ETH Zürich
Chair of Software Engineering

# Einführung in die Programmierung
# Introduction to Programming

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## Exercise Session 6

# Today

- Abstractions
- Exporting features
- Exercise: practicing contracts

# 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**

- 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 )

# Finding the right abstractions (classes)

Suppose you want to model your room:

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

door material location bed desk computer size furniture etc shape etc etc messy?

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

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
```

```
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)

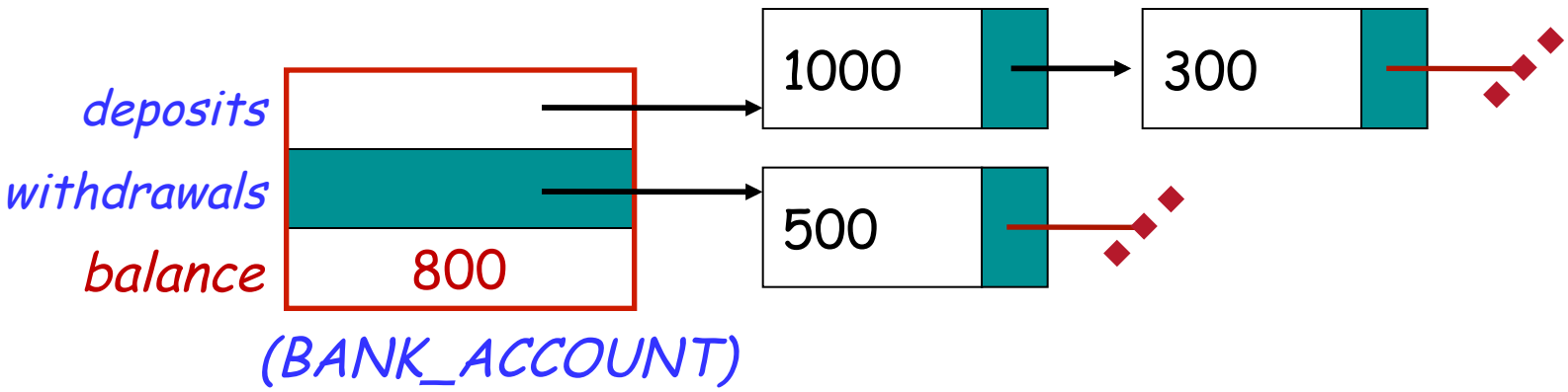

How would you model…

… the computer?

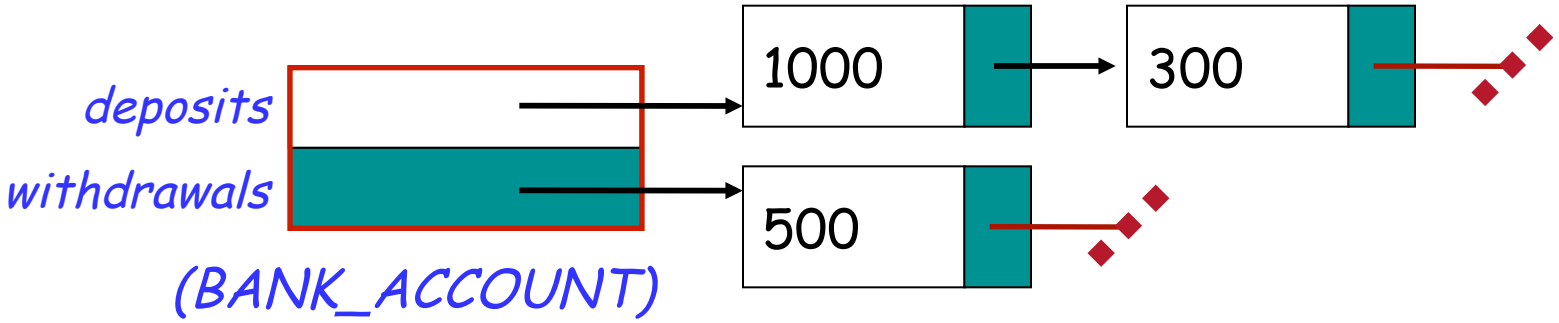
… the bed?

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?

