# CASE tool-based system development using UML/OCL

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## Motivation

- Why specify?
  - Complex software systems require a precise specification of architecture and components.
  - Semi-formal methods (like UML) are not strong enough.
- Why UML/OCL?
  - UML is the standard modeling language in OO development.
  - OCL is part of the OMG UML standard.

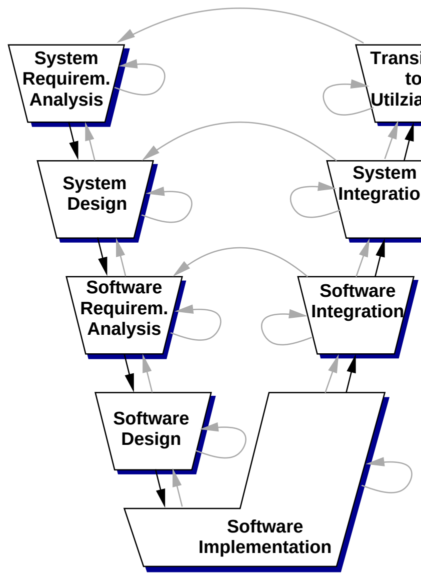
*Specification should not only generate documentation!*

## Overview

1. The V-Model
2. UML/OCL
3. Using specifications: code generation, verification, validation,. . .
4. Two examples:
   - Automated test case generation using UML/OCL
   - ArcSecure

## The V-Model (simplified)

- process and development model
- describes dependencies and (work) flows
- ISO standard
- an example of a phase-based development model



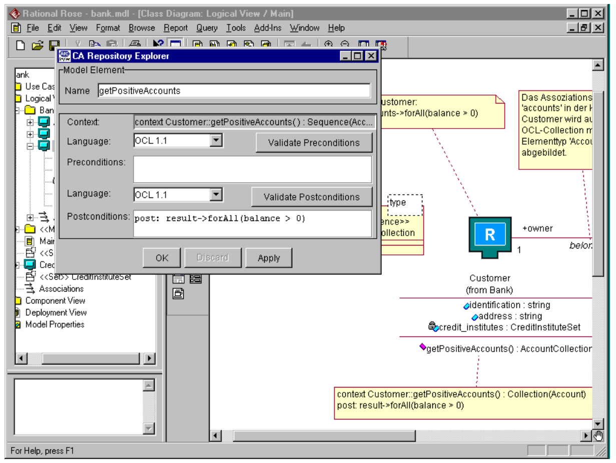
## Benefits of using a (semi-) formal specification

- understanding and communication
- Formal reasoning and analysis (verification, model checking)
- generating code
- runtime assertion checking
- generation of test data for validation (testing)
- use constraints for runtime assertion checking
- Documentation

## CASE Tools

**C**omputer **A**ided **S**oftware **E**ngineering tools support the software development process by providing a framework for:

- documentation
- specification
- code generation
- **validation**
- **verification**



Name: getPositiveAccounts

Context: context Customer::getPositiveAccounts() : Sequence(Acc...

Language: OCL 1.1

Preconditions:

Language: OCL 1.1

Postconditions: `post: result->forAll(balance > 0)`

ustomer:
nts->forAll(balance > 0)

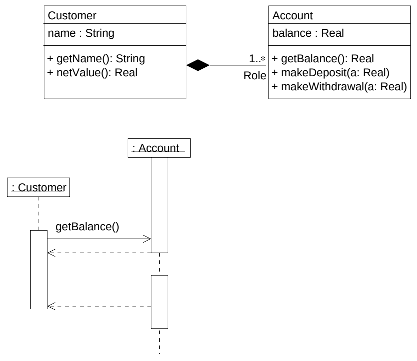
Das Assoziations
'accounts' in der K
Customer wird au
OCL-Collection m
Elementtyp 'Accou
abgebildet.

identification : string
address : string
credit_institutes : CreditInstituteSet
getPositiveAccounts() : AccountCollection

context Customer::getPositiveAccounts() : Collection(Account)
post: result->forAll(balance > 0)

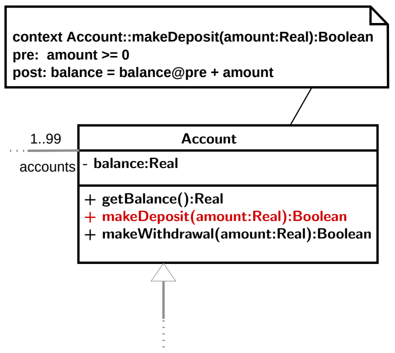
## The Unified Modeling Language (UML)

- visual modeling language
- many diagram types, e.g.
  - class diagrams (static)
  - state charts (dynamic)
  - use cases
- diagrammatic method
- OO development
- OMG standard
- widely used



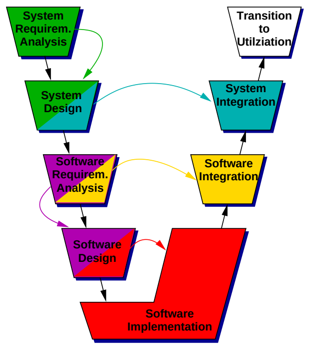
## The Object Constraint Language (OCL)

