I1-D5

XML Code Generation Component for the I1 Rule Modeling Tool

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Abstract
In this technical report we describe the XML code generation component for the rule modeling tool Strelka. The component implementation is based on the compositional mapping from the URML metamodel into R2ML XML markup. We define a mapping function for derivation, production and reaction rules.

Keyword List
Rules, URML, R2ML, Rule Markup Language, Semantic Web, Rule Interchange

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XML Code Generation Component for the I1 Rule Modeling Tool

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September 22, 2006

Abstract
In this technical report we describe the XML code generation component for the rule modeling tool Strelka. The component implementation is based on the compositional mapping from the URML metamodel into R2ML XML markup. We define a mapping function for derivation, production and reaction rules.

Keyword List
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Chapter 1

Introduction

The rule modeling tool Strelka ([3], [2]), developed in the REWERSE Working Group I1, supports modeling of derivation rules, production rules and reaction rules. The modeling approach is based on the UML-based Rule Modeling Language (URML) [1]. In order to support rules deployment into different rule engines, rules validation and rules interchange, we have implemented a code generation component for Strelka. The component serializes URML models into the REWERSE I1 Rule Markup Language (R2ML) [1]. R2ML is a general purpose rule markup language, which has an XML concrete syntax and serves as an interchange format between different rule languages.

The code generation is based on the compositional mapping, defined for URML metamodel into R2ML XML markup.

Chapter 2

Compositional Mapping of Derivation Rules

The general rules metamodel is depicted in Figure 2.1.

Let $DR = DerivationRule(RuleID(id), Cond(c_1), ..., Cond(c_n), Concl(con))$ be a URML derivation rule with an identifier *id*, conditions $c_1, ..., c_n$ and a conclusion *con*. We define a mapping function M for URML derivation rules as follows:
$M(DR) =$

```
<r2ml:DerivationRule r2ml:ruleID=id>
 <r2ml:conditions>
```

$M(c_1)$ ... $M(c_n)$

```
 <r2ml:conditions>
 <r2ml:conclusion>
```

$M(con)$

```
 </r2ml:conclusion>
</r2ml:DerivationRule>
```

Here and in the following definitions of M we insert values from the URML abstract syntax into the R2ML XML. For instance, in the above definition, $Rule(id)$ means that id is an identifier (a value) and in the corresponding R2ML markup `<r2ml:DerivationRule r2ml:ruleID=id>` it is inserted as a value of the `r2ml:ruleID` attribute.

2.1 Conditions

URML has three condition types (Figure 2.2):

- classification condition;
- association condition;

