UML for Java Developers

Model Constraints & The Object Constraint Language

Jason Gorman

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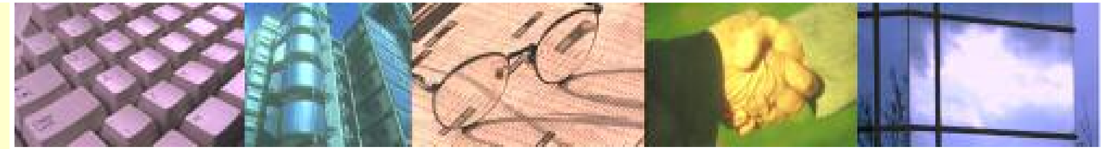

UML for Java Developers (5 Days)

Since Autumn 2003, over 100,000 Java and .NET developers have learned the Unified Modeling Language from **Parlez UML** (http://www.parlezuml.com) , making it one of the most popular UML training resources on the Internet.

UML for Java Developers is designed to accelerate the learning process by explaining UML in a language Java developers can understand – Java!

From Requirements to a Working System

Many UML courses focus on analysis and high-level design, falling short of explaining how you get from there to a working system. **UML for Java Developers** takes you all the way from system requirements to the finished code because that, after all, is why we model in the first place.

Learning By Doing

UML modeling is a practical skill, like driving a car or flying a plane. Just as we don't learn to drive just by looking at PowerPoint presentations, you cannot properly learn UML without getting plenty of practice at it.

Your skills will be developed by designing and building a working piece of software, giving you a genuine understanding of how UML can be applied throughout the development lifecycle.

www.parlezuml.com/training.htm

"I am currently working on a team which is [in] the process of adopting RUP and UML standards and practices. After one of our design sessions, I needed to lookup some information and came across your site. Absolutely great! Most [of] the information I've had questions about is contained within your tutorials and then some."

"Really great site... I have been trying to grasp UML since the day I saw Visual Modeler. I knew a few things but there were gaps. Thanks to your site they have shrunk considerably."

"I went on a UML training course three months ago, and came out with a big folder full of hand-outs and no real understanding of UML and how to use it on my project. I spent a day reading the UML for .NET tutorials and it was a much easier way to learn. 'Here's the diagram. Now here's the code.' Simple."

advertisement

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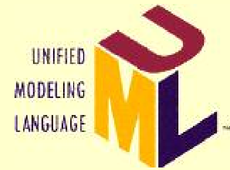
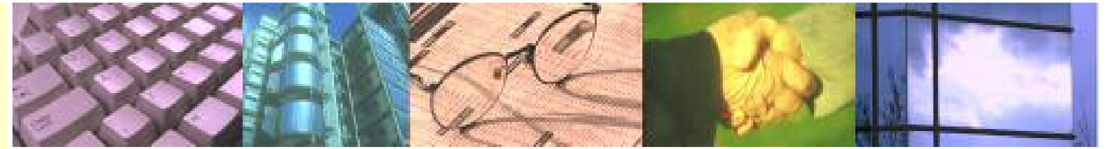
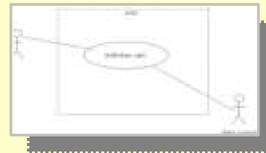


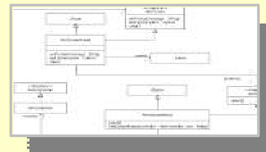


UML for Java Developers covers the most useful aspects of the UML standard, applying each notation within the context of an iterative, object oriented development process



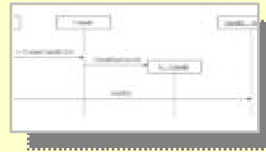
Use Case Diagrams

Model the users of the system and the goals they can achieve by using it



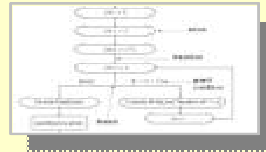
Class Diagrams

Model types of objects and the relationships between them.



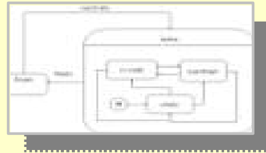
Sequence Diagrams

Model how objects interact to achieve functional goals



Activity Diagrams

Model the flow of use cases and single and multi-threaded code

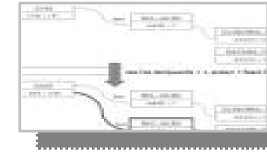


Statechart Diagrams

Model the behaviour of objects and event-driven applications

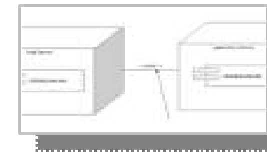
Design Principles

Create well-designed software that's easier to change and reuse



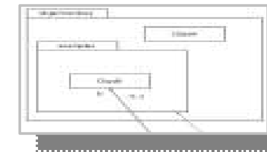
Object Diagrams & Filmstrips

Model snapshots of the running system and show how actions change object state



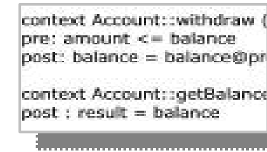
Implementation Diagrams

Model the physical components of a system and their deployment architecture



Packages & Model Management

Organise your logical and physical models with packages

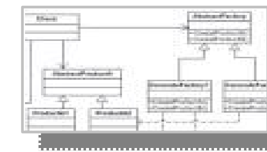


Object Constraint Language

Model business rules and create unambiguous specifications

User Experience Modeling

Design user-centred systems with UML



Design Patterns

Apply proven solutions to common OO design problems

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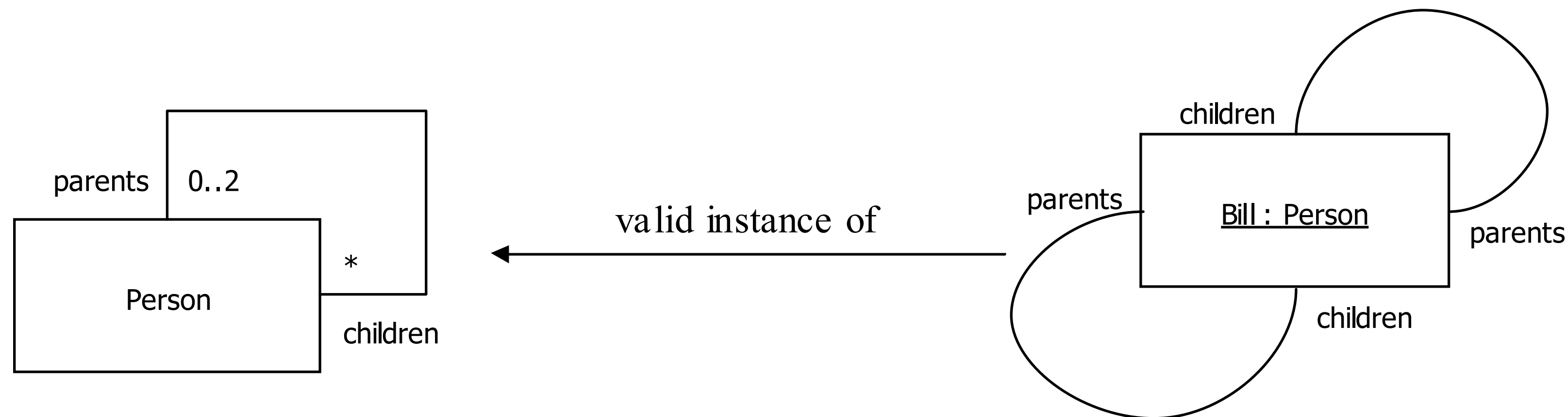
UML Diagrams Don't Tell Us Everything



