Computer Science 210: Data Structures

Arrays

Summary

- Today
  - arrays
  - arrays of objects
  - in-class: add an entry into an array
- Reading:

Collections of data

- The most common thing you want to do when writing algorithms/code is handle a bunch of data.
- How?
  - Arrays (today)
  - Linked lists (next time)

Arrays

```
int[] a;
//declare a to be an array; a is null

a = new int[10];
//create a: allocate space to hold 10 integers and assign
//a reference to this memory to a
```

- Accessing an array:
```
a[0], a[1]...a[9]
a.length
```
- Assigning arrays
```
int[] a = new int[10;
int[] b;
b = a;
```
- Today we'll see a general example of arrays, namely arrays of objects.

- suppose we have a class that stores game entries that looks like this

```
public class GameEntry {

 protected String name;  // name of the person earning this score
  protected int score;   // the score value

  /** Constructor to create a game entry */
  public GameEntry(String n, int s) {
    name = n;
    score = s;
  }

  /** Retrieves the name field */
  public String getName() { return name; }

  /** Retrieves the score field */
  public int getScore() { return score; }

  /** Returns a string representation of this entry */
  public String toString() {
    return "(" + name + ", " + score + ")";
  }

}
```

Arrays in Java

- Java provide a number of built-in methods for performing common tasks on array
- Java.util.Arrays
  - equals (a, b);
    - performs an element-by-element comparison of a and b and returns true if all elements are equal
  - binarySearch (a, val)
  - toString(a)
  - sort(a)
- Note: all static methods
  - Why? so that you can use them without having to instantiate an object

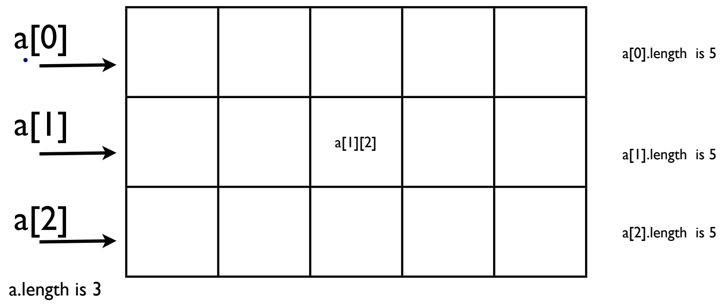
Arrays in Java

- Java.util.Arrays
  - equals (a, b);
  - binarySearch (a, val)
  - toString(a)
  - sort(a)

```
import java.util.Arrays;
...
int[] a = new int[100];
//assign values to a ...
//...
System.out.print("the arrays is: " + Arrays.toString(a));
Arrays.sort(a);
System.out.print("The sorted arrays is: " +
Arrays.toString(a));
```

2D-arrays

- int[][] a;
- int a = new int [3][5];
- //a is an array of 3 rows ; each row is an array of 5 columns



3D-arrays

- int [][][] a;
- a = new int [3][4][5];
- a is an array of 3 elements; each element of a is a 2D-array [4][5]
- a.length is 3
- a[0].length is 4
- a[0][0].length is 5

Exercise

- Suppose we want to store high scores for a video games. But we don't want to store ALL entries. We want store the top 10 highest entries.
- We are going to provide this functionality through a class called Scores
- Class Scores needs to store
  - maximum nb of entries
    - in our case 10
    - this should be a constant
  - actual number of entries
  - the entries
    - array of GameEntries
- Class Scores needs to provide an insert method that inserts a GameEntry while maintaining the invariant that entries[] represents the top 10 scores seen so far
- To make things easier (for the user, that is), we're going to maintain entries[] in order of scores
  - decreasing order (why is it better than increasing?)

```
/** Class for storing high scores in an array in non-decreasing order. */
public class Scores {

  public static final int maxEntries = 10; //number of high scores we keep
  protected int numEntries;          //number of actual entries
  protected GameEntry[] entries;     // array of game entries (names & scores)


 /** Default constructor */
  public Scores() {
    entries = new GameEntry[maxEntries];
    numEntries = 0;
  }

  /** Returns a string representation of the high scores list */
  public String toString() {
    String s = "[";
    for (int i = 0; i < numEntries; i++) {
      if (i > 0) s  += ", "; // separate entries by commas
      s += entries[i];
    }
    return s + "]";
  }

.......
}
```

Inserting an entry in Scores

- public void insert(GameEntry e)
- How do we want this to behave?
  - if entries[] has space:
    - insert e in the right spot; shift things to the right; increment numEntries
  - if entries[] is full:
    - if e is smaller than all scores, do nothing
    - else
      - find the right spot to insert e
      - shift everything to the right one position (thus the last entry is over-written)
- Class-work: come up with an implementation of insert
  - works on all cases
  - simple to read

Inserting an entry into Scores: solution

```
public void insert(GameEntry e) {

   int newScore = e.getScore();
   if (numEntries == MAX_ENTRIES) {
      //if array is full
      if (newScore <  entries[numEntries-1].getScore()  return;
   }  else numEntries++;

   //if we are here, e needs to be inserted;  numEntries includes the new
   //entry;  start from end and shift entries to the right until finding an
   //entry that's smaller
   int i = numEntries-1;
   while (i > 0 && entry[i-1].getScore() < newScore) {
      entry[i] = entry[i-1];
      i--;
   }                                    first check i>0                    check the entry to the left

   //entry[i-1] is the first entry that's larger than newScore
   //entry[i] was copied to the right, so all we need to do is replace it
   entry[i] = e;
}
```

Is this easy to understand?
Note: names of variables, commenting, spacing

```
public void insert(GameEntry e) {

    int newScore = e.getScore();
    if (numEntries == MAX_ENTRIES) {
       //if array is full
       if (newScore <  entries[numEntries-1].getScore()  return;
    }  else numEntries++;

    //if we are here, e needs to be inserted;  numEntries includes the new entry
    //start from end and shift entries to the right until finding an entry that's smaller
    int i = numEntries-1;
    while (i>0 && entry[i-1].getScore() < newScore) {
       entry[i] = entry[i-1];
       i--;
    }

    //entry[i] is the first entry that's larger than newScore; it has been copied to the
    //right, so all we need to do is replace it
    entry[i] = e;
}
```

Easy to read ===> easy to write, check that it works, implement, debug

Remove an entry from Scores

`public void remove(int i)`

- What should this do?
  - action: remove entry i
  - if i is outside the bounds, print some error message (or throw an exception)
  - otherwise shift all entries to the right o f i one position to the left, and decrement numEntries

Remove an entry from Scores: Solution

- `public void remove(int i)`
  - action: remove entry i
  - if i is outside the bounds, print some error message (or throw an exception)
  - otherwise shift all entries to the right of i one position to the left, and decrement numEntries

```
public void remove (int i) {
   if (i < 0 || i >= numEntries) {
      System.out.println("remove: invalid index");
      exit(1);
   }
   //if we are here then i is a valid index
   //shift everything one position to the left; be careful with
   last
   //element
   for (j = i; j < numEntries-1; j++)
      entries[j] = entries[j+1];
   numEntries--;
}
```