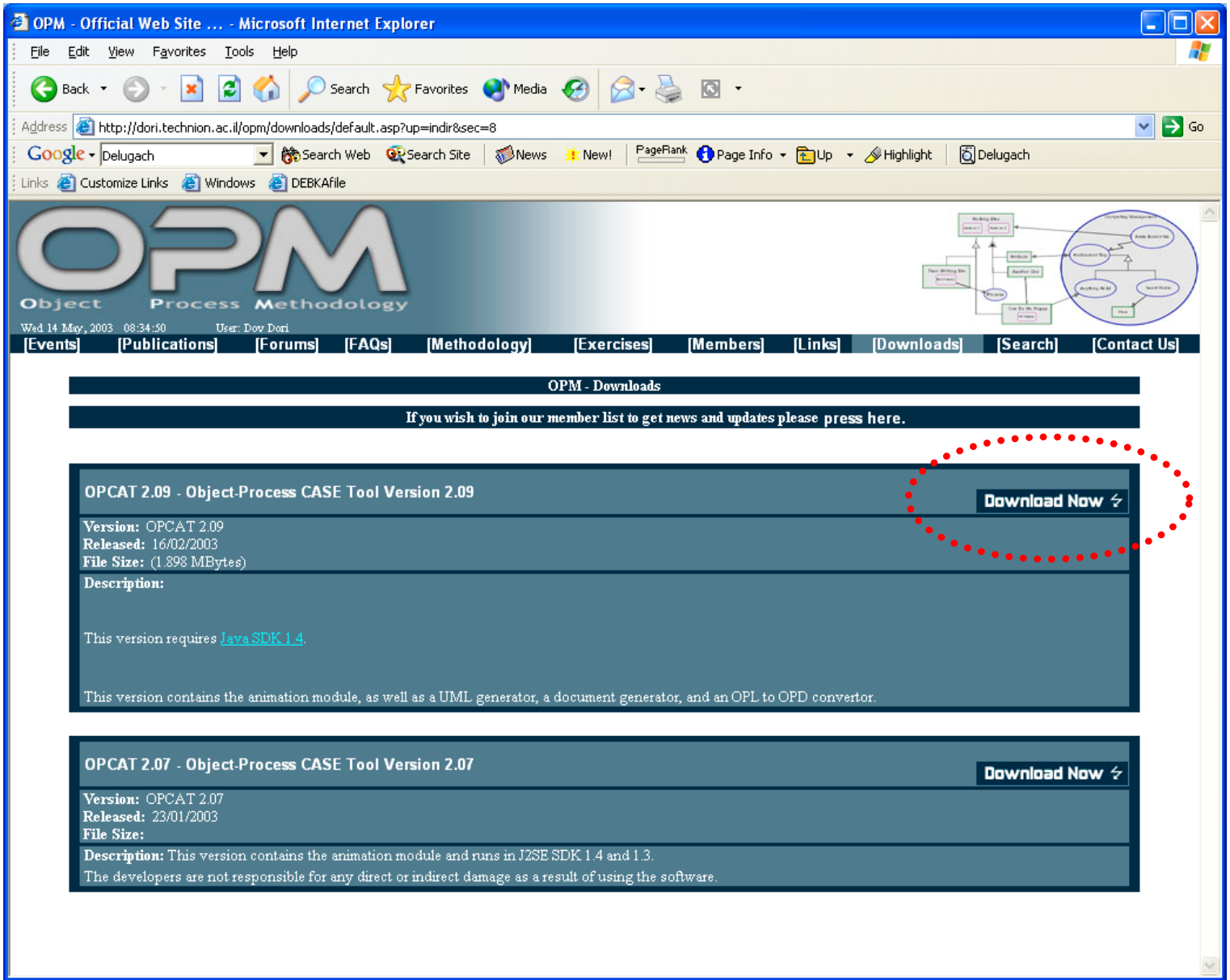
Roof is being constructed, Tiles consumed



