

ConceptBase Tutorial II: Metamodeling

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2012-10-04

1 Introduction

This tutorial extends the first tutorial by examples on metamodeling, i.e. to scenarios where you define objects, classes, and meta classes. Metamodeling is particularly useful in situations where you need to define your own modeling languages (domain-specific languages). You will see that you can use the ConceptBase query language to analyze the models created in your dedicated modeling languages and that it is rather easy to define simple modeling languages. Solutions to the exercises are at the end of this tutorial.

2 The Scenario

We start with a simple version of entity-relationship diagrams. First, we will define entity types and relationship types (meta classes). Then, define an example entity-relationship diagram (classes) plus some example data (objects).

In the next part, we add a simple process language to the existing entity-relationship language. We are interested in analyzing process models. In particular, we want to check whether one agent is responsible for two tasks t1 and t2, and there is a task t on the path between t1 and t2 that is assigned to another agent.

2.1 Start ConceptBase

There are several methods to start the ConceptBase server and its user interface CBIva. We decide for the simplest way: start the ConceptBase server from within CBIva. So, switch to the directory to which ConceptBase is installed on your computer and start the ConceptBase.cc user interface CBiva:

```
cbiva
```

Figure ?? shows the CBIva window just after starting it. The red label "Disconnected" at the lower left corner indicates that the user interface is not yet connected to a ConceptBase server. To do so, select the option "Start CBserver" of the "File" menu. CBIva will now ask you for some startup parameters of the CBserver as shown in figure ??.

Leave the parameters unchanged. The setting "Update Mode" is preset with the value "nonpersistent". That means that the ConceptBase server will not permanently store the definitions that you enter later. This is just fine for this tutorial. See the ConceptBase manual for more details.

2.2 Define a simple Entity-Relationship notation

Exercise 1: The task is to define two classes `EntityType` and `RelationshipType`. The class `RelationshipType` shall have an attribute `role` with value `EntityType`.

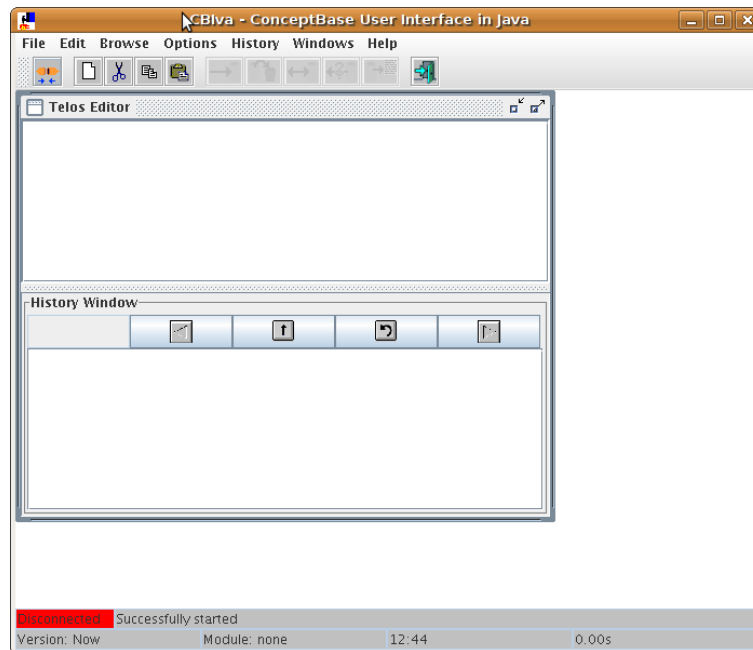


Figure 1: CBIva just after starting it

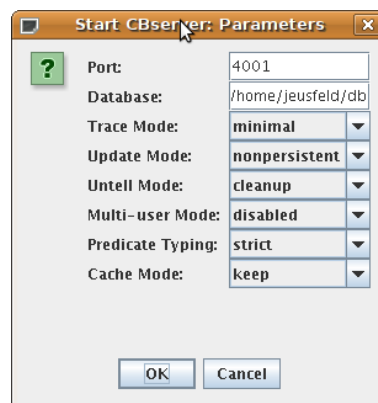


Figure 2: CBserver start parameters

Enter the definitions into the *Telos Editor* window and store them to the ConceptBase server with the "Tell" function.

