Testing Distributed Component Based Systems Using UML/OCL

Achim D. Brucker and Burkhart Wolff
{brucker,wolff}@informatik.uni-freiburg.de

Albert-Ludwigs Universität – Freiburg, Germany
Interactive Objects GmbH – Freiburg, Germany

Integrating Diagrammatic and Formal Specification Techniques
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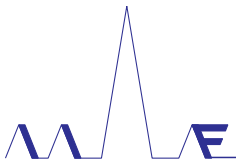
Motivation

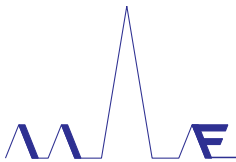
- Diagrammatic Methods raise interest:
  - Complex software systems increase the need for specification.
  - UML is the standard modeling language in industry.
- Middleware Architectures raise interest:
  - Distribution is the key–technology in the Internet.
  - Middleware offers possibilities to link new and legacy systems.
  - Well known middleware standards are CORBA and J2EE/EJB.

➤ *We explain the use of Diagrammatic Methods for modeling, specifying, and runtime testing of middleware architectures.*

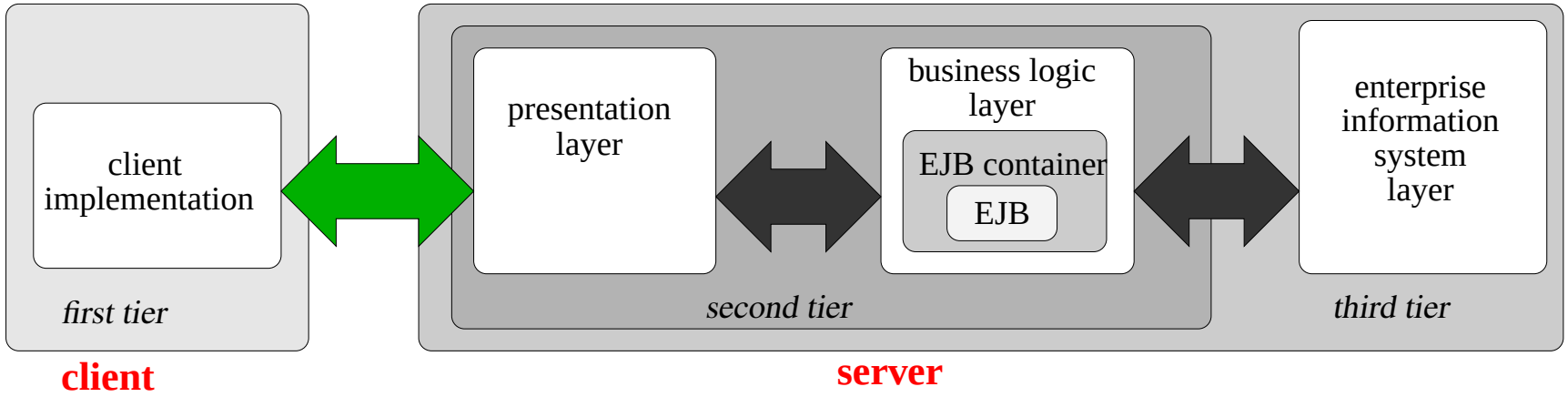


Roadmap

1. Introduction
2. Specification of EJBs and Testing
3. Design Patterns for EJBs
4. Practical Experience
5. Future Work



Distributed Systems Using J2EE: Overview

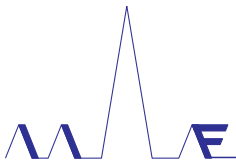


We have chosen the J2EE/EJB Architecture from Sun Microsystems:

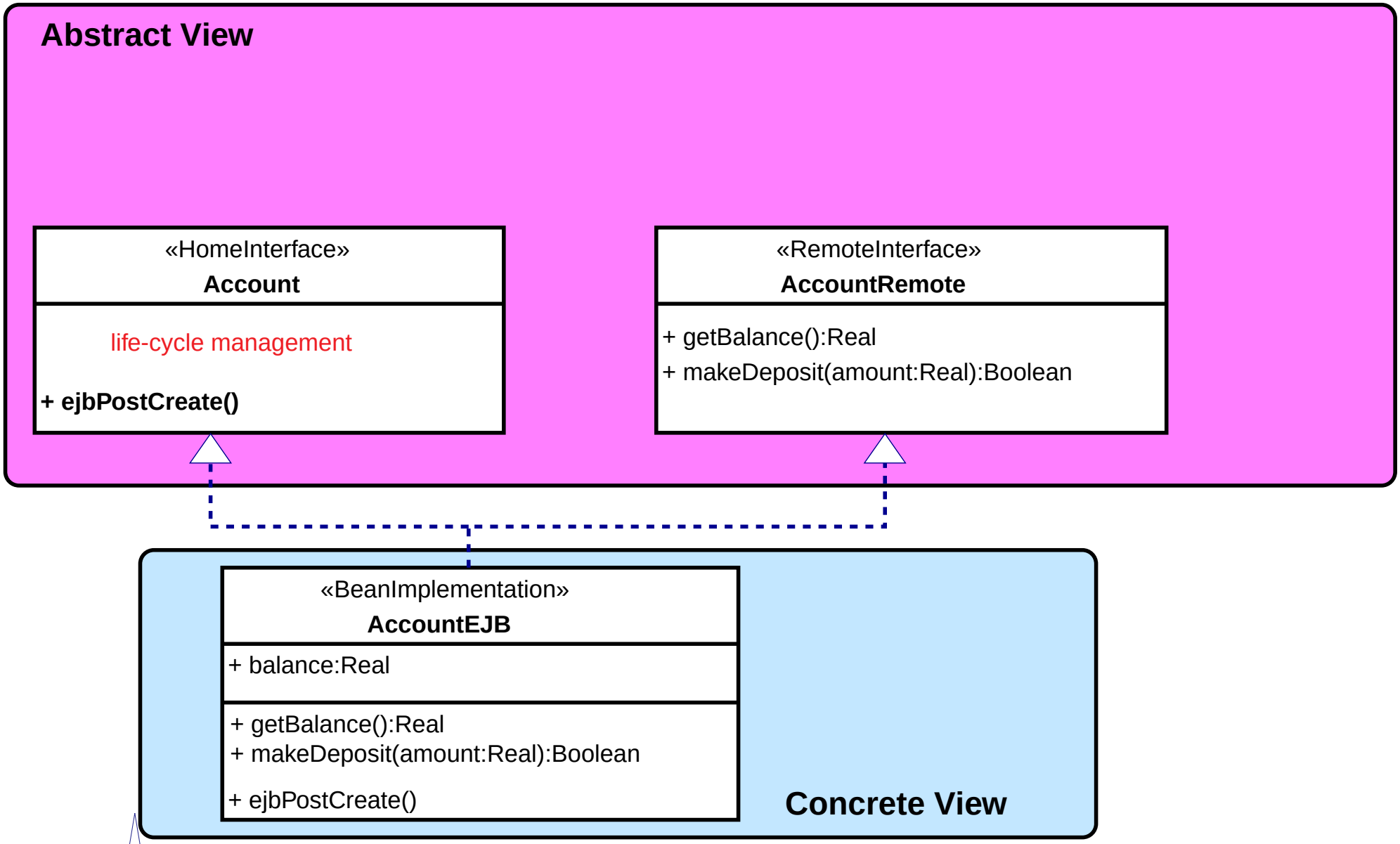
- J2EE is an extension of the Java language.
- Provides a wealth of additional services needed for distribution.
- Builds on existing tool support.