House ready, Raw Material gone



Downloading OPCAT 2: www.ObjectProcess.org

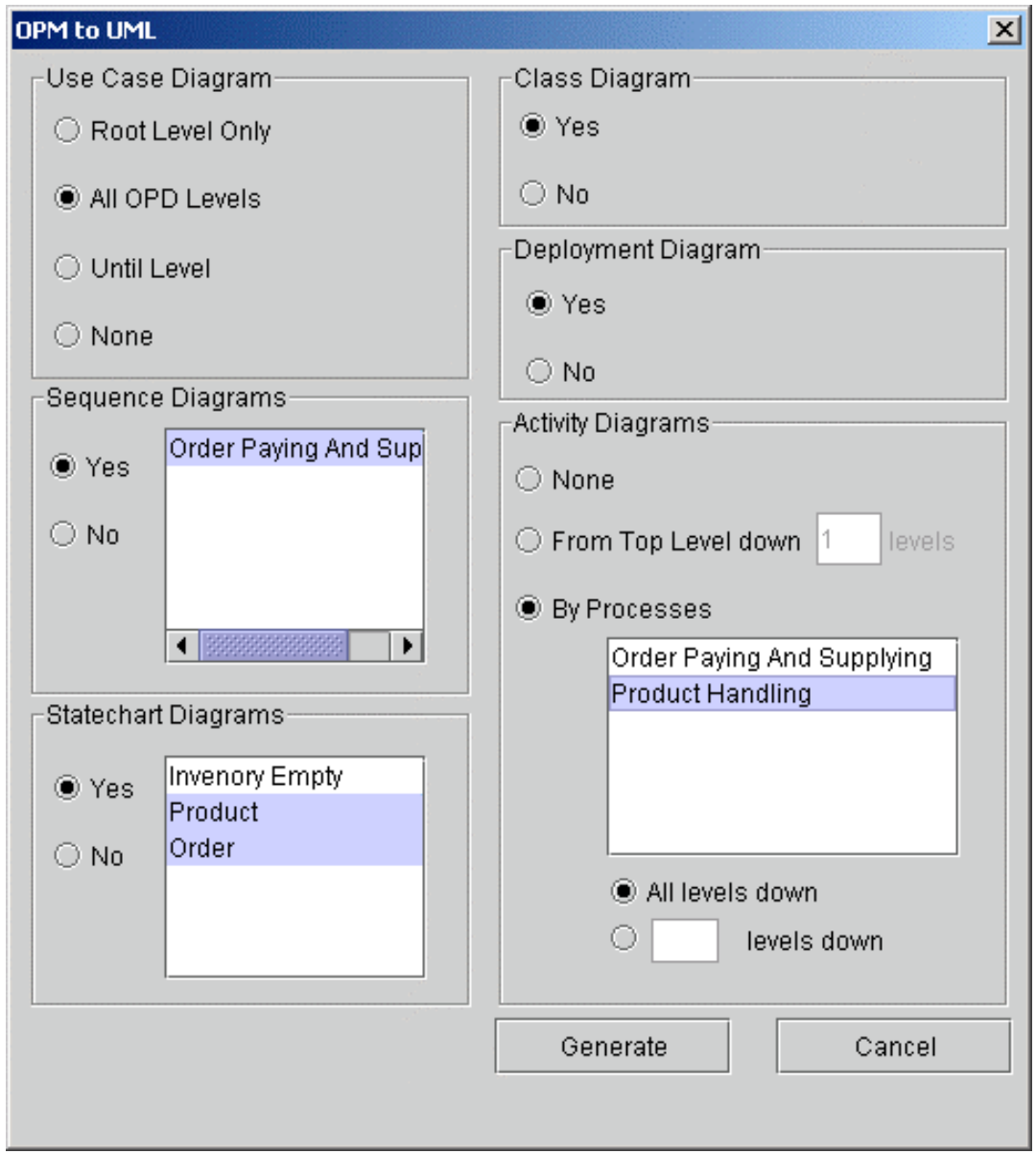


Translating to UML Diagrams

Use Case Diagram

Sequence Diagram

Statechart

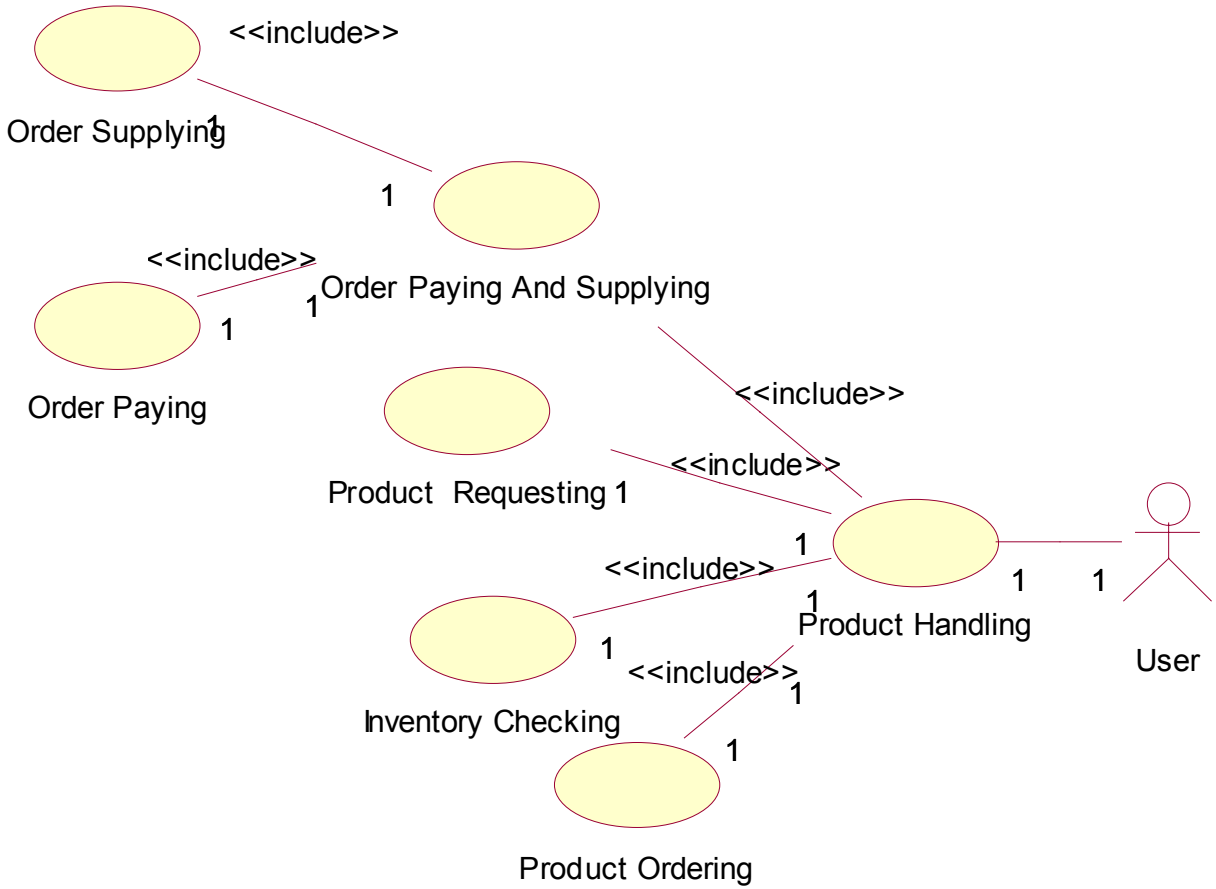


Class Diagram

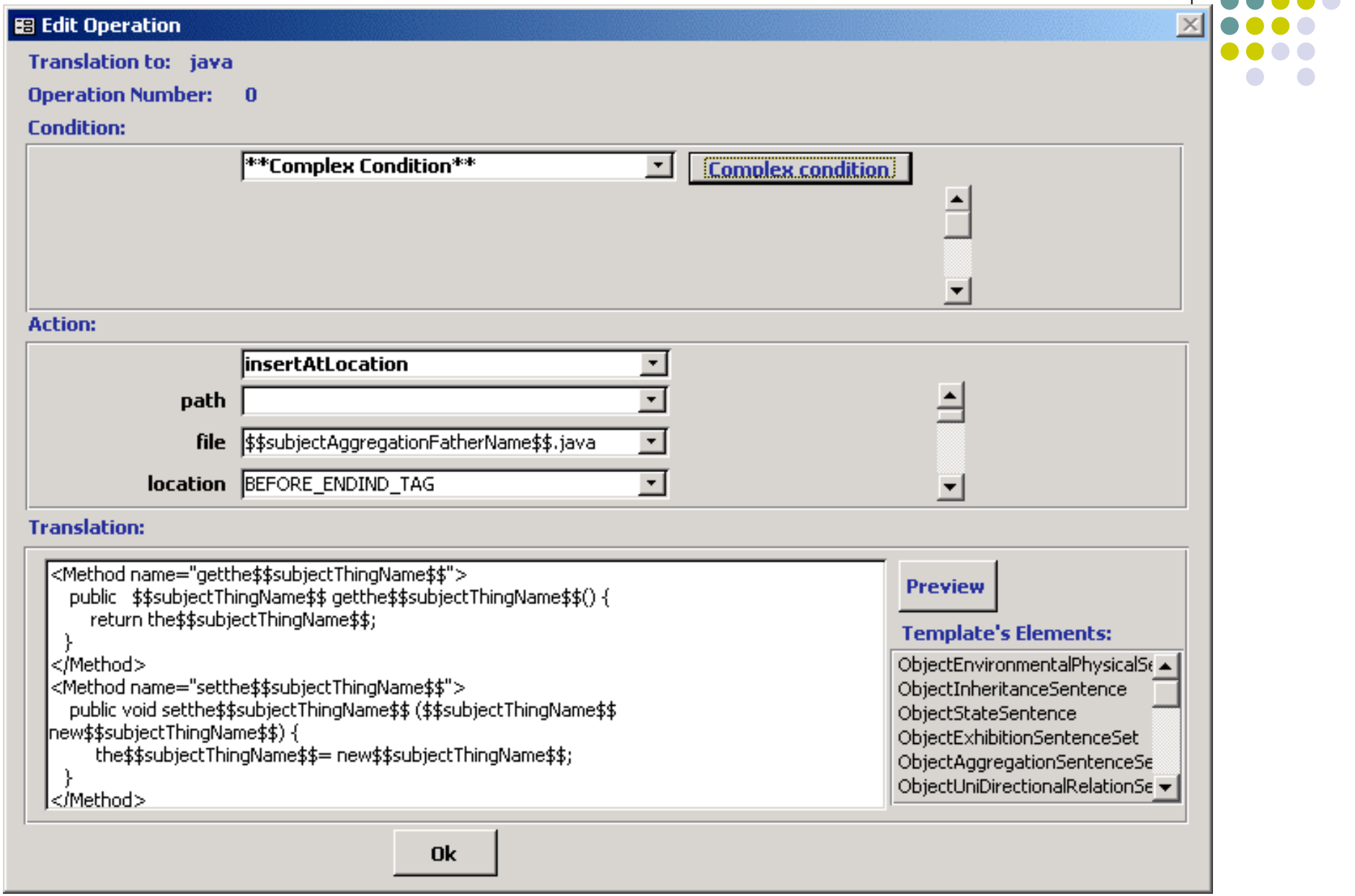
Deployment Diagram

Activity Diagram

UML Use Case Diagram



Example: Defining a JAVA Condition



Example of a generated JAVA complex process

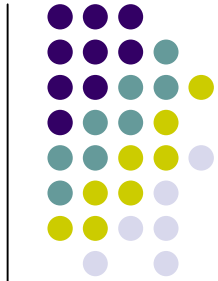
```
// File OrderPayingAndSupplying.java representing the complex process OrderPayingAndSupplying

package OrderSystem;

import opmTypes.*;

public class OrderPayingAndSupplying extends opmProcess {
          public OrderPayingAndSupplying () {
          }
          public boolean preConditionHolds (Boolean theInventoryEmpty) {
                    boolean check = true;
                    if (! ( (theInventoryEmpty.booleanValue()==false) ||
                              (theInventoryEmpty.booleanValue()==true)))
                              check=false;
                    return check;
        }
          public void run (Boolean theInventoryEmpty, Order theOrder, Product theProduct,
                                   Receipt theReceipt) {
                    if (preConditionHolds (theInventoryEmpty)) {
                              // Effect theOrder
                              // Effect theProduct
                              // Yield theReceipt
                              theReceipt = new Receipt();
                              OrderPaying  theOrderPaying = new OrderPaying();
                              theOrderPaying.run(theOrder, theReceipt);
                              OrderSupplying  theOrderSupplying = new OrderSupplying();
                              theOrderSupplying.run(theProduct, theOrder);
                    }
          }
}
```

ViSWeb – The Visual Semantic Web



Objectives:

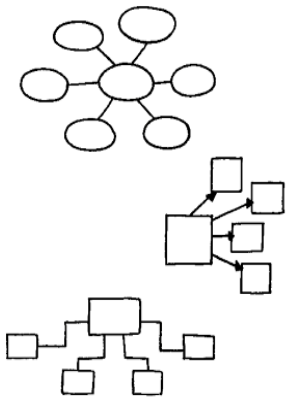
- Unifying human and machine knowledge representations with Object-Process Methodology (OPM)
- Enhancing the current Semantic Web technology
- Representing knowledge over the Web in a unified way that caters to human perceptions while also being machine-processable.

The Human-Machine Language Orientation Dilemma

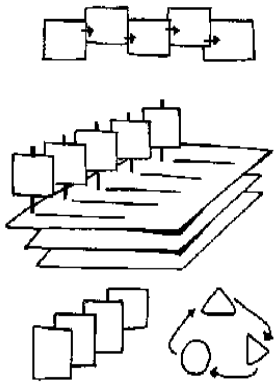
Semantic Web major assumption:

- Humans and machines must each use a different format of knowledge representation.
- **OWL Introduction:** *"…computational agents require **machine-readable** descriptions of the content and capabilities of web accessible resources. These descriptions **must be in addition** to the **human-readable** versions of that information."* – NOT TRUE!

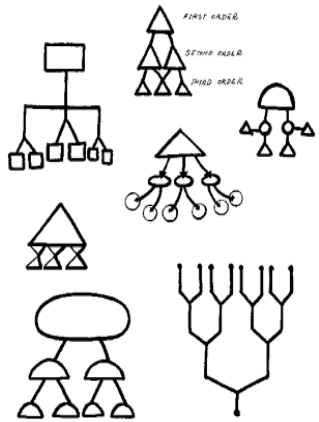
Graphic Knowledge Representations:
Concept Maps