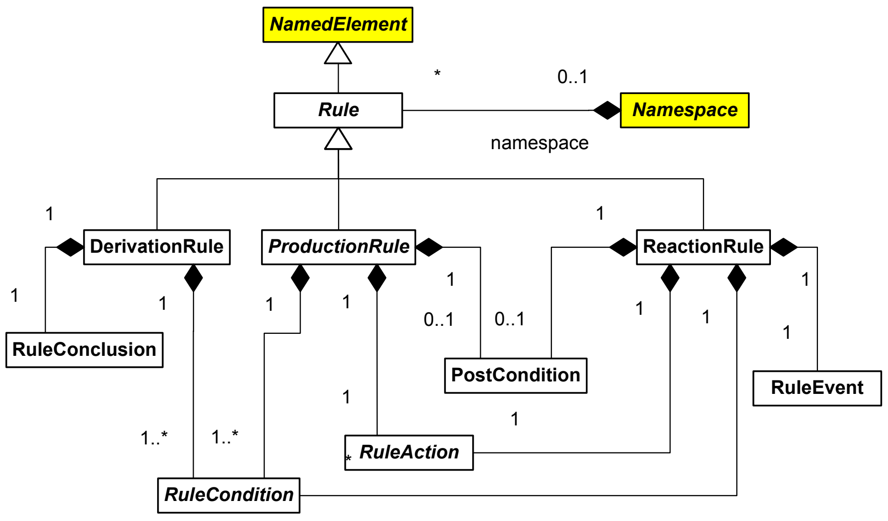

Figure 2.1: General Rules Metamodel

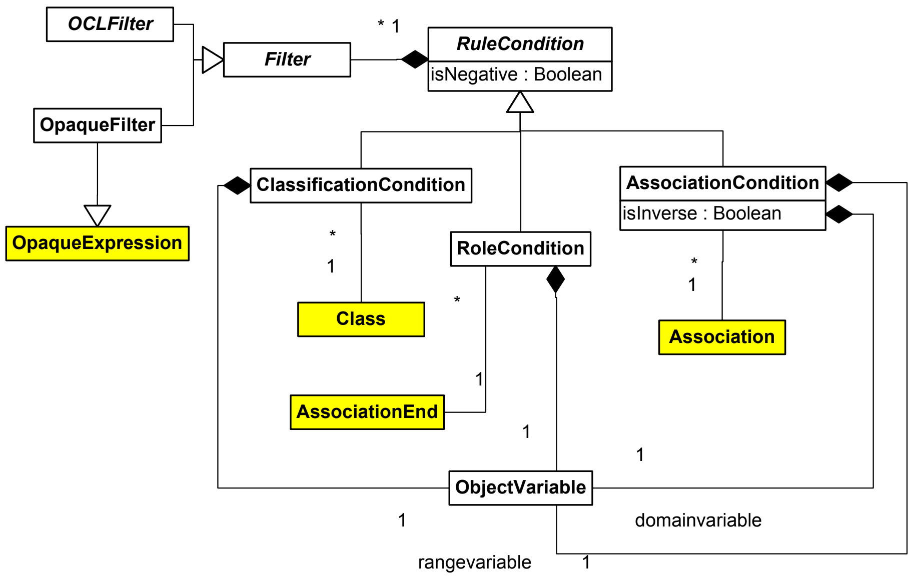

Figure 2.2: Rule Condition Metamodel

- role condition.

Each URML condition refers to a condition classifier, which is either a UML class, UML association end, or UML association, and consists of filter expressions. We defined a mapping function M case-wise for each type of URML condition.

2.1.1 Classification Condition

Let $CC = cond(Class(c), ObjVar(v), Filter(f), isNegative(b))$ be a URML classification condition with c as a UML class, v as an object variable of class c, f as a filter and $b \in \{true, false\}$.
$M(CC) =$

```
<r2ml:ObjectClassificationAtom r2ml:classID=c r2ml:isNegated=b>
 <r2ml:ObjectVariable r2ml:name=v/>
</r2ml:ObjectClassificationAtom>
```

$M(f)$

2.1.2 Association Condition

Let $AC = cond(Assoc(a, dc, rc), DomainVar(dv), RangeVar(rv), Filter(f), isNegative(b))$ be a URML association condition with a as a UML association and dc, rc as domain and range classes correspondingly, dv as a domain variable, rv as a range variable, f as a filter and $b \in \{true, false\}$.
$M(AC) =$

```
<r2ml:AssociationAtom r2ml:associationPredicateID=a r2ml:isNegated=b>
 <r2ml:objectArguments>
  <r2ml:ObjectVariable r2ml:name=dv r2ml:classID=dc/>
  <r2ml:ObjectVariable r2ml:name=rv r2ml:classID=rc/>
 </r2ml:objectArguments>
</r2ml:AssociationAtom>
```

$M(f)$

2.1.3 Role Condition

Let $RC = cond(Property(a), ObjVar(v), Filter(f), isNegative(b))$ be a URML role condition with a as a UML property, which denotes an association end, v as a property object variable of the association end class, f as filters and $b \in \{true, false\}$.
Such URML condition is mapped into R2ML ReferencePropertyAtom. Since the subject variable in such condition is existentially quantified and do not appear in the rule conclusion, it is not specified in the URML role condition, but generated automatically by the code generator. We assume, that the variable "sv" in the XML below is generated by the code generator.
$M(RC) =$

```
<r2ml:ReferencePropertyAtom r2ml:referencePropertyID=a r2ml:isNegated=b>
 <r2ml:subject>
  <r2ml:ObjectVariable r2ml:name=sv/>
 </r2ml:subject>
```

