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**

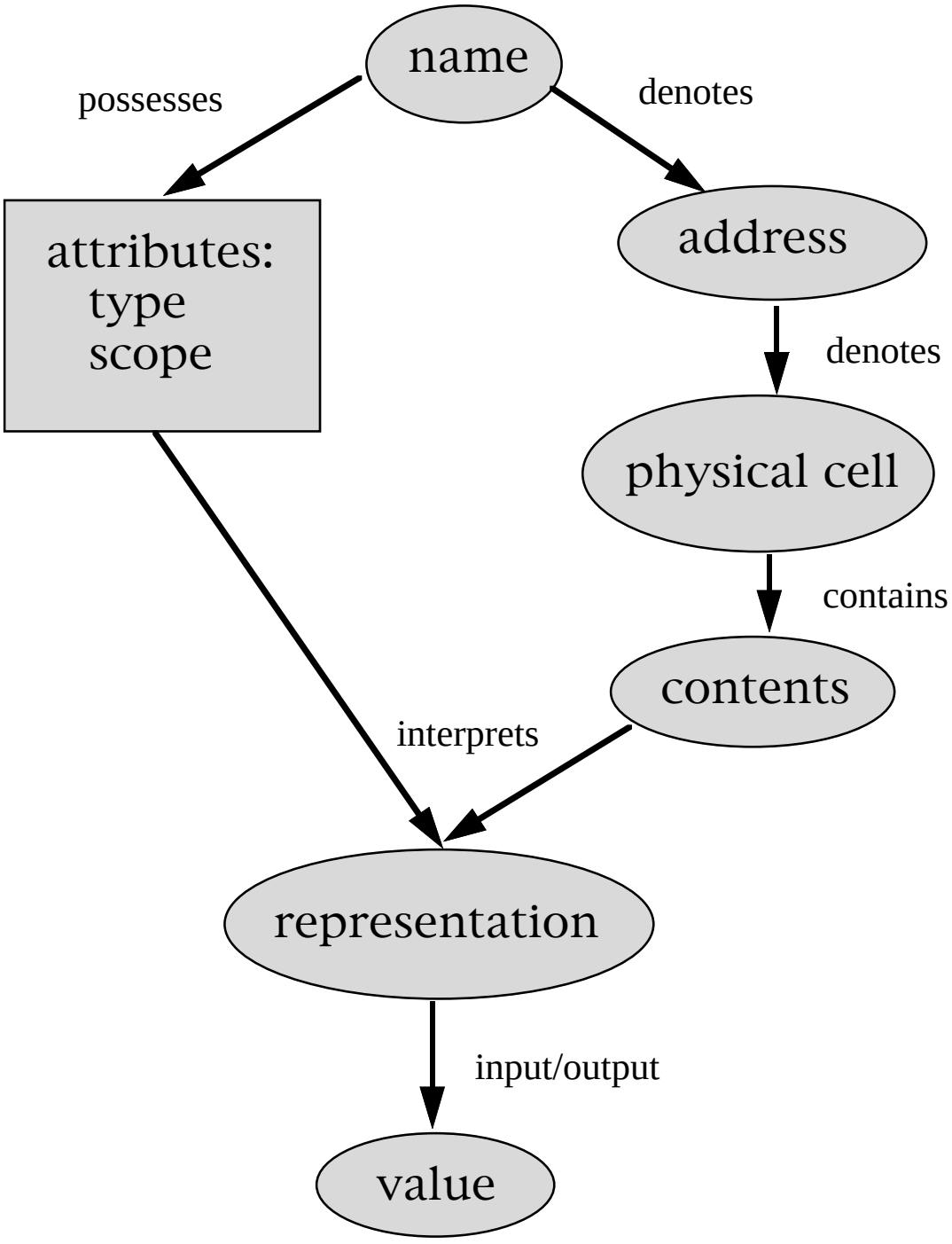
  Range of statements over which the variable is visible.

