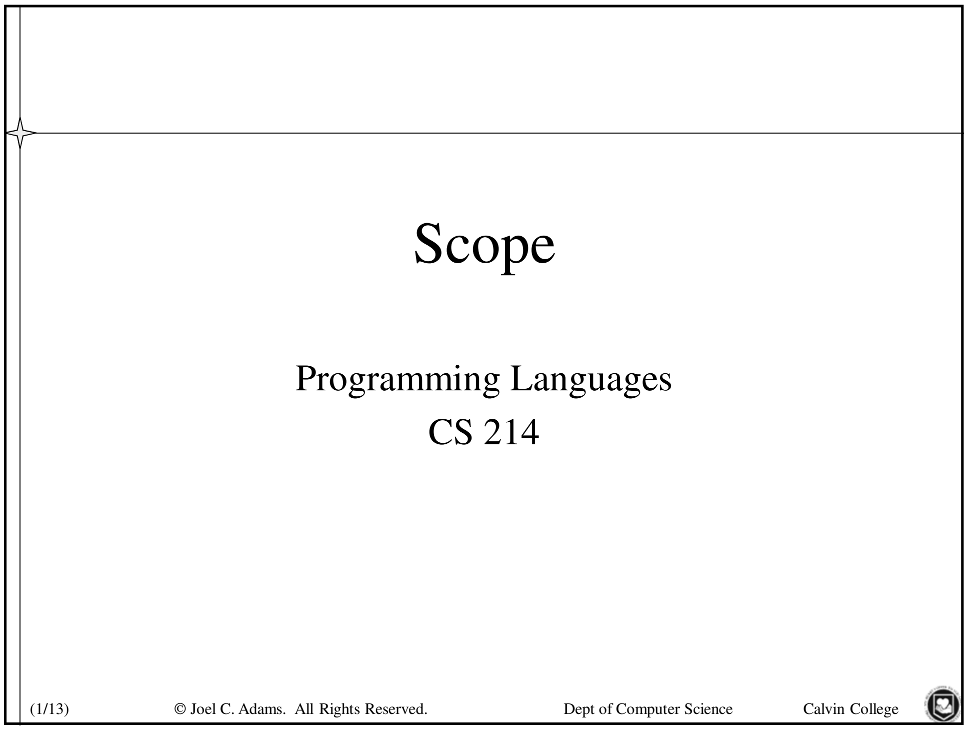
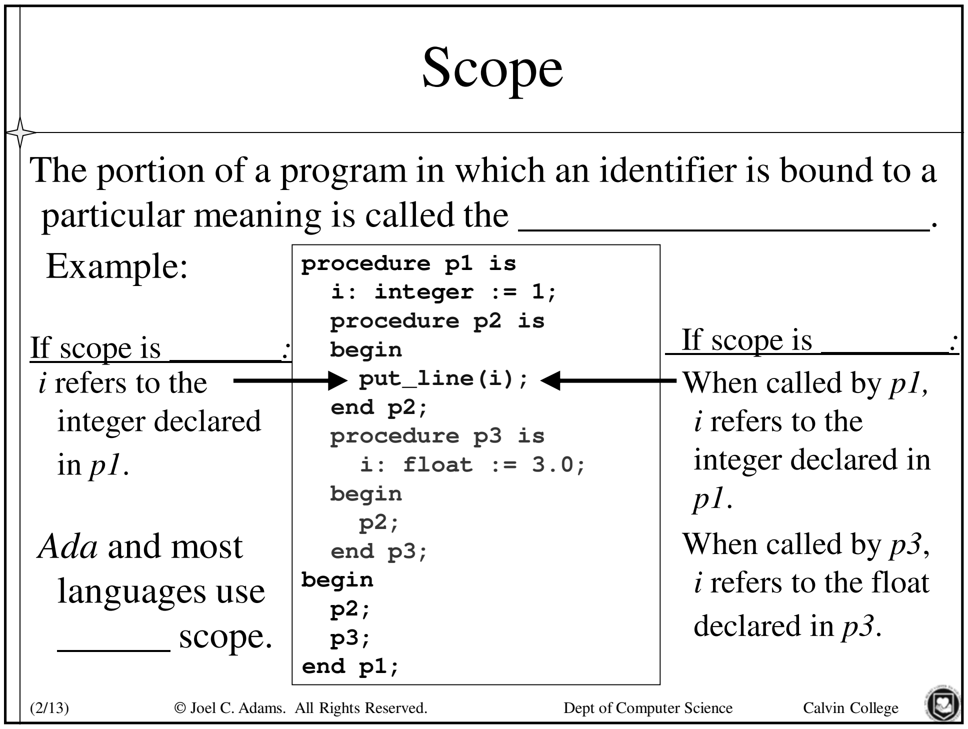


