Fondamenti della Programmazione: Metodi Evoluti

Prof. Enrico Nardelli

Lezione 4: Contratti

Abstraction

The client is interested in:

- a set of services that a software module provides, not its internal representation

class

- what a service does, not how it does it

feature

- Object-oriented programming is all about finding right abstractions
- To abstract is to capture the essence behind the details and the specifics
- However, the abstractions we choose can sometimes fail, and we need to find new, more suitable ones.

Routine: algorithm abstraction

To abstract is to capture the *essence* of a concept, ignoring details & specifics

Implies:

- *Removing* some information
- Giving a *name* to the result of the abstraction

A routine is also known as a **method**, or a **subprogram**

In programming:

- Data abstraction: class attributes
- Algorithm (operational) abstraction: **class routine**

A routine is one of the two kinds of feature

... the other is *attribute*

A routine

```
r (arg : TYPE ; ...)
                -- Header comment.
        require
                Preconditions (boolean expression)

        local
                local variables

        do
                Body (instructions)

        ensure
                Postconditions (boolean expression)

        end
```

Remember: two kinds of routine

Procedure: doesn’t return a result

```
p (arg : TYPE; …)
        do
                ……
        end
```

- Yields a **command**
- Calls to a procedure are **instructions**

Function: returns a result

```
f (arg : TYPE; …): RESULT_TYPE
        … (rest as before) …
```

- Yields a **query**
- Calls to a function are **expressions**

Features: the full story

A class declaration is structured in clauses:

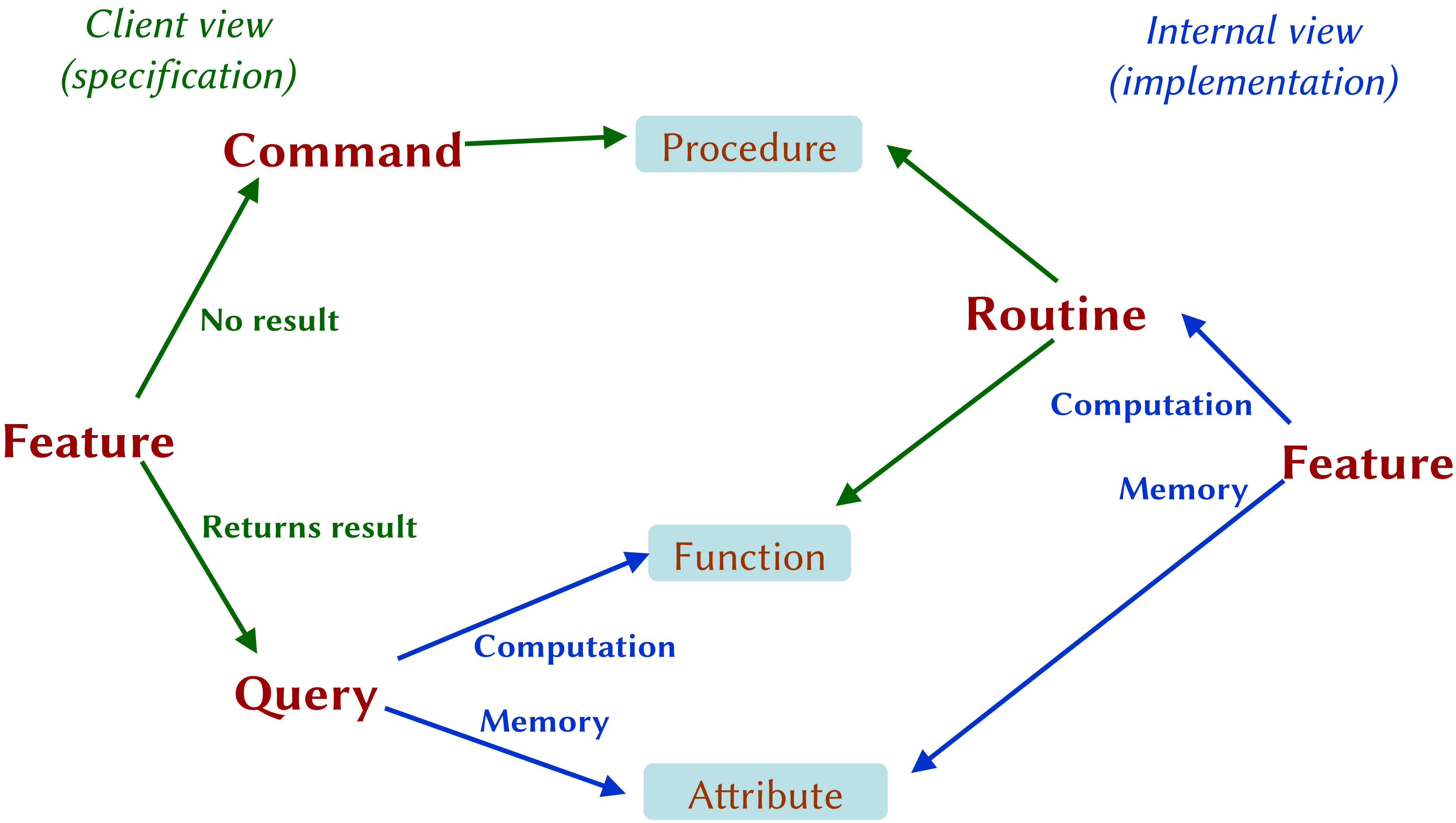
- Note
- Class
- Inherit
- Create
- Feature (any number of categories)
- Invariant
- End

