ETH Zürich
Chair of Software Engineering

Einführung in die Programmierung
Introduction to Programming

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Exercise Session 7

News (Reminder)

Mock exam next week!

- Attendance is highly recommended (and worth one point!)
- The week after we will discuss the results
- Assignment 7 due on November 13

Today

- Inheritance
- Genericity

Inheritance

Principle:

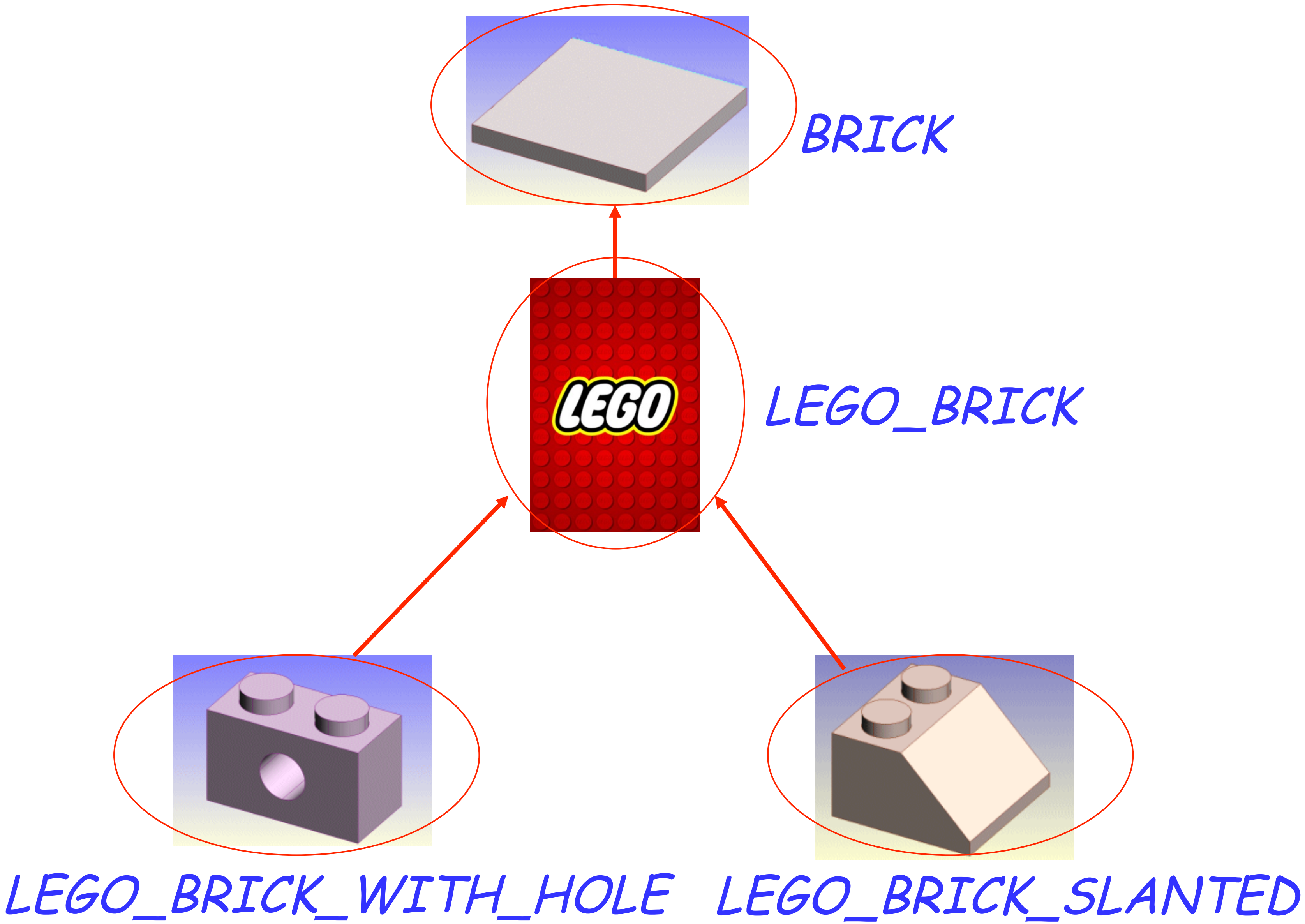
Describe a new class as extension or specialization of an existing class
(or several with ***multiple*** inheritance)

If *B* inherits from *A* :

- As modules: all the services of *A* are available in *B* (possibly with a different implementation)

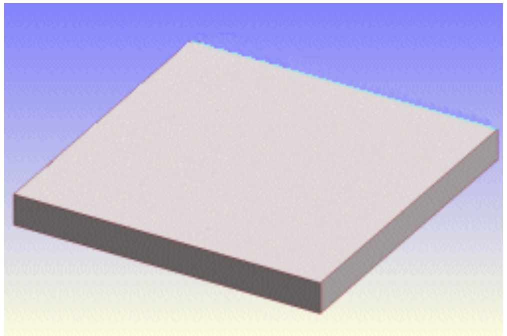
- As types: whenever an instance of *A* is required, an instance of *B* will be acceptable
("is-a" relationship)

Let's play Lego!



