CS062

DATA STRUCTURES AND ADVANCED PROGRAMMING

15: Comparators and Iterators

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Lecture 15: Comparators and Iterators

- Interface `Comparable`
- Interface `Comparator`
- Sorting
- Iterators

Some slides adopted from Algorithms 4th Edition or COS226

Comparable

- Interface with a single method that we need to implement:
  `public int compareTo(T that)`
- Implement it so that `v.compareTo(w)`:
  - Returns >0 if v is greater than w.
  - Returns <0 if v is smaller than w.
  - Returns 0 if v is equal to w.
- Corresponds to natural ordering.

How to make your class T comparable?

1. Implement `Comparable<T>` interface.
2. Implement `compareTo(T that)` method to compare `this` T object to `that` based on natural ordering.

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Comparator

- Sometimes the natural ordering is not the type of ordering we want.
- Comparator is an interface which allows us to dictate what kind of ordering we want by implementing the method:

```
public int compare(T this, T that)
```

- Implement it so that `compare(v, w)`:
  - Returns >0 if v is greater than w.
  - Returns <0 if v is smaller than w.
  - Returns 0 if v is equal to w.

How to define an alternative ordering for your class T?

1. Make a new class that implements `Comparator<T>` interface.
2. Implement `compare(T t1, T t2)` method to compare t1 object to t2 based on an alternative ordering.
3. Alternatively, implement an anonymous inner class:

```
public static Comparator<T> nameOfComparator = new Comparator<T>()
{
     @Override
     public int compare(T t1, T t2) {
      {
          //return something;
     }
};
```

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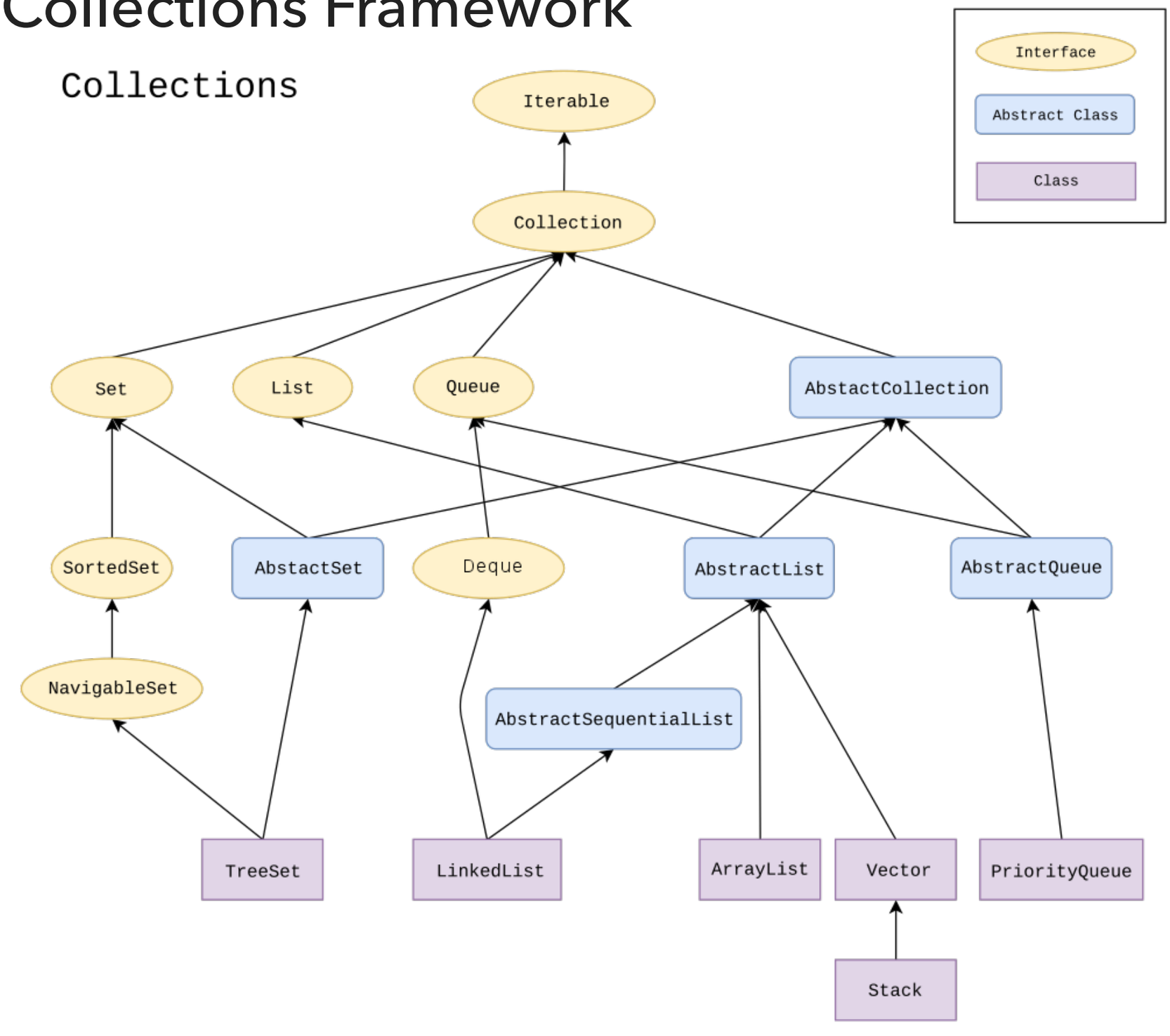
The Java Collections Framework



