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An Empirical Study of the UML Model Transformation Tool (UMT)

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Research Challenge

- OMG's MDA focus has drawn the attention towards model-driven transformation tools
- The UML Model Transformation Tool is just one of many proposed approaches, languages and tools
- How to evaluate these languages/tools?
- *Is it possible to identify a set of fairly **objective** and **easily checkable** requirements that measures the quality of a model-driven transformation tool?*
- Tool-dependant vs. language-dependant testing
- Ease-of-use? Robustness? Pricing? etc.
- Narrowed model scope in this study: ~~MOF~~ ✍ UML

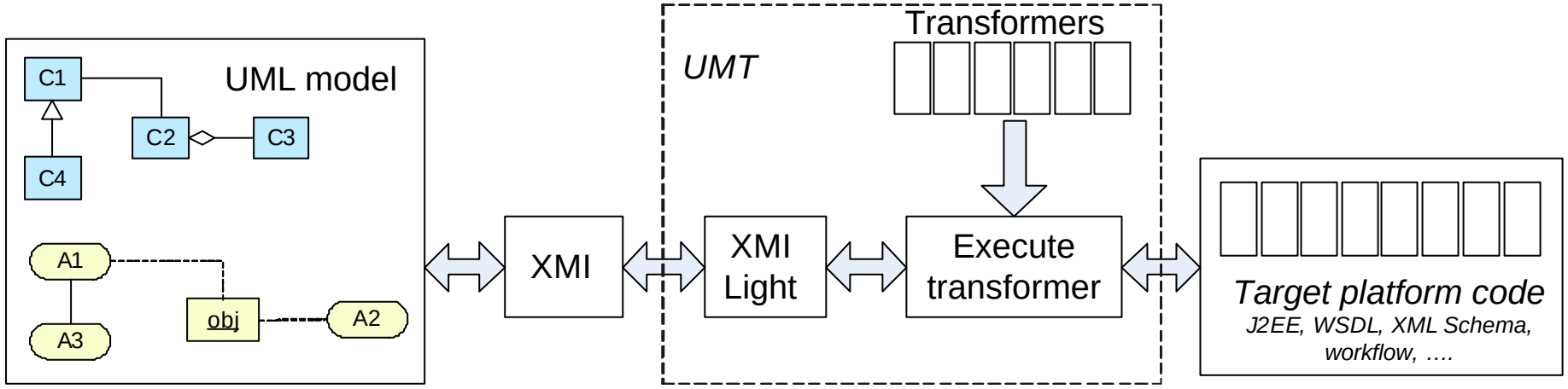
Quality of Transformation Language

- *Commonly-used language*. New, proprietary languages have a higher learning curve and require more effort to adopt.
- *Inheritance*. Easier to update and maintain transformations.
- *Graphical notation*. Most important for UML-to-UML. The graphical models provide a higher-level view on the transformation that is easier to communicate than the lexical counterpart.
- *Lexical notation*. Scales better than graphical. Handle complex or detailed transformations.
- *Declarative*. This makes the language side-effect free hopefully reduces code errors.
- *Bidirectional*. A language is bidirectional if it supports the definition of a transformation that is applicable two-ways. Easier specification and maintenance of bidirectional transformations.
- *XML support.* Built-in support to consume or produce XML, such as special support for handling general XML elements, attributes and namespaces. Important for text-to-UML and UML-to-text. Text formats nowadays often use XML.

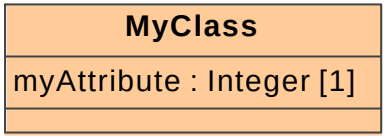
Tool Requirements

- Text-to-UML (reverse engineering). Legacy code, web services etc. exist without a relation to higher-level, graphical UML models
- UML-to-UML. Refinement of models, PIM-to-PSM, Transforming between different model views
- UML-to-text. Needed to implement running system as well as for documentation purposes.
- UML tool independence. Desirable so that the solution is not tied to a single UML tool.
- No proprietary intermediate structures. Such an additional structure increases the complexity for the transformation architect.
- Traceability. Explicit traces between source and target elements. Helps the user understand the transformation and its effects
- Metamodel-based. Source and target metamodels are explicitly defined and exploited in order to drive the transformation specification. Makes it easier to specify the transformation and to check that a transformation is valid.

UMT Architecture



Why have we invented XMI Light?



