TECHNISCHE
UNIVERSITÄT
DRESDEN

Faculty of Computer Science Institute of Software- and Multimedia-Technology, Software Technology Group

MODEL AND OBJECT VERIFICATION

Use Cases of OCL and the Dresden OCL Toolkit

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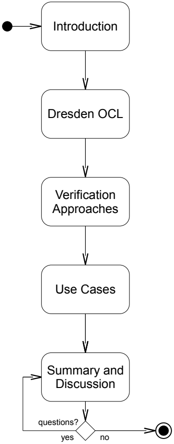
Dresden, Oct. 15th 2009

Overview

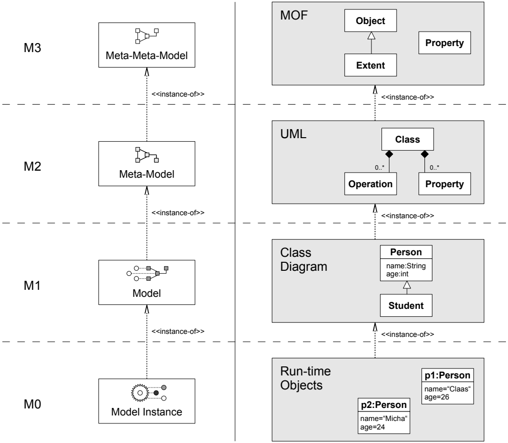
- Introduction
- Dresden OCL Toolkit
- Verification Approaches
  - Interpretative Approach
  - Generative Approach
- OCL Use Cases
  - Interpretative Use Cases
  - Generative Use Cases
- Summary



Introduction

What is OCL?

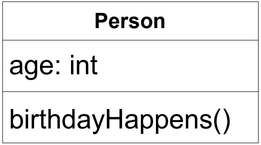
- Part of UML
- Additional Semantics
- Queries and Constraints
- On different MOF layers
- On different Meta-Models



Introduction

An Example

```
context Person
inv: self.age >= 0

context Person:birthdayHappens()
post: self.age = self.age@pre + 1

context Person
def isAdult: Boolean =
  if (age >= 18)
    then true
    else false
  endif
```



Person

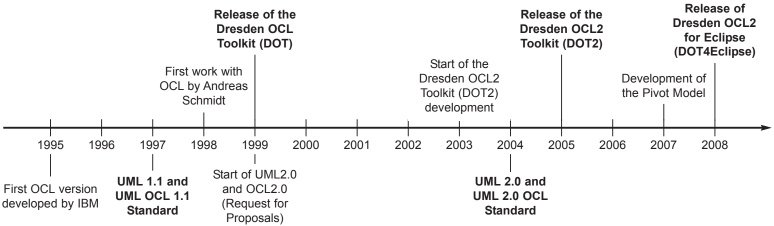
age: int

birthdayHappens()

Dresden OCL Toolkit

About the Project

- Started in 1999
- A toolkit to extend case tools with OCL
- `http://dresden-ocl.sourceforge.net/`



First OCL version developed by IBM

UML 1.1 and UML OCL 1.1 Standard

First work with OCL by Andreas Schmidt

Release of the Dresden OCL Toolkit (DOT)

Start of UML2.0 and OCL2.0 (Request for Proposals)

Start of the Dresden OCL2 Toolkit (DOT2) development

UML 2.0 and UML 2.0 OCL Standard

Release of the Dresden OCL2 Toolkit (DOT2)

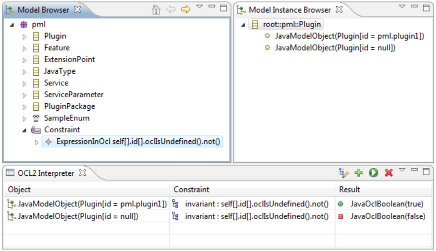
Development of the Pivot Model

Release of Dresden OCL2 for Eclipse (DOT4Eclipse)

Dresden OCL Toolkit

Dresden OCL2 for Eclipse

- Developed since 2007
- Meta-Model independent (Based on a Pivot Model)
- **Supported Meta-Models:**
  - EMF Ecore
  - Eclipse MDT UML2
  - Java
- **Provided Tools:**
  - OCL2 Parser
  - OCL2 Interpreter
  - OCL2toJava Code Generator
  - Meta-Model Adapter Generator



