ModelType

generic refactoring usecase

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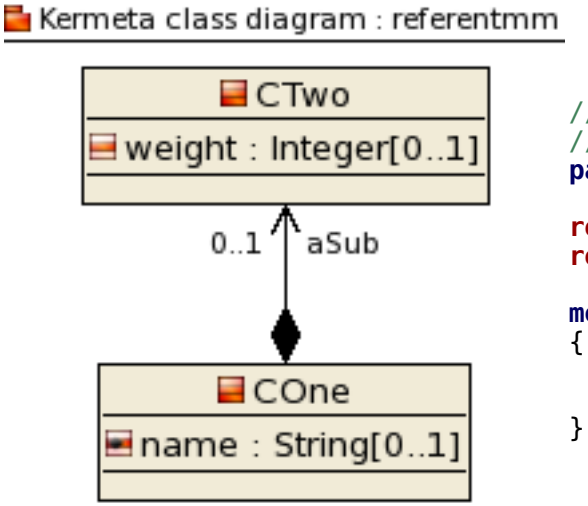
- ModelType conformance toughness
- *NonMatching* strategy
- Apply refactoring to new metamodels

ModelType

- Jim STEEL PhD thesis
- ***Type*** = set of values on which a set of operations can be performed successfully
- ***Conformance*** = weakest substitutability relation that guarantees type safety
- ***ModelType*** = a given metamodel as nominal input/output of a model processing program

ModelType

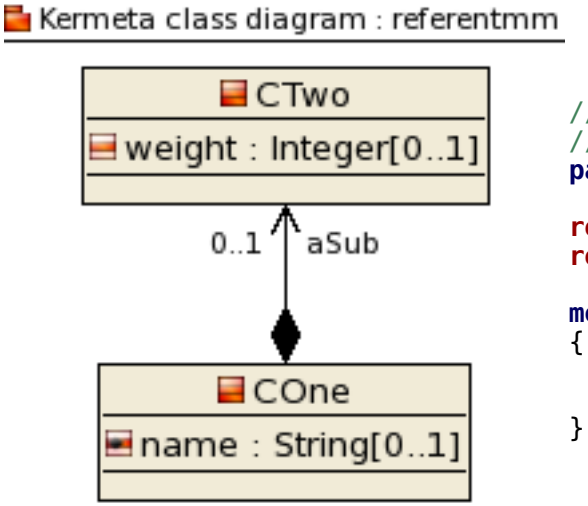
We define a
referent model
and its model type




```
//// ReferentMT.kmt file ////
// same root as the .km file
package referentmm;

require kermeta
require "ReferentMM.km"

modeltype ReferentMT
{
  COne,
  CTwo
}
```

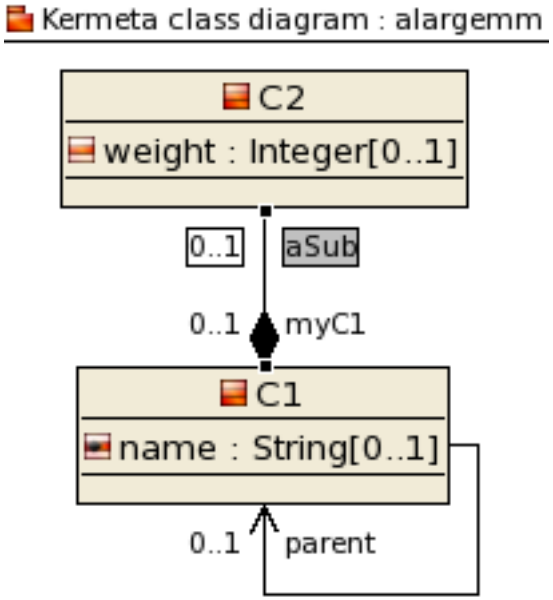
ModelType

We define a
referent model
and its model type




```
//// ReferentMT.kmt file ////
// same root as the .km file
package referentmm;

require kermeta
require "ReferentMM.km"

modeltype ReferentMT
{
  COne,
  CTwo
}
```