- extension based on logic and set theory
- designed for annotating UML diagrams
- in the context of class–diagrams:
  - preconditions
  - postconditions
  - invariants
- can be used for other diagram


context Account::makeDeposit(amount:Real):Boolean
pre: amount >= 0
post: balance = balance@pre + amount
1..99
accounts
Account
- balance:Real
+ getBalance():Real
+ makeDeposit(amount:Real):Boolean
+ makeWithdrawal(amount:Real):Boolean

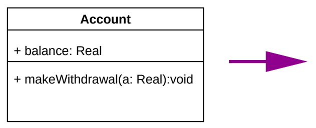
## Verification and Model Checking

- prove that a implementation fulfills its specification
- *abstract:* prove properties of an abstract model
- *source code level:* prove properties of a concrete implementation
- often not fully automated
- needs a formal specification

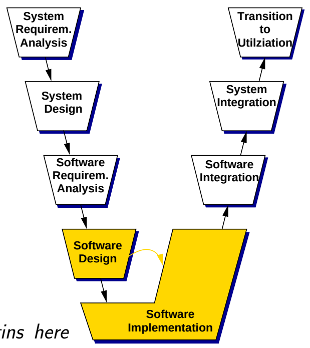


## Code Generation

- semi-formal: generate skeleton/stubs
- formal: generate implementation

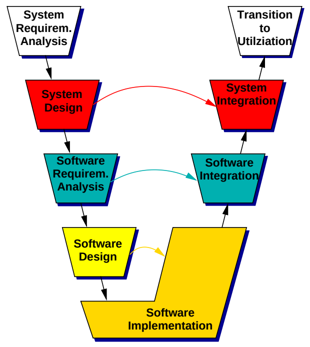


```
class Account{
    float balance;

    float getBalance(){
        return balance;
    }

    void setBalance(float balance){
        this.balance = balance;
    }

    void makeDeposit(float a){
        // user defined code begins here
        this.balance = this.balance + a;
        // end of user defined code
    }
}
```



## Assertion Checking

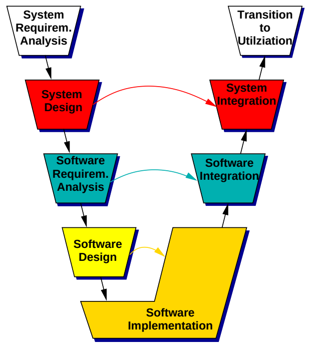
- generates runtime checks for constraints (pre-/post-conditions, invariants,. . . )
- slightly similar to `assert.h`
- a post-hoc debugging method
- needs a formal specification



## Test Case Generation (Validation)

- test the implementation with a specified input
- validates the implementation against its specification
- meaningful testing requires high grade sets of test data
- no formal proof of correctness
- needs a formal specification

```
if ( (a < 5) || ( a > 10) && (b=5)
{
  // Block A
}else{
  // Block B
}
```



## Test Case Generation (Example)

**Input:** three integer, representing the length of the sides of a triangle

**Output:** whether the input describes an equilateral, isosceles, scalene or invalid triangle

Based on an OCL specification, it is possible to determine partition for test case selection automatically.

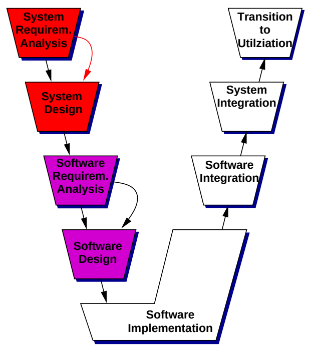
- already six partitions
- select test cases from these partitions, exploiting boundary cases

## Specifying Security (ArcSecure)

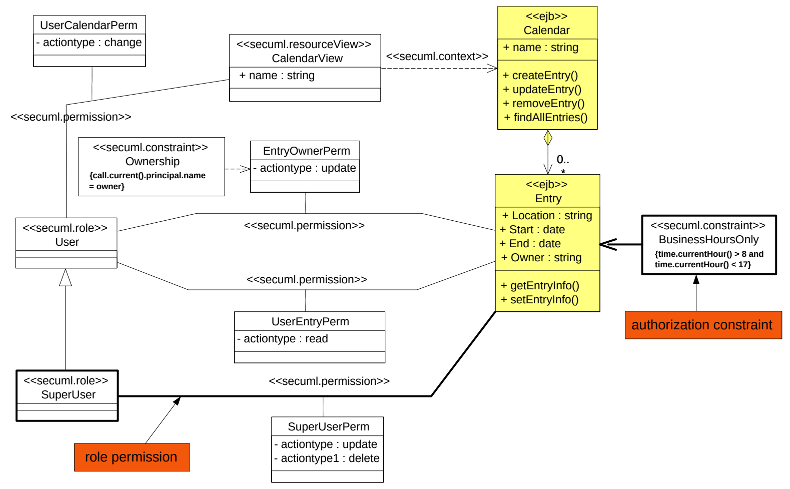
- model information needed for authorization
- based on RBAC with dynamic extensions
- code generation honors authorization constraints

- *only* for specification: informal possible
- further analysis requires semi-formal or formal specification

- ArcSecure can profit in all presented ways from the specification



## Specifying Security (Example)



## Conclusion

- Specification helps mastering complex projects
- Widely used CASE tools support:
  - documentation generation
  - code generation
  - assertion checking
- Specialized CASE tools and academia provide support for validation and verification.