Java - Collections and Exceptions

Horstmann Chapters 1.8, 1.11 and 8.3

CS 4354
Summer II 2016

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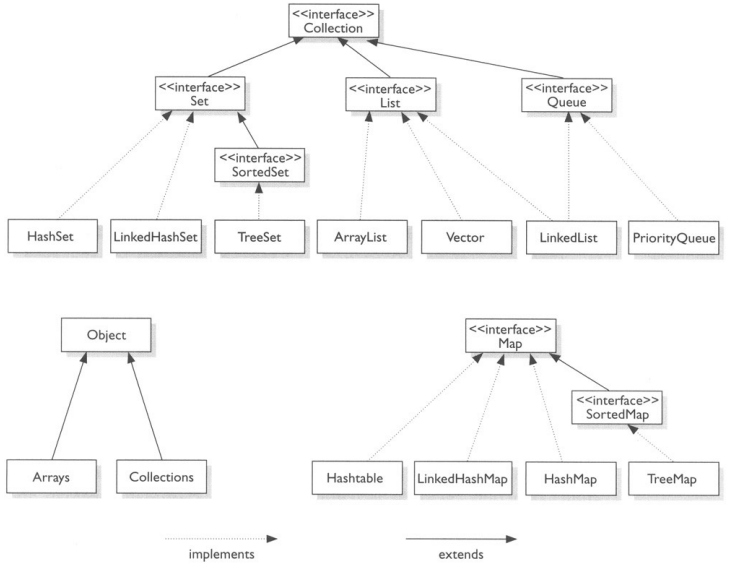
Collections in Java

- A collection is a data structure for holding elements
- java.util.Collection<T> is an interface implemented by many classes in Java. It has 3 extended interfaces:
  - ✦List<T> implemented by ArrayList<T> and LinkedList<T>, etc.
  - ✦Set<T> implemented by HashSet<T> and others
  - ✦Queue<T> implemented by PriorityQueue<T> and others
- Some methods in the Collection interface:
  - ✦isEmpty(), contains(e), add(e), remove(e), iterator()

Maps in Java

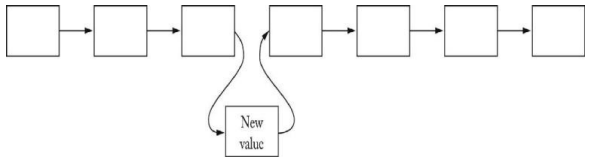
- A map is an object that associates keys with values.
- A map cannot contain duplicate keys; each key can map to at most one value.
- java.util.Map<K,V> is an interface implemented by many classes in Java
  - ✦HashMap<K,V>, Hashtable<K,V>
  - ✦TreeMap<K,V>
- Some methods in the Map interface:
  - ✦isEmpty, containsKey(e), put(k,v), get(k), remove(k)
  - ✦values(): Collection<V>, keySet(): Set<K>

Diagram of Collections and Maps in Java



Linked Lists in the Java Library

- An linked list supports efficient insertion and removal at any location:



- java.util.LinkedList<T> is an class that implements List<T>
  - ✦ void add(T e) appends to the end of the list
- T get(int i) and void set(int i, T e) are supported, but not efficient. Each call traverses the list.
- Use an iterator to access elements in the middle.

Iterators in Java

- An iterator is an object that cycles through all the elements in a collection. It points to an element of the collection.
- java.util.Iterator<T> is an interface with the following methods:
  - ✦public T **next**() returns the next element in the collection (and advances)
  - ✦public boolean **hasNext**() returns true if next() is not done.
  - ✦public void **remove**() (Optional) removes the last element returned by next.
- You can get Iterators from Collections (and Maps):
  - ✦ArrayList<Double> x = new ArrayList<Double>;
    Iterator<Double> it = x.iterator();
  - ✦HashMap<String,Double> hm = new HashMap<String,Double>;
    Iterator<Double> it = hm.values().iterator();

Collections and Iterators: example

```
public class ListIteratorTester {
    public static void main(String[] args) {
        LinkedList<String> countries = new LinkedList<String>();
        countries.add("Belgium");
        countries.add("Italy");
        countries.add("Thailand");
        Iterator<String> iterator = countries.iterator();
        while (iterator.hasNext())  {
            String country = iterator.next();
            System.out.println(country);
        }
        System.out.println();
        // Or use a for each loop
        for(String country : countries)
            System.out.println(country);
        System.out.println();
        // An Iterator can also remove elements:
        iterator = countries.iterator();  //reset to first element
        iterator.next();
        iterator.next();
        iterator.remove();  //removes second element
    }
}
```


Exceptions: Error Handling in Java

- Run time errors
  - ✦It is difficult to recover gracefully from run-time errors that occur in the middle of a program.
  - ✦At the point where the problem occurs, there often isn't enough information in that context (the method) to resolve the problem.
  - ✦ In Java, that method hands off the problem out to a higher context (a calling method) where someone is qualified to make the proper decision
- If the error can be resolved in the immediate context where it occurs, it is NOT called an exception.

Exception semantics - 1

- When an error occurs inside a method, the method creates an exception object.
  - ✦could be in a library method or a user-defined method
- Reporting and exception it to the runtime system is called *throwing an exception*.
- When a method throws an exception,
  - ✦the current path of execution is interrupted, and
  - ✦the runtime system attempts to find an appropriate place to continue executing the program.

