Object-Oriented Software Construction

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Lecture 21: Agents and tuples

Chair of Software Engineering
ETH

Agents: the basic idea

Encapsulating routines in objects

agent *r*

agent *r* (*x*, ?, *y*)

Mechanism will first be illustrated through event-driven programming

Handling traditional input

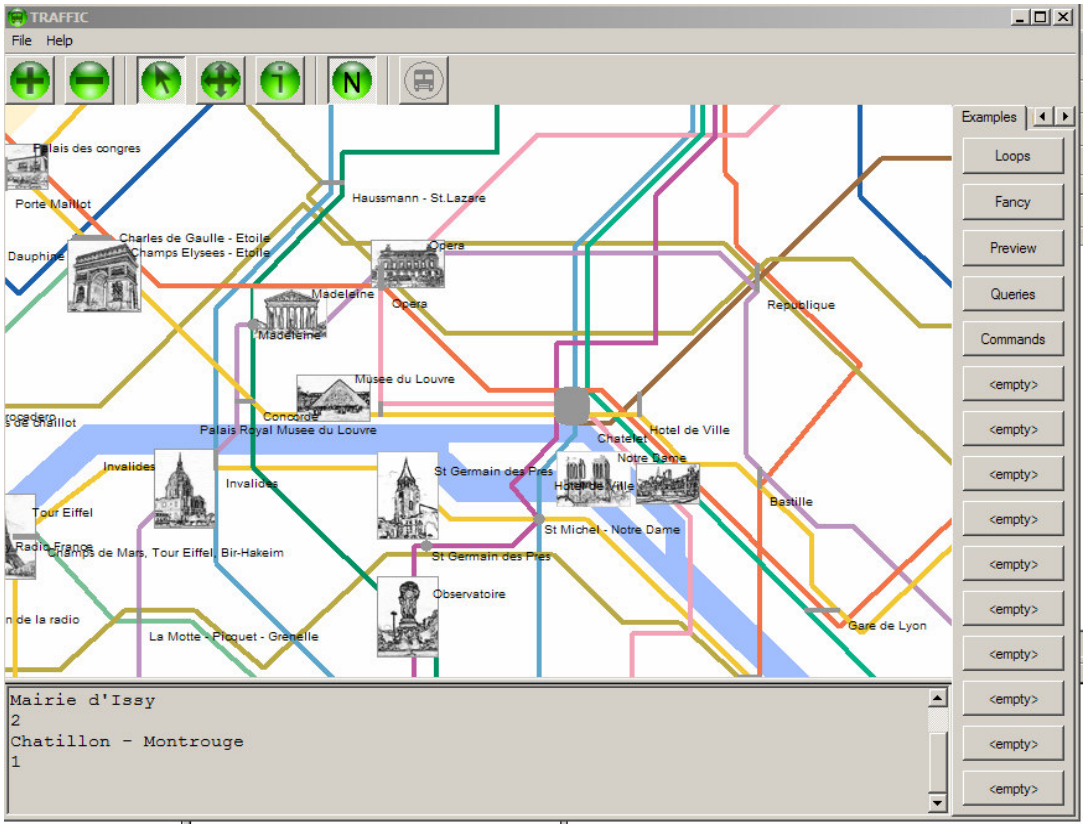
Program drives input:

```
from
    read_next_character
until  last_character = Enter loop
    i := i + 1
    Result.put (last_character, i)
    read_next_character
    end
```