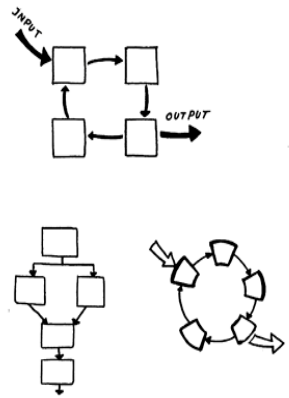
Spider



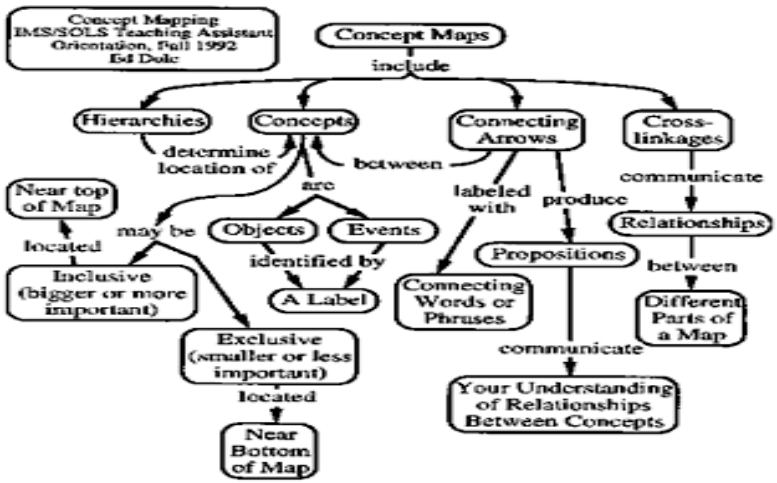
Flowchart



Hierarchy

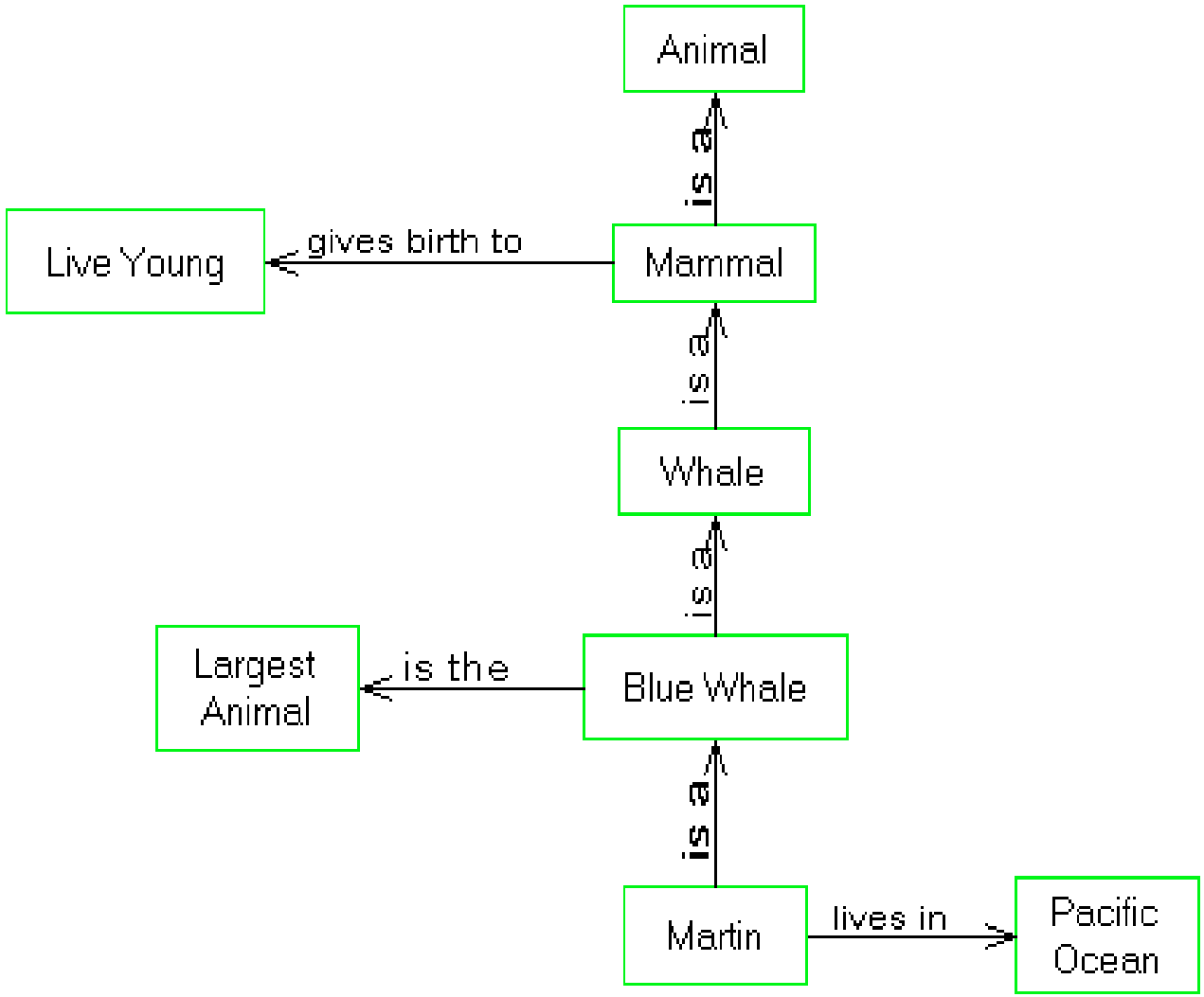


System

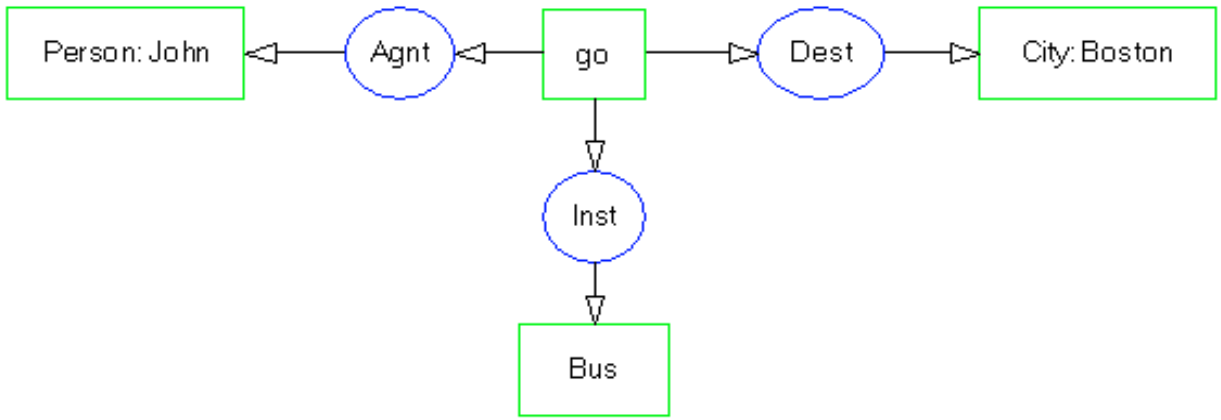


Concept map of concept map (Adapted from http://classes.aces.uiuc.edu/ACES100/Mind/CMap.html)

Graphic Knowledge Representations:
Semantic Network



Graphic Knowledge Representations:
Conceptual Graphs



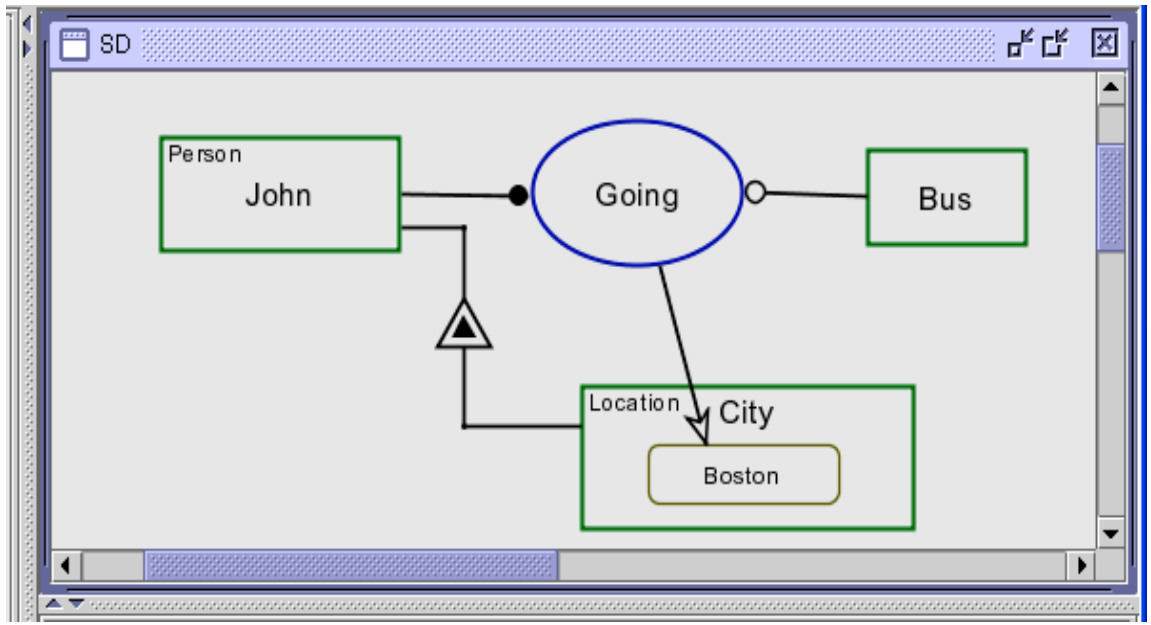
CG Display Form (DF) for "*John is going to Boston by bus*."

```
[Go]-
(Agnt)->[Person: John]
(Dest)->[City: Boston]
(Inst)->[Bus].
```

CG Linear Form (LF) for "*John is going to Boston by bus*."

Graphic Knowledge Representations:
The OPM equivalent

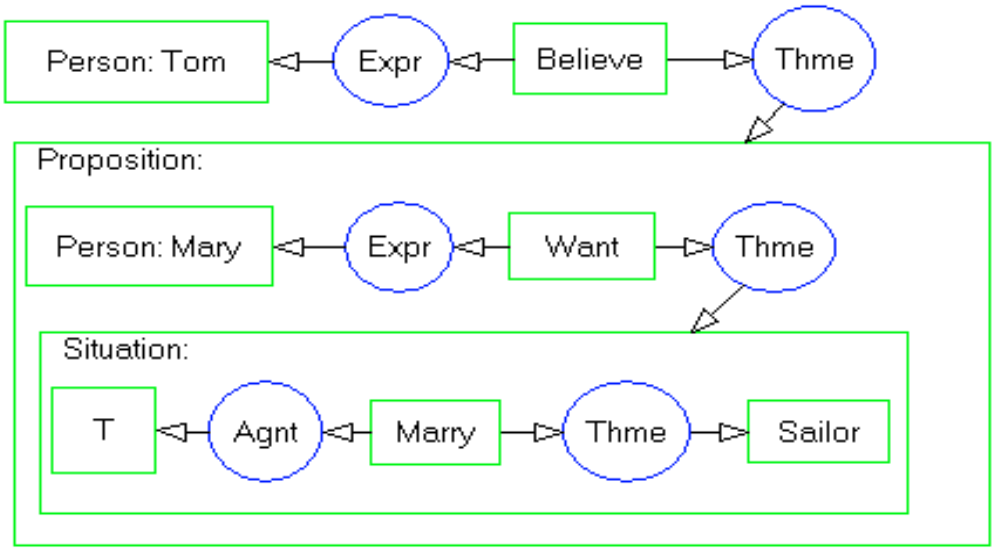
OPD:



OPL:

The **Person John** exhibits the **Location City.**
City is **Boston.**
John handles **Going.**
Going requires **Bus.**
Going changes **City** to **Boston.**

