Parameter Passing Methods

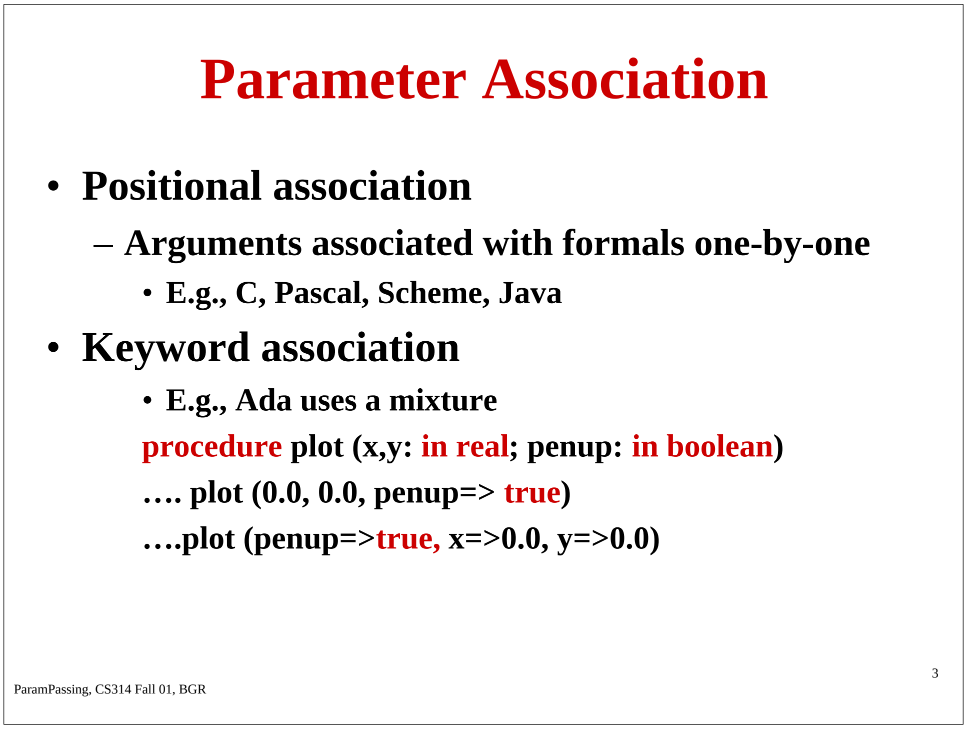
Procedural abstraction

- **Parameter passing methods**
  - **pass by value**
  - **pass by result**
  - **pass by value-result**
  - **pass by reference**
    - **aliasing**
  - **pass by name**
- **Procedures/functions as arguments**

Procedures

- **Modularize program structure**
  - ***Argument*: information passed from caller to callee (actual parameter)**
  - ***Parameter*: local variable whose value (sometimes) is received from caller (formal parameter)**
- **Procedure declaration**
  - **name, formal parameters, procedure body with local declarations and statement list, optional result type**

```
void translateX(point *p, int dx)
```