Class *BRICK*

```
deferred class
    BRICK

feature
    width: INTEGER
    depth: INTEGER
    height: INTEGER
    color: COLOR

    volume: INTEGER
        deferred
        end
end
```



Class *LEGO_BRICK*

Inherit all features of class *BRICK*.

New feature, number of nubs

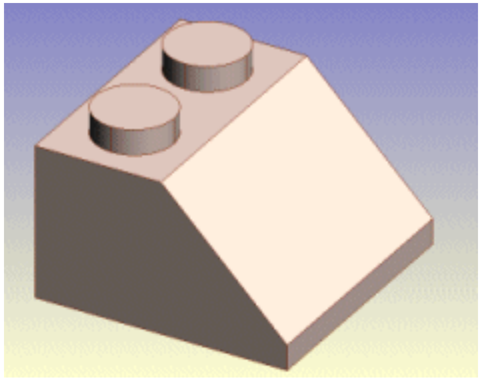
Implementation of *volume*.

```
class
    LEGO_BRICK

inherit
    BRICK

feature
    number_of_nubs: INTEGER

    volume: INTEGER
        do
            Result := ...
        end
end
```

Class *LEGO_BRICK_SLANTED*

The feature *volume* is going to be redefined (=changed). The feature *volume* comes from *LEGO_BRICK*

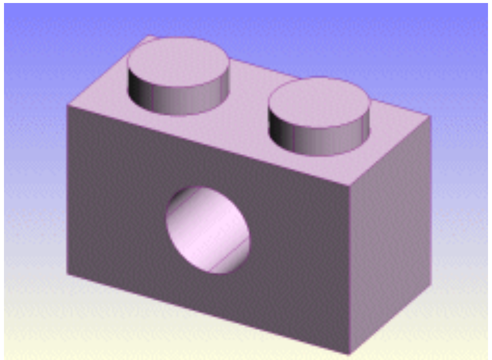
```
class
    LEGO_BRICK_SLANTED

inherit
    LEGO_BRICK
        redefine
            volume
        end

feature
    volume: INTEGER
        do
            Result := ...
        end
end
```



Class *LEGO_BRICK_WITH_HOLE*

The feature *volume* is going to be redefined (=changed). The feature *volume* comes from *LEGO_BRICK*

