SmartEiffel The GNU Eiffel Compiler
Tools and Libraries

Introducing (Smart) Eiffel. Design by contract. Software engineering. Multiple inherit / insert. Agents. Compiler technology.

Dominique.Colnet@loria.fr

Lisp

J.McCarthy

Smalltalk

A.Goldberg
72-80 Squeak

Eiffel

B.Meyer
86-89-ECMA

OCAML

96

SmartEiffel

May 2005

1960 — 1972 — 1980 — 1989 — 1995 — 2005

Simula-67

O.J.Dahl K.Nygaard

Ada

83-9X

ML

R.Milner
78-84

CAML

87

Self

D.Ungar
87

SmallEiffel

July 1995
-0.99 to -0.75

Lisaac

2003

"*Les langages à objets*" *G.Masini, A.Napoli, D.Colnet, D.Léonard, K.Tombre*

1989 - ISBN 2-7296-0275-5

Eiffel Initial Author and Origins

Object-Oriented

Software

Construction

Bertrand Meyer

1988 Prentice Hall

SmartEiffel

Goals / Market

Quality Software Design

Re-Usability

Security

Efficiency

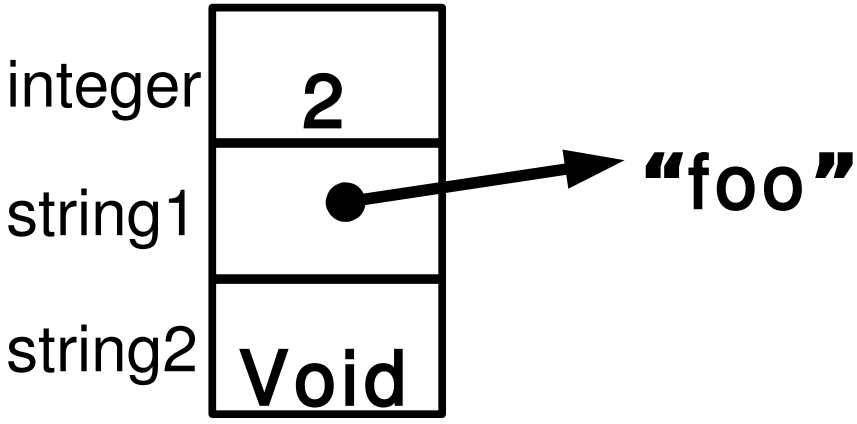
Large Team / Software

Keep those goals in mind.

http://shootout.alioth.debian.org

Efficiency: runtime requirements

```
integer: INTEGER
string1: STRING
string2: STRING
```



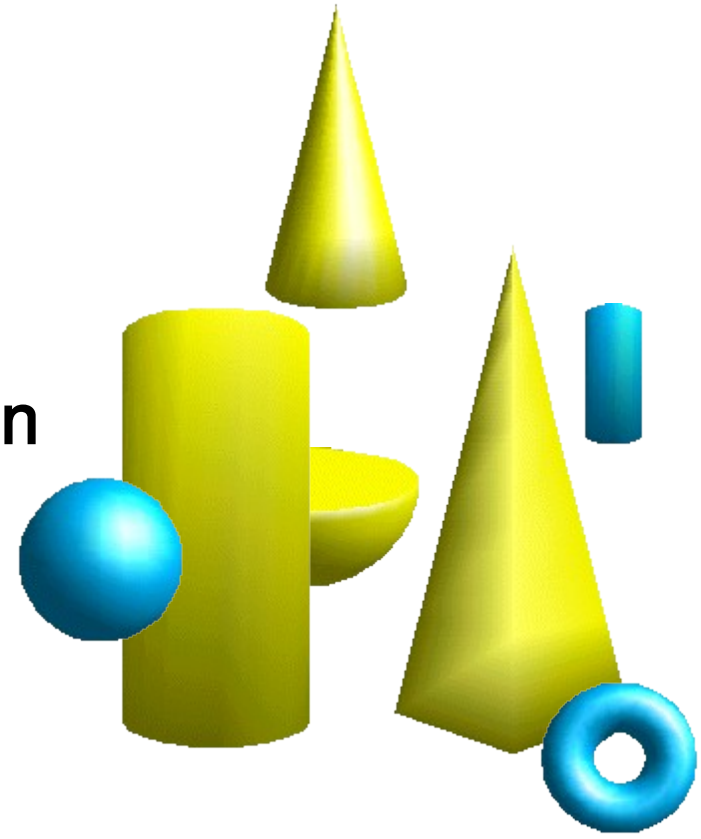

```
integer := 2
string1 := "foo"
string2 := Void
```

Expanded object

Eiffel Software Engineering

- Strong Static Typing (Genericity)
- Design by Contracts (Assertions)
- Truly Object-Oriented (Class Based)
- Multiple inherit / insert
- Powerful Exportation Rules
- Anchored Type Definition
- Infix / Prefix Operator Definition
- *frozen* Methods
- Abstract Class / Methods