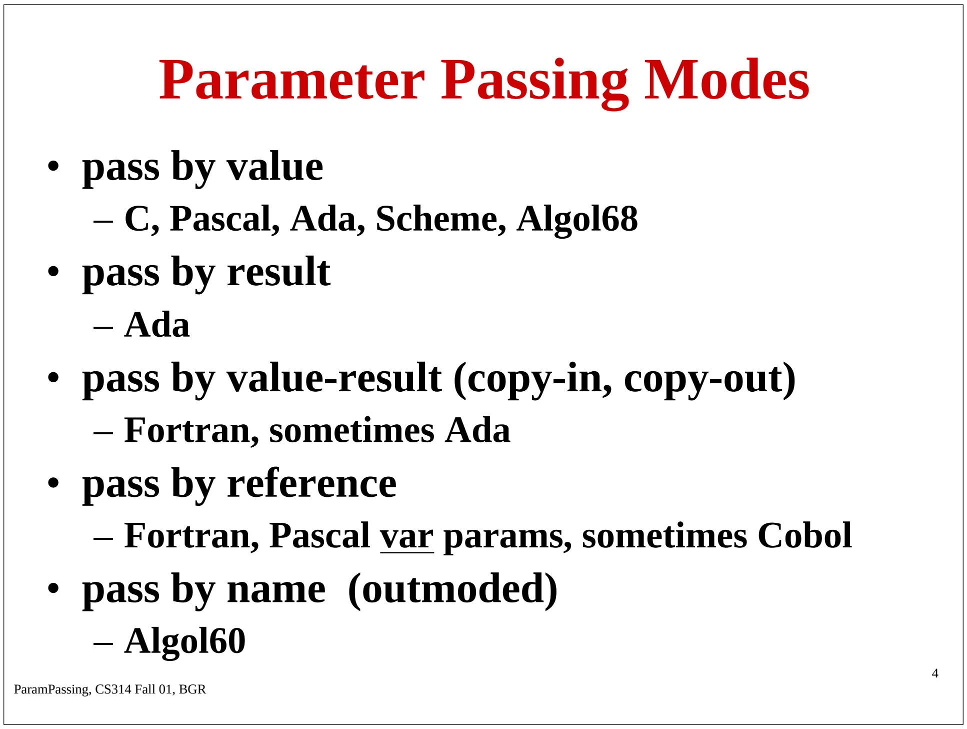
Parameter Association

- **Positional association**
  - – **Arguments associated with formals one-by-one**
    - **E.g., C, Pascal, Scheme, Java**
- **Keyword association**
    - **E.g., Ada uses a mixture**

procedure plot (x,y: in real; penup: in boolean)

…. plot (0.0, 0.0, penup=> true)

….plot (penup=>true, x=>0.0, y=>0.0)



Parameter Passing Modes

- **pass by value**
  - – **C, Pascal, Ada, Scheme, Algol68**
- **pass by result**
  - – **Ada**
- **pass by value-result (copy-in, copy-out)**
  - – **Fortran, sometimes Ada**
- **pass by reference**
  - – **Fortran, Pascal var params, sometimes Cobol**
- **pass by name (outmoded)**
  - – **Algol60**

Pass by Value

```
{   c: array [1..10] of integer;
    m,n : integer;
    procedure r (k,j : integer)
    begin
        k := k+1;
        j := j+2;
    end r;
…
    m := 5;
    n  := 3;
    r(m,n);
    write m,n;
}
```

By Value:

k	j
~~5~~	~~3~~
6	5

Output:
5 3

Pass by Value

- **Advantages**
  - – Argument protected from changes in callee
- **Disadvantages**
  - – Copying of values takes execution time and space, especially for aggregate values

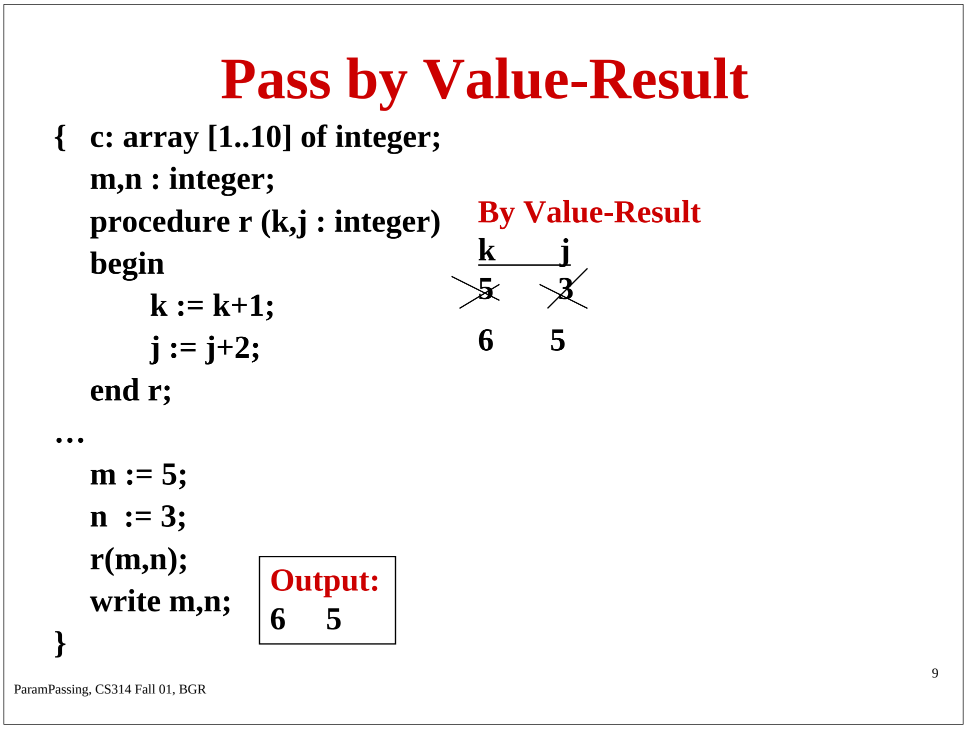
Pass by Result

```
{   c: array [1..10] of integer;
    m,n : integer;
    procedure r (k,j : integer)
    begin
          k := k+1;
          j := j+2;
    end r;
…
    m := 5;
    n  := 3;
    r(m,n);
    write m,n;
}
```

Error in procedure r:
can’t use parameters which
are uninitialized!

