Agents & Tuples

What is an Agent

- An **agent** is a routine – a function or procedure – that is passed as a parameter

- Agents implement a sub-set of functional programming
  - » **Functional programming is dealt with in the course CSE 3401**

Why have agents ?

- Many algorithms differ only in what function they apply
  - » **Consider integration of a function, where the function f can be x^2, $\sin(x)$ or any other function of one variable.**

$$\int_a^b f(x)$$

- In Eiffel we use agents in routines that implement first order predicate calculus expressions in assertions
  - » **For example**
    - > **All items in a string are spaces or integers or …**

Sum of Integers 1..n

```
sum_to_i ( n : INTEGER ) : INTEGER
local sum : INTEGER
      i : INTEGER
do
    from i := 1
    until i > n
    loop
          sum := sum + i
          i := i + 1
    end
    Result := sum
end
```

Sum Double of Integers 1..n

```
sum_to_double_i ( n : INTEGER ) : INTEGER
local sum : INTEGER
      i : INTEGER
do
    from i := 1
    until i > n
    loop
          sum := sum + i + i
          i := i + 1
    end
    Result := sum
end
```

Sum Square of Integers 1..n

```
sum_to_square_i ( n : INTEGER ) : INTEGER
local sum : INTEGER
      i : INTEGER
do
    from i := 1
    until i > n
    loop
        sum := sum + i * i
        i := i + 1
    end
    Result := sum
end
```

Abstract the function

```
sum_to ( n : INTEGER ; f : FUNCTION ) : INTEGER
local sum : INTEGER
      i : INTEGER
do
    from i := 1
    until i > n
    loop
        sum := sum + f(i)
        i := i + 1
    end
    Result := sum
end
```

Abstract the common parts and only supply the variations

Write one function for all cases

Problem with Syntax

```
sum_to ( n : INTEGER ; f : FUNCTION ) : INTEGER
local sum : INTEGER
      i : INTEGER
do
    from i := 1
    until i > n
    loop
        sum := sum + f(i)
        i := i + 1
    end
    Result := sum
end
```

Need to specify function
– arguments and types
– Result type

Need syntax to match function definition

Problem: Need type checking for the routine – additional syntax is required

Typing a Function

- General syntax

```
FUNCTION [ class_to_which_function_belongs ,
           argument_types ,
           Result_type ]
```

- Example for the **sum_to** function argument

```
f : FUNCTION [ ANY ,
               TUPLE [ INTEGER ] ,
               INTEGER ]
```

Generalized Sum_to

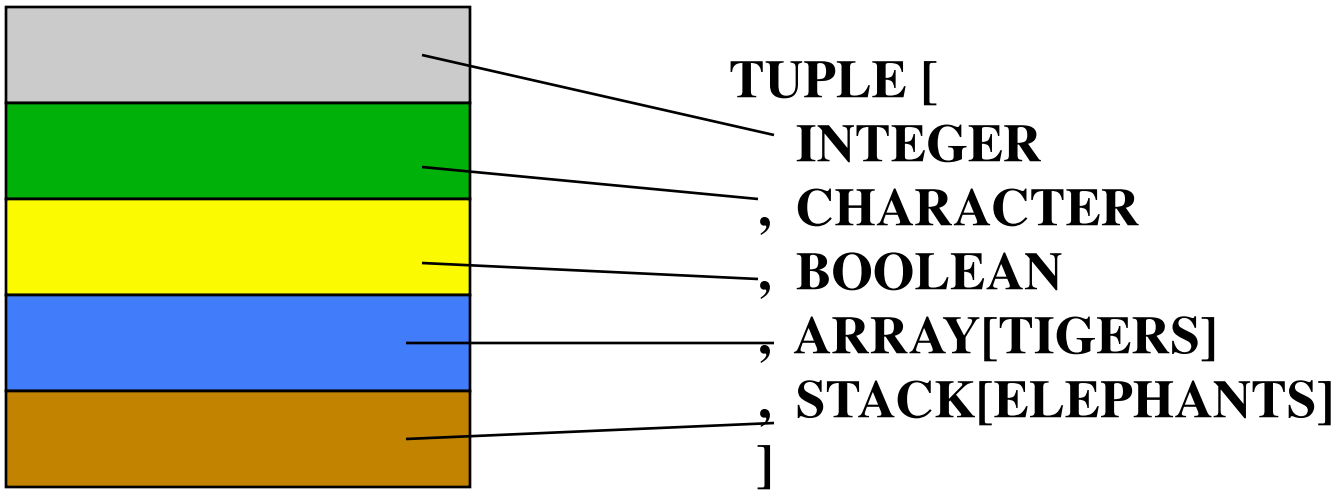
```
sum_to (n : INTEGER ;
            f : FUNCTION [ ANY , TUPLE [ INTEGER ] , INTEGER ]
        ) : INTEGER
local sum : INTEGER
      i : INTEGER
do
    from i := 1
    until i > n
    loop
        sum := sum + f . item ( [ i ] )
        i := i + 1
    end
    Result := sum
end
```

Specifies function
– arguments and types
– Result type

f is a function object. **item** is the feature that returns the function definition. The function is applied to the argument, which is of type TUPLE

What is a tuple?

