Concepts Introduced in Chapter 7

- Storage Allocation Strategies
  - Static
  - Stack
  - Heap
- Activation Records
- Access to Nonlocal Names
  - Access links

followed by Fig. 7.1

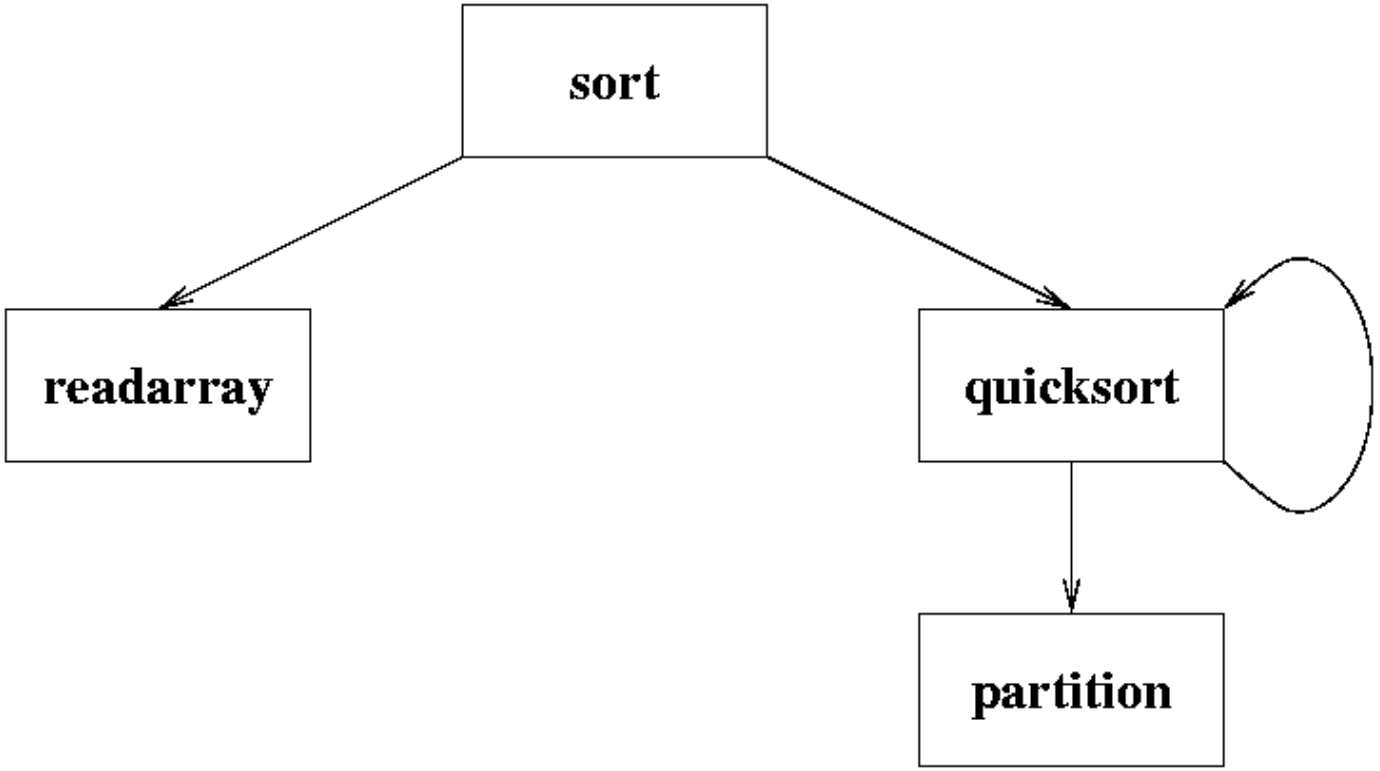
Activation Records

- An activation record is usually a contiguous block of storage that holds information relevant to one activation (execution) of a routine.
- Activation records can be placed in different storage areas depending on the run-time environment of the programming language.
  - Static data: FORTRAN
  - Stack: ALGOL, C, Pascal, Ada, C++
  - Heap: Functional Languages
    - LISP, ML, Haskell, Erlang

followed by Fig. 7.2, 7.3, 7.4

Call Graphs

- Call graphs represent the possible sequence of function calls in a program.



followed by Fig. 7.5

Typical Actions During Call / Return

- Calling sequence actions
  - caller assigns the actual arguments.
  - caller stores return address.
  - caller jumps to callee.
  - callee adjusts stack pointer for the activation record.
  - callee saves nonscratch register values it will use.
- Return sequence actions
  - callee assigns the return value.
  - callee restores nonscratch register values and stack pointer address.
  - callee jumps to the return address.
  - caller accesses the return value.