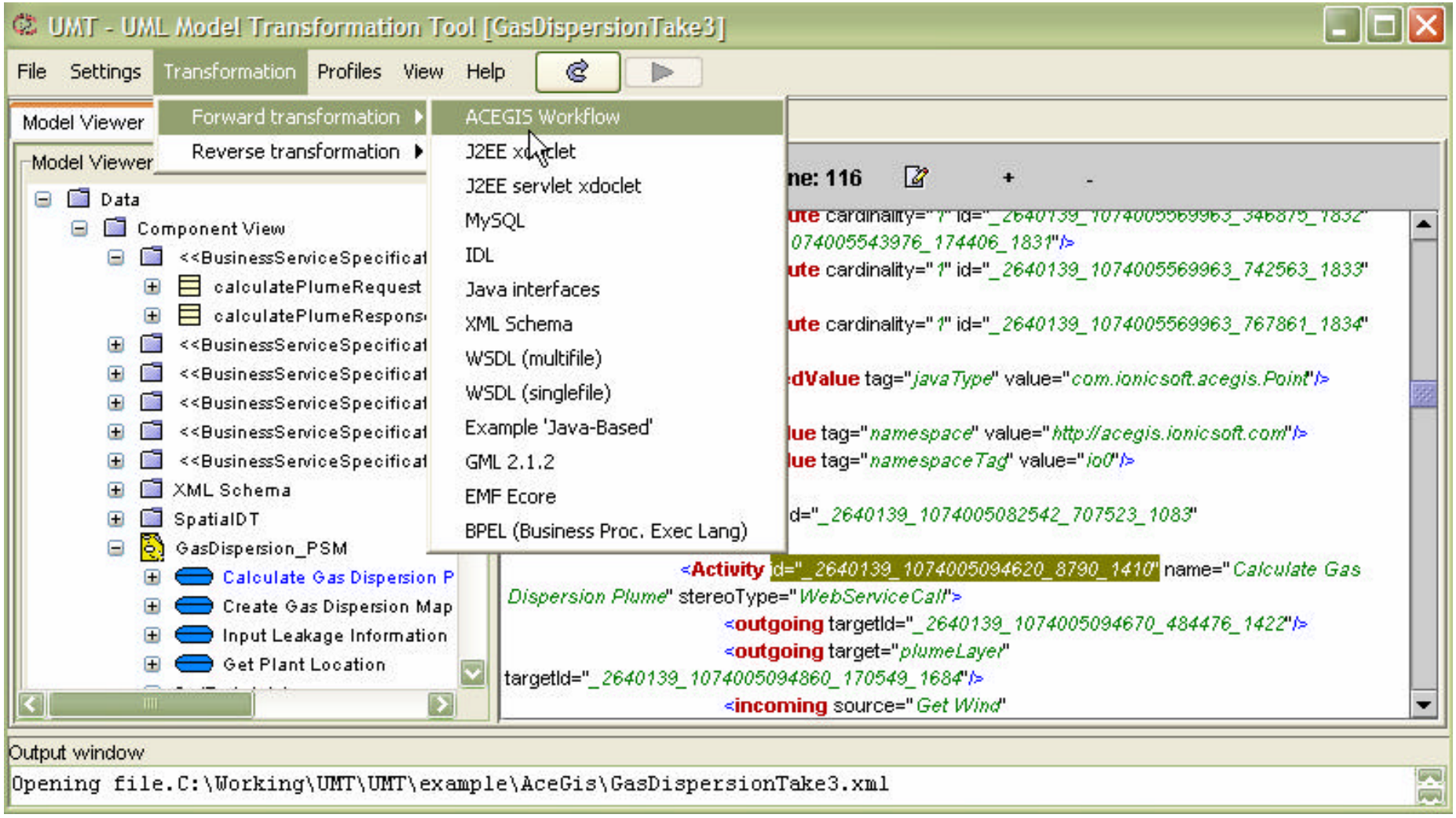
XMI Light

```
<datatype id="dt_Integer" name="Integer"/>
 <class abstract="false" id="class_MyClass" name="MyClass">
        <attribute cardinality="1..1" name="myAttribute" type="dt_Integer"/>
</class>
```

XMI 1.2

```
<UML:Class xmi.id = 'sm$1264eab:fe524af40b:-7fd4' name = 'MyClass' visibility = 'public'
        isSpecification = 'false' isRoot = 'false' isLeaf = 'false' isAbstract = 'false' isActive = 'false'>
        <UML:Classifier.feature>
          <UML:Attribute xmi.id = 'sm$1264eab:fe524af40b:-7fd5' name = 'myAttribute'
            visibility = 'public' isSpecification = 'false' ownerScope = 'instance' changeability = 'changeable'>
            <UML:StructuralFeature.multiplicity>
              <UML:Multiplicity xmi.id = 'sm$1264eab:fe524af40b:-7fd6'>
                <UML:Multiplicity.range>
                  <UML:MultiplicityRange xmi.id = 'sm$1264eab:fe524af40b:-7fd7' lower = '1' upper = '1'/>
                </UML:Multiplicity.range>
              </UML:Multiplicity>
            </UML:StructuralFeature.multiplicity>
            <UML:StructuralFeature.type>
              <UML:DataType xmi.idref = 'sm$1264eab:fe524af40b:-7fc7'/>
            </UML:StructuralFeature.type>
          </UML:Attribute>
        </UML:Classifier.feature>
      </UML:Class>
<UML:DataType xmi.id = 'sm$1264eab:fe524af40b:-7fc7' name = 'integer' visibility = 'public'
isSpecification = 'false' isRoot = 'false' isLeaf = 'false' isAbstract = 'false'/>
```