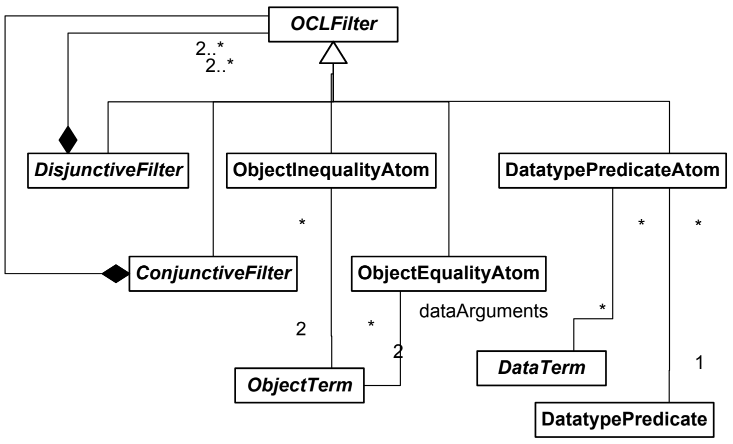

Figure 2.3: Filters Metamodel

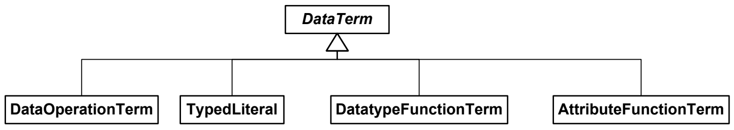

Figure 2.4: Data terms, supported in URML

```
 <r2ml:object>
  <r2ml:ObjectVariable r2ml:name=v/>
 </r2ml:object>
</r2ml:ReferencePropertyAtom>
```

$M(f)$

2.2 Filters

URML filters are used in rule conditions in order to filter instances of a condition classifier. The filters metamodel is depicted in Figure 2.3 This metamodel uses some term and atom concepts, which are presented in the R2ML as well. URML uses OCL-like syntax in order to express filters, which may contain terms and atoms, while R2ML uses XML syntax to represent these terms and atoms. In this section we describe terms and atoms, which can be used in URML filters. The definitions of terms and atoms by means of MOF/UML are provided in [1].

2.2.1 Data Terms

The following terms are allowed in URML filter expressions: TypedLiteral, DatatypeFunction-Term, AttributeFunctionTerm, DataOperationTerm (Figure 2.4).

2.2.1.1 TypedLiteral

URML TypedLiteral (integer, string, boolean, float) are mapped into R2ML TypedLiteral. Let $C = \mathit{TypedLiteral}(\mathit{DataType}(d), \mathit{LexVal}(v))$ be a typed literal with data type d and lexical value v.
$M(C) =$

```
 <r2ml:TypedLiteral r2ml:datatypeID=d r2ml:lexicalValue=v />
```

2.2.1.2 DatatypeFunctionTerm

The list of currently supported URML datatype functions is "+", "-", "*", "/". Let $DTF = \mathit{DatatypeFunctionTerm}(\mathit{Func}(p), \mathit{Arg}(a_1), ..., \mathit{Arg}(a_n))$ be a URML datatype function term with p as an datatype function and data terms $a_1, ..., a_n$ as arguments.
$M(DTF) =$

```
<r2ml:DatatypeFunctionTerm r2ml:datatypeFunctionID=p>
 <r2ml:dataArguments>
```

$M(a_1)$ ... $M(a_n)$

```
 </r2ml:dataArguments>
</r2ml:DatatypeFunctionTerm>
```

2.2.1.3 AttributeFunctionTerm

Let $AFT = \mathit{AttributeFunctionTerm}(\mathit{Attr}(a), \mathit{ContextVar}(v), \mathit{ContextClass}(c))$ be an attribute function term a with v as a context variable and c as a context class.
$M(AFT) =$

```
<r2ml:AttributeFunctionTerm r2ml:attributeID=a>
  <r2ml:contextArgument>
   <r2ml:ObjectVariable r2ml:name=v r2ml:classID=c/>
  </r2ml:contextArgument>
</r2ml:AttributeFunctionTerm>
```

