MDE Case Study: Using Model Transformations for UML and DSLs

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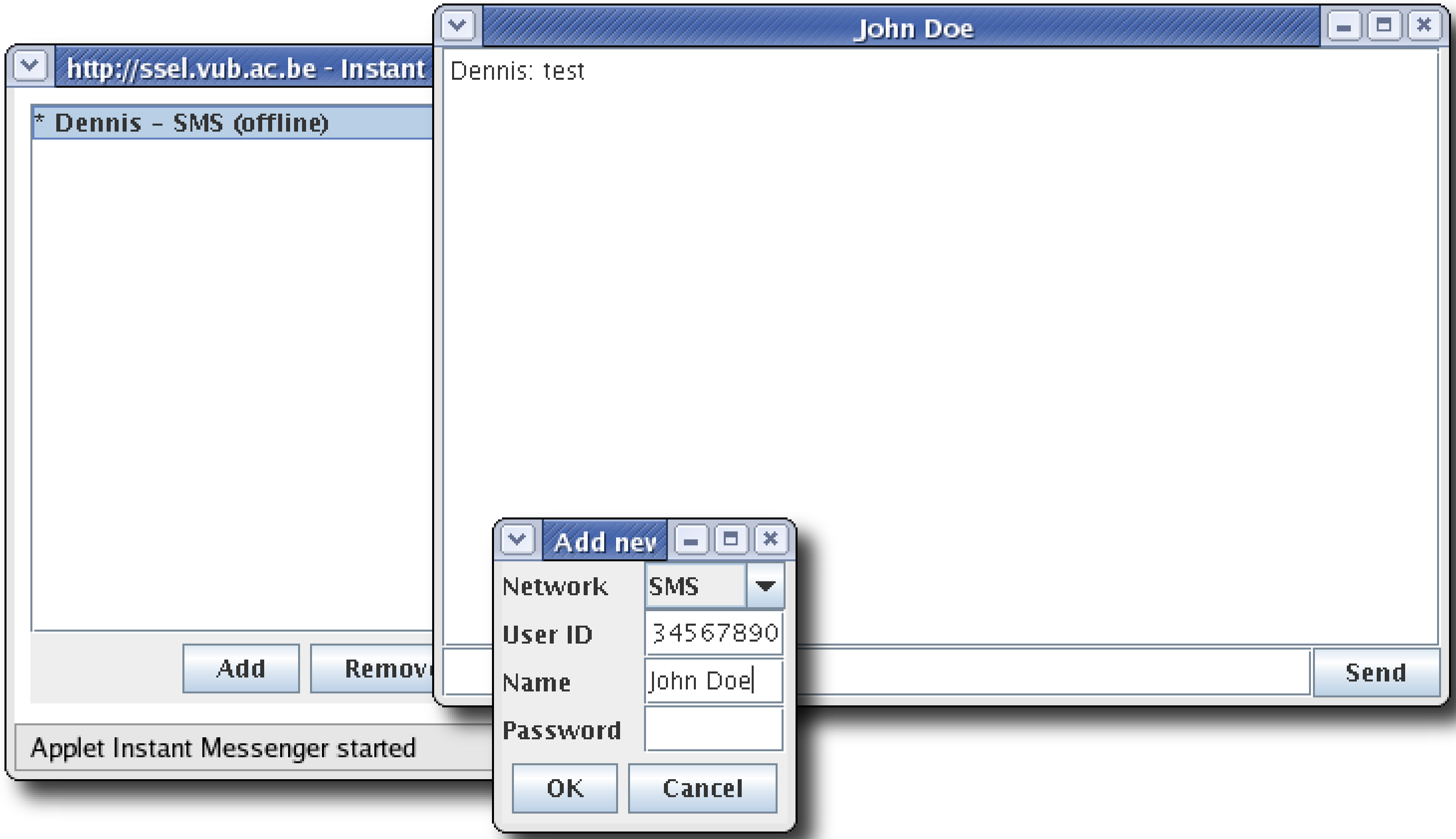
Use cases for model transformation

- Stepwise refinement of design abstractions
  - Multiple alternative/interchangeable refinements for each abstraction
- Translation to different languages/formats
  - Translate from one meta-model to another
  - Convert from one repository to another
- Code generation
  - Easy model navigation through direct meta-model access

Outline

- Case study: Instant Messenger (UML)
  - Goal: use the same 'code base' for all Java platforms
- Software architecture
  - Explains organisation of the software elements
- Build process roadmap
  - All steps involved to go from model to deployed software
- Evaluation
  - Experiences, recommendations and outlook

Case study: Instant Messenger


http://ssel.vub.ac.be - Instant
* Dennis - SMS (offline)
Add
Remov
Applet Instant Messenger started
John Doe
Send
Add nev
OK
Cancel