Exercise 2: *Add to `EntityType` an attribute `attr` with value `Domain`. Also define `Domain` as an object without attributes.*

This provides us with a very simple entity-relationship language. It just allows to define entity types with attributes, and relationship types with role links. Entity attributes are restricted to domains. So we need to specify the allowed domains.

Exercise 3: *Specify `Integer` and `String` as domains, i.e. as instances of the class `Domain`.*

The classes `Integer` and `String` are predefined in `ConceptBase`. Any integer number occurring in an object definition will automatically be an instance of `Integer`. Likewise any double-quoted string will be regarded as an instance of `String`.

Exercise 4: Specify a new domain `Date`. Include `"2009-05-19"` and `"2001-01-01"` as two possible values for dates.

The object `Date` is not predefined in `ConceptBase`. Hence, we need to take care ourselves about the set of possible values (=instances of `Date`).

After these exercises, you can visualize the current state with the graph editor. Use `RelationshipType` as start object. The graph editor is started from `CBIva` via the menu item `"Browse / Graph Editor"`. Expand the outgoing attributes of `RelationshipType` (right mouse button) and select `"Show all"`. Do the same with `EntityType`. For `Domain`, show the instances. For `Date`, show the instances as well.

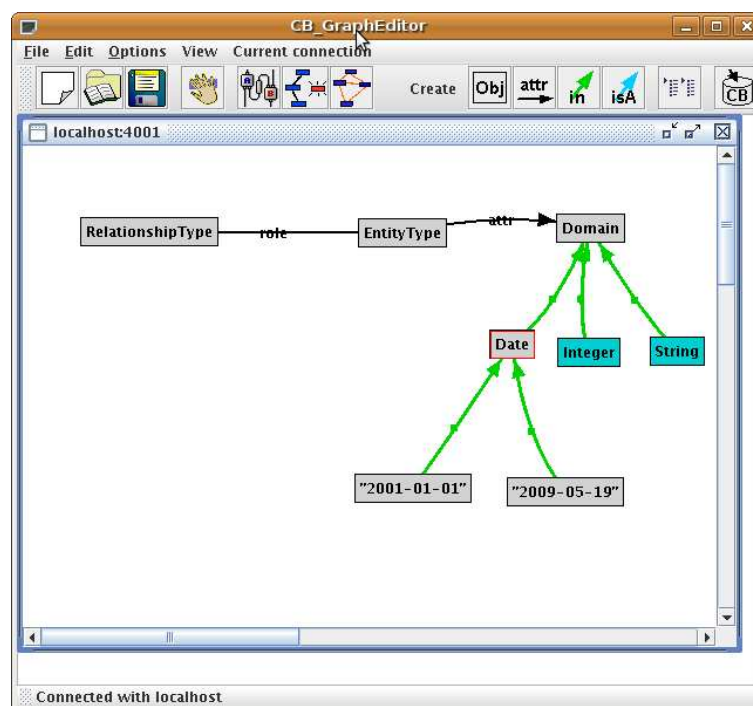


Figure 3: Graphical display of the ER language

The graph window shows already three abstraction levels: the objects `"2009-05-19"` and `"2001-01-01"` are at the lowest abstraction level (data level). The objects `Date`, `Integer`, and `String` are classes (model level), and the objects `RelationshipType`, `EntityType`, and `Domain` are meta classes (notation level).

2.3 Define an Entity-Relationship model

Exercise 5: Specify an example *ER* diagram for an insurance scenario. An insurance policy has a customer, a premium, a start date, and an end date. Customers have names and addresses. A claim has a description and is referring to an insurance policy.

