Object Constraint Language 2

Martin Nečaský
Dept. of Software Engineering
Faculty of Mathematics and Physics
Charles University in Prague

Type System

- predefined types in OCL standard library
  - generic types
    - `OclAny`, `OclInvalid`
  - basic types
    - similar to those in other known languages
    - `Boolean`, `Real`, `Integer`, `String`
  - collection types
    - results of navigation through associations in class diagrams
    - `Collection`
    - `Set`, `Bag`, `OrderedSet`, `Sequence`
- user-defined types
  - defined by a user in UML diagrams
  - every instantiable model element in UML diagrams is automatically a type in OCL expressions

`OclInvalid`

- `OclInvalid = {invalid}`
- conforms to all other types
  - i.e. `invalid` can be an instance of any type in OCL
- any property call applied on `invalid` results in invalid
  - except for `oclIsUndefined()` and `oclIsInvalid()`

OclAny

- behaves as a supertype for all OCL types
- `a = b, a <> b : Boolean`
  - equals, not equals
- `a.oclIsNew() : Boolean`
  - true if `a` is created during performing an operation
  - can only be used in the operation postcondition
- `a.oclIsUndefined() : Boolean`
  - true if `a` is equal to `invalid` or equal to `null`
- `a.oclIsInvalid() : Boolean`
  - true if `a` is equal to `invalid`
- `a.oclIsTypeOf(t : Classifier) : Boolean`
  - true if `a` is of the type `t` but not a subtype of `t`
- `a.oclIsKindOf(t : Classifier) : Boolean`
  - true if `a` is of the type `t` or a subtype of `t`
- `a.oclType() : Classifier`
  - evaluates to type of `a`

Boolean

- represents common true/false values
- `a or b, a xor b : Boolean`
- `a and b : Boolean`
- `a implies b : Boolean`
- `not (a) : Boolean`

Real

- mathematical concept of real
- `a + b, a - b, -a : Real`
- `a * b : Real`
- `a / b : Real`
- `a < b, a > b : Boolean`
- `a <= b, a >= b : Boolean`
- `a.abs() : Real`
- `a.floor(), a.round() : Integer`
- `a.min(b : Real) : Real`
- `a.max(b : Real) : Real`

Integer

- mathematical concept of integer
- subclass of `Real`
- `a + b, a - b, -a : Integer`
- `a * b : Integer`
- `a / b : Real`
- `a.abs() : Integer`
- `a.div(b : Integer) : Integer`
- `a.mod(b : Integer) : Integer`
- `a.min(b : Integer) : Integer`
- `a.max(b : Integer) : Integer`

String

- string is a sequence of characters in some suitable character set used to display information about the model
- `a + b : String`
- `a.size() : Integer`
- `a.concat(b) : String`
- `a.substring(s, e: Integer) : String`
  - substring starting and ending at positions between 1 and `a.size()`
- `a.toInteger() : Integer, ...`
- `a.toUpperCase() : String`
- `a.toLowerCase() : String`
- `...`

Collections

- navigation via properties (association ends or attributes) results in a `Collection`
- `Collection` is an abstract type with four concrete sub-types:
  - `Set`
  - `OrderedSet`
  - `Bag`
  - `Sequence`

Navigation

- navigation via property **`p`** from **`a`**

`a.p`

- **`a`** is `self` or a variable with an instance
- results to
  - single instance (object or value) or an empty **`Set`** when the max multiplicity of **`p`** equals to 1
  - a **`Set`** when the max multiplicity of **`p`** is greater than 1
  - an **`OrderedSet`** when the max multiplicity of **`p`** is greater than 1 and **`p`** is modified by **`{ordered}`**