Dennis: test

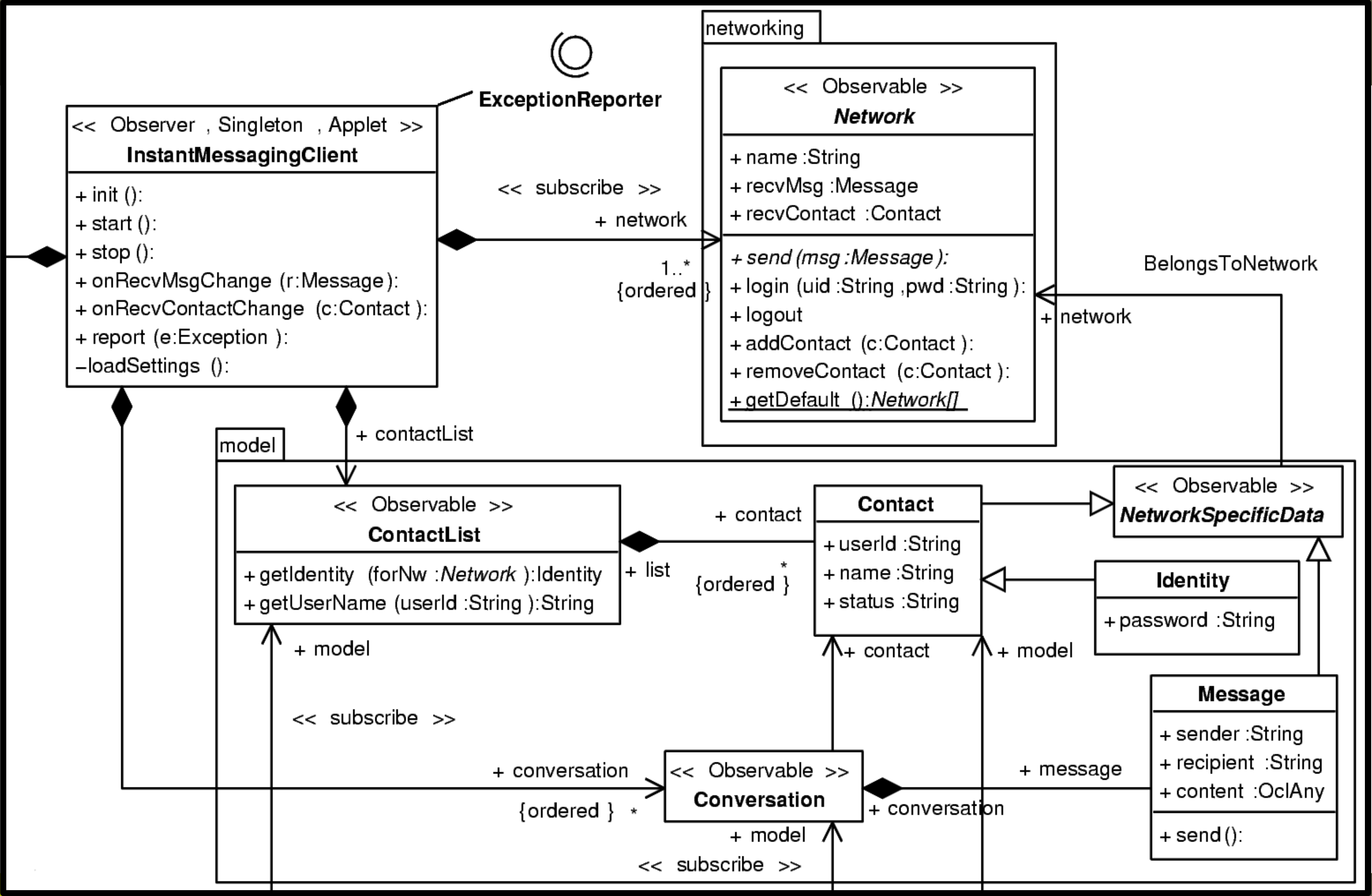
Network	SMS
User ID	34567890
Name	John Doe
Password	