  Static/dynamic

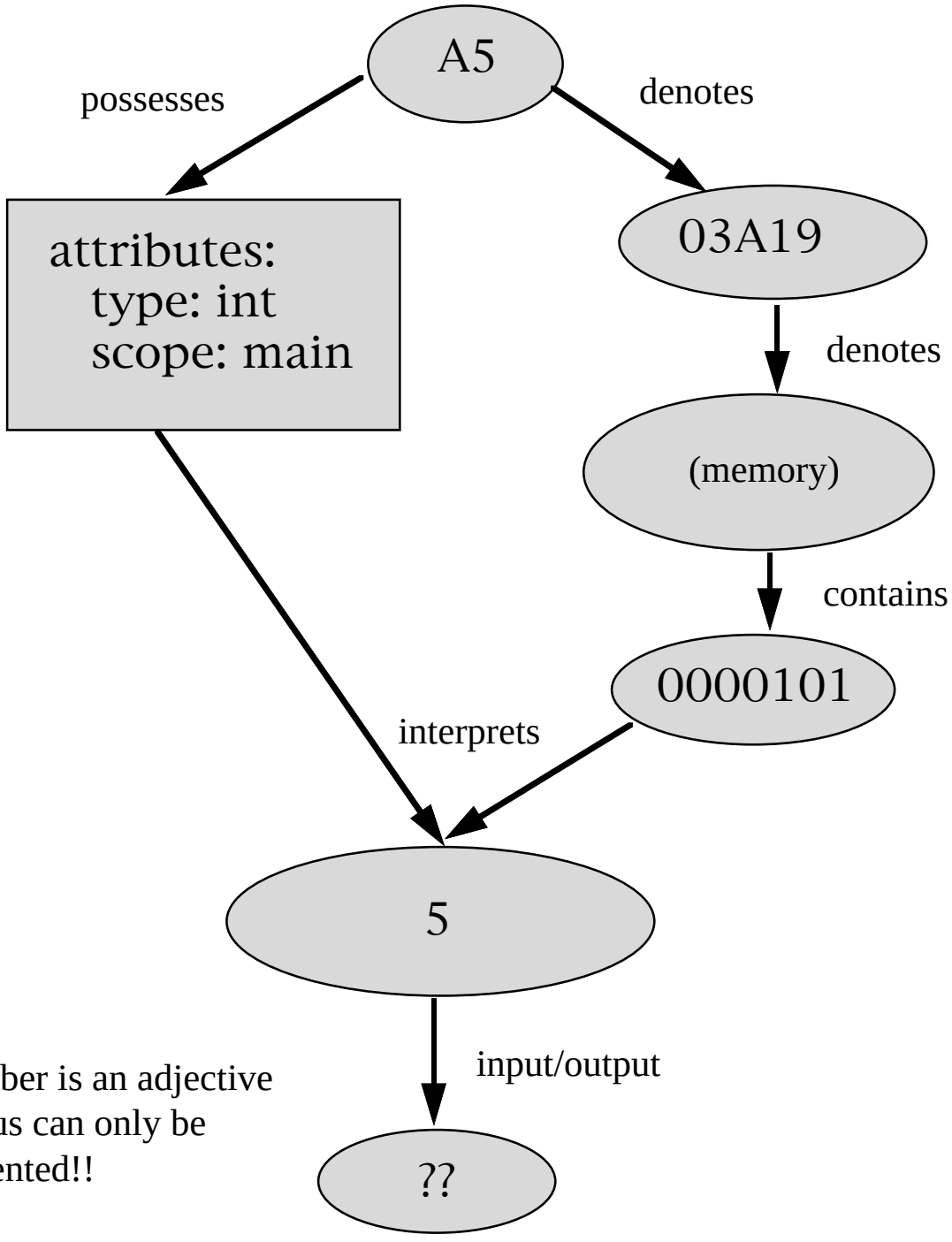
- **6. Lifetime**

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

Name/Value Graph

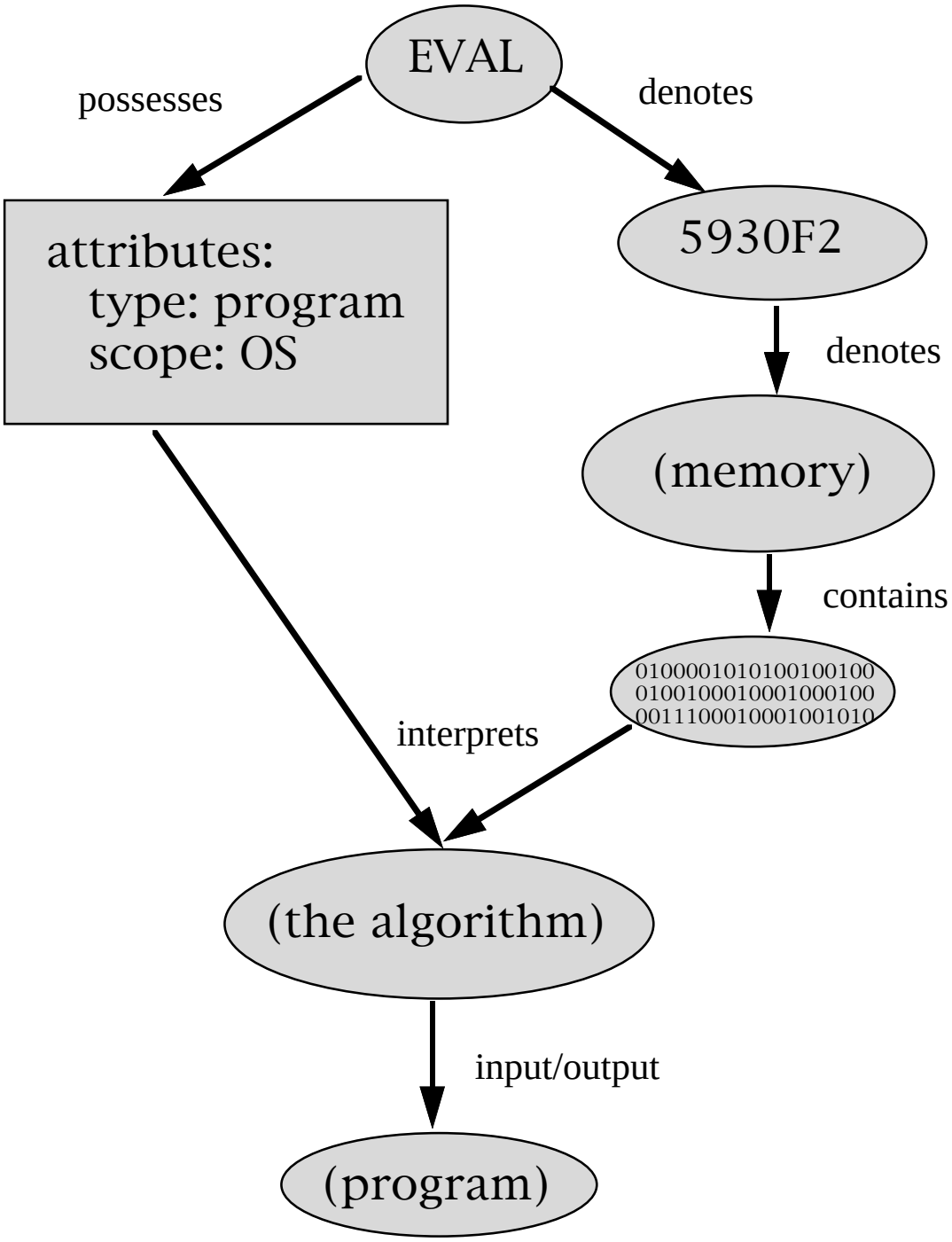


Name/Value Graph - Example I