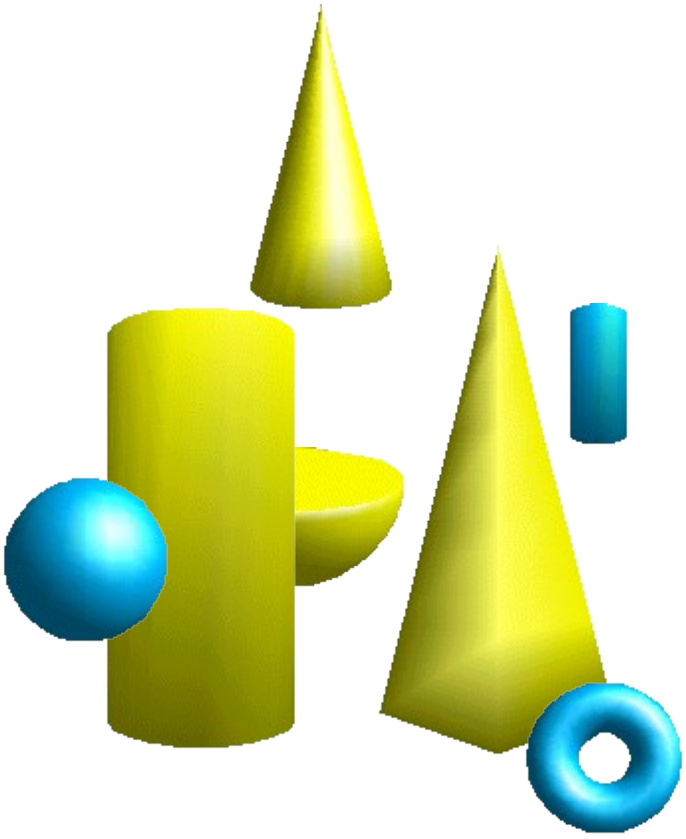
At Work



Eiffel Software Engineering

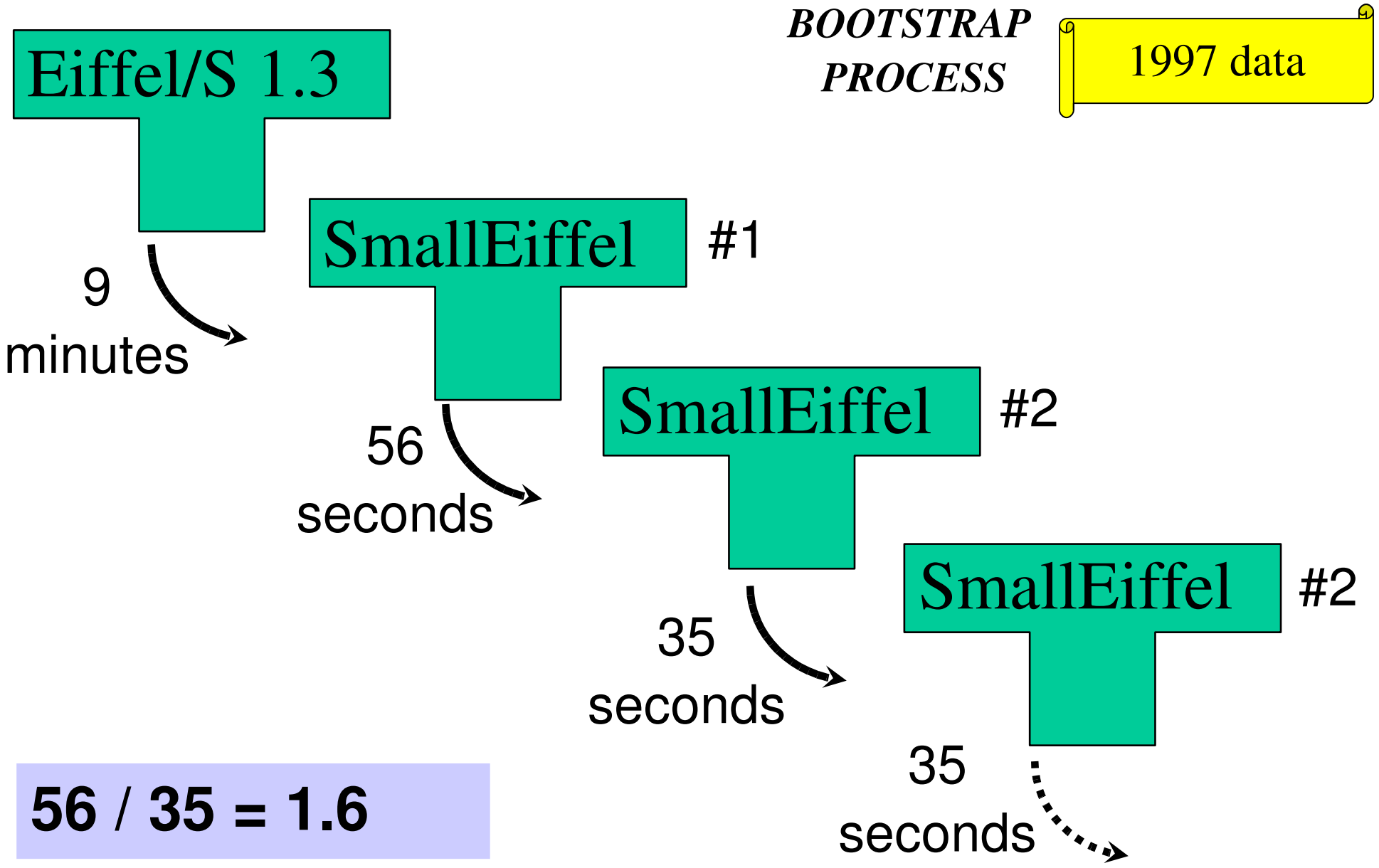
- *once* Methods
- *obsolete* Class / Methods
- *agents* (Code Manipulation)
- low level interface with C
- ...,
- SCOOP (concurrency)?

At Work



More than a Language !

All written in Eiffel (new technology)



56 / 35 = 1.6

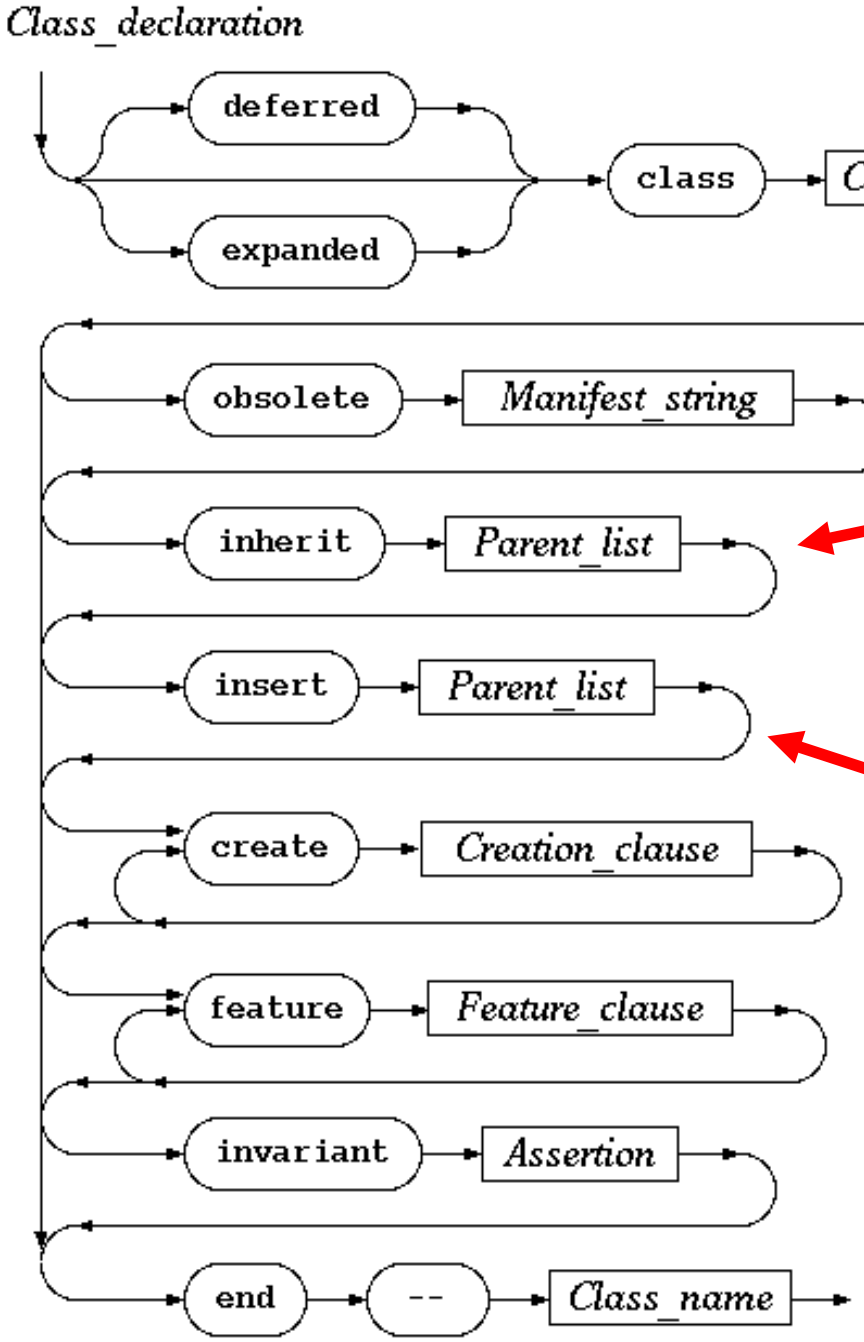
The Hello world example

```
class HELLO
   -- My first class.
create
   world

feature

   world is
      do
         io.put_string("Hello World !%N")
      end

end -- Of my HELLO class.
```

Looks like Pascal / Ada.

easy-to-read syntax

```
my_procedure (arg1: INTEGER; arg2: STRING) is
    -- The purpose of this procedure is just to show the syntax.
    local
        i: INTEGER
    do
        if arg1 > 0 then
            from
                i := arg1
            until
                i = 0
            loop
                print(arg2.to_string + "%N")
                i := i - 1
            end
        else
            print("Easy to read for beginners too.")
        end
    end
```



