Tuples and Agents

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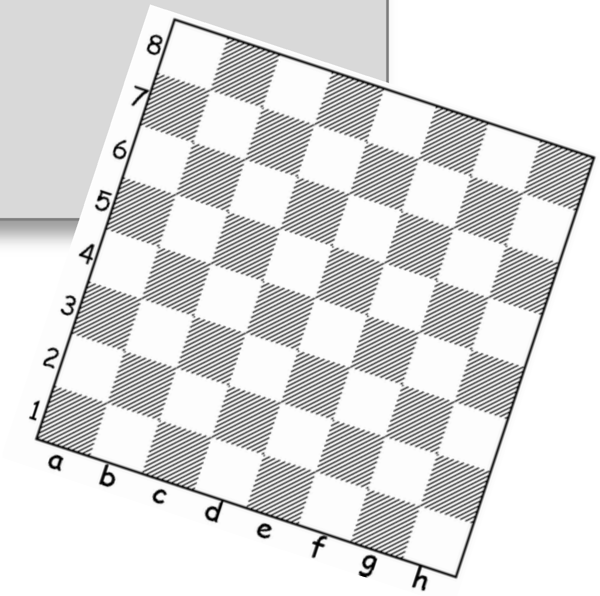
Motivation for Tuples

Imagine the following scenario:

Need to store click-coordinates on a chess-board

letter: value of a .. h
number: value of 1 .. 8



We want to store a coordinate as a single object.

Motivation for Tuples

Default approach to storing coordinates → write a small class

```
class
  COORDINATE

create
  make

feature {NONE} -- Initialization

  make (a_letter: CHARACTER; a_number: INTEGER)
      -- Creation procedure
    do
      letter := a_letter
      number := a_number
    end

feature {ANY} -- Attributes

  letter: CHARACTER
  number: INTEGER

invariant
  number_valid: number >= 1 and number <= 8
  letter_valid: letter >= 'a' and letter <= 'h'

end
```

Tuples-Motivation

Writing a full fledged class can feel “too heavy”

Eiffel offers an alternative with TUPLE

TUPLE is not a real class, but is a type that represents and infinite number of classes

TUPLE can have an arbitrary number of generic arguments, e.g.

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

A, B, C are some types

Tuple Example

Using a tuple to store chess-board coordinates

```
foo
  local
    coord: TUPLE [CHARACTER, INTEGER]
  do
    coord := ['a', 1] -- direct assignment

      -- an assignment using create
    create coord
    coord.put ('a', 1)
    coord.put (1, 2)
  end
```

Type of value is checked at runtime, not compile-time; could put anything

value, index

Tuples and Lables

A tuple can also have labels (easier to access that way)

```
TUPLE [author: STRING; year: INTEGER; title: STRING]
```

A labeled tuple type denotes the same type as its unlabeled form, here

```
TUPLE [STRING, INTEGER, STRING]
```

but facilitates access to individual elements

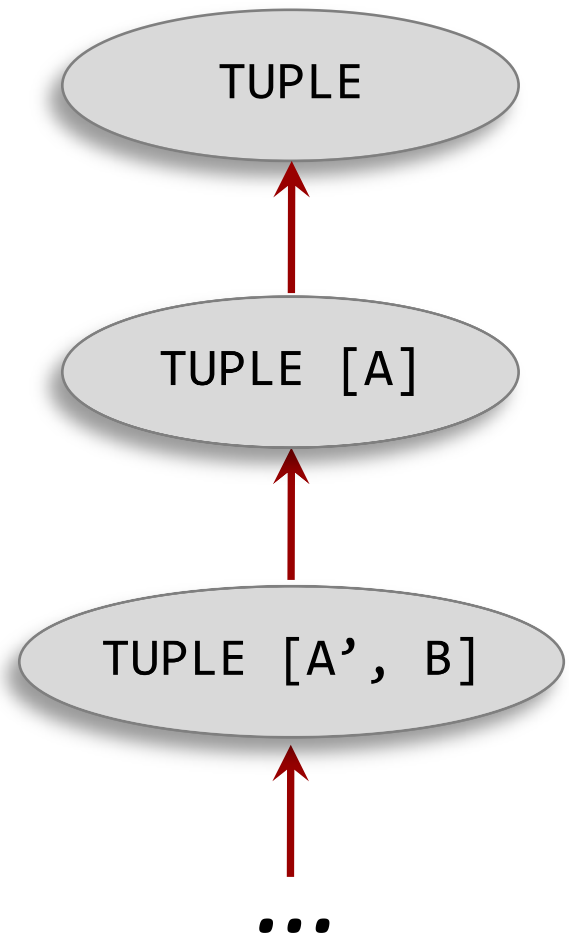
Denoting a particular tuple (labeled or not) remains the same:

```
[”Tolstoi”, 1865, ”War and Peace”]
```

