Chapter 9 : Holding the objects

To solve the general programming problem, you need to be able to create any number of objects, anytime, anywhere.

Java has several ways to hold objects : array & container classes.

9.1 Arrays

Features:

1. The array is the most efficient way that Java provides to store and randomly access a sequence of objects. ---- Its size is fixed and cannot be changed.

2. When you create an array, you create it to hold a specific type.

For efficiency and type checking it's always worth trying to use an array if you can.

9.1.1 Arrays are first-class objects

The array identifier is actually a reference to a true object that's created on the heap. ---- the object that holds the references to other objects.

Arrays of objects and arrays of primitives are almost identical in their use.

Sample : ArraySize.java

1. You can't find out how many elements are actually *in* the array ---- **length** tells you only how many elements *can* be placed in the array.

2. You can see whether a particular array slot has an object in it by checking whether it's **null**.

Dynamic aggregate initialization

```
hide(new Weeble[] { new Weeble(), new Weeble() });
```

Note : Container classes can hold only references to objects. It *is* possible to use the "wrapper" classes to place primitive values inside a container.

However, it's much more efficient to create and access an array of primitives than a container of wrapped primitives.

9.1.2 Returning an array

Actually, you're returning a reference to an array . And it will be around as long as you need it.

Sample : IceCream.java *

9.2 The Arrays class

java.util.Arrays

1. equals( ) ---- compare two arrays for equality.

2. fill( ) ---- fill an array with a value.

3. sort( ) ---- sort the array.

4. binarySearch( ) ---- find an element in a sorted array.

All of these methods are overloaded for all the primitive types and **Object**s.

While useful, the **Arrays** class isn't fully functional.

Supplemental utilities to the **Arrays** class

↕

C++ templates

Sample : Generator.java
BooleanGenerator.java
Arrays2.java

Random data generators are useful for testing. ---- Inner classes implementation.

9.2.1 Filling an array

Sample : FillingArrays.java

9.2.2 Copying an array

System.arraycopy( )

Sample : CopyingArrays.java

Both primitive arrays and object arrays can be copied. However, if you copy arrays of objects then only the references get copied.

9.2.3 Comparing arrays

Arrays.**equals( )** compares entire arrays for equality, using the **equals( )** for each element. For primitives, that primitive's wrapper class **equals( )** is used.

9.2.4 Array element comparisons

Writing generic sorting code ---- the code that stays the same is the general sort algorithm, and the thing that changes is the way objects are compared.

Java 2 provides two ways for comparison functionality.

1. With the *natural comparison method* ---- implement the **java.lang.Comparable** interface (compareTo( )).

Sample : CompType.java *

If **Comparable** hasn't been implemented, then you'll get a compile-time error message when you try to call **sort( )**.

2. Create a separate class that implements the **Comparator** interface. (compare( ) and equals( ))

Sample : ComparatorTest.java *

See Sample : AlphabeticSorting.java after class. (P436)

9.2.5 Searching a sorted array

With the built-in sorting methods, you can sort any array of primitives, and any array of objects that either implements **Comparable** or has an associated **Comparator**.

Once an array is sorted, you can perform a fast search for a particular item using **Arrays.binarySearch( )**.

Sample : ArraySearching.java

Arrays.binarySearch( ) produces a value (>= 0) if the search item is found. Otherwise, it produces a negative value (-(insertion point) - 1).

If the array contains duplicate elements, there is no guarantee which one will be found.

If you have sorted an object array using a **Comparator**, you must include that same **Comparator** when you perform a **binarySearch( ).**

Sample : AlphabeticSearch.java

Array summary :

Your first and most efficient choice to hold a group of objects should be an array, and you're forced into this choice if you want to hold a group of primitives.

9.3 Introduction to containers

Java container classes will automatically resize themselves.

Two kinds of container :

1. **Collection**: a group of individual elements ---- A **List and a Queue** must hold the elements in a particular sequence, and a **Set** cannot have any duplicate elements.

2. **Map**: a group of key-value object pairs. ---- A **Map** can return a **Set** of its keys, a **Collection** of its values, or a **Set** of its pairs.