Pass by Result

- **Assume we have *procedure p(k, j : int)* with *k* and *j* as result parameters. what is the interpretation of *p(m,m)*?**
  - **Assume parameter *k* has value 2 and *j* has value 3 at end of *p.* What value is *m* on return?**



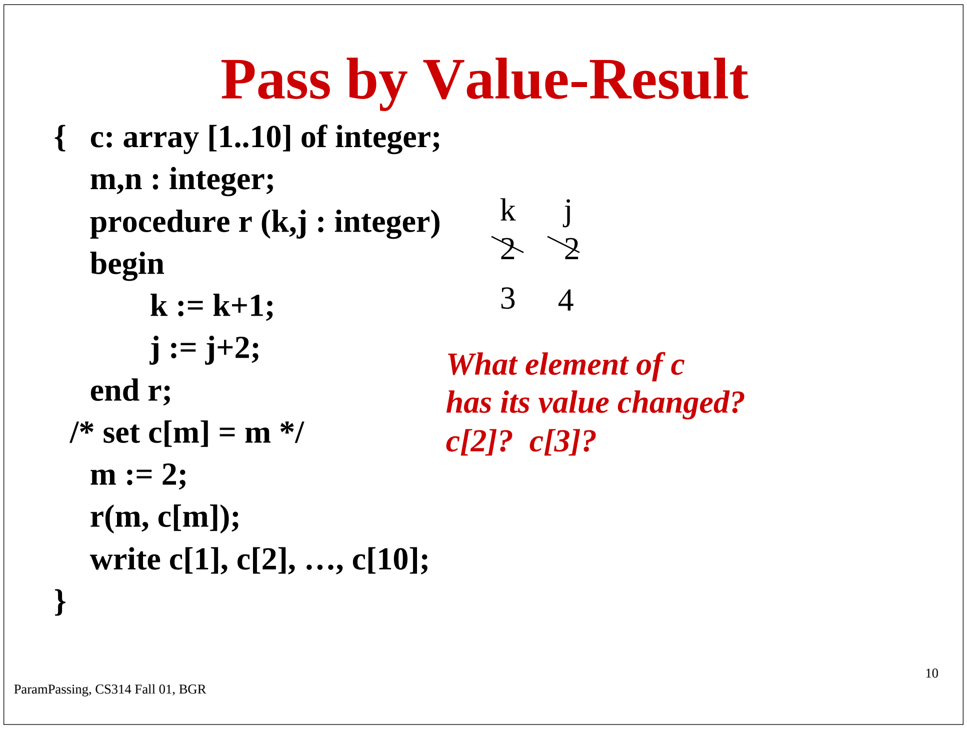
Pass by Value-Result

```
{   c: array [1..10] of integer;
    m,n : integer;
    procedure r (k,j : integer)
    begin
          k := k+1;
          j := j+2;
    end r;
…
    m := 5;
    n  := 3;
    r(m,n);
    write m,n;
}
```