2.2.1.4 DataOperationTerm

Let $DOT = \mathit{DataOperationTerm}(\mathit{Oper}(o), \mathit{ContextVar}(v), \mathit{ContextClass}(c), \mathit{Arg}(a_1), ..., \mathit{Arg}(a_n))$ be a data operation term o with v as a context variable, c as a context class and $a_1, ..., a_n$ as a data and object term arguments.
$M(AFT) =$

```
<r2ml:DataOperationTerm r2ml:operationID=o>
 <r2ml:contextArgument>
  <r2ml:ObjectVariable r2ml:name=v r2ml:classID=c>
 </r2ml:contextArgument>
 <r2ml:arguments>
```

$M(a_1)...M(a_n)$

```
 </r2ml:arguments>
</r2ml:DataOperationTerm>
```

2.2.2 Object Terms

URML supports three types of object terms: ObjectVariable, ReferencePropertyFunctionTerm and ObjectOperationTerm. These terms are defined in [1].

2.2.2.1 ObjectVariable

Let $OV = ObjectVariable(Name(v), Class(c))$ be an object variable with v as a name and c as a class id.
$M(OV) =$

```
<r2ml:ObjectVariable r2ml:name=v r2ml:classID=c/>
```

2.2.2.2 ReferencePropertyFunctionTerm

Let $RPA = ReferencePropertyFunctionTerm(Prop(p), Context(o))$ be a reference property atom with p as a reference property and an object term o as a context argument.
$M(RPA) =$

```
<r2ml:ReferencePropertyFunctionTerm r2ml:referencePropertyID=p>
 <r2ml:contextArgument>
```

M(o)

```
 </r2ml:contextArgument>
</r2ml:ReferencePropertyFunctionTerm>
```

2.2.2.3 ObjectOperationTerm

Let $OOT = ObjectOperationTerm(Oper(o), ContextVar(v), ContextClass(c), Arg(a_1), ..., Arg(a_n))$ be an object operation term o with v as a context variable, c as a context class and $a_1, ..., a_n$ as data and object term arguments.
$M(OOT) =$

```
<r2ml:ObjectOperationTerm r2ml:operationID=o>
 <r2ml:contextArgument>
  <r2ml:ObjectVariable r2ml:name=v r2ml:classID=c>
 </r2ml:contextArgument>
 <r2ml:arguments>
```

$M(a_1)...M(a_n)$

```
 </r2ml:arguments>
</r2ml:ObjectOperationTerm>
```

2.2.3 Datatype Predicate Atom

The list of currently supported datatype predicates is "<", ">", "<=", "=>", "<>", "=".
Let $BPA = DatatypePredicateAtom(Pred(p), Arg(a_1), ..., Arg(a_n), isNegated(b))$ be a URML datatype predicate atom with p as a predicate, data terms $a_1, ..., a_n$ as arguments and $b \in \{true, false\}$. $M(BPA) =$

```
<r2ml:DatatypePredicateAtom r2ml:datatypePredicateID=p
        r2ml:isNegated=b>
 <r2ml:dataArguments>
```

$M(a_1)...M(a_n)$

```
 </r2ml:dataArguments>
</r2ml:DatatypePredicateAtom>
```

2.2.4 Object Equality and Inequality Atoms

URML supports equality and inequality atoms in order to compare object terms. Let $OEA = ObjectEqualityAtom(ObjTerm(a_1), ObjTerm(a_2))$ be an object equality atom with two object terms a_1 and a_2.
$M(OEA) =$

```
<r2ml:EqualityAtom>
```

$M(a_1)$ $M(a_2)$

```
</r2ml:EqualityAtom>
```

Let $OIA = ObjectInequalityAtom(ObjTerm(a_1), ObjTerm(a_2))$ be an object inequality atom with two object terms a_1 and a_2.
$M(OIA) =$

```
<r2ml:InequalityAtom>
```

$M(a_1)$ $M(a_2)$

```
</r2ml:InequalityAtom>
```

2.2.5 Disjunctive Filter

Let $DF = Filter(f_1)or...orFilter(f_n)$ be a URML disjunctive filter.
$M(DF) =$

```
<r2ml:qf.Disjunction>
```

$M(f_1)...M(f_n)$

```
</r2ml:qf.Disjunction>
```

2.2.6 Conjunctive Filter

Let $CF = Filter(f_1)and...andFilter(f_n)$ be a URML conjunctive filter.
$M(CF) =$

```
<r2ml:qf.Conjunction>
```