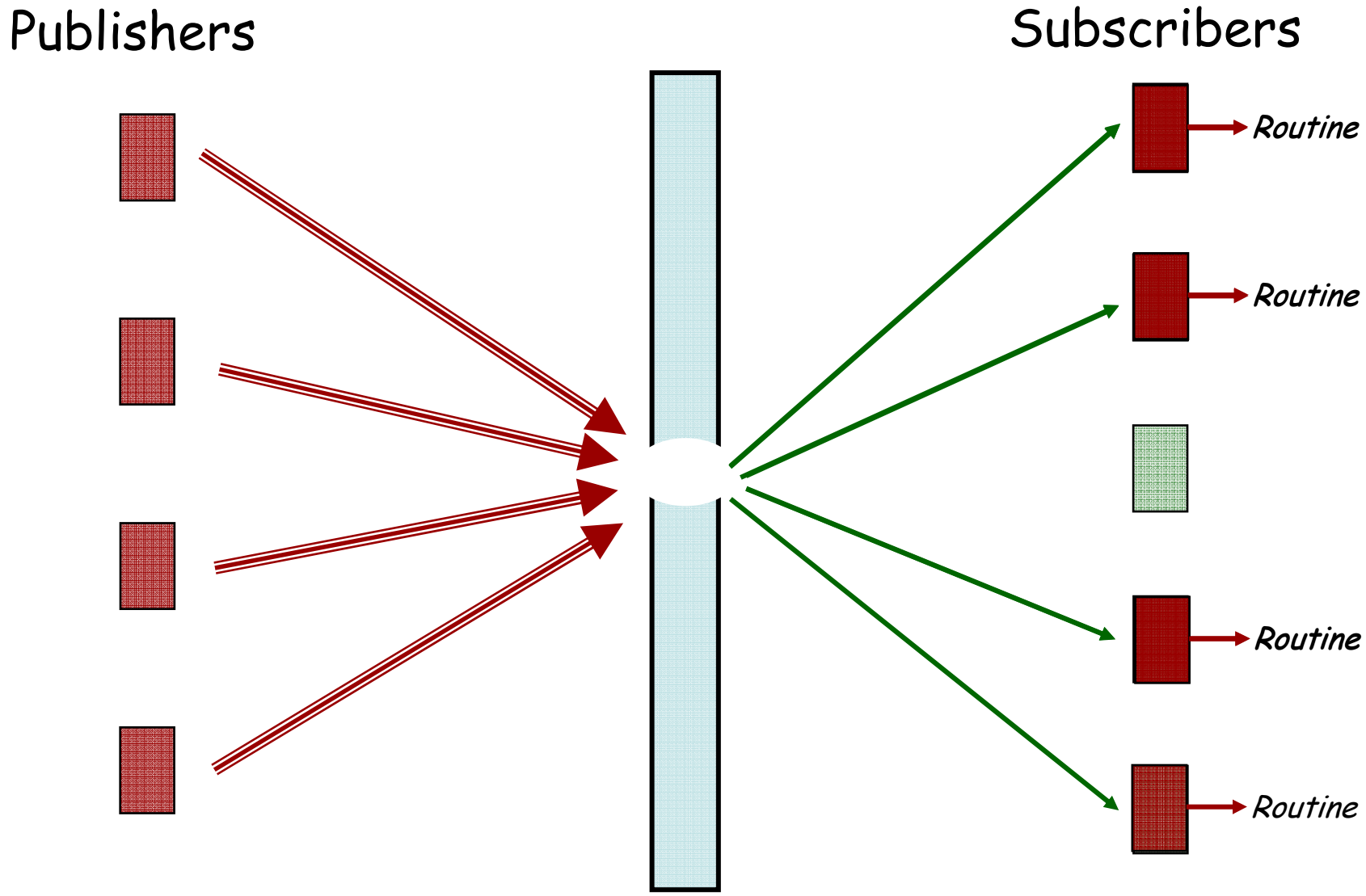
Handling input with modern GUIs

User drives program:

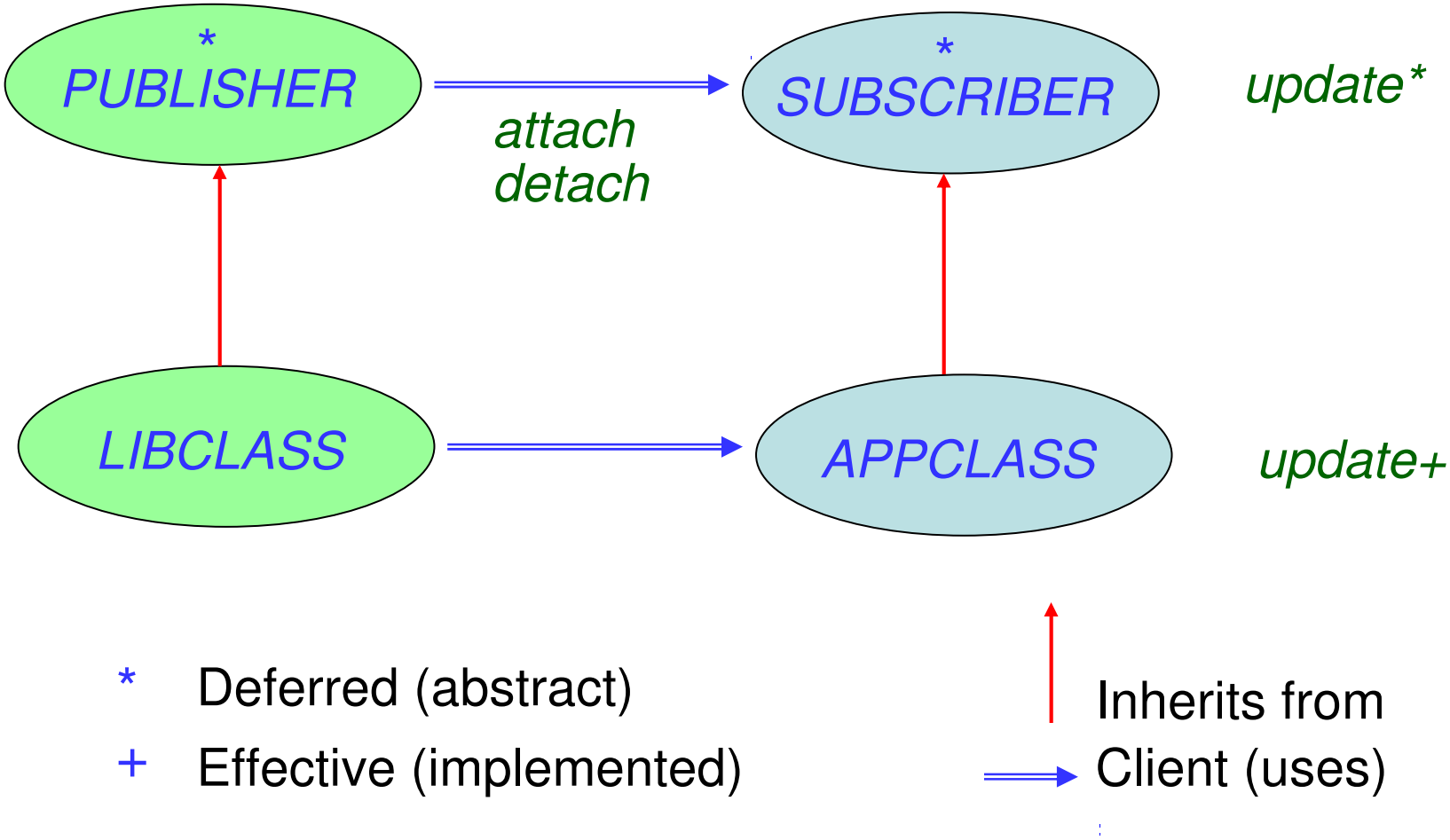
" When a user presses this button, execute that action from my program"



Event-driven programming



A solution: Observer Pattern



Observer pattern

Publisher keeps a list of observers:

subscribed : *LINKED_LIST* [*OBSERVER*]

To register itself, an observer may execute

subscribe (*some_publisher*)

where *subscribe* is defined in *OBSERVER*:

```
subscribe (p: PUBLISHER) is
                -- Make current object observe p.
        require
                publisher_exists: p /= Void
        do
                p.attach (Current)
        end
```