Scope

Programming Languages
CS 214



Scope

The portion of a program in which an identifier is bound to a particular meaning is called the ________________________.

Example:

```
procedure p1 is
  i: integer := 1;
  procedure p2 is
  begin
    put_line(i);
  end p2;
  procedure p3 is
    i: float := 3.0;
  begin
    p2;
  end p3;
begin
  p2;
  p3;
end p1;
```

If scope is ________:
i refers to the integer declared in *p1*.

Ada and most languages use _______ scope.

If scope is ________:
When called by *p1*, *i* refers to the integer declared in *p1*.
When called by *p3*, *i* refers to the float declared in *p3*.

Dynamic Scope

Lisp uses *dynamic scope*, in which an identifier's binding is ___________________________.

The meaning of a symbol depends on the *run-time context* in which it is accessed.

Example: If we write:

```
(setq i 0)

(defun p2 ()
  (princ i)
  (terpri))

(defun p3 ()
  (let ((i 3.0))
        (p2)))

(defun p1 ()
 (setq i 1)
 (p2)
 (p3))
```

and then call *p2* by itself:

```
(p2)    ;; call p2
_____   ;;  by itself
```

but if we call *p2* in different contexts (*p1* vs. *p3*):

```
(p1)    ;; call p2
_____   ;;  within p1
_____   ;;  within p3
```

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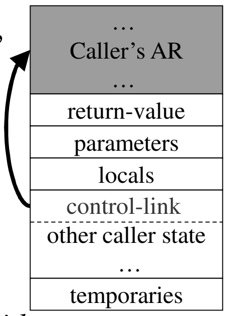
Dynamic Scope: What is happening?

Each activation record contains a ___________, pointing to the activation record of its caller:



When an identifier *id* is accessed, the system follows this algorithm:

```
a. temp = stack pointer;
b. do (in the AR pointed to by temp):
     1) found = search temp's parameters/locals for id;
     2) if not found: temp = temp->control_link;
   while temp != NULL && not found.
```

On a non-local access, dynamic scope ________________________ "down" through the run-time stack until a definition of *id* is found.

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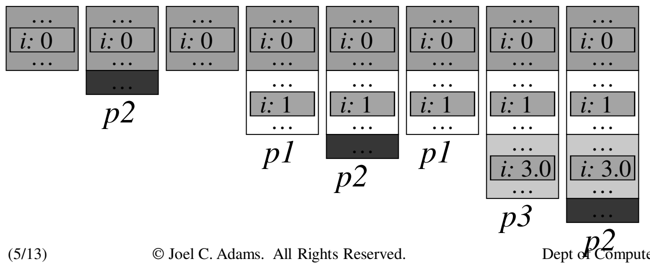
Dynamic Scope: Trace

The initial *setq* defines *i* globally...
We call *p2*, which searches down, finds *i* == 0
p2 terminates...
We call *p1* that defines *i* as the integer 1...
p1 calls *p2*, which searches down, finds *i* == 1
p2 terminates...
p1 calls *p3*, which defines *i* as the real 3.0
p3 calls *p2*, which searches down, finds *i* == 3.0

```
(setq i 0)

(defun p2 ()
  (princ i)
  (terpri))

(defun p3 ()
  (let ((i 3.0))
        (p2)))

(defun p1 ()
 (setq i 1)
 (p2)
 (p3))
```

```
(p2)
_____
```

```
(p1)
_____
_____
```



Static Scope

______________ *languages* bind identifiers at _____________.

The basic static scope rule:

The scope of a binding begins at an identifier's ___________; and ends at ____________________ __________________________.