$M(f_1)...M(f_n)$

```
</r2ml:qf.Conjunction>
```

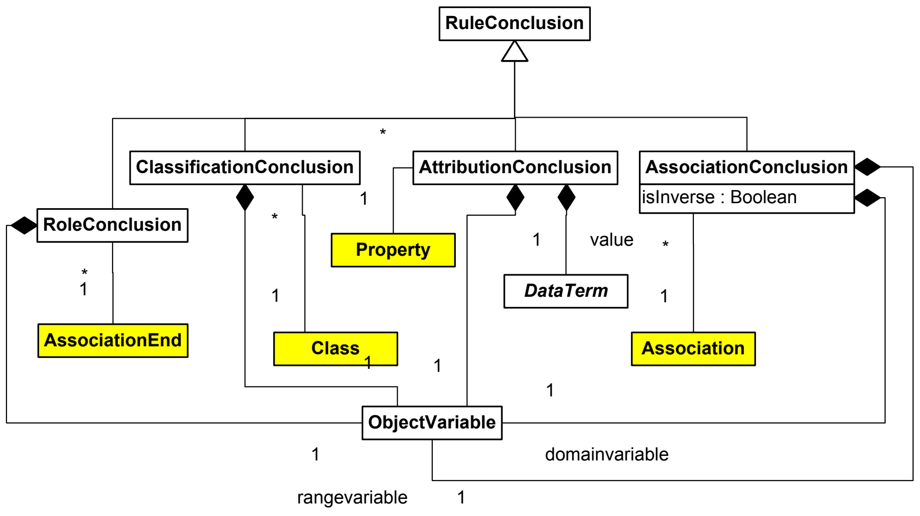

Figure 2.5: Rule Conclusion Metamodel

2.3 Derivation Rule Conclusion

URML supports three conclusion types:

- classification conclusion;
- association conclusion.
- role conclusion;
- attribution conclusion;

Each URML conclusion refers to a conclusion classifier, which is either a UML class, UML association end, UML association, or UML property (Figure 2.5). We define a mapping function M case-wise for each type of URML conclusion.

2.3.1 Classification Conclusion

Let $CC = concl(Class(c), Var(v))$ be a URML classification conclusion with c as a UML class and v as an object variable.
$M(CC) =$

```
<r2ml:ObjectClassificationAtom r2ml:classID=c>
 <r2ml:ObjectVariable r2ml:name=v/>
</r2ml:ObjectClassificationAtom>
```

2.3.2 Association Conclusion

Let $AC = concl(Assoc(a, dc, rc), DomainVar(dv), RangeVar(rv))$ be a URML association conclusion with a as a UML association and dc, rc as domain and range classes correspondingly,

dv as a domain variable, rv as a range variable.
$M(AC) =$

```
<r2ml:AssociationAtom r2ml:associationPredicateID=a>
 <r2ml:objectArguments>
  <r2ml:ObjectVariable r2ml:name=dv r2ml:classID=dc/>
  <r2ml:ObjectVariable r2ml:name=rv r2ml:classID=rc/>
 </r2ml:objectArguments>
</r2ml:AssociationAtom>
```

2.3.3 Role Conclusion

Let $RC = concl(Property(a), SubjVar(sv), ObjVar(ov))$ be a URML role conclusion with a as a UML property, sv as a subject variable and ov as an object variable.
$M(RC) =$

```
<r2ml:ReferencePropertyAtom r2ml:referencePropertyID=a>
 <r2ml:subject>
  <r2ml:ObjectVariable r2ml:name=sv/>
 </r2ml:subject>
 <r2ml:object>
  <r2ml:ObjectVariable r2ml:name=ov/>
 </r2ml:object>
</r2ml:ReferencePropertyAtom>
```

2.3.4 Attribution Conclusion

Let $AttrC = concl(Prop(p), Var(v), Value(u))$ be a URML attribution conclusion with p as a UML property, object term v as a subject and data term u as a property value.
$M(AttrC) =$

```
<r2ml:AttributionAtom r2ml:attributeID=p>
 <r2ml:subject>
```

$M(v)$

```
</r2ml:subject>
 <r2ml:dataValue>
```

$M(u)$

```
 </r2ml:dataValue>
</r2ml:ReferencePropertyAtom>
```

The mapping functions $M(v)$ and $M(u)$ for the property value data term is defined in Section 2.2.1.

