Compiler Design

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Run Time Environments

Compiler must do the storage allocation and provide access to variables and data.

- The allocation and deallocation of data objects is managed by the **runtime support package**, consisting of routines loaded with the generated target code.
- Each execution of a procedure is referred to as an **activation** of the procedure.
- If the procedure is **recursive**, several of its activations may be alive at the same time.

Activation Trees

we make the following assumptions about the flow of control among procedures during execution of a program:

- Control flows sequentially; that is the execution of a program consists of a sequence of steps, with control being at some specific point in the program at each step.
- Each **execution** of a procedure starts at the beginning of the procedure body and eventually returns the control to the point immediately following the place where the procedure was called.

Lifetime : refers to a consecutive sequence of steps during the execution of a program.

Sketch of a Quicksort Programe

```
int a[11];
void readArray() { /* Reads 9 integers into a[1], ..., a[9]. */
    int i;
    ...
}
int partition(int m, int n) {
    /* Picks a separator value v, and partitions a[m..n] so that
       a[m..p-1] are less than v, a[p] = v, and a[p+1..n] are
       equal to or greater than v. Returns p. */
    ...
}
void quicksort(int m, int n) {
    int i;
    if (n > m) {
        i = partition(m, n);
        quicksort(m, i-1);
        quicksort(i+1, n);
    }
}
main() {
    readArray();
    a[0] = -9999;
    a[10] = 9999;
    quicksort(1,9);
}
```

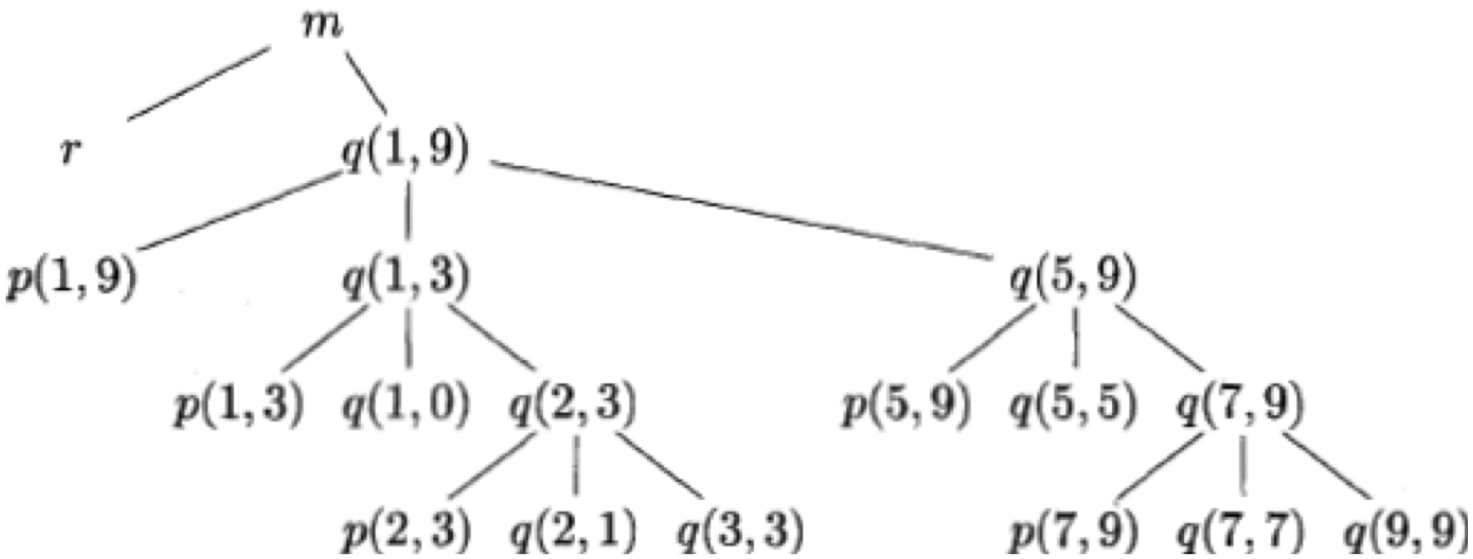
Activations for Quicksort

```
enter main()
    enter readArray()
    leave readArray()
    enter quicksort(1,9)
        enter partition(1,9)
        leave partition(1,9)
        enter quicksort(1,3)
            ...
        leave quicksort(1,3)
        enter quicksort(5,9)
            ...
        leave quicksort(5,9)
    leave quicksort(1,9)
leave main()
```