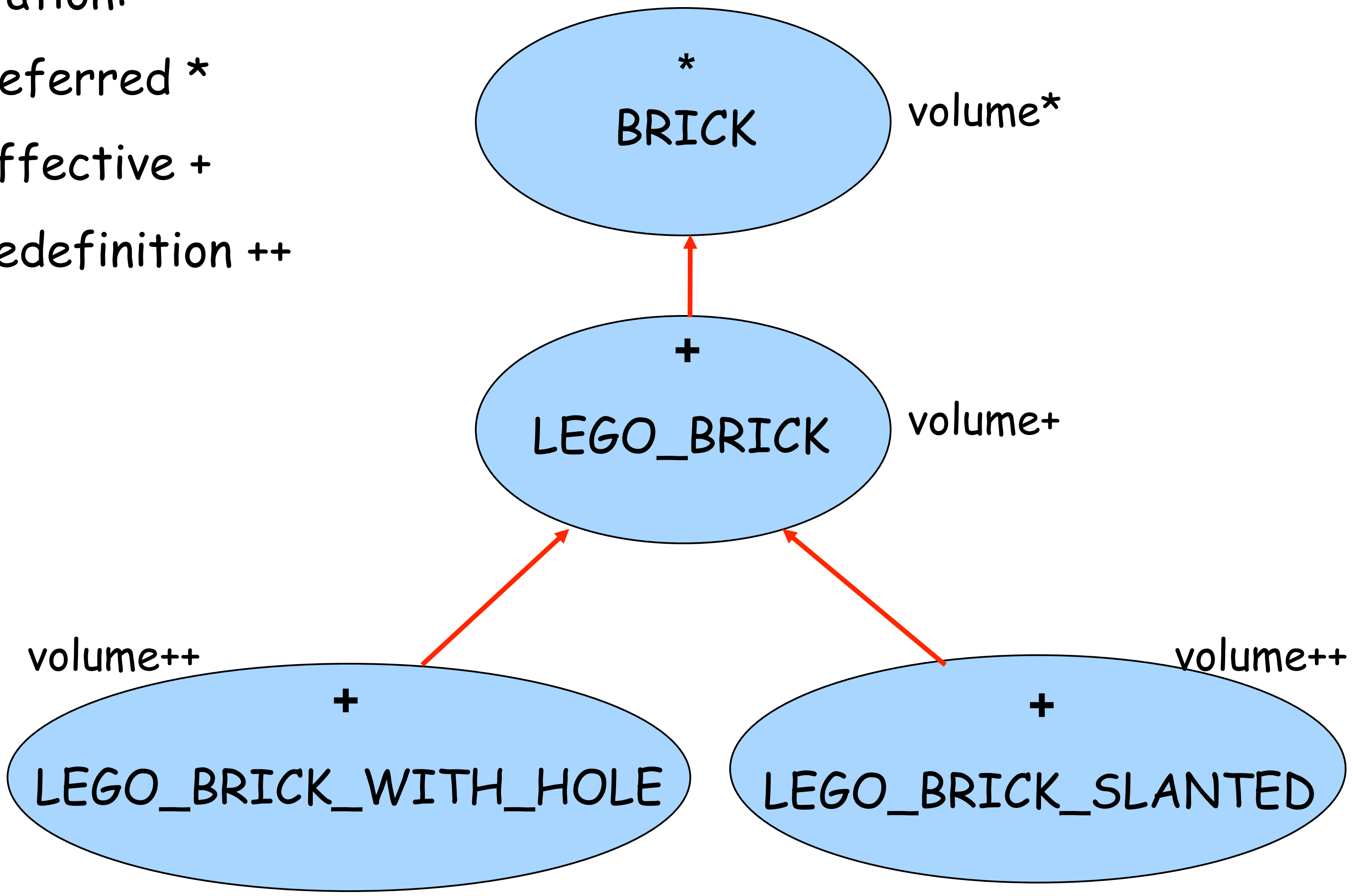
```
class
    LEGO_BRICK_WITH_HOLE

inherit
    LEGO_BRICK
        redefine
            volume
        end

feature
    volume: INTEGER
        do
            Result := ...
        end
end
```



Inheritance Notation

Notation:

- Deferred *
- Effective +
- Redefinition ++



Deferred

- Deferred
  - Deferred classes can have deferred features.
  - A class with at least one deferred feature must be declared as deferred.
  - A deferred feature does not have an implementation yet.
  - Deferred classes cannot be instantiated and hence cannot contain a create clause.

Can we have a deferred class with no deferred features?

Effective

- Effective
  - Effective classes do not have deferred features (the "standard case").
  - Effective routines have an implementation of their feature body.

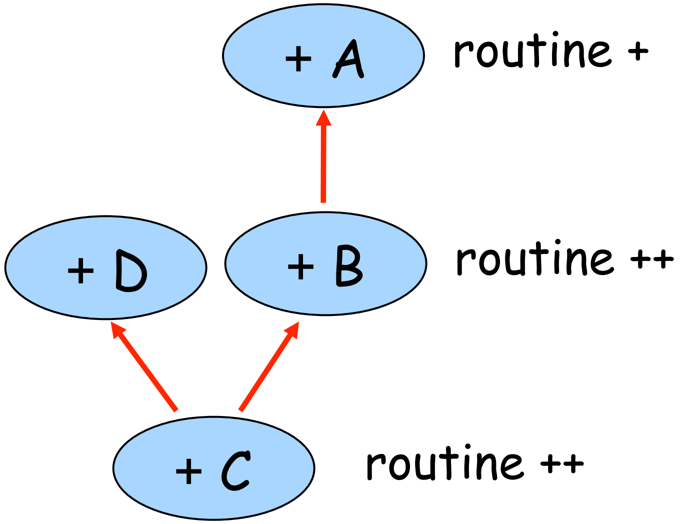
Precursor

- If a feature was redefined, but you still wish to call the old one, use the **Precursor** keyword.

```
volume: INTEGER
    do
        Result := Precursor - ...
    end
```

