ETH Zürich
Chair of Software Engineering

Einführung in die Programmierung
Introduction to Programming

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Exercise Session 7

News (Reminder)

Mock exam next week!

- Monday exercise groups: November 8
- Tuesday exercise groups: November 9
- You have to be present
- The week after we will discuss the results
- Assignment 7 due on November 16

Today

- Abstractions
- Uniform Access Principle
- Naming conventions
- Exporting features

Abstraction

To abstract is to capture the essence behind the details and the specifics.

The client is interested in:

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

  hence, the class abstraction

- what a service does, not how it does it

  hence, the feature abstraction

- Object-oriented programming is all about finding right abstractions
- However, the abstractions we choose can sometimes fail, and we need to find new, more suitable ones.

Abstraction

"A simplification of something much more complicated that is going on under the covers. As it turns out, a lot of computer programming consists of building abstractions.

What is a string library? It's a way to pretend that computers can manipulate strings just as easily as they can manipulate numbers.

What is a file system? It's a way to pretend that a hard drive isn't really a bunch of spinning magnetic platters that can store bits at certain locations, but rather a hierarchical system of folders-within-folders containing individual files that in turn consist of one or more strings of bytes."

(extract from http://www.joelonsoftware.com/articles/LeakyAbstractions.html)

Discussing abstractions

Hands-On

What abstractions were used in the *temperature converter* from assignment 4?

- Why it is better to have a class for *TEMPERATURE* than to store the value in an *INTEGER* variable?

- How was the Celsius value obtained? What about the Kelvin value? Did you see that difference in the class *TEMPERATURE_APPLICATION*?

Finding the right abstractions (classes)

Suppose you want to model your room:

```
class ROOM
feature
        -- to be determined
end
```

Your room probably has thousands of properties and hundreds of things in it:

Finding the right abstractions (classes)

door

computer

bed

furniture

material

shape

size

desk

etc

etc

location

etc

messy?

Therefore, we need a first abstraction: What do we want to model?

In this case, we focus on the size, the door, the computer and the bed.

Finding the right abstractions (classes)

To model the size, an attribute of type *DOUBLE* is probably enough, since all we are interested in is it's value:

```
class ROOM
feature
        size: DOUBLE
                -- Size of the room.

end
```

Finding the right abstractions (classes)

Now we want to model the door.

If we are only interested in the state of the door, i.e. if it is open or closed, a simple attribute of type *BOOLEAN* will do:

```
class ROOM
feature
        size: DOUBLE
                -- Size of the room.
        is_door_open: BOOLEAN
                -- Is the door open or closed?
        ...
end
```

Finding the right abstractions (classes)

But what if we are also interested in what our door looks like, or if opening the door triggers some behavior?

- Is there a daring poster on the door?
- Does the door squeak while being opened or closed?
- Is it locked?
- When the door is being opened, a message will be sent to my cell phone

In this case, it is better to model a door as a separate class!

Finding the right abstractions (classes)

```
class ROOM
feature
        size: DOUBLE
                -- Size of the room in square meters.
        door: DOOR
                -- The room's door.
end
```

Finding the right abstractions (classes)

```
class DOOR
feature
        is_locked: BOOLEAN
                -- Is the door locked?
        is_open: BOOLEAN
                -- Is the door open?
        is_squeaking: BOOLEAN
                -- Is the door squeaking?
        has_daring_poster: BOOLEAN
                -- Is there a daring poster on the door?
        open
                -- Opens the door
            do
                -- Implementation of open, including sending a message
            end

        -- more features…
end
```

Finding the right abstractions (classes)