By Value-Result

k	j
~~5~~	~~3~~
6	5

Output:
6   5

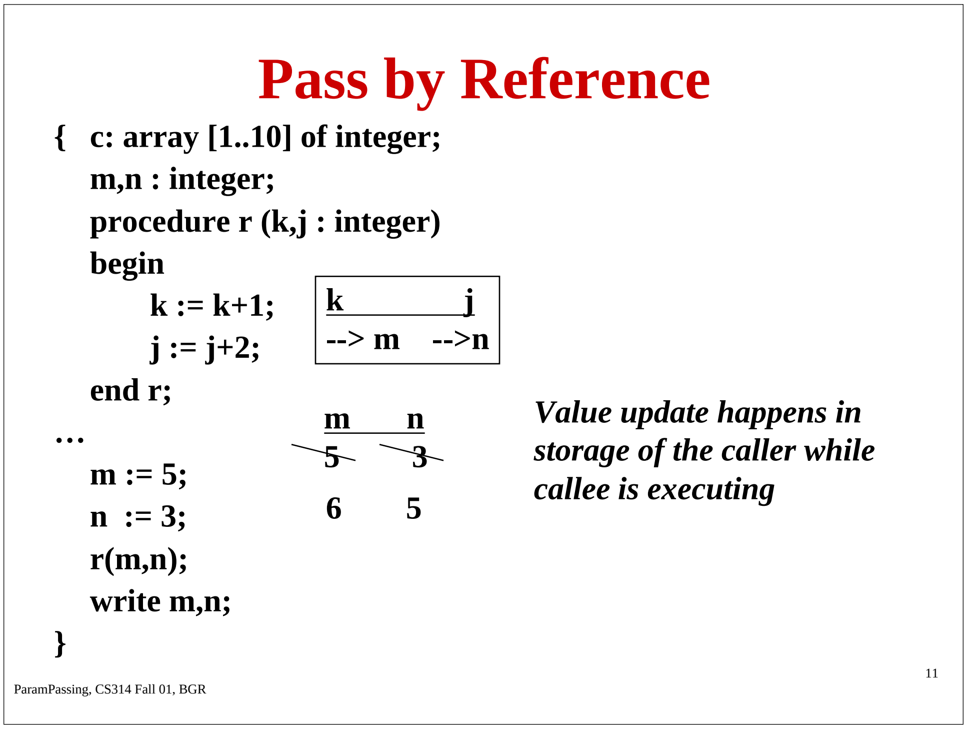


Pass by Value-Result

```
{   c: array [1..10] of integer;
    m,n : integer;
    procedure r (k,j : integer)
    begin
          k := k+1;
          j := j+2;
    end r;
  /* set c[m] = m */
    m := 2;
    r(m, c[m]);
    write c[1], c[2], …, c[10];
}
```

k	j
~~2~~	~~2~~
3	4

What element of c has its value changed? c[2]? c[3]?



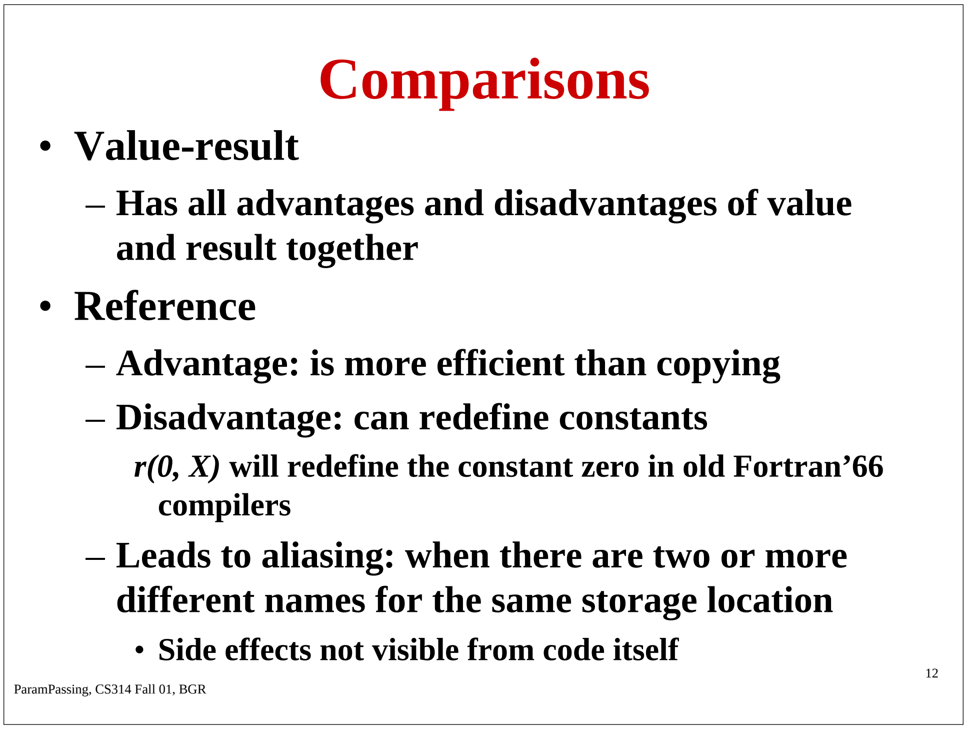
Pass by Reference

```
{   c: array [1..10] of integer;
    m,n : integer;
    procedure r (k,j : integer)
    begin
          k := k+1;
          j := j+2;
    end r;
…
    m := 5;
    n  := 3;
    r(m,n);
    write m,n;
}
```

