Name, Binding and Scope

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November 7, 2020

Name

- Name - character string used to represent something else.
  - identifiers,
  - operators (+, &, *).
- Use symbol instead of **address** to refer an entity.
- Abstraction

Definition

- Binding - the operation of associating two things.
- Binding time - the moment when the binding is performed.

Some issues

- Early binding vs. Late binding
- Static binding vs. Dynamic binding
- Polymorphism - A name is bound to more than one entity.
- Alias - Many names are bound to one entity.

Binding Time

- Language design time
- Language implementation time
- Programming time
- Compilation time
- Linking time
- Load time
- Runtime

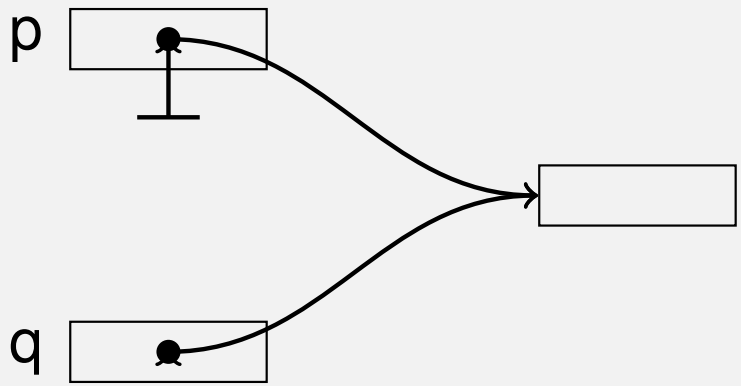
Object Lifetime

- *Object* - any entity in the program.
- *Object lifetime* - the period between the object creation and destruction.
- *Binding lifetime*
- *Dangling reference*

```
p = new int;
q = p;
delete p;
*q;
```

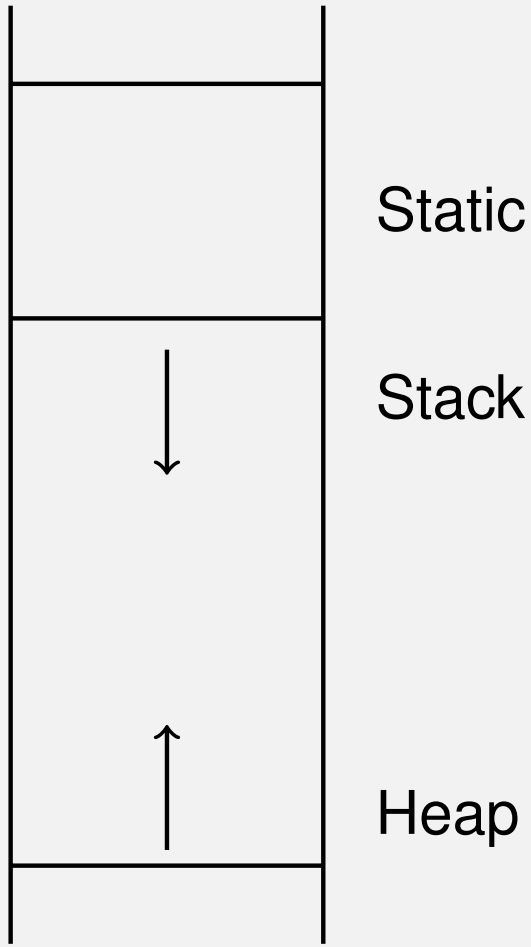
- *Leak memory - Garbage*

```
p = new int;
p = null;
```



Object Allocation

- Static
- Stack Dynamic
- Explicit Heap Dynamic
- Implicit Heap Dynamic



Definition

Scope of a binding is the textual region of the program in which the binding is effective.

Static vs. Dynamic

- Static scope, or lexical scope, is determined during compilation
  - Current binding - in the block most closely surround
  - Global scope
  - Local static scope
- Dynamic scope is determined at runtime.
  - Current binding - the most recently execution but not destroyed

Definition

A block is a textual region, which can contain declarations to that region

Example,

```
procedure foo()
var x:integer;
begin
    x := 1;
end;
```

```
{
    int x;
    x = 1;
}
```

Staic Scope Rules for Blocks

- A reference to an identifier is always bound to **its most local declaration**
- A declaration is **invisible** outside the block in which it appears
- Declarations in enclosing blocks are **visible** in **inner blocks**, unless they have been **re-declared**
- Blocks may be named and its name declaration is considered as a **local declaration of outer** block.

Example on Static scope

```
var A, B, C: real; //1
procedure Sub1 (A: real); //2
        var D: real;
        procedure Sub2 (C: real);
                var D: real;
                begin
                        ... C:= C+B; ...
                end;
        begin
                ... Sub2(B); ...
        end;
begin
        ... Sub1(A); ...
end.
```

Variable	Scope
A:real //1	Main
B:real //1	Main, Sub1, Sub2
C:real //1	Main, Sub1
A:real //2	Sub1, Sub2
...	