In an activation tree:

- each node represents an activation of a procedure.
- the root represents the activation of the main program.
- The node *a* is the parent of the node for *b* if and only if control flows from activation a to b;
- The node for a is to the left of the node for b if and only if the lifetime of a occurs before the lifetime of b.

Activation tree representing calls during an execution of quicksort

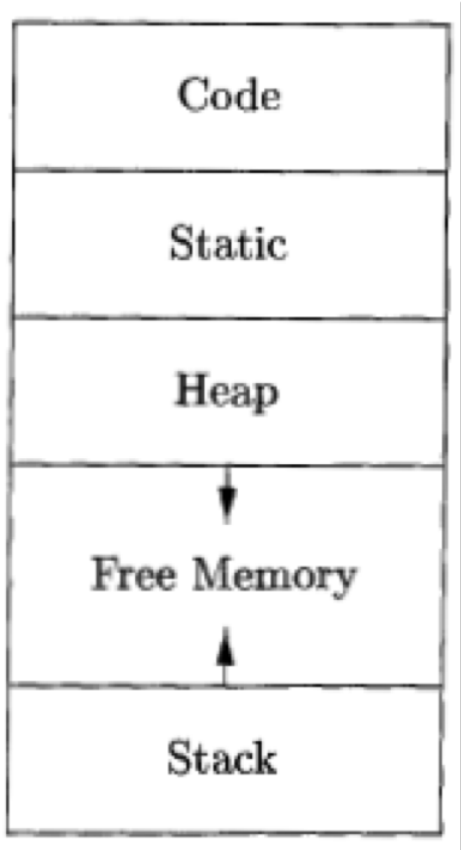


Storage Organization

Suppose that the compiler obtains a block of storage from the operating system for the compiled program to run in. Run time storage might be subdivided to hold:

- the generated target code,
- data objects, and
- a counter part of the control stack to keep track of procedure activation.

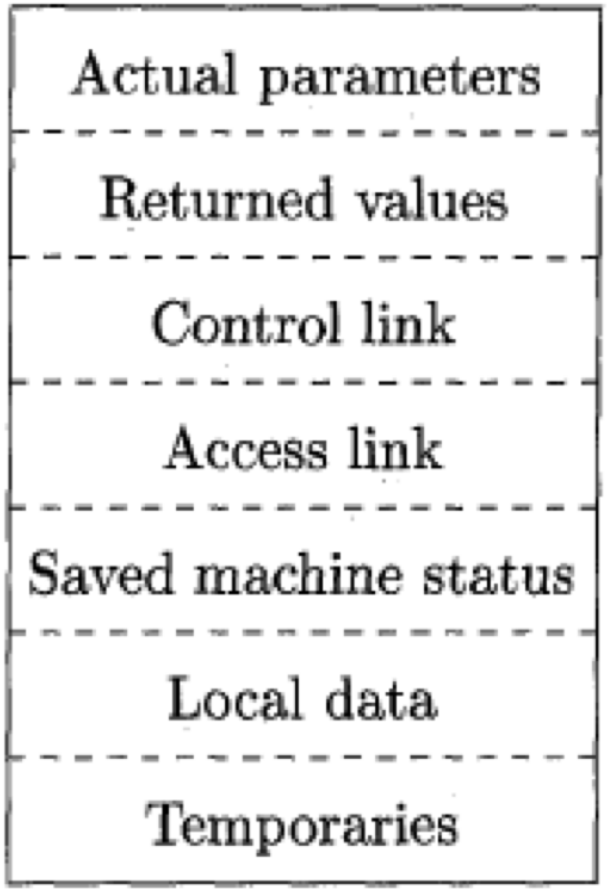
Typical subdivision of run-time memory into code and data areas



Activation Records

- Procedure calls and returns are usaully managed by a run-time stack called the control stack.
- Each live activation has an active record (sometimes called frame).
- The root of activation tree is at the bottom of the stack.
- The current execution path specifies the content of the stack with the last activation has record in the top of the stack.