k	j
--> m	-->n

m	n
~~5~~	~~3~~
6	5

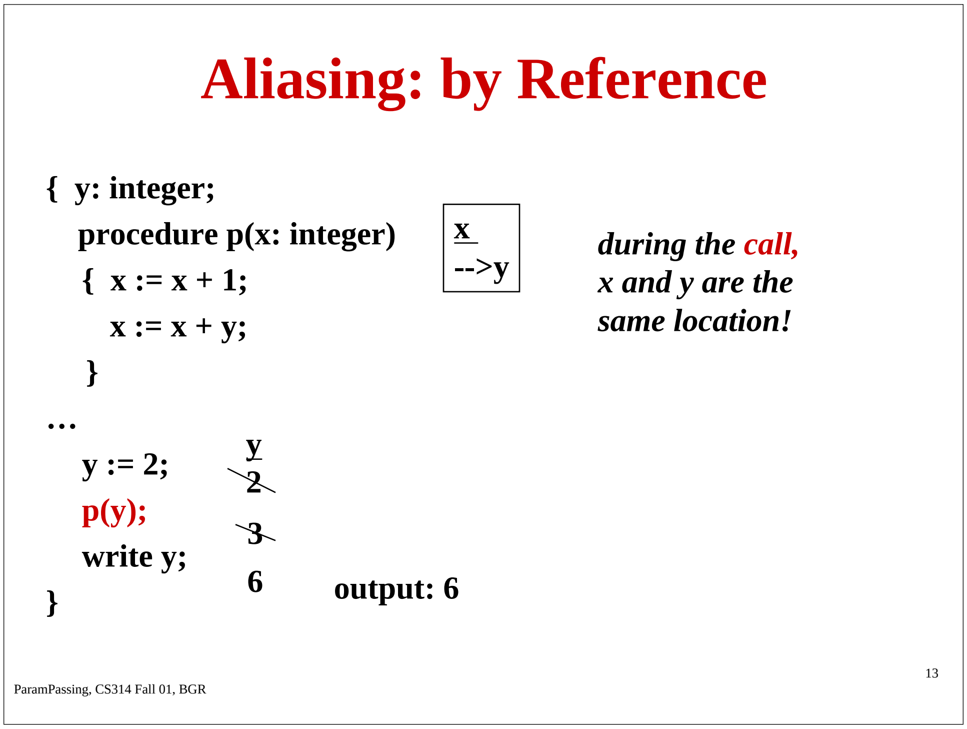
Value update happens in storage of the caller while callee is executing



Comparisons

- Value-result
  - – Has all advantages and disadvantages of value and result together
- Reference
  - – Advantage: is more efficient than copying
  - – Disadvantage: can redefine constants

    r(0, X) will redefine the constant zero in old Fortran’66 compilers
  - – Leads to aliasing: when there are two or more different names for the same storage location
    - Side effects not visible from code itself



Aliasing: by Reference

```
{  y: integer;
   procedure p(x: integer)
   {  x := x + 1;
      x := x + y;
   }
…
   y := 2;
   p(y);
   write y;
}
```

x

-->y

during the call, x and y are the same location!

