On the Functional Interpretation of OCL

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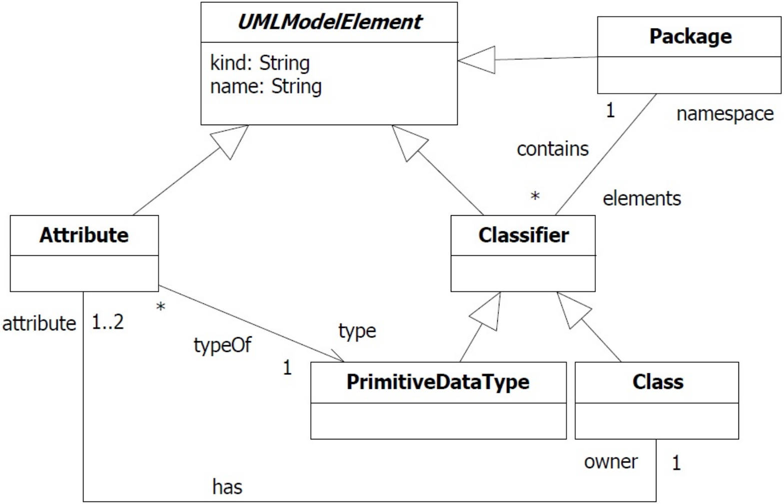
  - semantic interpretation of many OCL aspects
- What's next?

Running Example: UML Class Diagrams Metamodel



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- Subclasses of a class *Class* represented by a field of type *ClassCh*

```
data UMLModelElementCh = UMLMECAtt Attribute
                       | UMLMECPck Package
                       | UMLMECCla Classifier
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                       | UMLMECPck Package
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```

- If the class is not abstract, the field is wrapped with *Maybe*

```
-- Classifier(namespace:Package) + subtypes
data Classifier = Classifier Int (Maybe ClassifierCh)
```

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  - In case of non-primitive types an integer represents the identifier of the element

```
  -- Attribute(typ:Classifier, owner:Class)
data Attribute = Attribute Int Int
```

  - Multiplicities that accept many elements are represented by lists

```
  -- Class(atts:Set(Attribute))
data Class = Class [Int]
```

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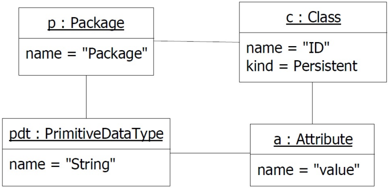

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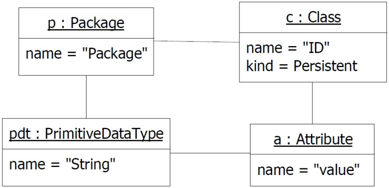

$$
\begin{array}{l}
\mathit{example} = \mathit{Model} \\
\quad [\mathit{UMLModelElement}\ 1\ \texttt{"Persistent"}\ \texttt{"Package"}\ (\mathit{UMLMECPck}\ \$\ \mathit{Package}\ [2,3]) \\
\quad , \mathit{UMLModelElement}\ 2\ \texttt{"Persistent"}\ \texttt{"String"}\ (\mathit{UMLMECCla}\ \$\ \mathit{Classifier}\ 1 \\
\qquad (\mathit{Just}\ \$\ \mathit{ClassifierChPri}\ \ \mathit{PrimitiveDataType})) \\
\quad , \mathit{UMLModelElement}\ 3\ \texttt{"Persistent"}\ \texttt{"ID"}\ (\mathit{UMLMECCla}\ \$\ \mathit{Classifier}\ 1 \\
\qquad (\mathit{Just}\ \$\ \mathit{ClassifierChCla}\ (\mathit{Class}\ [4]))) \\
\quad , \mathit{UMLModelElement}\ 4\ \texttt{"Persistent"}\ \texttt{"value"}\ (\mathit{UMLMECAtt}\ \$\ \mathit{Attribute}\ 2\ 3) \\
\quad]
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$$

This representation can be automated by means of a model-to-text transformation

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- The translation mimics the structure of the OCL invariants

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\begin{aligned}
&\mathit{chk1} \quad\;\; = \mathit{context}\ \_\mathit{Class}\ [\mathit{inv1}\,]\\
&\mathit{inv1}\ \mathit{self} = \mathit{ocl}\ \mathit{self}\ \mathtt{|.|}\ \mathit{atts}\ \mathtt{|\text{-}>|}\ \mathit{forAll}\ (\lambda(\mathit{Val}\ (\mathit{a1}, \mathit{a2})) \rightarrow\\
&\quad (\mathit{ocl}\ \mathit{a1}\ \mathtt{|<>|}\ \mathit{ocl}\ \mathit{a2})\ \mathtt{|==>|}\ ((\mathit{ocl}\ \mathit{a1}\ \mathtt{|.|}\ \mathit{name})\ \mathtt{|<>|}\ (\mathit{ocl}\ \mathit{a2}\ \mathtt{|.|}\ \mathit{name})))\\
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- We defined an Embedded Domain Specific Language

Representation of OCL (2)

```
context Class inv:
  Class.allInstances()->forAll (c : Class |
    c.attribute->iterate ( a:Attribute; result:Boolean=true |
                           result and
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chk2   = context _Class [inv2]
inv2 _ = ocl _Class |.| allInstances |->| forAll (λc →
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- The type *OCL m a* is a *Reader* monad

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type OCL m a = Reader m a
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representing computations which read from a shared environment of type m and return a value of type a.

The OCL Monad

- Monads structure computations in terms of values and sequences of (sub)computations that use these values.
  - Allow to incorporate side-effects and state

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- A sequence of computations describes the navigation through properties and functions
- The shared environment can be used to look up the elements referred by others.

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$$
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(|\text{->}|) ::\ & \mathit{OCL}\ m\ (\mathit{Val}\ [\mathit{Val}\ a]) \rightarrow (\mathit{Val}\ [\mathit{Val}\ a] \rightarrow \mathit{OCL}\ m\ (\mathit{Val}\ b))\\
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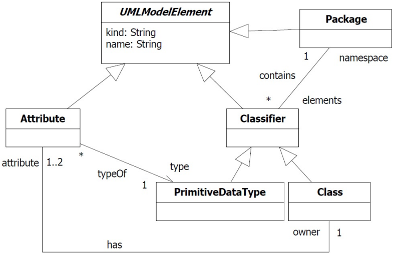


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Collection Operators

- The `iterate` OCL operator is almost directly translated to the *fold* recursion scheme of Haskell.

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&iterate :: (Val\ b \rightarrow Val\ a \rightarrow OCL\ m\ (Val\ b)) \rightarrow Val\ b \rightarrow Val\ [Val\ a]\\
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- Most collection operators correspond to well-known functional programming abstractions, like *map* and *filter*.

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But can also be directly defined in Haskell.

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- The functional infrastructure can be automatically generated

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  - Pattern Matching
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  - Lambda abstraction for collection operators
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  - Safe navigation
  - Pattern Matching
  - Lazy Evaluation
- We can put functional programming abstractions to work on MDE problems.

Thank you