

Topic 24

Sorting and Searching arrays

"There's nothing in your head the sorting hat can't see. So try me on and I will tell you where you ought to be."

-The Sorting Hat,
*Harry Potter and
the Sorcerer's Stone*



Searching

- ▶ Given an array of ints find the index of the first occurrence of a target int

<i>index</i>	0	1	2	3	4	5
<i>value</i>	89	0	27	-5	42	11

- ▶ Given the above array and a target of 27 the method returns 2
- ▶ What if not present?
- ▶ What if more than one occurrence?

Clicker 1

- ▶ Given an array with 1,000,000 distinct elements in random order, how many elements do you expect to look at (on average) when searching if:

item present

item not present

- | | | |
|----|-----------|-----------|
| A. | 1 | 1,000,000 |
| B. | 500,000 | 1,000,000 |
| C. | 1,000,000 | 1,000,000 |
| D. | 1,000 | 500,000 |
| E. | 20 | 1,000,000 |

linear or sequential search

Sorting

XKCD

<http://xkcd.com/1185/>

INEFFECTIVE SORTS

```
DEFINE HALFHEARTEDMERGESORT(LIST):  
  IF LENGTH(LIST) < 2:  
    RETURN LIST  
  PIVOT = INT(LENGTH(LIST) / 2)  
  A = HALFHEARTEDMERGESORT(LIST[:PIVOT])  
  B = HALFHEARTEDMERGESORT(LIST[PIVOT:])  
  // UMMMMMM  
  RETURN [A, B] // HERE. SORRY.
```

```
DEFINE FASTBOGOSORT(LIST):  
  // AN OPTIMIZED BOGOSORT  
  // RUNS IN O(N LOG N)  
  FOR N FROM 1 TO LOG(LENGTH(LIST)):  
    SHUFFLE(LIST):  
    IF ISSORTED(LIST):  
      RETURN LIST  
  RETURN "KERNEL PAGE FAULT (ERROR CODE: 2)"
```

```
DEFINE JOBSITEINTERVIEWQUICKSORT(LIST):  
  OK SO YOU CHOOSE A PIVOT  
  THEN DIVIDE THE LIST IN HALF  
  FOR EACH HALF:  
    CHECK TO SEE IF IT'S SORTED  
    NO, WAIT, IT DOESN'T MATTER  
    COMPARE EACH ELEMENT TO THE PIVOT  
    THE BIGGER ONES GO IN A NEW LIST  
    THE EQUAL ONES GO INTO, UH  
    THE SECOND LIST FROM BEFORE  
    HANG ON, LET ME NAME THE LISTS  
    THIS IS LIST A  
    THE NEW ONE IS LIST B  
    PUT THE BIG ONES INTO LIST B  
    NOW TAKE THE SECOND LIST  
    CALL IT LIST, UH, A2  
    WHICH ONE WAS THE PIVOT IN?  
    SCRATCH ALL THAT  
    IT JUST RECURSIVELY CALLS ITSELF  
    UNTIL BOTH LISTS ARE EMPTY  
    RIGHT?  
    NOT EMPTY, BUT YOU KNOW WHAT I MEAN  
    AM I ALLOWED TO USE THE STANDARD LIBRARIES?
```

```
DEFINE PANICSORT(LIST):  
  IF ISSORTED(LIST):  
    RETURN LIST  
  FOR N FROM 1 TO 10000:  
    PIVOT = RANDOM(0, LENGTH(LIST))  
    LIST = LIST[PIVOT:] + LIST[:PIVOT]  
    IF ISSORTED(LIST):  
      RETURN LIST  
  IF ISSORTED(LIST):  
    RETURN LIST  
  IF ISSORTED(LIST): // THIS CAN'T BE HAPPENING  
    RETURN LIST  
  IF ISSORTED(LIST): // COME ON COME ON  
    RETURN LIST  
  // OH JEEZ  
  // I'M GONNA BE IN SO MUCH TROUBLE  
  LIST = [ ]  
  SYSTEM("SHUTDOWN -H +5")  
  SYSTEM("RM -RF ./")  
  SYSTEM("RM -RF ~/*")  
  SYSTEM("RM -RF /")  
  SYSTEM("RD /S /Q C:\*") // PORTABILITY  
  RETURN [1, 2, 3, 4, 5]
```

Sorting

- ▶ A fundamental application for computers
- ▶ Done to make finding data (searching) faster
- ▶ Many different algorithms for sorting
- ▶ One of the difficulties with sorting is working with a fixed size storage container (array)
 - if resize, that is expensive (slow)
 - Trying to apply a human technique of sorting can be difficult
 - try sorting a pile of papers and clearly write out the algorithm you follow

Selection Sort

- ▶ To sort a list into ascending order:
 - Find the smallest item in an array, the minimum
 - Put that value in the first element of the array
 - Where to put the value that was in the first location?
 - And now...?

Selection Sort in Practice

44 68 191 119 119 37 83 82 191 45 158 130 76 153 39 25

<http://tinyurl.com/d7kxxxf>

animation of selection sort algorithm

Implementation of Selection Sort

- ▶ Include println commands to trace the sort

Clicker 2

► Determine how long it takes to sort an array with 100,000 elements in random order using selection sort. When the number of elements is increased to 200,000 how long will it take to sort the array?