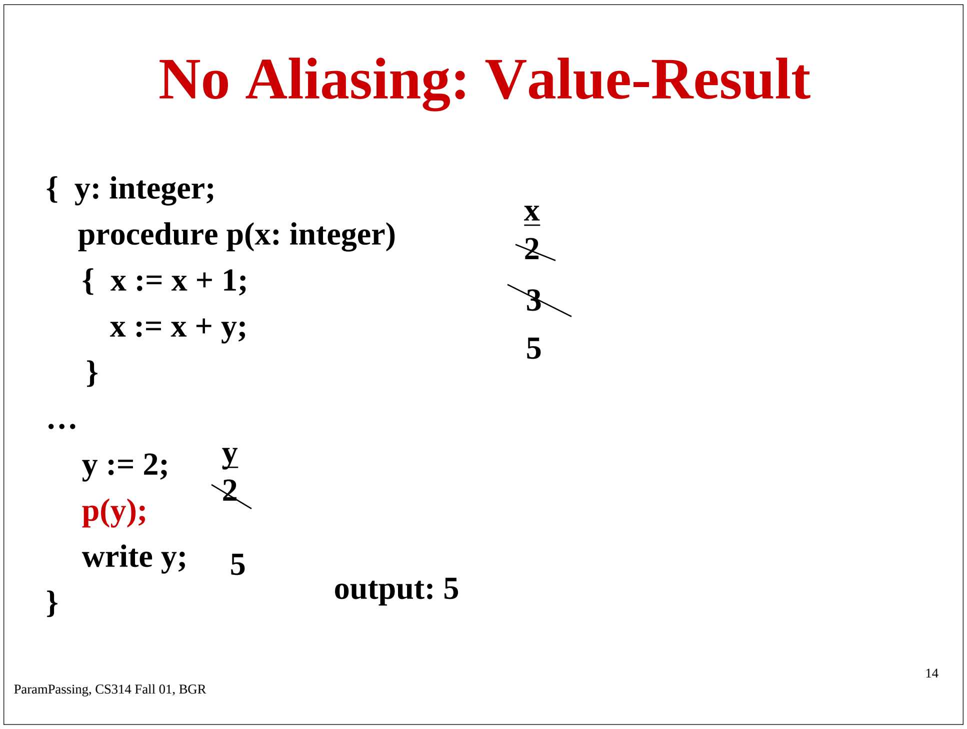
y

~~2~~

~~3~~

6

output: 6



No Aliasing: Value-Result

```
{  y: integer;
   procedure p(x: integer)
   {  x := x + 1;
      x := x + y;
   }
…
   y := 2;
   p(y);
   write y;
}
```

x

~~2~~

~~3~~

5

y

~~2~~

5

output: 5

Another Aliasing Example

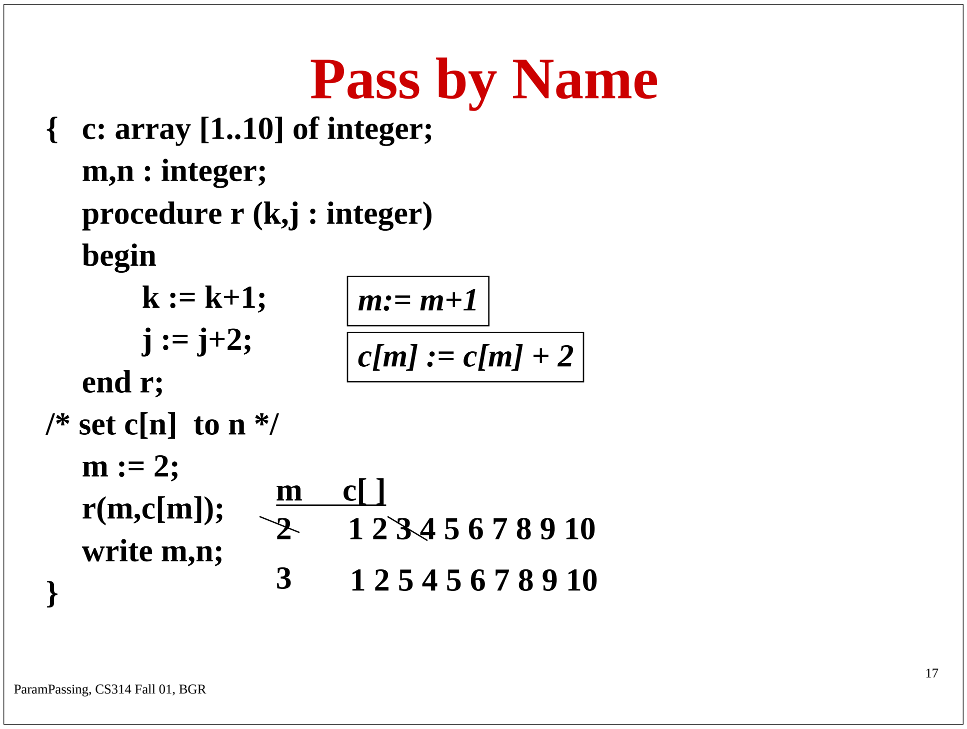
```
{   j, k, m :integer;
    procedure q( a, b: integer)
    {   b := 3;
        m := m *a;
    }
...
s1:  q(m, k);
…
s2: q(j, j);
…
}
```

global-formal aliases: <m,a> <k,b> associations during call S1;

formal-formal aliases: <a,b> during call S2;