Attaching an observer

In class *PUBLISHER*:

```
attach (s: SUBSCRIBER) is
        -- Register s as subscriber to current publisher.
    require
        subscriber_exists: p /= Void
    do
        subscribed.extend (s)
    end
```

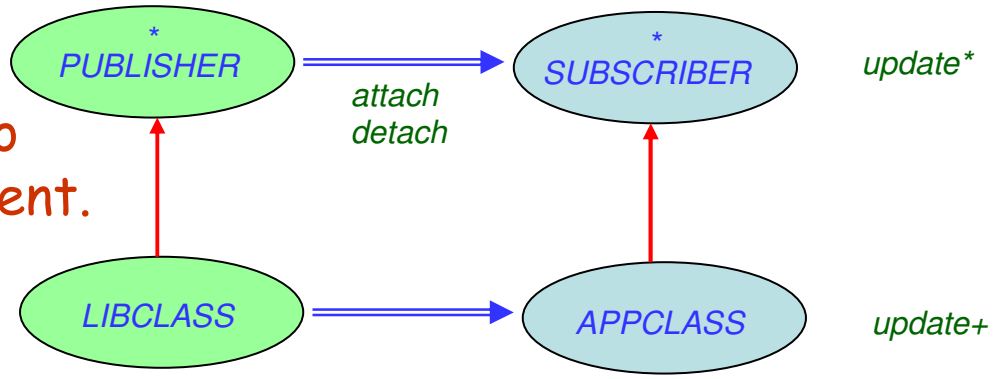
Note that invariant of *PUBLISHER* includes the clause

```
subscribed /= Void
```

(List *subscribed* is created by creation procedures of *PUBLISHER*)

Triggering an event

```
trigger is
        -- Ask all observers to
        -- react to current event.
    do
        from
            subscribed.start
        until
            subscribed.after
        loop
            subscribed.item. update
            subscribed.forth
        end
    end
```



Each descendant of *OBSERVER* defines its own version of *update*

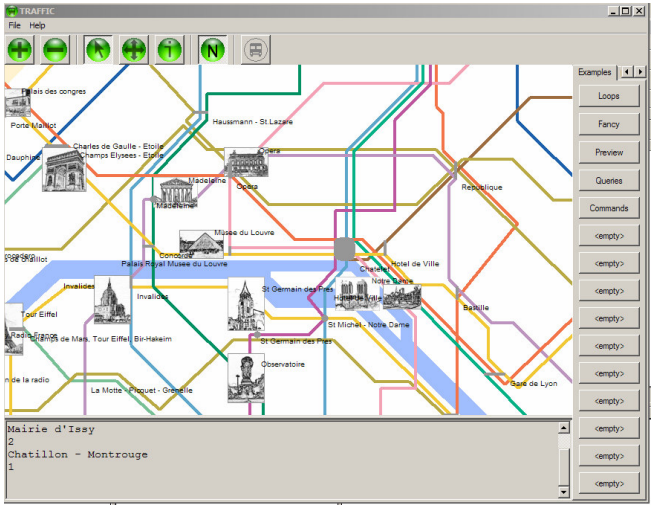
Observer pattern

- Publishers know about subscribers
- Subscriber may subscribe to at most one publisher
- May subscribe at most one operation
- Not reusable — must be coded anew for each application

Another approach: action-event table

Set of triples

[Event, Context, Action]



Event: any occurrence we track

Example: a mouse click

Context: object for which the event is interesting

Example: a particular button

Action: what we want to do when the event occurs in the context

Example: save the file

Action-event table may be implemented as e.g. a hash table.