Storage Allocation Strategies

- Static Allocation - lays out storage for all data objects at compile time
  - Restrictions
    - size of object must be known and alignment requirements must be known at compile-time
    - no recursion
    - no dynamic data structures

Storage Allocation Strategies (cont.)

- Stack allocation - manages run-time storage as a stack (LIFO model)
  - Activation record is pushed on as function is entered.
  - Activation record is popped off as function is exited.
  - Restrictions
    - Values of locals cannot be retained when an activation ends.
    - A called activation cannot outlive a caller.

followed by Fig. 7.6, 7.7

Issues to Address in Calling Conventions

- Responsibility of the caller versus the callee.
- Identifying registers for special purposes.
  - stack pointer, frame pointer, return address
- Preserving the value of registers across calls.
  - callee save, caller save
- Passing arguments.
  - through registers, on the stack

followed by Fig. 7.8

Dangling Reference

```
main ( )
{
    int *p;
    p = dangle ( );
}

int *dangle ( )
{
    int i = 23;
    return &i;
}
```

Storage Allocation Strategies (cont.)

- Heap Allocation - allocates and deallocates storage as needed at run-time from a data area known as a heap
  - Most flexible
  - Most inefficient

Heap Storage Reclamation Strategies

- explicit reclamation
  - used in Pascal, Ada, C, C++
  - complicates programming
- implicit reclamation
  - used in Lisp and Java
  - reference counts
  - mark and sweep (garbage collection)

Access to Nonlocal Names

- The scope of a declaration in a block-structured language is given by the most closely nested rule:
  - The scope of a declaration in a block B includes B.
  - If a name X is not declared in a block B, then an occurrence of X in B is in the scope of a declaration of X in an enclosing block B´ such that
    - B´ has a declaration of X, and
    - B´ is more closely nested around B than any other block with a declaration of X.

Lexical Scope without Nested Procedures

- The lexical-scope rules for a language without nested procedures, such as C, are simpler than those of a block-structured language, such as Pascal.
- The scope of a declaration outside a function consists of the function bodies that follow the declaration.

Lexical Scope without Nested Procedures (cont.)

- C functions accesing a nonlocal variable `a`.

```
int a[11];
readarray() { ... a ... }
int partition(int y, int z) { ... a ... }
quicksort(int m, int n) { ... a ... }
main() { ... a ... }
```

- Note that all functions access the same `a`.
- Functions in C can be easily passed as parameters and can be returned as a function result.

Lexical Scope with Nested Procedures

- In a block structured language, a procedure can access nonlocal names that are local variables in other procedures.
- Since such variables are local variables in other procedures, they are placed in activation records on the run-time stack.
- How can they be accessed at run-time?

followed by Fig. 7.10

Referencing Variables with Access Links

- An access link points to most recent activation of the procedure that contains the current procedure.
- Suppose
  - Np is the nesting depth of procedure `p` that refers to a nonlocal variable `a`.
  - Na is the nesting depth of procedure that contains `a`.
- Np - Na access links would have to be traversed when in procedure `p` to get to the activation record that contains `a`.

followed by Fig. 7.11, 7.12, 7.13

Establishing Access Links

- Suppose p calls x.
- Two cases for setting up the access link.
  - If Np < Nx
    - Procedure x is nested more deeply than procedure p. x must be declared within p. The access link should point to the caller.
  - If Np ≥ Nx
    - Follow Np –Nx + 1 access links from the caller to reach the activation record of the procedure that encloses the called procedure x most closely.

followed by Fig. 7.14