Navigation

- navigation via a chain of properties **`p1...pn`** from **`a`**

`a.p1.....pn`

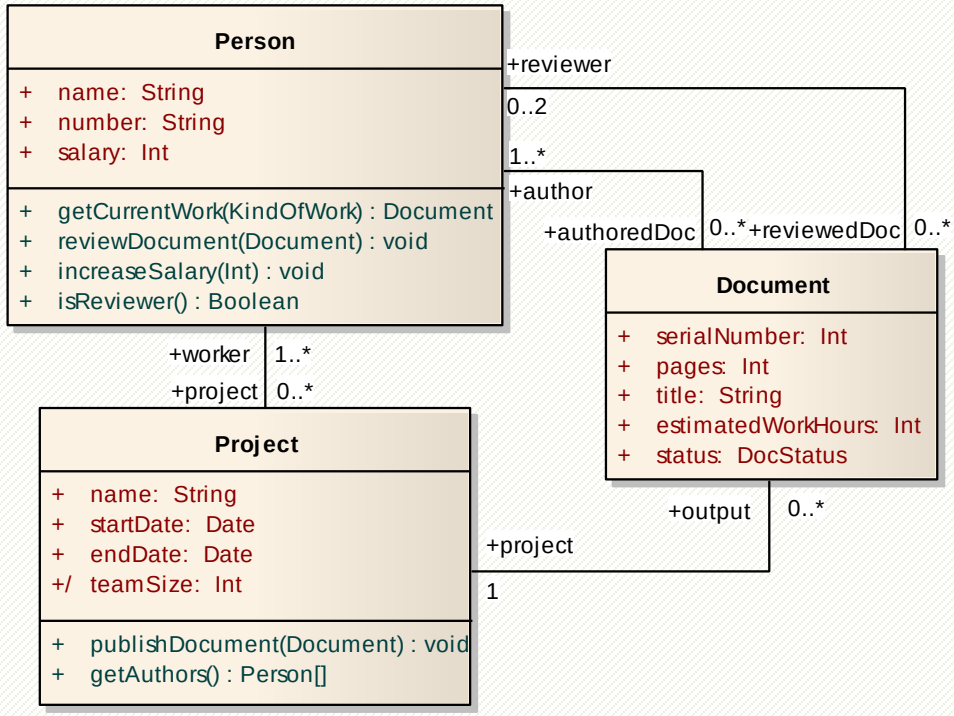
- results to **`Bag`**

Collection Constants

```
Set{1,2,5,88}
Sequence{'apple', 'orange', 'pear'}
Sequence{1..(6+4)}
```

Collection Iterator Operations

- different operations which iterate a collection and create a new collection from the existing one
- `select` and `reject` – specify a selection from a collection
- `collect`
- `forAll`
- `exists`
- `closure`
- `iterate`
- ... and more



Collection Iterator Operations

- general syntax of iterator operations is

```
col->op(expression)
```

or

```
col->op(v | expression-with-v)
```

or

```
col->op(v: Type | expression-with-v)
```

- sub-expressions of **`expression`** and **`expression-with-v`** implicitly start with the iteration variable when it is not present
  - contextual instance is referred by **`self`** reserved word but **`self`** is not implicit

```
context Person
inv: project
      ->op(startDate
           > self.startDate)
```

```
context Person
inv: self.project
      ->op(p|p.startDate
           > self.startDate)
```

Select and Reject Operations

- `select` specifies a subset of a collection containing all elements of the original collection for which a given expression evaluates to true

```
collection->select(boolean-expression)
```

