Comments about Lab 11

Start of Breakout game

Start Final Project

- Differences between graphics in acm package and normal graphics from javax.swing:
  - import `acm.graphics.*, acm.program.*, java.awt.*, java.awt.event.*`, and `acm.util.*`
  - In main, create object **obj** of the class type and call **obj.start()**
  - The **start** method invokes a call to the run method of the program.
  - Use an object of the RandomGenerator class to generate random numbers

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Start Final Project

- Differences between graphics in acm package and normal graphics from javax.swing:
  - No need to implement any listeners; for example, just use call to **addMouseListeners** and then add the mouse response methods you need.
  - Can add a component, use the method **waitForClick()**, and then remove message. All GObjects can be added and removed using **add** and **remove**
  - Uses a loop to move, pause, and move again instead of a Timer
  - Easier to detect collisions between any two GObjects, returning the GObject in collision.

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Comparable and Comparator

Nuts and Bolts

Nuts and bolts

- Four methods underlie many of Java's important Collection types: `equals`, `compare`, `compareTo`, and `hashCode`
  - To put your own objects into a Collection, you need to ensure that these methods are defined properly
  - Any collection with some sort of *membership test* uses `equals` (which, in many cases, defaults to `==`)
  - Any collection that depends on *sorting* requires larger/equal/smaller comparisons (`compare` or `compareTo`)
- Some of Java's classes, such as `String`, already define all of these properly for you
  - For your own objects, you have to do it yourself

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Comparing our own objects

- The `Object` class provides `public boolean equals(Object obj)` and `public int hashCode()` methods
  - For objects that we define, the inherited `equals` method uses the object's address in memory
  - We can (and often should) override this method
- The `Object` class does not provide any methods for "less" or "greater"—however,
  - There is a `Comparable` interface in `java.lang`
  - There is a `Comparator` interface in `java.util`

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Outline of a Student class

```
public class Student implements Comparable {

   public Student(String name, int score) {...}

   public int compareTo(Object o)
              throws ClassCastException {...}

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

Constructor for Student

-
  ```
  public Student(String name, int score) {
       this.name = name;
       this.score = score;
  }
  ```
- We will be sorting students according to their score
- This example will use sets, but that's irrelevant—comparisons happen between two *objects,* whatever kind of collection they may or may not be in

The main method, version 1

```
public static void main(String args[]) {
    TreeSet<Student> set = new TreeSet<Student>();

    set.add(new Student("Ann", 87));
    set.add(new Student("Bob", 83));
    set.add(new Student("Cat", 99));
    set.add(new Student("Dan", 25));
    set.add(new Student("Eve", 76));