Distributed Systems Using J2EE: An EJB

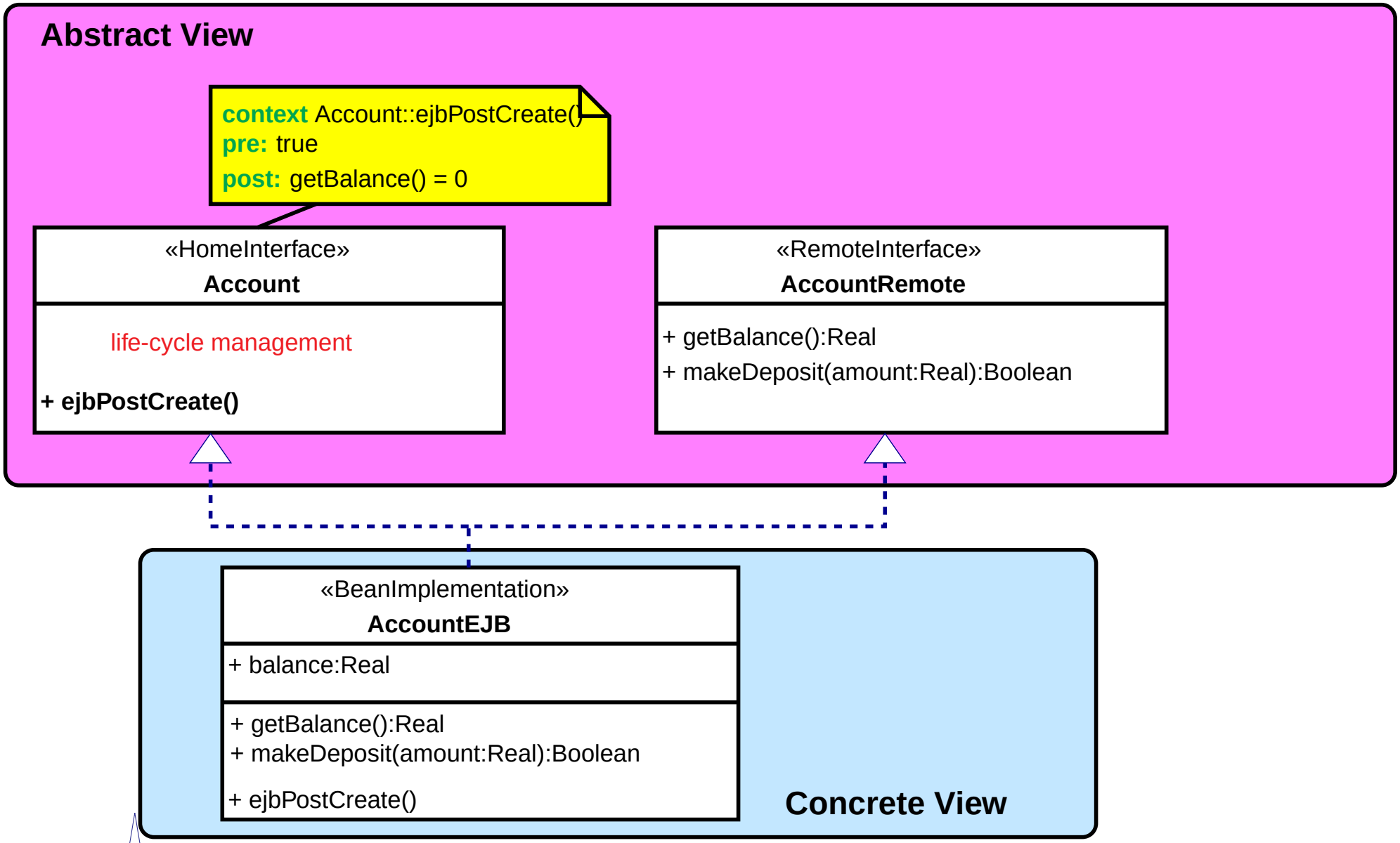
- The “interface” of the EJB is used by the client and the server.
- An EJB is mainly described by three parts:
  - **Home–Interface H:** describing the life–cycle management
  - **Remote–Interface R:** describing the functional behavior
  - **Bean–Implementation I:** implements **H** and **R**
- Special life–cycle management (creation, passivation, deletion).