We want to find “it”
in a larger model




```
//// ALargeMT.kmt file ////
package alargemm;

require kermeta
require "ALargeMM.km"

// we aim for it to correspond
// referent model type
modeltype ALargeMT
{
  C1,
  C2
}
```

ModelType

We write a program on ReferentMT

```
//// ReferentCode.kmt ////
package referentmm;

require kermeta
require "ReferentMT.kmt"

using kermeta::standard

// we define a generic class typed with ReferentMT
class Code<MT : ReferentMT>
{
 operation createNewCOne(name : String) : MT::COne is do
  // We are manipulating ReferentMM elements
  result := MT::COne.new
  result.name := name

  stdio.writeln("ReferentCode.kmt ----------")
  stdio.writeln("  createNewCOne() - instance = "
       + result.toString + "\n")
 end
}
```

ModelType

We write a program on ReferentMT

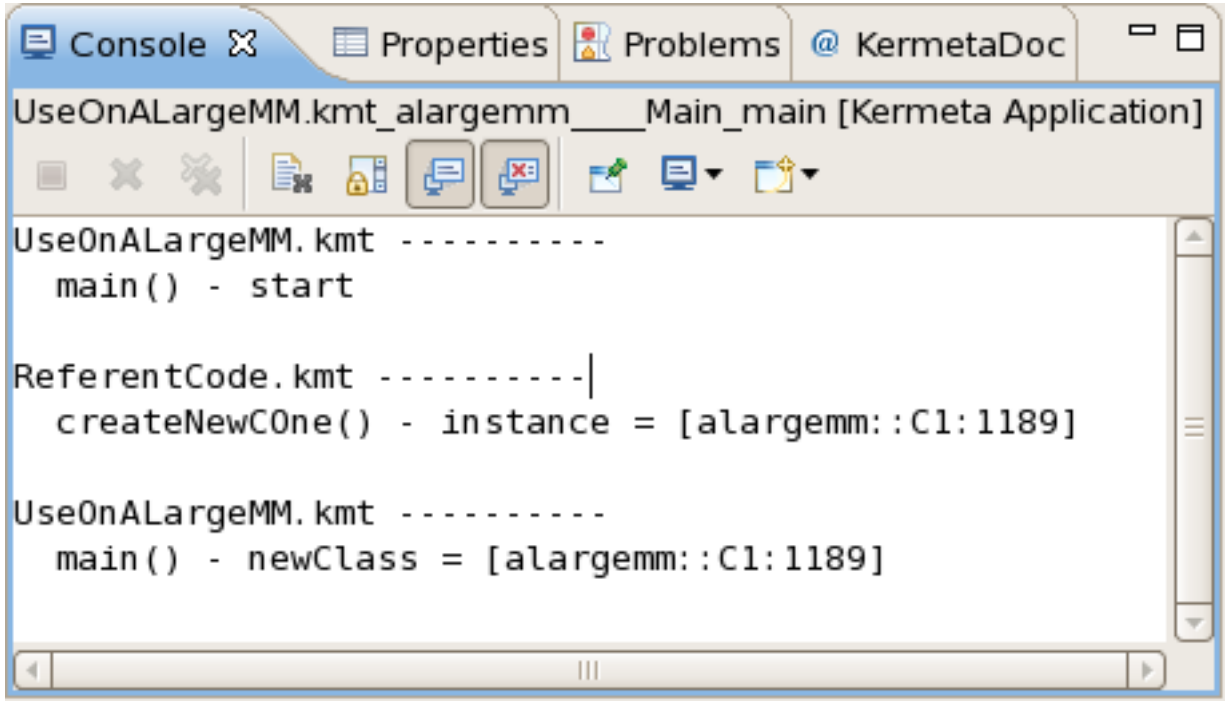
```
//// ReferentCode.kmt ////
package referentmm;

require kermeta
require "ReferentMT.kmt"

using kermeta::standard

// we define a generic class typed with ReferentMT
class Code<MT : ReferentMT>
{
 operation createNewCOne(name : String) : MT::COne is do
  // We are manipulating ReferentMM elements
  result := MT::COne.new
  result.name := name

  stdio.writeln("ReferentCode.kmt ----------")
  stdio.writeln("  createNewCOne() - instance = "
       + result.toString + "\n")
 end
}
```