    Iterator<Student> iter = set.iterator();
    while (iter.hasNext()) {
      Student s = iter.next();
      System.out.println(s.name + "  " + s.score);
    }
}
```

Using the TreeSet

- In the main method we have the line
  `TreeSet set = new TreeSet();`
- Later we use an iterator to print out the values in order, and get the following result:
  ```
  Dan  25
  Eve  76
  Bob  83
  Ann  87
  Cat  99
  ```
- How did the iterator know that it should sort Students by score, rather than, say, by name?

Implementing Comparable<T>

- public class Student implements Comparable
- This means it must implement the method
  `public int compareTo(Object o)`
- Notice that the parameter is an Object
- In order to implement this interface, our parameter must also be an Object

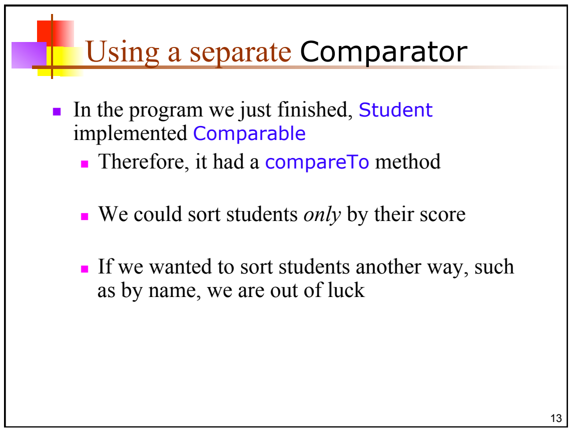
-
  ```
  public int compareTo(Object o) throws ClassCastException {
     if (o instanceof Student)
        return score - ((Student)o).score;
     else
        throw new ClassCastException("Not a Student!");
  }
  ```
- A ClassCastException should be thrown if we are given a non-Student parameter

An improved method

- Since casting an arbitrary Object to a Student may throw a classCastException for us, we don't need to throw it explicitly:

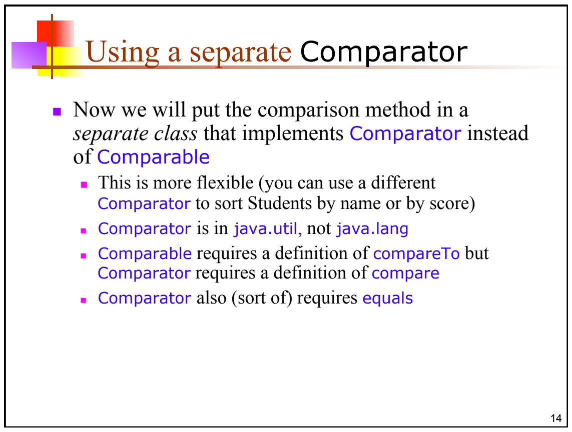
-
  ```
  public int compareTo(Object o) throws ClassCastException {
     return score - ((Student)o).score;
  }
  ```
- Moreover, since classCastException is a subclass of RuntimeException, we don' t even need to declare that we might throw one:

-
  ```
  public int compareTo(Object o) {
     return score - ((Student)o).score;
  }
  ```



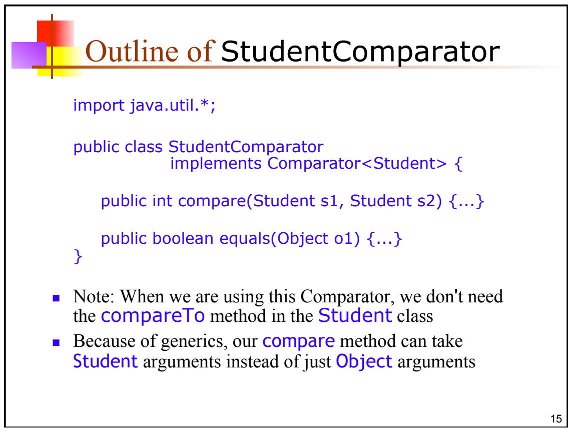
Using a separate Comparator

- In the program we just finished, Student implemented Comparable
  - Therefore, it had a compareTo method
  - We could sort students *only* by their score
  - If we wanted to sort students another way, such as by name, we are out of luck



Using a separate Comparator

- Now we will put the comparison method in a *separate class* that implements Comparator instead of Comparable
  - This is more flexible (you can use a different Comparator to sort Students by name or by score)
  - Comparator is in java.util, not java.lang
  - Comparable requires a definition of compareTo but Comparator requires a definition of compare
  - Comparator also (sort of) requires equals



Outline of StudentComparator

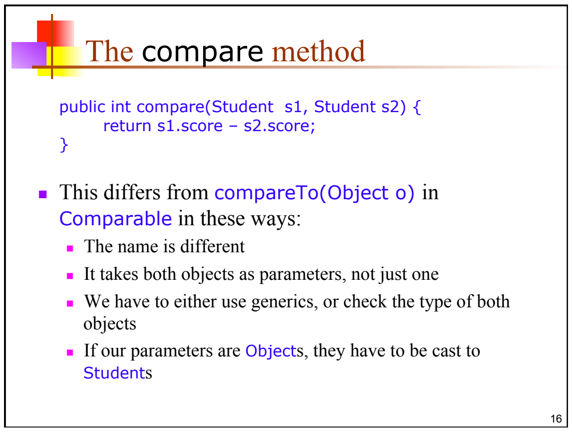
```
import java.util.*;