9.3.1 Printing containers

Unlike arrays, the containers print nicely without any help.

Sample : PrintingContainers.java

A **Collection** is printed surrounded by "[ ]", with each element separated by a ",". A **Map** is surrounded by "{ }", with each key and value associated with an "=".

1.The **List** holds the objects exactly as they are entered.

2.The **Set** only accepts one of each object and it uses its own ordering method.

3.The **Map** also only accepts one of each type of item, based on the key, and it also has its own ordering.

9.3.2 Filling containers

Collections.fill( ) just duplicates a single object reference throughout the container, and only works for **List** objects and not **Set**s or **Map**s.

Supplemental utilities to the **Collections** class

Sample : Pair.java MapGenerator.java
Collections2.java CountryCapitals.java

Sample : FillTest.java

9.4 Container disadvantage: unknown type

You lose type information when you put an object into a container. The container holds references to **Object**.

1.There's no restriction on the type of object that can be put into a container. (not including primitives)

2.You must perform a cast to the correct type before you use a reference in a container.

You can think of **ArrayList** as "an array that automatically expands itself."

Sample : CatsAndDogs.java

It's something that can create difficult-to-find bugs.

Making a type-conscious ArrayList :

A more ironclad solution is to create a new class using the **ArrayList**, such that it will accept and produce only a specific type.

Sample : MouseList

Note :If **MouseList** had instead been *inherited* from **ArrayList**, the **add(Mouse)** method would simply overload the existing **add(Object)** and there would still be no restriction on type.

```
mice.add(new Pigeon()); ✗
```

9.5 Iterators

In any container class, you must have a way to put things in and a way to get things out.

An iterator is an object whose job is to move through a sequence of objects and select each object without the client programmer knowing the underlying structure of that sequence.

An iterator is usually a "light-weight" object: one that's cheap to create.

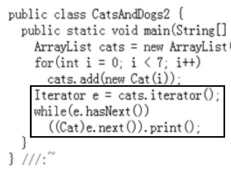
Java **Iterator** :

1.Ask a container to hand you an **Iterator** using **iterator( )**.

2.Get the next object in the sequence with **next( )**.

3.See if there *are* any more objects in the sequence with **hasNext( )**.

4.Remove the last element returned by the iterator with **remove( )**.



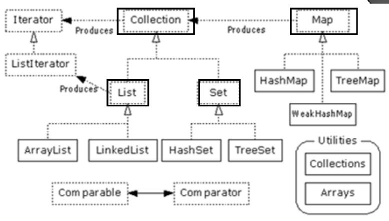
```
public class CatsAndDogs2 {
  public static void main(String[] args) {
    ArrayList cats = new ArrayList();
    for(int i = 0; i < 7; i++)
      cats.add(new Cat(i));
    Iterator e = cats.iterator();
    while(e.hasNext())
      ((Cat)e.next()).print();
  }
} ///:~
```

With the **Iterator**, you don't need to worry about the number of elements in the container.

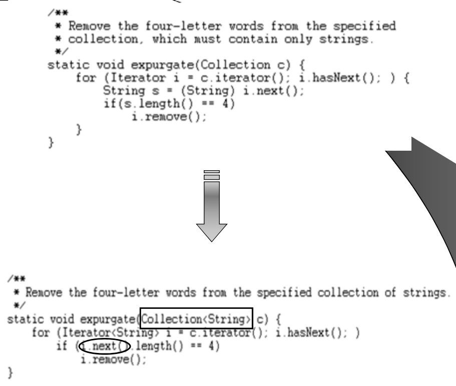
Sample : HamsterMaze.java

Hint : Improvements in JDK 1.5

9.6 Container taxonomy



Generics



```
/**
 * Remove the four-letter words from the specified
 * collection, which must contain only strings.
 */
static void expurgate(Collection c) {
    for (Iterator i = c.iterator(); i.hasNext(); ) {
        String s = (String) i.next();
        if(s.length() == 4)
            i.remove();
    }
}
```

```
/**
 * Remove the four-letter words from the specified collection of strings.
 */
static void expurgate(Collection<String> c) {
    for (Iterator<String> i = c.iterator(); i.hasNext(); )
        if (i.next().length() == 4)
            i.remove();
}
```