- Analogous to describing the types for the fields of a record
  - » **Example of a 5 field record with sufficient space in each field to hold items of the indicated type**



Accessing tuple items

- Tuple items are accessed using array syntax
  - » **Numbering begins at 1**

```
local
   tr : TUPLE [ STRING, INTEGER, ARRAY [ LIONS ] ]
do
   if attached {STRING} tr [ 1 ] as tuple_str then
         Use tuple_str here
   end
   if attached {INTEGER} tr [ 2 ] as tuple_int then
         Use tuple_int here
   end if attached {ARRAY [ LIONS ] } tr [ 3 ] as tuple_arr then
         Use tuple_arr here
   end
end
```

Functions: Identity, Double & Square

```
identity ( i : INTEGER ) : INTEGER
  -- Return the argument
  do Result := i end

double ( i : INTEGER ) : INTEGER
  -- Return double the argument
  do Result := i + i end

square ( i : INTEGER ) : INTEGER
  -- Return square of the argument
  do Result := i * i end
```

Using Agents

```
sum_to ( 5 , agent identity (?) )
sum_to ( 5 , agent double (?) )
sum_to ( 5 , agent square (?) )
```

- The function to pass is identified as an agent so both
  - » The function definition is passed, instead of being evaluated
  - » the proper type checking is done
- Argument type of the passed functions are defined in the function sum_to
  - » a ? is used as a place marker showing that these functions have one argument (for type checking)

Checking items in an array

- Pass agents for = ≠ < ≤ > ≥

```
all_satisfy ( size : INTEGER  ;  aValue : ARRAY[INTEGER]
            ; comparator : FUNCTION [ ANY
                                     , TUPLE [ INTEGER, INTEGER ]
                                     , BOOLEAN ]
            ) : BOOLEAN
-- Result  = ∀i : aValue.lower .. aValue.upper • size :comparator: aValue [ i ]
local i : INTEGER
   do
      from i := aValue.lower ; Result := true
      until i > aValue.upper or not Result
      loop
         Result := comparator . item ( [ size, aValue [ i ] ] )
         i := i + 1
      end
   end
```

All_satisfy using <

- The agent

```
less_than ( i, j : INTEGER ) : BOOLEAN
    -- Result = i < j
do
        Result := i < j
end
```

- Using the agent – note the place markers for 2 parameters
  - » The result is true iff 3 is less_than all array elements

```
all_satisfy ( 3, a, agent less_than ( ?, ? ) )
```

Fixing a parameter for an agent

- When agents have multiple parameters we can make one or more of the arguments to be constants at the time the agent is used.

```
all_satisfy_1 ( a, agent less_than (3, ?) )
```

- The function **all_satisfy_1** checks that 3 is less than all array elements

Fixing a parameter for an agent – 2

all_satisfy_1 (a, agent less_than (3, ?))

- A new all satisfy function is required because we are actually passing a one parameter function
  - » **all_satisfy_1 supplies only one value for the agent**
  - » **As a consequence the expression has only one ?**

Mathematically the first parameter of the agent has been **curried**

– The two parameter **less_than** is converted to a one parameter **less_than** by using the constant **3** as the first parameter

All_Satisfy_1

- The agent is now a one-parameter function
- Size is not a parameter of all_satisfy_1, instead it is a curried parameter of less_than (see previous slide)

```
all_satisfy_1 ( aValue : ARRAY [ INTEGER ]
        ; comparator : FUNCTION [ ANY, TUPLE [ INTEGER ] ,
                                   BOOLEAN ] ) : BOOLEAN
local i : INTEGER
 do
  from i := aValue.lower ; Result := true
  until i > aValue.upper or not Result
  loop
   Result := comparator.item( [ aValue [ i ] ] )
   i := i + 1
  end
 end
```

Typing a Procedure

- General syntax

  PROCEDURE [class_to_which_procedure_belongs

  , argument_types]

- Same as for a function, except there is no return type
- There is a different mechanism to invoke a procedure

  procedure . call (tuple)

  » **versus**

  function . item (tuple)