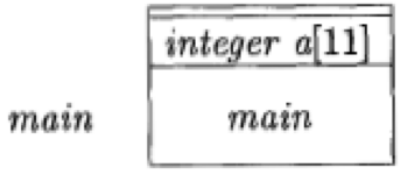
A general Activation Record



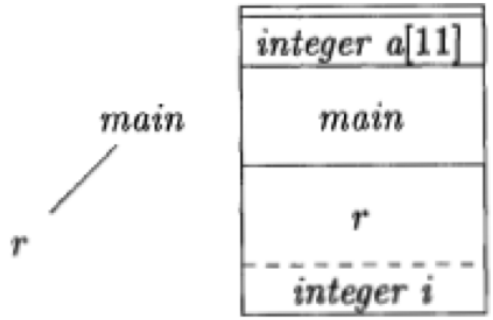
Activation Record

- **Temporary Values** - stores those which are arising in the evaluation of expression.
- **Local Data** - holds data that is local to an execution.
- **saved machine status** - holds information about the state of the machine just before the procedure call. This information typically includes the *return address*.
- **access link** - used to refer non-local data held in other activation records.
- **control link** - points to the activation record of the caller.
- Space for the **return value** of the called function.
- **Actual parameters** used by the calling procedure.

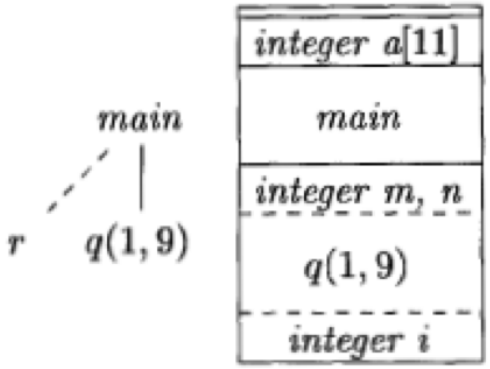
Downward growing stack of the activation records

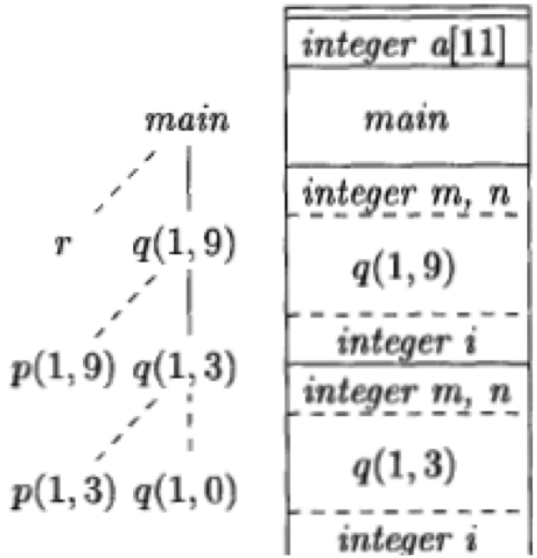


(a) Frame for *main*



(b) r is activated





Possible call Sequences

- The Caller Evaluates actuals.
- The Caller stores a return address and the old value of *top_sp* in to the callee's activation record. The caller then increments *top_sp* and moved past the caller's local data and temporaries and the callee's parameter and status field.
- The callee saves register values and other status information.
- The callee initializes its local data and begin execution.

A possible return sequences:

- The callee places a return value next to the activation record of the caller.
- using the information in the status field, the callee restores *top_sp* and other registers and branches to a return address in the caller's code.