Name/Identifiers and their 6 Attributes

- **1. Name**

  = identifier

  length, legal chars, case-sensitivity, special words

  can be one-one, many-one, or none-one mapping to memory

  aliasing

  anonymous - new (p)
  p^ points to location that has no associated name

- **2. Address**

  point to a location in memory

  may vary dynamically

- **3. Type**

  range of values + legal operations

  variable, constant, label, pointer, program, ...

- **4. Representation/Value**

  interpreted contents of the location

  - l-value (address)
  - r-value (value)

- **5. Scope**

  Range of statements over which the variable is visible.

  Static/dynamic

- **6. Lifetime**

  Time during which the variable is bound to a storage location.

Binding

- **How and when are attributes bound to identifiers?**
  - ➙ ***Static***

    occurs before runtime (compile time, link/load time)

    constant throughout program execution
  - ➙ ***Dynamic***

    occurs or can change during runtime

- **In many ways, the various binding times determine the flavor of a language.**

- **As binding time gets earlier:**
  - ➙ **efficiency goes up**
  - ➙ **safety goes up**
  - ➙ **flexibility goes down**

BINDING TIMES

- **LANGUAGE DESIGN**
- **COMPILER DESIGN/IMPLEMENTATION**
- **COMPILE TIME**
- **LINK/LOAD TIME**
- **RUN TIME**

BINDING TIMES

	Language Design	Compiler Design	Compiler Time	Link/Load Time	Run Time
Type					
Set of objects in Type					
Association of Type with Identifier					
Initial value "of" identifier					
Possible Meanings of Operators					
Represent-ation of Values					

Type Binding

When is type bound to variable?

How is binding specified?

- ***Static typing* (before runtime)**
  - ➡ **explicit declaration**

    var x: integer
  - ➡ **implicit declaration by prior agreement**

    e.g., Fortran:

    I = 5 First mention of I -- integer

    PI = 3.14 First mention of PI -- real

- **Advantages:**
  - ➡ **cheaper**
  - ➡ **safer**
- **Disadvantage:**
  - ➡ **less flexible**

Type Binding

- ***Dynamic Binding* (after compile time)**
  - **Identifier gets type of value assigned to it as needed.**

    x := 5 -- x is of type integer

    ...