We use it on ALargeMT

```
//// UseOnALargeMM.kmt ////
@mainClass "alargemm::Main"
@mainOperation "main"

package alargemm;

require kermeta
require "ALargeMT.kmt"
require "ReferentCode.kmt"

class Main
{
 operation main() : Void is do
  stdio.writeln("UseOnALargeMM.kmt ----------\n  main() - start\n")

  // we use referent code through targeted modeltype
  var code : referentmm::Code<alargemm::ALargeMT>
        init referentmm::Code<alargemm::ALargeMT>.new

  // we try to create a new C1 class using the referent code
  var newClass : alargemm::C1 init code.createNewCOne("MyC1Class")

  // we obtain an effective C1 class
  stdio.writeln("UseOnALargeMM.kmt ----------")
  stdio.writeln("  main() - newClass = " + newClass.toString)
 end
}
```

ModelType

Even the referent code manipulates the targeted metamodel elements



Conformance Toughness

Targeted metamodels must comply to ModelType enough to typecheck

- Be similar is not sufficient, as ModelType is considered like any other Type in compiling domain
- The ModelType theory has defined rules of compliance between a top metamodel and variants
- The Kermeta typechecker implements the corresponding matching algorithm
- There is cycles between elements of a metamodel so the match of others elements may depend on an element with circularity
- Two similar elements of the targeted metamodel may compete for one element of generic metamodel, forbidding global match

Conformance Toughness

req: generic metamodel element (required properties)

prov: targeted metamodel element (as provided)

- On **multiplicity**
  - req.upper = 1 *implies* prov.upper = 1
  - req.upper >= prov.upper
  - req.lower <= prov.lower
  - req.isOrdered *implies* prov.isOrdered
  - req.isUnique *implies* prov.isUnique
- On **EClass**
  - (*not* req.isAbstract) *implies* (*not* prov.isAbstract)
  - all req attributes *are matched* by prov attributes
  - all req operations *are matched* by prov operations

Conformance Toughness

- On **EProperty**
  - prov.name = req.name *(annotations are planned to weak it)*
  - prov multiplicity matches with req multiplicity
  - req.isReadOnly *implies* prov.isReadOnly
  - req.isComposite *implies* prov.isComposite
  - (req.opposite->isOclUndefined) *implies* (prov.opposite->isOclUndefined)
  - prov.opposite.name = req.opposite.name

- On **EOperation**
  - prov.name = req.name *(annotations are planned to weak it)*
  - prov multiplicity matches with req multiplicity
  - prov.ownedParameter.size = req.ownedParameter.size
  - all req parameters *are matched* by prov parameters

Generic Refactoring Usecase

Our goal

- Define a library of generic refactorings
- Apply it on many similar metamodels
  - UML class diagrams
  - Kermeta program models
  - Java program models