Model Browser

- pml
  - Plugin
  - Feature
  - ExtensionPoint
  - JavaType
  - Service
  - ServiceParameter
  - PluginPackage
  - SampleEnum
  - Constraint
    - ExpressionInOcl self[].id[].oclIsUndefined().not()

Model Instance Browser

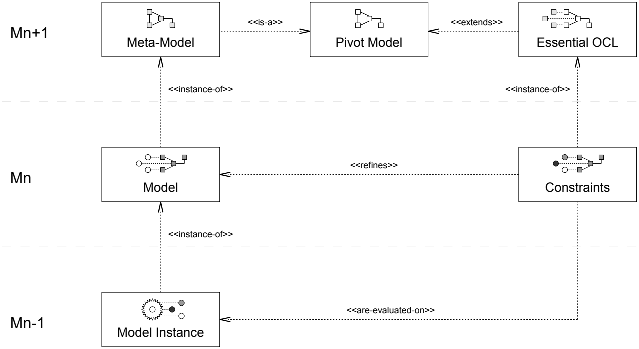
- root::pml::Plugin
  - JavaModelObject(Plugin[id = pml.plugin1])
  - JavaModelObject(Plugin[id = null])

OCL2 Interpreter

Object	Constraint	Result
JavaModelObject(Plugin[id = pml.plugin1])	invariant : self[].id[].oclIsUndefined().not()	● JavaOclBoolean(true)
JavaModelObject(Plugin[id = null])	invariant : self[].id[].oclIsUndefined().not()	■ JavaOclBoolean(false)

Dresden OCL Toolkit

The Generic Three Layer Metadata Architecture



Verification Approaches

Two different approaches exists:

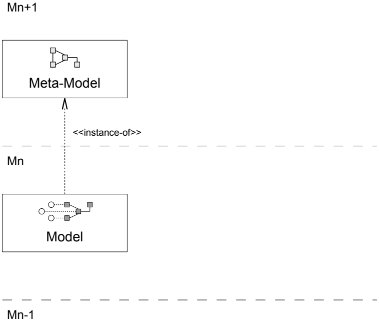
1. **Interpretative Approach**
   - Verification by interpretation