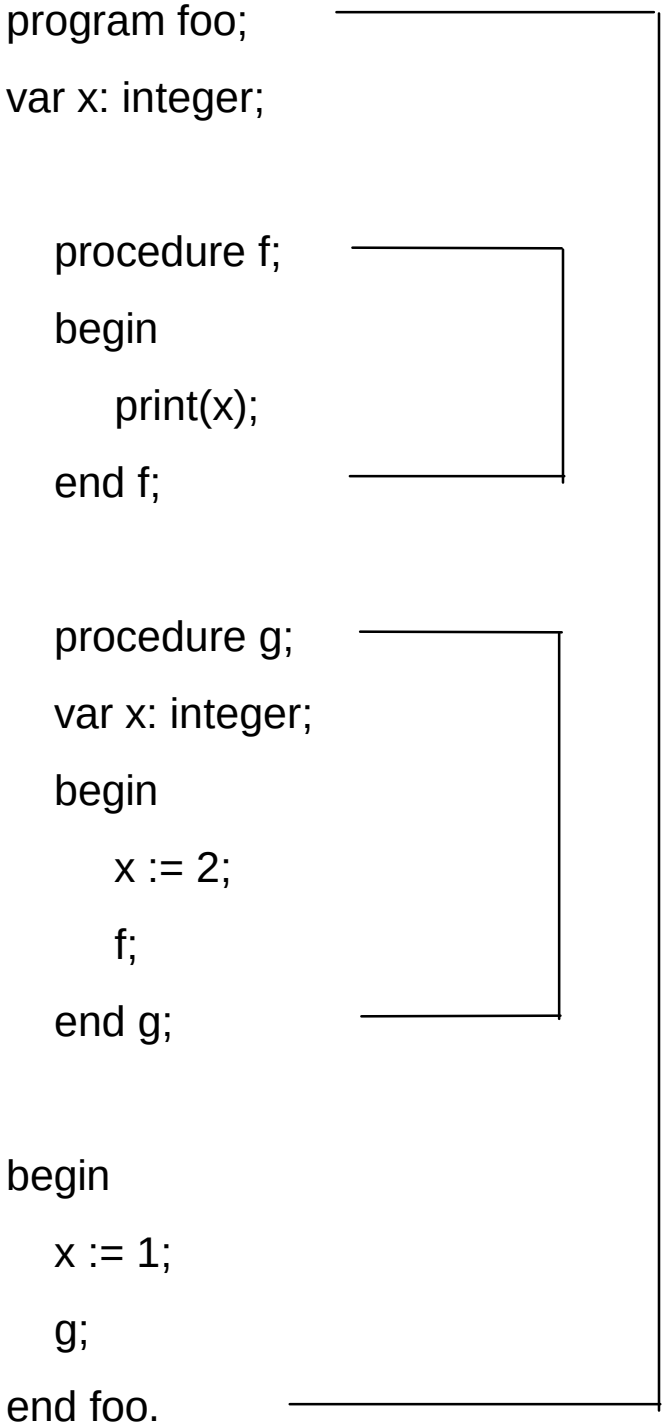
    x := "foo" -- x is of type string

- **Advantage:**
  - **flexibility**
- **Disadvantages:**
  - **runtime overhead -- extra work at run-time**
  - **poor error detection -- type checking is replaced by type changing**
- **More about types later. . .**

Scope

- ***Static (lexical) scope***
  - ➥ **Scope of a identifier is determined by the textual layout of the program.**
  - ➥ **In block structured languages, scope of an identifier is**
    - the unit in which it is defined, plus
    - all units immediately nested inside the declaring unit (excluding those in which the variable is redeclared), plus
  - ➥ **To find the declaration of an identifier,**
    (1) lift all declarations to the top of the unit
    (2) look through the statically enclosing units until a declaration is found.
- ***Dynamic Scope***
  - ➥ **Scope of an identifier depends on program execution, and therefore changes dynamically.**
  - ➥ **To find declaration, look up through the call chain.**

Example (evaluate both ways)



Lifetime (= extent)

- **The lifetime of a variable is the interval of time during which it is bound to a specific memory location.**

- **Static variables**
  - ➡ **bound to memory cells before execution (load time)**
  - ➡ **retain same binding throughout execution**
  - ➡ **efficient, inflexible**
  - ➡ **allow history-sensitivity**
  - ➡ **do not support recursion**
  - ➡ **Ex: FORTRAN variables**

- **Stack- dynamic variables**
  - ➡ **storage allocated when unit is called**
  - ➡ **storage deallocated when unit returns**
  - ➡ **allows recursion**
  - ➡ **Ex: Variables declared in Pascal Procedures**

Lifetime (continued)

- **Explicit Heap - Dynamic Variables**
  - **storage allocated and deallocated by programmer**
  - ***new*, *dispose* in Pascal**
  - **flexible and efficient, but dangerous**
  - **Ex: Pointer variables**
- **Implicit Heap - Dynamic Variables**
  - **automatically bound to storage as needed**
  - **storage automatically reclaimed when no longer needed**
  - **flexible, safe, less efficient**
  - **Ex: lists in LISP, Prolog**

Scope ≠ Lifetime

- **lifetime > scope: storage that can't be accessed through that variable.**

```
var p: ^integer;
begin
   ...
   new(p)
   ...
end
```

here, storage is still allocated but p is not defined,
Lifetime > Scope

- **scope > lifetime: variable without storage.**

```
var p: ^integer;
begin
   ...
   new (p)                    addr of mem   i   "name"
   ...
   dispose(p)
end
```

here, p is defined but has no value,
Scope > Lifetime

Scope ≠ Lifetime (continued)

- **Also, scope has "holes" during execution, but lifetime does not.**

```
procedure f;
begin
    ...
end


procedure g;
var x: integer;
begin
    ...
    f
    ...
end
```

out of x's scope during execution of f (assuming static scope), but x's lifetime persists.