To access tuple elements: use e.g. *t.year*

Tuples and Inheritance

Inheritance structure



- Generic types A, A'
  must *conform* to each other,
  otherwise no subtype
  realtionship

- Remember *conforms*:

  Y *conforms* to X if
  Y inherits from X

Tuple Conformance

```
tuple_conformance
    local
        t0: TUPLE
        t2: TUPLE [INTEGER, INTEGER]
    do
        create t2
        t2 := [10, 20]
        t0 := t2
        print (t0.item (1).out + "%N")
        print (t0.item (3).out)
    end
```

Not necessary in this case

Implicit creation

Runtime error, but will compile

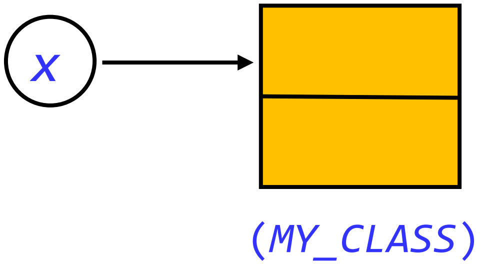
Agents

Motivation for Agents

Assignment in Eiffel (other languages)

```
x: MY_CLASS
        -- declaration of x
…
x := create MY_CLASS.make
        -- assigning a value to x
```

`x` is a reference to an object of type `MY_CLASS`



Motivation for Agents

By default

- OO-design encapsulates **data** into objects
- Operations are **not** treated as objects

```
r := my_operation
      -- assigning an operation to r
```

} not possible by default

But, sometimes we would like to represent operations as objects

- Could include operations in object structures (e.g. LIST)
- Traverse the structure a some later point
- Execute the operations

Concrete examples → next slide

Motivation for Agents

Examples where we could use operations as objects

- GUI programming
  - Event occurs, e.g. a mouse click on some button
  - Button holds a reference to an operation object that shall be executed
- Iteration on data structures
  - Introduce general-purpose routine `do_all` that applies an arbitrary operation to all elements of the structure
  - Can provide operation object to routine `do_all`

Agents

Eiffel supports such operation objects, they are called

Agents

Same concept in other languages:

- C and C++: “function pointers”
- C#: delegates
- Functional languages: closures

Creating an Agent

Given a routine

```
my_printer (i, j, k: INTEGER)
   -- this is a printing routine
do
  print("Value of i: " + i.out + "%N");
  print("Value of j: " + j.out + "%N");
  print("Value of k: " + k.out + "%N");
end
```

we can create an operation object for `my_printer` as follows

```
r := agent my_printer(?,?,?)
```

But what's the type of r???

agent keyword wraps operation into an objeczt

Routine expects 3 arguments which we don't know yet

An Agent's Type

An agent creates an object (that wraps an operation)

```
r := agent my_printer (?,?,?)
```

Official terminology is "agent definition" but you can think of it as a **`create`** for operation objects

What is the type of that object?

- Either the object represents a `PROCEDURE` or
- The object represents a `FUNCTION`

Thus, the type of `r` would be `PROCEDURE`

```
r: PROCEDURE [ANY, TUPLE[INTEGER, INTEGER, INTEGER]]
```

Let's have a closer look what those generic arguments are…

An Agent's Type

Given an agent declaration for a procedure

```
r: PROCEDURE [ANY, TUPLE[INTEGER, INTEGER, INTEGER]]
```

1st argument represents the class (type) to which **r** belong

In practice, we always put ANY, as every class is of type ANY

2nd argument represents the type of the arguments of **r**

The Full Picture

```
class
  AGENT_DEMO

feature

  r: PROCEDURE [ANY, TUPLE[INTEGER, INTEGER, INTEGER]]
       -- declaration of the agent

  foo
      -- some routine, where the agent is created
    do
      r := agent my_printer (?,?,?)
    end

  my_printer (i, j, k: INTEGER)
      -- this is a printing routine
    do
      print("Value of i: " + i.out + "%N");
      print("Value of j: " + j.out + "%N");
      print("Value of k: " + k.out + "%N");
    end
end
```

More on Agent Types

How to declare an agent for a Function rather than a Procedure?