The EiffelVision style

```
my_button.click.action_list.extend (agent my_procedure)
```

Mechanisms in other languages

C and C++: "function pointers"

C#: delegates (more limited form of agents)

With .NET delegates: publisher (1)

P1. Introduce new class ClickArgs inheriting from EventArgs, repeating arguments types of myProcedure:

```
public class Clickargs {... int x, y; ...}
```

P2. Introduce new type ClickDelegate (delegate type) based on that class

```
public void delegate ClickDelegate  (Object sender,  e)
```

P3. Declare new type Click (event type) based on the type ClickDelegate:

```
public event ClickDelegate Click
```

With .NET delegates: publisher (2)

P4. Write new procedure OnClick to wrap handling:

```
protected void OnClick (int x, int y)
    {if (Click != null) {Click (this, x, y)}}
```

P5. For every event occurrence, create new object (instance of ClickArgs), passing arguments to constructor:

```
ClickArgs myClickargs = new Clickargs (h, v)
```

P6. For every event occurrence, trigger event:

```
OnClick (myclickargs)
```

With .NET delegates: subscriber

D1. Declare a delegate myDelegate of type ClickDelegate.
(Usually combined with following step.)

D2. Instantiate it with myProcedure as argument:

```
ClickDelegate = new ClickDelegate (myProcedure)
```

D3. Add it to the delegate list for the event:

```
YES_button.Click  += myDelegate
```

Using the Eiffel approach

Event: each event *type* will be an object

Example: mouse clicks

Context: an object, usually representing element of user interface

Example: a particular button

Action: an agent representing a routine

Example: routine to save the file

The EiffelVision style

```
YES_button.click.action_list.extend (agent my_procedure)
```

Event Library style

The basic class is *EVENT_TYPE*

On the publisher side, e.g. GUI library:

- (Once) declare event type:

  click: EVENT_TYPE [TUPLE [INTEGER, INTEGER]]

- (Once) create event type object:

  create *click*

- To trigger one occurrence of the event:

  click.publish ([*x_coordinate, y_coordinate*])

On the subscriber side, e.g. an application:

click.subscribe (**agent** *my_procedure*)

Subscriber variants

click.subscribe (**agent** *my_procedure)*

my_button. click.subscribe (**agent** *my_procedure)*

click.subscribe (**agent** *your_procedure* (*a*, ?, ?, *b*))

click.subscribe (**agent** *other_object.other_procedure*)

Another example of using agents

$$\int_a^b my\_function\,(x)\,dx$$

$$\int_a^b your\_function\,(x,\,u,\,v)\,dx$$

my_integrator.*integral* (**agent** *my_function* , *a*, *b*)

my_integrator.*integral* (**agent** *your_function* (? , *u*, *v*), *a*, *b*)

Applications of agents

- Undo-redo
- Iteration
- High-level contracts
- Numerical programming
- Introspection (finding out properties of the program itself)

Using an iterator

```
all_positive := my_integer_list.for_all
                    (agent is_positive (?))
```

Iterators

In class *LINEAR* [*G*], ancestor to all classes for lists, sequences etc., you will find:

for_all

there_exists

do_all

do_if

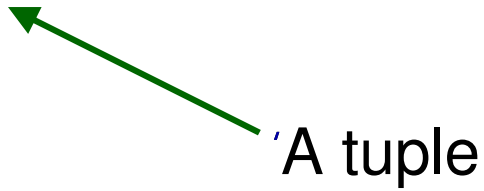
do_while

do_until

Calling the associated routine

Given an agent, you may call the associated routine through the feature "*call*" :

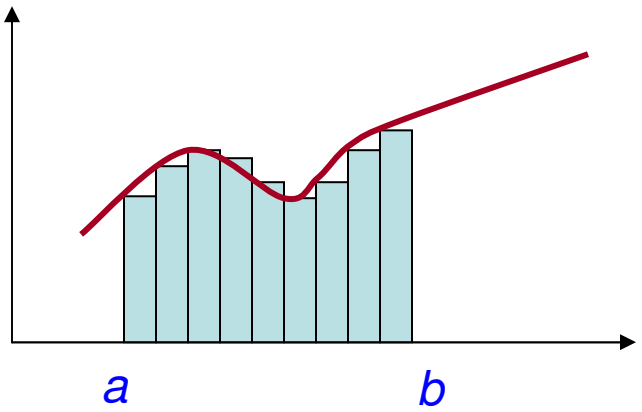
a.call ([*horizontal_position, vertical_position*])



If *a* is associated with a function, *a.item* ([..., ...]) gives the result of applying the function.