Graphic Knowledge Representations:
Conceptual Graphs: Context



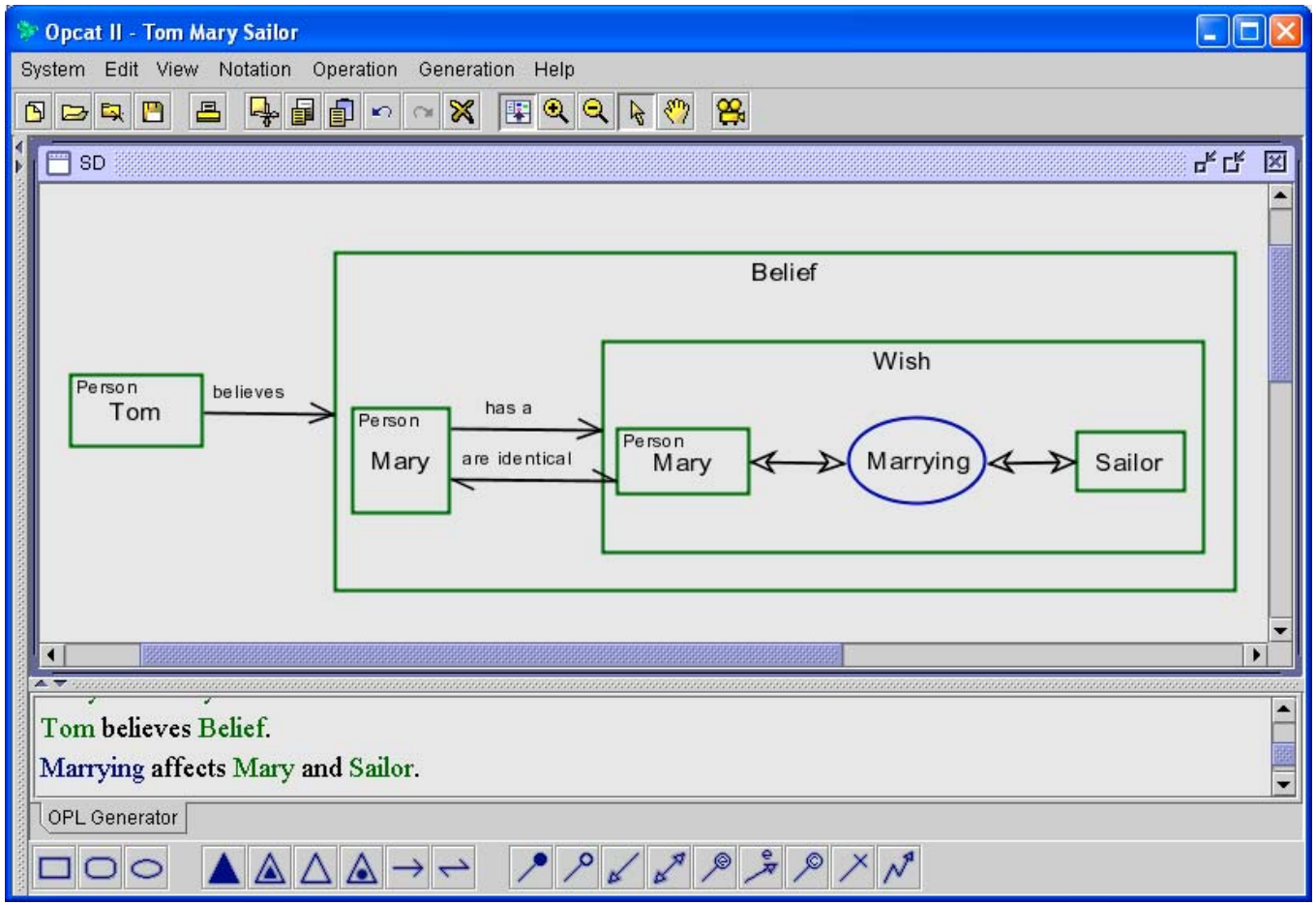
CG Display Form (DF) for "*Tom believes that Mary wants to marry a sailor*".

```
[Person: Tom]<-(Expr)->[Believe]->(Thme)-
[Proposition:  [Person: Mary *x] <-(Expr)<-[Want]->(Thme)-
[Situation:  [?x] <-(Agnt) <-[Marry] ->(Thme) ->[Sailor]]].
```

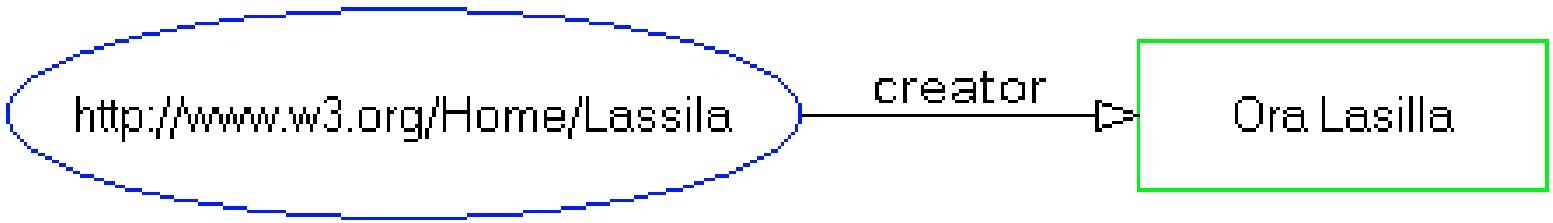
CG Linear Form (LF) for "*Tom believes that Mary wants to marry a sailor*".

Graphic Knowledge Representations:
The OPM equivalent

OPD:



Graphic Knowledge Representations: RDF



"*http://www.w3.org/Home/Lassila has creator Ora Lassila*",

and in general

"*<subject> HAS <predicate> <object>*".