Exception semantics - 2

- The runtime system searches the call stack for an appropriate exception handler
  - ✦the call stack: the list of methods that have been called and are waiting for the current method to return.
  - ✦A calls B that calls C that calls D: The call stack contains A, B, C and D with D on the top.
- The runtime system is looking for a previous method call that is embedded in a block that has an exception handler associated with it.
  - ✦It starts at the top of the call stack and goes down (in reverse order in which the methods were called)

Exception semantics - 3

- The runtime system is searching for an **appropriate** exception handler
  - ✦An exception handler is considered appropriate if the type of the exception object thrown matches the type that can be handled by the handler
- The first exception handler encountered that matches the exception is said to **catch** the exception.
- If the runtime system exhaustively searches all the methods on the call stack without finding an appropriate exception handler, the runtime system terminates the program.
  - ✦And usually the exception is output to the screen

Exception syntax: how to throw an exception

- To throw an exception, use the keyword throw.
- To create an exception, use the appropriate constructor.

```
if (t==null)
  throw new NullPointerException();
```

- Exception classes can be found in the API website: see `java.lang.Exception`

Exception syntax: how to catch an exception

- To catch an exception, use the try-catch block.
- Surround the code that might generate an exception in the try
- Make an exception handler (a catch clause) for every type of exception you want to catch.

```
try {
  // Code that calls methods that might throw exceptions
} catch(Type1 id1) {
  // Handle exceptions of Type1
} catch(Type2 id2) {
  // Handle exceptions of Type2
} catch(Type3 id3) {
  // Handle exceptions of Type3
}

// etc...
```


Exception syntax: how to catch an exception

- Each catch clause is like a little method that takes one argument of a particular type.
- The parameters (id1, id2, and so on) can be used inside the handler, just like a method argument.
- If the handler catches an exception, its catch block is executed, and the flow of control proceeds to the next statement after (outside) the try/catch.
  - ✦only the first matching catch clause is executed.

Exception simple example

```
import java.io.*;
public class ExceptionTester{

   public static void main(String args[]){
      try{
         int a[] = new int[2];
         System.out.println("Access element three :" + a[3]);
         System.out.println("After element access");
      }catch(ArrayIndexOutOfBoundsException e){
         System.out.println("Exception thrown  :" + e);
      }
      System.out.println("Out of the block");
   }
}
```

- What part of the code throws the exception?
- Output:

```
Exception thrown  :java.lang.ArrayIndexOutOfBoundsException: 3
Out of the block
```


The exception specification: being civil

- In Java, you are (strongly!) encouraged to inform the client programmer, who calls your method, of the exceptions that might be thrown from your method
  - ✦Then the caller can know exactly what catch clauses to write to catch all potential exceptions.
- The exception specification states which exceptions are thrown by a method.

```
void f() throws TooBig, TooSmall, DivZero { //...
```

  - ✦Also use the @throws tag in the javadoc comment to describe these in more detail (when/why each one is thrown).
- Catch or specify requirement: If the method throws exceptions, it must handle them or specify them in the signature.
  - ✦Otherwise it's a compiler error.

Catch or Specify: example

```
public class ListOfNumbers {
    private ArrayList<Integer> ints;
    private static final int SIZE = 10;

    public ListOfNumbers () {
        ints = new ArrayList<Integer>();
        for (int i = 0; i < SIZE; i++) {
            ints.add(i);
        }
    }

    public void writeList()  {
        PrintWriter out = new PrintWriter(new FileWriter("OutFile.txt"));
        for (int i = 0; i < SIZE; i++) {
            out.println("Value at: " + i + " = " + ints.get(i));
        }
        out.close();
    }
}
```

```
ListOfNumbers.java:16: error: unreported exception IOException;
must be caught or declared to be thrown
  PrintWriter out = new PrintWriter(new FileWriter("OutFile.txt"));
```


Catch or Specify: solution 1

```
public class ListOfNumbers {
    private ArrayList<Integer> ints;
    private static final int SIZE = 10;

    public ListOfNumbers () {
        ints = new ArrayList<Integer>(SIZE);
        for (int i = 0; i < SIZE; i++) {
            ints.add(i);
        }
    }

    public void writeList() throws IOException {
        PrintWriter out = new PrintWriter(new FileWriter("OutFile.txt"));
        for (int i = 0; i < SIZE; i++) {
            out.println("Value at: " + i + " = " +  ints.get(i));
        }
        out.close();
    }
}
```

This compiles with no errors.

Catch or Specify: solution 2

```
public void writeList()  {

    PrintWriter out = null;

    try {
       out = new PrintWriter(new FileWriter("OutFile.txt"));
       for (int i = 0; i < SIZE; i++) {
            out.println("Value at: " + i + " = " + ints.get(i));
       }
    } catch (IOException e) {
        e.printStackTrace();
    }

    if (out != null)
       out.close();
}
```

This compiles with no errors.

Runtime Exceptions: an exception to the rule

- RuntimeExceptions are a special (sub)class of Exceptions.
  - ✦They are thrown automatically by Java in certain contexts
  - ✦This is part of the standard run-time checking that Java performs for you
- These exceptions are “unchecked exceptions”, they do not need to conform to the “Catch or specify rule.
  - ✦Methods are not required to indicate if they might throw one
  - ✦Methods are not required to try to catch them
- What if they are not caught?
  - ✦If a RuntimeException gets all the way out to main( ) without being caught, printStackTrace( ) is called for that exception as the program exits

You can create your own exceptions

- If one of the Java Exceptions is not appropriate for your program, you can create your own Exception classes
  - ✦The class must inherit from an existing exception class, preferably one that is close in meaning to your new exception.

```
class SimpleException extends Exception {}

class SimpleExceptionDemo {
    public void f() throws SimpleException {
        System.out.println("Throw SimpleException from f()");
        throw new SimpleException();
}}
public class DemoDriver {
    public static void main(String[] args) {
        SimpleExceptionDemo sed = new SimpleExceptionDemo();
        try {
            sed.f();
        } catch(SimpleException e) {
            System.err.println("Caught it!");
        }
}}
```