The integration function

```
integral ( f : FUNCTION [ANY, TUPLE [REAL], REAL];
          low, high: REAL): REAL is
              -- Integral of f over the interval [low, high]
        local
                    x: REAL; i: INTEGER
        do
              from x := low until x > high loop

                    Result := Result + step * f.item ([x])
                    i := i + 1
                    x := a + i * step
              end
        end
```



Behind agents: Tuples

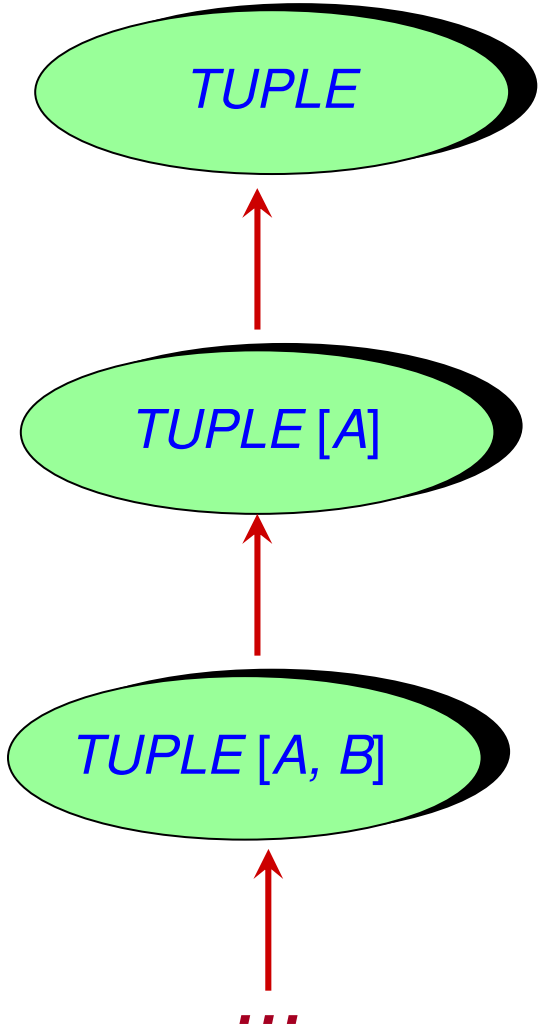
Tuple types (for any types *A*, *B*, *C*, ...):

TUPLE
TUPLE [*A*]
TUPLE [*A*, *B*]
TUPLE [*A*, *B*, *C*]
...

A tuple of type *TUPLE* [*A*, *B*, *C*] is a sequence of at least three values, first of type *A*, second of type *B*, third of type *C*

Tuple values: e.g. [*a1*, *b1*, *c1*]

Tuple type inheritance



Accessing and modifying tuple elements

To obtain *i*-th element of a tuple *t*, use

t.item (i)

May need assignment attempt:

x ?= t.item (i)

To change *i*-th element, use *t.put (x, i)*

Agents and their arguments

An agent can have both "closed" and "open" arguments

Closed arguments set at time of agent definition; open arguments set at time of each call.