An example EJB Specification



An example EJB Specification



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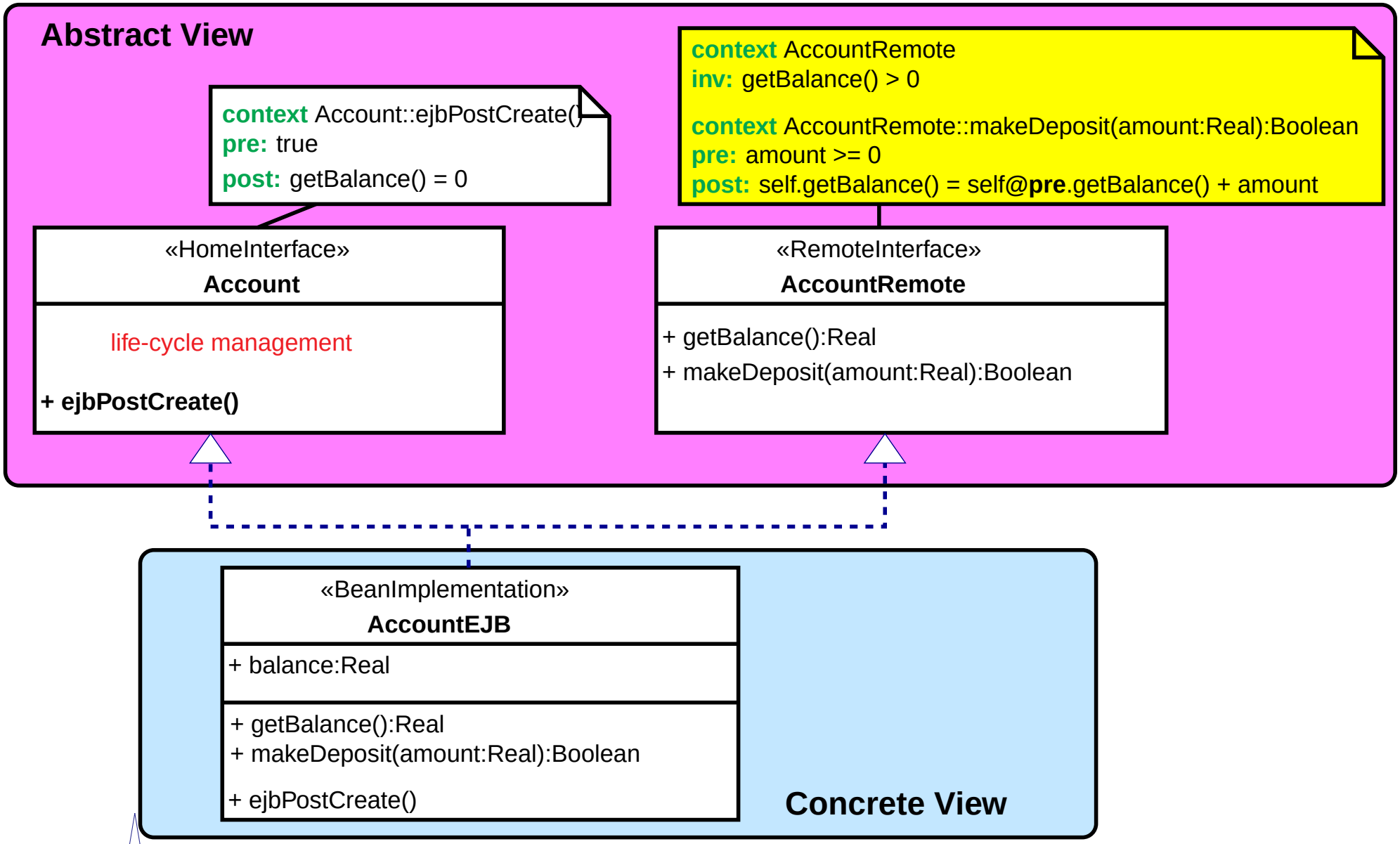
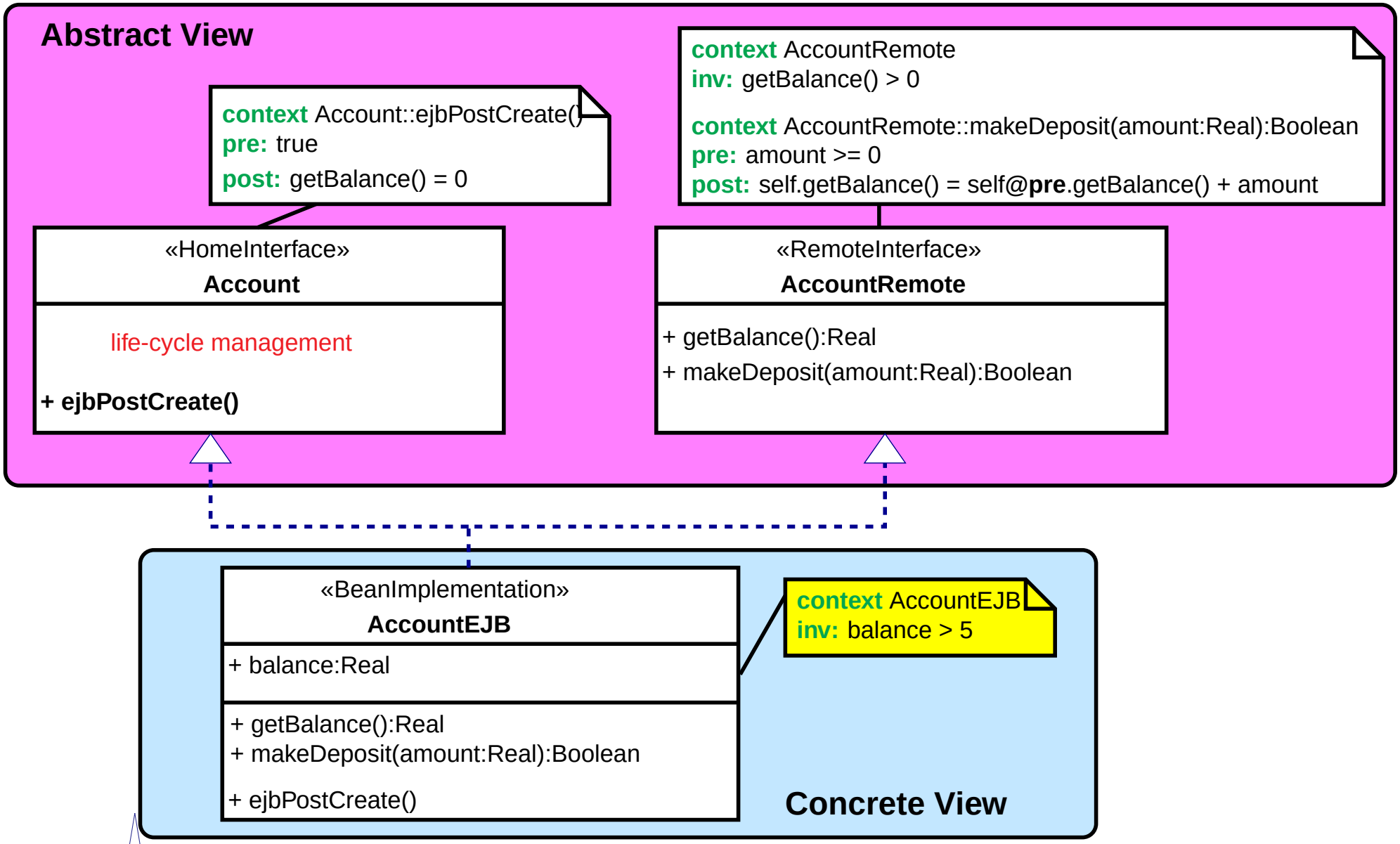


An example EJB Specification



Specification of Enterprise Java Beans

J2EE does not provide a concept of a "formal specification" of an EJB.