A class is characterized by its features

Each feature operates on the corresponding objects: **query** or **command**

Features are grouped into categories for readability (e.g. creation, access, status report, constants, basic operations, conversions, etc.)

Features: the full story



Client view (specification)

Internal view (implementation)

Command

Procedure

Routine

No result

Feature

Computation

Feature

Memory

Returns result

Function

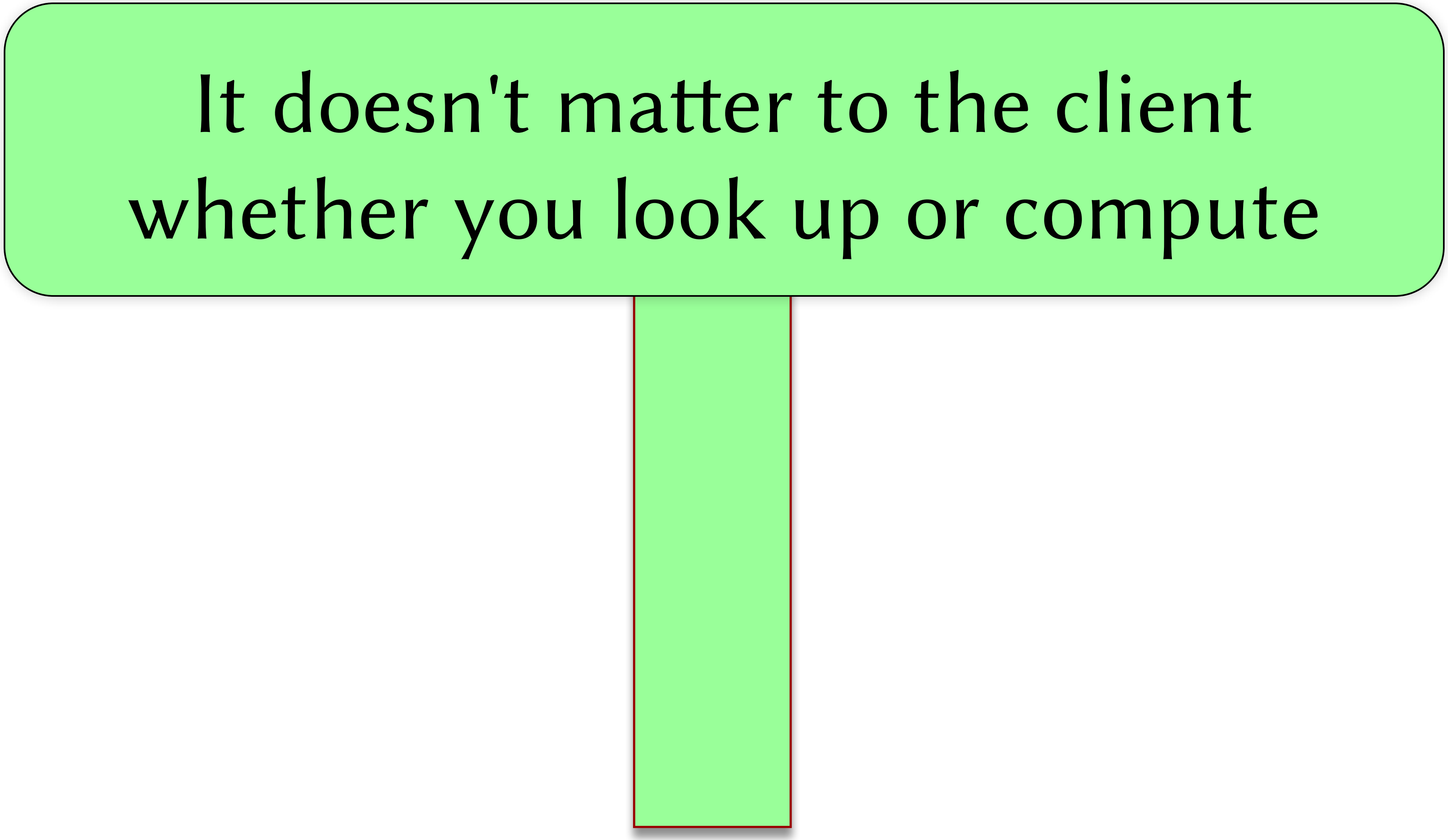
Computation

Query

Memory

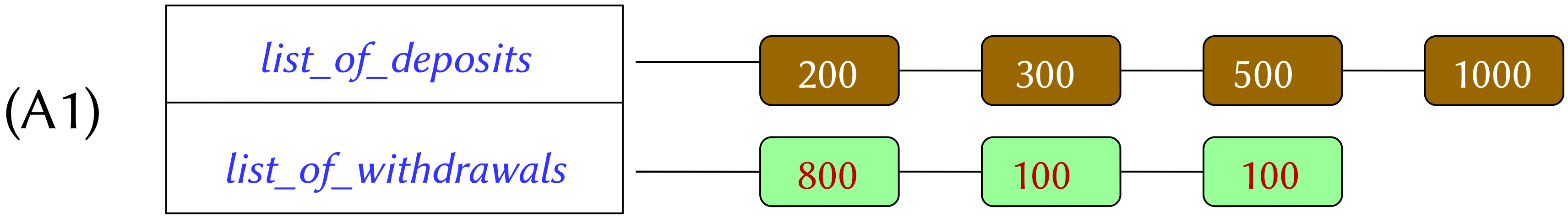
Attribute

The Uniform Access principle

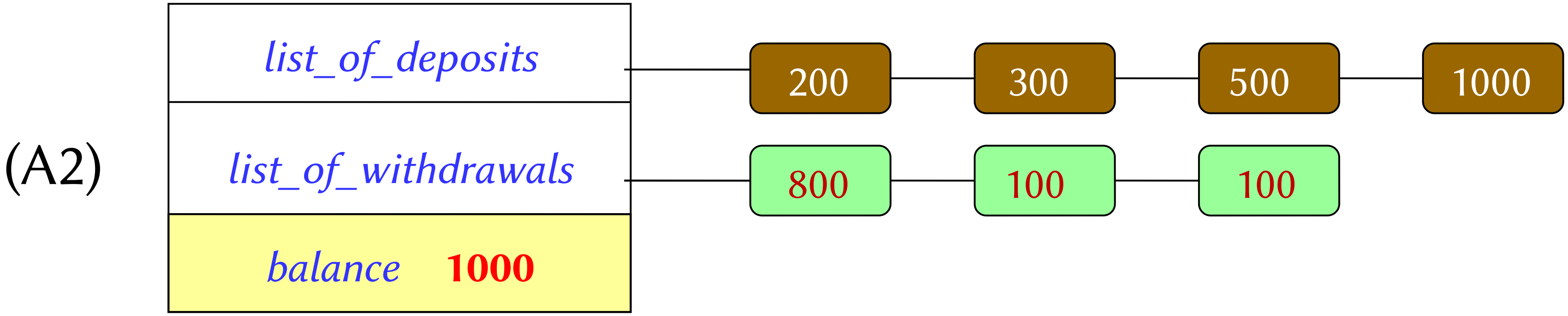


It doesn't matter to the client whether you look up or compute

Uniform Access: an example



balance = list_of_deposits.total – list_of_withdrawals.total



A call such as

your_account.balance