To keep an argument open, just replace it by a question mark:

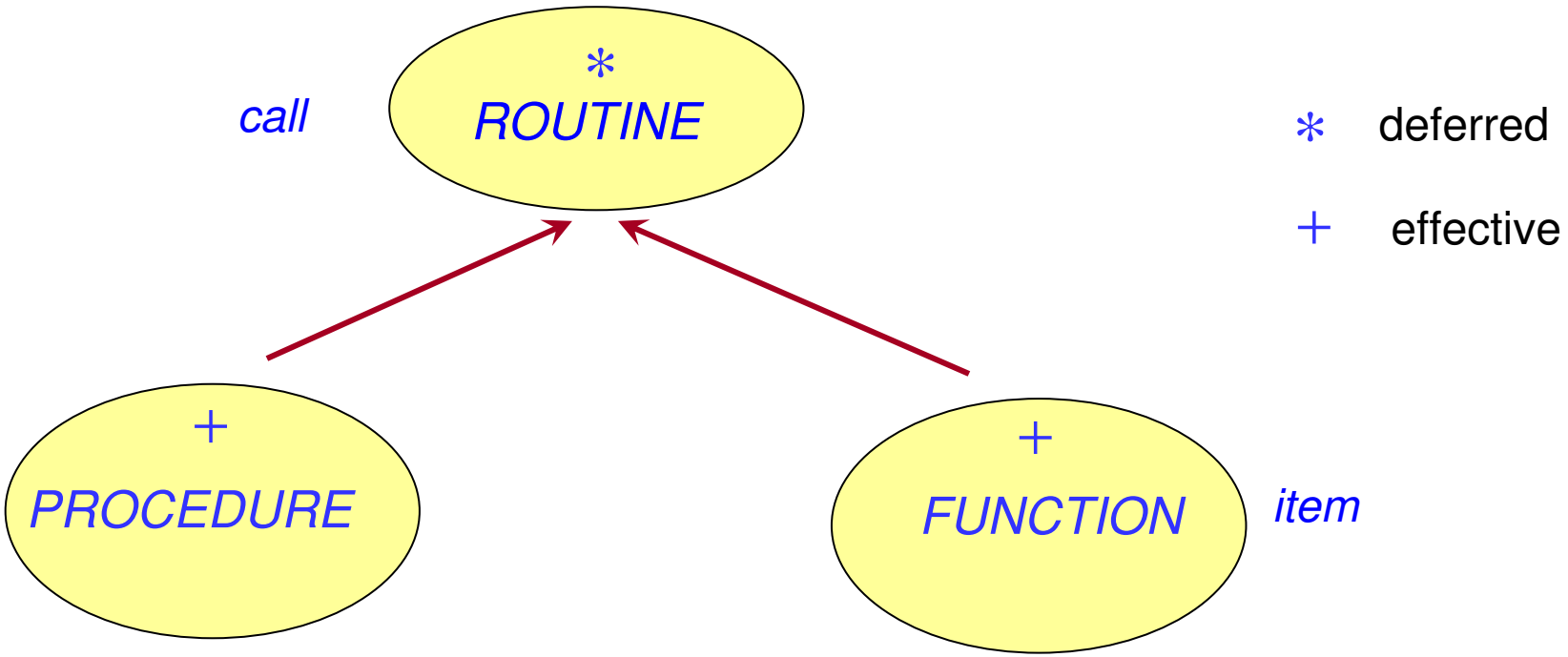
```
u := agent a0.f (a1, a2, a3) -- All closed (as before)

    w := agent a0.f (a1, a2, ?)

    x := agent a0.f (a1, ?, a3)

    y := agent a0.f (a1, ?, ?)

    z := agent a0.f (?, ?, ?)
```

Calling an agent with arguments

```
f (x1: T1; x2: T2; x3: T3)
a0: C; a1: T1; a2: T2; a3: T3
```

`u := agent a0.f (a1, a2, a3)`	`u.call ([])`
`v := agent a0.f (a1, a2, ?)`	`v.call ([a3])`
`w := agent a0.f (a1, ?, a3)`	`w.call ([a2])`
`x := agent a0.f (a1, ?, ?)`	`x.call ([a2, a3])`
`y := agent a0.f (?, ?, ?)`	`y.call ([a1, a2, a3])`

EiffelBase classes representing agents



Agent types

ROUTINE [BASE, ARGS -> TUPLE]

PROCEDURE [BASE, ARGS -> TUPLE]

FUNCTION [BASE, ARGS -> TUPLE, RESTYPE]

