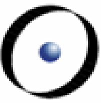
ETH Zürich

Chair of Software Engineering



Einführung in die Programmierung
Introduction to Programming

Prof. Dr. Bertrand Meyer

Exercise Session 6

News

Mock exam in 2 weeks (November 10)

- You have to be present
- No assignment that week
- The week after we will discuss the results

Today

- Conditional
- Loop
- Linked list

Inside the routine body

- The body of each routine consists of instructions (command calls, creations, assignments, etc.)
- In the programs you've seen so far they were always executed in the order they were written

```
create passenger.make_with_route (Route3, 1.5)
passenger.go
passenger. set_reiterate (True)
Paris.put_passenger (passenger)
create tram.make_with_line (Line1)
tram.start
Paris.put_tram (tram)
```

- Programming languages have structures that allow you to change the order of execution

Structured programming

- If the order of execution could be changed arbitrarily, it would be hard to understand programs
- In structured programming instructions can be combined only in three ways:

- Each of these blocks has a single entrance and exit and is itself an instruction

Conditional

- Basic syntax:

```
if c then
    i_1
else
    i_2
end
```

Condition

Instruction

Instruction

- *c* is a boolean expression (e.g., entity, query call of type *BOOLEAN*)
- **else**-part is optional:

```
if c then
    i_1
end
```

Compilation error? Runtime error? (1)

Hands-On

```
f (x, y: INTEGER): INTEGER
	do
		if (x // y) then
			1
		else
			0
		end
	end
```

Compilation error:

integer expression instead of boolean

Compilation error:

expression instead of instruction

Compilation error? Runtime error? (2)

Hands-On

```
f (x, y: INTEGER): INTEGER
    do
        if (False) then
            Result := x // y
        end
        if (x /= 0) then
            Result := y // x
        end
    end
```

Everything is OK

(during both compilation and runtime)

Calculating function's value

Hands-On

```
f (max: INTEGER; s: STRING): STRING
	do
		if s.is_equal ("Java") then
			Result := "J**a"
		else
			if s.count > max then
				Result := "<an unreadable German word>"
			end
		end
	end
```

Calculate the value of:

- *f* (3, "Java") → "J**a"
- *f* (20, "Immatrikulationsbestätigung") → "<an unreadable German word>"
- *f* (6, "Eiffel") → **Void**

What does this routine do?

Hands-On

```
abs (x: REAL): REAL
    do
        if (x >= 0) then
            Result := x
        else
            Result := -x
        end
    end
```

Write a routine...

Hands-On

- ... that computes the maximum of two integers:

    max (*a*, *b*: *INTEGER*): *INTEGER*

- ... that increases time by one second inside class *TIME*:

```
class TIME
    hour, minute, second: INTEGER

    second_forth
        do ... end
    ...
end
```

Comb-like conditional

If there are more than two alternatives, you can use the syntax:

Condition

Instruction

```
if c1 then
        i_1
elseif c2 then
        i_2
...
elseif c_n then
        i_n
else
        i_e
end
```

instead of:

```
if c_1 then
   i_1
else
   if c_2 then
        i_2
   else
        ...
        if c_n then
              i_n
        else
              i_e
        end
        ...
   end
end
```

Multiple choice

If all the conditions have a specific structure, you can use the syntax:

```
inspect expression
when const_1 then
        i_1
when const_2 then
        i_2
...
when const_n1 .. const_n2 then
        i_n
else
        i_e
end
```

Integer or character expression

Integer or character constant

Instruction

Interval

Lost in conditions

Rewrite the following multiple choice:

- using a comb-like conditional
- using nested conditionals

```
inspect user_choice
when 0 then
        print ("Here is your hamburger")
when 1 then
        print ("Here is your Coke")
else
        print ("Sorry, not on the menu today!")
end
```