Figure ?? graphically displays the insurance model. ConceptBase can also assign dedicated graphical symbols to certain objects, e.g. diamond shapes to relationship types. We skip this feature in this tutorial and refer you to the user manual for more details on this.

The green links are instantiations. Hence the insurance model is one abstraction level below the ER language.

2.4 Enter data for the insurance model

Exercise 6: Enter data objects for the following facts. Customer `mary` signed an insurance policy with start date "2009-05-19" (no end date). The premium is 1000.

The display of the data objects in figure ?? completes all three abstraction levels (meta classes, classes, data objects).

2.5 Define a process modeling notation

Process models can be used to denote workflows, business processes, and algorithms. We are in particular interested in a process modeling notation that allows us to analyze process models for certain patterns. Before we start defining the notation, we define the *transitivity construct* that shall be useful subsequently for defining the pattern.

```

Proposition in Class with
  attribute
    transitive: Proposition
  rule
    trans_R: $ forall x,y,z,R/VAR
      AC/Proposition!transitive C/Proposition
      P(AC,C,R,C) and (x in C) and (y in C) and (z in C) and
      A_e(x,R,y) and (y R z) ==> (x R z) $
end

```

The predicate `A_e(x, R, y)` is true if there is an explicit attribute between objects `x` and `y` that has the category `R`.

Exercise 7: Define a process notation that allows tasks to be defined. Tasks can have successor tasks. Agents execute tasks. The successor relation shall be transitive.

The process modeling notation is very simple but it has the ability to represent very complex workflows. Let now distinguish start statements and predicate statements.

Exercise 8: A start statement is a task that has no predecessor (no task has a start statement as successor). A predicate statement is a task that has more than one successor. Define these concepts as query classes.

You can define end statements in a similar way. A more tricky concept is the following.

Exercise 9 (difficult): Define the concept of a loop task, i.e. a task that is part of a loop. The name of the query shall be `LoopTask`.

There can be several loops inside a process model. Loops can also be nested, i.e. a task can be member of several loops. Note that the regular attribution predicate $(t1 \text{ successor } t2)$ is closed under transitivity!

Now that we have defined loops, let us tackle the pattern "agent with split responsibility".

Exercise 10 (difficult): Assume that an agent A is responsible for tasks $t1$ and $t2$ in a process model but there is a task t between $t1$ and $t2$ that is executed by another agent. This matches situations where an agent does some work, then passes control to another agent, and afterwards resumes control. Define this patterns as a query class named `AgentWithSplitResponsibility` that returns agents with split responsibility.

2.6 Define an example process model

Recall the insurance scenario. Now we need to represent a workflow in this domain with our newly defined process modeling notation.

Exercise 11: Claim handling starts with an insurance agent receiving the claim. Afterwards, the policy is checked. Afterwards, either a payment is proposed or an assessor is assigned. The assessor assesses the damage. On that basis, the insurance agent proposes a payment. After proposing the payment, we either can continue with processing the payment (customers accepts the proposal), or we need to iterate i.e. check again the policy and possibly repropose a new payment. The workflow is finished after processing the payment.

Exercise 12: Ask the two queries `LoopTask` and `AgentWithSplitResponsibility`.

You can also visualize the results of the queries by the graph editor. The example process model together with the classification to the two query classes is shown in figure ??.

The dotted green links are derived instantiations. So, an object that is in the answer set of a query class is regarded as a derived instance of that query class. Indeed, query classes are classes where the instances are derived via the membership condition of the query class.

2.7 Link the two notations

We have created two simple notations, one for data modeling and the second for process modeling. Now let us combine these two. The most natural way appears to regard object types (entity types and relationship types) as possible inputs and outputs of tasks in a process model.

Exercise 13: Define a new construct `ObjectType` that generalizes `EntityType` and `RelationshipType`.

So, this was easy. We now can link the two notations via `ObjectType`.

Exercise 14: Define object type as possible input/output of tasks in process models.