Example on Dynamic Scope

```
procedure Big is
    X : Real;
    procedure Sub1 is
        X : Integer;
        begin – of Sub1
            ...
        end; – of Sub1
    procedure Sub2 is
        begin – of Sub2
            ...X...
        end; – of Sub2
begin – of Big
    ...
end; – of Big
```

X in Sub2 ?
Calling chain:
Big $\rightarrow$ Sub1 $\rightarrow$ Sub2
X $\Rightarrow$ X:Integer in Sub1
Calling chain:
Big $\rightarrow$ Sub2
X $\Rightarrow$ X:Real in Big

Referencing Environment

- The referencing environment of a **statement** is the collection of all names that are visible to the statement
- In a static-scoped language, it is the local names plus all of the visible names in all of the enclosing scopes
- In a dynamic-scoped language, the referencing environment is the local bindings plus all visible bindings in all active subprograms

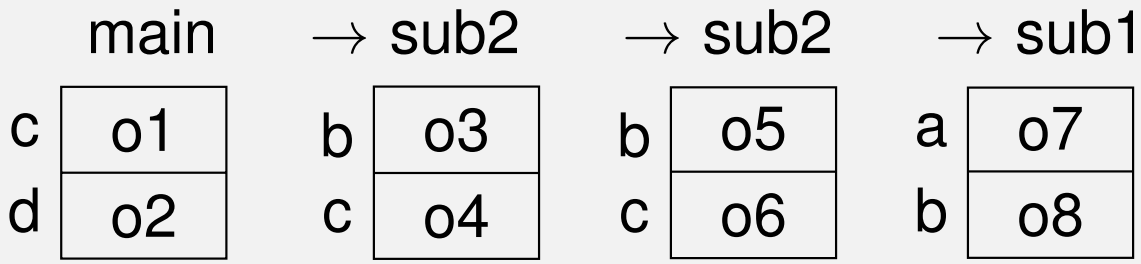
Example on Static-scoped Language

```
var A, B, C: real; //1
procedure Sub1 (A: real); //2
        var D: real;
        procedure Sub2 (C: real);
                var D: real;
                begin
                        ... C:= C+B; ...
                end;
        begin
                ... Sub2(B); ...
        end;
begin
        ... Sub1(A); ...
end.
```

Function	Referencing Environment
Main	A, B, C, Sub1
Sub1	A, B, C, D, Sub1, Sub2
Sub2	A, B, C, D, Sub1, Sub2

Example on Dynamic-scoped Language

```
void sub1() {
        int a, b;
        ...
} /* end of sub1 */
void sub2() {
        int b, c;
        ...
        sub1;
} /* end of sub2 */
void main() {
        int c, d;
        ...
        sub2();
} /* end of main */
```



Frame	Referencing Environment
main	c → o1, d → o2
sub2	b → o3, c → o4, d → o2
sub2	b → o5, c → o6, d → o2
sub1	a → o7, b → o8, c → o6, d → o2

```
def <func-name>(<parameter-list>):
 <stmt-list>
```

- nested function
- pass-by-value (pointer)
- matched by position and by name
- default value
- arbitrary parameters
- arbitrary keyword parameters
- return statement

Nested Functions

```
def outer(x):
    y = x + 1
    def inner(z):
        return z + 1
    return inner(y)
print(outer(3)) => 5
print(inner(2)) => wrong
```

- **inner** function is visible inside **outer** but invisible outside **outer**

Match by position and by name

```
def foo(param1, param2 = 0):
    print(param1, param2)
print(foo(1,2)) => 1 2
print(foo(param2 = 2,param1 = 1)) => 1 2
print(foo(1)) => 1 0
```

Arbitrary Arguments, *args

```
def my_func(*kids):
    print("My third child is" + kids[2])
my_func('Tuong', 'Ca', 'Mam', 'Muoi')
```

- Allow arbitrary number of arguments
- Access the parameter as a *tuple*
- Define after normal parameters

Arbitrary keyword Arguments, **kwargs

```
def my_func(**rec):
    for x,y in rec.items():
        print(x,y)
my_func(ho='nguyen',ten='thi ha',
    namsinh=1996,mssv='0123456')
```

- Allow arbitrary number of keyword arguments
- Access the parameter as a *dictionary*
- Define after normal and arbitrary parameters

Return Statement

- Syntax:

  return (<exp> (, <exp>)*)?

- Example:

```
def my_func(x):
    x = 2
    return x,x+2
a,b = my_func(0)
print(a,b) =>2 4
```

- Stop executing of a function call and return the result
- If no expression after **return**, *None* is returned
- If many expressions after **return**, a *tuple* is returned

- Read: Block rule, where a function is a block
  - ⇓ Local
  - ⇓ Nonlocal
  - ⇓ Global
  - Built-in or imported environments
- Write: **global**, **nonlocal**

Scope Example

```
from functools import *   => imported env.
x = 3                     => global
def f():
    y = 4                 => nonlocal of g
    def g():
        t = 2             => local of g
        print(z)
```

- ⇓ declaration of z is looked firstly in local environment
- ⇓ and then in nonlocal environments that enclose the local
- ⇓ and then in global environment
- and lastly in imported environments

global Example

```
1  x,y = 3,4                    => x,y: global
2  def f():
3      x = 2                    => x: local of f
4      return x + y             => x: local of f; y global
5  def g():
6      global x
7      x = 2                    => x: global
8      return 2 + x
9  f()
10 print(x)                     => 3
11 g()
12 print(x)                     => 2
```

- firstly assigning to a variable makes the declaration of the variable in the current environment
- to assign to a global variable in a function, the declaration of **global** is required

nonlocal Example

```
1  x,y = 3,4                  => x,y: global
2  def f():
3      x,z = 2,5              => x,z: local of f
4      def g():
5          nonlocal x
6          x = 2 * y          => x: nonlocal=>local of f;y:global
7          return z + x       => x,z:nonlocal=>local of f;
8      print(g())             => 13
9      print(x)               => 8
10 f()
11 print(x)                   => 3
```

- like **global** but for **nonlocal** variables

Summary [1]

- Name
- Binding
- Scope
- Referencing Environment

References I


, Maurizio Gabbrielli and Simone Martini, Programming Languages: Principles and Paradigms, Chapter 4, Springer, 2010.