THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

COMP 110
Introduction to Programming

Tuesday November 11, 2014

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Fall 2014
TR 9:30 – 10:45, GS-G100

Previous Class

- What did we discuss?

Announcements

- **Lab 6 – Due today, Nov 11**
- **Assignment 5: Due Fri, Nov 21**

Sorting

- Think about your own field – Biology, Psychology, Math, Business…
- Can you think of examples when you need to search and sort data?
- How do you do it?

Algorithms

- All those applications you use for sorting data or searching for a specific piece of information in a large database use **algorithms**!
- Anyone use Google? ☺

Sorting - example

- Given an array of numbers, sort it into ascending/descending order
- Before sorting:

4	7	3	9	6	2	8

- After sorting:

2	3	4	6	7	8	9

Searching Arrays

- Searching arrays for a particular value
- Sorting arrays
  - makes searching for a particular value easier (and quicker)

Searching Arrays

- Find one particular element in an array of many elements
- Find several particular elements in an array of many elements
- Complexity (How Long To Search?)
  - find a parking space – *linear (go down the line…)*
  - look up a word in a dictionary - *complex*
    - 500K+ words in OED
  - Web search - *very complex*
    - Trillions of web pages

Searching Arrays

- Linear search
  - it's like looking for a parking space
- Binary search
  - (sort of like) searching for a word in the dictionary

Linear Search

- Check the first item, then the second item, and so on… until?
  - you find the target item, OR
  - you reach the end of the list
- That is **linear** (or sequential) search

Linear Searching

- Given a target value and an array of integers
  - the array list can be sorted (or not)
  - walk through the array
    - repeatedly ask: Is this a match?
    - quit when the answer is yes (use break stmt)
  - if you reach the end of the array, there is no match
- Inefficient
  - worst time to search is ~ length
  - average time to search is ~ length/2
- Relatively easy to program

Linear Search - Integers

```
// Linear search of unordered list of integers

int[] list = {17, 14, 9, 23, 18, 11, 62, 47, 33, 88}; // unordered list

int searchFor = 33; // look for this value in the list

// Loop thru list until we find match

int foundAt = -1; // where found (default)

    for (int index = 0; index < list.length; index++) {

        if (list[index] == searchFor) {
            foundAt = index;
            break;                  // jump out of the loop
        }
    }
// foundAt is now index of item "searchFor" or -1 if not found
```

Linear Search - Strings

```
// Linear search of unordered list of Strings

// unordered list
String[] list = {"Bart", "Homer", "Marge", "Lisa", "Maggie", "Millhouse"};

String searchFor = "Maggie"; // look for this value in the list

// Loop thru list until we find match
int foundAt = -1; // where found (default)

        for (int index = 0; index < list.length; index++) {

                if (list[index].equals(searchFor)) {
                        foundAt = index;
                        break;          // jump out of the loop
                }
        }
// foundAt is now index of item "searchFor" or -1 if not found
```

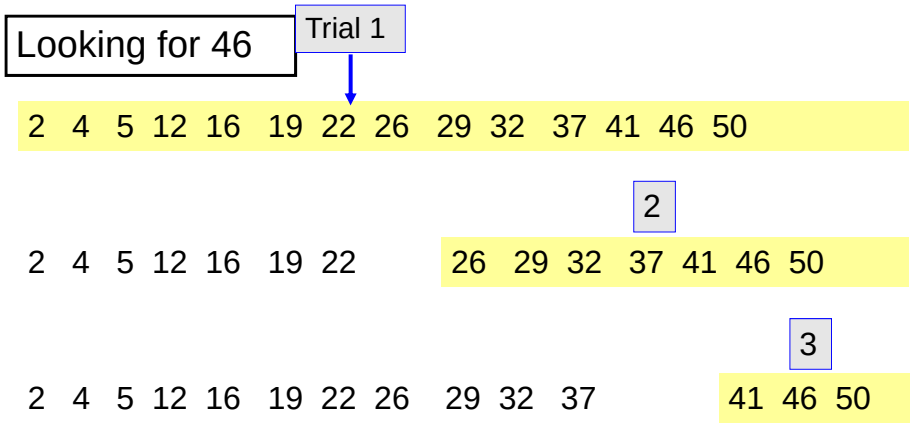

Binary Search

- How would you search a word in a dictionary? E.g. "Spring" ?
- You look in the second half of the dictionary!
- Dictionary is sorted…
- We already use **binary search**!