Hands-On

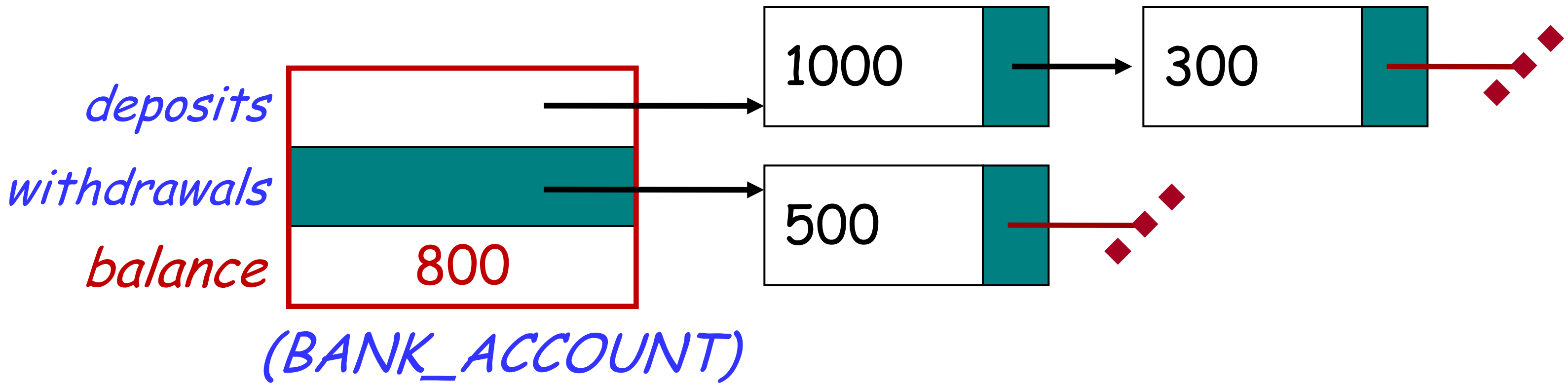
How would you model…

… the computer?

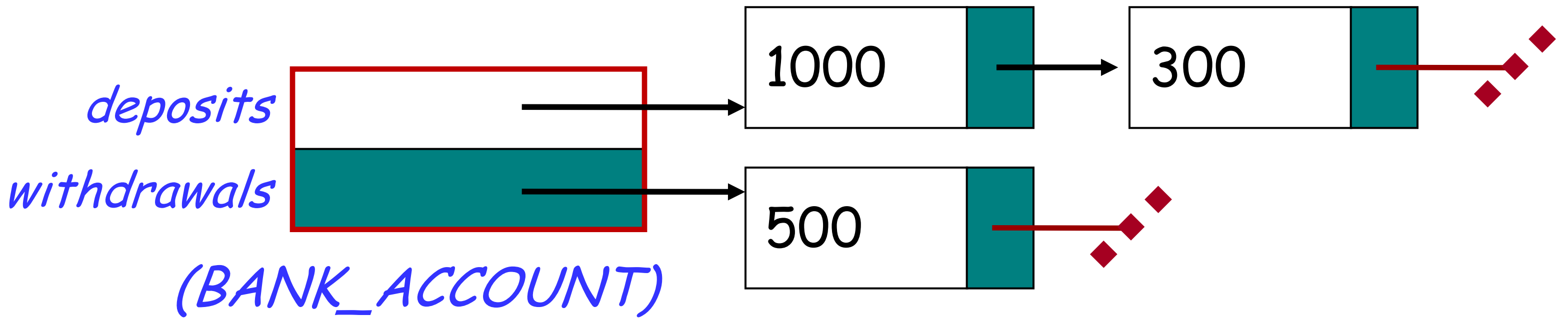
… the bed?

How would you model an elevator in a building?

Finding the right abstractions (features)



invariant: *balance = total (deposits) – total (withdrawals)*



Which one would you choose and why?

