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

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The work reported in this paper is carried out in the context of MODELWARE, an EU IP-project in FP62003/IST/2.3.2.3
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

![Diagram showing UMT Architecture]

- **UML model**
  - C1
  - C2
  - C3
  - A1
  - A3
  - obj
  - A2

- **XMI**
  - UMT
  - Transformers
  - Execute transformer

- **Target platform code**
  - J2EE, WSDL, XML Schema, workflow, ...
Why have we invented XMI Light?

MyClass
myAttribute : Integer [1]

XMI 1.2

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>

<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>
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Why have we invented XMI Light?
UMT – Graphical User Interface

Opening file: C:\Working\UMT\example\AceGis\GasDispersionTake3.xml
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

```xml
<stylesheet>
<template name="ActivityGraph" />
<template name="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"/>
    </when>
  </choose>
  ...</out:invoke>
</template>
<call-template name="outgoingFlows">
  <with-param name="current" select=""/>
</call-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

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<th>Requirements</th>
<th>UMT w/XSLT</th>
<th>ATL</th>
<th>YATL</th>
<th>BOTL</th>
<th>MOLA</th>
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# OMG Proposals: QVTMerge, QVT-Compuware/Sun, and MOFScript

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<tr>
<th>Requirements</th>
<th>UMT w/XSLT</th>
<th>QVTMerge</th>
<th>QVT-Compuware/Sun</th>
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</table>
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:


“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
- Download: umt-qvt.sourceforge.net

Questions