So *p2 always* accesses integer *i*, because *p2* lies within its scope, and not within the scope of float *i*.

A *scope context* is the construct used by a particular language to delimit a binding's scope.

```
procedure p1 is
  i: integer := 1;
  procedure p2 is
  begin
    put_line(i);
  end p2;
  procedure p3 is
    i: float := 3.0;
  begin
    p2;
  end p3;
begin
  p2;
  p3;
end p1;
```

Static Scope: Holes

A nested declaration of the same identifier creates a _______ in the scope of the outer binding:

- Within *p3*, references to *i* access float *i*, not integer *i*.
- Ada provides a workaround: within *p3* , _____ will access integer *i*.

```
procedure p1 is
  i: integer := 1;
  procedure p2 is
  begin
    put_line(i);
  end p2;
  procedure p3 is
    i: float := 3.0;
  begin
    p2;
  end p3;
begin
  p2;
  p3;
end p1;
```

Holes are not limited to Ada...

```
char i = 'J';
{
  int i = 1;    // char i now
 if (  …  )    // hidden
  {
    double i = 3.0;
  } // char, int i both hidden
}
```

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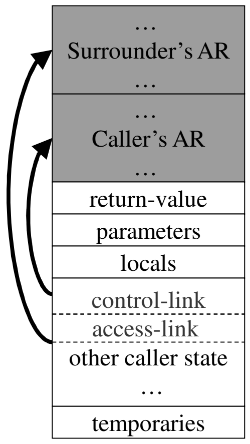
Static Scope: How it works

In addition to the control-link, static-scoped languages add an _____________ that points to the AR of the *textually-surrounding scope context* (which may or may not be the caller).

– The textually-surrounding scope context is guaranteed to be already on the stack; otherwise this subprogram could not be called.

– *Non-local accesses* ____________________ to find the definition, instead of control-links.



Access-link traversal occurs at run-time, so ______________ ______________________________ than accesses to locals.

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Static Scope: Trace

We run our program (*p1*)...

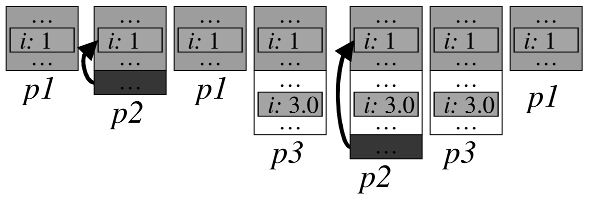
p1 calls *p2*, which traverses its access-links to find integer *i* == 1

p2 terminates...

p1 calls *p3*, which defines *i* as the real 3.0

p3 calls *p2*, which traverses its access-links to find integer *i* == 1

p2 terminates... *p1* terminates...



```
procedure p1 is
  i: integer := 1;
  procedure p2 is
  begin
    put_line(i);
  end p2;
  procedure p3 is
    i: float := 3.0;
  begin
    p2;
  end p3;
begin
  p2;
  p3;
end p1;
```

Note: *i*'s *physical address* is ________________________________...

Non-local Accesses

Non-locals should be avoided where possible because:

- Non-local accesses take 2+ times as long as local accesses
  - Traversal of access-links at run-time increases access time.
- Non-local accesses separate the *use* of an identifier from its *declaration*, ______________________*and maintainability*.
- Subprograms that access non-locals are *not self-contained*, *reducing their modularity*, as they ________ *the non-local*.
- If a subprogram accesses no non-locals, then *it doesn't matter whether the language uses static or dynamic scope*
  - Static- and dynamic-scoped languages ______________________ ____.