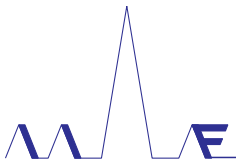
We fill this gap by adopting OCL. This means:

- **Syntactically:**

  Abstract View: The union of the signatures of $\mathbf{H}$ and $\mathbf{R}$ extended by further accessor methods for the (public) variables of $\mathbf{I}$, and annotated by OCL formulae.

  Concrete View: The bean implementation $\mathbf{I}$ annotated by OCL formulae.

- **Semantically:**
  What is the operational semantics of OCL formulae written on the different views?



Operational Semantics of the Specification Refinement

Abstract View

context
AccountRemote::makeDeposit(amount:Real):Boolean
pre:
amount > 0

makeDeposit(amount:Real):Boolean

context
AccountRemote::makeDeposit(amount:Real):Boolean
post:
self.getBalance() = self@**pre**.getBalance() + amount

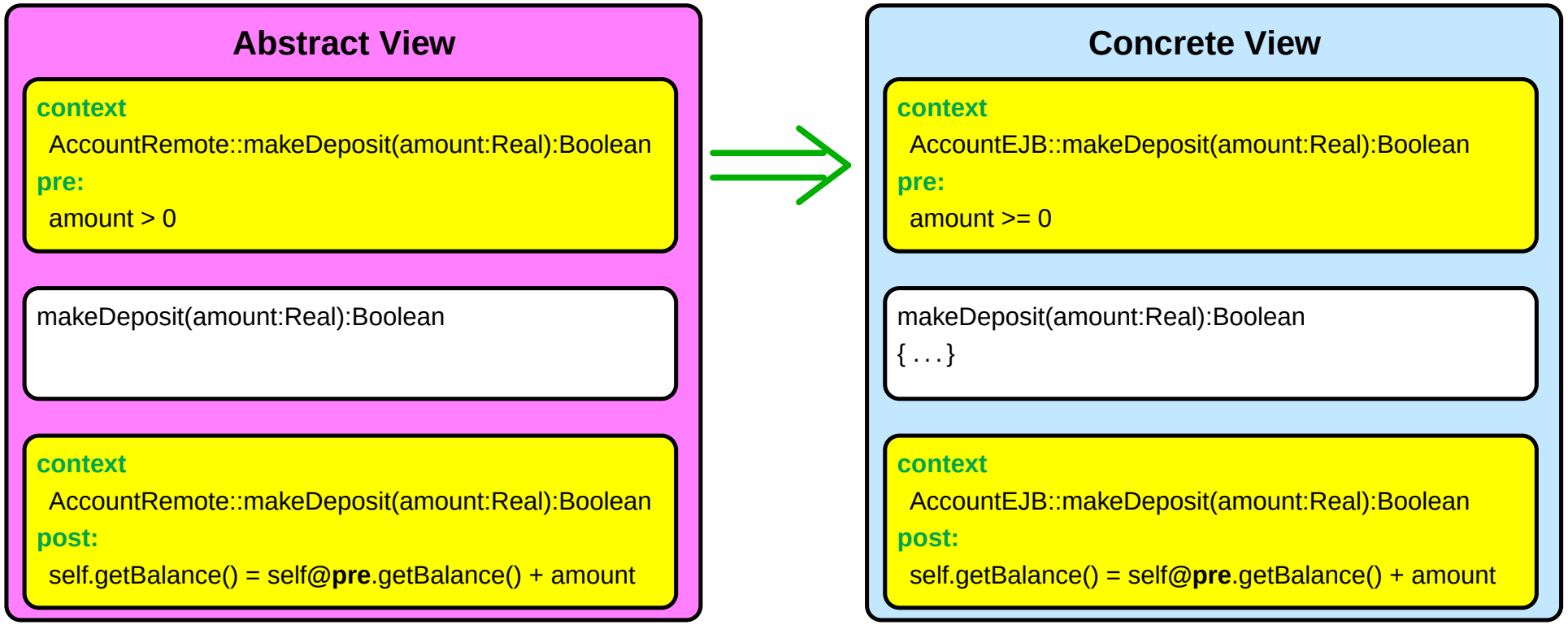
Concrete View

context
AccountEJB::makeDeposit(amount:Real):Boolean
pre:
amount >= 0

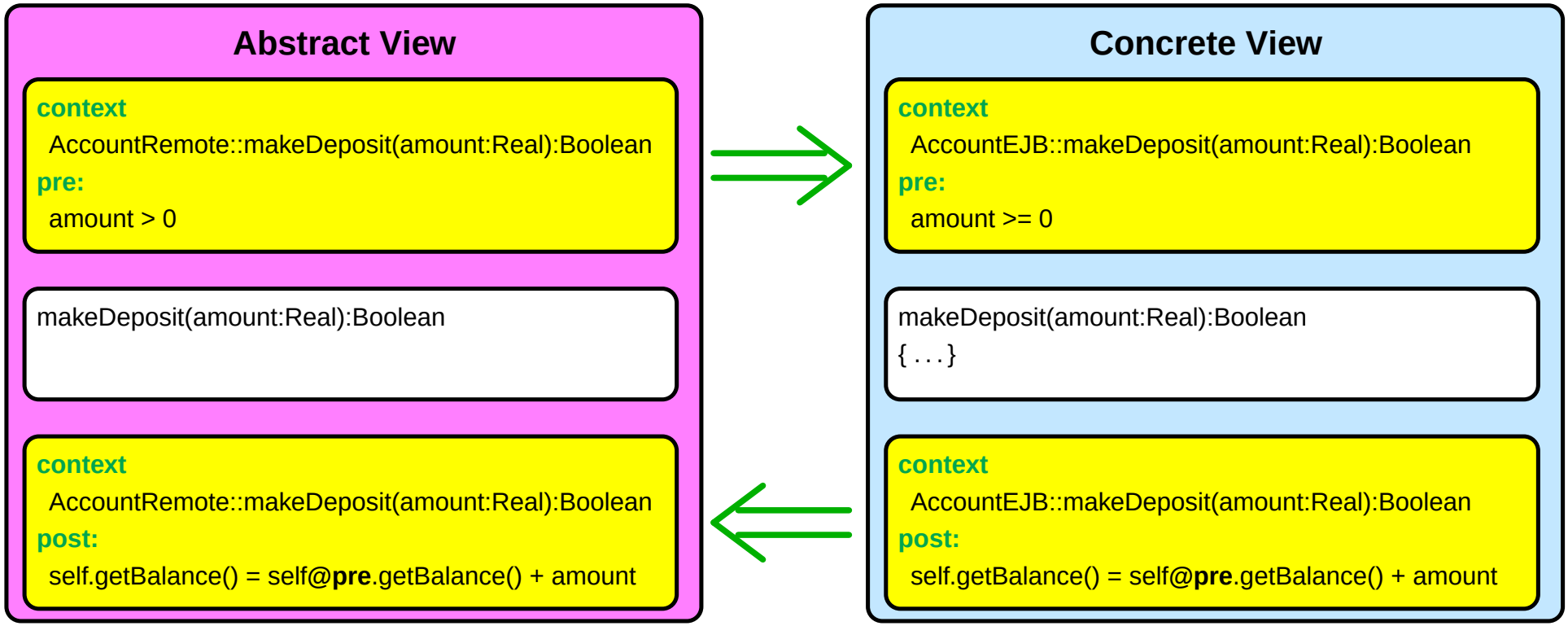
makeDeposit(amount:Real):Boolean
{ . . . }

context
AccountEJB::makeDeposit(amount:Real):Boolean
post:
self.getBalance() = self@**pre**.getBalance() + amount

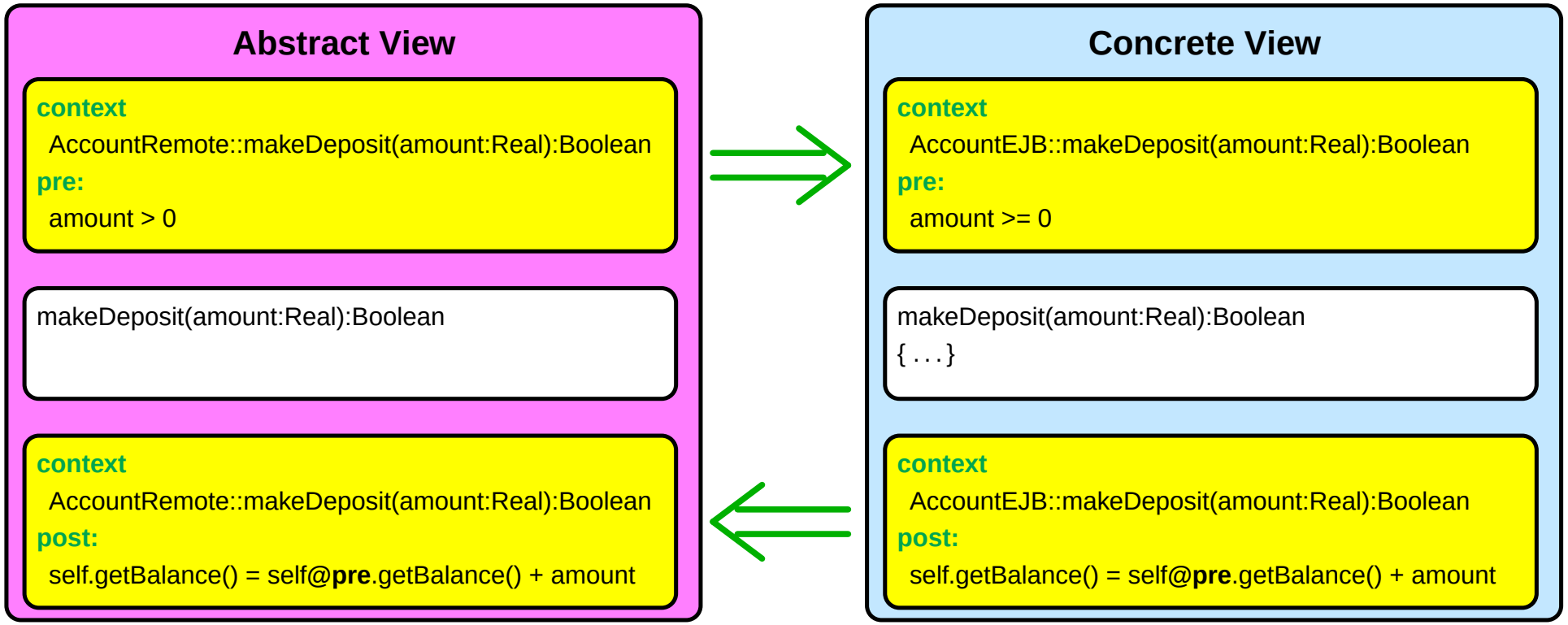
Operational Semantics of the Specification Refinement



Operational Semantics of the Specification Refinement



Operational Semantics of the Specification Refinement

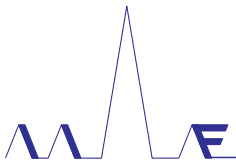


➤ *The Concrete View is a refinement of the Abstract View.*

Operational Semantics of the Specification Black Box Testing

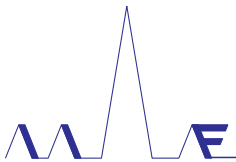
- Based on the specification of the Abstract View:
  - Testing the “external view”.
  - Suited for system implementor using pre–configured components.
- Based on the specification of the Concrete View:
  - Testing the “internal view”.
  - Suited for component developers.

