Object-Oriented Software Construction

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Lecture 6: Genericity

Genericity

Unconstrained

LIST [G]

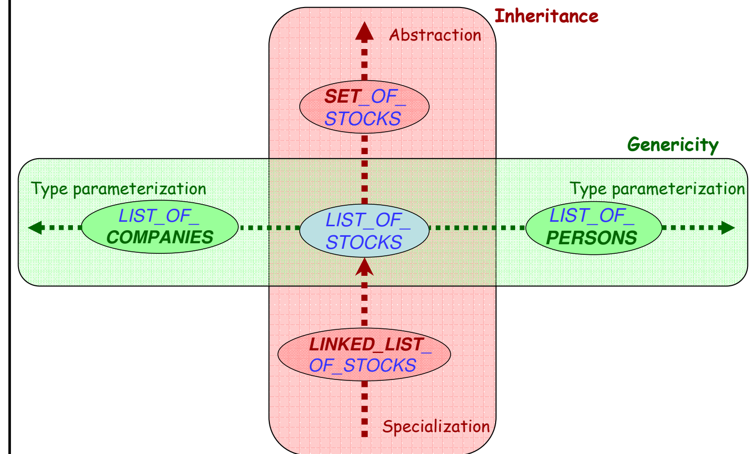
e.g. LIST [INTEGER], LIST [PERSON]

Constrained

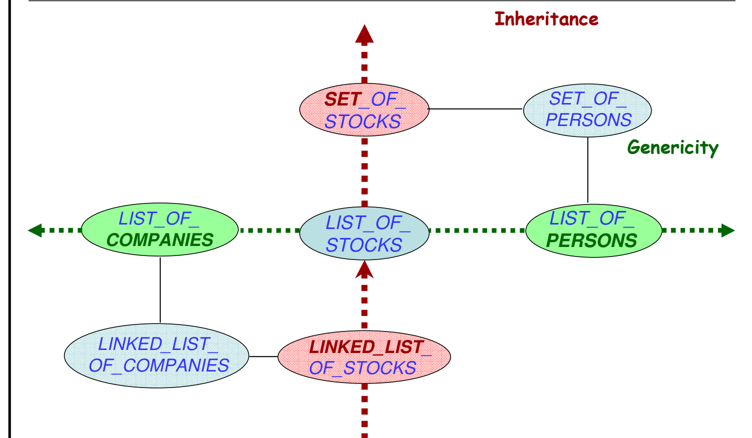
HASH_TABLE [G —> HASHABLE]

VECTOR [G —> NUMERIC]

Extending the basic notion of class



Extending the basic notion of class



Genericity: Ensuring type safety

How can we define consistent "container" data structures, e.g. list of accounts, list of points?

Dubious use of a container data structure:

```
    c : COMPANY
    a : PERSON
        companies: LIST ...
    people: LIST ...

    companies.extend (c)
    people.extend (a)

    c := people.last

        c.change_recommendation (Buy)
```


Possible approaches

- Wait until run time; if types don't match, trigger a run-time failure. (Smalltalk)
- Cast to a universal type, such as "pointer to void" in C.
- Duplicate code, manually or with help of macro processor.
- Parameterize the class, giving an explicit name *G* to the type of container elements. This is the Eiffel approach.

A generic class

Formal generic parameter

```
class LIST [G]  feature
    extend (x: G) is ...
    last: G is ...
  end
```

To use the class: obtain a generic derivation, e.g.

```
    companies: LIST [COMPANY]
```

Actual generic parameter

Conformance rule

- *B* [*U*] conforms to *A* [*T*] if and only if *B* is a descendant of *A* and *U* conforms to *T*.

Using generic derivations


```
companies: LIST [COMPANY]
people: LIST [PERSON]
c: COMPANY
p: PERSON
...
companies.extend (c)

people.extend (p)


c := companies.last
c. change_recommendation (Buy)
...
```


Genericity and static typing

Compiler will reject

```
people.extend (c)

companies.extend (p)
```

To define more flexible data structures (e.g. stack of figures): use inheritance, polymorphism and dynamic binding.

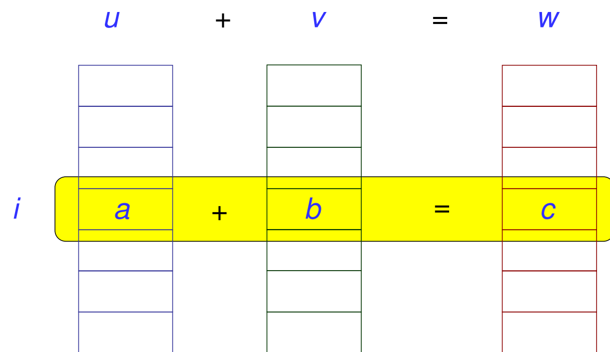
Typing in an O-O context

An object-oriented language is statically typed if and only if it is possible to write a “static checker” which, if it accepts a system, guarantees that at run time, for any execution of a feature call *x.f*, the object attached to *x* (if any) will have at least one feature corresponding to *f*.

Constrained genericity


```
class VECTOR [G            ] feature
   infix "+" (other: VECTOR [G]): VECTOR [G] is
              -- Sum of current vector and other
         require
              lower = other.lower
              upper = other.upper
         local
              a, b, c: G
         do
              ... See next ...
         end
   ... Other features ...
end
```

Adding two vectors



Constrained genericity

Body of **infix** "+":

```
create Result.make (lower, upper)

from
    i := lower
until
    i > upper
loop
    a := item (i)
    b := other.item (i)
    c := a + b   -- Requires “+” operation on G!
    Result.put (c, i)
    i := i + 1
end
```


The solution

Declare class *VECTOR* as

```
class VECTOR [G –> NUMERIC]  feature
        ... The rest as before ...
end
```

Class *NUMERIC* (from the Kernel Library) provides features **infix** "+", **infix** "*" and so on.

Improving the solution

Make *VECTOR* itself a descendant of *NUMERIC*, effecting the corresponding features:

```
class VECTOR [G –> NUMERIC] inherit
    NUMERIC
feature
    ... The rest as before, including infix "+"...
end
```

Then it is possible to define

```
v :   VECTOR [INTEGER]
vv :  VECTOR [VECTOR [INTEGER]]
vvv : VECTOR [VECTOR [VECTOR [INTEGER]]]
```

A generic library class: Arrays

Using arrays:

```
a: ARRAY [REAL]
    ...
    create a.make (1, 300)
a.put (3.5, 25)

    x := a.item (i)
                        -- Alternatively: x := a @ i
                            -- Using the function
infix "@"
```

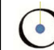
Also: *ARRAY2* [*G*] etc.

Class *ARRAY* (1)


```
class ARRAY [G]  create
    make
feature
    lower, upper: INTEGER

    count: INTEGER

        make (min: INTEGER, max: INTEGER) is
            -- Allocate array with bounds min and max.
        do
        ...
    end
```


Class *ARRAY* (2)


```
    item, infix "@" (i: INTEGER): G is
            -- Entry of index i
            require
                lower <= i
            i <= upper
            do ...  end

        put (v: G; i: INTEGER) is
            -- Assign the value of v to the entry of index
    i.
            require
                lower <= i
            i <= upper
            do ...  end

invariant
        count = upper - lower + 1
end
```

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