

Object Constraint Language (OCL)

(Based on [OMG 2012])

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Outline

- Introduction
- Relation with UML Models
- Values, Types, and Expressions
- Objects and Properties
- Collection Operations

About the OCL

- The Object Constraint Language (OCL) is a **formal** language for writing **expressions** (such as invariants) on UML models.
- It can also be used to specify **queries** over objects.
- OCL expressions are pure specifications **without side effects** (they do not alter the state).
- The OCL is a **typed** first-order language, using a familiar programming language-like syntax.
- The current version OCL 2.3.1 was published in January 2012.

Why OCL

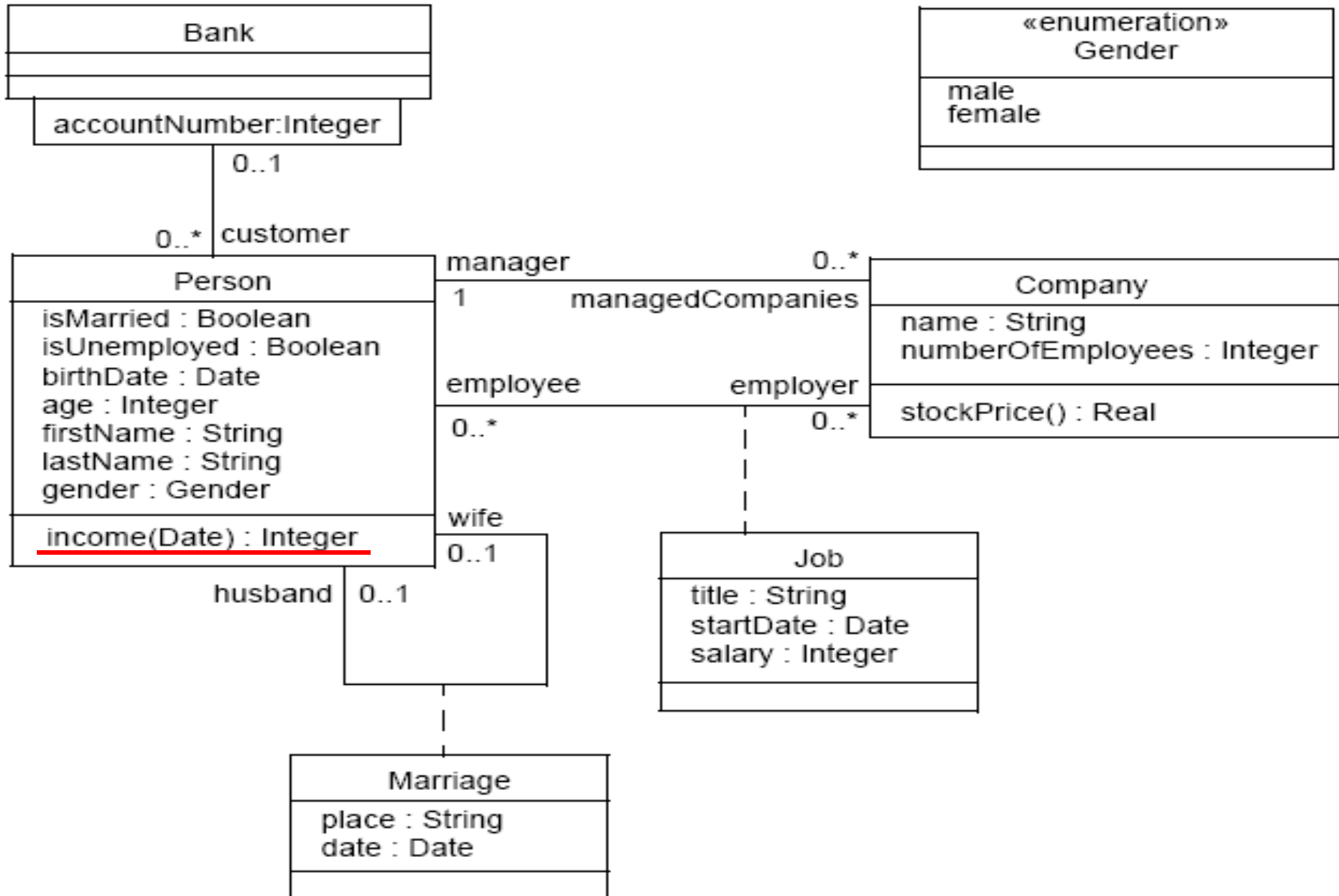
- UML diagrams do not provide all the relevant aspects of a specification.
- Additional constraints expressed by a **natural language** may be **ambiguous**.
- Traditional **formal languages** are precise, but hard to use.
- OCL tries to be **formal** and yet **easy to use**.