➤ *Runtime OCL constraint checking provides an a posteriori debugging method.*

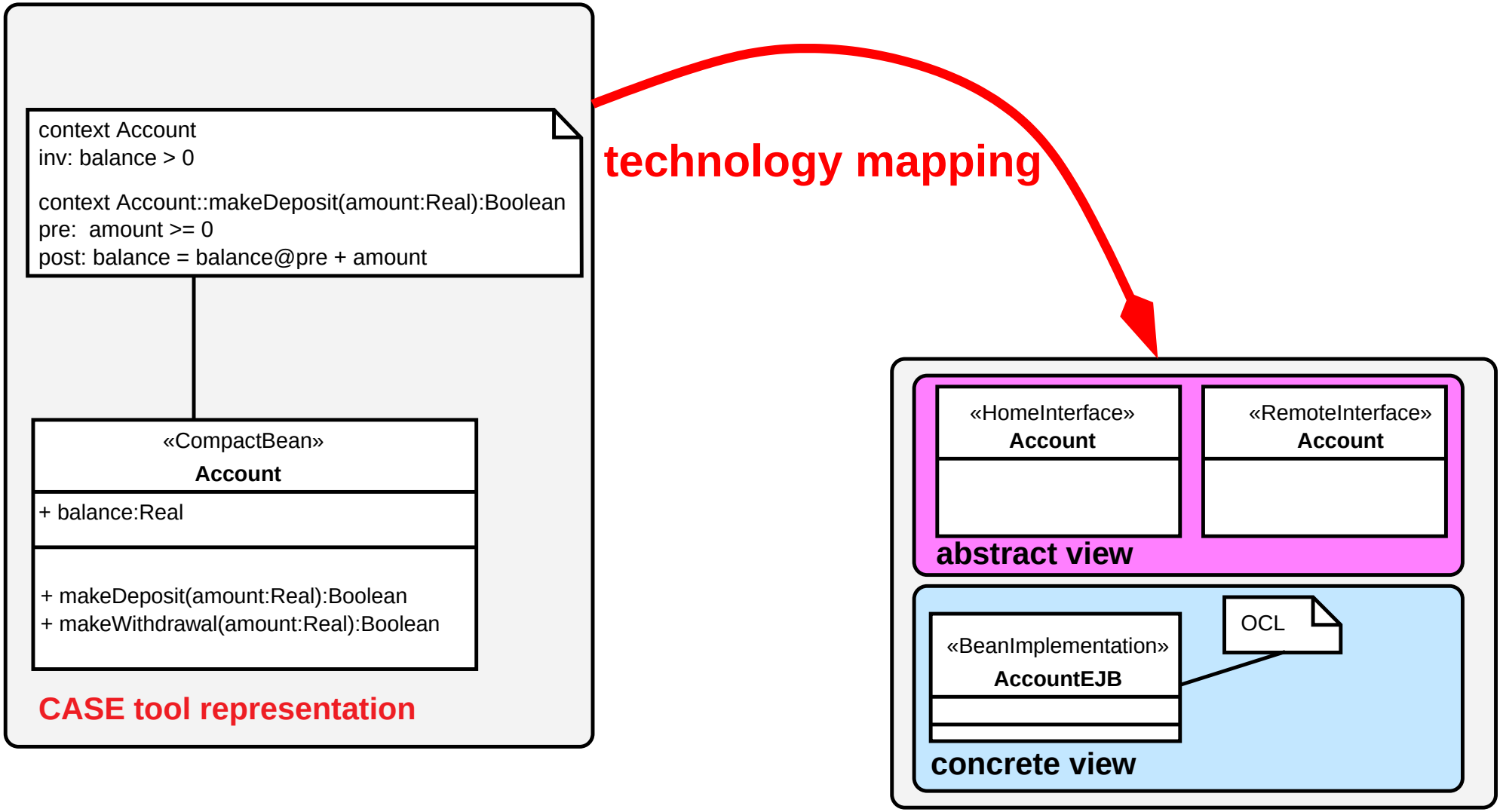


EJB Design Pattern

- Reduces complexity of specification for test data generation.
- We introduce the concept "**ExpandedBean**" where an EJB can consists out of several home or remote interfaces.
- We provide three patterns:
  - **CompactBean** for standard development: Models an EJB with one remote interface, one home interface and one implementation.
  - **ExpandedBeanHome** for technological optimization: Extends the CompactBean by allowing several home interfaces.
  - **ExpandedBeanRemote** for modeling different kind of accesses: Extends the CompactBean by allowing several remote interfaces.



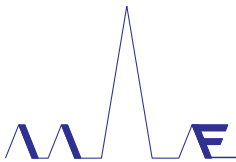
The Compact Bean Pattern



Constraint Checking and Practical Experience

- We integrated a OCL type checker into a CASE Tool for EJB support.
- We integrated a constraint checking code generator into a CASE Tool for EJB support.

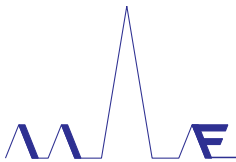
- Type checking is based on the tools developed at the University Dresden.
- Runtime checking is done via “method–wise” wrapping code.
- Internal method invocations are checked.



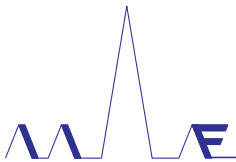
Further Work

- Specification of transactions.
- Systematic generation of test–data based on the OCL specification.
- Formal analysis of the relation between Abstract View and Concrete View.

➤ *We will develop a declarative semantics of OCL, which is done through an embedding of OCL into an theorem prover.*