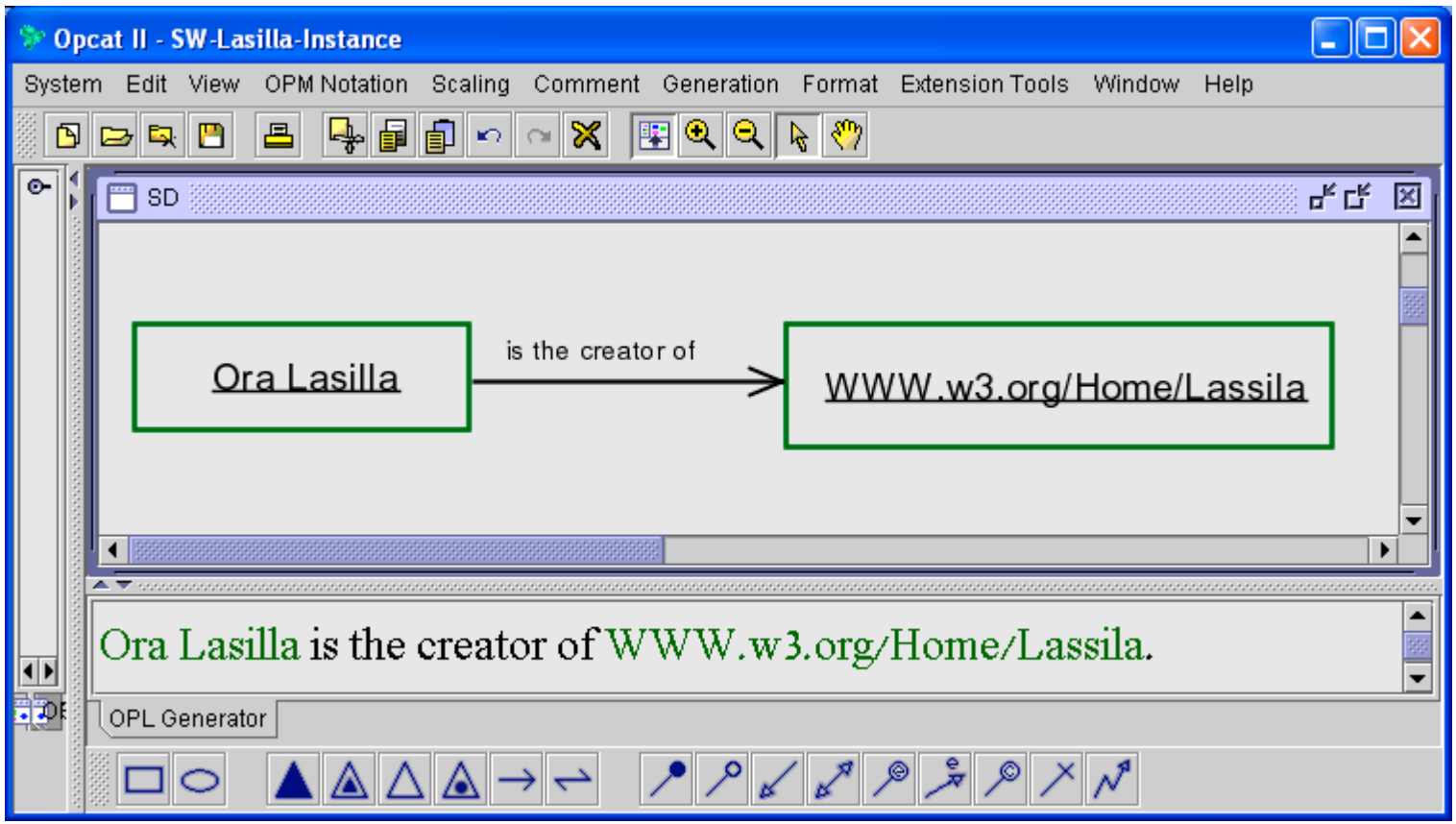
RDF – more realistic with

RDF/XML Validation Service

http://www.w3.org/RDF/Validator/

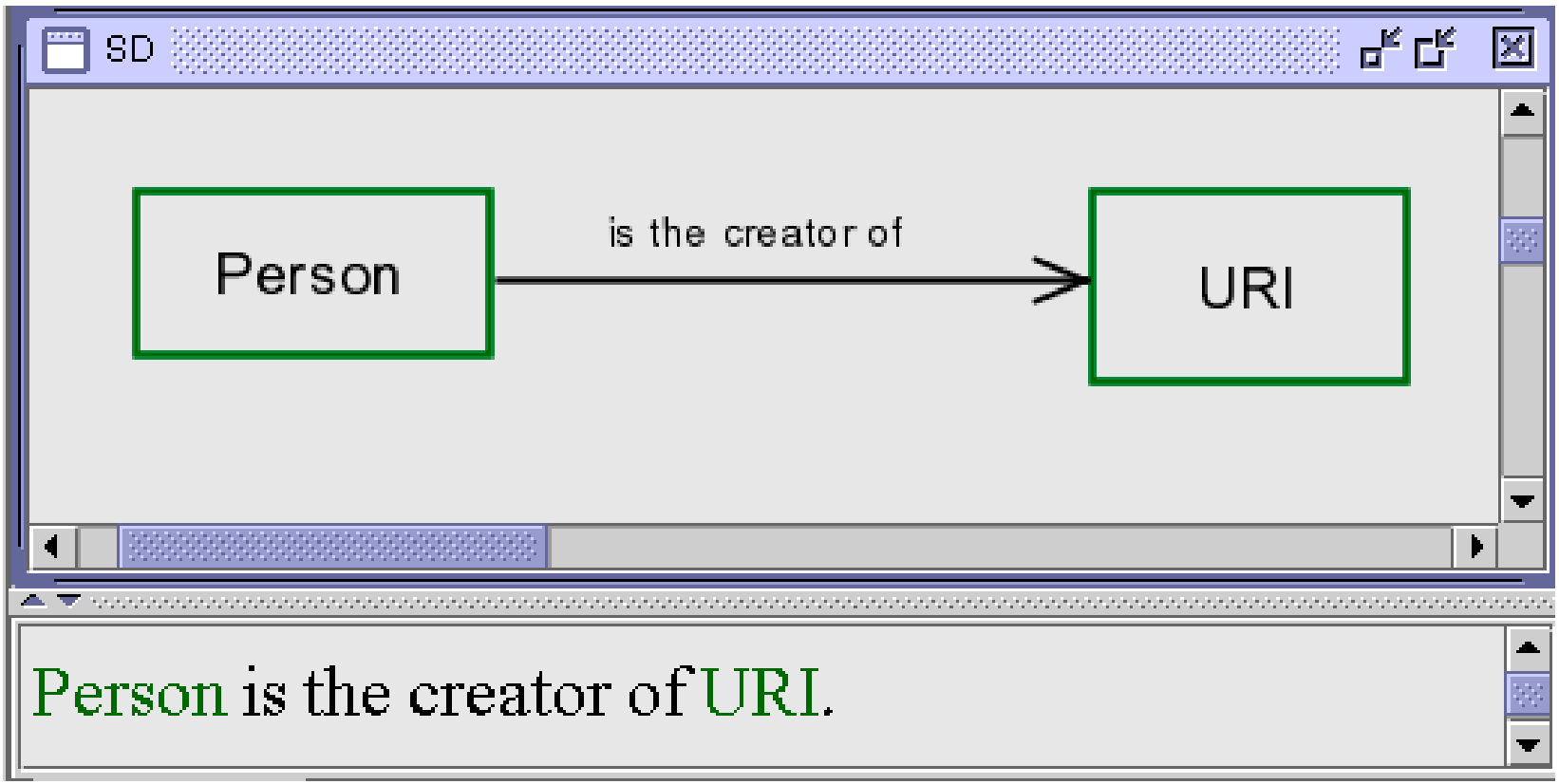

```
<?xml version="1.0"?>
<rdf:RDF
  xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
  xmlns:s="http://description.org/schema/">
  <rdf:Description about="http://www.w3.org/Home/Lassila">
    <s:Creator>Ora Lassila</s:Creator>
  </rdf:Description>
</rdf:RDF>
```

ViSWeb: An OPM-Based Visual Semantic Web Spec Alternative



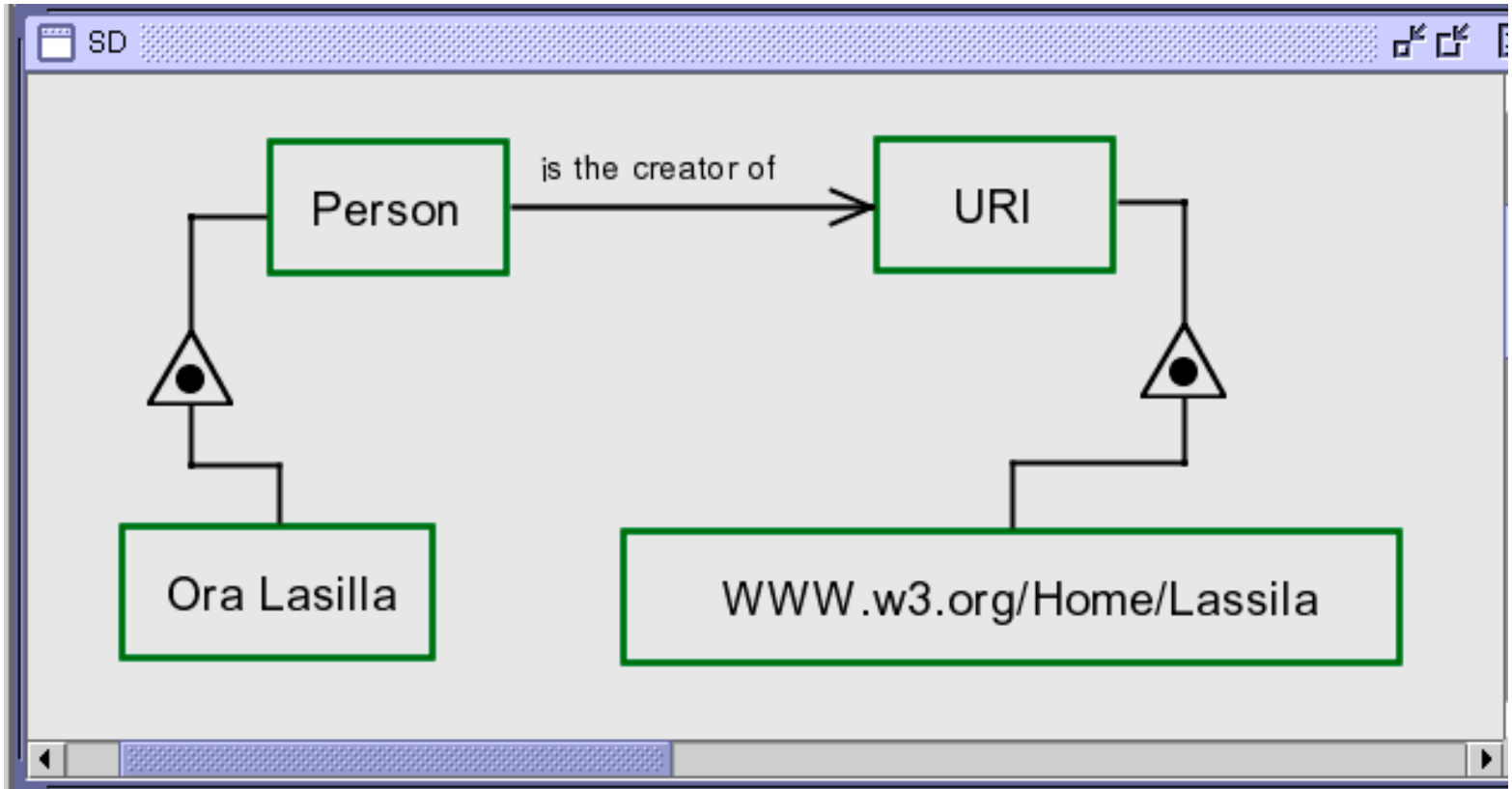
Ora Lasilla is the creator of WWW.w3.org/Home/Lassila.

The ViSWeb Schema: Adding Class Information



Person is the creator of URI.

Instantiating the ViSWeb Schema

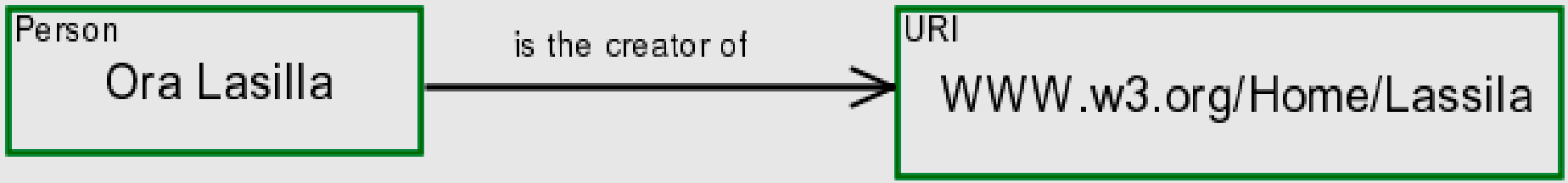


Person is the creator of URI.

WWW.w3.org/Home/Lassila is an instance of URI.

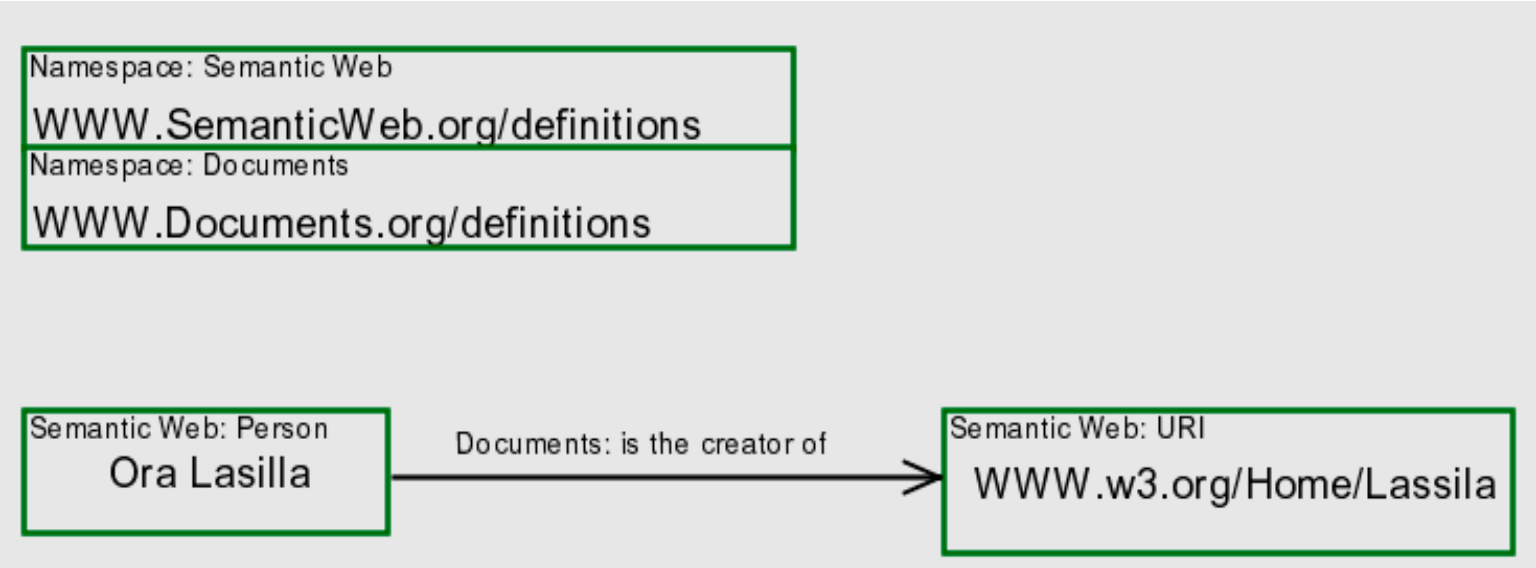
Ora Lasilla is an instance of Person.