Chapter 3

Production Rules

Let $PR = ProductionRule(RuleID(id), Cond(c_1), ..., Cond(c_n), Action(a), Postcond(pcond))$ be a URML production rule with an identifier id, conditions $c_1, ..., c_n$, a produced action a and postcondition $pcond$. We define a mapping function M for URML production rules as follows: $M(PR) =$

```
<r2ml:ProductionRule r2ml:ruleID=id>
 <r2ml:conditions>
```

$M(c_1)$ ... $M(c_n)$

```
 <r2ml:conditions>
 <r2ml:producedAction>
```

$M(a)$

```
 </r2ml:producedAction>
 <r2ml:postCondition>
```

$M(pcond)$

```
 <r2ml:postCondition>
</r2ml:ProductionRule>
```

Mapping function for conditions is defined in Section 2.1. The mapping function for a postcondition is similar to the mapping function for a condition.

3.1 Production Rule Actions

URML supports four action types: assign action, create action, delete action, and invoke action. The action metamodel is depicted in Figure 3.1.

We define a mapping function M case-wise for all action types.

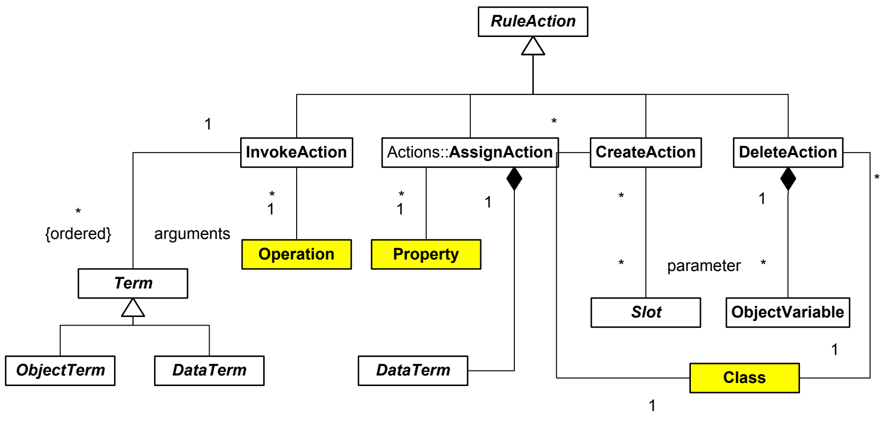

Figure 3.1: Actions Metamodel

3.1.1 Assign Action

Let $AA = AssignAction(Prop(p, o), Value(v))$ be an assign action with p as a property of object o and data term v as a property value.
$M(AA) =$

```
<r2ml:AssignActionExpression r2ml:propertyID=p>
 <r2ml:contextArgument>
  <r2ml:ObjectVariable r2ml:name=o/>
 </r2ml:contextArgument>
```

$M(v)$

```
</r2ml:AssignActionExpression>
```

The mapping $M(v)$ is the same as for attribution conclusion of derivation rules and is defined in Section 2.2.1.

3.1.2 Create Action

Let $CA = CreateAction(Class(c), Slot(s_1), ..., Slot(s_n))$ be a create action with c as a class of the created object and $s_1, ..., s_n$ is a list of slots as parameters.
$M(CA)$=

```
<r2ml:CreateActionExpression r2ml:classID=c>
```

$M(s_1)...M(s_n)$

```
</r2ml:CreateActionExpression>
```

Let $S = Slot(Attr(a), Val(v))$ be a slot with a as an attribute name and term v as a value for the attribute a. The mapping function $M(S) =$

```
<r2ml:DataSlot r2ml:attributeID=a>
 <r2ml:value>
```

$M(v)$

```
 </r2ml:value>
</r2ml:DataSlot>
```

The mapping function $M(v)$, where v is a term, is defined in Section 2.2.1.