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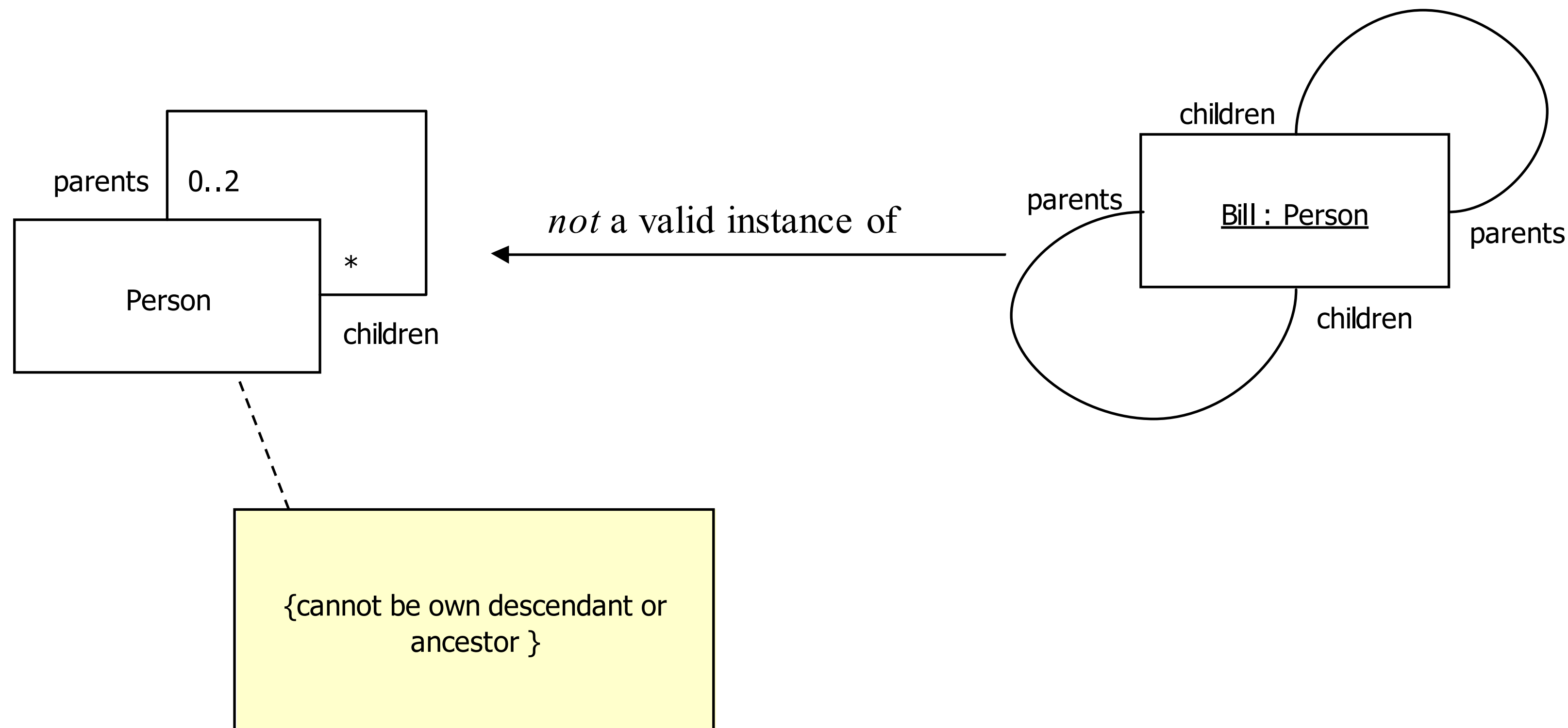
Constraints Make Models More Precise



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What is the Object Constraint Language?

- A language for expressing necessary extra information about a model
- A precise and unambiguous language that can be read and understood by developers and customers
- A language that is purely declarative – ie, it has *no side-effects* (in other words it describes *what* rather than *how*)

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What is an OCL Constraint?

- An OCL constraint is an OCL expression that evaluates to true or false (a Boolean OCL expression, in other words)

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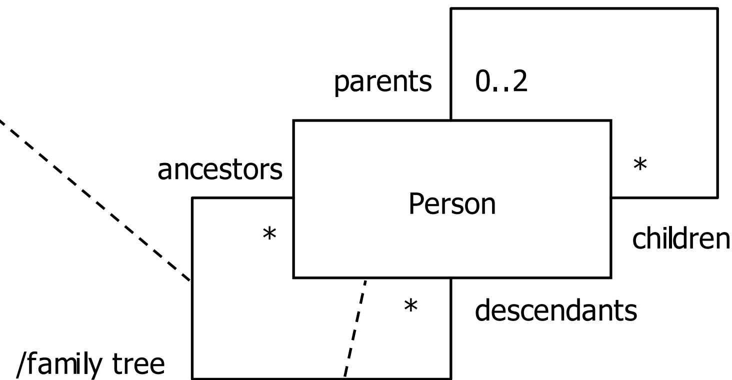
OCL Makes Constraints Unambiguous

```
{ancestors = parents->union(parents.ancestors->asSet())}
{descendants = children->union(children.descendants->asSet())
```




```
{ancestors->excludes(self) and descendants->excludes(self) }
```

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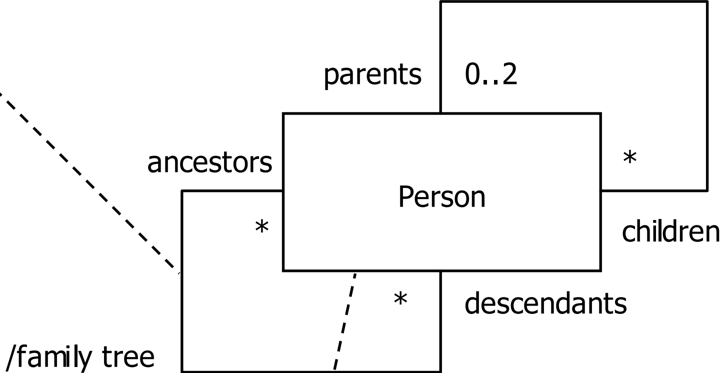
Introducing OCL – Constraints & Contexts

{ancestors = parents->union(parents.ancestors->asSet())}
{descendants = children->union(children.descendants->asSet())}