Demo

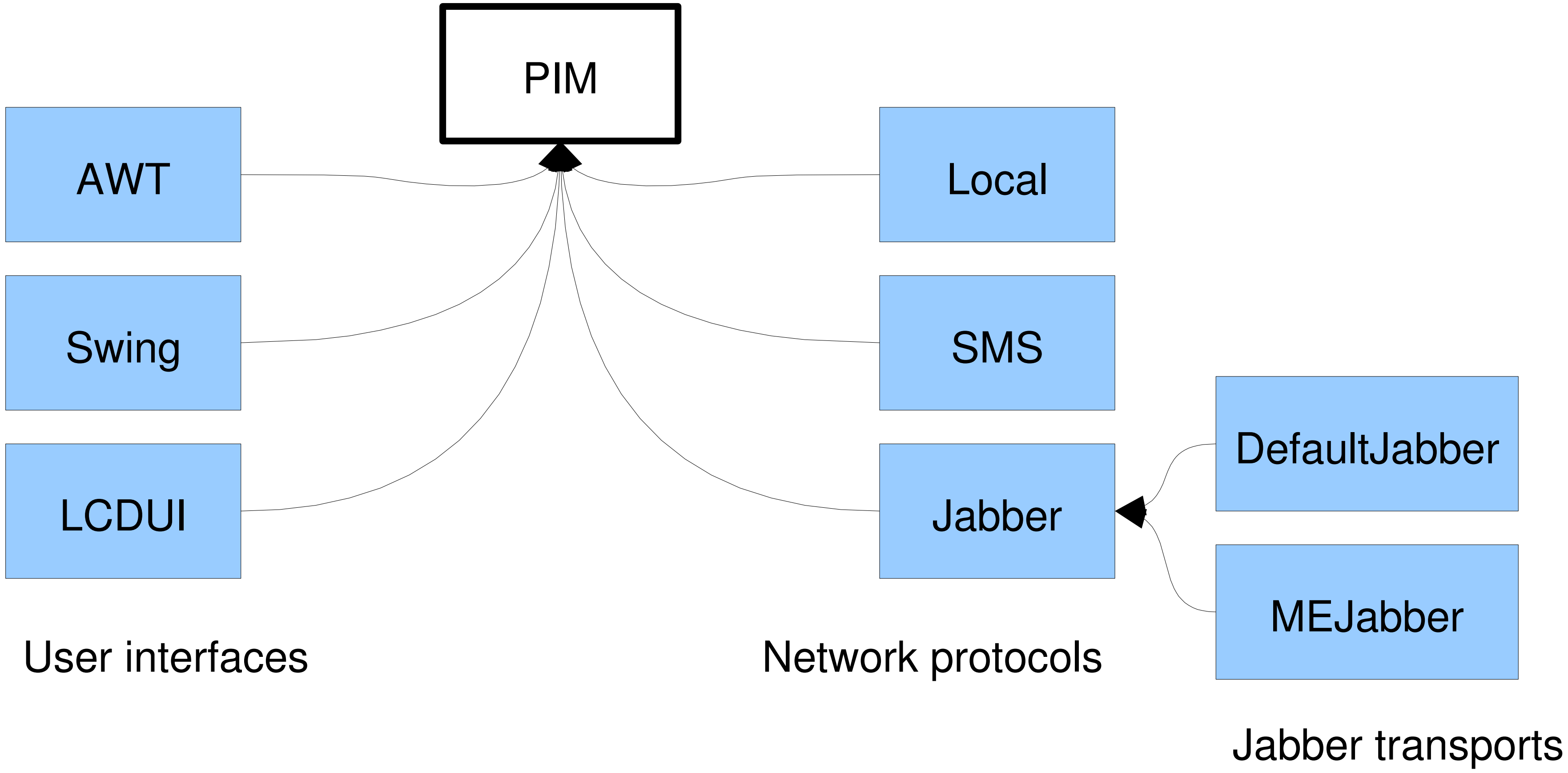
Software architecture

- PIM in UML
  - Using Java as Action Language
- Add-on features in separate UML models
  - Semi platform-dependent models that can be merged with the PIM
- PIM-PSM refinement transformations in ATL
  - Add bindings to platform-specific API
- Configuration Management using DSL

Instant Messenger: PIM (part)



Add-on features



Refinement transformations

AssociationAttributes	Java2AssociationAttributes
Accessors	Java2Accessors
Observer	JavaObserver
Applet	MIDlet
Singleton	
AsyncMethods	
DataTypes	Java2DataTypes

Example: AssociationAttributes Transformation

```
module AssociationAttributes;
create ATTRIBUTES : UML refining IN : UML;
...
rule AssociationEndAttribute {
        from s : UML!AssociationEnd (s.isNavigable)
        to t : UML!Attribute (
               name <- s.name,
               owner <- s.navigableFrom(),
               type <- s.type(),
               visibility <- s.visibility,
               ownerScope <- s.targetScope,
               changeability <- s.changeability,
               initialValue <- v),
           v : OUTMODEL!Expression (
               language <- 'java',
               body <- s.instance())
}
```

AssociationAttributes: Helpers

```
helper context UML!AssociationEnd def : isSingle() : Boolean =
       self.multiplicity.range->select(r|r.upper<>1)->isEmpty();

helper context UML!AssociationEnd def : type() : UML!Classifier
    if self.isSingle() then
       self.participant
    else
       'java.util.Vector'.class()
    endif endif;

helper context UML!AssociationEnd def : instance() : String =
    if self.isSingle() then
       ‘null’
    else
       ‘new java.util.Vector()’
    endif;
```