3.1.3 Invoke Action

Let $IA = \mathit{InvokeAction}(Oper(o, v), Arg(a_1), ..., Arg(a_n))$ be an invoke action with o as an operation on object v and $a_1, ..., a_n$ a list of terms as operation arguments.
$M(IA)$=

```
<r2ml:InvokeActionExpression r2ml:operationID=o>
 <r2ml:contextArgument>
  <r2ml:ObjectVariable r2ml:name=v/>
 </r2ml:contextArgument>
 <r2ml:arguments>
```

$M(a_1)...M(a_n)$

```
 </r2ml:arguments>
</r2ml:InvokeActionExpression>
```

The mapping function M for arguments is defined in Section 2.2.1.

3.1.4 Delete Action

Let $DA = \mathit{DeleteAction}(Class(c), Var(v))$ be a delete action with c as a class and v as a variable, denoting the object to be deleted.
$M(DA)$=

```
<r2ml:DeleteActionExpression r2ml:classID=c>
 <r2ml:contextArgument>
  <r2ml:ObjectVariable r2ml:name=v/>
 </r2ml:contextArgument>
</r2ml:DeleteActionExpression>
```

Chapter 4

Reaction Rules

Let $RR = ReactionRule(RuleID(id), Event(e), Cond(c_1), ..., Cond(c_n), Action(a), Pcond(p))$ be a URML reaction rule with an identifier id, triggering event e, conditions $c_1, ..., c_n$, a produced action a and a postcondition p. We define a mapping function M for a URML reaction rule as follows:
$M(RR) =$

```
<r2ml:ReactionRule r2ml:ruleID=id>
 <r2ml:triggeringEvent>
```

$M(e)$

```
 </r2ml:triggeringEvent>
 <r2ml:conditions>
```

$M(c_1)$ ... $M(c_n)$

```
 </r2ml:conditions>
 <r2ml:producedAction>
```

$M(a)$

```
 </r2ml:producedAction>
 <r2ml:postCondition>
```

$M(p)$

```
 </r2ml:postCondition>
</r2ml:ReactionRule>
```

The mapping function for URML events is not defined yet since the work on reaction rules metamodel for URML and R2ML is still in progress. The mapping function $M(p)$ for postcondition is defined, as well as the mapping function for conditions, in Section 2.1.

Chapter 5

Mapping Example

Let's consider a derivation rule, which URML model, depicted in Figure 5.1:

> If the reservation date of the rental is five days before the start date of the rental then give discount 10 on the rental.

This rule as an instance of rule metamodel is depicted in Figure 5.2.

5.1 Mapping Derivation Rule

Let's use the mapping function M, defined in the previous chapters in order to obtain R2ML XML. Metamodel diagram objects are denoted by their role names and we use these role names in path expressions as parameters to the transformation M.
$M(id1) =$

```
<r2ml:DerivationRule r2ml:ruleID="id1">
 <r2ml:condition>
```