Pass by Reference

- **Disadvantage: if an error occurs, harder to trace values since some side-effected values are in environment of the caller**
- **What happens when someone uses an expression argument for a by reference parameter?**
  - **(2*x)??**



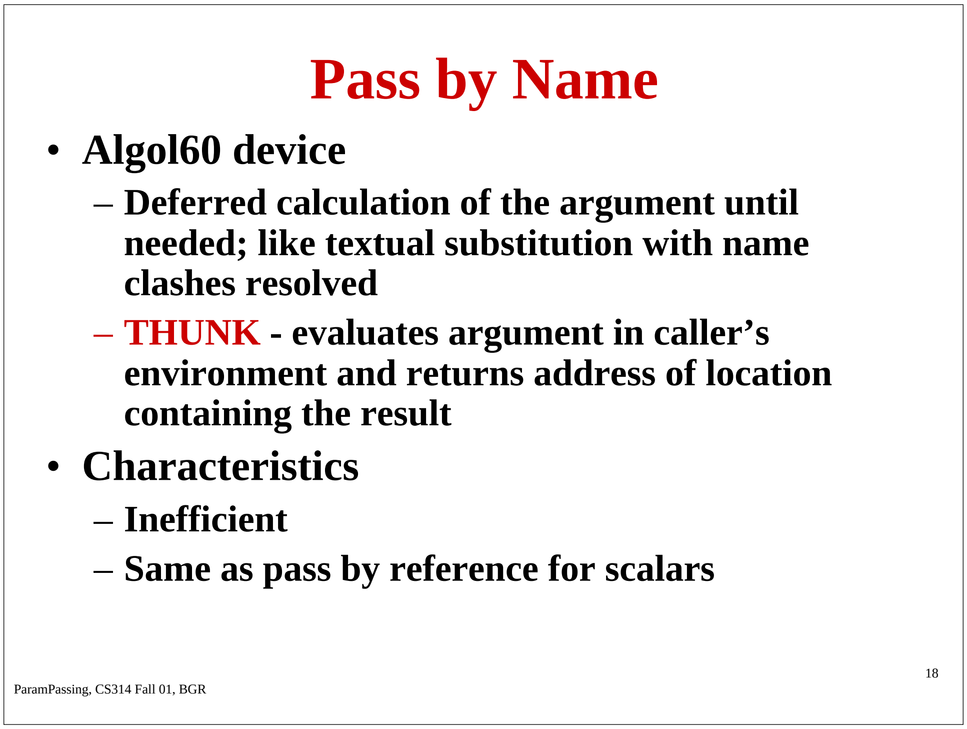
Pass by Name

```
{   c: array [1..10] of integer;
    m,n : integer;
    procedure r (k,j : integer)
    begin
         k := k+1;
         j := j+2;
    end r;
/* set c[n]  to n */
    m := 2;
    r(m,c[m]);
    write m,n;
}
```