- Type of an agent for a procedure (we've already seen)

```
PROCEDURE [T, ARGS]
```

- Type of an agent for a function

```
FUNCTION [T, ARGS, RES]
```

The type of the result of the function

Agent for a Function

```
class
  AGENT_FUNCTION_DEMO

feature

  f: FUNCTION [ANY, TUPLE[INTEGER], INTEGER]
        -- declaration of the agent

  foo
      -- some routine, where the agent is created
    do
      f := agent square (?)
    end

  square (a_number: INTEGER): INTEGER
      -- this returns the square of `a_number’
    do
      Result := a_number * a_number
    end
end
```

Executing an Agent

So far, we've declared and created agents.

How about running them?

Notice the brackets; we provide a TUPLE

- ✓ If `a` represents a **procedure**, `a.call ([argument_tuple])` calls the procedure
- ✓ If `a` represents a **function**, `a.item ([argument_tuple])` calls the function and returns its result

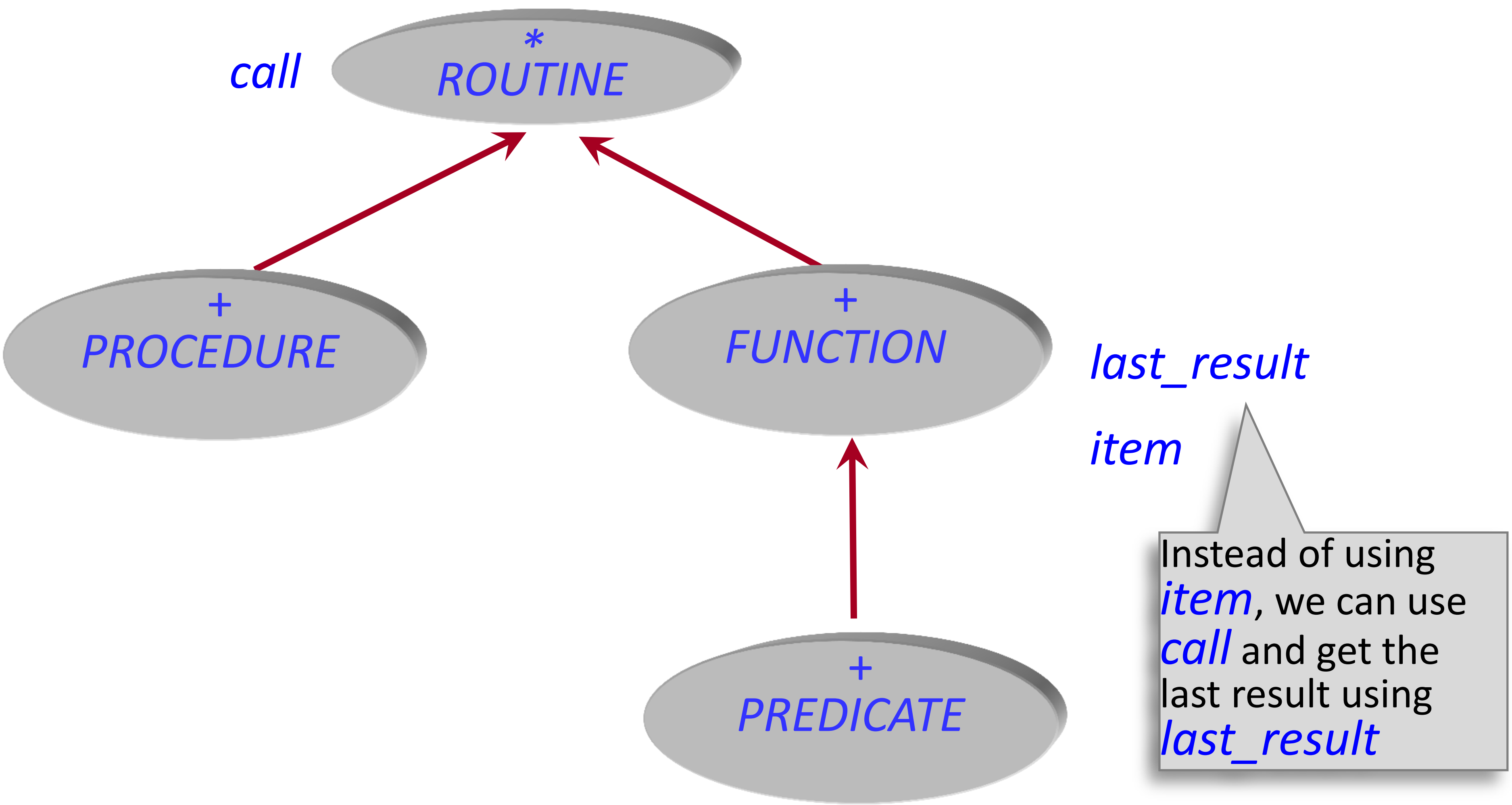
Executing an Agent (for a Procedure)

```
class
  AGENT_DEMO

feature

  r: PROCEDURE [ANY, TUPLE[INTEGER, INTEGER, INTEGER]]
        -- declaration of the agent

  foo
      -- some routine, where the agent is created
    do
      r := agent my_printer (?,?,?)
      r.call ([1, 2, 3])
    end

  my_printer (i, j, k: INTEGER)
      -- this is a printing routine
    do
      print("Value of i: " + i.out + "%N");
      print("Value of j: " + j.out + "%N");
      print("Value of k: " + k.out + "%N");
    end
end
```