Subtyping

multiple inheritance

Implementation

multiple inheritance

New
2004 -2006

Inherit

Subtyping

Polymorphism

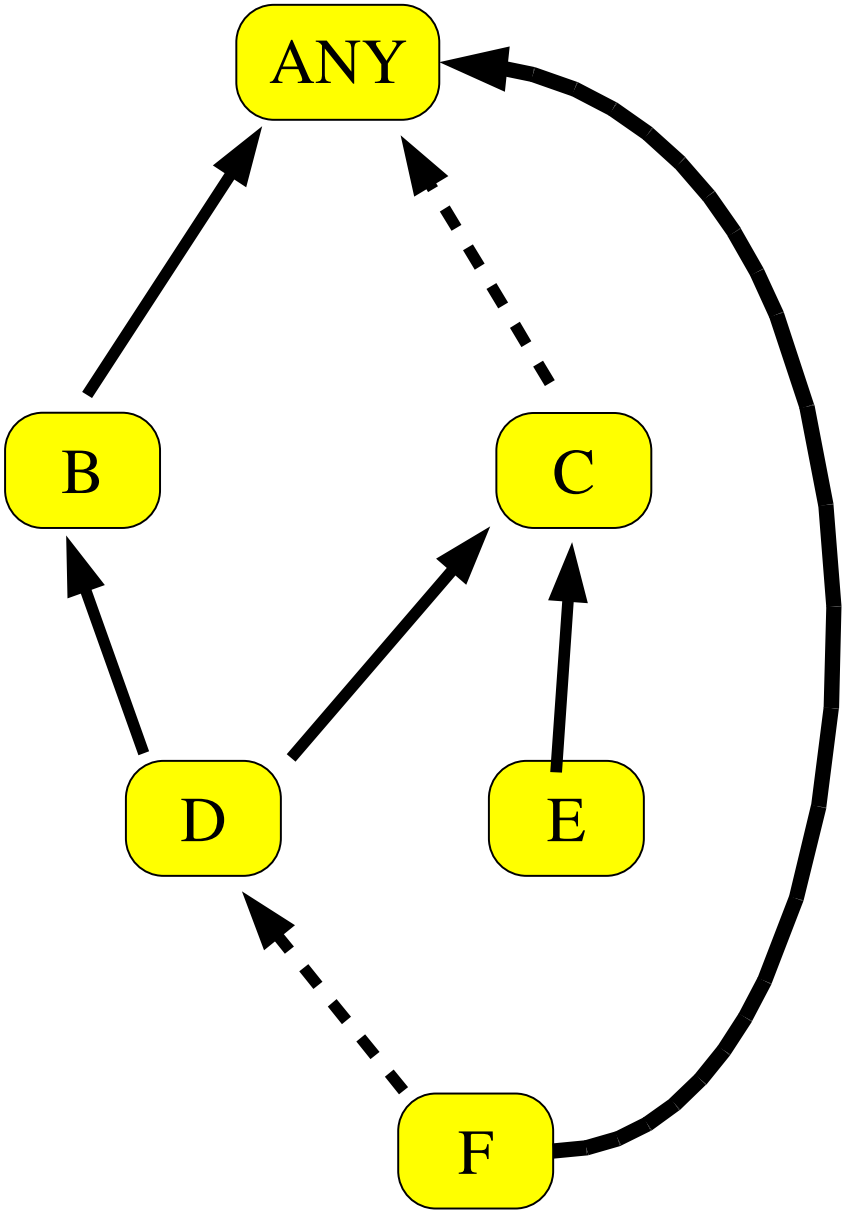
Insert

Implementation

No Polymorphism

ANY : *the only one class with no ancestor (the common ancestor).*

Inherit+Insert = *Acyclic Directed Graph.*



Inherit relationship:

B inherits from ANY
D inherits from ANY
D inherits from B
D inherits from C
E inherits from C
F inherits from ANY

Insert relationship:

C inserts ANY
E inserts ANY
F inserts B
F inserts C
F inserts D

Typing and Checking Policy

- What can be assigned into what?
- What type can be used when some method or attribute is overridden?
- What type can be used in case of a generic derivation?
- What about constrained genericity?

Typing and Checking Policy

- Rule 1 (assignment): *An expression of type* A *can be assigned into a variable of type* B *if and only if* A *and* B *are the same type or* A *inherits from* B.

- Rule 2 (argument passing): *An expression of type* A *can be passed as an argument of formal type* B *if and only if* A *and* B *are the same type or* A *inherits from* B.

Typing and Checking Policy

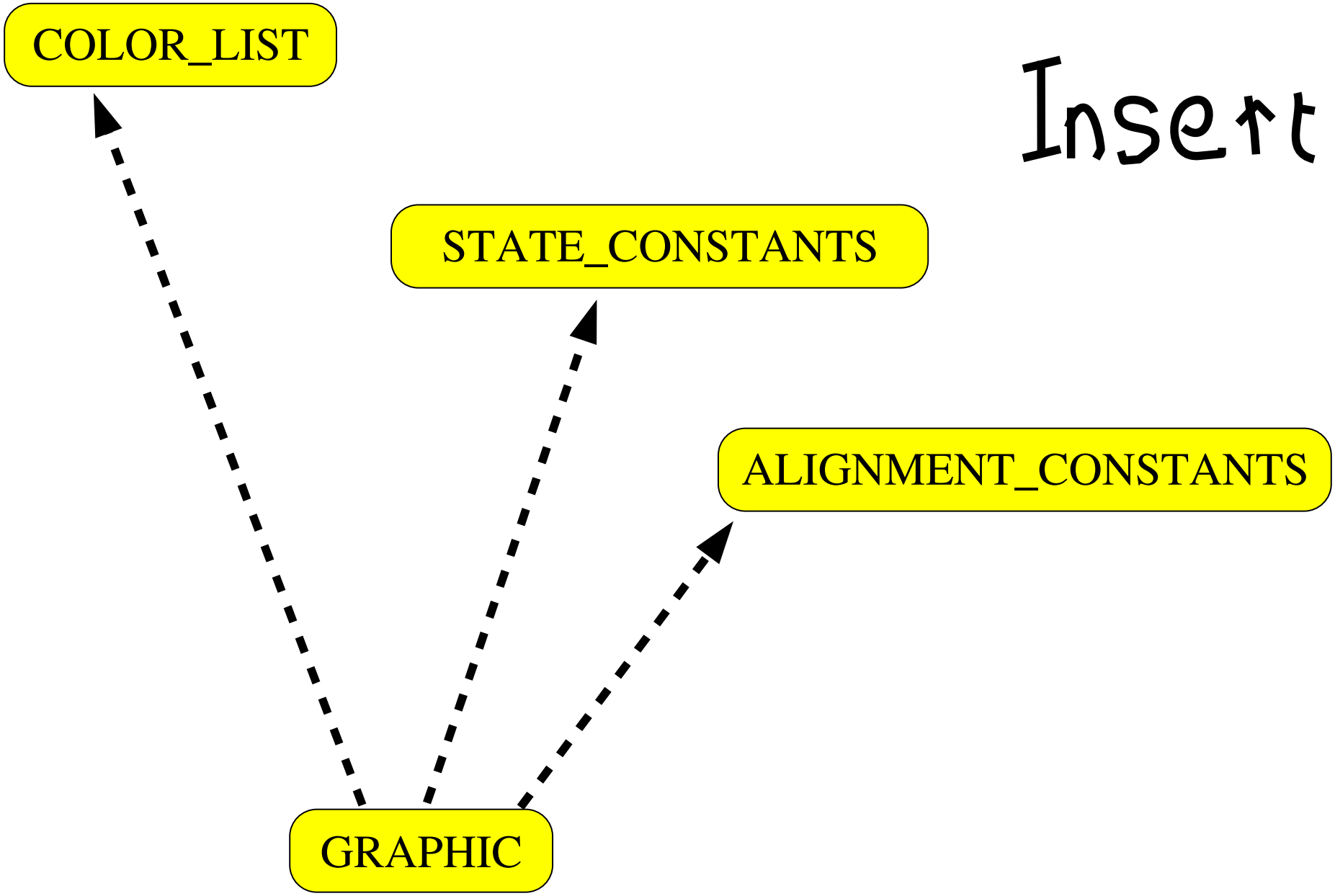
- Rule 3 (redefinition under inheritance): *When overriding an inherited method or attribute, the type of any argument and/or of its result can be replaced covariantly with a type that inherits from the replaced type (i.e. a subtype).*

CAT calls are still there!