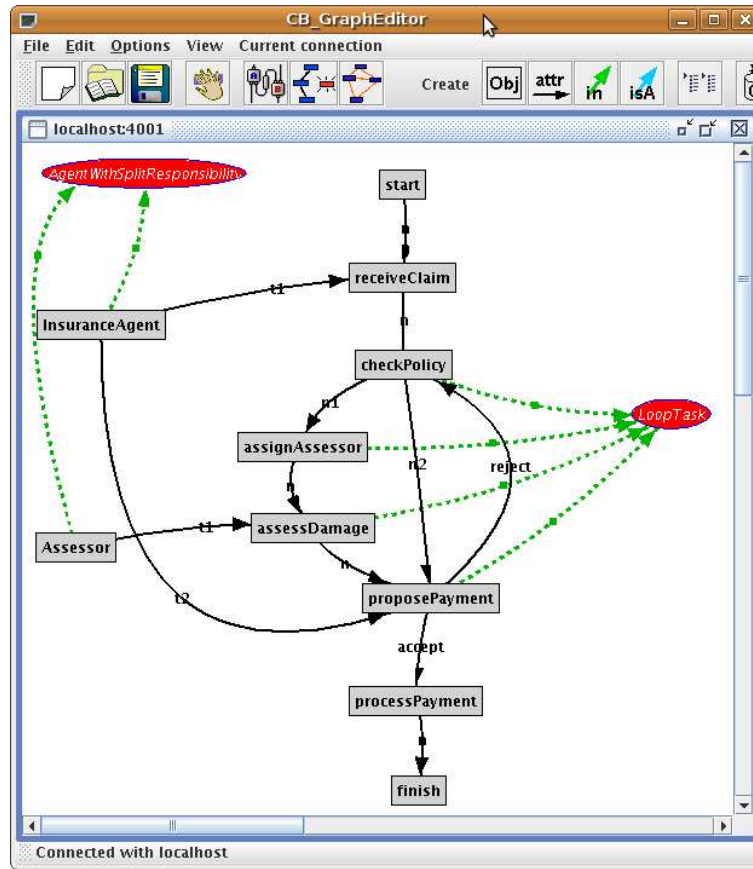


Figure 4: Classifying a process model via query classes

Attributes in ConceptBase are by default multi-valued, ie. they can have zero, one or many values. This is exactly what we want in this case.

We finalize this tutorial by attaching some objects types as input/output of tasks.

Exercise 15: Define some of the object types of exercise 5 as input/output of the process model of exercise 11.

3 Conclusions

In this tutorial, we defined two simple notations, one for data modeling, another for process modeling. We defined queries to analyze process models for non-trivial patterns, building on a newly defined construct for transitivity. We created example models for both notations. Finally, we linked the two notations to form an integrated method for data and process modeling.

The two notations were both very simple. For example, the ER notation lacks cardinalities of role links. The process modeling notation cannot represent parallel splits. Adding the missing construct would not require too much effort. The interested reader is referred to the CB-Forum (<http://conceptbase.sourceforge.net/CB-Forum.html>) for extended examples.

4 Solutions to the Exercises

Exercise 1

```
EntityType end

RelationshipType with
  attribute
    role: EntityType
end
```

Exercise 2

```
EntityType with
  attribute
    attr: Domain
end
```

```
Domain end
```

Exercise 3

```
Integer in Domain end
String in Domain end
```

Exercise 4

```
Date in Domain end
"2009-05-19" in Date end
"2001-01-01" in Date end
```

Exercise 5

```
Customer in EntityType with
  attr
    name: String;
    address: String
end
```

```
Policy in EntityType with
  attr
    startdate: Date;
    enddate: Date;
    premium: Integer
end
```

```

holds in RelationshipType with
  role
    customer: Customer;
    policy: Policy
end

Claim in EntityType with
  attr
    description: String
end

claim_policy in RelationshipType with
  role
    claim: Claim;
    policy: Policy
end