Binary Search

- Requires ordered (sorted) list
- Set a searchRange – begin with the entire list
- Repeat:
  - pick a "test value" in the middle of searchRange
  - if test value == value searching for
    - Stop!
  - if test value > value searching for
    - searchRange = lower half of searchRange
  - if test value < value searching for
    - searchRange = upper half of searchRange

Binary Search - Example



Notes on Binary Searches

- List must be ordered (sorted)
- Much more efficient than linear search
  - in example, took 3 iterations instead of 13 for linear
  - linear
    - worst case ~ listLength
    - average ~ listLength/2
  - for 100K words: 17 iterations versus 50,000
- More complex to program

Question (take 2 min; do it yourself)

2 10 17 45 49 55 68 85 92 98

How many comparisons are needed to determine if the following items are in the list of 10 items?

number	linear search	binary search
15	10 (3, if know list sorted)	3 (49, 10, 17)
49	5	1
98	10	4 (49, 85, 92, 98)
2	1	3 (49, 10, 2)

Sorting

- Put elements of an array in some order
  - alphabetize names
  - order grades lowest to highest
- Two simple sorting algorithms
  - selection sort
  - insertion sort

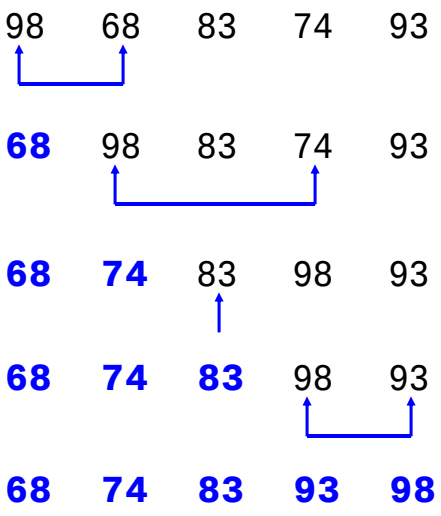
Sorting

- Sorts by putting values directly into their final, sorted position
- For each value in the list, the selection sort finds the value that belongs in that position and puts it there

Selection Sort

- Scan the list to find the smallest value
- Exchange (swap) that value with the value in the first position in the list
- Scan rest of list for the next smallest value
- Exchange that value with the value in the second position in the list
- And so on, until you get to the end of the list

Selection Sort at work



Selection Sort

- Sorts in ascending order
- Can be changed to sort in descending order
  - look for max instead of min

Selection Sort Pseudocode

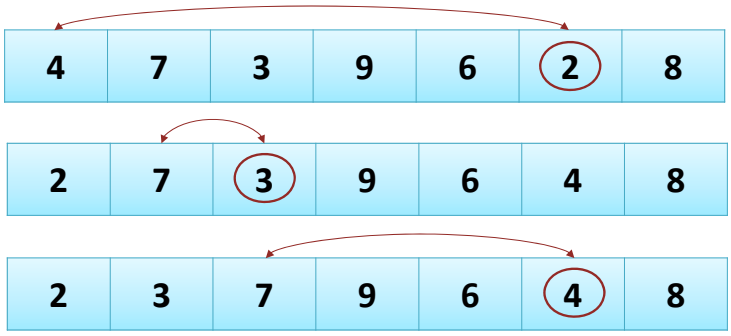
```
for (index = 0; index < length; index++){

    Find index of smallest value of array
        between current index and end of array;

    Swap values of current index and the
        index with the smallest value;

}
```

Selection Sort – another example



and so on…

Swap

```
private static void swap(int i, int j, int[] a) {
      int temp = a[i];
      a[i] = a[j];
      a[j] = temp;
}
```

- This method will swap the value of a[i] and a[j]

Selection Sort - example

- Open up Eclipse
- Create a new Java Project – call it **Sorting**
- Create a new class – call it **SelectionSortExample**