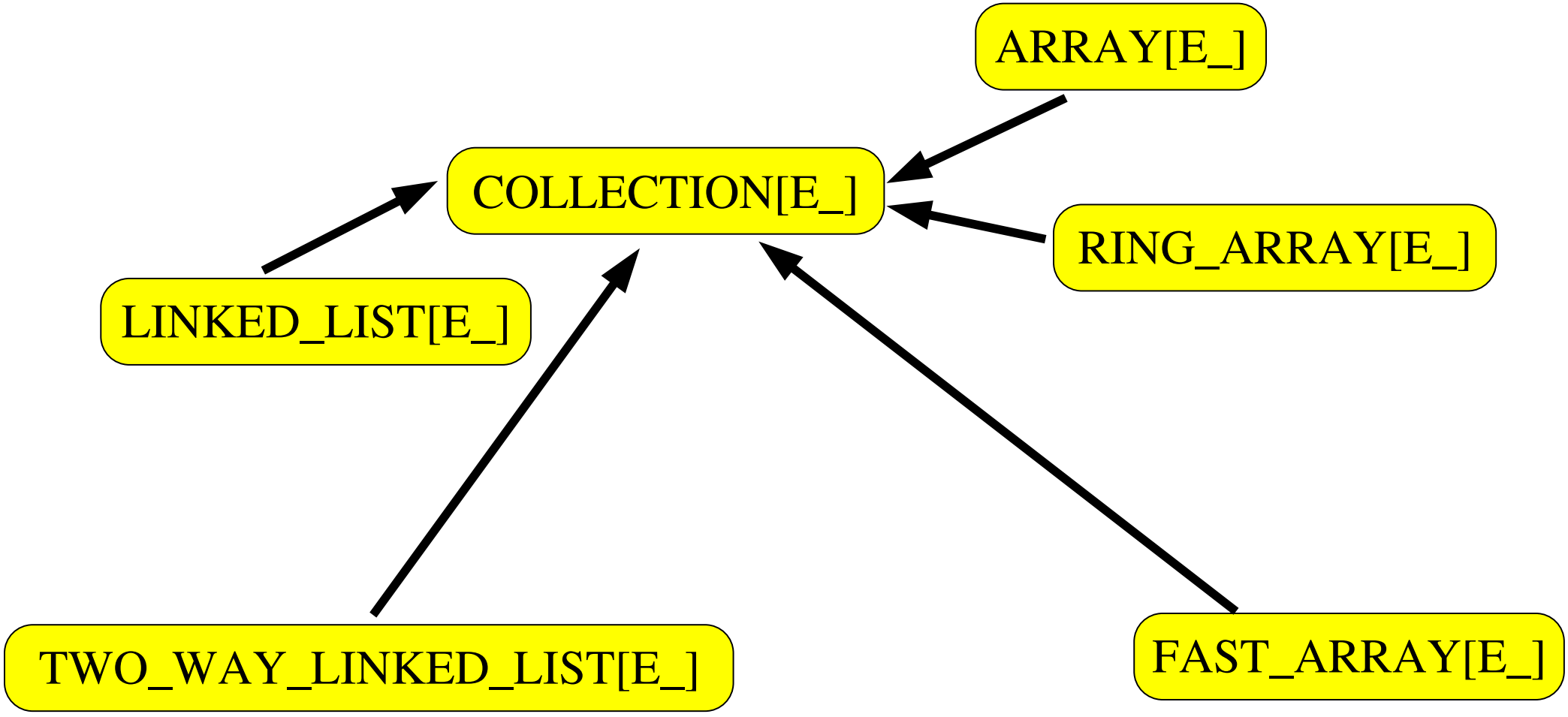
Typing and Checking Policy

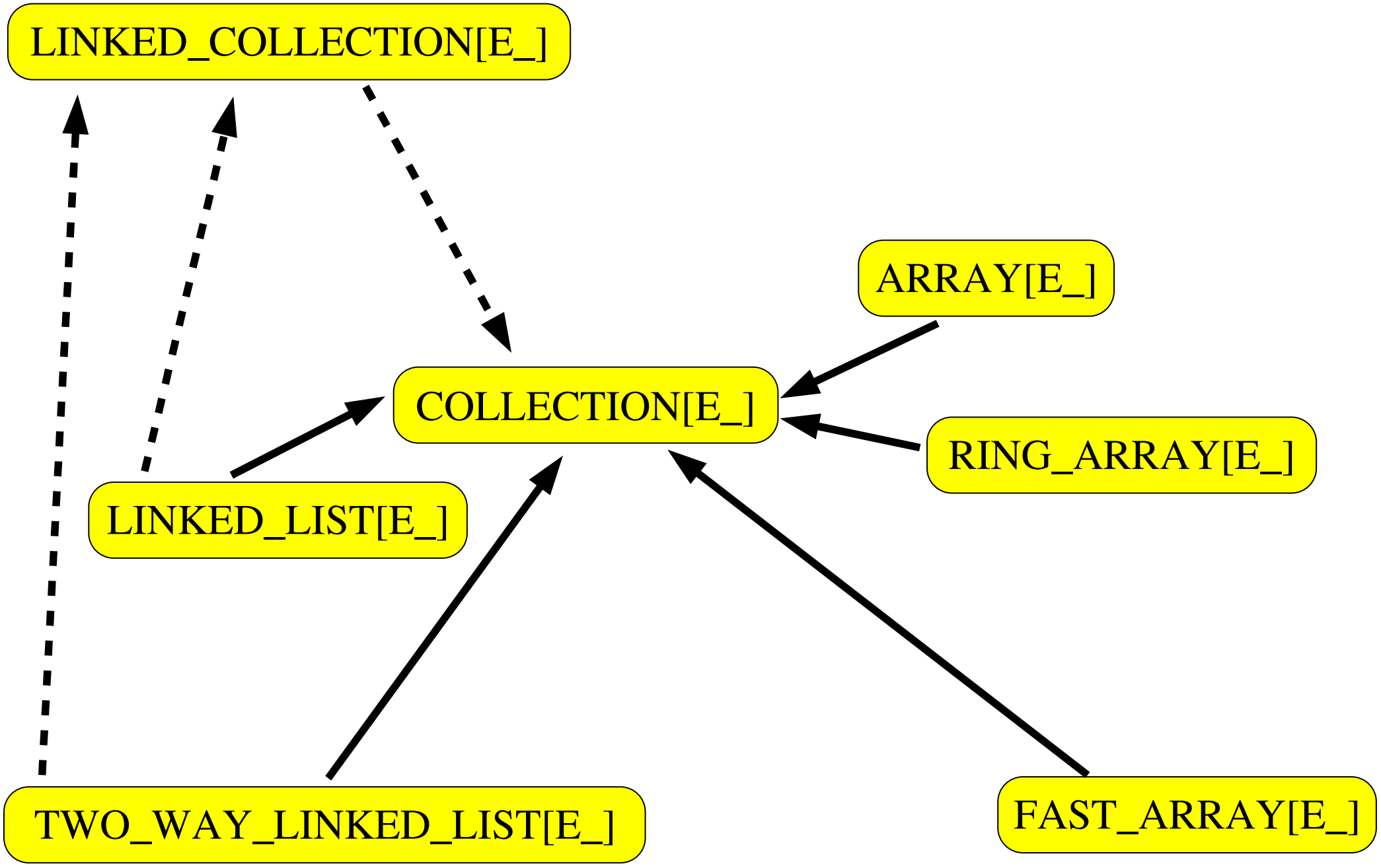
- Rule 4 (redefinition under insertion): *When overriding an inserted method or attribute, the type of any argument and/or of its result can be replaced covariantly with a type that inherits from* ***or inserts*** *the replaced type.*