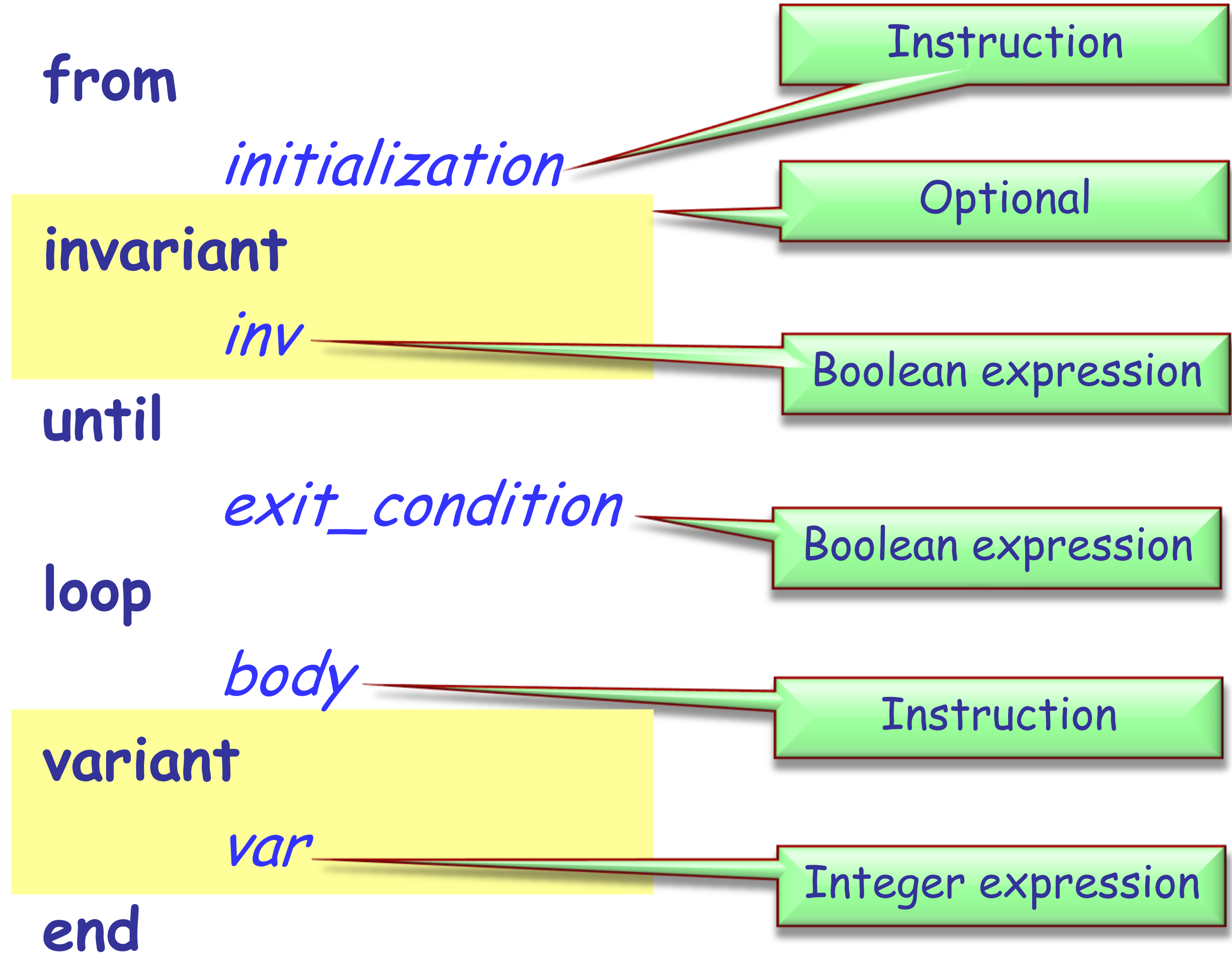
Lost in conditions: solution

```
if user_choice = 0 then
        print ("Here is your hamburger")
elseif user_choice = 1 then
        print ("Here is your Coke")
else
        print ("Sorry, not on the menu today!")
end
```

```
if user_choice = 0 then
        print ("Here is your hamburger")
else
        if user_choice = 1 then
                print ("Here is your Coke")
        else
                print ("Sorry, not on the menu today!")
        end
end
```

Loop

Syntax:



Simple loop (1)

Hands-On

How many times will the body of the following loop be executed?

```
i: INTEGER
...
from
    i := 1
until
    i > 10
loop
    print ("I will not say bad things about assistants")
    i := i + 1
end
```

In Eiffel we usually start counting from 1

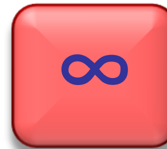
10

Simple loop (2)

Hands-On

And what about this one?

```
i: INTEGER
...
from
        i := 10
until
        i < 1
loop
        print ("I will not say bad things about assistants")
end
```



What does this function do?

Hands-On

```
factorial (n: INTEGER): INTEGER is
        local
            i: INTEGER
        do
            from
                i := 2
                Result := 1
            until
                i > n
            loop
                Result := Result * i
                i := i + 1
            end
        end
```

Invariant and variant

Loop invariant (do not mix with class invariant)

- holds after execution of **from** clause and after each execution of **loop** clause
- captures how the loop iteratively solves the problem: e.g. "to calculate the sum of all *n* elements in a list, on each iteration *i* (*i* = 1..*n*) the sum of first *i* elements is obtained"

Loop variant

- integer expression that is nonnegative after execution of **from** clause and after each execution of **loop** clause and strictly decreases with each iteration
- a loop with a variant can not be infinite (why?)