Q: To what which type this constraint apply?
A: Person

```
context Person
inv: ancestors->excludes(self) and descendants->excludes(self)
```

Q: When does this constraint apply?
A: inv = invariant = always

{ancestors->excludes(self) and descendants->excludes(self) }

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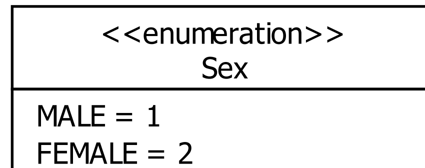
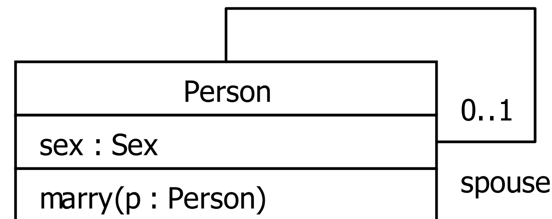
Operations, Pre & Post-conditions





optional constraint name

applies to the marry() operation of the type Person

```
context Person::marry(p : Person)
pre cannot_marry_self:  not (p = self)
pre not_same_sex: not (p.sex = self.sex)
-- neither person can be married already
pre  not_already_married: self.spouse->size() = 0 and p.spouse->size() = 0
post : self.spouse = p and p.spouse = self
```

comments start with --

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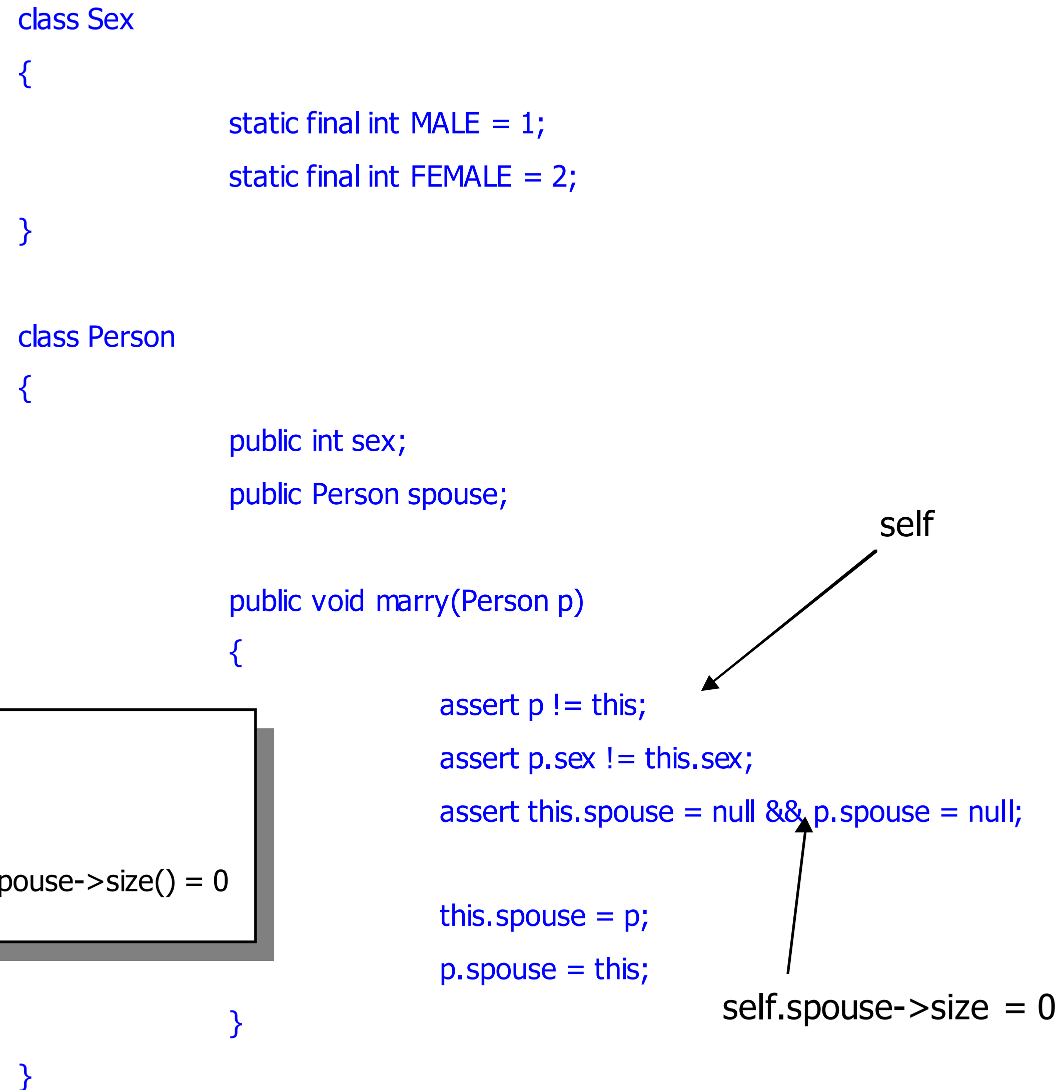
Design By Contract :assert




```
context Person::marry(p : Person)
pre cannot_marry_self: not (p = self)
pre not_same_sex: not (p.sex = self.sex)
-- neither person can be married already
pre not_already_married: self.spouse->size() = 0 and p.spouse->size() = 0
post : self.spouse = p and p.spouse = self
```

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Defensive Programming : Throwing Exceptions

```
class Person
{
        public int sex;
        public Person spouse;

        public void marry(Person p) throws ArgumentException {
                if(p == this) {
                        throw new ArgumentException("cannot marry self");
                }
                if(p.sex == this.sex) {
                        throw new ArgumentException("spouse is same sex");
                }
                if((p.spouse != null || this.spouse != null) {
                        throw new ArgumentException("already married");
                }

                this.spouse = p;
                p.spouse = this;
        }
}
```

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Referring to previous values and operation return values

Account
balance : Real = 0
deposit(amount : Real) withdraw(amount : Real) getBalance() : Real

```
context Account::withdraw (amount : Real)
pre: amount <= balance
post: balance = balance@pre - amount

context Account::getBalance() : Real
post : result = balance
```

balance before execution of operation

return value of operation

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@pre and result in Java

```
context Account::withdraw(amount : Real)
pre: amount <= balance
post: balance = balance@pre - amount

context Account::getBalance() : Real
post : result = balance
```

```
class Account
{
        private float balance = 0;

        public void withdraw(float amount) {
                assert amount <= balance;

                balance = balance - amount;
        }

        public void deposit(float amount) {
                balance = balance + amount;
        }

        public float getBalance() {
                return balance;      <- result = balance
        }
}
```

```
public void testWithdrawWithSufficientFunds() {
        Account account = new Account();

        account.deposit(500);

        float balanceAtPre = account.getBalance();

        float amount = 250;

        account.withdraw(amount);

        assertTrue(account.getBalance() == balanceAtPre – amount);
}
```

balance = balance@pre - amount

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OCL Basic Value Types

Account
balance : Real = 0 name : String id : Integer isActive : Boolean
deposit(amount : Real) withdraw(amount : Real)