Java2AssociationAttributes: Helpers

```
helper context UML!AssociationEnd def : isSingle() : Boolean =
       self.multiplicity.range->select(r|r.upper<>1)->isEmpty();

helper context UML!AssociationEnd def : type() : UML!Classifier
    if self.isSingle() then
       self.participant
    else
       'java.util.List'.interface()
    endif endif;

helper context UML!AssociationEnd def : instance() : String =
    if self.isSingle() then
       ‘null’
    else
       ‘new java.util.ArrayList()’
    endif;
```

Code generation

```
query UMLtoJava = UML!Classifier.allInstances()->collect(e |
    if e.ignore() then true
    else e.toFileString().writeTo(e.pathName())
    endif);

...

helper context UML!Classifier def : toFileString() : String =
    self.packageDecl() + self.importDecl() + '\n' +
    self.toString();

...
```

Code generation: Class

```
helper context UML!Class def : toString() : String =
    self.visibility() + self.isAbstract() + 'class ' + self.name +
    self.extendsClause() + self.implementsClause() +
    ' {\n' +
    self.ownedElement->select(e|e.oclIsKindOf(UML!Classifier))->
        iterate(e; acc : String = '' | acc + e.toString()) +
    self.feature->select(f | f.oclIsKindOf(UML!Attribute))->
        iterate(e; acc : String = '' | acc + e.toString()) +
    self.feature->select(f | f.oclIsKindOf(UML!Method))->
        iterate(e; acc : String = '' | acc + e.toString()) +
    '}\n\n';

...
```

Code generation: Interface

```
helper context UML!Interface def : toString() : String =
    self.visibility() + self.isAbstract() + 'interface ' +
    self.name + self.extendsClause() +
    ' {\n' +
    self.ownedElement->select(e|e.oclIsKindOf(UML!Classifier))->
        iterate(e; acc : String = '' | acc + e.toString()) +
    self.feature->select(f|f.oclIsKindOf(UML!Method))->
        iterate(e; acc : String = '' | acc + e.toString()) +
    '}\n\n';

...
```

Configuration management

- Which features can be combined?
  - Example: LCDUI and AWT don’t compile together
- Which refinement transformations can be combined and in which order?
  - Example: don’t mix “Java2” and “Java1” variants
- Other issues: external resources, packaging, deployment, ...

Configuration DSL

- Domain-Specific Language defined in EMF
  - Each model in this language describes a configuration
  - Meta-model defines which models are valid
  - Ant files for invoking the model transformations can be generated from these configuration models with ATL
  - Meta-model can be split into **general** refinements and **specific** instant messenger features

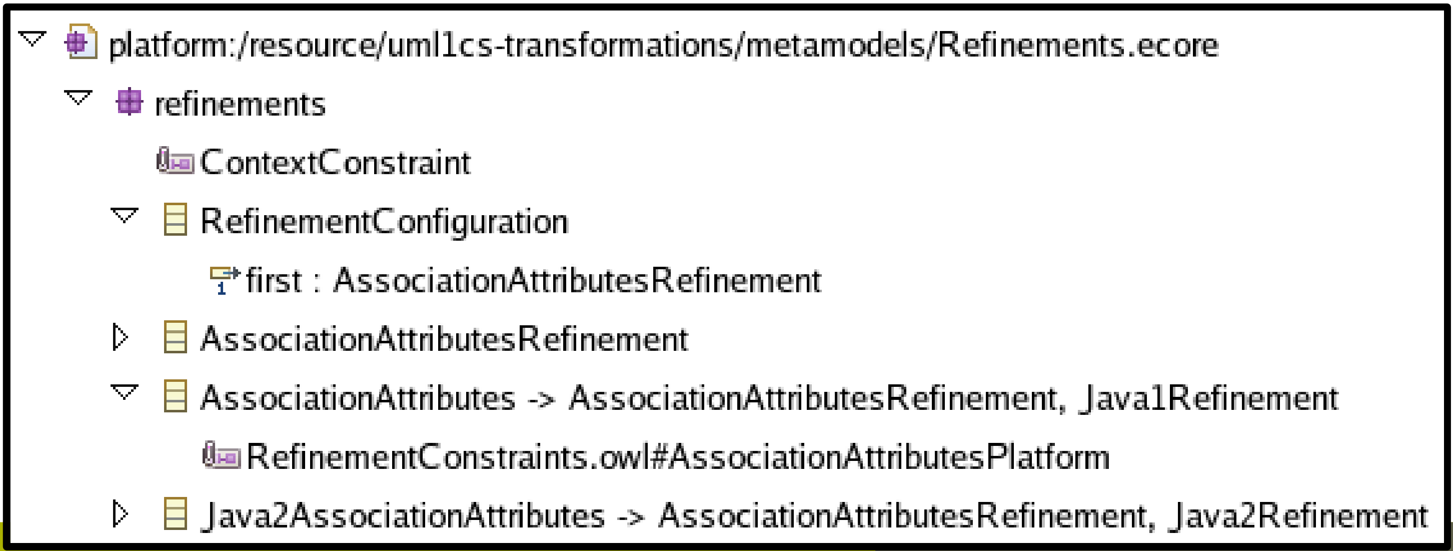
Demo

Platform dependencies (1/3)