```

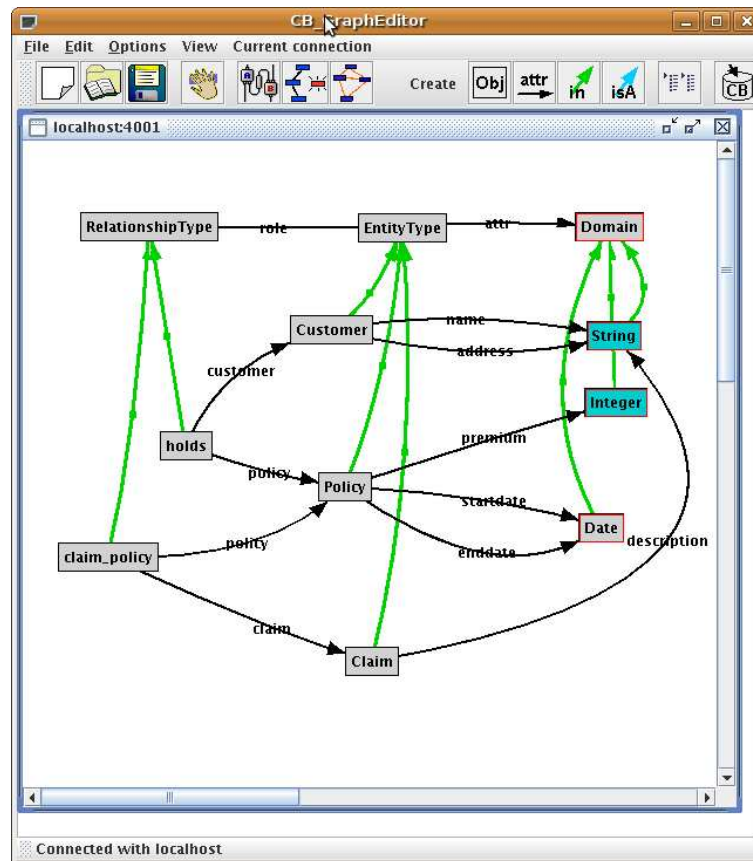


Figure 5: The insurance model as instantiation of the ER language

Exercise 6

```
mary in Customer end
policy1 in Policy with
  startdate d: "2009-05-19"
  premium p: 1000
end
```

```
holds1 in holds with
  customer c: mary
  policy p: policy1
end
```