A more compact version:



The **Person Ora Lasilla is the creator of** the **URI** WWW.w3.org/Home/Lassila**.**

OPM Namespace Specification



The namespace **Semantic Web** is at URL WWW.SemanticWeb.org/definitions.
The namespace **Documents** is at URL WWW.Documents.org/definitions.

(Namespace declaration sentences)

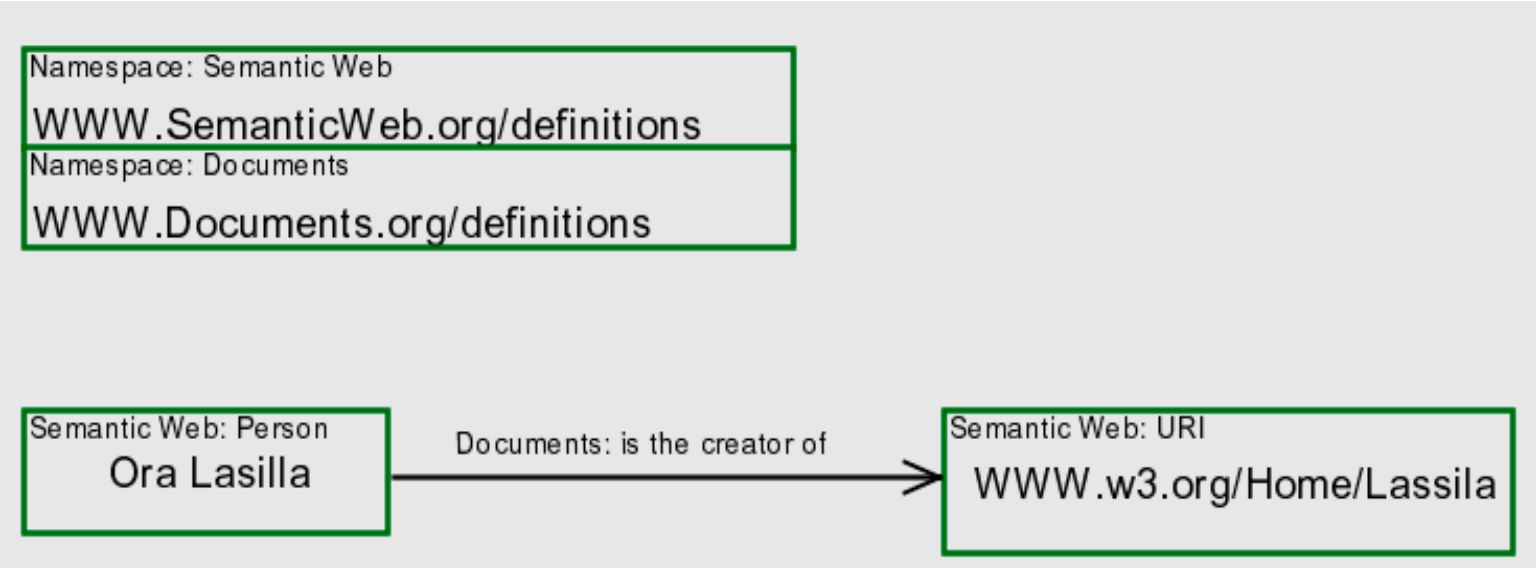
The namespace **Semantic Web** defines the class **Person.**
The namespace **Semantic Web** defines the class **URL.**

(Class definition sentences)

The namespace **Documents** defines the relation **'is the creator of'.**

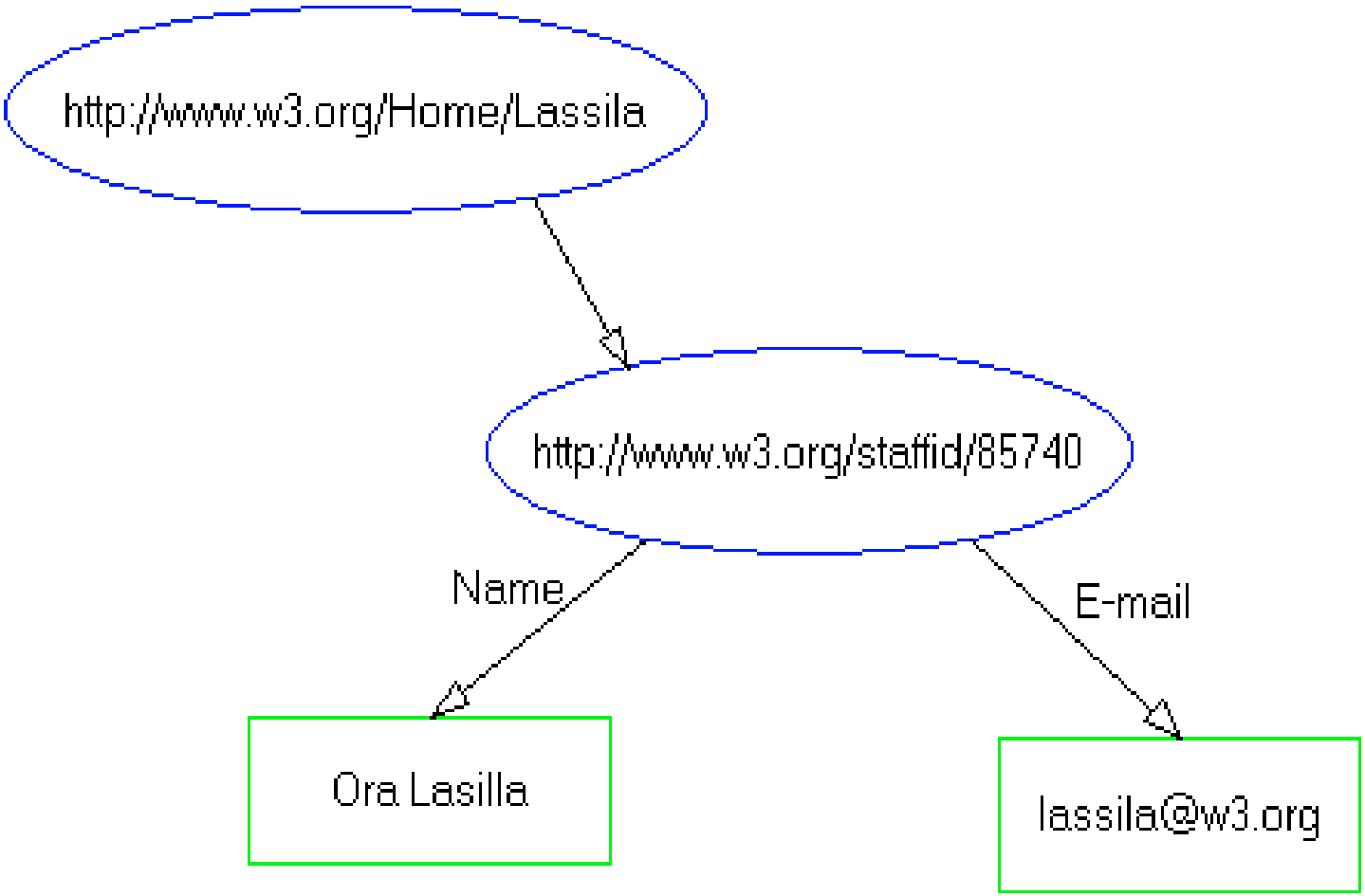
(Relation definition sentence)