- **Integer** : A whole number of any size
- **Real** : A decimal number of any size
- **String** : A string of characters
- **Boolean** : True/False

id : Integer	balance : Real = 0	name : String	isActive : Boolean
int id;	double balance = 0;	string name;	boolean isActive;
long id;	float balance = 0;	char[] name;	
byte id;			
short id;			

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Operations on Real and Integer Types

Operation	Notation	Result type
equals	a = b	Boolean
not equals	a <> b	Boolean
less more	a < b a > b	Boolean Boolean
less or equal more or equal plus	a <= b a >= b a + b	Boolean Boolean Integer or Real
minus	a - b	Integer or Real
multiply divide	a * b a / b	Integer or Real Real
modulus	a.mod(b)	Integer
integer division absolute value	a.div(b) a.abs	Integer Integer or Real
maximum	a.max(b)	Integer or Real
minimum round floor	a.min(b) a.round a.floor	Integer or Real Integer Integer

Eg, 6.7.floor() = 6

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Operations on String Type

Operation	Expression	Result type
concatenation	s.concat(string)	String
size	s.size	Integer
to lower case	s.toLower	String
to upper case	s.toUpper	String
substring	s.substring(int, int)	String
equals	s1 = s2	Boolean
not equals	s1 <> s2	Boolean

Eg, ‘jason’.concat(‘ gorman’) = ‘jason gorman’
Eg, ‘jason’.substring(1, 2) = ‘ja’

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Operations on Boolean Type

Operation	Notation	Result type
or	a or b	Boolean
and	a and b	Boolean
exclusive or	a xor b	Boolean
negation	not a	Boolean
equals	a = b	Boolean
not equals	a <> b	Boolean
implication	a implies b	Boolean
if then else	if a then b1 else b2 endif	type of b

Eg, true or false = true

Eg, true and false = false

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Navigating in OCL Expressions

In OCL:

account.holder

Evaluates to a customer object who is in the role holder for that association

And:

customer.accounts

Evaluates to a *collection* of Account objects in the role accounts for that association

```
Account account = new Account();
Customer customer = new Customer();

customer.accounts = new Account[] {account};
account.holder = customer;
```

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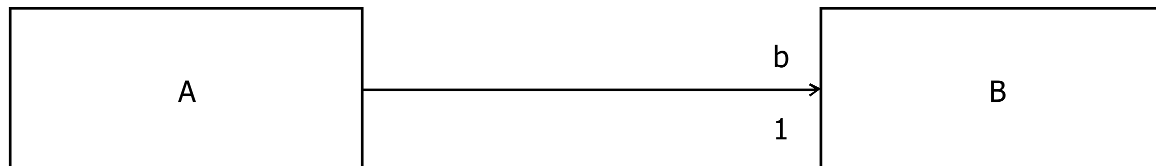
Navigability in OCL Expressions



a.b is allowed

b.a is *not* allowed – it is not navigable

```
class A
{
        public B b;
}

class B
{
}
```

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Calling class features

Account
id : Integer status : enum{active, frozen, closed} balance : Real nextId : Integer
deposit(amount : Real) withdraw(amount : Real) fetch(id : Integer) : Account

```
context Account::createNew() : Account
post: result.oclIsNew() and
      result.id = Account.nextId@pre and
      Account.nextId = result.id + 1
```

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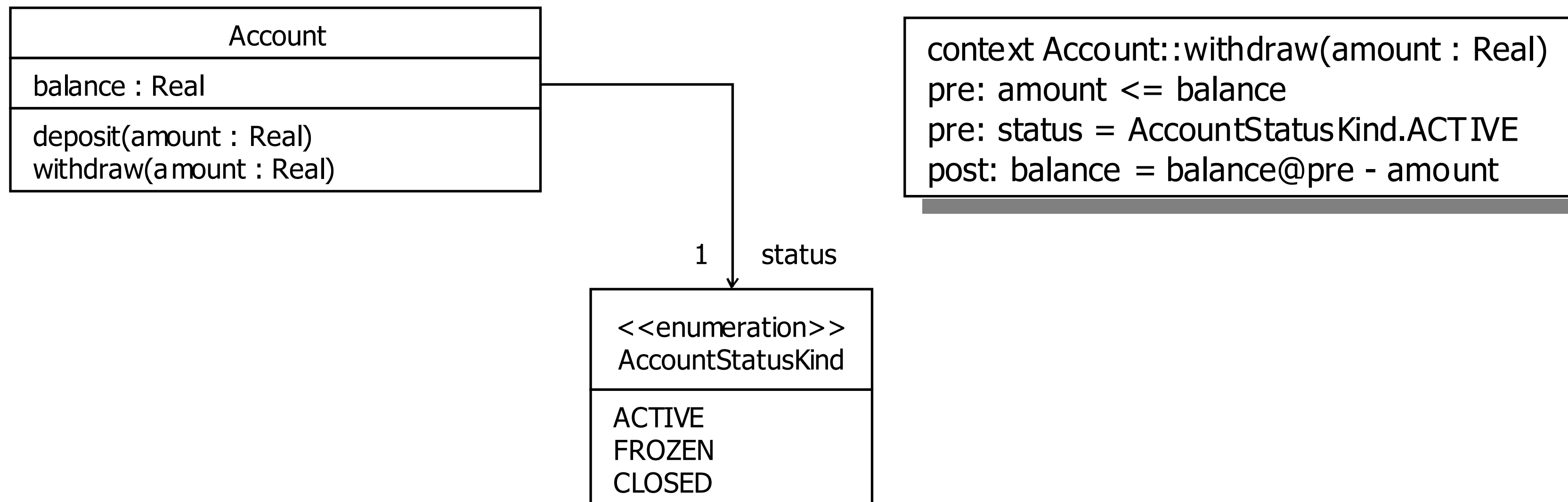
Enumerations in OCL



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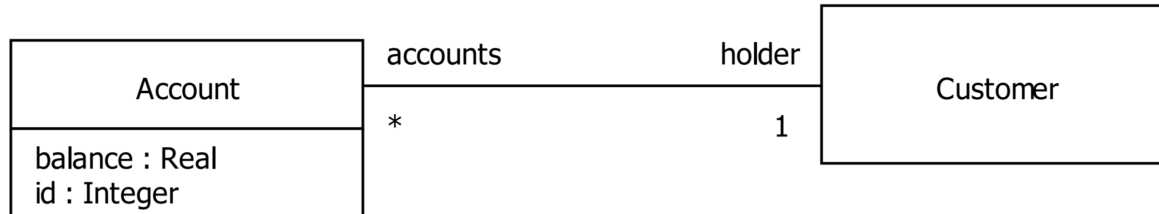
Collections in OCL



customer.accounts.balance = 0 is *not* allowed

customer.accounts->select(id = 2324).balance = 0 is allowed

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Collections in Java

```
class Account
{
        public double balance;
        public int id;
}

class Customer
{
        Account[] accounts;

        public Account SelectAccount(int id)
        {
                Account selected = null;

                for(int i = 0; i < accounts.length; i++)
                {
                        Account account = accounts[i];
                        if(account.id = id)
                        {
                                selected = account;
                                break;
                        }
                }

                return selected;
        }
}
```