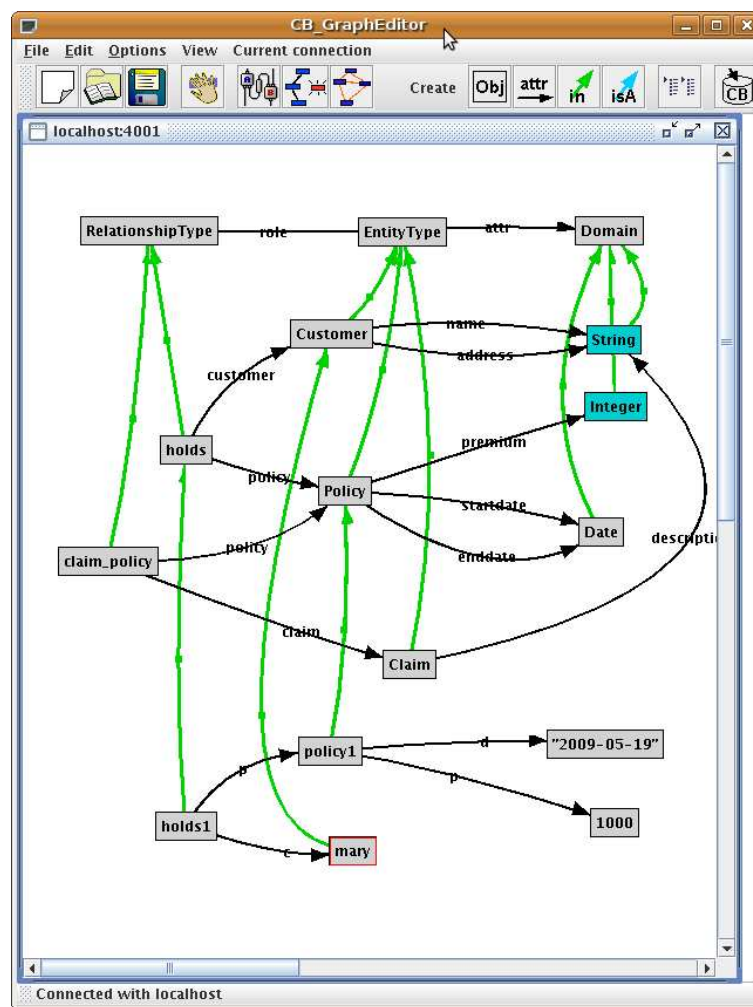


Figure 6: Sample data for the insurance model

Exercise 7

```
Task with
  attribute,transitive
  successor: Task
end
```

```
Agent with
  attribute
  executes: Task
end
```

Exercise 8

```
StartStatement in QueryClass isA Task with
  constraint
  c1: $ not exists t/Task (t successor this) $
end
```

```
PredicateTask in QueryClass isA Task with
  constraint
  c1: $ exists s1,s2/Task A_e(this,successor,s1) and
      A_e(this,successor,s2) and (s1 \= s2) $
end
```

Exercise 9

```
LoopTaskOf in GenericQueryClass isA Task with
  parameter
  rep: Task
  constraint
  c: $ (this successor rep) and (rep successor this) and
      (exists s/Task A_e(rep,successor,s) and (s successor rep)) $
end
```

```
LoopTask in QueryClass isA LoopTaskOf
end
```

The parameter `rep` in the first query stands a representative of a loop. Note that there may be many loops inside a process model and we would like to be able to query, which tasks belong to the same loop. The second query just returns all loop statements regardless of the representative. It is sufficient to leave out a value for parameter `rep` in this case.

Exercise 10

```
AgentWithSplitResponsibility in QueryClass isA Agent with
  constraint
    c1: $ exists t1,t2,t/Task a/Agent (this executes t1) and
        (this executes t2) and (t1 successor t) and
        (t successor t2) and (a executes t) and (a \= this)$
end
```

The condition (a \= this) makes sure that the middle task t is executed by a different agent.

Exercise 11

```
start in Task with
  successor
    n: receiveClaim
end

receiveClaim in Task with
  successor
    n: checkPolicy
end

checkPolicy in Task with
  successor
    n1: assignAssessor;
    n2: proposePayment
end

assignAssessor in Task with
  successor
    n: assessDamage
end

assessDamage in Task with
  successor
    n: proposePayment
end

proposePayment in Task with
  successor
    accept: processPayment;
    reject: checkPolicy
end

processPayment in Task with
  successor
    n: finish
end

finish in Task end
```

```

Assessor in Agent with
    executes
        t1: assessDamage
end

InsuranceAgent in Agent with
    executes
        t1: receiveClaim;
        t2: proposePayment
end

```

Exercise 12

The answer to LoopTask is checkPolicy, assignAssessor, assessDamage, proposePayment. The answer to AgentWithSplitResponsibility is InsuranceAgent, Assessor. Note that the task assessDamage is in a loop with proposePayment. Hence, a sequence assessDamage-proposePayment-checkPolicy-assignAssessor-assessDamage is possible and is the reason to classify both agents into the query class AgentWithSplitResponsibility.

Exercise 13

```

ObjectType end
EntityType isA ObjectType end
RelationshipType isA ObjectType end

```

Exercise 14

```

Task with
    attribute
        input: ObjectType;
        output: ObjectType
end

```

Exercise 15

```

receiveClaim with
    output o1: Claim
end

checkPolicy with
    input i1: claim_policy
end

```