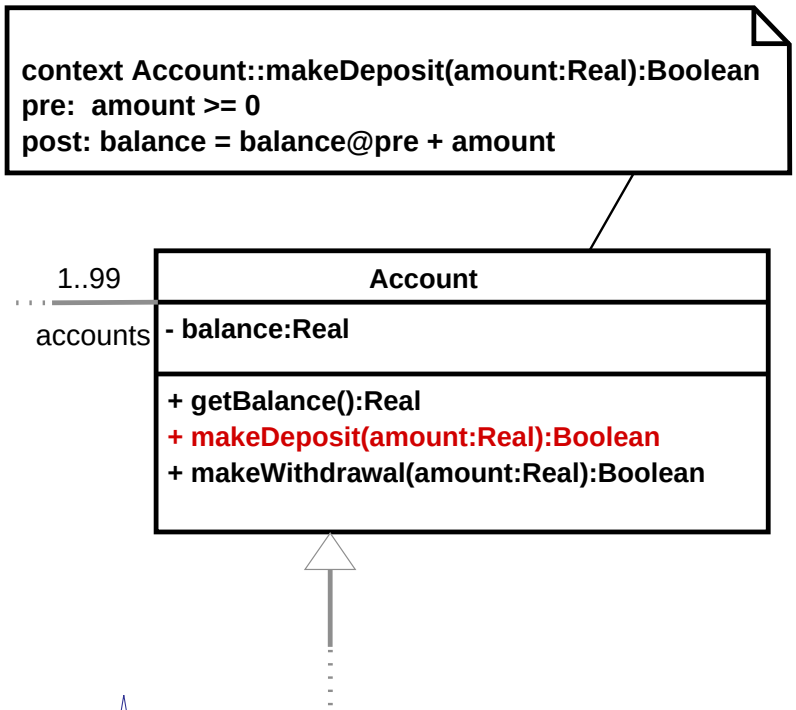
Appendix



UML and OCL

UML

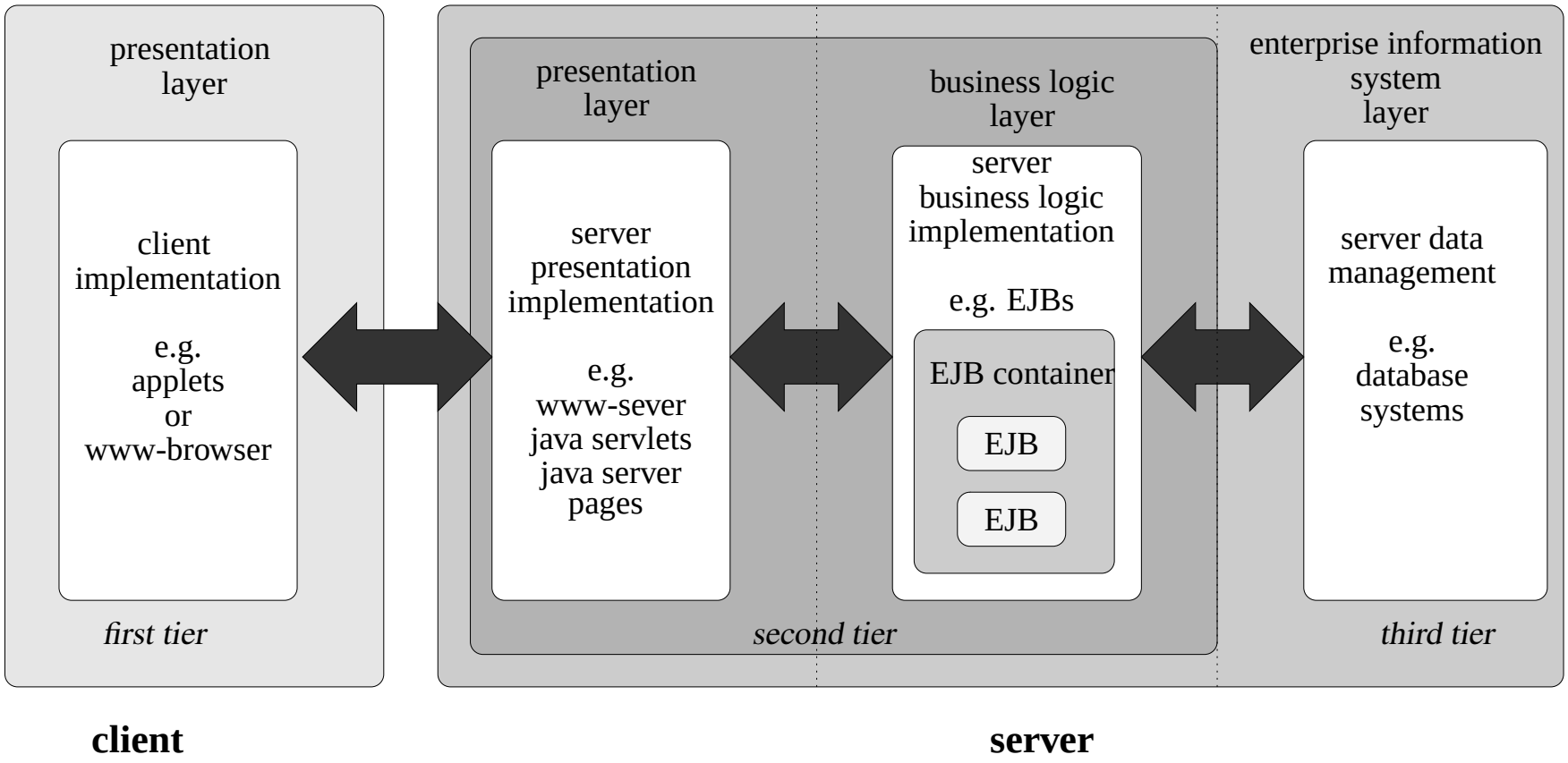
- several diagram types
- diagrammatic method
- metamodeling approach
- OMG standard
- widely accepted (in industry)