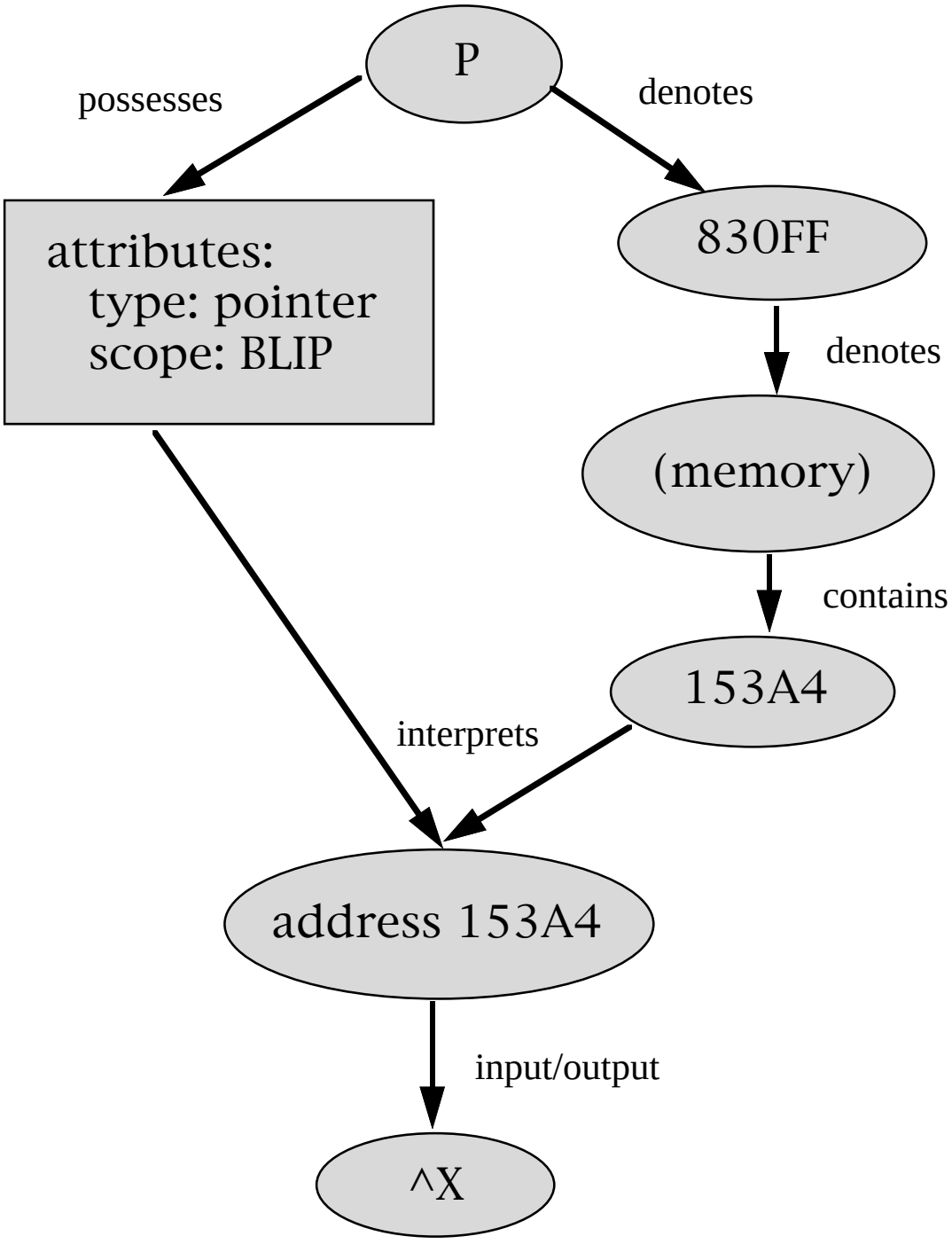


A number is an adjective and thus can only be represented!!

Name/Value Graph - Example II



Name/Value Graph - Example III



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**

  → **you will lose 5 points in an homework assignment for reusing identifiers**

- **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
  - all units within which the declaring unit is nested.