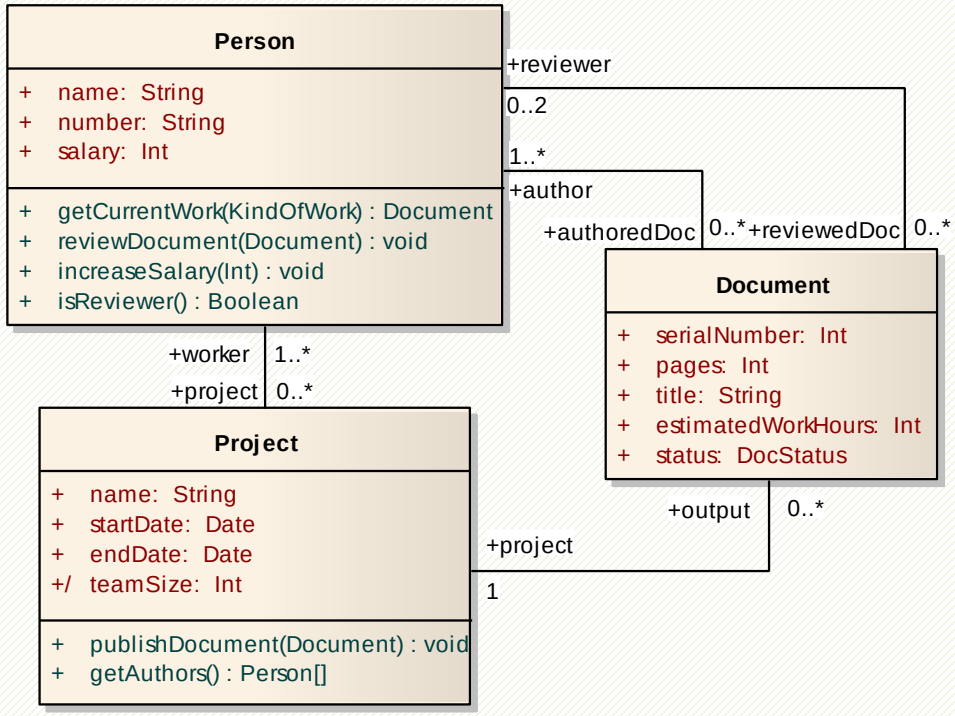
  - for each element of the original collection, evaluate the expression and put the result into the new collection

Select and Reject Operations

- `reject` specifies a subset of a collection containing all elements of the original collection for which a given expression evaluates to false

```
collection->reject(boolean-expression)
                        ~
collection->select(not(boolean-expression))
```

Select and Reject Operations




```
context Person
inv: self.authoredDoc
       ->reject(d|self.project.output->includes(d))
           ->size()=0
```

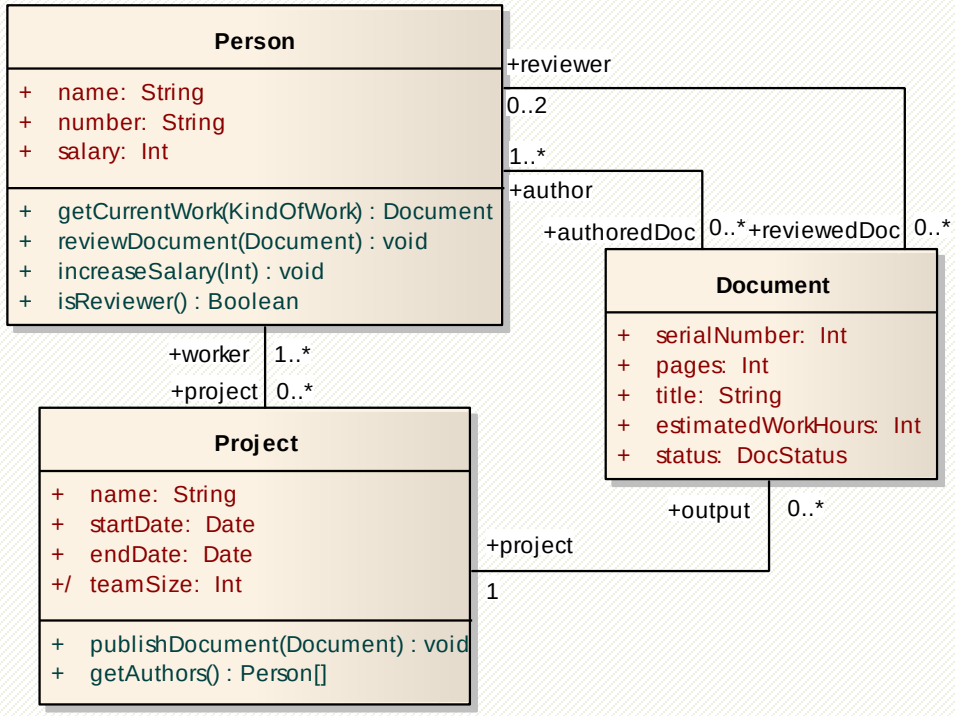
Collect Operation

- `collect` specifies a collection that is computed from other collection
  - the new collection is not a sub-collection but contains elements computed/derived from the elements of the original collection

    ```
    collection->collect(expression)
    ```

  - for each element of the original collection, evaluate the expression and put the result into the new collection