public class StudentComparator
              implements Comparator<Student> {

    public int compare(Student s1, Student s2) {...}

    public boolean equals(Object o1) {...}
}
```

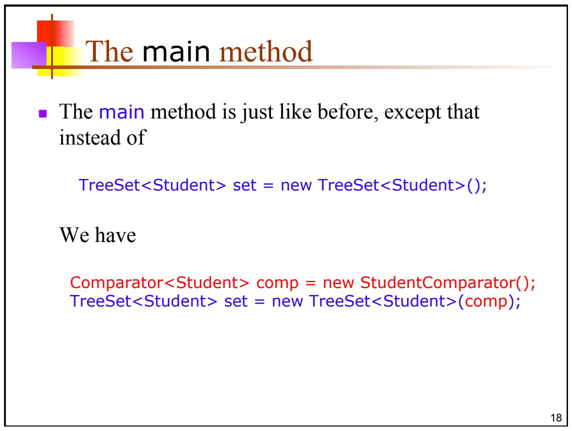
- Note: When we are using this Comparator, we don't need the compareTo method in the Student class
- Because of generics, our compare method can take Student arguments instead of just Object arguments



The compare method

```
public int compare(Student  s1, Student s2) {
       return s1.score – s2.score;
}
```

- This differs from compareTo(Object o) in Comparable in these ways:
  - The name is different
  - It takes both objects as parameters, not just one
  - We have to either use generics, or check the type of both objects
  - If our parameters are Objects, they have to be cast to Students



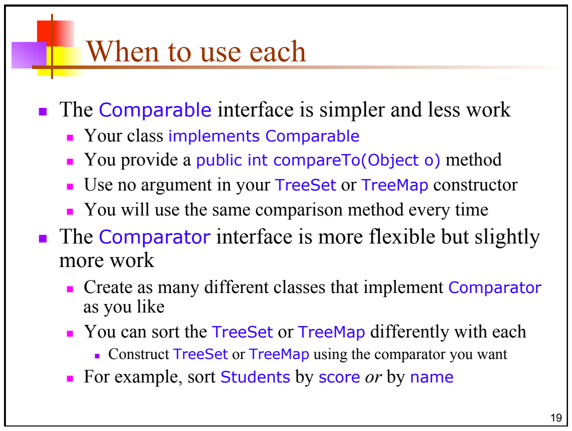
The main method

- The main method is just like before, except that instead of

```
TreeSet<Student> set = new TreeSet<Student>();
```

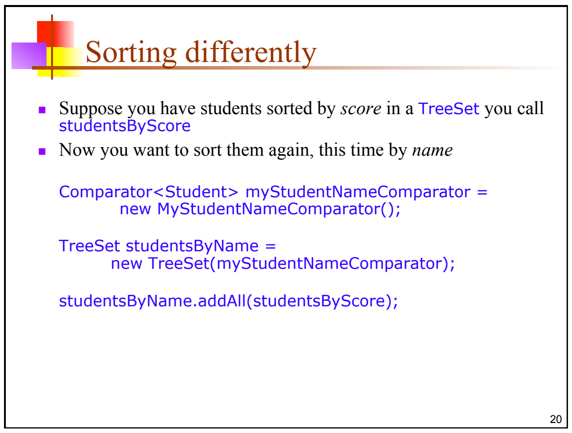
We have

```
Comparator<Student> comp = new StudentComparator();
TreeSet<Student> set = new TreeSet<Student>(comp);
```



When to use each

- The Comparable interface is simpler and less work
  - Your class implements Comparable
  - You provide a public int compareTo(Object o) method
  - Use no argument in your TreeSet or TreeMap constructor
  - You will use the same comparison method every time
- The Comparator interface is more flexible but slightly more work
  - Create as many different classes that implement Comparator as you like
  - You can sort the TreeSet or TreeMap differently with each
    - Construct TreeSet or TreeMap using the comparator you want
  - For example, sort Students by score *or* by name



Sorting differently

- Suppose you have students sorted by *score* in a `TreeSet` you call `studentsByScore`
- Now you want to sort them again, this time by *name*

```
Comparator<Student> myStudentNameComparator =
        new MyStudentNameComparator();

TreeSet studentsByName =
        new TreeSet(myStudentNameComparator);

studentsByName.addAll(studentsByScore);
```

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