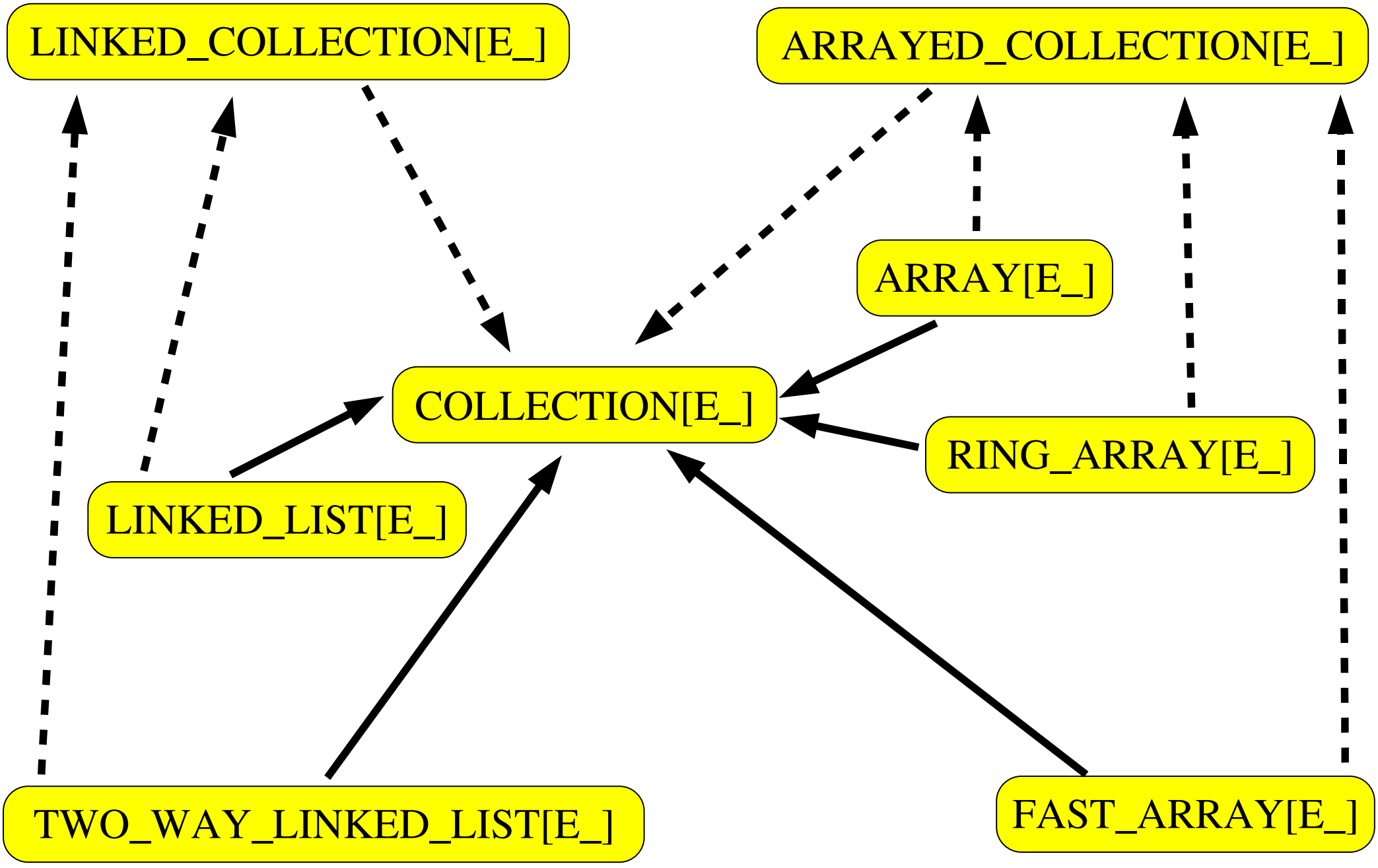
No CAT calls here!