A huge difficulty

- Find a modeltype that match all of them

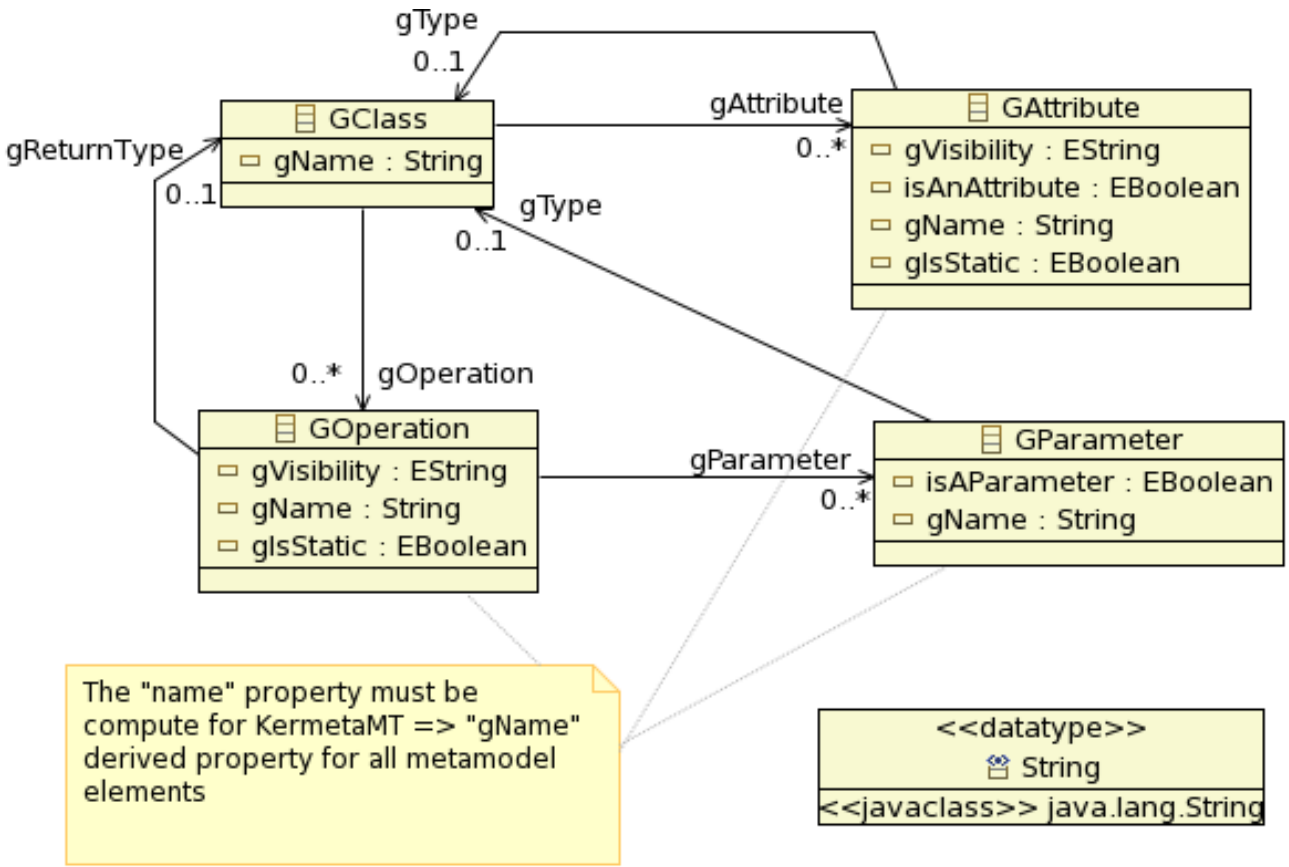
An effective solution

the **NonMatching Strategy**

NonMatching Strategy

The generic metamodel

obvious names are prefixed by a “g” to avoid matching in original targeted metamodels



NonMatching Strategy

Generic refactoring code

```
package refactor;
require kermeta
require "GenericMT.kmt"

class Refactor<MT : GenericMT>
{
  operation encapsulateField(field : MT::GAttribute,
                             fieldClass : MT::GClass,
                             getterName : kermeta::standard::String,
                             setterName : kermeta::standard::String) : Void is do

    ///////// manage the setter /////////
    if not fieldClass.gOperation.exists{ op | op.gName == setterName } then
      //  no setter so we must add it
      var op1 : MT::GOperation init MT::GOperation.new
      op1.gName := setterName
      fieldClass.gOperation.add(op1)

      // it is a setter so we have input parameter)
      var par : MT::GParameter init MT::GParameter.new
      par.gName := field.gName
      par.gType := field.gType
      op1.gParameter.add(par)
    end

    ///////// manage the getter /////////
    if not fieldClass.gOperation.exists{ op | op.gName == getterName } then
      //  no getter so we must add it
      var op : MT::GOperation init MT::GOperation.new
      op.gName := getterName
      fieldClass.gOperation.add(op)
      // it is a getter so we have a return type
      op.gType := field.gType
    end
  end
}
```