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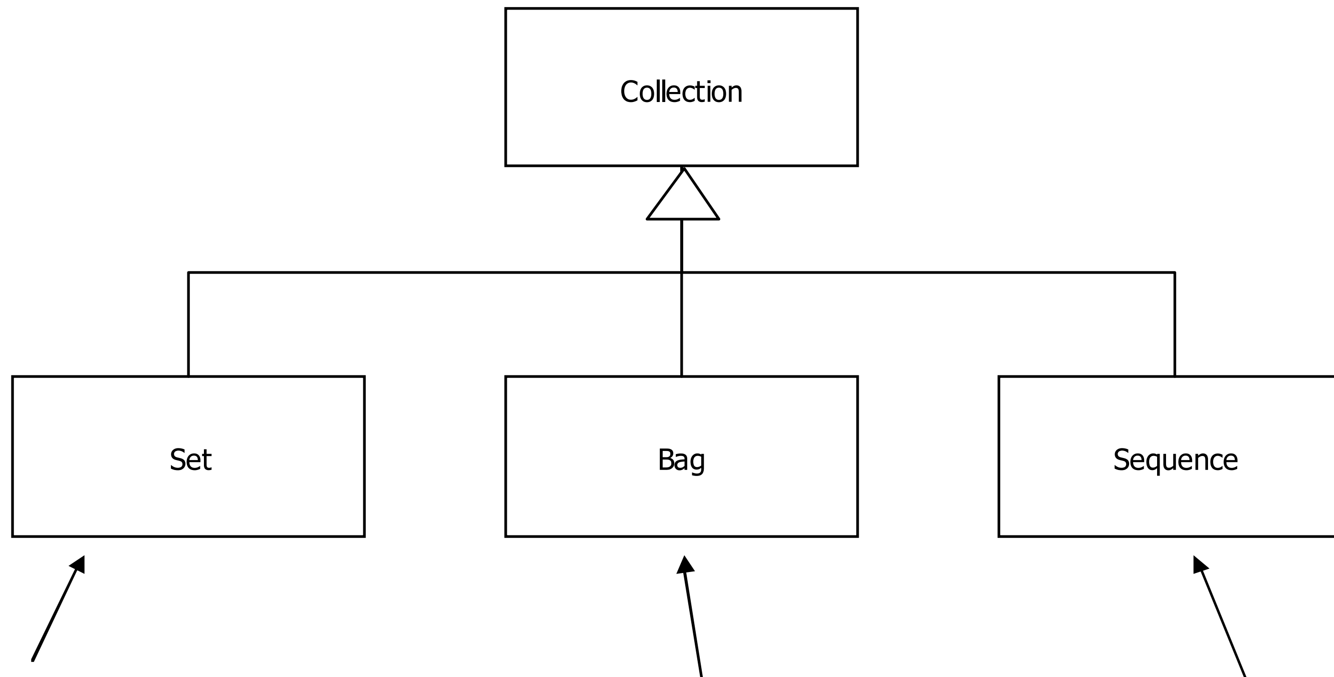
The OCL Collection Hierarchy



Elements can be included only once, and in no specific order

Elements can be included more than once, in no specific order

Elements can be included more than once, but in a specific order

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Operations on All Collections

Operation	Description
size	The number of elements in the collection
count(object)	The number of occurences of object in the collection.
includes(object)	True if the object is an element of the collection.
includesAll(collection)	True if all elements of the parameter collection are present in the current collection.
isEmpty	True if the collection contains no elements.
notEmpty	True if the collection contains one or more elements.
iterate(expression)	Expression is evaluated for every element in the collection.
sum(collection)	The addition of all elements in the collection.
exists(expression)	True if expression is true for at least one element in the collection.
forAll(expression)	True if expression is true for all elements.
select(expression)	Returns the subset of elements that satisfy the expression
reject(expression)	Returns the subset of elements that do not satisfy the expression
collect(expression)	Collects all of the elements given by expression into a new collection
one(expression)	Returns true if exactly one element satisfies the expression
sortedBy(expression)	Returns a Sequence of all the elements in the collection in the order specified (expression must contain the < operator

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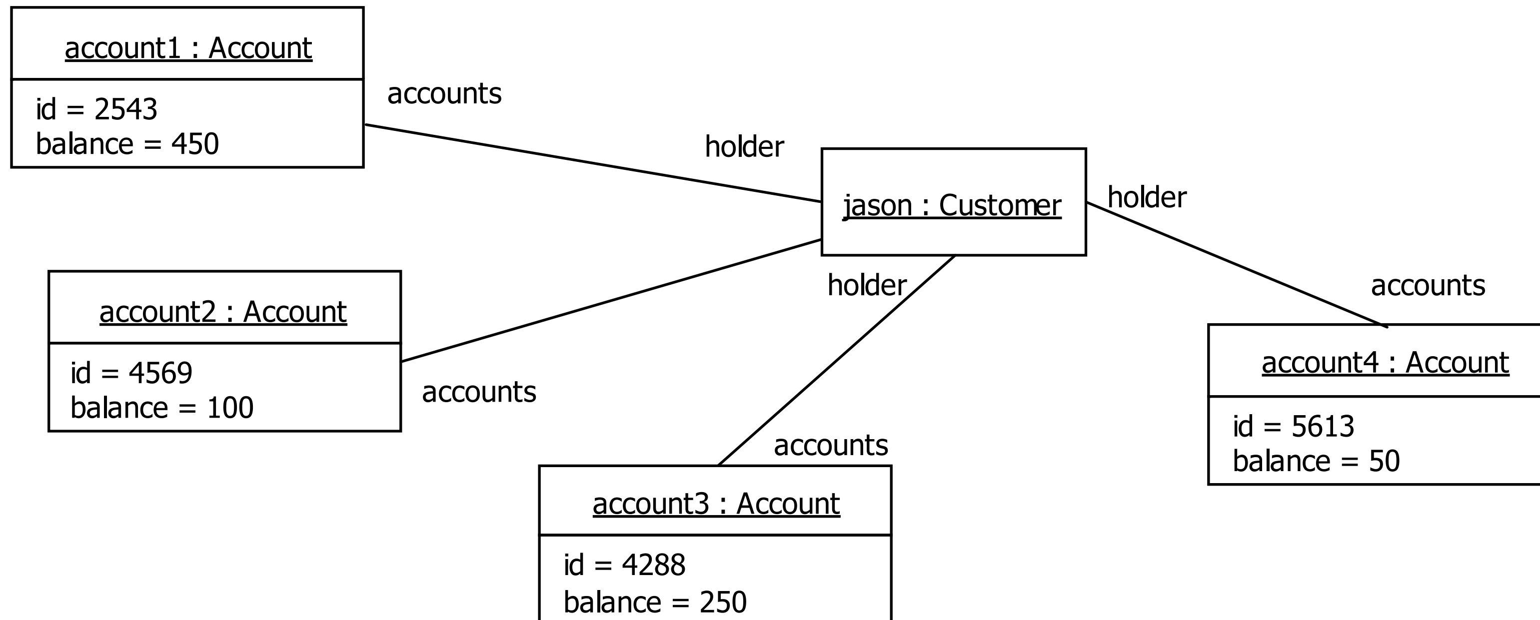
Examples of Collection Operations