UMT – Graphical User Interface

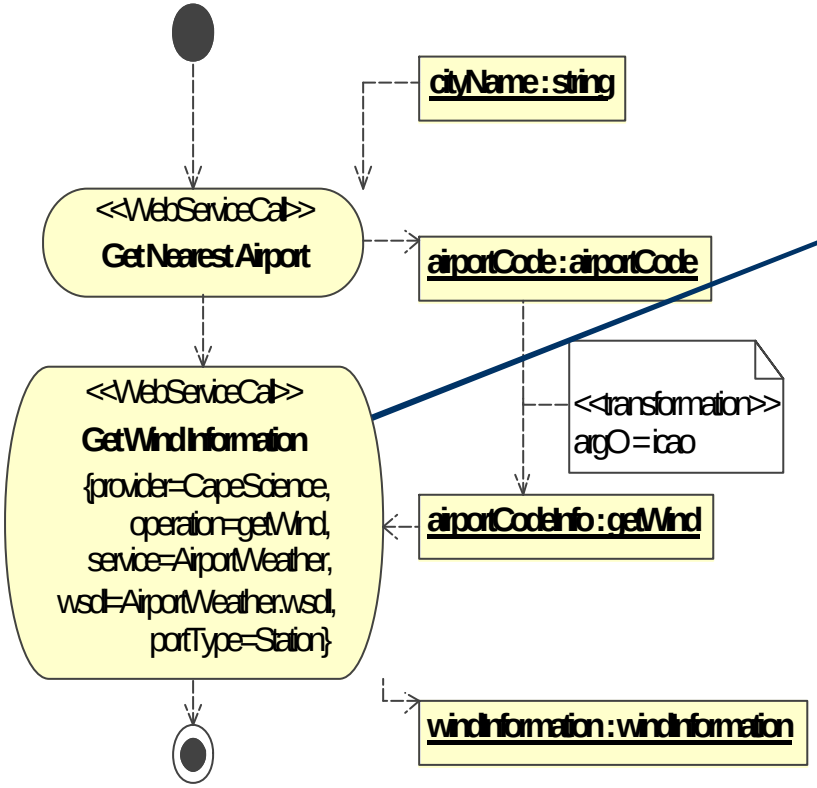


UMT – Transformation Kinds

- *UML-to-text transformation*.
  - UML models are exported to XMI from a UML tool.
  - XMI is converted to XMI Light by UMT.
  - **Write transformation** from XMI Light to the desired text or code format. Use XSLT or Java with XMI Light as input source
- *UML-to-UML transformation*.
  - UML models are exported to XMI from a UML tool.
  - XMI is converted to XMI Light by UMT.
  - **Write transformation** from XMI Light to XMI Light using XSLT/Java.
  - Convert XMI Light to XMI by UMT.
  - Import XMI into a UML tool
- *Text-to-UML transformation*.
  - **Write transformation** from text to XMI Light using Java (or XSLT).
  - Convert XMI Light to XMI by UMT.
  - Import XMI into a UML tool

Example: UML to BPEL —

Step 1: Producing XMI Light from UML (xmi)




```
<ActivityGraph name="UML2004">
        <PseudoState kind="initial"…/>
        <PseudoState kind="final"…/>
        <Activity name="Get Nearest Airport"…/>
        <ObjectFlow name="cityName"…/>
        <ObjectFlow name="windInformation"…/>
        <ObjectFlow name="airportCode"…/>
        <ObjectFlow name="airportCodeInfo…/>
<Activity name="Get Wind Information"
        stereoType="WebServiceCall">
    <outgoing targetId="final-ID"/>
    <outgoing target="windInformation"…/>
    <incoming sourceId="Get Nearest Airport-ID"/>
    <incoming source="airportCodeInfo"…/>
    <taggedValue tag="provider" value="CapeScience"/>
    <taggedValue tag="operation" value="getWind"/>
    <taggedValue tag="service" value="AirportWeather"/>
    <taggedValue tag="wsdl" value="AirportWeather.wsdl"/>
    <taggedValue tag="portType" value="Station"/>
</Activity>
</ActivityGraph>
```