  → **To find the declaration of an identifier,**

  (1) lift all declarations to the top of the unit

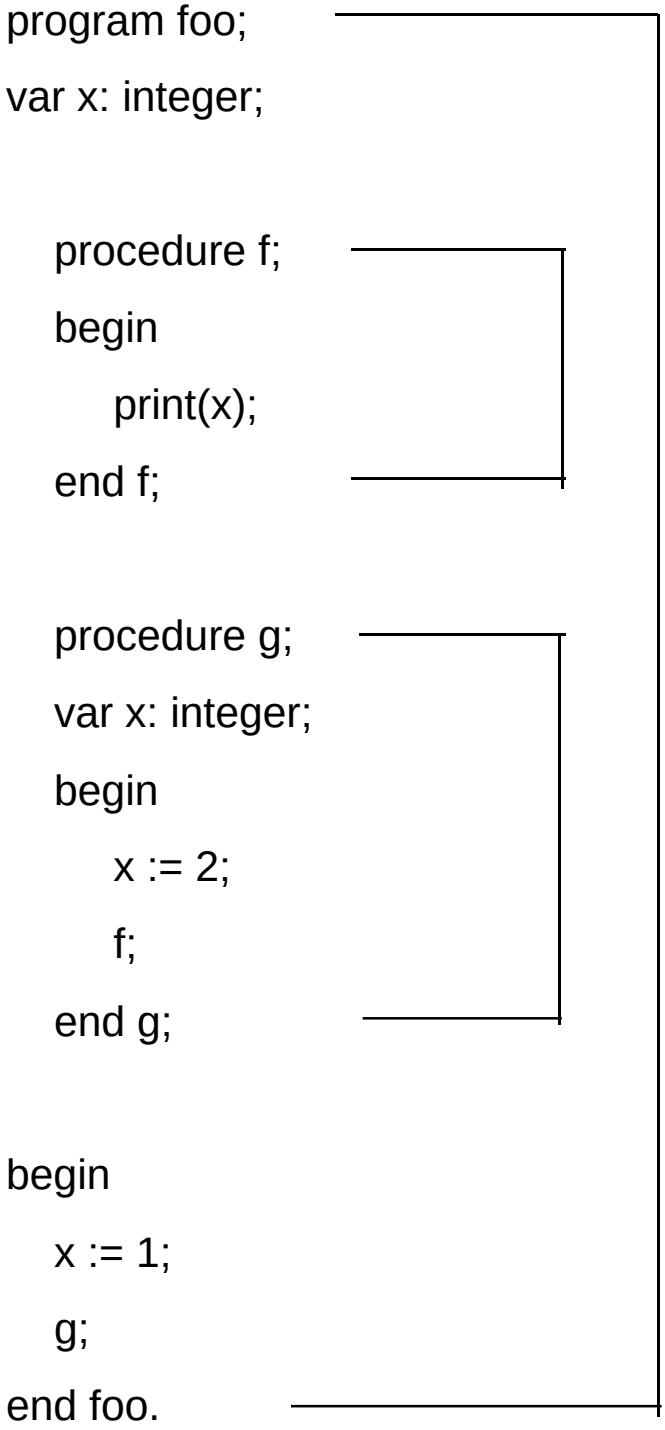
  (2) look through the statically enclosing units until a declaration is found.

- ***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 identifiers**
  - → **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**

- **Semidynamic identifiers**
  - → **storage allocated when unit is called**
  - → **storage deallocated when unit returns**
  - → **allows recursion**
  - → **Ex: Variables declared in Pascal Procedures**

Lifetime (continued)

- **Explicit Dynamic Identifiers**
  - → **storage allocated and deallocated by programmer**
  - → ***new*, *dispose* in Pascal**
  - → **flexible and efficient, but dangerous**
  - → **Ex: Pointer variables**
- **Implicit Dynamic Identifiers**
  - → **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)
```

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

```
end
```

Scope ≠ Lifetime (continued)

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

```
procedure f;
var x: real;
begin
    ...
end


procedure g;
var x: integer;
begin
    ...                    out of x's scope during
                           execution of f (assuming static
                           scope), but x's lifetime persists.
    f

    ...
end
```

Variable Initialization

- **static or dynamic**
- **once for static variables, at each allocation for dynamic variables**
- **many possible methods:**

```
sum: integer := 0;          (Ada)
int first := 10             (Algol 68 initialization)
int first = 10              (Algol 68 constant declaration)
```

- **unavailable in Pascal**
- **default initializations**

Aliasing

- **Two variables are aliases if they share the same storage.**

```
var x,y:  ^integer;
begin
   new (x);
   x^ := 5;
   y := x;
   x^ := 10;
   writeln (y^);
end
```

```
var x,y:  integer;
        begin
   x := 5;
   y := x;
   x := 10;
   writeln (y);
end
```

- **Also results from *var* parameters:**

```
procedure p (var x,y: integer);
....
p (a,b);
p (x1,x1);
```