Note: OCL does not seem to be in wide use, perhaps due to other similar competing specification languages such as JML; however, this exposition shows how UML specifications can be made more precise.

How Can the OCL Be Used

- **Queries** over objects
- **Invariants** on classes and types
- **Pre** and **post-conditions** on operations
- **Guards**
- **Target sets** for messages and actions
- **Constraints** on operations
- **Derivation rules** for attributes

Class Diagram Example



Relation with UML Models: Contexts

- Each OCL expression is written in the **context** of an instance of a specific type.
- The reserved word *self* is used to refer to the **contextual instance**.
- The context may be specified by a **context declaration**.
- An explicit context declaration may be omitted if the OCL expression is properly placed in a diagram.

Context for Invariants

- Inside the class diagram, as part of the constraint stereotype <<invariant>>

Example:

```
self.numberOfEmployees > 50
```

specifies that the number of employees (of an object in the class Company) must always exceed 50.

- Alternatively (in a separate file),

```
context Company inv:
```

```
self.numberOfEmployees > 50
```


Context for Invariants (cont.)

- The keyword *self* may be omitted.
- Also, a different name may be used for *self* :
context c : Company **inv**:
 c.numberOfWorkers > 50
- The invariant itself can also be given a name (after **inv**) for later references:
context c : Company **inv** enoughEmployees:
 c.numberOfWorkers > 50

Context for Pre and Post-Conditions

- As part of the <<precondition>> and <<postcondition>> constraint stereotypes associated with an operation
- Here, *self* refers to an instance of the class that owns the operation.
- Basic form:

context Typename::operationName(param1 : Type1, ...): Return Type

pre: param1 > ...

post: **result** = ... (result is a reserved keyword)

Context for Pre and Post-Conditions (cont.)

- Example:

```
context Person::income(d : Date) : Integer
```

```
    post: result = 5000
```

- Names may be given:

```
context Typename::operationName(param1 :  
Type1, ... ): ReturnType
```

```
    pre parameterOk: param1 > ...
```

```
    post resultOk: result = ...
```

Package Context

- When necessary, the package context can be given.

- Package statement:

package Package::SubPackage

context X inv:

... some invariant ...

context X::operationName(..)

pre: ... some precondition ...

endpackage

Context for Initial and Derived Values

context Person::income : Integer

init: parents.income->sum() * 1%

-- pocket allowance

-- the “income” attribute will be defined later

derive: if underAge

then parents.income->sum() * 1%

-- pocket allowance

else job.salary -- income from regular job

endif

Basic (Predefined) Values and Types

- **Boolean**: true, false
- **Integer**: 1, -5, 2, 34, 26524, ...
- **Real**: 1.5, 3.14, ...
- **String**: 'To be or not to be', 'This is a system message', ...
- **Others**
 - Collection: Set, Bag, Sequence
 - Tuple

Basic Operations (partial list)

- Integer: $*$, $+$, $-$, $/$, $\text{abs}()$
- Real: $*$, $+$, $-$, $/$, $\text{floor}()$
- Boolean: and , or , xor , not , implies , if-then-else
- String: $\text{concat}()$, $\text{size}()$, $\text{substring}()$
- Collection: select , reject , forAll , exists , ... (to be described later)

Other Types

■ Classifiers

- All classifiers of a UML model are **types** in its OCL expressions.

