"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

<table>
<thead>
<tr>
<th>index</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>value</td>
<td>89</td>
<td>0</td>
<td>27</td>
<td>-5</td>
<td>42</td>
<td>11</td>
</tr>
</tbody>
</table>

- Given the above array and a target of 27 the method returns 2
- What if not present?
- What if more than one occurrence?
Given an array with 1,000,000 distinct elements in random order, how many elements do you expect to look at when searching if:

<table>
<thead>
<tr>
<th>item present</th>
<th>item not present</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 0</td>
<td>1,000,000</td>
</tr>
<tr>
<td>B. 500,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>C. 1,000,000</td>
<td>1,000,000</td>
</tr>
<tr>
<td>D. 1,000</td>
<td>500,000</td>
</tr>
<tr>
<td>E. 20</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>
linear or sequential search
### INEFFECTIVE Sorts

**Halfhearted Merge Sort**

```plaintext
DEFINE HALFHEARTEDMERGESORT(list):
    IF LENGTH(list) < 2:
        RETURN list
    Pivot = INT(LENGTH(list) / 2)
    A = HALFHEARTEDMERGESORT(list[:Pivot])
    B = HALFHEARTEDMERGESORT(list[Pivot:])
    // UMMMM
    RETURN [A, B] // HERE. SORRY.
```

**Bogo Sort**

```plaintext
DEFINE FASTBOGOSORT(list):
    // AN OPTIMIZED BOGOSORT
    // Runs in O(N LOGN)
    FOR n FROM 1 TO LOG(LENGTH(list)):
        SHUFFLE(list):
    IF ISORTED(list):
        RETURN list
    RETURN "KERNEL PAGE FAULT (ERROR CODE: 2)"
```

**Job Interview Quick Sort**

```plaintext
DEFINE QUICKSORT(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 SAME 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?
```

**Panic Sort**

```plaintext
DEFINE PANSORT(list):
    IF ISORTED(list):
        RETURN list
    FOR n FROM 1 TO 10000:
        PIVOT = RANDOM(0, LENGTH(list))
        LIST = LIST[:PIVOT] + LIST[:PIVOT]
    IF ISORTED(list):
        RETURN list
    IF ISORTED(list): // THIS CAN'T BE HAPPENING
        RETURN list
    IF ISORTED(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 /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

http://tinyurl.com/d7kxxxf

animation of selection sort algorithm
Implementation of Selection Sort

- Include println commands to trace the sort
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. 16 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

My client couldn't have killed anyone with this arrow, and I can prove it!

I'd like to examine your proof, Zeno. You may approach the bench.

—But never reach it!
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)

and so forth…
Implement Binary Search

<table>
<thead>
<tr>
<th></th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
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<tr>
<td></td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>7</td>
<td>11</td>
<td>13</td>
<td>17</td>
<td>19</td>
<td>23</td>
<td>29</td>
<td>31</td>
<td>37</td>
<td>41</td>
<td>43</td>
<td>47</td>
<td>53</td>
</tr>
</tbody>
</table>
Trace When Key == 3
Trace When Key == 30
Variables of Interest?
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:

<table>
<thead>
<tr>
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<th>item not present</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. 0</td>
<td>500,000</td>
</tr>
<tr>
<td>B. 20</td>
<td>20</td>
</tr>
<tr>
<td>C. 1</td>
<td>1,000,000</td>
</tr>
<tr>
<td>D. 1,000</td>
<td>500,000</td>
</tr>
<tr>
<td>E. 1,000</td>
<td>1,000</td>
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