Invariant and variant

Hands-On

What are the invariant and variant of the "factorial" loop?

```
from
        i := 2
        Result := 1
invariant
        Result = factorial (i - 1)
until
        i > n
loop
        Result := Result * i
        i := i + 1
variant
        n - i + 2
end
```

Result = 6 = 3!

Writing loops

Hands-On

Implement a function that calculates Fibonacci numbers, using a loop

```
fibonacci (n: INTEGER): INTEGER
            -- n-th Fibonacci number
      require
            n_non_negative: n >= 0
      ensure
            first_is_zero: n = 0 implies Result = 0
            second_is_one: n = 1 implies Result = 1
            other_correct: n > 1 implies Result =
                  fibonacci (n - 1) + fibonacci (n - 2)
      end
```

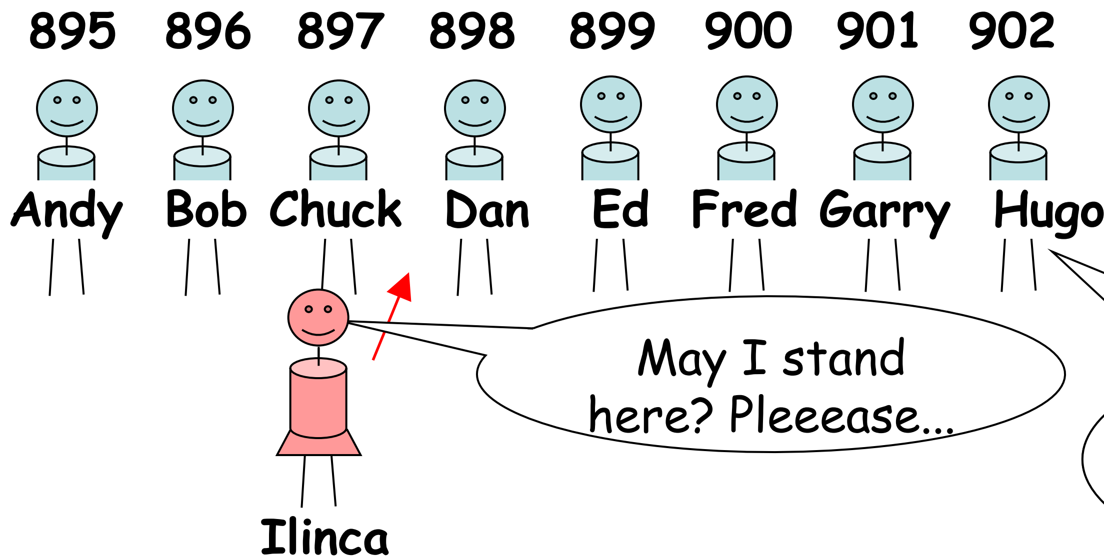
Writhing loops (solution)

Hands-On

```
fibonacci (n: INTEGER): INTEGER
        local
                a, b, i: INTEGER
        do
                if n <= 1 then
                        Result := n
                else
                        from
                                a := fibonacci (0)
                                b := fibonacci (1)
                                i := 1
                        invariant
                                a = fibonacci (i - 1)
                                b = fibonacci (i )
                        until
                                i = n
                        loop
                                Result := a + b
                                a := b
                                b := Result
                                i := i + 1
                        variant
                                n - i
                        end
                end
        end
```

Two kinds of queues

Electronic queue (like in the post office)



Two kinds of queues

Live queue

Chuck is after me

Dan is after me

...

Bob is after me

I am the last

Andy **Bob** **Chuck** **Dan** **Ed** **Fred** **Garry** **Hugo**

May I stand here? Pleeease...