A more general example of using Precursor

```
    -- Class A
routine (a_arg1 : TYPE_A): TYPE_R
    do … end

    -- Class C
routine (a_arg1 : TYPE_A): TYPE_R
    local
        l_loc : TYPE_R
    do
            -- pre-process
        l_loc := Precursor {B} (a_arg1 )
            -- Not allowed: l_loc := Precursor {A} (a_arg1 )
            -- post-process
    end
```



Today

- Inheritance
- Genericity

Genericity - motivation

- Assume we want to create a list class capable of storing objects of any type.

```
class
    LIST -- First attempt

feature

    put: (a_item: ANY)
        do
            -- Add item to the list
        end

    item: ANY
        do
            -- Return the first item in the list
        end

    -- More feature for working with the list

end
```

We could choose ANY as the item type

Working with this list – first attempt

```
insert_strings (a_list_of_strings: LIST)
    do
        a_list_of_strings.put("foo")
        a_list_of_strings.put(12);
        a_list_of_strings.put("foo")
    end

print_strings (a_list_of_strings: LIST)
    local
        l_printme: STRING
    do
        across a_list_of_strings as l loop
            l_printme := l.item
            io.put_string (l_printme)
        end
    end
```

Here we are inserting an INTEGER

Compile error: cannot assign ANY to STRING

Working with this list – the right way

```
insert_strings (a_list_of_strings: LIST)
    do
        a_list_of_strings.put("foo")
        a_list_of_strings.put(12);
        a_list_of_strings.put("foo")
    end

print_strings (a_list_of_strings: LIST)
    local
        l_current_item: ANY
    do
        across a_list_of_strings as l loop
            l_current_item := l.item
            if attached {STRING} l_current_item as itemstring then
                io.put_string (itemstring)
            else
                io.put_string ("The list contains a non-string item!")
            end
        end

    end
```

Still nobody detects this problem

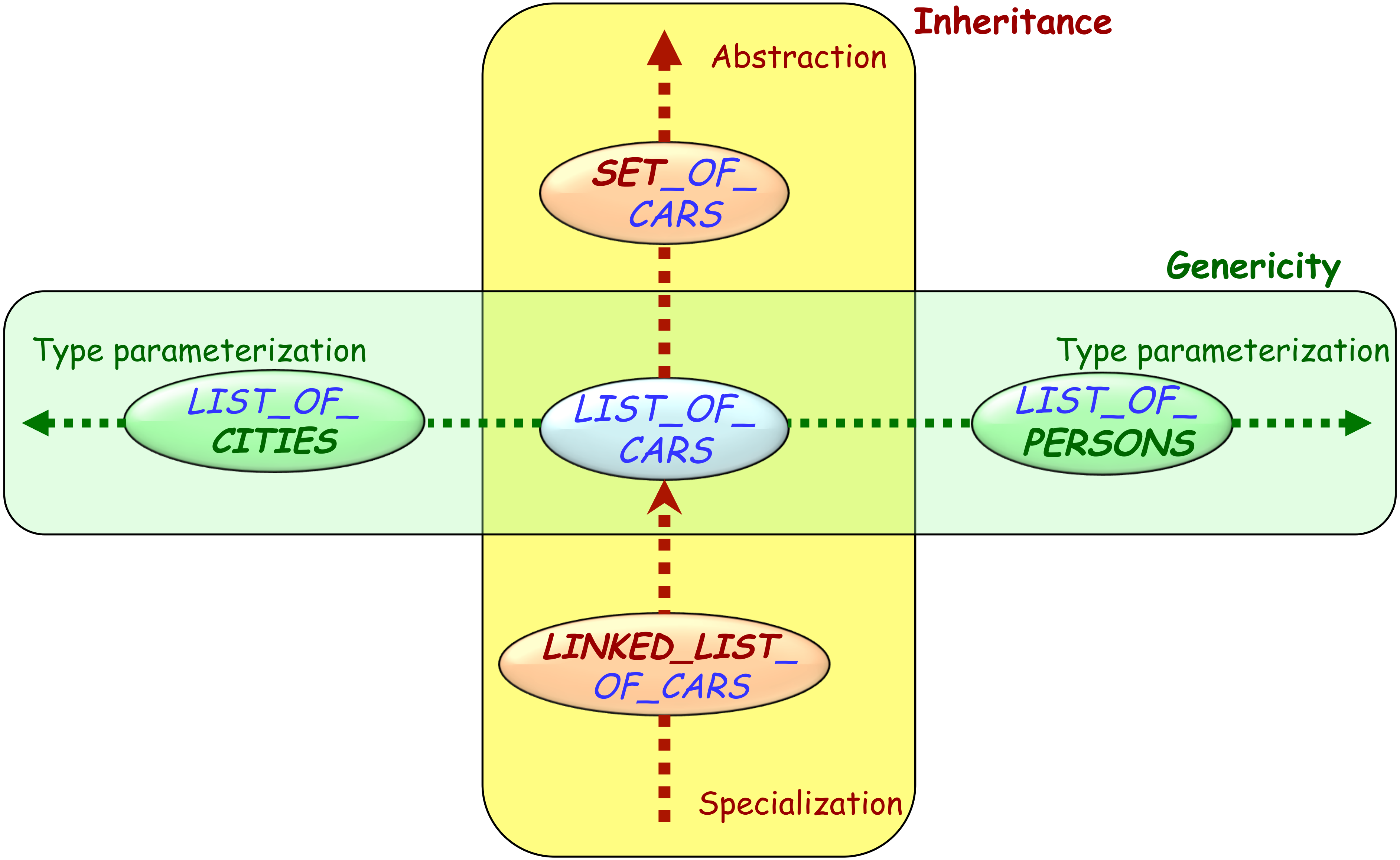
This solution works, but wouldn't it be nice to detect this mistake at compile time?