Non-local Accesses (ii)

Non-local accesses cannot be completely avoided though…

```
#include <iostream> using namespace std;

class Point {
 public:
  Point(int x, int y) { myX = x; myY = y; }
  int getX() const { return myX; }
  int getY() const { return myY; }
  void print(ostream & out)
    { out << '(' << myX << ',' << myY << ')'; }
 private:
  int myX, myY;
};

int main() {
  Point aPoint(0, 0);
  aPoint.print(cout);
}
```

How many non-local accesses can you find in this example ?

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Non-local Accesses (ii)

Non-local accesses cannot be completely avoided though…

```
#include <iostream> using namespace std;

class Point {
 public:
  Point(int x, int y) { myX = x; myY = y; }
  int getX() const { return myX; }
  int getY() const { return myY; }
  void print(ostream & out)
    { out << '(' << myX << ',' << myY << ')'; }
 private:
  int myX, myY;
};

int main() {
  Point aPoint(0, 0);
  aPoint.print(cout);
}
```

How many non-local accesses can you find in this example ?

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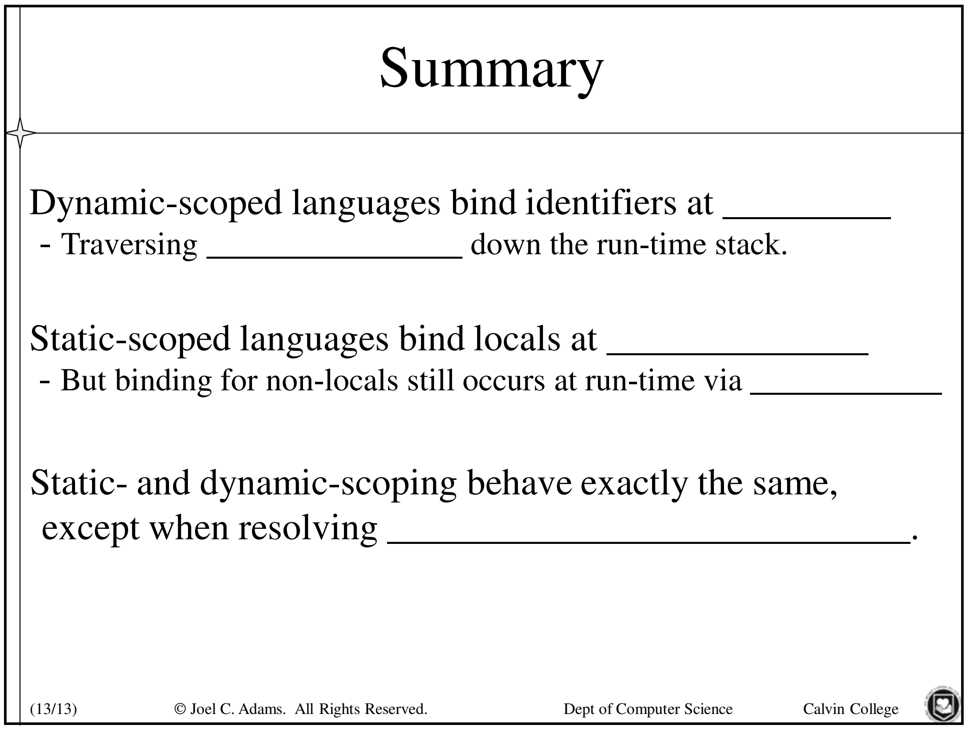

Summary

Dynamic-scoped languages bind identifiers at _________
- Traversing ______________ down the run-time stack.

Static-scoped languages bind locals at ______________
- But binding for non-locals still occurs at run-time via __________

Static- and dynamic-scoping behave exactly the same, except when resolving ____________________________.

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