CSCI 136
Data Structures &
Advanced Programming

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Lecture 20

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Administrative Details

- Lab 7 is today
  - Any questions?
- Lab 6 was due yesterday
  - If you are using late days, please do not work on Lab 6 during lab today! You need to get started on Lab 7…

Last Time

- Discussed iterators (Ch 8)
  - Used for efficient data traversal
  - Reviewed the Iterator interface
    - next() and hasNext() (and remove())
  - Reviewed the AbstractIterator class
    - Leaves get(), next(), hasNext(), and reset() undefined (as indicated by "abstract" label in javadocs)

More Iterator Examples

- In addition to our "typical" iterators, we can also make specialized iterators
  - Another SLL Example (SpecialIterator.java)
- TestIterator.java

Today's Outline

- Learn about ordered structures (Ch 11)
  - An interesting twist on Lists and Vectors

Ordered Structures

- Until now, we have not required a specific *ordering* to the data stored in our structures
  - If we wanted the data ordered/sorted, we had to do it ourselves
- We often want to keep data ordered
  - Allows for faster searching
  - Easier data mining - easy to find best/worst/average/median values

Ordering Structures

- The key to establishing order is being able to compare objects and rank them
- We already know how to compare two objects…how?
- Comparators and `compare(Object a, Object b)`
- Comparable interface and `compareTo(Object that)`

An Aside: Natural Comparators

- NaturalComparators bridge the gap between Comparators and Comparables

```
class NaturalComparator implements Comparator {
    public int compare(Object a, Object b) {
           return ((Comparable)a).compareTo(b);
    }
}
```

Another Aside: Comparable Associations

- What if we extend Associations to be Comparable?
  - You might have used this in lab a few weeks ago…

```
public class ComparableAssociation extends Association
  implements Comparable {
  public ComparableAssociation(Comparable key, Object val){
        super(key, val);
  }
  pubic int compareTo(Object other) {
        ComparableAssociation otherAssoc =
          (ComparableAssociation)other;
        Comparable thisKey = (Comparable) getKey();
        Comparable otherKey = (Comparable) other.getKey();
        return thisKey.compareTo(otherKey);
  }
}
```

Back to Ordered Vectors

- We want to create a Vector that is always sorted
  - When new elements are added, they are inserted into correct position
  - We still need the standard set of Vector methods
    - add, remove, contains, size, iterator, …
- Two choices
  - Extend Vector (like sorting lab)
  - New class (like StackVector)
    - Gives a more narrow interface
    - Not all vector methods are defined (e.g., random access add/set)
- Let's implement a new class (OrderedVector)
  - Start with Comparables
  - Generalize to use Comparators instead of Comparables

Summary

```
public class OrderedVector<E extends Comparable<E>>
  implements OrderedStructure<E> {
   protected Vector<E> data;

   public OrderedVector() {
        data = new Vector<E>();
   }

   public void add(E value) {
        int pos = locate(value);
        data.add(pos, value);
   }

   protected int locate(E value) {
        //use modified binary search to find position of value
        //return position
   }
```

Summary

```
public boolean contains(E value) {
     int pos = locate(value);
     return pos < size() && data.get(pos).equals(value);
}

public Object remove (E value) {
     if (contains(value)) {
            int pos = locate(value);
            return data.remove(pos);
     }
     else return null;
}
```

Performance:
add - O(n)
contains - O(log n)
remove - O(n)

How would we generalize to Comparators?

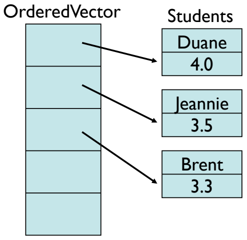
Generalizing OV…

```
public class OrderedVector<E extends Comparable<E>>
   implements OrderedStructure<E> {
   protected Vector<E> data;
   protected Comparator<E> comp;

   public OV() {
        data = new Vector<E>();
        this.comp = new NaturalComparator<E>();
   }

   public OV(Comparator<E> comp) {
        data = new Vector<E>();
        this.comp = comp;
   }

   protected int locate(E value) {
        //use modified binary search to find position of value
        //return position
        //use comp.compare instead of compareTo
   }

   //rest stays same…
```

Ordered Lists

- Similar to OrderedVector
- Uses SinglyLinkedList instead of Vector as underlying data structure
- add, contains, remove runtime?
  - All O(n)…why?
- OrderedLists use Comparators rather than Comparables (as in OrderedVector) in structure5

Example



- Students compared to each other by GPA
- Suppose next semester I get a 3.3 and Brent gets a 3.7

What's the problem?

- We have to recompute GPAs each semester
- What happens if the ordering changes?
- We may need to resort vector
- So…we need a resort method
  - But since this isn't part of the interface, it may be forgotten
- Rule: Avoid using mutable keys in OrderedStructures
- So for our example, we should use names instead of GPAs to rank Students