NonMatching Strategy

We then adapt UML metamodel to add the generic elements through derived properties

```
// "UmlPlus.kmt" file
package uml;

require "UmlHelper.kmt"

aspect class Class
{
  property gOperation : Operation[0..*]
    getter is do
      var coll : kermeta::standard::ClassOperationsOSet<Operation>
             init kermeta::standard::ClassOperationsOSet<Operation>.new
      coll.owner := self
      // we must duplicate data in the wrapping collection
      coll.addAll(self.ownedOperation)
      // we pass the wrapper as derived property value
      result := coll
    end

    property gAttribute : Property[0..*]
      [.. idem ..]
    end

  property gName : kermeta::standard::String
    getter is do
      result := self.name
    end

  property isAClass : kermeta::standard::Boolean
}
   [.. other properties ..]
```

NonMatching Strategy

We then adapt UML metamodel to add the generic elements through derived properties

```
// "UmlPlus.kmt" file
package uml;

require "UmlHelper.kmt"

aspect class Class
{
  property gOperation : Operation[0..*]
    getter is do
      var coll : kermeta::standard::ClassOperationsOSet<Operation>
             init kermeta::standard::ClassOperationsOSet<Operation>.new
      coll.owner := self
      // we must duplicate data in the wrapping collection
      coll.addAll(self.ownedOperation)
      // we pass the wrapper as derived property value
      result := coll
    end

    property gAttribute : Property[0..*]
      [.. idem ..]
    end

  property gName : kermeta::standard::String
    getter is do
      result := self.name
    end

  property isAClass : kermeta::standard::Boolean
}
   [.. other properties ..]
```

managing multiplicity > 1

managing multiplicity = 1

managing similarity

NonMatching Strategy

Final steps: ModelType + call of refactoring

```
// "UmlMT.kmt" file
package uml;


require kermeta
require "UmlPlus.kmt"

modeltype UmlMT
{
  Class,
  Property,
  Operation,
  Parameter
}
```

```
// "UmlGenericRefactoring.kmt" file
@mainClass "refactor::Main"
@mainOperation "main"

package refactor;

require kermeta
require "../../metamodels/UmlMT.kmt"
require "GenericRefactor.kmt"

class Main
{
  operation main() : Void is do
    // initialization
    [.. loading model ..]

    var node : uml::Class
    var nameField : uml::Property
    [.. retrieving elements ..]

    refactor.encapsulateField(nameField, node, "getName", "setName", false)

    // we save the refactored UML model
    [.. saving result ..]
  end
}
```

