Sorting 2: Comparators, Merge Sort, Abstract Classes

Instructors: Sam McCauley and Dan Barowy

March 9, 2022

Admin

- Practice midterm posted later today
  - Much longer than the actual midterm will be!
  - Some sample solutions posted as well.
- Midterm review next Wednesday (3/16)
  - Come with questions!
- No class next Friday (3/18)

Sorting Objects

Sorting with `compareTo`

- Let's add a `compareTo()` method to `Student`
- This method compares the name of this student
- How does this choice affect what a sorted vector looks like?
- Let's try sorting `Student`s with a `compareTo` method

Making InsertionSort generic

- We never used the fact that this is a vector of students (other than the `compareTo()` method
- What kind of types can we sort?
- We want this class to have a `compareTo()` method. How can we require this?
- With an interface!

`Comparable<T>` Interface

- This is a Java interface, *not structure5*. (Built-in; don't need to import anything.)
- `Comparable<T>` has only one method: `public int compareTo(T other)`
- Let's tell Java that our `Student` class implements this interface

Generic Upper Bounds

- Way to tell Java that a generic type needs to meet certain requirements
- That way, at compile time, Java can make sure our types match up
- These are called *upper bounds*
- Let's say we only want to accept objects that meet the requirements of the `List` interface. Rather than `<E>`, we write something like `<E extends List>`
  - (Yes, it's `extends` and not `implements`. There are some good back-end reasons for this.)
- What do we want for our `insertionSort` method?
  - Want `<E extends Comparable<E>>`
  - That is to say: we want a type `E` that implements `Comparable<E>`. That is to say: need that objects of type `E` have a `compareTo` method that takes objects of type `E` as argument

Where we are

- Can sort any object so long as it implements `Comparable<E>`
- What are the downsides of this?
    - What if we want to sort objects that aren't already comparable and we don't want to modify the class?
    - Can only sort objects one way. (What if we want to sort `Students` by grade? Would need to rewrite the `Student` class!
- There are upsides as well; we'll come back to this after we talk about `Comparators`

Sorting with Comparators

- Way to sort objects without changing the class.
- Let's try to sort students by age, *without rewriting* `Student`. How can we do that?
- Idea: use an object whose job it is to compare students
  - This object will not store any data
  - Will just have a `int compare(Student, Student)` method to compare two students
- In general: `Comparator<T>` has a `int compare(T, T)` method
  - `compare` returns < 0 if first is smaller; 0 if equal; > 0 if second is smaller
  - Only job: compare objects of type `T`
  - Need to `import java.util.Comparator`

Writing a `Comparator<Student>`

- This is a class that implements `Comparator<Student>`
- Goal: sort students by *age*

Using a Comparator

- Let’s say we want a sort method that uses a comparator, rather than a comparable object
- (Our sort should work for *any* comparator)
- Idea: take a comparator object as an argument. Then we can use its compare method to compare the objects!

Abstract Classes

Object Oriented Programming

- One advantage: Helps break down data and code into self-contained chunks
- Also: can use objects as building blocks to create other objects!
  - Improved portability, extensibility
  - *Avoid repetition!*
- Today: abstract classes
- Wraps up Linked Lists

Interfaces

- “Recipe” for the methods that must be available in any class implementing the interface
- Allows us to use multiple objects of different class types, through a united interface
- Limitation: can’t write any code in an interface.
  - (For now.)
  - When is that a problem?
  - What if several different classes implement the *exact* same method?

Example: Lists

- Vector and SinglyLinkedList both implement the List interface
- That means they both have a method `addFirst(E)`
- In fact, both have the same method!

```
public void addFirst(E value) {
   add(0,value);
}
```

Abstract Classes

- If many classes have identical methods, want to only write that method once

- Idea: use an *abstract class* to store these methods

Abstract Class: Definition and Notation

- An abstract class is a *partial* implementation of the class; uses the `abstract` keyword
- Have *some* methods written out
    - Can also have instance variables
- Don’t need to write all methods, even if implementing an interface
- Like an interface: cannot instantiate an object of an abstract class type
- Idea: this is just a *part* of a class! Need to fill in the details with a non-abstract class