# Exporting features: The stolen exam

```
class ASSISTANT

create
    make
feature
    make (a_prof: PROFESSOR)
        do
            prof := a_prof
        end
feature
     prof: PROFESSOR
feature
    propose_draft (a_draft: STRING)
        do
            prof.review(a_draft)
        end
end
```

# For your eyes only

```
class PROFESSOR

create
    make
feature
    make
        do
            exam_text := "exam is not ready"
        end
feature
    exam_text: STRING

    review_draft (a_draft: STRING)
        do
            -- review  'a_draft' and put the result into 'exam_text'
        end
end
```

# Exploiting a hole in information hiding

```
class STUDENT

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

# Don’t try this at home!

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

**create** *your_prof.make*
**create** *your_assi.make (your_prof)*
**create** *you.make (your_prof, your_assi)*

*your_assi.propose_draft (*“top secret exam!”*)*

*stolen_exam := you.stolen_exam*

# Secretive professor

```
class STUDENT

create
    make
feature
    make (a_assi: ASSISTANT )
        do
            assi := a_assi

        end
feature

    assi: ASSISTANT
feature
    stolen_exam: STRING
        do
            Result := assi.prof.exam_text
        end
end
```

# Fixing the issue: hint

```
class
        A

feature
      g ...

feature  {B, C}

     f...

end
```

*Use selective export for the features*

# Fixing the issue


```
class PROFESSOR
create
    make
feature
    make
        do
            exam_text := "exam is not ready"
        end

feature  {PROFESSOR, ASSISTANT}
    exam_text: STRING

    review_draft (a_draft: STRING)
        do
            -- review  'a_draft' and put the result into 'exam_text'
        end
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_text
        end
end
```

Invalid call!

# 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?


```
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

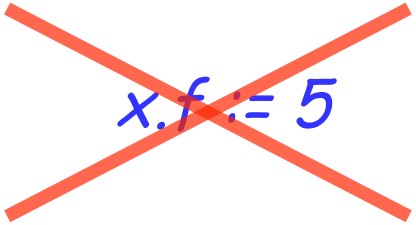
OK: exported to all

Error: not exported to PERSON

OK: unqualified call

# Exporting attributes

Exporting an attribute only means giving read access




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!

# Information hiding vs. creation routines

```
class PROFESSOR
create
    make
feature {None}
    make
        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
        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* ?

# Specification of a card game

A deck is initially made of 36 cards

Every card in the deck represents a value in the range 2..10

Every card also represents 1 out of 4 possible colors

The colors represented in the game cards are:
red ('R'), white ('W'), green ('G') and blue ('B')

As long as there are cards in the deck, the players can look at the top card and remove it from the deck

# Class CARD create make


```
make (a_color: CHARACTER, a_value: INTEGER)
                -- Create a card given a color and a value.
        require
                ...

        do
                ...

        ensure
                ...

        end

color: CHARACTER
                -- The card color.
value: INTEGER
                -- The card value.
```

# Class CARD create make


```
make (a_color: CHARACTER, a_value: INTEGER)
                -- Create a card given a color and a value.
        require
                is_valid_color (a_color)
                is_valid_range (a_value)
        do
                color := a_color
                value := a_value
        ensure
                color_set: color = a_color
                value_set: value = a_value
        end

color: CHARACTER
                -- The card color.
value: INTEGER
                -- The card value.
```

# Class CARD: which colors are valid?


```
is_valid_color (c: CHARACTER): BOOLEAN
                -- Is c a valid color?
        require
                ...
        do
                ...
        ensure
                ...
        end
```

# Class CARD: which colors are valid?


```
is_valid_color (c: CHARACTER): BOOLEAN
                -- Is c a valid color?
        require

        do
                Result := (c = 'R' or c = 'B' or c = 'W' or c = 'G')
        ensure
                Result = (c = 'R' or c = 'B' or c = 'W' or c = 'G')
        end
```

# Class CARD: which ranges are valid?


```
is_valid_range (n: INTEGER): BOOLEAN
                -- Is `n' in the acceptable range of values?
        require
                ...
        do
                ...
        ensure
                ...
        end
```

# Class CARD: which ranges are valid?


```
is_valid_range (n: INTEGER): BOOLEAN
                -- Is `n' in the acceptable range of values?
        require

        do
                Result := (2 <= n and n <= 10)
        ensure
                Result = (2 <= n and n <= 10)
        end
```

# Class DECK create make


```
make
                -- Create a deck with random cards.
        require
                ...
        do
                ...
        ensure
                ...
        end

feature {NONE} -- Implementation

card_list: LINKED_LIST [CARD]
                -- Deck as a linked list of cards.
top_card: CARD
                -- The deck's top card.
```

# Class DECK queries


```
is_empty: BOOLEAN
                -- Is Current deck empty?
        do ...
        end

count: INTEGER
                -- Number of remaining cards in the deck.
        do ...
        end

remove_top_card
                -- Remove the top card from the deck.
        do ...
        end
```

# The class invariant




**invariant**

is_legal_deck: 0 <= count and count <= 36

top_card_available: is_empty = (top_card = Void)

count_empty_relation: is_empty = (count = 0)

card_list_exists: card_list /= Void

count_corresponds: count = card_list.count

top_card_is_first: not is_empty implies top_card = card_list.first