Semantic Analysis
&
Symbol Table Mnagement

Lecture 6

Announcements

- PA 2
  - Due today (13 Feb.) at 11:59pm
- WA 2
  - Due next Thursday (20 Feb.) at 11:59pm
- PA 3
  - Released today

Static versus Dynamic Checking

- *Static checking*: the compiler enforces programming language's *static semantics*
  - Program properties that can be checked at compile time

- *Dynamic semantics*: checked at run time
  - Compiler generates verification code to enforce programming language's dynamic semantics

Static Checking Examples

- Type checks: *in A := B + C, all operands should have the same type*
- Flow-of-control checks: *check whether a e.g. break statement has somewhere to return control.*
- Uniqueness checks: *In some languages names must be unique*
- Named-related checks: *In ADA for loops can have name, and it must appear twice (before the for keyword and before the end statement).*

Type Checks, Overloading, and Coercion

```
int op(int), op(float);
int f(float);
int a, c[10], d;

d = c+d;        error: invalid conversion from 'int*' to 'int'
                d = d + c;
                    ↑
*d = a;         error: invalid type argument of unary '*'
                *d = a;
                  ↑
a = op(d);              // OK: overloading (C++)

a = f(d);               // OK: coercion of d to float
```

Flow-of-Control Checks

```
myfunc()
{ …
  break; // ERROR
}
```

```
myfunc()
{ …
  while (n)
  { …
    if (i>10)
      break; // OK
  }
}
```

```
myfunc()
{ …
  switch (a)
  { case 0:
      …
      break; // OK
    case 1:
      …
  }
}
```

Uniqueness Checks

```
myfunc()
{ int i, j, i; // ERROR
  …
}
```

```
struct myrec
{ int name;
};
struct myrec // ERROR
{ int id;
};
```

```
myfunc(int a, int a) // ERROR
{   …
}
```

Nested Related Checks

```
LoopB: for (int J = 0; J < m; J++)
        {
                LoopA: for (int I = 0; I < n; I++)
                 { …
                        if (a[I] == 0)
                         break LoopB; // Java labeled loop
          …
                 }
        }
```

One-Pass versus Multi-Pass Static Checking

- One-pass compiler: static checking in C, Pascal, Fortran, and many other languages is performed in one pass while intermediate code is generated
  (Influences design of a language: placement constraints)

- Multi-pass compiler: static checking in Ada, Java, and C# is performed in a separate phase, sometimes by traversing a syntax tree multiple times

Dynamic Checking

- A piece of object code is added to the compiled program to perform the checking in the execution time

- Example:
  var a[10] int; …; read (I); a(I) := 0;

- Generated code is as such the last statement would have been:

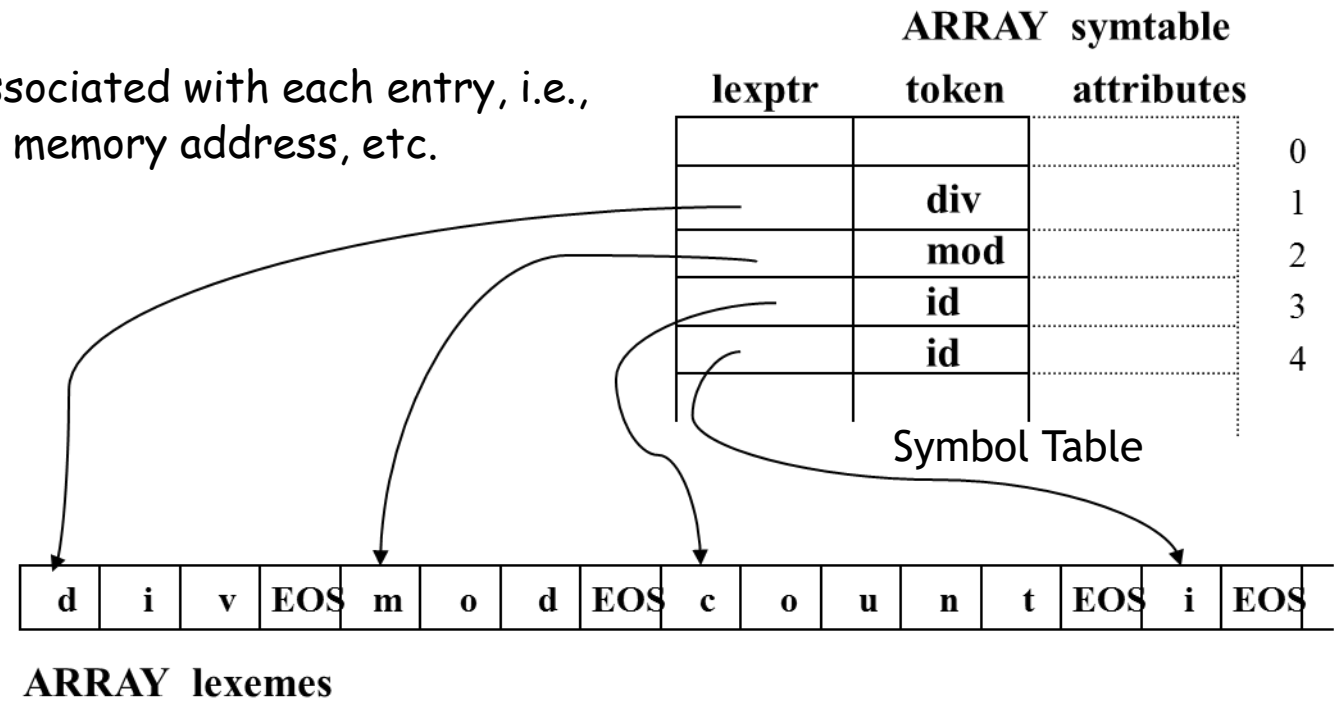
  If I <= 10 then a(I) := 0 else print ("subscript out of range error")