- What about platform dependencies?
  - Not all features run on all platforms
  - Not all API bindings generated by the refinement transformations run on all platforms

Platform dependencies (2/3)

- External model of platform + constraints
- Use platform constraint annotations in the DSL meta-model:

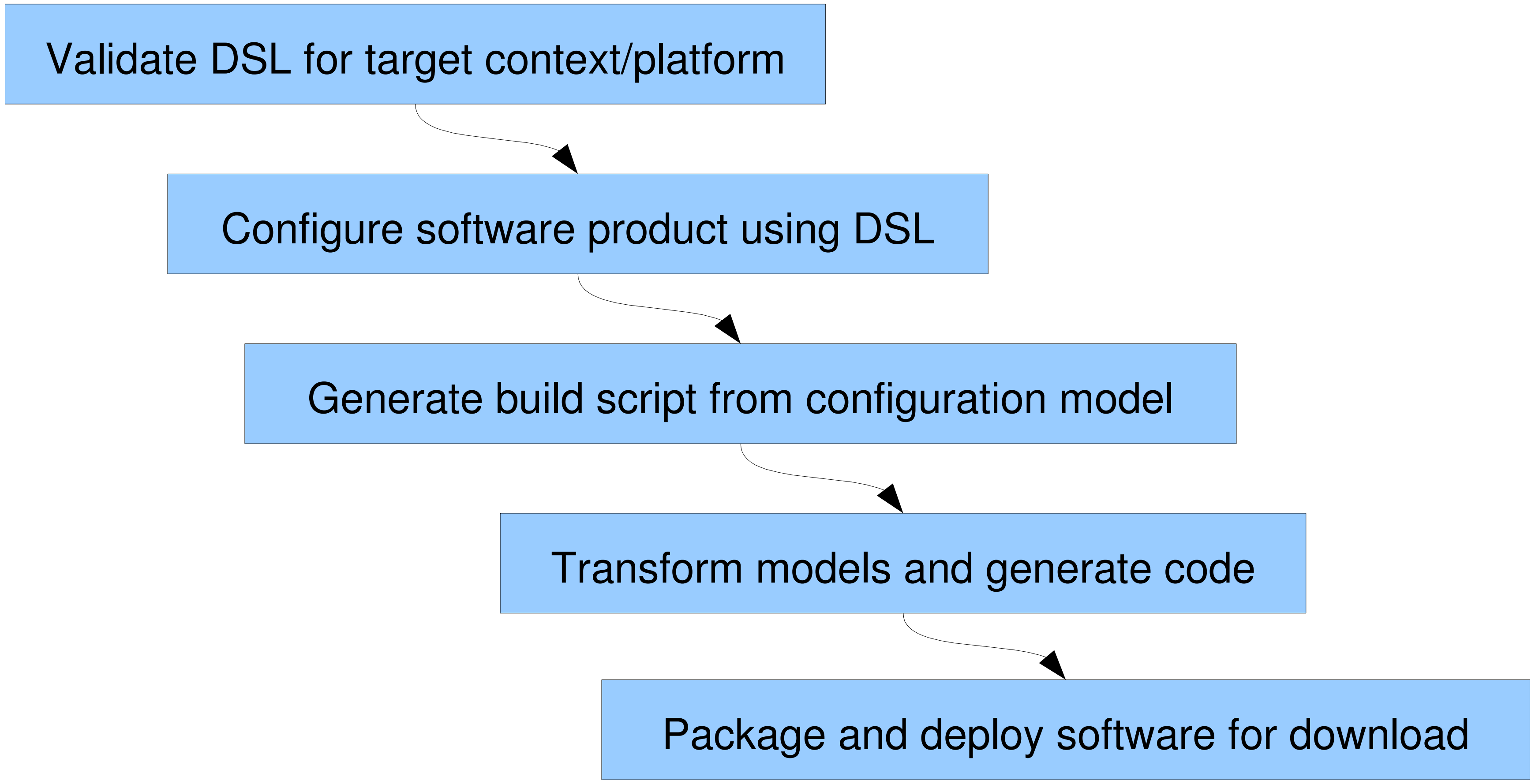


```
▽ platform:/resource/uml1cs-transformations/metamodels/Refinements.ecore
  ▽ refinements
      ContextConstraint
    ▽ RefinementConfiguration
        first : AssociationAttributesRefinement
    ▷ AssociationAttributesRefinement
    ▽ AssociationAttributes -> AssociationAttributesRefinement, Java1Refinement
        RefinementConstraints.owl#AssociationAttributesPlatform
    ▷ Java2AssociationAttributes -> AssociationAttributesRefinement, Java2Refinement
```

