CENG3420
Lab 1-3: Quick Sort

Haoyu Yang

Department of Computer Science and Engineering
The Chinese University of Hong Kong

hyyang@cse.cuhk.edu.hk

Spring 2018

香港中文大學
The Chinese University of Hong Kong

Last Time

Array Definition

```
    .data
a: .word 1 2 3 4 5}
```

`a` is the address of first element

Branch

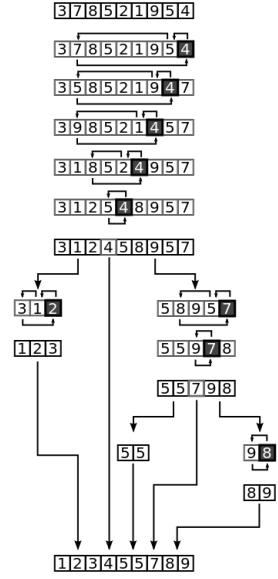
`jal` (PC is stored in $ra)

`j jr beq blt bgt`

Quick Sort

Quick Sort Overview

Quicksort is a divide and conquer algorithm. Quicksort first divides a large array into two smaller sub-arrays: the low elements and the high elements. Quicksort can then recursively sort the sub-arrays.

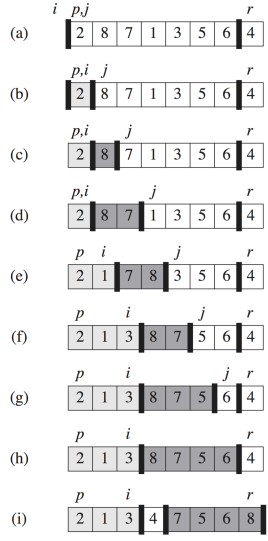


Quick Sort: Partitioning

- Pick an element, called a pivot, from the array.
- Reorder the array so that all elements with values less than the pivot come before the pivot, while all elements with values greater than the pivot come after it (equal values can go either way).

```
1:  function PARTITION(A, lo, hi)
2:      pivot ← A[hi]
3:      i ← lo-1;
4:      for j = lo; j ≤ hi-1; j ← j+1 do
5:          if A[j] ≤ pivot then
6:              i ← i+1;
7:              swap A[i] with A[j];
8:          end if
9:      end for
10:     swap A[i+1] with A[hi];
11:     return i+1;
12: end function
```

Example of Partition()



∗

∗In this example, p = lo and r = hi.

Quick Sort: Sorting

- Recursively apply the partition to the sub-array of elements with smaller values and separately to the sub-array of elements with greater values.

```
1: function QUICKSORT(A, lo, hi)
2:     if lo < hi then
3:         p ← partition(A, lo, hi);
4:         quicksort(A, lo, p - 1);
5:         quicksort(A, p + 1, hi);
6:     end if
7: end function
```

Compiling a Recursive Procedure

A procedure for calculating factorial

```
int fact (int n)
{
    if (n < 1) return 1;
    else return (n * fact (n-1));
}
```

- A recursive procedure (one that calls itself!)

```
fact (0) = 1
fact (1) = 1 * 1 = 1
fact (2) = 2 * 1 * 1 = 2
fact (3) = 3 * 2 * 1 * 1 = 6
fact (4) = 4 * 3 * 2 * 1 * 1 = 24
. . .
```

- Assume n is passed in `$a0`; result returned in `$v0`

Compiling a Recursive Procedure (cont.)

```
fact: addi  $sp, $sp, -8      #adjust stack pointer
      sw    $ra, 4($sp)       #save return address
      sw    $a0, 0($sp)       #save argument n
      slti  $t0, $a0, 1       #test for n < 1
      beq   $t0, $zero, L1    #if n >=1, go to L1
      addi  $v0, $zero, 1     #else return 1 in $v0
      addi  $sp, $sp, 8       #adjust stack pointer
      jr    $ra               #return to caller
L1:   addi  $a0, $a0, -1      #n >=1, so decrement n
      jal   fact              #call fact with (n-1)
                              #this is where fact returns
bk_f: lw    $a0, 0($sp)       #restore argument n
      lw    $ra, 4($sp)       #restore return address
      addi  $sp, $sp, 8       #adjust stack pointer
      mul   $v0, $a0, $v0     #$v0 = n * fact(n-1)
      jr    $ra               #return to caller
```

Assignment

Quick Sort the following array in ascending order:

assignment

```
-1 22 8 35 5 4 11 2 1 78
```

Submission Method:

Prepare a package onto blackboard, including

- All source codes (`<name-sid>-lab1-x.s`)
- A lab report (`<name-sid>-lab1.pdf`) with step-by-step algorithm of quicksort and all console results.