NonMatching Strategy

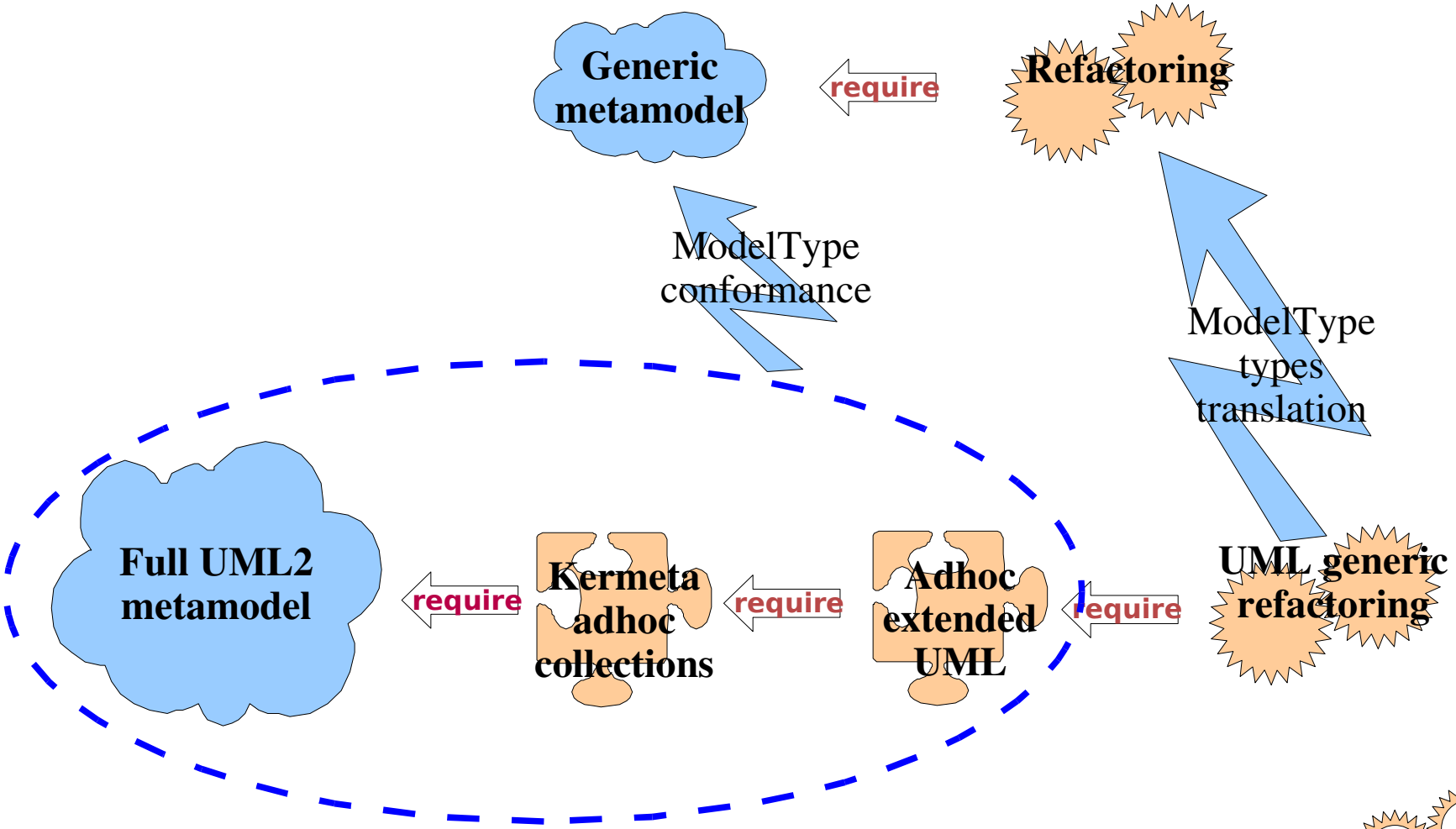
As we derive all generic features, we must include management of [0..*] multiplicities

We extend Kermeta collections to derived the generic references with multiplicity > 1

```
// "UmlHelper.kmt" file

package kermeta;


require kermeta
require "http://www.eclipse.org/uml2/2.1.0/UML"

package standard {

  /** dedicated class for derived property on 'uml::Class' 'ownedOperation' attribute,
    because of its [0..*] multiplicity */
  aspect class ClassOperationsOSet<O : uml::Operation>
              inherits kermeta::standard::OrderedSet<uml::Operation> {

    reference owner : uml::Class

    method add(element : uml::Operation) is do
    owner.ownedOperation.add(element)
    // we must maintain equivalence between real collection and the wrapping one
    super(element)
  end
}
```