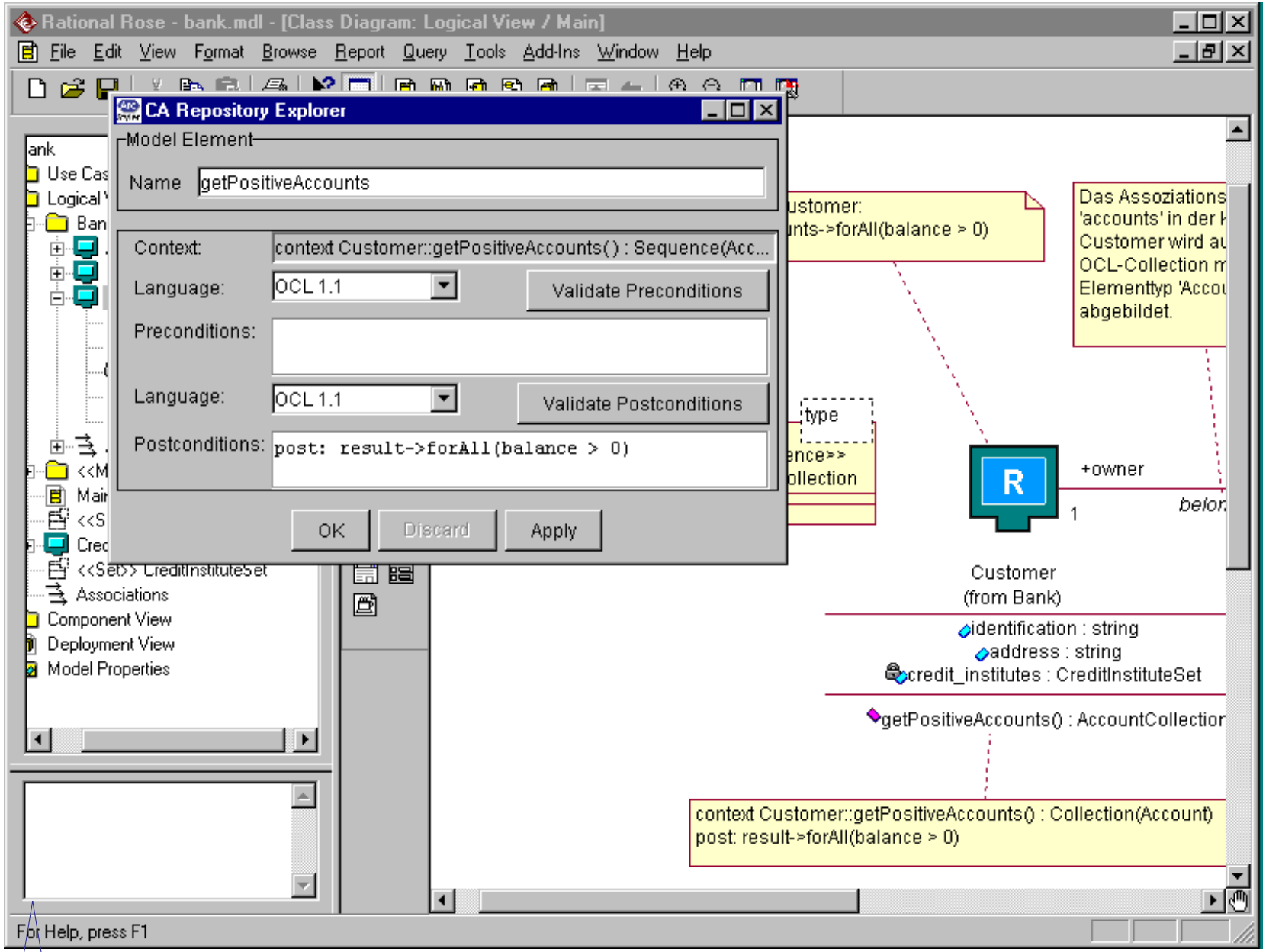
OCL

- textual extension
- based on logic and set theory
- designed for annotation of UML diagrams
- class–diagrams:
  - preconditions
  - postconditions
  - invariants
- part of the UML
- no declarative semantics

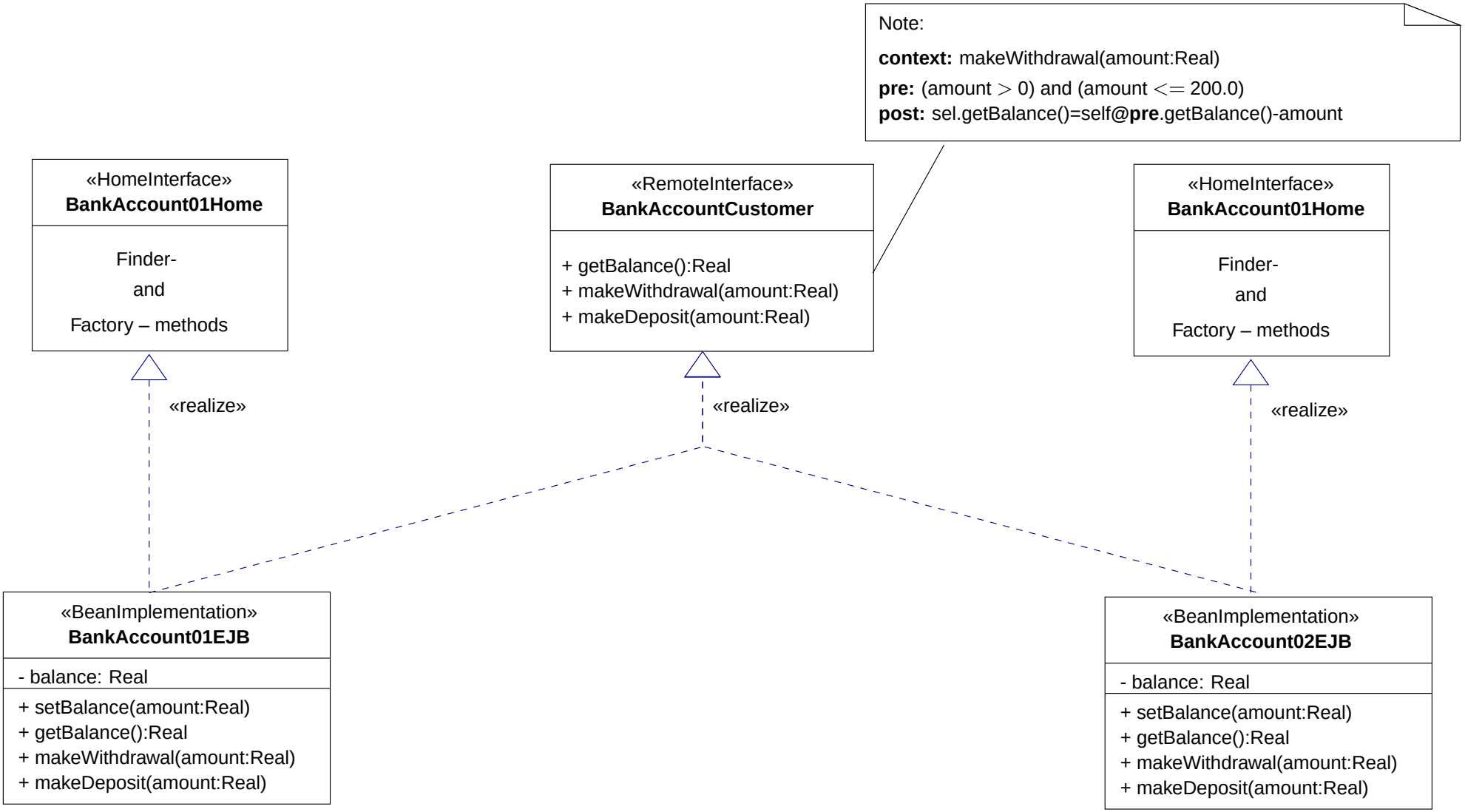
The J2EE Application Model



Modeling EJBs using UML/OCL with ArcStyler



The ExpandedBeanHome Pattern



The ExpandedBeanRemote Pattern