Uniform access principle

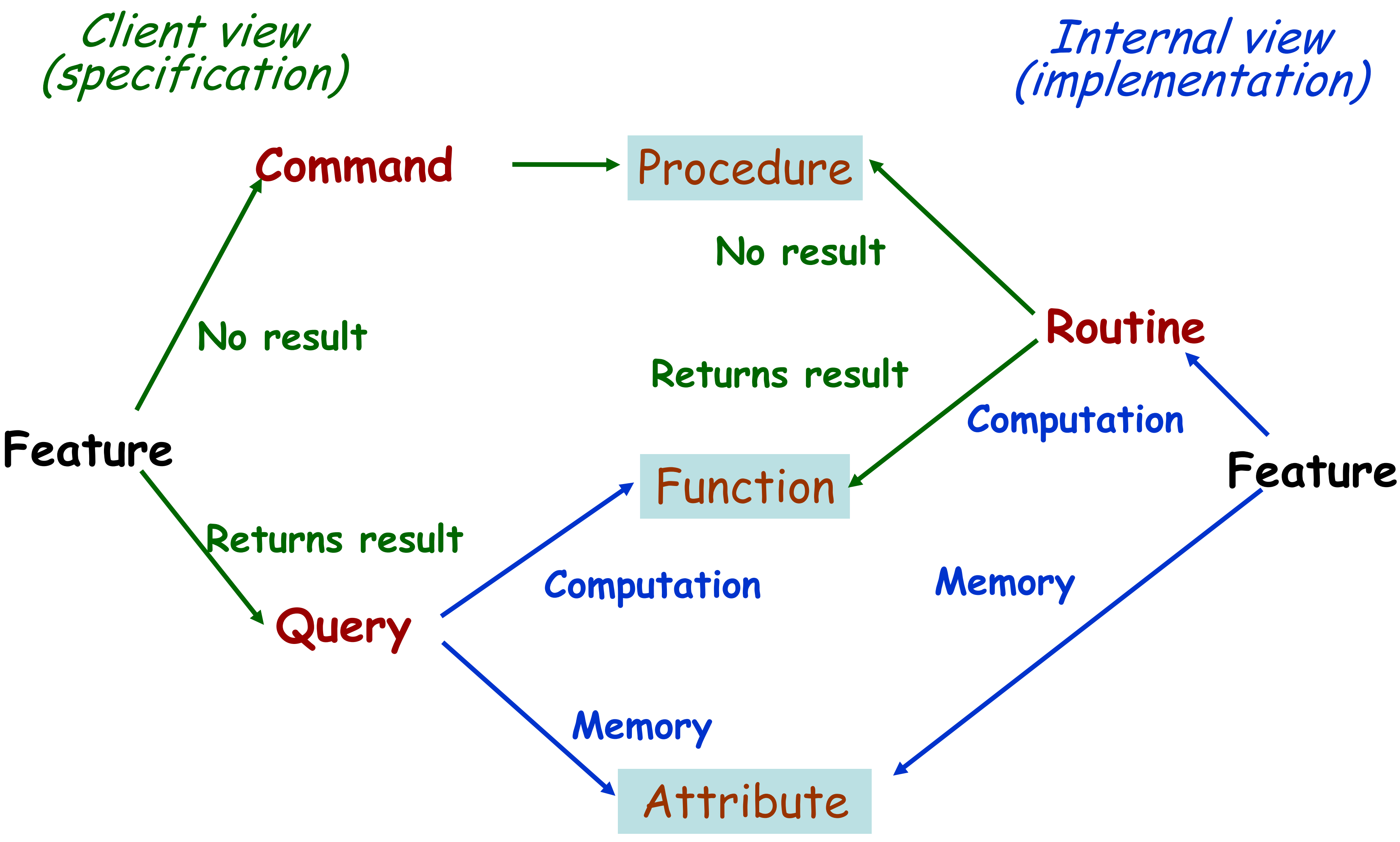
The client is interested in what a service does, not how it does it.

It doesn't matter for the client, whether you store or compute, he just wants to obtain the *balance.*

Features should be accessible to clients the same way, no matter whether they are implemented by storage or computation

my_account.balance

Features: the full story (again…)



Two kinds of queries

Attribute

- from the client's viewpoint it is a query
- call is an expression
- from the implementation's viewpoint uses memory

Function

- from the client's viewpoint is a query
- call is an expression
- from the implementation's viewpoint uses computation

Exporting features

```
class
    A

feature
    f ...
    g ...

feature {NONE}

    h, i ...

feature {B, C}

    j, k, l ...

feature {A, B, C}

    m, n...
end
```

Status of calls in a client with *a1* of type *A*:

- *a1.f*, *a1.g*: valid in any client
- *a1.h*: invalid everywhere (including in *A*'s text!)
- *a1.j*: valid in *B*, *C* and their descendants (invalid in *A*!)
- *a1.m*: valid in *B*, *C* and their descendants, as well as in *A* and its descendants.