could use an attribute or a function

The Uniform Access principle

Expressed more technically:

Features should be accessible to clients the same way whether implemented by storage or by computation

Software construction

Finding appropriate classes is a central part of **software design**

Also called the development of the **architecture** of a program

Writing down the details is part of **implementation**

Style rule: header comments

Don’t even *think* of writing a feature without immediately including a header comment explaining what it’s about

NO STOPPING ANYTIME
RED ZONE
DON'T EVEN THINK OF PARKING HERE
SP-145C
DEPT OF TRANSPORTATION

Remember the BANK_ACCOUNT project?

Let's look at it again

First variation

We want to ensure only a positive sum is withdrawn

We want to ensure balance is always non negative

```
withdraw (sum : INTEGER)
          -- Withdraw sum from the account
          -- (Warning: use only if sum is positive and >= balance)
```

Nice try, but...

...still not good enough:

- A comment is just an informal explanation
- The constraint needs a more official status in the interface

Contracts

A **contract** is a semantic condition characterizing correct usage properties of some construct, expressed through logic

Three kinds of contracts for classes and features:

- Precondition
- Postcondition
- Class invariant

Specific contracts for iteration instructions:

- Loop invariant
- Loop variant

One generic version:

- Checking a property

Precondition

Property that a feature imposes on every client:

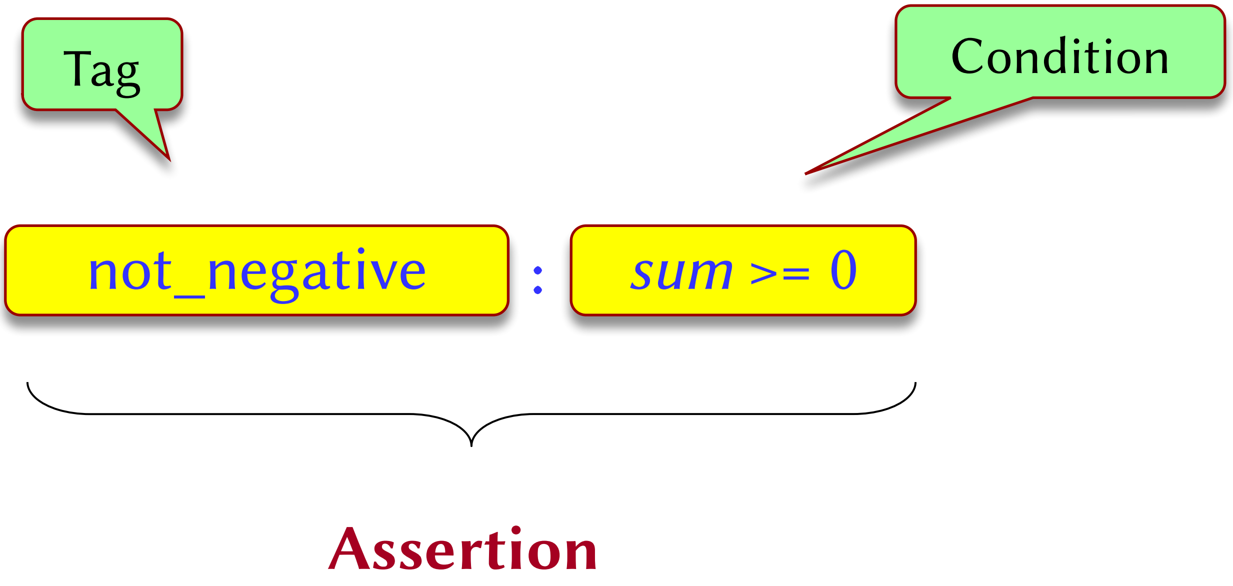
```
withdraw (sum: INTEGER)
        -- Withdraw sum from the balance
    require
        not_negative: sum >= 0
        covered: sum <= balance
```