Declaring an agent

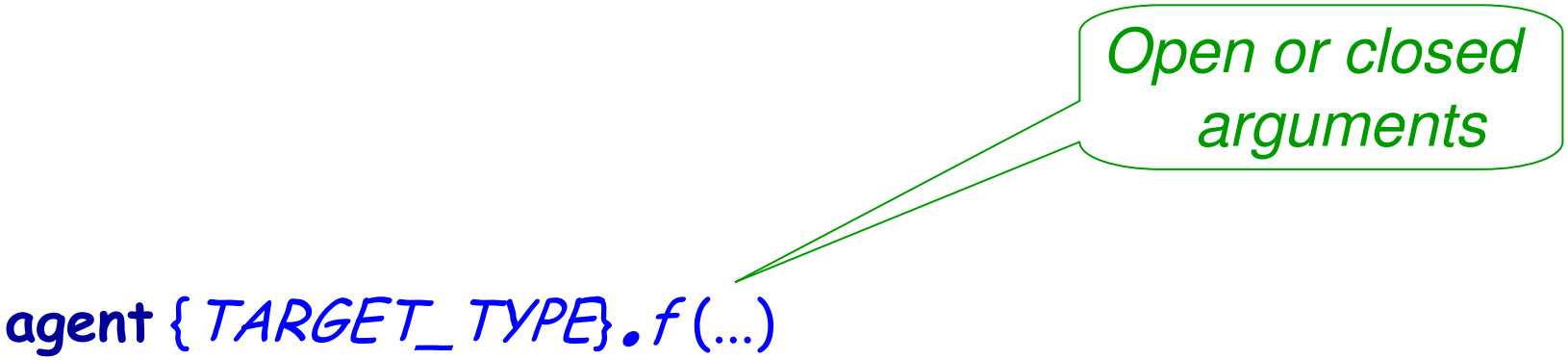
```
p: PROCEDURE [ANY, TUPLE]
                -- Agent representing a procedure,
                -- no open arguments

q: PROCEDURE [ANY, TUPLE [X, Y, Z]]
                -- Agent representing a procedure,
                -- 3 open arguments

f: FUNCTION [ANY, TUPLE [X, Y, Z], RES]
                -- Agent representing a procedure,
                -- 3 open arguments, result of type RES
```

Calling an agent with arguments

f (*x1*: *T1*; *x2*: *T2*; *x3*: *T3*), declared in class *B*
a0: *C*; *a1*: *T1*; *a2*: *T2*; *a3*: *T3*

u := **agent** *a0.f* (*a1*, *a2*, *a3*)	*PROCEDURE* [*B*, *TUPLE* [ ]]	*u.call* ([])
v := **agent** *a0.f* (*a1*, *a2*, ?)	*PROCEDURE* [*B*, *TUPLE* [*T3*]]	*v.call* ([*a3*])
w := **agent** *a0.f* (*a1*, ?, *a3*)	*PROCEDURE* [*B*, *TUPLE* [*T2*]]	*w.call* ([*a2*])
x := **agent** *a0.f* (*a1*, ?, ?)	*PROCEDURE* [*B*, *TUPLE* [*T2*, *T3*]]	*x.call* ([*a2*, *a3*])
y := **agent** *a0.f* (?, ?, ?)	*PROCEDURE* [*B*, *TUPLE* [*T1*, *T2*, *T3*]]	*y.call* ([*a1*, *a2*, *a3*])

Making the target open



Iterating on the target or the arguments

Procedures in class *COMPANY*:

- *downgrade* -- No argument
- *record_value* (*val*: *REAL*; *d*: *DATE*) -- Two arguments

Then with

companies: *LIST* [*COMPANY*]
values: *LIST* [*REAL*]
some_company: *COMPANY*

you may use both:

companies.do_all (**agent** {*COMPANY*}.*downgrade*)

values.do_all (**agent** *my_company.record_value* (?, *Today*))

End of lecture 21