2. **Generative Approach**
   - Verification through generated check code

Verification Approaches

Interpretative Approach

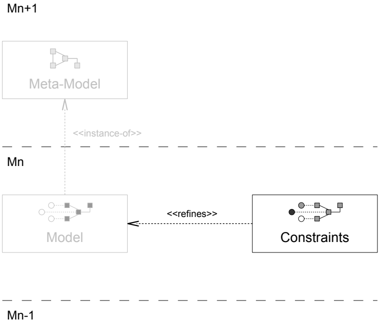
1. Modeling



Verification Approaches

Interpretative Approach

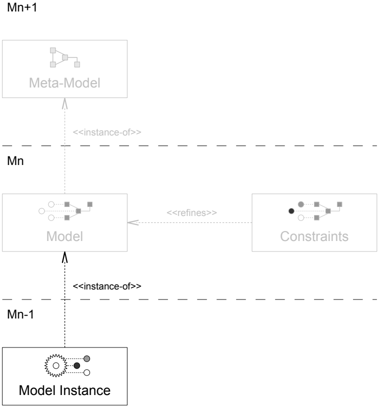
1. Modeling
2. Constraint specification



Verification Approaches

Interpretative Approach

1. Modeling
2. Constraint specification
3. Model Instance definition/generation

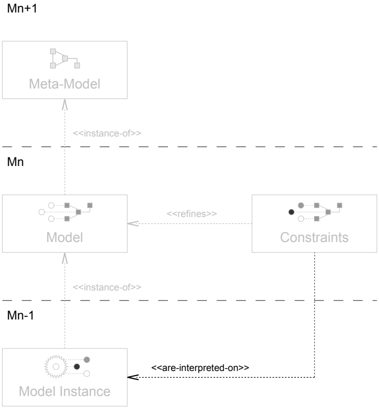


Verification Approaches

Interpretative Approach

1. Modeling
2. Constraint specification
3. Model Instance definition/generation
4. Interpretation

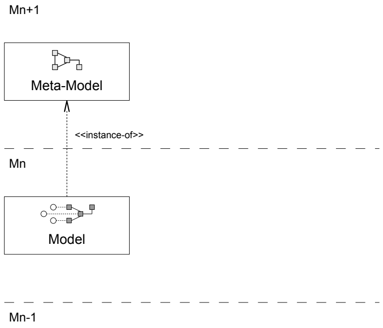
Verification is part of the Interpretative Approach



Verification Approaches

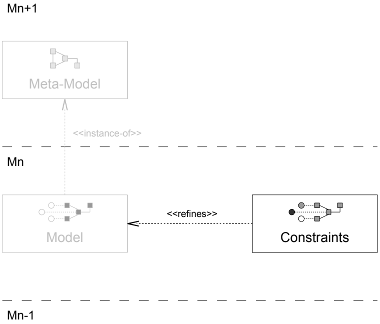
Generative Approach

1. Modeling



Verification Approaches

Generative Approach

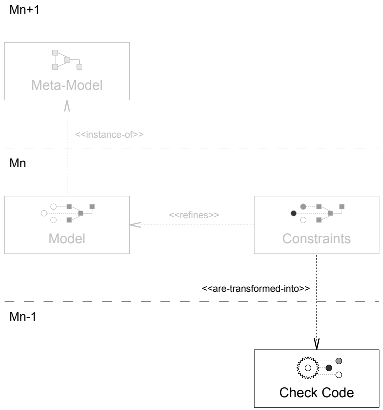


1. Modeling
2. Constraint specification

Verification Approaches

Generative Approach

1. Modeling
2. Constraint specification
3. Code generation

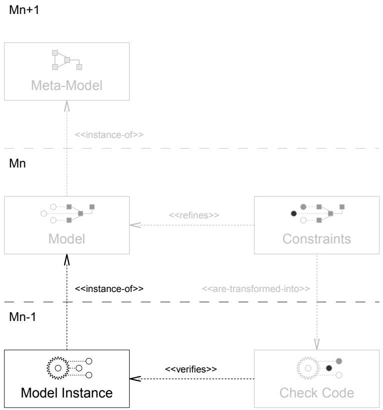


Verification Approaches

Generative Approach

1. Modeling
2. Constraint specification
3. Code generation

Execution and Verification are not part of the Generative Approach



OCL Use Cases

- **Interpretative Approaches**
  - Model Verification
  - Testing
  - Run-time (Object) Verification
  - Simulation/Animation
  - Querying
- **Generative Approaches**
  - Testing
  - Run-time (Object) Verification
  - Simulation/Animation
  - Model Transformation

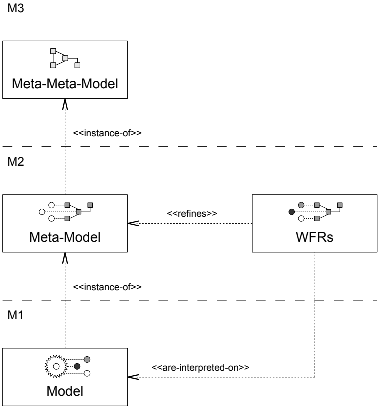
OCL Use Cases

- **Interpretative Approaches**
  - **Model Verification**
  - Testing
  - **Run-time (Object) Verification**
  - Simulation/Animation
  - **Querying**
- **Generative Approaches**
  - **Testing**
  - **Run-time (Object) Verification**
  - Simulation/Animation
  - Model Transformation

OCL Use Cases

Interpretative Approaches: Model Verification

- Constraints on Meta-Models
  - Well-Formedness Rules
  - Modeling Guide-Lines
- Interpretation/Verification of Models during Modeling

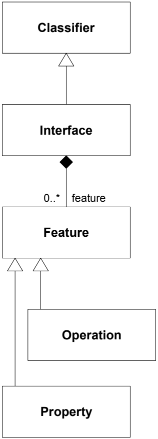


OCL Use Cases

Interpretative Approaches: Model Verification - WFRs and Modeling Guidelines in UML [OMG09]

```
context Interface
inv featuresArePublic:
self.feature
  ->forAll(f | f.visibility = #public)
```