Collect Operation




```
context Person
inv: self.authoredDoc->collect(d|d.project)
```

Collect Operation

```
collection->collect(PropertyName)
```

~

```
collection.PropertyName
```

ForAll Operation

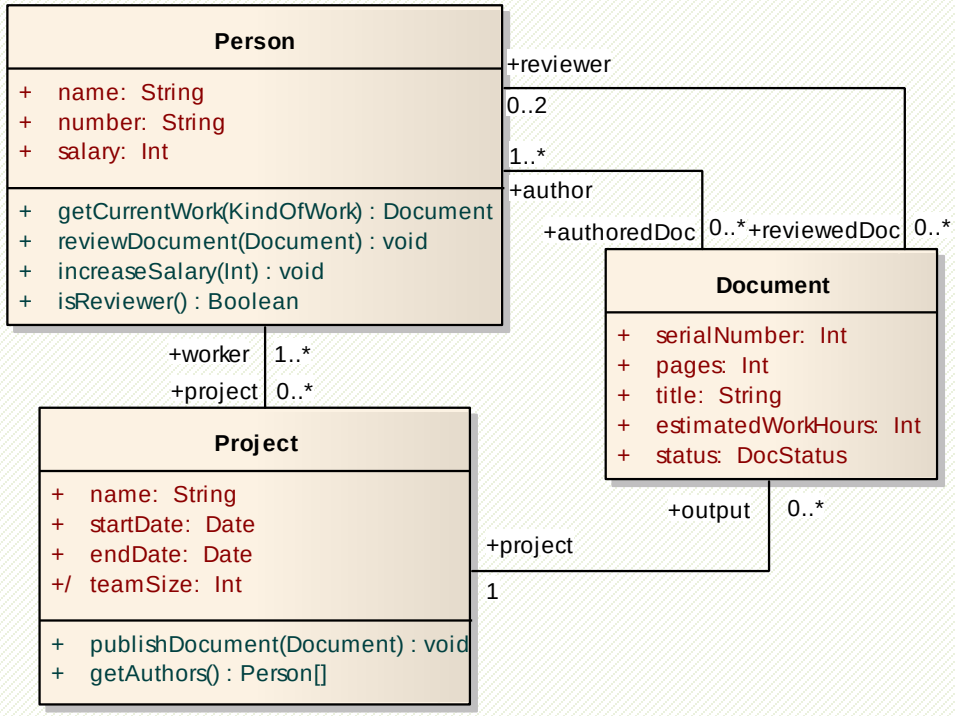
- `forAll` specifies a Boolean expression which must hold for all objects in a collection

```
collection->forAll(expression)
```

- extended variant with more than one iterators of the same collection
  - iterator variables must be used in this case

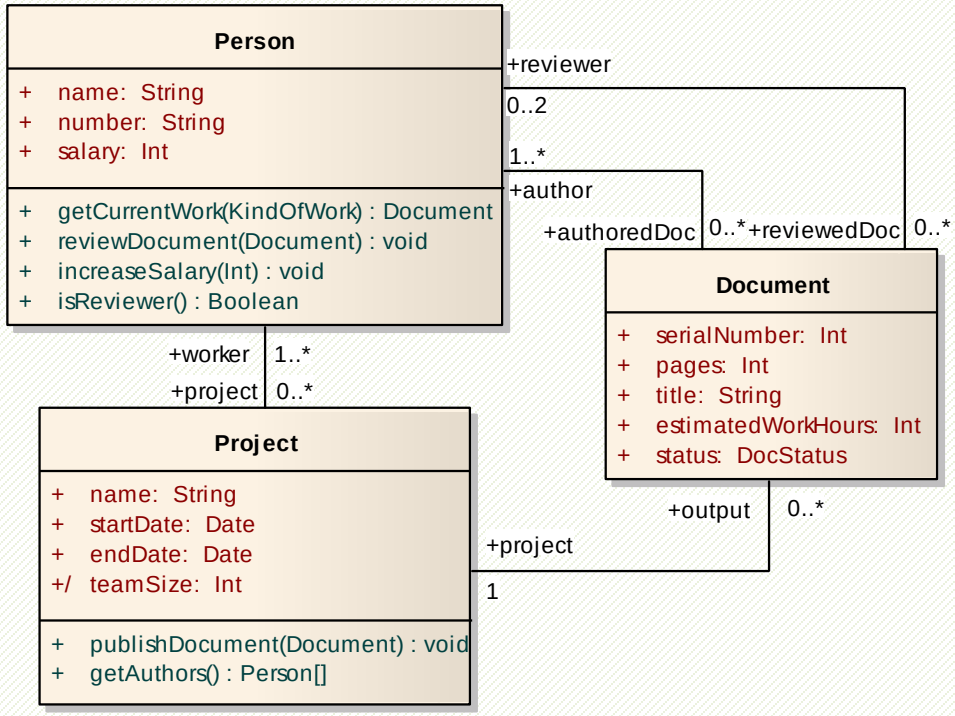
```
collection->forAll(v1,v2 | expression)
                    ~
collection->forAll(v1 |
  collection->forAll(v2 | expression)
```