Symbol Table Management

OPERATIONS: Insert (string, token_ID)
Lookup (string)

NOTICE: Reserved words are placed into symbol table for easy lookup

Attributes may be associated with each entry, i.e., typing info, size info, memory address, etc.



Example

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        begin … a … end;

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    procedure quicksort(m, n: integer);
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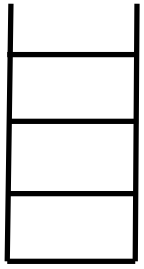

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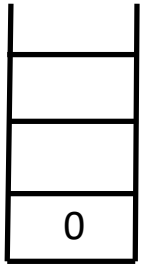

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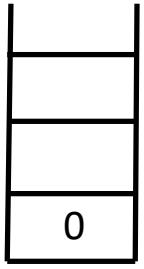

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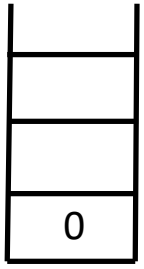

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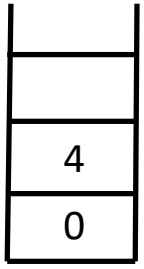

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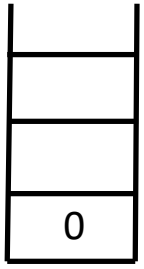

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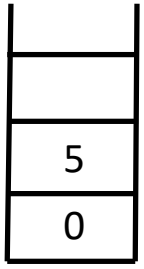

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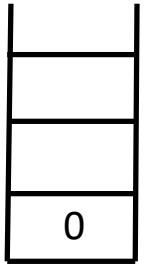

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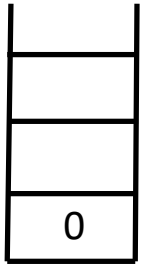

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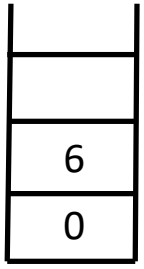

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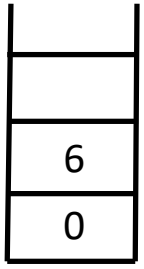

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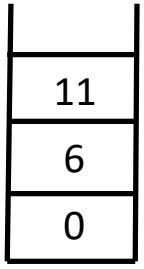

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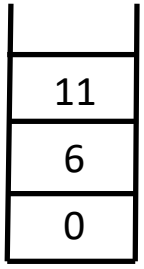

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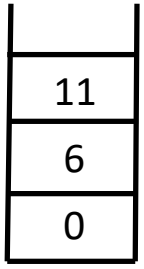

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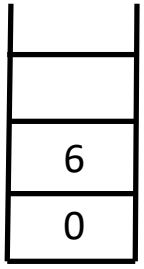

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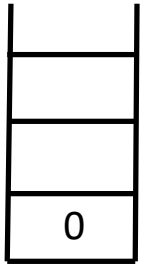

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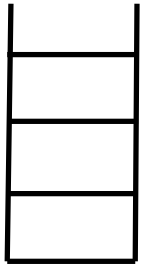
    procedure exchange( i, j, : integer);
        begin
                x := a[i]; a[i] := a[j]; a[j] := x
        end
    procedure quicksort(m, n: integer);
        var k, v : integer;
        function partition(y, z: integer) : integer;
            var i, j : integer;
            begin   … a …
                    … v …
                    … exchange(i, j); …
        end { partition };
        begin … end { quicksort }
begin … end { sort }.
```

Example (Cont.)



Scope Stack

symbol table

	lexeme	type	attributes
0			
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			

```
program sort(input, output);
    var a : array [0 .. 10] of integer; x : integer;
    procedure readarray;
        var i : integer;
        begin … a … end;
    procedure exchange( i, j, : integer);
        begin
                x := a[i]; a[i] := a[j]; a[j] := x
        end
    procedure quicksort(m, n: integer);
        var k, v : integer;
        function partition(y, z: integer) : integer;
            var i, j : integer;
            begin    … a …
                     … v …
                     … exchange(i, j); …
        end { partition };
        begin … end { quicksort }
begin … end { sort }.
```