NonMatching Strategy

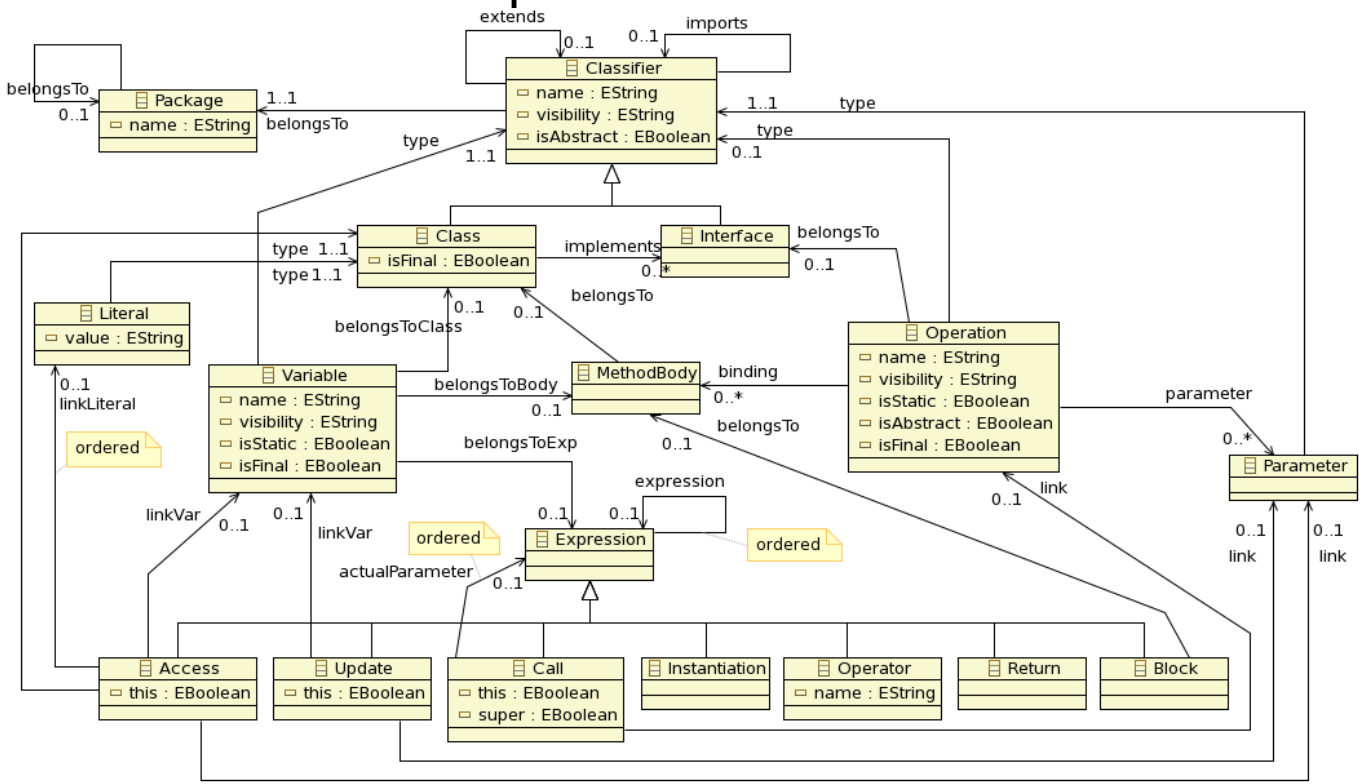
General scheme of the system



NonMatching Strategy

We want to refactor non UML models

- Example: java program models
- A given JavaProgram metamodel
- Different semantic
  - classes do not know operations
  - ...