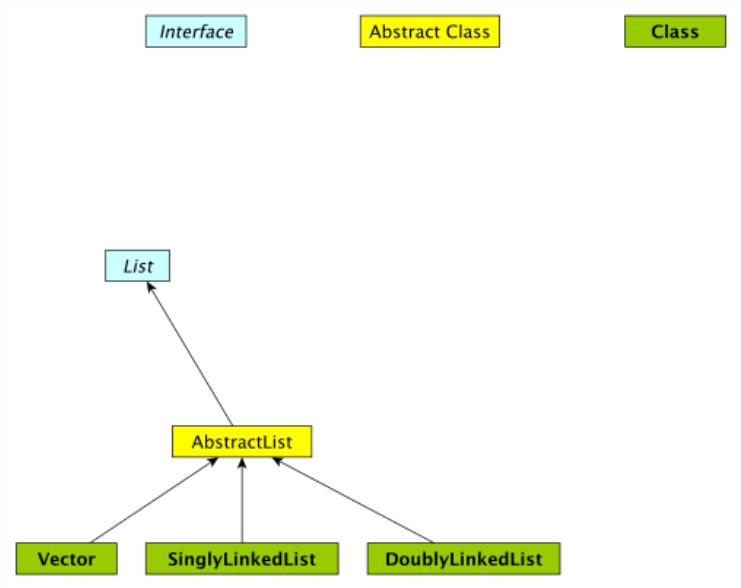
Abstract Class Usage

- We write some methods in an abstract class
- When writing a new class, can use the `extends` keyword to use the methods in that abstract class
- If we extend an abstract class, we can use any of its methods! Plus any additional ones we implement.

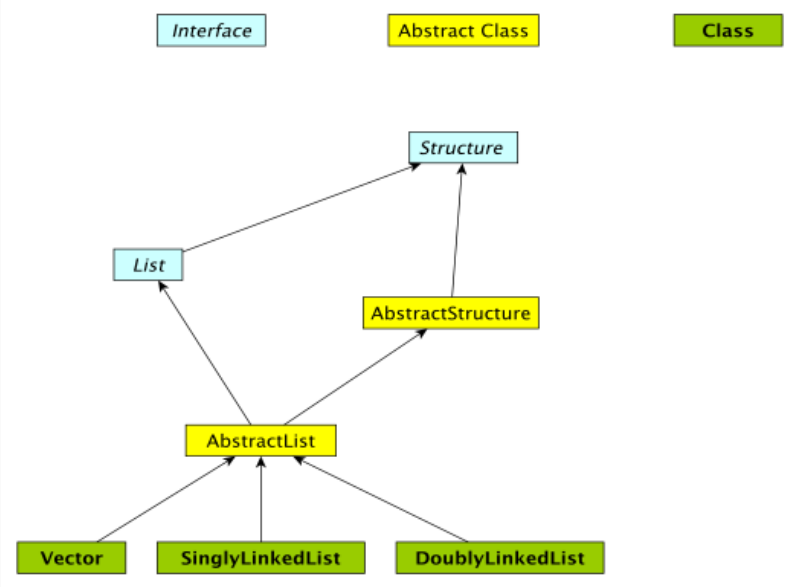
Abstract Classes with Lists

- In structure5, have an `AbstractList` class that implements methods that would be identical in all `Lists`
    - `addFirst`, `addLast`, `contains`, etc.
- Our lists then extend `AbstractList` to allow us to use these methods
- Let's look at the code

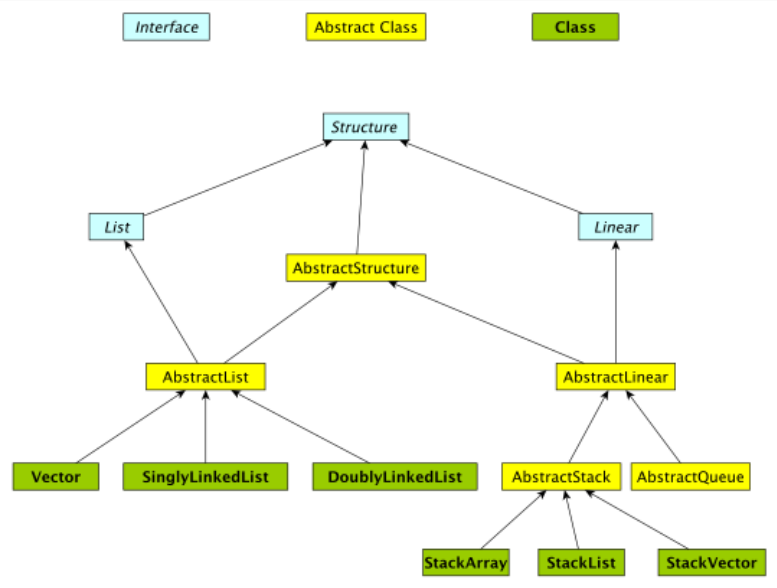
The structure5 universe (almost)



The structure5 universe (so far)



The structure5 universe (after break)



Summary

- `abstract` keyword declares a class as abstract
- `extends` means that we are adding more methods on to an existing (abstract in this case) class
- We can replace abstract class methods with our own if we want, or use them as-is
- Cannot instantiate objects of abstract class type!