Default Namespace Specification



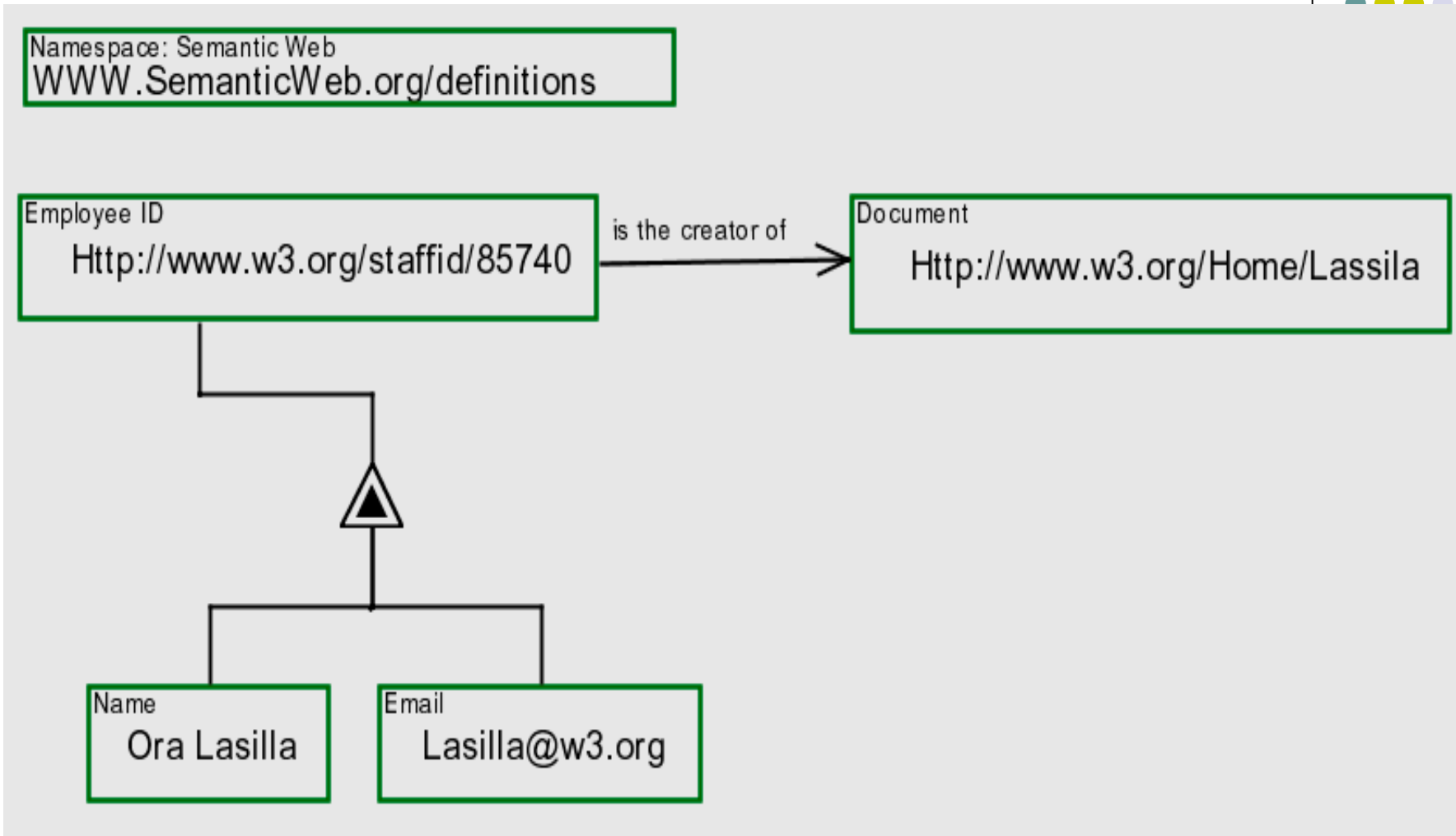
The default namespace **Semantic Web** is at WWW.SemanticWeb.org/definitions**.**
The namespace **Documents** is at WWW.Documents.org/definitions**.**
The namespace **Documents** defines the relation **'is the creator of'.**
The **Person Ora Lasilla is the creator of** the **URI** WWW.w3.org/Home/Lassila**.**

Adding Attributes



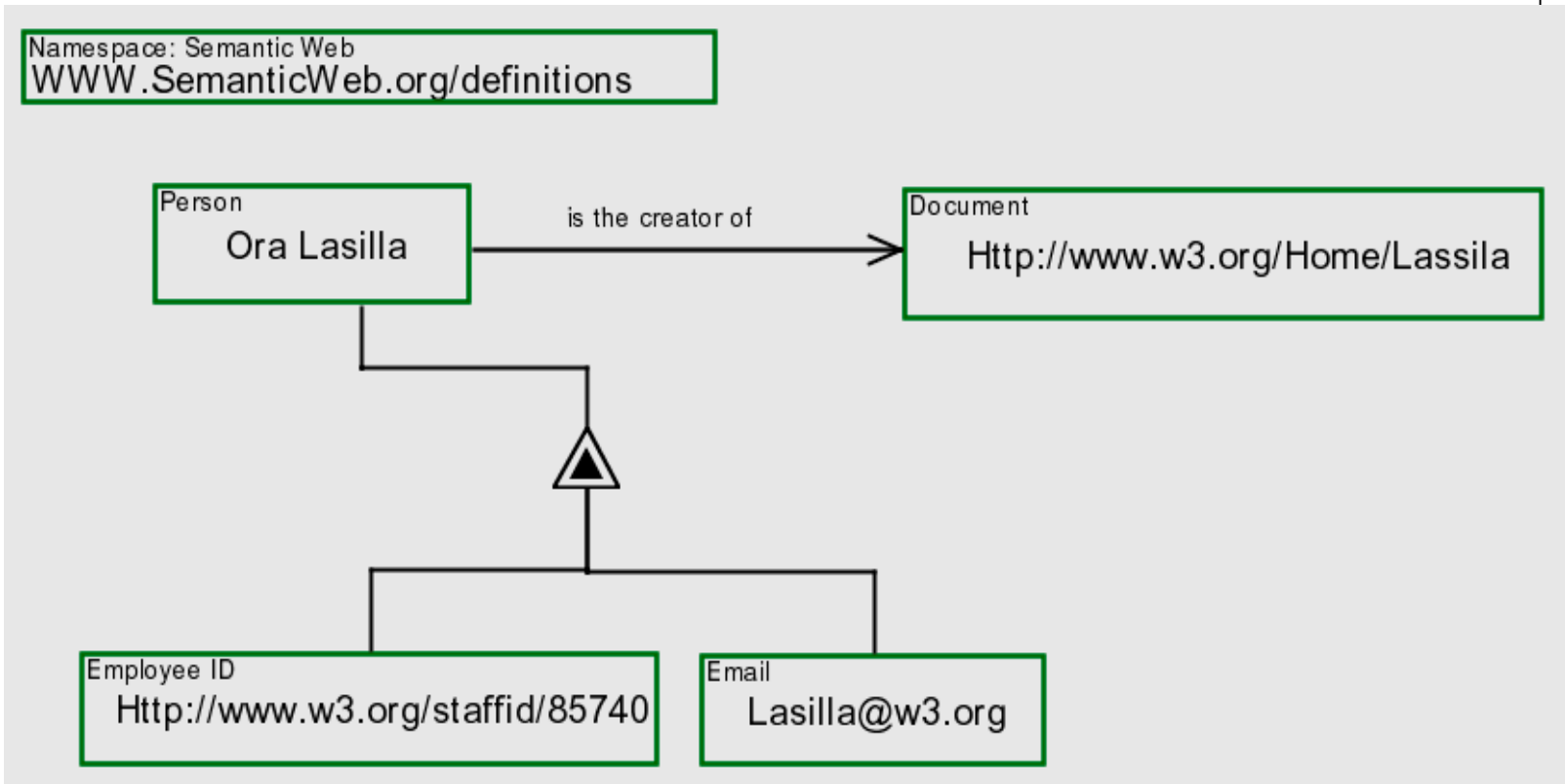
An identified property with structured value