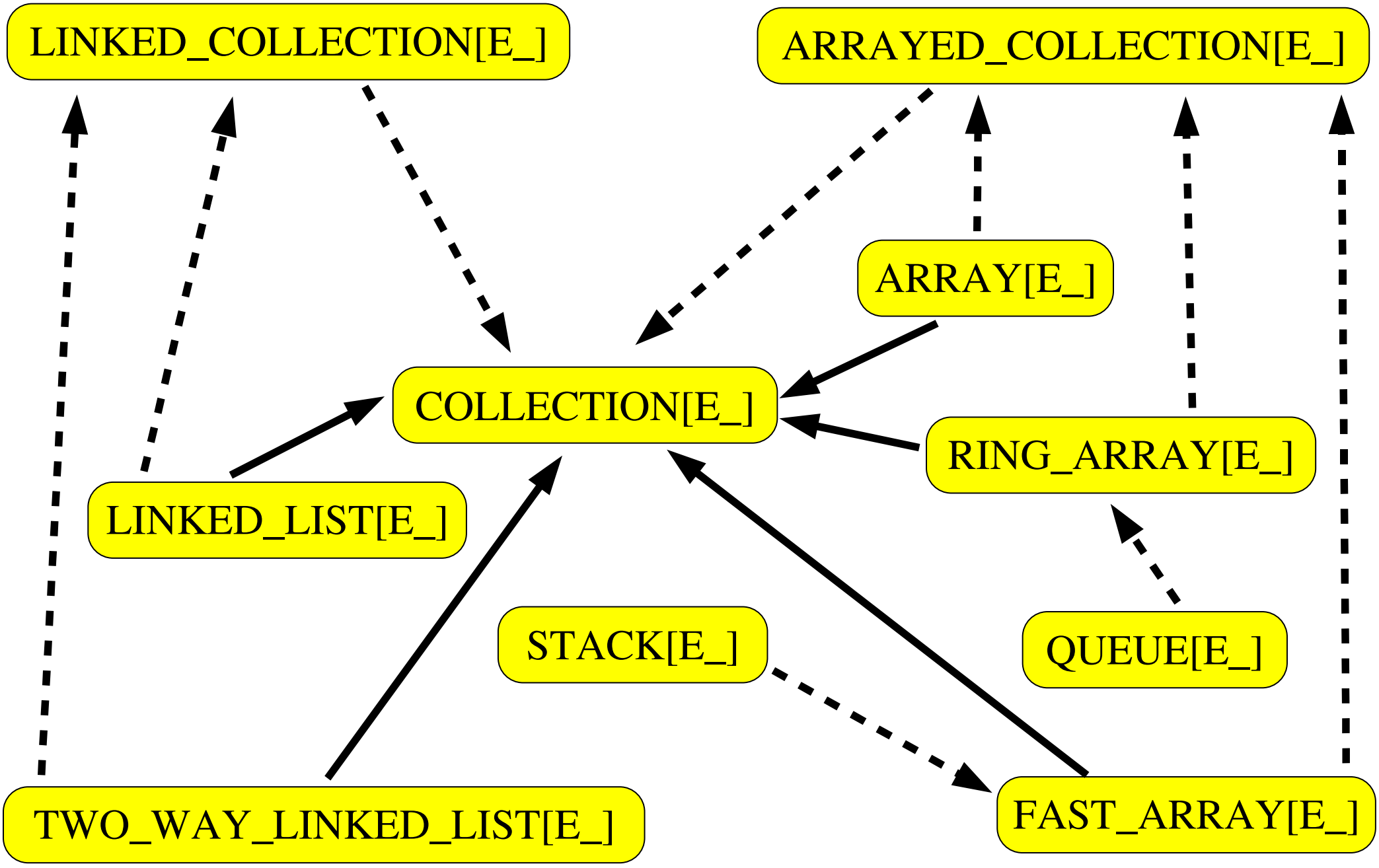


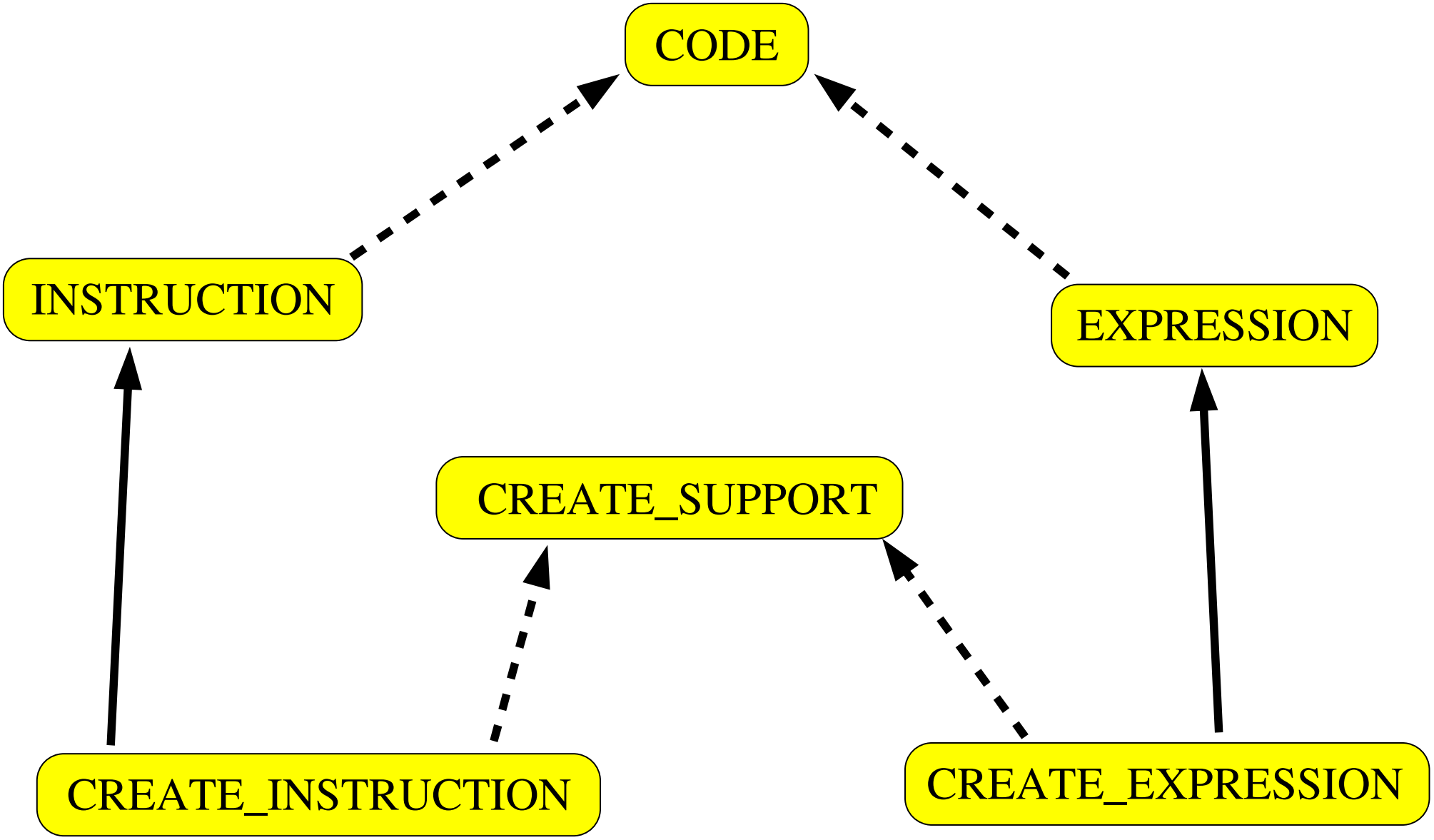
Insert


ARRAY[E_]
COLLECTION[E_]
RING_ARRAY[E_]
LINKED_LIST[E_]
TWO_WAY_LINKED_LIST[E_]
FAST_ARRAY[E_]


LINKED_COLLECTION[E_]
ARRAY[E_]
COLLECTION[E_]
RING_ARRAY[E_]
LINKED_LIST[E_]
TWO_WAY_LINKED_LIST[E_]
FAST_ARRAY[E_]


LINKED_COLLECTION[E_]
ARRAYED_COLLECTION[E_]
ARRAY[E_]
COLLECTION[E_]
RING_ARRAY[E_]
LINKED_LIST[E_]
TWO_WAY_LINKED_LIST[E_]
FAST_ARRAY[E_]


LINKED_COLLECTION[E_]
ARRAYED_COLLECTION[E_]
ARRAY[E_]
COLLECTION[E_]
RING_ARRAY[E_]
LINKED_LIST[E_]
STACK[E_]
QUEUE[E_]
TWO_WAY_LINKED_LIST[E_]
FAST_ARRAY[E_]


CODE
INSTRUCTION
EXPRESSION
CREATE_SUPPORT
CREATE_INSTRUCTION
CREATE_EXPRESSION

```
-- Somewhere in a routine.
local
   point: POINT
do
   create point.with(2.5, 6.7)
   point.translate(1.1, 2.2)
   point.display_on(std_output)
   ...
```

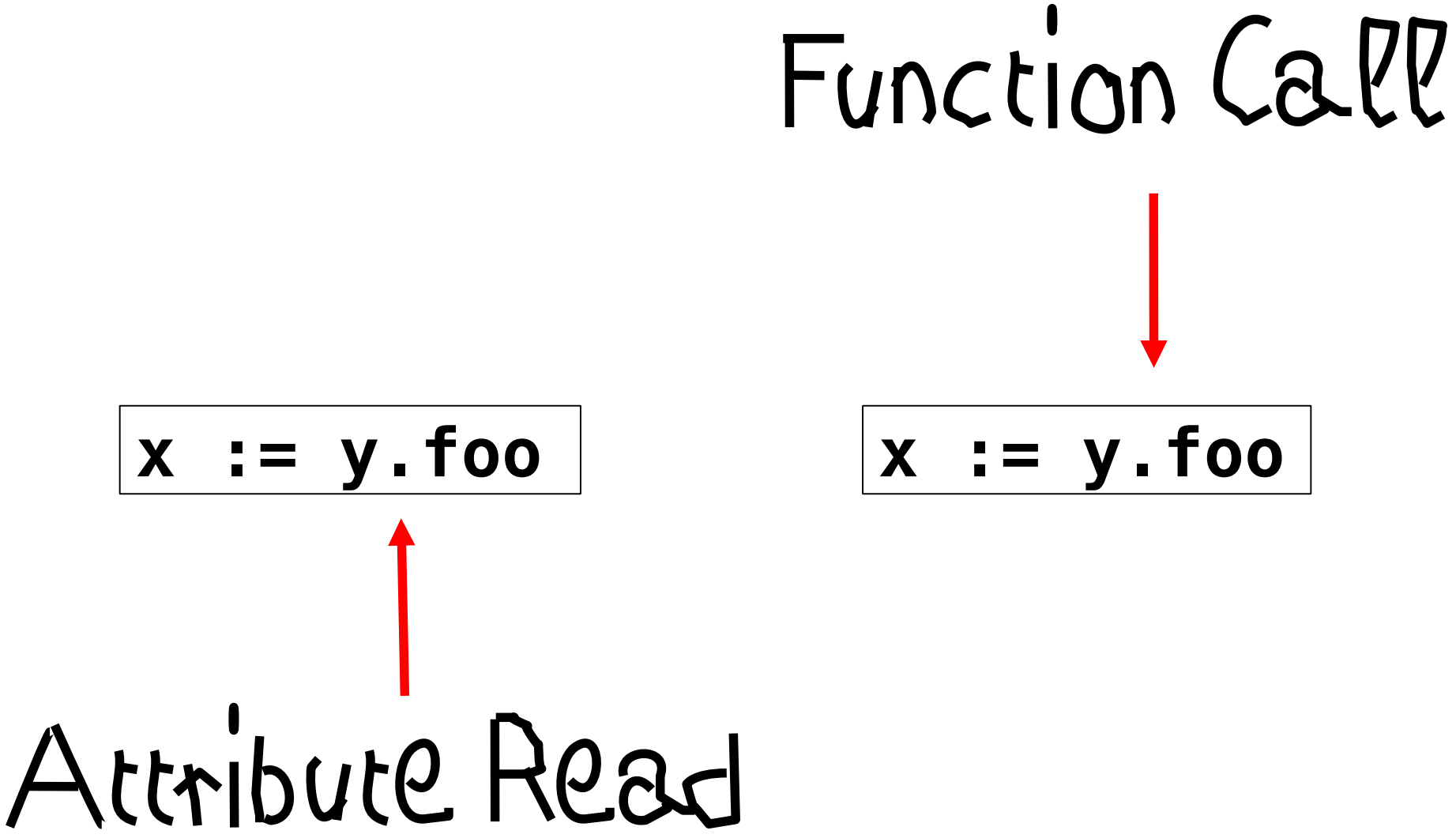
Object-Oriented

Check for the traditional POINTclass in our tutorial.