The precondition of *withdraw*

A feature with no **require** clause is always applicable, as if it had

```
        require
            always_OK: True
```

Assertions



Tag

Condition

not_negative : *sum* >= 0

Assertion

Precondition principle

A ***client*** calling a feature must make sure that the precondition holds before the call

A client that calls a feature without satisfying its precondition is faulty (buggy) software.

Postcondition

Property that a feature guarantees on termination:

```
close
        -- Close the account
    ensure
        account_closed: closed = true
```

The postcondition of *close*

A feature with no **ensure** clause always satisfies its postcondition, as if the postcondition reads

```
ensure
        always_OK: True
```

Postcondition

Constraint on values **before** and **after** execution:

```
withdraw (sum : INTEGER)
        -- Withdraw sum from the balance
    ensure
        decreased: balance = old balance - sum
```

Expression value captured on entry

old notation

Denotes value of an expression as it was on routine entry

Usable **in postconditions only**

CANNOT be used in the body

Another example:

```
deposit (sum : INTEGER)
            -- Add sum to account.
      require
            positive: sum > 0
      do
            ...
      ensure
            added: balance = old balance + sum
      end
```

Postcondition principle

A ***feature*** must make sure that, if its precondition held at the beginning of its execution, its postcondition will hold at the end.

A feature that fails to ensure its postcondition is buggy software.

Preconditions and postconditions

Establish contractual relations between client and supplier

Precondition: **obligation** for clients

Postcondition: **benefit** for clients

All the clauses (assertions) in contracts must be true

They are checked in top down order

They are checked at run-time

Class invariants

The invariant expresses consistency requirements for instances of a class between feature calls

For a class REGULAR_ACCOUNT

```
invariant

        limited: balance <= Max_amount
```

Each clause of the class invariant must be true:

- before each feature execution
- after each feature execution

Comparison among contracts (1)

A **pre-condition** must be true before the execution of a feature, not necessarily afterwards.

A **post-condition** must be true after the execution of its feature, not necessarily before its execution or after the execution of other features

A **class invariant** must be true before/after the execution of each feature

Comparison among contracts (2)

A class invariant may be violated during the execution of code internal to a feature

Class invariants of *x*, instance of *C*, are **not** checked:

- when **leaving** the feature (before its termination) to execute
  - features of other objects
    - but class invariants of the called objects **are checked**!
  - other features of *x* if called through an unqualified call
- when **re-entering** the feature after execution of other features

Contract to check a property

Use the **check** instructions (normally disabled in **finalized** mode)

Contains expression(s) ensuring that a certain property is satisfied at a specific point

Help document a piece of software

```
some_feature …
    do
            … some implementation …
        check
            tag_A : boolean_expression_stating_property_A
            tag_B : boolean_expression_stating_property_B
            …
        end
            … some implementation …
    end
```

Contracts

Contracts are useful for debugging: getting the software right

Contracts are useful for interface documentation, in particular, documenting API

Contracts execution is under compiler control (see Projects -> Settings under EiffelStudio)

Contract checking may be disabled in the finalized version for better performances

Contracts for iteration instructions will be seen later

Contracts outside of Eiffel

Java: Java Modeling Language (JML), iContract etc.

C#: Spec# (Microsoft Research extension)

UML: Object Constraint Language

Python

C++: Nana

etc.

Contracts in practice

Let's add contracts to the bank account example!