ForAll Operation




```
context Person
inv: self.authoredDoc
       ->forAll(d|self.project.output->includes(d))
```

ForAll Operation




```
context Project
inv: self.output->forAll(d1,d2| d1<>d2 implies
                          d1.serialNumber <> d2.serialNumber)
```

Exists Operation

- **`exists`** specifies a Boolean expression which must hold for at least one object in a collection

```
collection->exists(expression)
```

- extended variant with more than one iterators is also possible

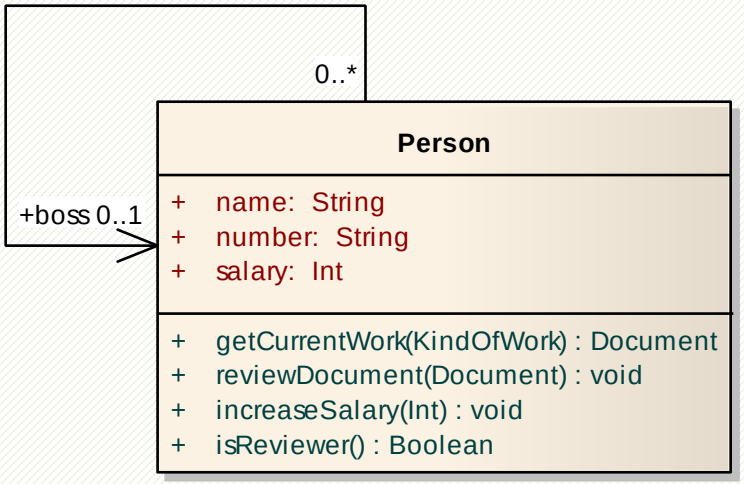
Closure Operation

- `closure` specifies a new collection created by a recursive application of an expression

```
collection->closure(expression)
```

- allows for expressing a transitive closure
  - the expressive power of OCL exceeds the power of relationally complete languages

Closure Operation




```
context Person
inv: self->asSet()->closure(boss)->size() <= 3
```

Iterate Operation

- **iterate** is a general loop operation

```
collection->iterate(
   element : Type1;
   result : Type2 = <initial-value-expression>
      | <expression-with-element-and-result>)
```

- **element** is iterator
- **result** accumulates the resulting value
  - it is also called accumulator
- for each element in **collection**, the **expression** is calculated using the previous value of **result**

Iterate Operation

```
source->forAll(v | body ) =
      source->iterate(
            v; result : Boolean = true
                  | result and body(v))

source->exists(v | body ) =
      source->iterate(
            v; result : Boolean = false
                  | result or body(v))
```

Other Operations on Collections

- `collection->count(object) : Integer`
  - the number of occurences of the object in the collection
- `collection->includes(object) : Boolean`
  - true if the collection contains the object
- `collection->isEmpty() : Boolean`
  - true if the collection is empty
- `collection->size() : Integer`
  - the number of elements in the collection
- … and more

Other Operations on Collections

- difference to the iterator operations is that the default context variable is **`self`**, not the iteration variable

```
context Person
inv: self.authoredDoc->
  excludesAll(reviewedDoc)

context Person
inv: self.authoredDoc->
  excludesAll(self.reviewedDoc)
```