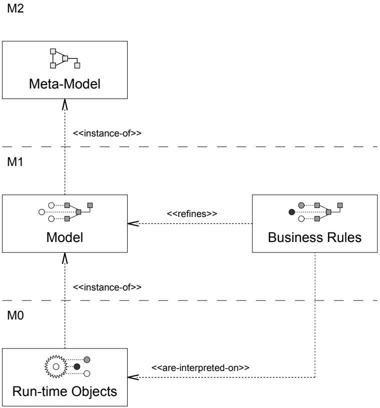
```
context Class
inv SingleInheritance:
   self.generalization->size()<=1
```



OCL Use Cases

Interpretative Approaches: Run-Time (Object) Verification

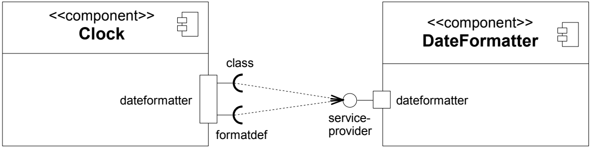
- Constraints are defined on a Model
- Interpretation/Verification of objects during run-time



OCL Use Cases

Interpretative Approaches: Run-Time (Object) Verification in Treaty [DJ08, Tre09]

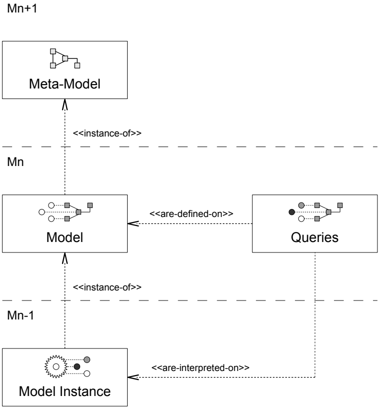
```
context DateFormatter::format(aDate: Date): String
post containsDay:
  let day: String = aDate.toString().substring(9, 10)
  in result.contains(day)
```



OCL Use Cases

Interpretative Approaches: Querying

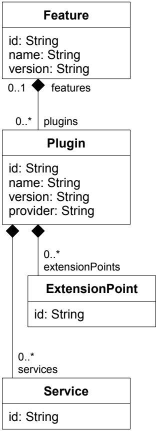
- Queries on Models or Meta-Models
- Interpreter queries on an instance of the Model or Meta-Model
- Collect invalid Objects
- Compute Model Metrics



OCL Use Cases

Interpretative Approaches: Querying non-well-formed Model Objects in a PML model [Brä07]

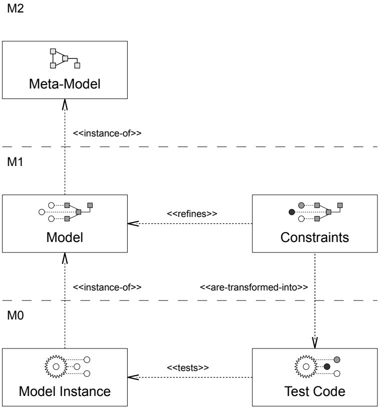
```
context Plugin
def getIllegalPlugins():
  Set(Plugin) =

   self.allInstances()
    ->select(id.oclIsUndefined())
```



OCL Use Cases

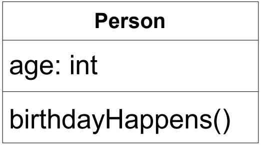
Generative Approaches: Testing

- Constraints are defined on Models
- Code Generator generates Test Code
- Test Code tests Model Instances



OCL Use Cases

Generative Approaches:
Testing - JUnit Code Generation



Person

age: int

birthdayHappens()

```
context Person
inv ageIsPositive: self.age >= 0
```

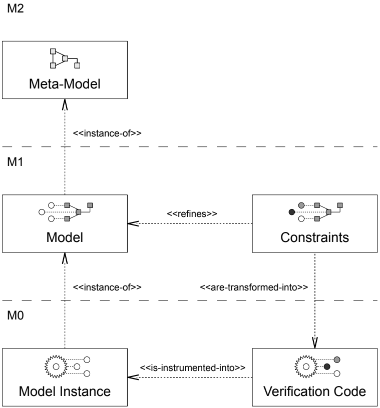
In Java:

```
@Test
public void testAgeIsPositive() {
  Person aPerson = new Person();
  assertTrue(aPerson.age >= 0);
}
```