Example: UML to BPEL —

Step 2: Producing BPEL from XMI Light

```
<stylesheet>
  <template name="ActivityGraph" .../>
  <template match="Activity">
    <choose>
      <when test="@stereoType='WebServiceCall'">
        <variable name="operation"
                  select="taggedValue[@tag='operation']/@value"/>
        <variable name="portType"
                  select="taggedValue[@tag='portType']/@value"/>
        <out:invoke partner="{$provider}-{$operation}"
                    portType="{$portType}"
                    operation="{$operation}">
          <call-template name="inputOutputDataObjects"/>
        </out:invoke>
        ...
    </choose>
        <call-template name="outgoingFlows">
          <with-param name="current" select="."/>
        </call-template>
  </template>
  <template name="genDataTransformations".../>
</stylesheet>
```

```
<process
  <sequence>
    <receive name="cityName"…/>
    <invoke operation="GetNearestAirport"…/>
    <invoke portType="Station"
                outputVariable="windStr"
                operation="getWind"
                inputVariable="airportCodeInfo"
                partner="CapeScience-getWind"/>
    <reply name="windInformation"…/>
  </sequence>
</process>
```

Transformation Languages/Tools

Requirements	UMT w/XSLT	ATL	YATL	BOTL	MOLA	UMLX	VMT
Commonly-used language	**yes**	no	no	no	no	no	partly
Inheritance	**no**	yes	no	no	no	no	yes
Graphical notation	**no**	no	no	yes	yes	yes	yes
Lexical notation	**yes**	yes	yes	no	no	no	yes
Declarative	**yes**	no	no	yes	no	yes	no
Bidirectional	**no**	no	no	yes	no	no	no
XML support	**yes**	no	no	no	no	no	no
Text-to-UML	**yes**	no	no	no	yes	no	no
UML-to-UML	**yes**	yes	yes	yes	yes	yes	yes
UML-to-text	**yes**	yes	no	no	no	no	no
UML tool independence	**yes**	yes	yes	yes	no	yes	no
No proprietary intermediate structures	**no**	yes	yes	yes	yes	yes	yes
Traceability	**no**	no	yes	no	no	yes	yes
Metamodel/MOF-based	**no**	yes	yes	yes	yes	yes	no

OMG Proposals: QVTMerge, QVT-Compuware/Sun, and MOFScript

Requirements	UMT w/XSLT	QVTMerge	QVT-Compuware/ Sun	MOFScript
Commonly-used language	yes	no	no	no
Inheritance	no	yes	yes	yes
Graphical notation	no	yes	yes	no
Lexical notation	yes	yes	yes	yes
Declarative	yes	yes/no	no	no
Bidirectional	no	yes	yes	no
XML support	yes	no	no	yes
Text-to-UML	yes	no	no	no
UML-to-UML	yes	yes	yes	no
UML-to-text	yes	no	no	yes
UML tool independence	yes	yes	yes	yes
No proprietary intermediate structures	no	yes	yes	yes
Traceability	no	yes	no	no
Metamodel/MOF-based	no	yes	yes	yes

Conclusions about UMT

- The three kinds of model transformations are unified in one tool/approach
- Proven success with reverse-engineering and code generation
- Drawbacks:
  - Not metamodel-based
  - No specialized model transformation language
  - Proprietary format: XMI Light
  - No graphical notation

Discussion

- Declarative vs. imperative
- Graphical vs. textual
- MDA community: ”XML, XMI and XSLT is too low level”
- OCL-based solutions
- Metamodel-based. Hard work to define the source and target metamodel ✍ metamodel repository?
- Most focus so far has been on model-to-model transformations

Related Work

- Watch closely: OMG's QVT and MOF Model to text
- Evaluations and recommendations for QVT submissions:
  - Gardner et al. *A review of OMG MOF 2.0 Query / Views / Transformations Submissions and Recommendations towards the final Standard*. 2003.
  - Langlois et al. *THALES recommendations for the final OMG standard on Query / Views / Transformations*. 2003.
- Graphical composition of transformations – Sendall et al. *Supporting Model-to-Model Transformations: The VMT Approach*. 2003.
- "OCL quickly leads to complex query statements even for simple queries" – Stein et al. *A graphical notation to specify model queries for MDA transformations on UML models*. 2004

Future Work

- Evaluate QVT and Model-to-text submissions
- Detailing of the requirements
- How to measure – more details
- Different levels of support
- Assigning weights
- Required vs. optional
- Computation algorithm – overall score
- What about *Ease-of-use*? – Reference examples and case studies are needed

UMT is available at SourceForge

- Open Source License: Lesser GNU Public License
- Dowload: **umt-qvt.sourceforge.net**

- **Questions**