$\boxed{m := m+1}$

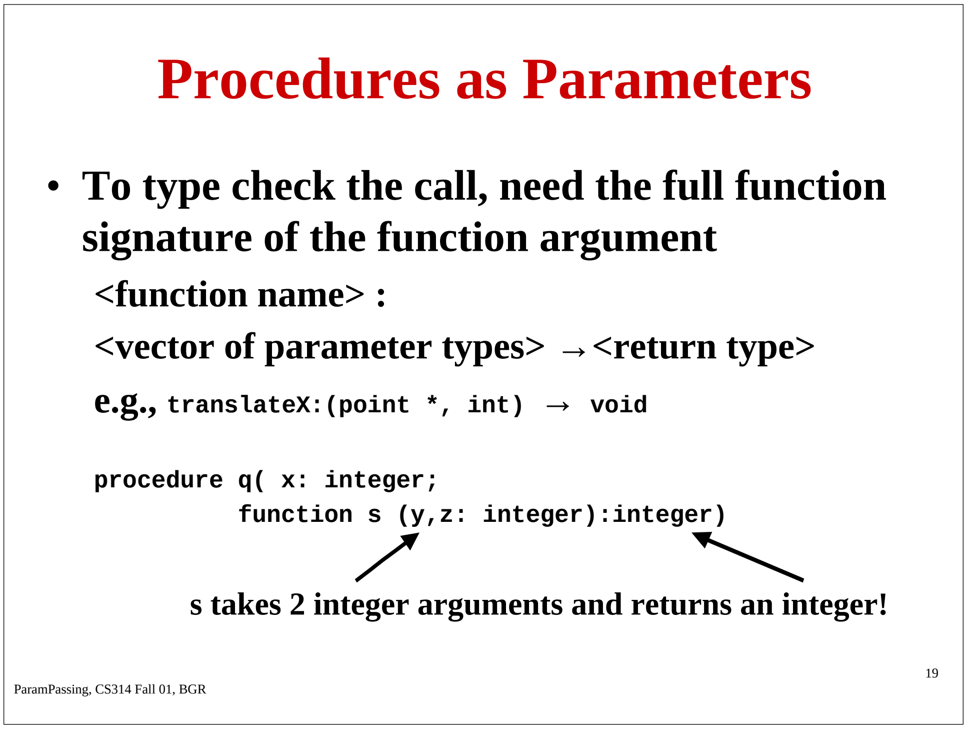
$\boxed{c[m] := c[m] + 2}$

m	c[ ]
~~2~~	1 2 ~~3~~ 4 5 6 7 8 9 10
3	1 2 5 4 5 6 7 8 9 10



Pass by Name

- Algol60 device
  - Deferred calculation of the argument until needed; like textual substitution with name clashes resolved
  - THUNK - evaluates argument in caller’s environment and returns address of location containing the result
- Characteristics
  - Inefficient
  - Same as pass by reference for scalars



Procedures as Parameters

- To type check the call, need the full function signature of the function argument

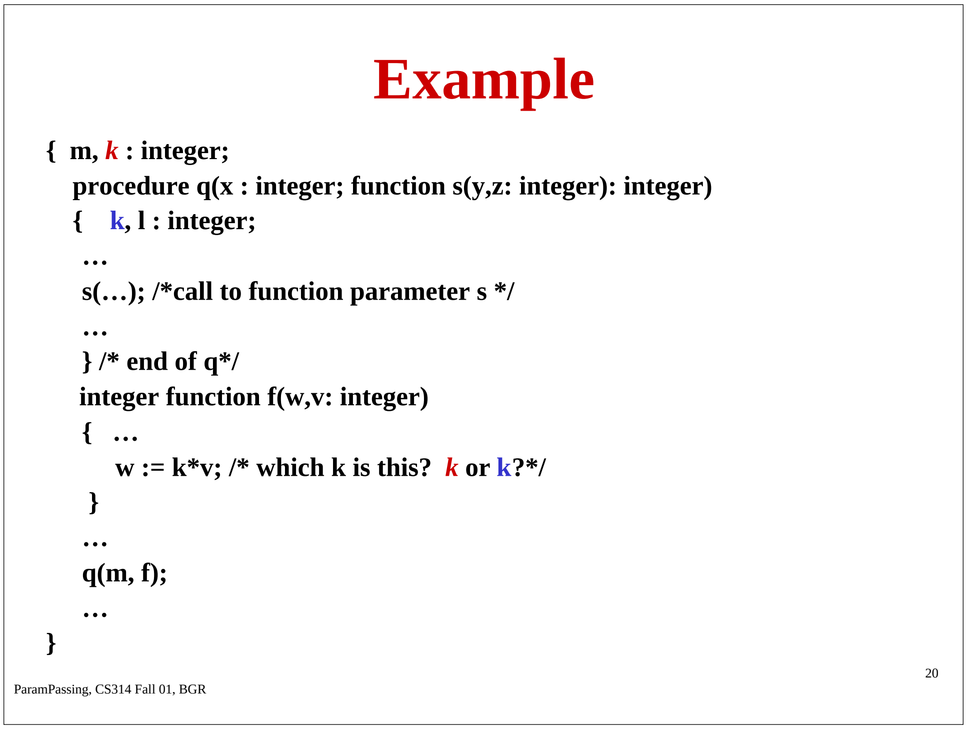
  <function name> :

  <vector of parameter types> →<return type>

  e.g., `translateX:(point *, int) → void`

```
procedure q( x: integer;
          function s (y,z: integer):integer)
```

s takes 2 integer arguments and returns an integer!



Example

```
{  m, k : integer;
   procedure q(x : integer; function s(y,z: integer): integer)
   {    k, l : integer;
    …
    s(…); /*call to function parameter s */
    …
    } /* end of q*/
    integer function f(w,v: integer)
    {  …
        w := k*v; /* which k is this?  k or k?*/
     }
    …
    q(m, f);
    …
}
```