Adding Attributes



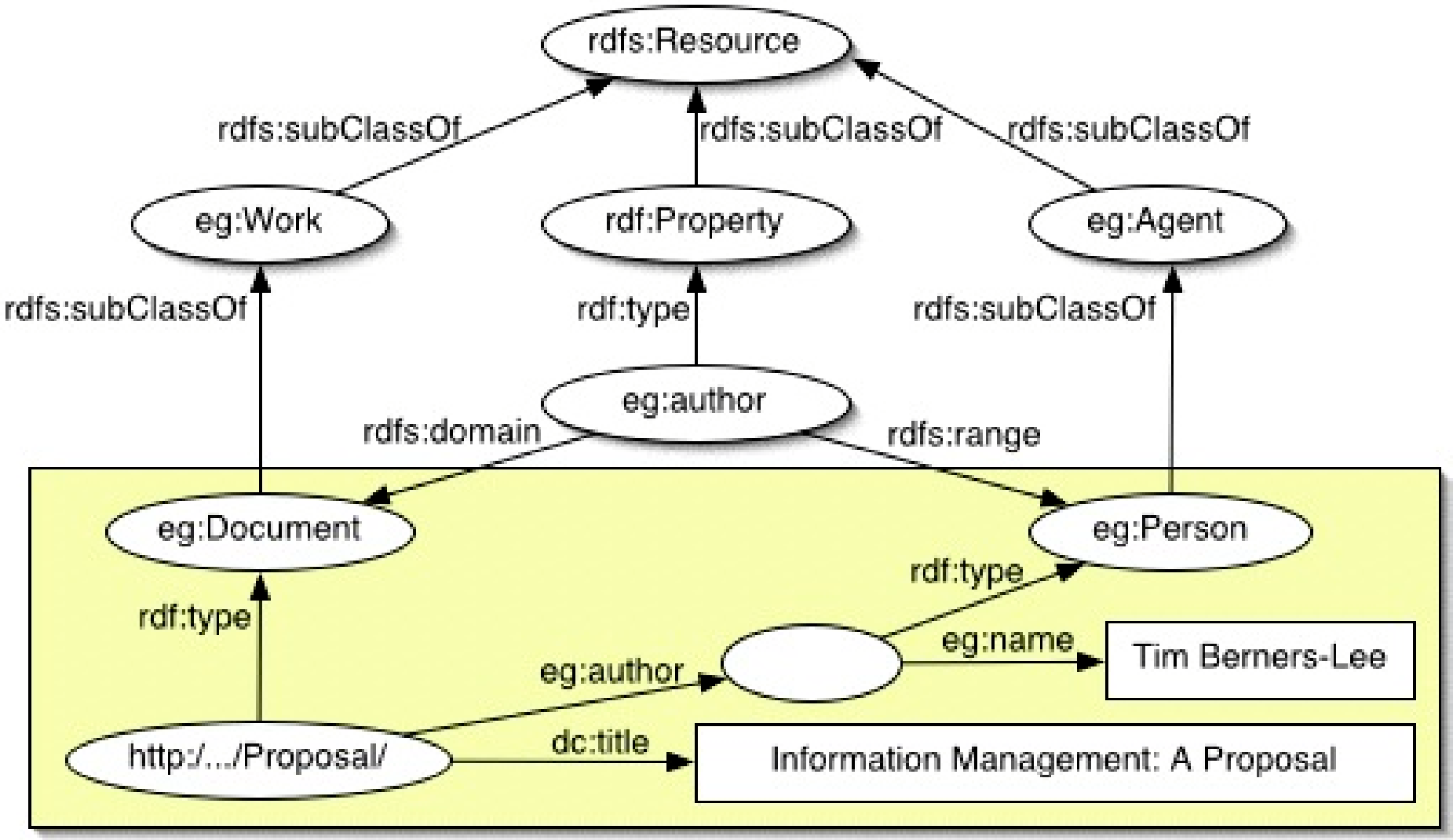
The corresponding OPD

A better representation

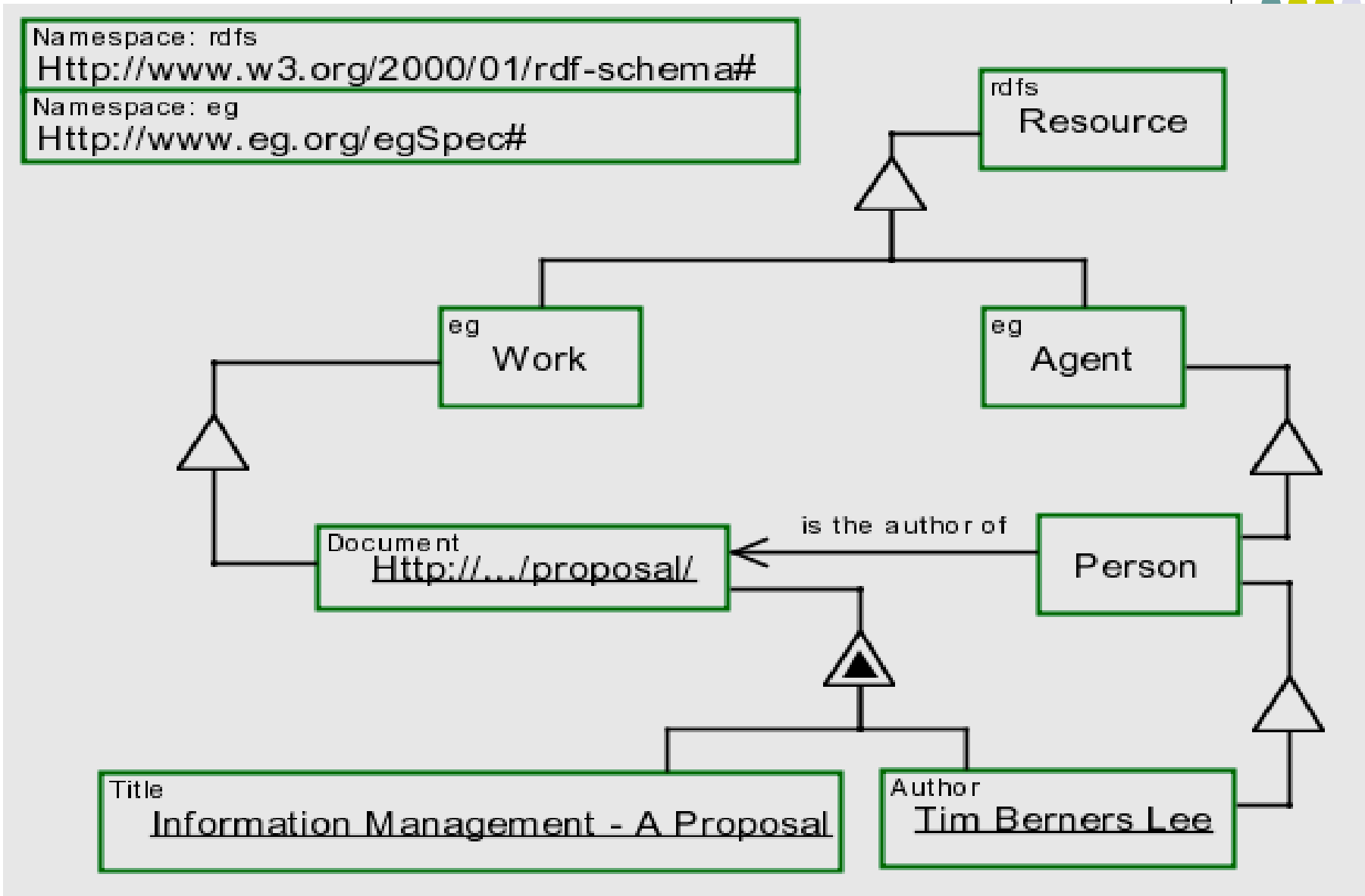


The default namespace **Semantic Web** is at WWW.SemanticWeb.org/definitions.
The **Person Ora Lasilla is the creator of** the **Document** WWW.w3.org/Home/Lassila.
The **Person Ora Lasilla** exhibits the **Employee ID** WWW.w3.org/staffid/85740 and the **Email** Lasilla@w3.org.

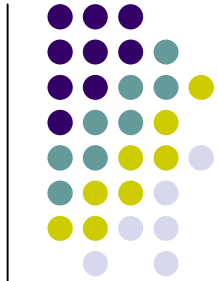
A final RDF and OPM example



A final RDF and OPM example



A final RDF and OPM example



The default namespace **rdfs** is at WWW.w3.org/2000/01/rdf-schema#.
The namespace **eg** is at WWW.eg.org/egSpecs#.
The namespace **eg** defines **Work** and **Agent.**
Work and **Agent** are **Resources.**
Document is a **Work.**
Person is an **Agent.**
Author is a **Person.**
Document exhibits **Author** and **Title.**
The **Document** Http://.../Proposal exhibits the **Author Tim Berners Lee** and the **Title Information Management – A Proposal.**

Advantages of the VisWeb Paradigm

- **Graphic-text knowledge representation:**
  - The powerful graphic-text bimodal representation of OPM is extended to the Visual Semantic Web paradigm.
  - Rather than mentally parsing cryptic XML scripts, knowledge is presented to the user in a subset of natural language as well as diagrammatically.
  - Puts to work the "two sides of the human brain," the visual and the lingual.

Advantages of the VisWeb Paradigm

- **Visual navigability:**
  - diagrammatic display enables users to surf and navigate the Web in a visual way in search for knowledge.
  - Objects, processes, classes and links can be hyperlinked to pertinent Web sites, which themselves may contain VSW or any other multimedia knowledge representations.

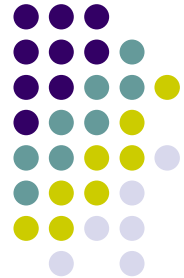
Advantages of the VisWeb Paradigm

- **Semantic sentence interpretation:**
  - the basis of the RDF framework is syntactic rather than semantic:
  - It draws on the concepts of *subject*, *predicate* and *object*, which are parts of speech used to analyze natural language sentences from a syntactic viewpoint.
  - The same semantics can be expressed by inverse syntactic expressions.
  - VisWeb is based on a sound ontology of *objects* with *states* and *processes*:

Advantages of the VisWeb Paradigm

- **Semantic sentence interpretation (cont.):**
  - VisWeb is based on a sound ontology of *objects* with *states* and *processes*:
  - Objects are things that exist, (possibly at some state)
  - Processes are things that happen to objects and transform them:
    - create or destroy them, or
    - change their state
  - Based on this ontology, sentences can be interpreted semantically rather than syntactically.

Advantages of the VisWeb Paradigm

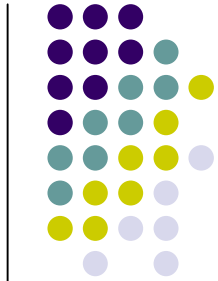


- **Specification of system dynamics:**
  - Current work on the Semantic Web places emphasis on declaratively specifying structural knowledge, which relates to the static aspect of systems.
  - A major part of the knowledge about a system is functional (what is its purpose) and dynamic (how it operates).
  - Since OPM combines function, structure, and behavior in the same bimodal model, it provides a sound infrastructure for representing system dynamics and function in the ViSWeb model.

Advantages of the VisWeb Paradigm

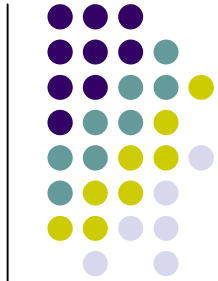
- **Complexity management:**
  - A major problem in real-life systems is their complexity due to the sheer amount of knowledge details.
  - OPM has built in abstraction-refinement mechanisms, including in-zooming and out-zooming, unfolding and folding, and state expression and suppression.
  - These provide for building hierarchies of knowledge representation in general and over the Web in particular, enabling navigation up and down abstraction-refinement hierarchies.

Summary



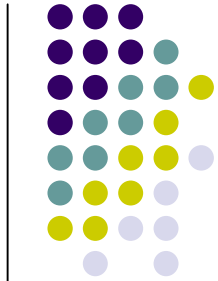
- The Visual Semantic Web (VisWeb) paradigm proposes to unify human and machine representations of knowledge.
- The foundation for this unification is OPM.
- OPM advocates the integration of a system's structure and behavior is a single, graphic and textual model.
- Like OPM, the VisWeb model enables the representation of static and dynamic knowledge.

Summary 2



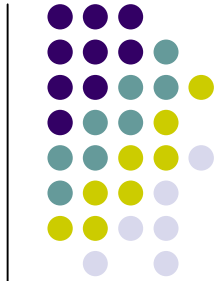
- VisWeb uses a combination of Object-Process Language (OPL), a subset of English, and Object-Process Diagrams (OPDs), an equivalent visual formalism.
- The advantages of this approach:
  - graphic-text knowledge representation,
  - visual navigability,
  - semantic sentence interpretation,
  - specification of system dynamics, and
  - complexity management.
  - As noted in [7], "It is also important to understand that this XML syntax is only one possible syntax for

Summary 3



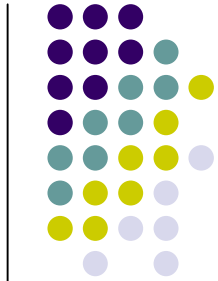
- As noted in W3C RDF Documentation
- *"It is also important to understand that this XML syntax is only one possible syntax for RDF and that alternate ways to represent the same RDF data model may emerge."*
- Indeed, the OPM-based approach to representing the Semantic Web on top of the RDF data model, is expressed
  - graphically, using OPDs, and
  - textually in Object-Process Language

Future Work – Theoretical



- Proceed in both the theoretical and practical paths.
- The theory will focus on extending the idea behind the VisWeb paradigm to other knowledge and system representation aspects.
- VisWeb should be able to also handle procedural, dynamic behavioral aspects, as well as functional ones.

Future Work – Practical



- The practical work will augment the current capabilities of OPCAT so it can
  - model the various VisWeb requirements
  - provide the services of bi-directional RDF-VSW compilation.
- Design and build a Web crawler which will automatically generate VSW representations of knowledge stored in Web pages.
- Accomplishing even some of these goals will greatly benefit the huge World Wide Web user community.