Platform dependencies (3/3)

- Context-Driven Development Toolkit:
  - Uses platform/context models expressed in OWL-DL
  - Uses DL reasoner (eg. Racer) for constraint-checking and context optimisation (best-match)
  - Leverages DSL meta-model annotations to validate and compare concrete configurations
  - Can be used at deploy-time to determine optimal product configuration that is still valid for the client platform

Build process roadmap


Validate DSL for target context/platform
Configure software product using DSL
Generate build script from configuration model
Transform models and generate code
Package and deploy software for download

Demo

Evaluation: Case study experiences (1/2)

- ATL can be used for real-world models
  - Execution speed is not optimal (esp. model merging)
  - Debugging tools are usable
  - Active support by developers
- Not all platform dependencies can be abstracted out easily
  - Creating design abstractions costs time
  - Alternative: use add-in platform-specific models

Evaluation: Case study experiences (2/2)

- EMF meta-modelling language lacks power for complex configuration rules in DSL
  - Advanced rule validation can be done with a model transformation

Evaluation: Platform dependencies

- Platform dependencies can be managed by an external tool (eg. CDDToolkit)
  - Use meta-model annotations to provide tool input
  - Decreases platform testing/debugging effort
  - Allows optimised deployment of product configurations

Evaluation: Tool maturity

	Maturity	Audience
Eclipse	Stable	Java developers
EMF	Stable	Java modelling experts
ATL	Development	Modelling experts/researchers
CDDToolkit	Proof-of-concept	Researchers

Evaluation: Recommendations

- Use made-to-measure transformations
  - No superfluous functionality (improved performance)
  - No time-consuming fixing of generated models/code
- Use transformation bootstrapping
  - Use transformations to generate transformations consisting of repetitive code
  - Use transformations to generate complex build scripts

Evaluation: Outlook

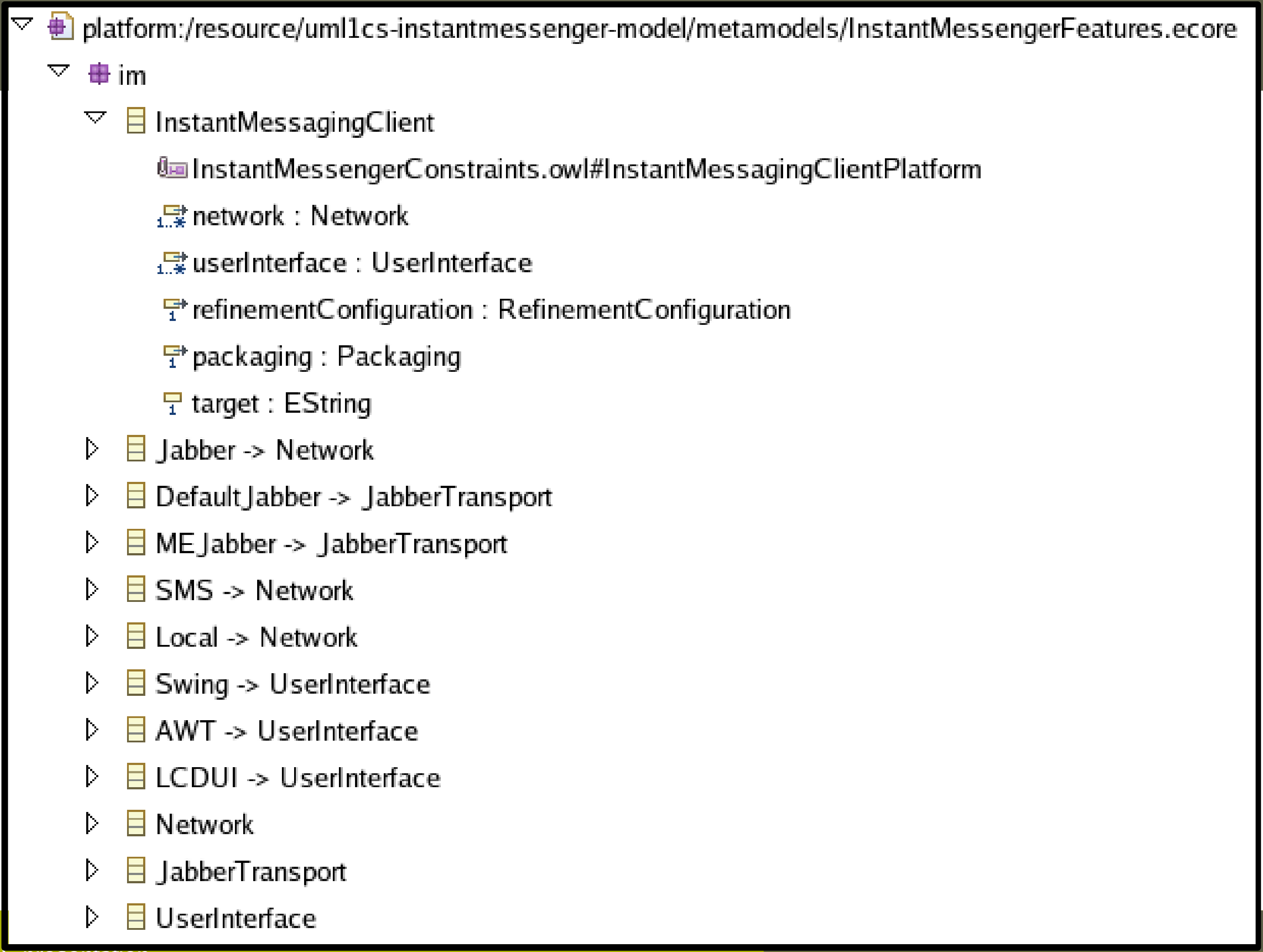
- Adapt generated DSL editor to provide integrated access to:
  - Advanced model validation transformations
  - Platform dependency checking
  - Build file generation
- Translate often-used transformations to Java to improve build time
  - E.g. copying and merging transformations