- A. About the same
- B. 1.5 times as long
- C. 2 times as long
- D. 4 times as long
- E. 8 times as long

Insertion Sort

- ▶ Another of the Simple sort
- ▶ The first item is sorted
- ▶ Compare the second item to the first
 - if smaller swap
- ▶ Third item, compare to item next to it
 - need to swap
 - after swap compare again
- ▶ And so forth...

Insertion Sort in Practice

44 68 191 119 119 37 83 82 191 45 158 130 76 153 39 25

<http://tinyurl.com/d8spm2l>

animation of insertion sort algorithm

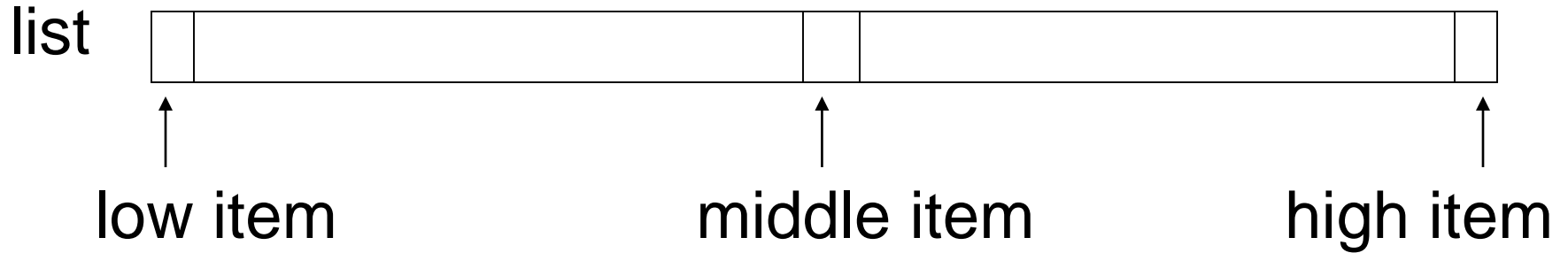
Binary Search



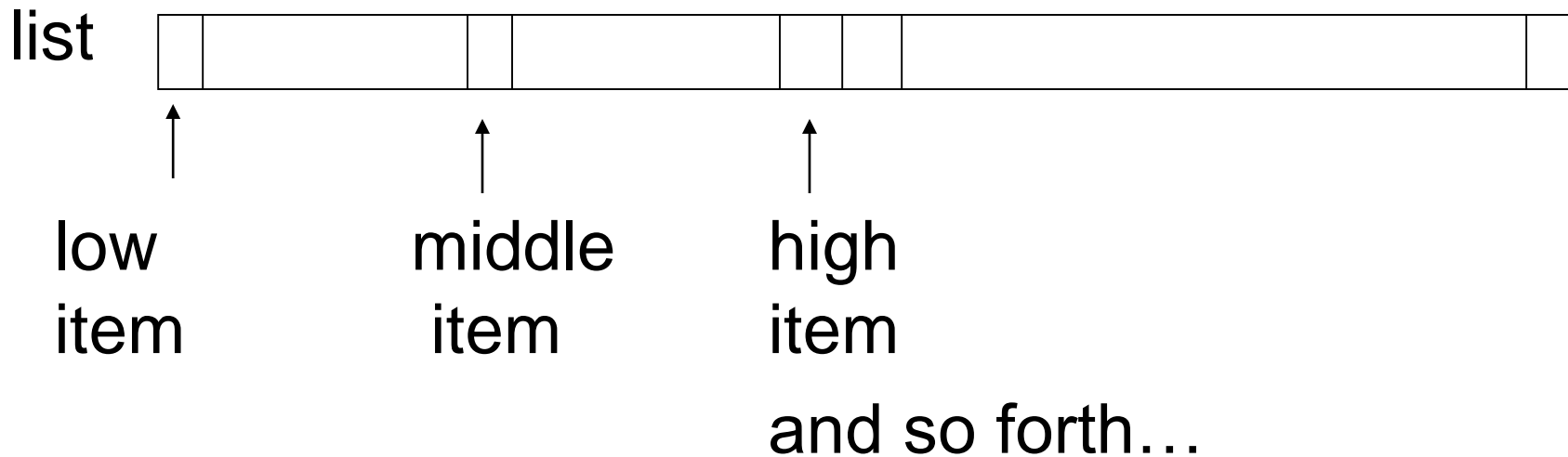
Searching in a Sorted List

- ▶ If items are sorted then we can *divide and conquer*
- ▶ dividing your work in half with each step
 - generally a good thing
- ▶ The Binary Search on List in Ascending order
 - Start at middle of list
 - is that the item?
 - If not is it less than or greater than the item?
 - less than, move to second half of list
 - greater than, move to first half of list
 - repeat until found or sub list size = 0

Binary Search



Is middle item what we are looking for? If not is it more or less than the target item? (Assume lower)



Implement Binary Search

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2	3	5	7	11	13	17	19	23	29	31	37	41	43	47	53

Trace When Key == 3
Trace When Key == 30

Variables of Interest?

Clicker 3

- ▶ Given an array with 1,000,000 elements in sorted order, how many elements do you expect to look at when searching (with binary search) for a value if:

	item present once	item not present
--	-------------------	------------------

- | | | |
|----|-------|-----------|
| A. | 1 | 500,000 |
| B. | 20 | 20 |
| C. | 1 | 1,000,000 |
| D. | 1,000 | 500,000 |
| E. | 1,000 | 1,000 |