OCL Use Cases

Generative Approaches: Run-Time (Object) Verification

- Constraints are defined on Models
- Code Generator generates Constraint Code
- Constraint code is instrumented or woven into Model code
- Constraints are verified during Model Instance execution



OCL Use Cases

Generative Approaches:
Run-Time Verification - AspectJ Code Generation [Wil09]

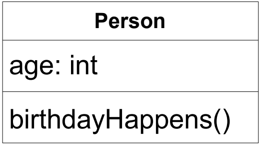
```
context Person
inv ageIsPositive: self.age >= 0
```

In Java:

```
pointcut ageChanged(Person aPerson):
  set(* Person.age) && this(aPerson);

after(Person aPerson) : ageChanged(Person) {
  if (!aPerson.age >= 0) {
    throw new RuntimeException(
          "The age of a person must not be negative");
  }
}
```

OCL Use Cases

Generative Approaches: Run-time Verification - OCL2 to SQL Transformation [Hei05]



```
context Person
inv ageIsPositive: self.age >= 0
```

SQL Integrity View
(contains all objects that violate the constraint):

```
create view AGEISPOSITIVE as
select * from PERSON SELF
where not (SELF.AGE >= 0)
```

Summary

- **Object Constraint Language**
  - Model Verification
  - Object Verification
- **Dresden OCL2 for Eclipse**
  - Generic Three Layer Metadata Architecture
  - Supports both Model, and Object Verification
  - A Set of Tools for other Case Tools
- **Two groups of Verification Use Cases**
  - Interpretative Approaches
  - Generative Approaches

Summary

- **We are interested in other OCL use cases and your own experiences with OCL!**
- Feedback is welcome!
- Dresden OCL Toolkit
  `http://dresden-ocl.sourceforge.net/`
- Use our mailinglists at
  `http://sourceforge.net/projects/dresden-ocl/`
- Direct Contact: info@claaswilke.de

References I

Bräuer, Matthias:
Models and Metamodels in a QVT/OCL Development Environment.
Großer Beleg (Minor Thesis), TU Dresden, May 2007

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In: *Proceedings of the Thirteenth International Workshop on Component-Oriented Programming (WCOP'2008)*, 2008, S. 33–38

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  Diploma Thesis, TU Dresden, April 2006. –
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- Object Management Group (OMG):
  OMG Unified Modeling Language^{TM} (OMG UML), Superstructure.
  `http://www.omg.org/spec/UML/2.2/Superstructure`.
  Version: 2.2, February 2009

- *Treaty Project Website.*
  Google Code Project Website.
  `http://code.google.com/p/treaty/`.
  Version: July 2009

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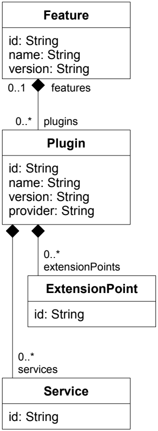
Java Code Generation for Dresden OCL2 for Eclipse.
Großer Beleg (Minor Thesis), TU Dresden, February 2009

OCL Use Cases

Interpretative Approaches: WFRs in PML [Brä07]

```
context Plugin
inv:
not self.id.oclIsUndefined()

context Feature
inv: self.plugins
  ->isUnique(plugin | plugin.id)
```



OCL Use Cases

Generative Approaches - Run-time Verification - OCL2 to XMLSchema/XQuery Transformation [Hei06]

XMLSchema:

```
<xs:complexType name="Person">
  <xs:element name="age" type="xs:integer" />
</xs:complexType>
```

XQuery Integrity Query

(contains all objects that violate the constraint):

```
for $SELF in fn:doc("modelInstance.xml")/Person
where not ($SELF/age >= 0)
return $SELF
```