Questions?

- More info on:
  - http://ssel.vub.ac.be/ssel/research:mdd:casestudies

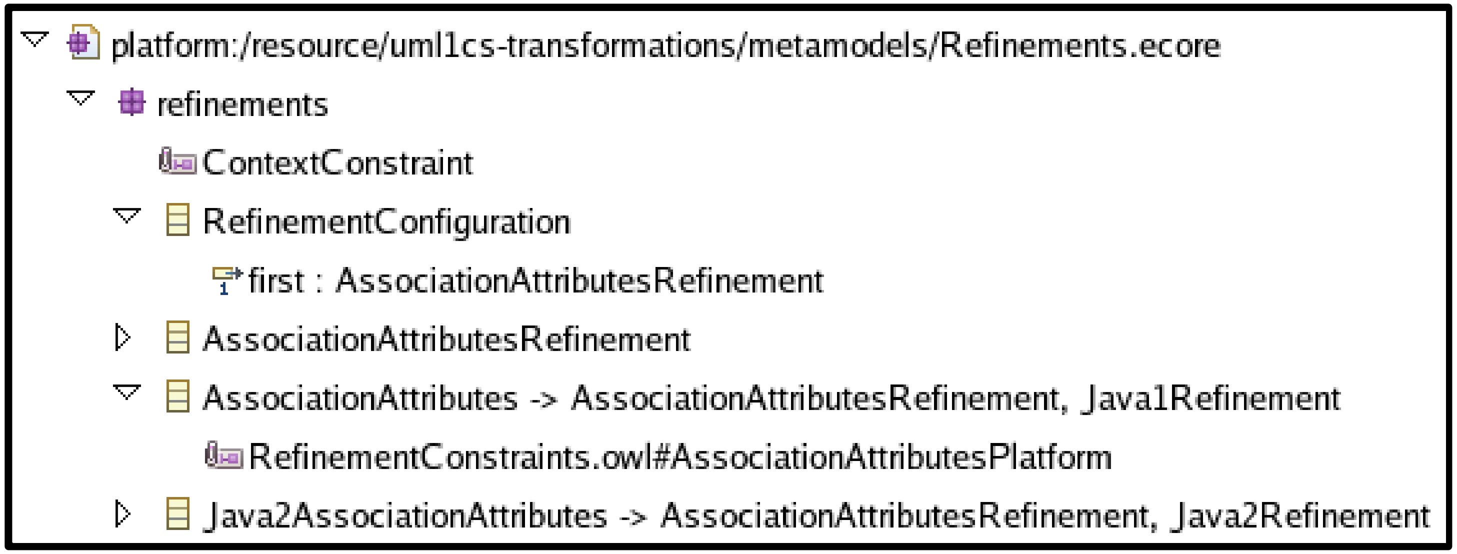
Spare slides…

DSL: Instant Messenger features



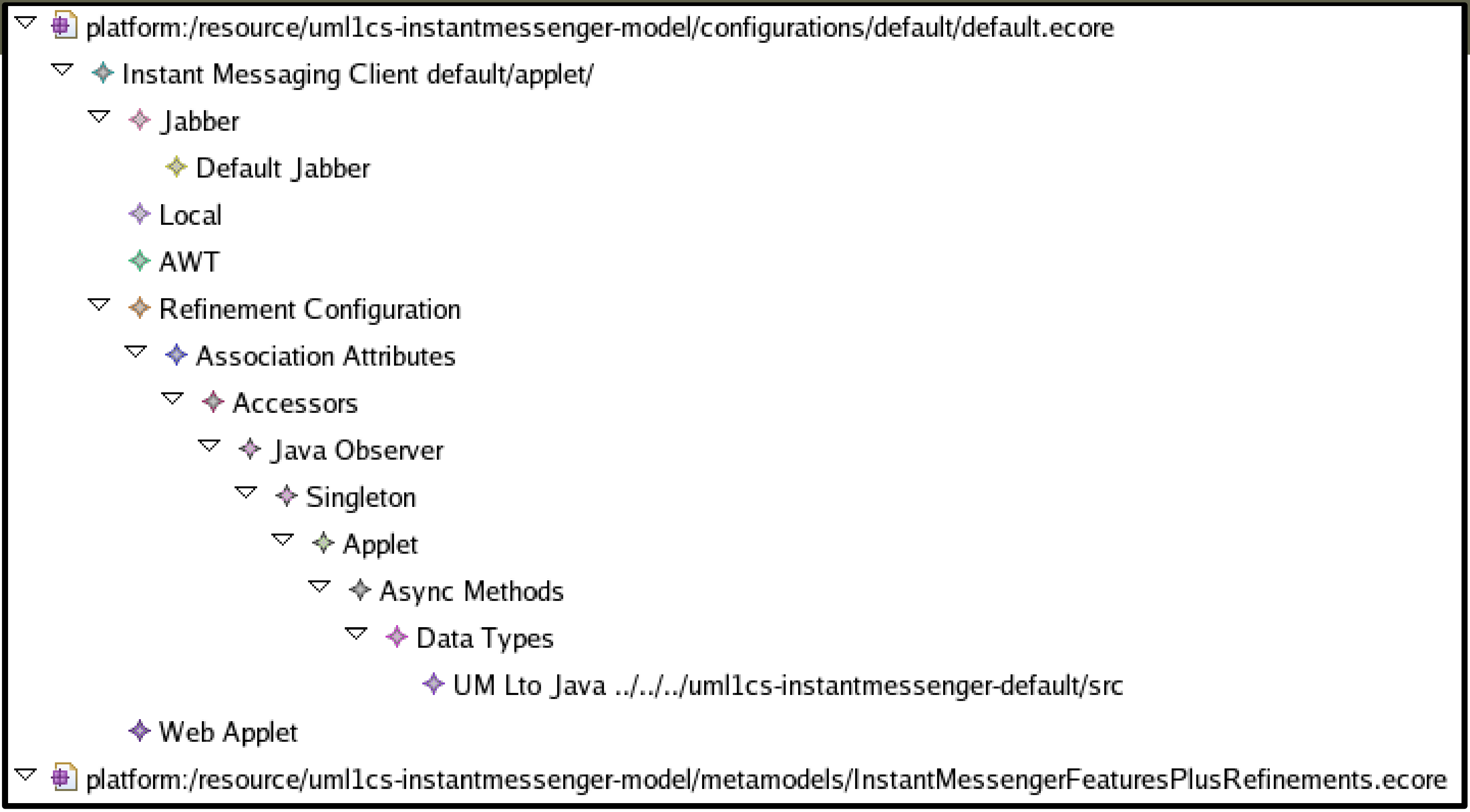
```
platform:/resource/uml1cs-instantmessenger-model/metamodels/InstantMessengerFeatures.ecore
  im
    InstantMessagingClient
      InstantMessengerConstraints.owl#InstantMessagingClientPlatform
      network : Network
      userInterface : UserInterface
      refinementConfiguration : RefinementConfiguration
      packaging : Packaging
      target : EString
    Jabber -> Network
    DefaultJabber -> JabberTransport
    MEJabber -> JabberTransport
    SMS -> Network
    Local -> Network
    Swing -> UserInterface
    AWT -> UserInterface
    LCDUI -> UserInterface
    Network
    JabberTransport
    UserInterface
```

DSL: Refinement transformations



```
platform:/resource/uml1cs-transformations/metamodels/Refinements.ecore
    refinements
        ContextConstraint
        RefinementConfiguration
            first : AssociationAttributesRefinement
        AssociationAttributesRefinement
        AssociationAttributes -> AssociationAttributesRefinement, Java1Refinement
            RefinementConstraints.owl#AssociationAttributesPlatform
        Java2AssociationAttributes -> AssociationAttributesRefinement, Java2Refinement
```

DSL: Example configuration



```
▽ platform:/resource/uml1cs-instantmessenger-model/configurations/default/default.ecore
    ▽ Instant Messaging Client default/applet/
        ▽ Jabber
              Default Jabber
          Local
          AWT
        ▽ Refinement Configuration
            ▽ Association Attributes
                ▽ Accessors
                    ▽ Java Observer
                        ▽ Singleton
                            ▽ Applet
                                ▽ Async Methods
                                    ▽ Data Types
                                          UM Lto Java ../../../uml1cs-instantmessenger-default/src
          Web Applet
▽ platform:/resource/uml1cs-instantmessenger-model/metamodels/InstantMessengerFeaturesPlusRefinements.ecore
```