- class INTEGER
- class STRING
- class CHARACTER
- class BOOLEAN
- class REAL
- class ...
- class ...

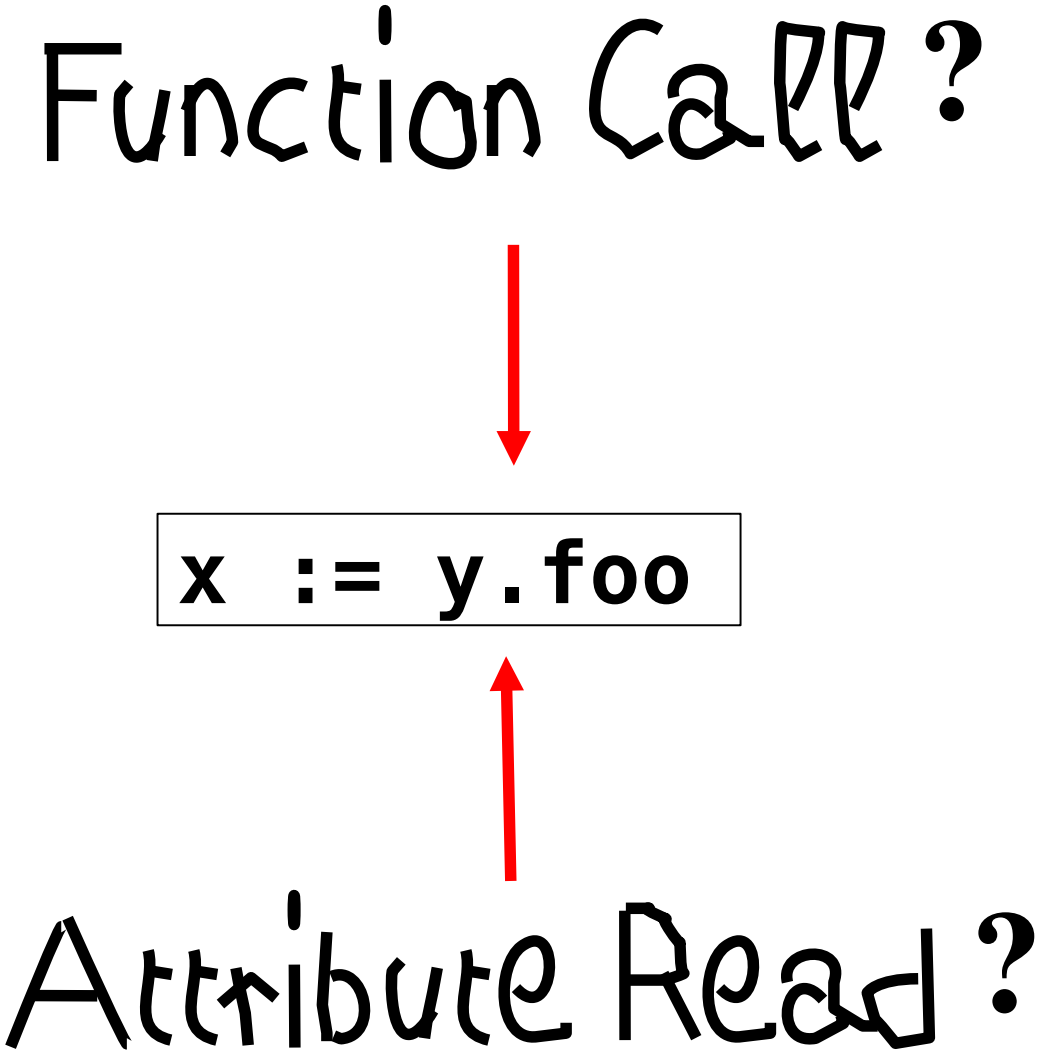
```
-- Somewhere in a routine.
local
   string: STRING; integer: INTEGER
do
   integer := 2 + 2
   string := integer.to_string
   ...
```

Uniform access.



No direct write permission on attribute (Smalltalk way).

Uniform access.



No direct write permission on attribute (Smalltalk way).

Genericity

No Cast !

```
local
    integer: INTEGER
    list: LINKED_LIST[INTEGER]
do
    create list.make
    list.add_last(1)
    integer := list.last
    ...
```

```
local
    string: STRING
    list: LINKED_LIST[STRING]
do
    create list.make
    list.add_last("foo")
    string := list.last
    ...
```

Compile-Time checks !

Works on all types.

```
local
    string: STRING
    array: ARRAY[STRING]
    list: LINKED_LIST[ARRAY[STRING]]
do
    create array.make(1, 1)
    array.put("foo")
    create list.make
    list.add_last(array)
    string := list.last.item(1)
    ...
```

Design-by-Contract

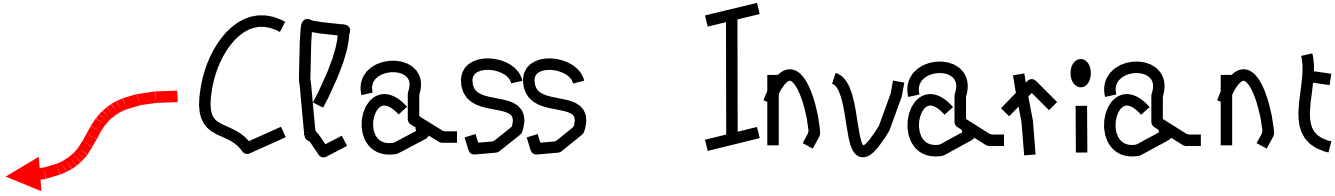
Automatic Documentation Extraction.

class STRING

```
put (c: CHARACTER; i: INTEGER) is
    -- Put `c' at index `i'.
    require
        valid_index(i)
    do
        storage.put(c, i - 1)
    ensure
        item(i) = c
    end
```