Selection Sort - example

- Go to:

  http://cs.unc.edu/~aikat/courses/comp110/docs/SelectionSort.doc
- Copy and paste this into Eclipse; run it
- Your console should show the unsorted and sorted arrays:

  [10, 9, 8, 7, 6, 5, 4, 3, 2, 1]

  [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]

Selection Sort - discussion

- There is one class
- How many methods?
  - *main*
  - *selectionSort*
  - *getIndexOfSmallest*
  - *interchange*

Selection Sort – part1 (main method)

```
public static void main(String[] args) {

    int[] myArray = {10,9,8,7,6,5,4,3,2,1};

    // using an Array method to convert the input array to a string...
    // ... because println takes a string as argument
    // print the input (unsorted) array
    System.out.println( Arrays.toString( myArray ) );

    // calling your own method "selectionSort" (defined below); array is input
    selectionSort(myArray);

    System.out.println( Arrays.toString( myArray ) ); // print the sorted array
}
```

Selection Sort – part2 (selectionSort method)

```
// Method selectionSort takes the array as input, and sorts it; in turn, it calls  two
more methods

public static void selectionSort(int[] myArray) {
    for (int index = 0; index < myArray.length-1; index++) {

        // calling method "getIndexOfSmallest" with two inputs;
            // then, store return integer value
        int indexOfNextSmallest = getIndexOfSmallest(index, myArray);

        // calling method "interchange" with three arguments
        interchange(index, indexOfNextSmallest, myArray);
    }
}
```


Selection Sort – part3 (getIndexOfSmallest)

```
private static int getIndexOfSmallest(int startIndex, int[] a) {

    int min = a[startIndex];
    int indexOfMin = startIndex;

    for (int index = startIndex + 1; index < a.length; index++) {

        if (a[index] < min) {
                min = a[index];
                indexOfMin = index;
        }
    }
    return indexOfMin;

}
```

Selection Sort – part4 (interchange)

```
// Method interchange used to swap the two array elements

private static void interchange(int i, int j, int[] a) {

      int temp = a[i];
      a[i] = a[j];
      a[j] = temp; //original value of a[i]
}
```

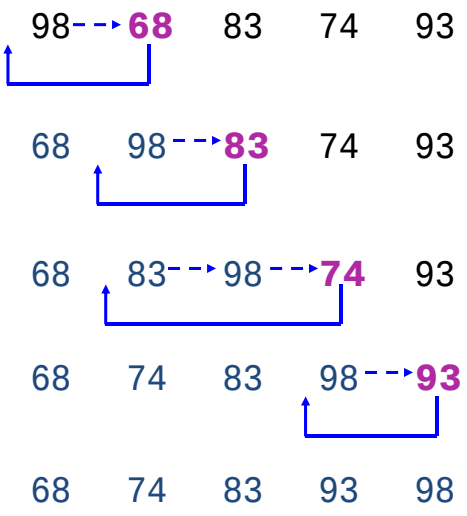

Insertion Sort

- Take an unsorted list and build a final sorted list by adding in one item at a time (we humans sort like this)
- Insert each new item into an already sorted list
- Each unsorted element is inserted at the appropriate spot in the sorted subset until the list is sorted

Insertion Sort: General Algorithm

- Sort the first two values (swap, if necessary)
- Repeat:
  - insert list's next value into the appropriate position relative to the first ones (which are already sorted)
- Each time insertion made, number of values in the sorted subset increases by one
- Other values in array shift to make room for inserted elements

Insertion Sort at work



SORTED!

Insertion Sort

- Outer loop controls the index in the array of the next value to be inserted
- Inner loop compares the current insert value with values stored at lower indexes
- Each iteration of the outer loop adds one more value to the sorted subset of the list, until the entire list is sorted

Sorting Things other than numbers

- characters
  - same as integers (compare with < and >)
- Strings
  - use the built-in compareTo method
- Other Objects
  - we write a compareTo method
  - use the compareTo method

Demo

http://www.sorting-algorithms.com/

Next class (Thu, Nov 13)

- More on classes…