https://en.wikipedia.org/wiki/Java_collections_framework

Sorting Collections

- Collections class contains:
  - `public static <T extends Comparable<? super T>> void sort(List<T> list)`
  - Generic methods introduce their own type parameters.
    - Use `extends` with generics, even if the type parameter implements an interface.
- The class `T` itself or one of its ancestors implements `Comparable`.
- `Collections.sort(list)`
  - Implemented as optimized mergesort, that is timsort.
  - If list's elements do not implement `Comparable`, throw `ClassCastException`.

Alternative sorting of `Collections`

- Collections class contains:
  - `static <T> void sort(List<T> list, Comparator<? super T> c)`
- `Collections.sort(list, someComparator);`
  - `Collections.sort(list, new ExternalComparatorClass());` or:
  - `Collections.sort(list, T.InnerAnonymousClass);`
  - If list's elements do not implement `Comparable` or cannot be compared with `Comparator`, throw `ClassCastException`.

Example: Natural and alternative sorting for `Employees`

https://github.com/pomonacs622020sp/LectureCode/blob/master/ComparatorsIterators/Employee.java

https://stackoverflow.com/questions/2266827/when-to-use-comparable-and-comparator

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Iterator Interface

- Interface that allows us to traverse a collection one element at a time.

```
public interface Iterator<E> {
  //returns true if the iteration has more elements
  //that is if next() would return an element instead of throwing an exception
  boolean hasNext();

  //returns the next element in the iteration
  //pre: hasNext has been called
  //post: advances the iterator to the next value
  E next();

  //removes the last element that was returned by next
  default void remove(); //optional, better avoid it altogether
}
```

https://docs.oracle.com/javase/8/docs/api/java/util/Iterator.html

Iterator Example for java.util.ArrayList

```
List<String> myList = new ArrayList<String>();
//… operations on myList

Iterator listIterator = myList.iterator();

while(listIterator.hasNext()){
  String elt = listIterator.next();
  System.out.println(elt);
}
```

Java8 introduced lambda expressions

- `Iterator` interface now contains a new method.
- `default void forEachRemaining(Consumer<? super E> action)`
- Performs the given action for each remaining element until all elements have been processed or the action throws an exception.

```
listIterator.forEachRemaining(System.out::println);
```

`Iterable` Interface

- Interface that allows an object to be the target of a for-each loop:

```
for(String elt: myList){
  System.out.println(elt);
}
```

```
interface Iterable<E>{
  //returns an iterator over elements of type E
  Iterator<E> iterator();

  //Performs the given action for each element of the Iterable until all elements
  //have been processed or the action throws an exception.
  default void forEach(Consumer<? super E> action);
}
myList.forEach(elt-> {System.out.println(elt)});
myList.forEach(System.out::println);
```

https://docs.oracle.com/javase/8/docs/api/java/lang/Iterable.html

How to make your data structures of E elements iterable?

1. Implement `Iterable<E>` interface.
2. Make a private inner class that implements the `Iterator<E>` interface.
3. Override `iterator()` method to return an instance of the private inner class.

Example: making our own ArrayList iterable and traversing it

https://github.com/pomonacs622020sp/LectureCode/blob/master/ComparatorsIterators/ArrayList.java

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Readings:

- Textbook:
  - Chapter 2.1 (Page 247), Chapter 2.5 (Pages 338-339)
- Code:
  - Comparators and Iterators: https://github.com/pomonacs622020sp/LectureCode/blob/master/ComparatorsIterators/
- Oracle Documentation:
  - Collections: https://docs.oracle.com/javase/tutorial/collections/intro/index.html
  - Comparable: https://docs.oracle.com/javase/8/docs/api/java/lang/Comparable.html
  - Comparator: https://docs.oracle.com/javase/8/docs/api/java/util/Comparator.html
  - Iterator: https://docs.oracle.com/javase/8/docs/api/java/util/Iterator.html
  - Iterable: https://docs.oracle.com/javase/8/docs/api/java/lang/Iterable.html