Executing an Agent (for a Function)

```
class
  AGENT_FUNCTION_DEMO

feature

  f: FUNCTION [ANY, TUPLE[INTEGER], INTEGER]
        -- declaration of the agent

  foo
      -- some routine, where the agent is created
    do
      f := agent square (?)
      print ((f.item ([3])).out)
    end

  square (a_number: INTEGER): INTEGER
      -- this returns the square of `a_number’
    do
      Result := a_number * a_number
    end
end
```

Classes representing agents



Open and Closed Agent Arguments

Up to now, we have provided all arguments once we call the agent

```
r := agent my_printer (?,?,?)
r.call ([1, 2, 3])
```

? are called open arguments

What if we'd like to **fix** the arguments at the time we create the agent? We can do that:

here we have closed arguments

```
r := agent my_printer (1,2,3)
r.call ([])
```

Open and Closed Agent Arguments

Closed arguments are set at agent definition time.

Open arguments are set at agent call time.

We can also mix open and closed arguments

```
u := agent a0.f (a1, a2, a3) -- All closed
w := agent a0.f (a1, a2, ?)
x := agent a0.f (a1, ?, a3)
y := agent a0.f (a1, ?, ?)
z := agent a0.f (?, ?, ?) -- All open
```

Do closed arguments affect the type?

Open and Closed Arguments

The agent's type must reflect the number of **open** arguments

Example 1:

```
r: PROCEDURE [ANY, TUPLE[INTEGER, INTEGER, INTEGER]]
r := agent my_printer (?,?,?)
r.call ([1, 2, 3])
```

Example 2:

```
r: PROCEDURE [ANY, TUPLE[INTEGER]]
r := agent my_printer (1,2,?)
r.call ([3])
```

Agents with open Target

All examples seen so far were based on routines of the enclosing class. This is not required.

```
class
  APPLICATION

feature

  printer: AGENT_PROCEDURE -- class from previous slide
  my_agent: PROCEDURE [ANY, TUPLE[INTEGER]]

  foo
      -- some routine, where the agent is created
    do
      create printer
      my_agent := agent printer.my_printer (1, ?, 3)
      my_agent.call ([2])
    end
end
```

Calls `my_printer` of object `printer`

Inline Agents

So far, we assumed that there already exists some routine that we wish to represent with an agent.

Sometimes the only usage of such a routine could be as an agent. We can use **inline agents**, i.e. write a routine in the agent declaration:

```
demo_list.do_all (agent (i: INTEGER)
                   do
                     print (“Value: ”" + i.out + "%N")
                   end)
```

Doing something to a list

Hands-On

Given a simple ARRAY [G] class, with only the features \`count' and \`at', implement a feature which will take an agent and perform it on every element of the array.

```
do_all (do_this : PROCEDURE[ANY, TUPLE[G]])
        local
                i : INTEGER
        do
                from
                        i := 1
                until
                        i > count
                loop
                        do_this.call ([at (i)])
                        i := i + 1
                end
        end
```

For-all quantifiers over lists

Hands-On

```
for_all (pred : PREDICATE [ANY, TUPLE[G]]): BOOLEAN
        local
                i : INTEGER
        do
                Result := True
                from
                        i := 1
                until
                        i > count or not Result
                loop
                        Result := pred.item ([at (i)])
                        i := i + 1
                end
        end
```