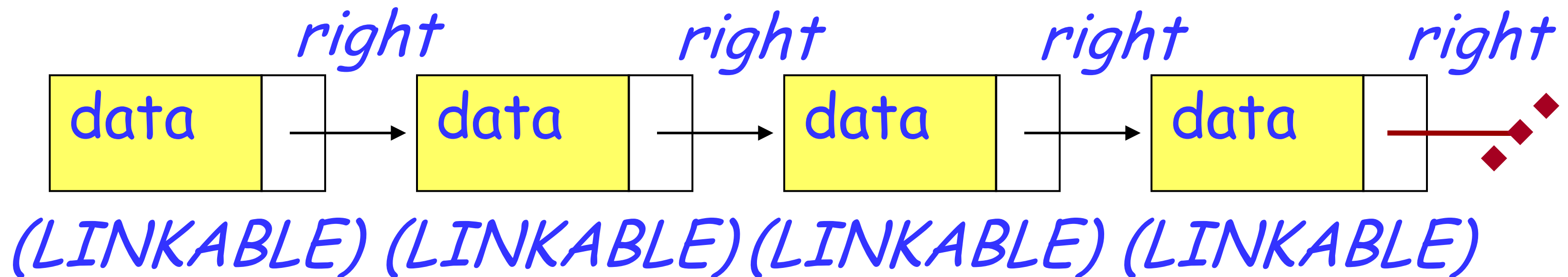
Ilinca

Sure! Just remember that Dan is after you

LINKABLE

To make it possible to link infinitely many similar elements together, each element should contain a reference to the next element

```
class LINKABLE
        feature
                ...
                 right: LINKABLE
end
```



INT_LINKABLE

```
class INT_LINKABLE
create put
feature
        item: INTEGER

        put (i: INTEGER)
                do item := i end

        right: INT_LINKABLE

        put_right (other: INT_LINKABLE)
                do right := other end
end
```

INT_LINKED_LIST

```
class INT_LINKED_LIST
feature
        first_element: INT_LINKABLE
                -- First cell of the list

        last_element: INT_LINKABLE
                -- Last cell of the list

        count: INTEGER
                -- Number of elements in the list

        ...
end
```

INT_LINKED_LIST : inserting at the end

count ~~3~~ 4

first_element

last_element

16

item right

(INT_LINKABLE)

4 | 8 | 15

item right | item right | item right

(INT_LINKABLE) (INT_LINKABLE) (INT_LINKABLE)

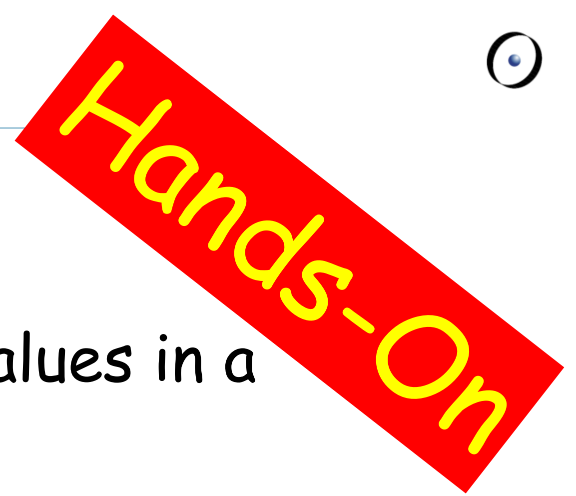
INT_LINKED_LIST: inserting at the end

```
extend (v: INTEGER)
        -- Add v to end.
    local
        new: INT_LINKABLE
    do
        create new.put (v)
        if first_element = Void then
            first_element := new
        else
            last_element.put_right (new)
        end
        last_element := new
        count := count + 1
    end
```

INT_LINKED_LIST: search

```
has (v: INTEGER): BOOLEAN
            -- Does list contain v?
    local
            temp: INT_LINKABLE
    do
            from
                    temp := first_element
            until
                    (temp = Void) or Result
            loop
                    if temp.item = v then
                            Result := True
                    end
                    temp := temp.right
            end
    end
```

INT_LINKED_LIST



Write a routine that

- calculates the sum of all positive values in a list

sum_of_positive: *INTEGER*
  do ... **end**

- inserts an element after the first occurrence of a given value and does nothing if the value is not found

insert_after (*i*, *j*: *INTEGER*)
  do ... **end**

INT_LINKED_LIST: sum_of_positive

```
sum_of_positive: INTEGER
            -- Some of positive elements
    local
            temp: INT_LINKABLE
    do
            from
                    temp := first_element
            until
                    temp = Void
            loop
                    if  temp.item > 0 then
                            Result := Result + temp.item
                    end
                    temp := temp.right
            end
    end
```

INT_LINKED_LIST: insert_after

```
insert_after (i, j: INTEGER)
        -- Insert `j' after `i' if present
    local
        temp, new: INT_LINKABLE
    do
        from
            temp := first_element
        until
            temp = Void   or else  temp.item = i
        loop
            temp := temp.right
        end
        if  temp /= Void then
            create  new.put (j)
            new.put_right (temp.right)
            temp.put_right (new)
            count := count + 1
            if  temp = last_element  then
                last_element := new
            end
        end
    end
```