XI. The Object Constraint Language

The Object Constraint Language (OCL)
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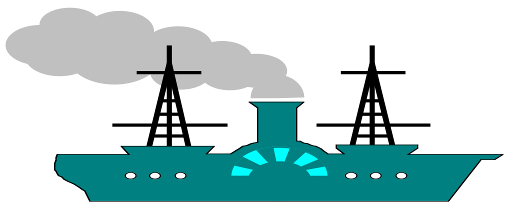


The Object Constraint Language

- *Some constraints can be adequately expressed in the graphical language (e.g., multiplicity of an association).*
- *Some can not. For example, constraints within operation specifications (pre- and post-conditions)*
- *The Object Constraint Language (OCL) provides a formal language for specifying constraints which can supplement the models created in terms of UML diagrams.*
- *The language has a precise syntax that enables the construction of unambiguous statements.*
- *Each expression has an associated* ***context****, which is usually the class to which the expression is attached.*

OCL Examples

OCL expression	Interpretation
Person `self.age`	In the context of a specific person, the value of the property 'age' of that person—i.e. a person's age.
Person `self.income >= 5,000`	The property 'income' of the person under consideration must be greater than or equal to 5,000.
Person `self.wife->notEmpty` **implies** `self.wife.sex = female`	If the set 'wife' associated with a person is not empty, then the value of the property 'sex' of the wife must be female. The boldface denotes an OCL keyword, but has no semantic import in itself.
Company `self.employee->size <= 50`	The size of the set of the property 'employee' of a company must be less than or equal to 50. That is, a company cannot have more than 50 employees.
Company `self.employee->select (age > 50)`	This specifies the set of employees of a company whose age is greater than 50.

Invariants

- ***Invariants** can be associated with classes and describe properties that must hold true for all the instances of the class.*
- *For example, for an LCBO store with a customer database, represented by a* `Customer` *class*

  ```
  Customer
  age ≥ 18
  ```

  says that every customer must have an age attribute value greater than 18.
- *For a* `CustomerCard` *class, the invariants*

  ```
  CustomerCard
  validFrom.isBefore(today)
  expiresAt.isAfter(today)
  ```

  make sure that the card is valid at the time of use.

More on Invariants

- *Instead of writing*

  `validFrom.isBefore(today)`

  we can write

  `validFrom --> isBefore(today)`

  `isBefore` *is a binary operation associated with dates.*
- *Sometimes the value of one attribute can be computed from those of others (**derived attribute**):*

```
Customer
printedName = firstName.concat(lastName)
```


Invariants Between Classes

- *We can also specify invariants between the instances of two or more classes.*
- *For example, the* `Customer` *class may have an invariant*

  `card.customer = customer`

  We assume here that `card` *is an attribute of* `Customer` *and* `customer` *is an attribute of* `CustomerCard`*, and we want to make sure that the values of these attributes match.*
- *Likewise, for the* `CustomerCard` *class we may have an invariant*

  `printedName = customer.title.concat(customer.name)`

  which states that the value of `printedName` *of* `CustomerCard` *should be the same with the concatenation of* `customer.name` *and* `customer.title`*.*

Set-Theoretic Constraints

- *Attributes are single-valued in UML, but associations are not (unless their multiplicity specifies so.) We want to define constraints on sets of objects too.*
- *For example, if we have a class* `GoodCustomer` *which a specialization of* `Customer`*, and* `Customer` *has an association* `bought` *with an attribute* `amount`*,then we may want a constraint*

  `bought.amount --> sum ≤ $5000`

  which says that the sum of all products bought by a good customer is greater than $5K.
- *One-product customers have the constraint*

  `bought --> size = 1` *(or,* `bought.size = 1`*)*

Set-Theoretic Functions and Predicates

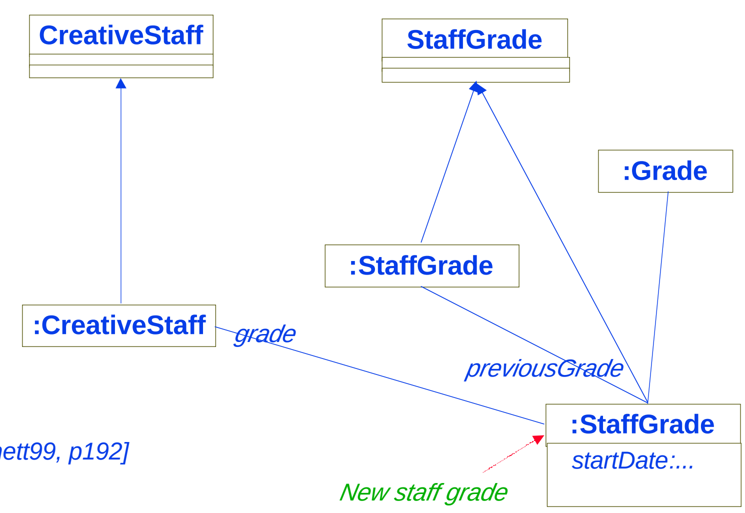
`size(set)` - *returns the size (cardinality) of the set*
`sum(set)` - *returns the sum of the set (assumed to contain numbers)*
`average(set)` - *returns the average of the set*
`min(set)` - *returns the minimum of the set*
`max(set)` - *returns the maximum of the set*
`notEmpty(set)` - *true if the set is not empty*
`includes(object)` - *true if the set includes the object*
`union(set)` - *returns the union of two sets*
`intersection(set)` - *returns the intersection of two sets*

Pre- and Post-conditions in OCL

- Pre-condition and post-condition expressions are associated to an operation/method and they describe
  - ✓ What must be true before the operation is executed (pre-condition);
  - ✓ What will be true once the operation is executed (post-condition).
- For example, we may want to say:
  - ✓
```
Customer::buy(product)
pre: acctBal-product.price > 0
post: acctBal = acctBal@pre - product.price
```

The value of `acctBal` ***before*** the operation

What Does the Post-Condition Mean?



[Bennett99, p192]

Pre- and Post-Conditions

```
CreativeStaff::changeGrade(newGrade:StaffGrade,
                              gradeChangeDate:Date)
pre:   grade->notEmpty
       gradeChangeDate >= today
post:  grade = newGrade
       grade.previousGrade = grade@pre
       grade.previousGrade.gradeFinishDate
              = gradeChangeDate
```

(assumes no retroactive changes)

Additional Readings

- *[Warmer99]* Warmer, J. Kleppe, A. *The Object Constraint Language: Precise Modeling with UML,* Addison-Wesley 1999.
- *http://dec.bournemouth.ac.uk/dec_ind/swebster/UML_OCL/index.htm*