NonMatching Strategy

We need

- Adhoc collections => JavaProgramHelper.kmt
- Derived properties => JavaProgramPlus.kmt
- ModelType => JavaProgramMT.kmt
- Launcher => JavaProgramGenericRefactoring.kmt

Main toughness: add lacking semantic

- Access to operations from class
  - => add opposites to metamodel at runtime: as it is not working currently for model loading, we replace them by adhoc computing in derived properties
- JavaProgram metamodel implies flat models (all model elements are stored at the resource root)
  - => manipulate the resource when adding elements

NonMatching Strategy

A flat model example

platform:/resource/org.kermeta.refactoring/tests/model/lan_simulation_java2.xmi
- Package lang
- Package java
- Class Integer
- Class String
- Class Vector
- Package lansimulation
- Package nodes
- Package files
- Package packets
- Class Node
- Class Packet
- Class Figure
- Class Document
- Class ASCIIDocument
- Class PostscriptDocument
- Class Workstation
- Class PrintServer
- Variable _name
- Variable _nextNode
- Operation Node
- Method Body
- Parameter
- Operation Node
- Method Body
- Parameter
- Parameter
- Operation getName
- Method Body
- Operation getNextNode

Similar UML model

platform:/resource/org.kermeta.refactoring/tests/model/lan_simulation2.uml
- <Model>
  - <Package> lan_simulation
    - <Data Type> String
    - <Data Type> Integer
    - <Data Type> Vector
    - <Package> nodes
      - <Class> Node
        - <Property> _name : String
        - <Property> _nextNode : Node
        - <Operation> Node (name : String)
          - <Parameter> name : String
        - <Operation> Node (name : String, nextNode : Node)
          - <Parameter> name : String
          - <Parameter> nextNode : Node
        - <Operation> getNextNode () : Node
        - <Operation> setNextNode (nextNode : Node)
        - <Operation> accept (p : Packet)
        - <Operation> send (p : Packet)
        - <Operation> getName () : String
      - <Class> Printserver
      - <Class> Workstation
    - <Package> packets
      - <Class> Packet
    - <Package> files
      - <Class> Document
        - <Property> _content : String
        - <Property> _name : String
        - <Operation> Document (content : String, name : String)
        - <Operation> getContent () : String

NonMatching Strategy

Managing flat model structure

Adding a new element in model (adhoc collection)

```
// "JavaProgramHelper.kmt" file
package kermeta;

package standard {

  /** dedicated class for derived property on 'uml::Class' 'ownedOperation'
      attribute, because of its [0..*] multiplicity */
  aspect class ClassOperationsOSet<O : javaprogram::Operation> inherits
                 kermeta::standard::OrderedSet<javaprogram::Operation> {

    reference owner : javaprogram::Class

    operation initialize(ownerColl : javaprogram::Operation[0..*]) is do
      self.addAll(ownerColl)
    end

    method add(element : javaprogram::Operation) is do
      // we must create a body if the operation have no body corresponding to the class
      var opBody : javaprogram::MethodBody init element.binding.detect{ body |
        body.belongsTo == owner or body.belongsTo.isVoid
      }
      if opBody == void then
        opBody := javaprogram::MethodBody.new
        element.binding.add(opBody)
        owner.containingResource.add(opBody)
        // we expect the operation is a new one and needs to be inserted in the resource
        owner.containingResource.add(element)
      end
      opBody.belongsTo := owner
      // we must maintain equivalence between real collection and the wrapping one
      super(element)
    end
} }
```

NonMatching Strategy

Managing flat model structure

Adding a new element in model (derived property)

```
// "JavaProgramPlus.kmt" file
package javaprogram;

require kermeta
require "JavaProgramHelper.kmt"

aspect class Class
{
  property gOperation : Operation[0..*]
    getter is do
      var coll : kermeta::standard::ClassOperationsOSet<Operation>
            init kermeta::standard::ClassOperationsOSet<Operation>.new
      coll.owner := self
      // we must duplicate data in the wrapping collection
      self.containingResource.each{ o |
        var op : Operation
        op ?= o
        if op != void then
          op.binding.each{ body |
            if body.belongsTo == self then
              coll.add(op)
            end
          }
        end
      }
      // we pass the wrapper as derived property value
      result := coll
    end
  [.. other derived properties ..]
}
```