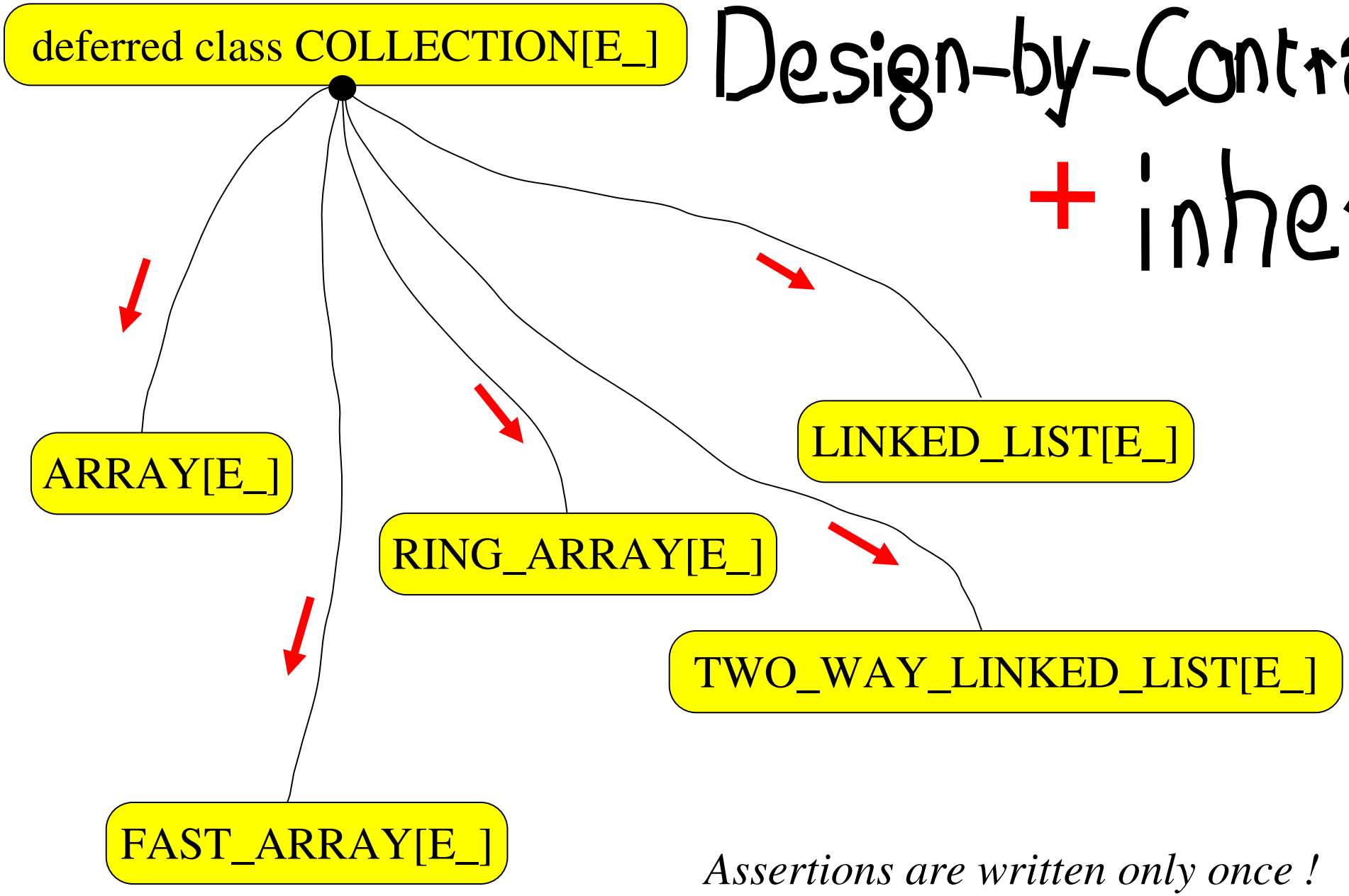
```
remove_last (n: INTEGER) is
    -- Remove `n' last characters.
    -- If `n' >= `count', remove all.
    require
        n >= 0
    do
        if (n > count) then
            count := 0
        else
            count := count - n
        end
    ensure
        count = (0).max(old count - n)
    end
```

```
class STRING
-- Resizable STRINGs of CHARACTERs indexed from `1` to `count`.
   ...
   ...
   ...

   count: INTEGER
      -- Actual length.

   capacity: INTEGER
      -- Capacity of the `storage` area.

invariant

   count >= 0

   count <= capacity

end -- of class STRING
```



Now looking at the interface of class STRING using command short ... and then, the SmartEiffel web site.

Design-by-Contract + inherit



Assertions are written only once !

*Now looking at the interface of class **COLLECTION[E]**.*

Export Control

```
feature {ANY}
    ...
```

```
feature {}
    ...
```

```
feature {STRING}
    ...
```

```
feature {ARRAY, LINKED_LIST, RING_ARRAY, FAST_ARRAY}
    ...
```

```
feature {STRING,INTEGER}
    ...
```

```
feature {COLLECTION}
    ...
```

Smart Tuning !

Relationship between modules (i.e. who can do what.)

Anchored Types

```
collection: ARRAY[STRING]
```

```
is_equal (other: like Current): BOOLEAN is
   ...
```

Just change the anchor ... others will follows automatically.

```
storage: LINKED_LIST[INTEGER];

foo: like storage;

bar: like foo;
```

```
clone: like Current is
   ...
```

Smart Typing !

*Now looking at the source code of class **COLLECTION[E]**.*

Example

Design-by-Contract

```
class DICTIONARY [V, K -> HASHABLE]
--
-- Associative memory. Values of type `V' are stored using Keys of type `K'.
--
feature
    ...
    ...
end -- DICTIONARY
```

Documentation + Validation + Testing + Performances !

```
class DICTIONARY [V, K -> HASHABLE]
```

```
at (key: K): V is
    require
        has(key)
    do not_yet_implemented
    end
```

```
has (key: K): BOOLEAN is
    require
        key /= Void
    do  not_yet_implemented
    end
```

```
put (value: V; key: K) is
    require
        key /= Void
    do not_yet_implemented
    ensure
        value = at(key)
    end
```

```
add (value: V; key: K) is
    require
        not has(key)
    do not_yet_implemented
    ensure
        count = 1 + old count
        value = at(key)
    end
```

```
class DICTIONARY [V, K -> HASHABLE]
```

```
at (key: K): V is
    require
        has(key)
    do not_yet_implemented
    end
```

```
has (key: K): BOOLEAN is
    require
        key /= Void
    do  not_yet_implemented
    end
```

```
put (value: V; key: K) is
    require
        key /= Void
    do not_yet_implemented
    ensure
        value = at(key)
    end
```

Fast

```
add (value: V; key: K) is
    require
        not has(key)
    do not_yet_implemented
    ensure
        count = 1 + old count
        value = at(key)
    end
```

Agents

How to make call-back ?

How can Eiffel handles code as data ?

Ordinary valid code example used for next slides

```
object.method(arg1, arg2)
```

```
code := agent object.method(?, arg2)
```

step-1 *Capture of given operands in the agent object.*

step-2 *Passing missing operands and fires the method.*

```
code.call([arg1])
```

Agents at Work

```
code := agent object.method(arg1, ?)
```

step-1 *Capture of given operands in the agent object.*

step-2 *Passing missing operands and fires the method.*

```
code.call([arg2])
```

Agents at Work

```
code := agent object.method(?, ?)
```

step-1 *Capture of given operands in the agent object.*

step-2 *Passing missing operands and fires the method.*

```
code.call([arg1, arg2])
```

Agents at Work

```
code := agent {TOBJECT}.method(?, ?)
```

step-1 *Capture of given operands in the agent object.*

step-2 *Passing missing operands and fires the method.*

```
code.call([object, arg1, arg2])
```

Agents at Work

```
code := agent object.method(arg1,arg2)
```

step-1 *Capture of given operands in the agent object.*

step-2 *Passing missing operands and fires the method.*

```
code.call([])
```

Agents at Work

http://SmartEiffel.loria.fr

gnu

Thank you for your attention.

Contact: Dominique.Colnet@loria.fr

Ideal for CS teaching too.

Give it a try !

Questions ?

CAT call example (1/3)

```
class POINT
   x, y: REAL
   binary ( other: POINT ) is
      do
         ... other.x ...
      end
   ...
end – class POINT
```

CAT call example (2/3)

```
class PIXEL

inherit POINT redefine binary

   status: BOOLEAN

   binary ( other: PIXEL ) is

      do

         ... other.status ...

      end

   ...
```

CAT call example (3/3)

```
local
   point1, point2: POINT;
do
   point1 := create {POINT};
   point2 := create {PIXEL};
   point2.binary(point1)
   ...
```

CAT call (generics Java version)

```
public class JavaCATcall {
    public static void main (String [] args) {
     Integer [] integerArray = new Integer[10];
     Object [] objectArray = null;

     objectArray = integerArray;
     objectArray[1] = “BANG!”;
    }
}
```