■ Enumerations

Sub-expressions: the Use of *let*

context Person **inv:**

let income : Integer = self.job.salary->sum() **in**

if isUnemployed **then**

 income < 100

else

 income >= 100

endif

Definition Expressions

- Variables and operations may be introduced for reuse across multiple OCL expressions.

- Example:

context Person

def: income : Integer = self.job.salary->sum()

def: nickname : String = 'Little Red Rooster'

def: hasTitle(t : String) : Boolean
= self.job->exists(title = t)

Previous Values in Post-Conditions

- **context** Person::birthdayHappens()
post: age = age@pre + 1

- **context** Company::hireEmployee(p : Person)
post: employees = employees@pre->including(p)
and
stockprice() = stockprice@pre() + 10

Previous Values in Post-Conditions (cont.)

a.b@pre.c

- takes the old value of property b of a, say x
- and then the new value of c of x.

a.b@pre.c@pre

- takes the old value of property b of a, say x
- and then the old value of c of x.

More about Types and Operations

- Type conformance (like in an object-oriented language)
- Casting (re-typing)
 - Syntax: `object.oclAsType(OclType)`
- Precedence rules
- Infix operators
 - Example: “`a.+(b)`” as “`a+b`”

Properties

- More generally, OCL expressions may talk about things called **properties**.
- A property is one of the following:
 - An **Attribute**
 - context** Person **inv:** self.age > 0
 - An **AssociationEnd**
 - An **Operation with *isQuery*** (no side effects)
 - A **Method with *isQuery*** (no side effects)
- Syntax: object.property
- Multiplicities greater than 1 result in collections.

Properties: AssociationEnds

- Starting from an object, we can **navigate an association** to refer to other objects.
- Example:
 - **context** Person
 - inv:** `self.manager.isUnemployed = false`
 - inv:** `self.employee->notEmpty()`
- By default, navigation results in a Set.
- When the multiplicity is 1, the result may be treated as a single object.

Collections

- OCL Collection Types:
 - Set
 - Bag (may contain duplicates)
 - Sequence (like a bag, but ordered)
- Collection literals:
 - Set { 1, 2, 5 }
 - Bag { 1, 3, 4, 3 }
 - Sequence { 1..10 }
- The OCL defines many operations on collections.

Collection Operations

- Select

context Company **inv:**

self.employee->**select**(age > 50)->notEmpty()

- Reject

context Company **inv:**

self.employee->**reject**(isMarried)->isEmpty()

- The select and reject operations always give a sub-collection of the original collection.

Derived Collections

- From a collection, one may also derive a collection of *different* objects.
- Examples:

```
self.employee->collect( birthDate )
```

```
self.employee->collect( p | p.birthDate )
```

```
self.employee->collect( p:Person | p.birthDate )
```
- The result above is a Bag, which may be turned into a Set:

```
self.employee->collect( birthDate )->asSet()
```

Collection Operation: ForAll

context Company

inv: self.employee->forAll(age <= 65)

inv: self.employee->forAll(p | p.age <= 65)

inv: self.employee->forAll(p : Person | p.age <= 65)

context Company **inv:**

self.employee->forAll(e1, e2 : Person |

e1 <> e2 implies e1.firstName <> e2.firstName)

Collection Operation: Exists

context Company **inv**:

self.employee->exists(firstName = 'Jack')

context Company **inv**:

self.employee->exists(p | p.firstName = 'Jack')

context Company **inv**:

self.employee->exists(p : Person | p.firstName = 'Jack')

The Iterate Operation

- *Reject*, *Select*, *forAll*, *Exists*, and *Collect* can all be described in terms of *iterate*.

- Example:

collection->**collect**(x : T | x.property)

-- is identical to

collection->**iterate**(x : T; acc : T2 = Bag{} |

acc->**including**(x.property))

-- here x is the *iterator* and acc is the *accumulator*

Features on Classes Themselves

- It is also possible to use features defined on classes themselves.
- A predefined feature is *allInstances*, which gives the set of all instances at the time of evaluation.
- Example:

context Person **inv**:

```
Person.allInstances()->forall(p1, p2 |  
p1 <> p2 implies p1.firstName <> p2.firstName)
```