jason.accounts->forAll(a : Account | a.balance > 0) = true

jason.accounts->select(balance > 100) = {account1, account3}

jason.accounts->includes(account4) = true

jason.accounts->exists(a : account | a.id = 333) = false

jason.accounts->includesAll({account1, account2}) = true

jason.accounts.balance->sum() = 850

Jason.accounts->collect(balance) = {450, 100, 250, 50}

```
bool forAll = true;
foreach(Account a in accounts)
{
        if(!(a.balance > 0))
        {
                forAll = forAll && (a.balance > 0);
        }
}
```

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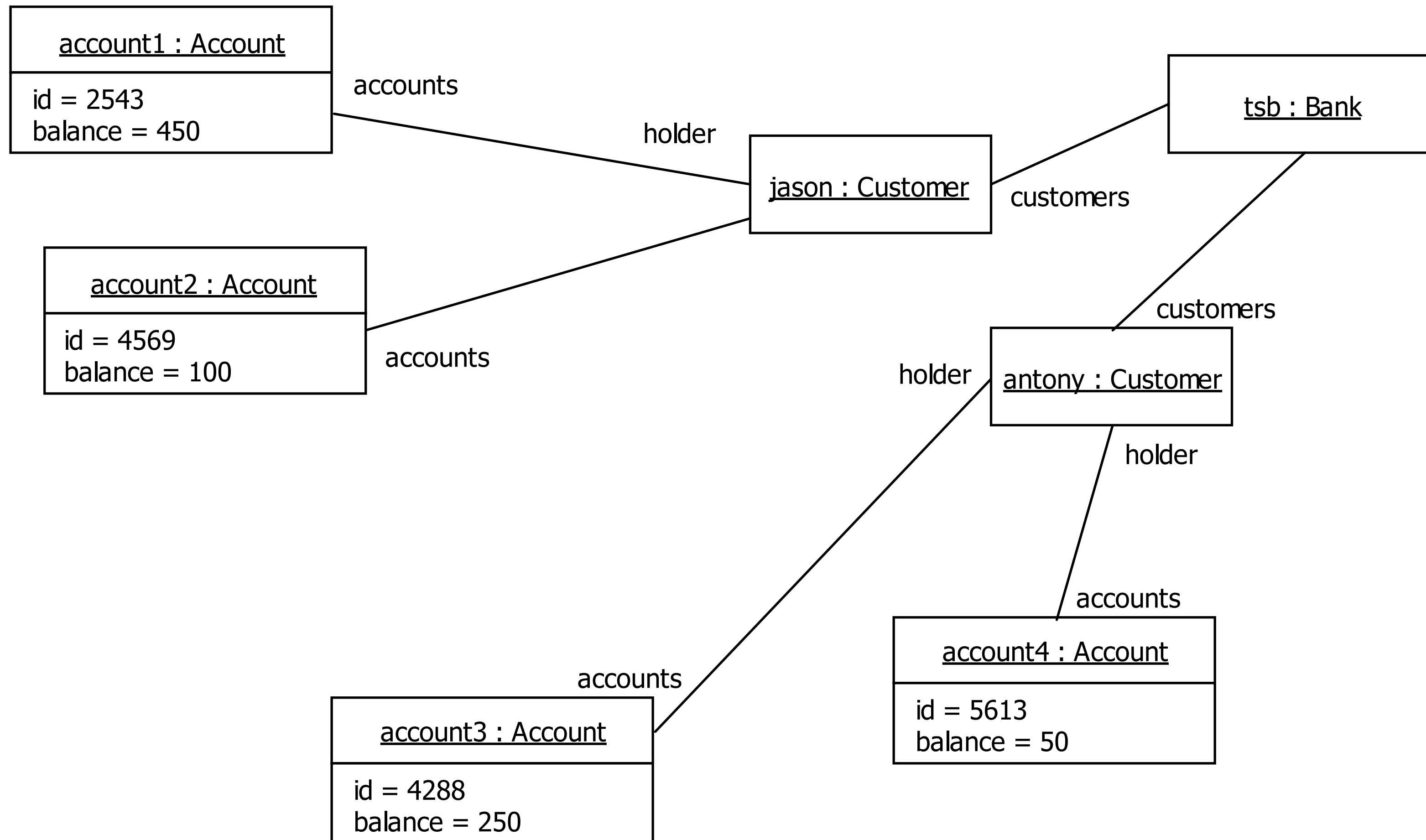
Navigating Across & Flattening Collections



tsb.customers.accounts = {account1, account2, account3, account}
tsb.customers.accounts.balance = {450, 100, 250, 50}