Correct. This synctactical construct is called 'object test'.

Genericity

- Genericity lets you parameterize a class. The parameters are types. A single class text may be reused for many different types.

Genericity



Inheritance
Abstraction
SET_OF_CARS
Genericity
Type parameterization
Type parameterization
LIST_OF_CITIES
LIST_OF_CARS
LIST_OF_PERSONS
LINKED_LIST_OF_CARS
Specialization

A generic list

Formal generic parameter

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

In the class body, *G* is a valid type name

Query *last* returns an object of type *G*

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

Actual generic parameter

```
cities : LIST [CITY]
```

A generic list with constraints

```
class
    STORAGE [G}> RESOURCE

inherit
    LIST [G]

feature
    consume_all
        do
            from start until after
            loop
                item.consume
                forth
            end
        end
end
```

constrained generic parameter

The feature *item* is of type G. We cannot assume *consume*.

assume this.

Type-safe containers

- Using genericity you can provide an implementation of type safe containers.

```
x: ANIMAL
animal_list: LINKED_LIST [ANIMAL]
a_rock: MINERAL

animal_list.put (a_rock) -- Does this rock?
```

Compile error!

Definition: Type

We use types to declare entities, as in

x : SOME_TYPE

With the mechanisms defined so far, a type is one of:

- A non-generic class e.g. *METRO_STATION*
- A generic derivation, i.e. the name of a class followed by a list of ***types***, the actual generic parameters, in brackets (also recursive)
  e.g. *LIST [ARRAY [METRO_STATION]]*
  LIST [LIST [CITY]]
  TABLE [STRING, INTEGER]

So, how many types can I possibly get?

Two answers, depending on what we are talking about:

- Static types

  Static types are the types that we use while writing Eiffel code to declare types for entities (arguments, locals, return values)

- Dynamic types

  Dynamic types on the other hand are created at run-time. Whenever a new object is created, it gets assigned to be of some type.

Static types

```
class EMPLOYEE
feature
        name: STRING
        birthday: DATE
end

class DEPARTMENT
feature
        staff: LIST [EMPLOYEE]
end
```

bound by the program text:

EMPLOYEE

STRING

DATE

DEPARTMENT

LIST[G]

becomes *LIST[EMPLOYEE]*

Object creation, static and dynamic types

```
class TEST_DYNAMIC _CREATION
feature
    ref_a: A; ref_b: B
        -- Suppose B, with creation feature make_b,
        -- inherits from A, with creation feature make_a

    do_something
        do
            create ref_a.make_a
                -- Static and dynamic type is A

            create {B} ref_a.make_b
                -- Static type is A, dynamic type is B

            create ref_b.make_b
            ref_a := ref_b
        end
end
```

Dynamic types: another example

```
class SET[G] feature
  powerset: SET[SET[G]] is
    do
          create Result
          -- More computation…
    end

  i_th_power (i: INTEGER): SET[ANY]
    require i >= 0
    local n: INTEGER
    do
          Result := Current
          from n := 1 until n > i loop
                Result := Result.powerset
                n := n + 1
          end
    end
end
```

Dynamic types from *i_th_power* :

SET[ANY]

SET[SET[ANY]]

SET[SET[SET[ANY]]]

…

From http://www.eiffelroom.com/article/fun_with_generics