Compilation error?

Hands-On

```
class PERSON
feature
        name: STRING
feature {BANK}
        account: BANK_ACCOUNT
feature {NONE}
        loved_one: PERSON
        think
                do
                        print ("Thinking of " + loved_one.name)
                end
        lend_100_franks
                do
                        loved_one.account.transfer (account, 100)
                end
end
```

OK: unqualified call

OK: exported to all

Error: not exported to PERSON

OK: unqualified call

The strange case of the stolen exam

```
class PROFESSOR

create
        make
feature
        make (an_exam_draft: STRING)
                do
                        exam_draft := an_exam_draft
                end
feature
        exam_draft: STRING
end
```

For your eyes only

```
class ASSISTANT

create
        make
feature
        make (a_prof: PROFESSOR)
                do
                        prof := a_prof
                end
feature
         prof: PROFESSOR
feature
        review_draft
                do
                        -- review  prof.exam_draft
                end
end
```

Exploiting a hole in information hiding

```
class STUDENT

create
        make
feature
        make (a_prof: PROFESSOR; an_assi: ASSISTANT)
                do
                        prof := a_prof
                        assi := an_assi
                end
feature
        prof: PROFESSOR
        assi: ASSISTANT
feature
        stolen_exam: STRING
                do
                        Result := prof.exam_draft
                end
end
```

Don't try this at home!

```
you: STUDENT
your_prof: PROFESSOR
your_assi: ASSISTANT
stolen_exam: STRING

create your_prof.make ("top secret exam!")
create your_assi.make (your_prof)
create you.make (your_prof, your_assistant)

stolen_exam := you.stolen_exam
```

Fixing the issue

Hands-On

```
class PROFESSOR
create
        make
feature
        make (a_exam_draft: STRING)
                do
                        exam_draft := a_exam_draft
                end
feature {PROFESSOR, ASSISTANT}
        exam_draft: STRING
end
```

The export status does matter!

```
class STUDENT
create
        make
feature
        make (a_prof: PROFESSOR; a_assi: ASSISTANT)
                do
                        prof := a_prof
                        assi := a_assi
                end
feature
        prof: PROFESSOR
        assi: ASSISTANT
feature
        stolen_exam: STRING
                do
                        Result := assi.prof.exam_draft
                end
end
```

Invalid call!

Information hiding vs. creation routines

```
class PROFESSOR
create
        make
feature {None}
        make (an_exam_draft: STRING)
                do
                        ...
                end
end
```

Can I create an object of type *PROFESSOR* as a client?

After creation, can I invoke feature *make* as a client?

Controlling the export status of creation routines

```
class PROFESSOR
create {COLLEGE_MANAGER}
        make
feature {None}
        make (an_exam_draft: STRING)
                do
                        ...
                end
end
```

Can I create an object of type *PROFESSOR* as a client?
After creation, can I invoke feature *make* as a client?
What if I have **create** *{NONE} make* instead of
create *{COLLEGE_MANAGER} make* ?

Exporting attributes

Exporting an attribute only means giving read access

$\cancel{x.f := 5}$

Attributes of other objects can be changed only through commands

- protecting the invariant
- no need for getter functions!

Example

```
class TEMPERATURE
feature
        celsius_value: INTEGER

        make_celsius (a_value: INTEGER)
            require
                above_absolute_zero: a_value >= - Celsius_zero
            do
                celsius_value := a_value
            ensure
                celsius_value_set := celsius_value = a_value
            end
...
end
```

Assigners

If you like the syntax

x.f := 5

you can declare an assigner for *f*

- In class *TEMPERATURE*

  celsius_value: INTEGER **assign** *make_celsius*

- In this case

  t.celsius_value := 36

  is a shortcut for

  t.make_celsius (36)

- ... and it won't break the invariant!