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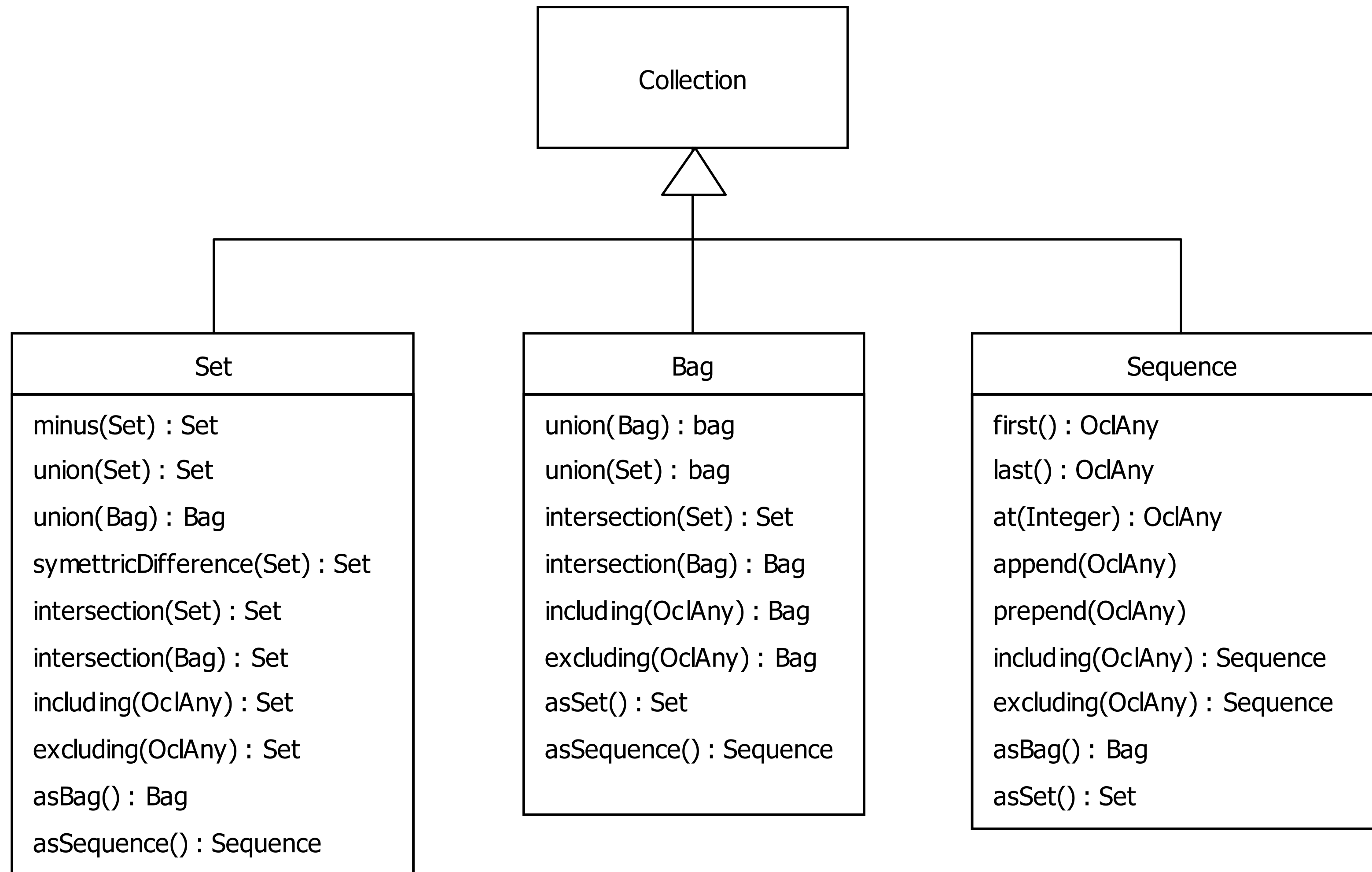
Specialized Collection Operations



Eg, Set{4, 2, 3, 1}.minus(Set{2, 3}) = Set{4, 1}
Eg, Bag{1, 2, 3, 5}.including(6) = Bag{1, 2, 3, 5, 6}
Eg, Sequence{1, 2, 3, 4}.append(5) = Sequence{1, 2, 3, 4, 5}

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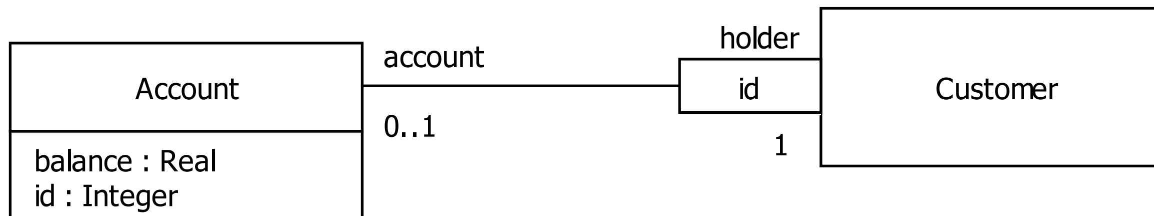
Navigating across Qualified Associations



customer.account[3435]

Or

customer.account[id = 3435]

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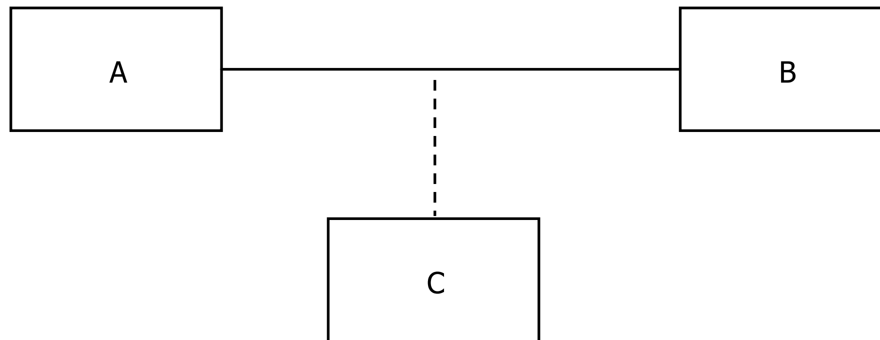
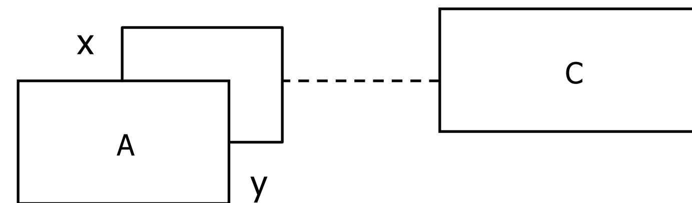
Navigating to Association Classes



context A inv: self.c

context B inv: self.c



context A inv: self.c[x]

context A inv: self.c[y]

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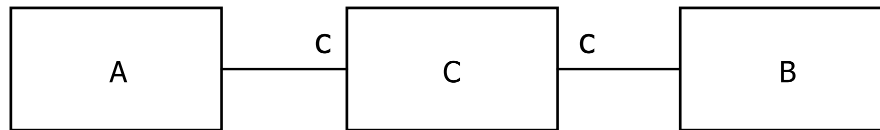
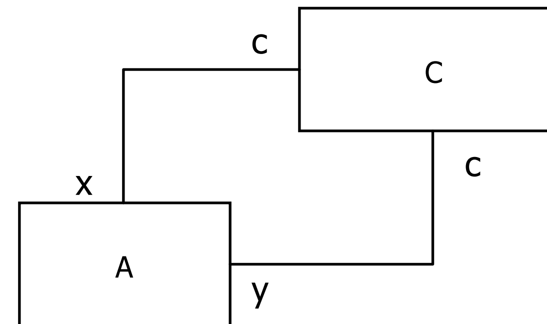
Equivalents to Association Classes