$M(id1.condition)$

```
 <r2ml:conditions>
 <r2ml:conclusion>
```

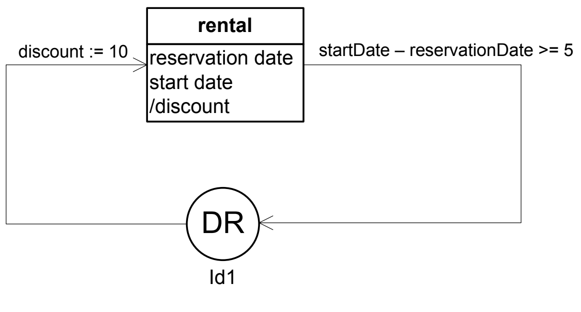

Figure 5.1: Sample Derivation Rule

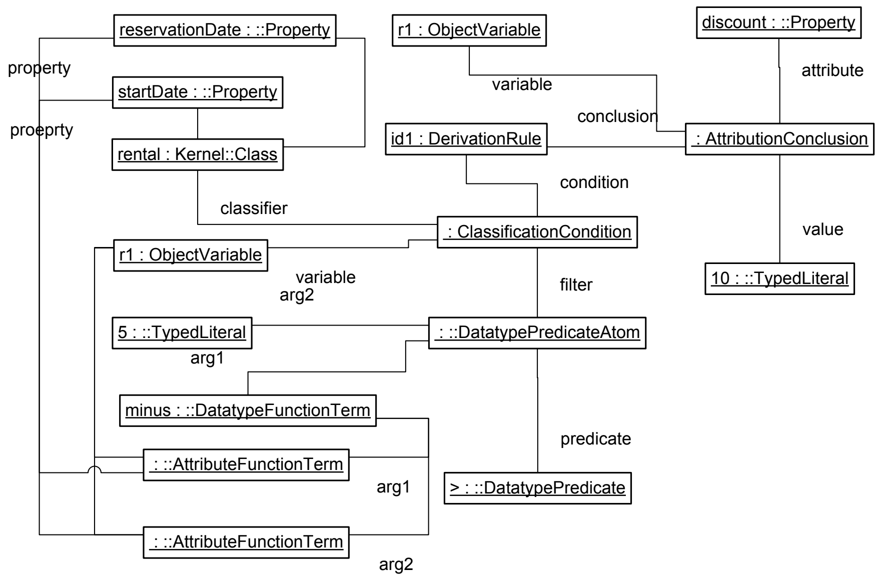

Figure 5.2: Rule Metamodel Instance

$M(id1.conclusion)$

```
 </r2ml:conclusion>
</r2ml:DerivationRule>
```

5.1.1 Condition mapping

$M(id1.condition) =$

```
<r2ml:ObjectClassificationAtom r2ml:classID="rental"
                               r2ml:isNegated="false">
 <r2ml:ObjectVariable r2ml:name="r1"/>
</r2ml:ObjectClassificationAtom>
```

$M(id1.condition.filter)$

5.1.1.1 Condition filter as a DatatypePredicateAtom

$M(id1.condition.filter) =$

```
<r2ml:DatatypePredicateAtom
      r2ml:datatypePredicateID="swrlb:greaterThan"
      r2ml:isNegated="false">
 <r2ml:dataArguments>
```

$M(id1.condition.filter.arg1)$ $M(id1.condition.filter.arg2)$

```
 <r2ml:dataArguments>
</r2ml:DatatypePredicateAtom>
```

$M(id1.condition.filter.arg2) =$

```
<r2ml:TypedLiteral r2ml:datatypeID="xs:integer" r2ml:lexicalValue="5">
```

5.1.1.2 Mapping DatatypeFunctionTerm

The DatatypeFunctionTerm in this rule consists of two AttributeFunctionTerm's.
$M(id1.condition.filter.arg1) =$

```
<r2ml:DatatypeFunctionTerm r2ml:datatypeFunctionID="swrlb:substract">
 <r2ml:dataArguments>
```

$M(id1.condition.filter.arg1.arg1)$ $M(id1.condition.filter.arg1.arg2)$

```
 </r2ml:dataArguments>
</r2ml:DatatypeFunctionTerm>
```

$M(id1.condition.filter.arg1.arg1) =$

```
<r2ml:AttributeFunctionTerm r2ml:attributeID="startDate">
 <r2ml:contextArgument>
  <r2ml:ObjectVariable r2ml:name="r1"/>
 </r2ml:contextArgument>
</r2ml:AttributeFunctionTerm>
```

$M(id1.condition.filter.arg1.arg2) =$

```
<r2ml:AttributeFunctionTerm r2ml:attributeID="reservationDate">
 <r2ml:contextArgument>
  <r2ml:ObjectVariable r2ml:name="r1"/>
 </r2ml:contextArgument>
</r2ml:AttributeFunctionTerm>
```

5.1.2 Conclusion mapping example

$M(id1.conclusion) =$

```
<r2ml:AttributionAtom r2ml:attributeID="discount">
 <r2ml:subject>
  <r2ml:ObjectVariable r2ml:name="r1"/>
 </r2ml:subject>
 <r2ml:dataValue>
  <r2ml:TypedLiteral r2ml:datatypeID="xs:integer" r2ml:lexicalValue="5">
 </r2ml:dataValue>
</r2ml:AttributionAtom>
```

5.2 Report Conclusion

In this technical report we have described a compositional mapping, which is used in the implementation of the code generation component for the rule modeling tool Strelka. We have demonstrated the mapping by means of an example. The further work on improvements is towards serialization of reaction rules, modeled with URML. The work on metamodel specification for the reaction rules in URML and R2ML is still in progress.

Bibliography

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