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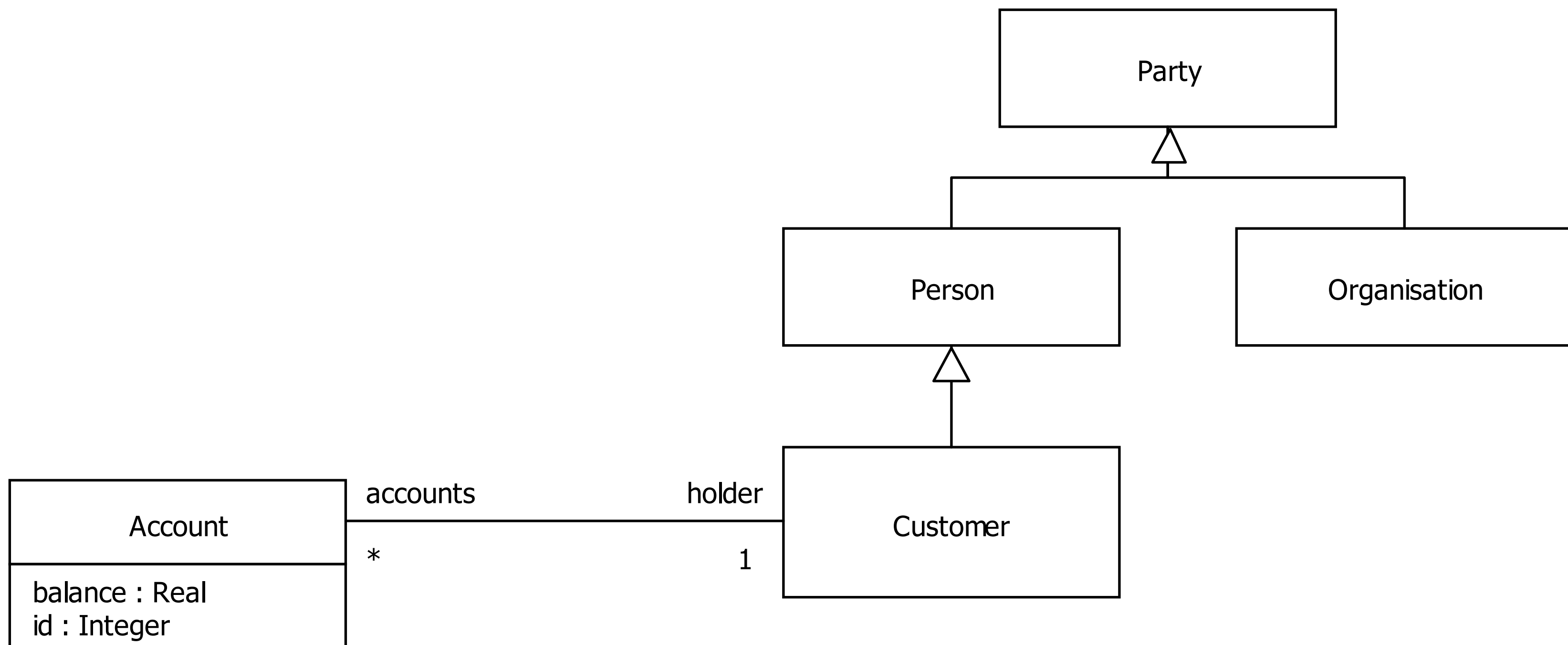
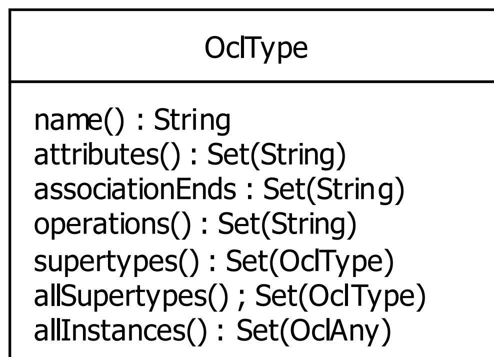
Built-in OCL Types : OclType





Eg, Account.name() = “Account”

Eg, Account.attributes() = Set{“balance”, “id”}

Eg, Customer.supertypes() = Set{Person}

Eg, Customer.allSupertypes() = Set{Person, Party}

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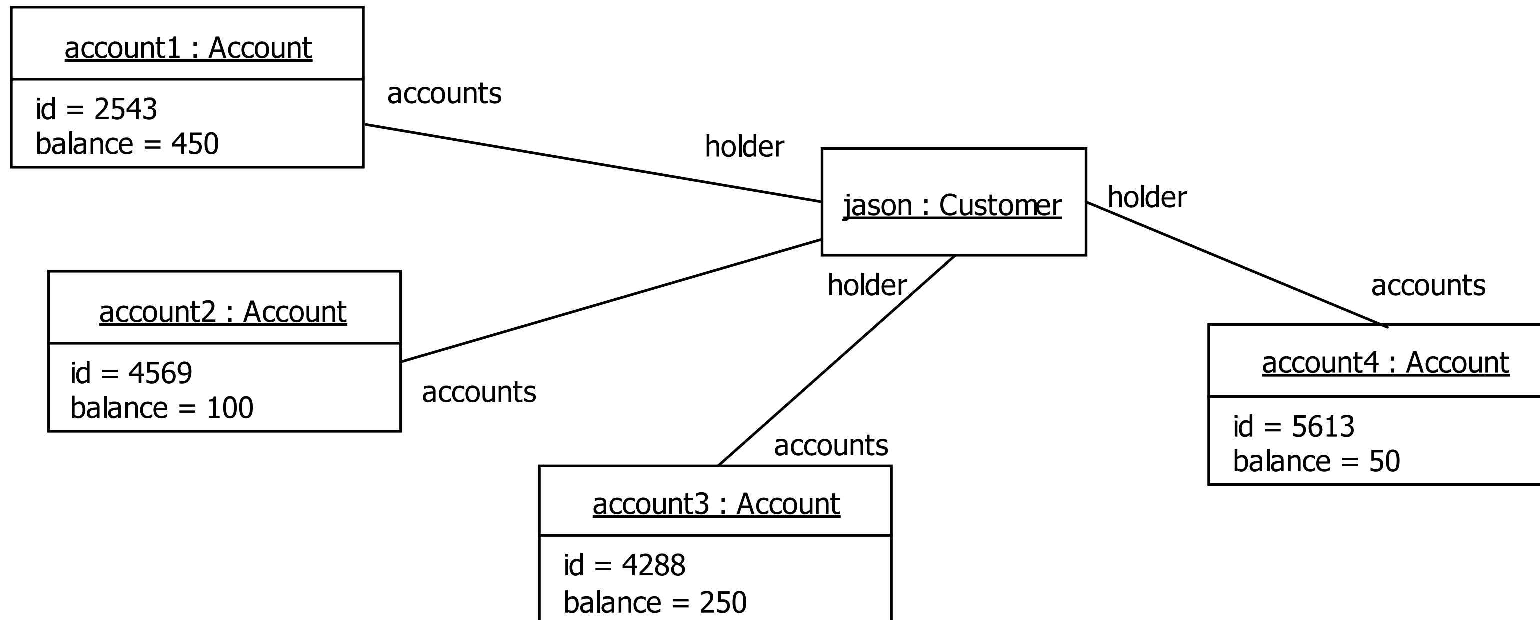
Built-in OCL Types : OclAny



OclAny
oclIsKindOf(OclType) : Booelan oclIsTypeOf(OclType) : Boolean oclAsType(OclType) : OclAny oclInState(OclState) : Boolean oclIsNew() : Boolean oclType() : OclType

Eg, jason.oclType() = Customer

Eg, jason.oclIsKindOf(Person) = true

Eg, jason.oclIsTypeOf(Person) = false

Eg, Account.allInstances() = Set{account1, account2, account3, account4}

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More on OCL

- OCL 1.5 Language Specification
- OCL Evaluator – a tool for editing, syntax checking & evaluating OCL
- Octopus OCL 2.0 Plug-in for Eclipse

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