•Enhanced for loop

```
void cancelAll(Collection c) {
    for (Iterator i = c.iterator(); i.hasNext(); ) {
        TimerTask tt = (TimerTask) i.next();
        tt.cancel();
    }
}
```

```
void cancelAll(Collection c) {
    for (Object o : c)
        ((TimerTask)o).cancel();
}
```

```
void cancelAll(Collection<TimerTask> c) {
    for (TimerTask task : c)
        task.cancel();
}
```

•Autoboxing / unboxing

```
public class Freq {
    private static final Integer ONE = new Integer(1);

    public static void main(String args[]) {
        // Maps word (String) to frequency (Integer)
        Map m = new TreeMap();

        for (int i=0; i<args.length; i++) {
            Integer freq = (Integer) m.get(args[i]);
            m.put(args[i], (freq==null ? ONE :
                  new Integer(freq.intValue() + 1)));
        }
        System.out.println(m);
    }
}
```

```
public class Frequency {
   public static void main(String[] args) {
      Map<String, Integer> m = new TreeMap<String, Integer>();
      for (String word : args) {
          Integer freq = m.get(word);
          m.put(word, (freq == null ? 1 : freq + 1));
      }
      System.out.println(m);
   }
}
```

You'll typically make an object of a concrete class, upcast it to the corresponding **interface**, and then use the **interface** throughout the rest of your code.

Sample : SimpleCollection.java

9.7 Collection functionality

See the table in textbook, P463

If you want to examine all the elements of a **Collection** you must use an iterator.

9.8 List functionality

See the table in textbook, P467

Sample : List1.java

9.8.1 Making a stack from a LinkedList

Sample : StackL.java

If you want only stack behavior, inheritance is inappropriate because it would produce a class with all the rest of the **LinkedList** methods.

9.8.2 Making a queue from a LinkedList

Sample : Queue.java

9.9 Set functionality

Set has exactly the same interface as **Collection.** A Set refuses to hold more than one instance of each object value.

See the table in textbook, P473

A **Set** needs a way to maintain a storage order, so you must implement the **Comparable** interface when creating your own classes.

Sample : Set2.java

The order maintained by the **HashSet** is different from **TreeSet.**

You must define an **equals( )** in both cases, but the **hashCode( )** is absolutely necessary only if the class will be placed in a **HashSet**.

A Hash**Set** implementation should generally be your first choice.

9.10 Map functionality

It seems like an **ArrayList**, but instead of looking up objects using a number, you look them up using *another object.*

See the table in textbook, P477

A **HashMap** takes the **hashCode( )** of the object and uses it to quickly hunt for the key.

The **keySet( )** method produces a **Set** backed by the keys in the **Map**. The **values( )** method produces a **Collection** containing all the values in the **Map.**

See Sample : Map1.java

Note :keys must be unique, while values may contain duplicates.

Sample : Statistics.java *

In **main( )**, each time a random number is generated it is wrapped inside an **Integer** object so that reference can be used with the **HashMap**.

9.10.1 Hashing and hash codes

1. **Object**'s **hashCode( )** method is used to generate the hash code for each object, and by default it just uses the address of the object.

2. The default **Object.equals( )** simply compares object addresses.

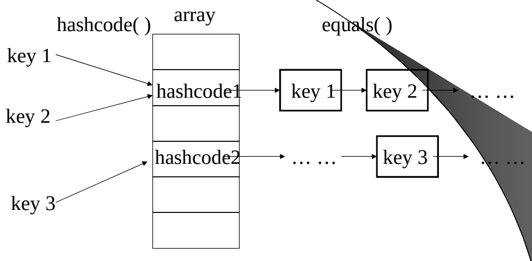
Summary : To use your own classes as keys in a **HashMap**, you must override both **hashCode( )** and **equals( ).**

Sample : SpringDetector2.java

The **hashCode( )** is not required to return a unique identifier, but the **equals( )** must be able to strictly determine whether two objects are equivalent.

9.10.2 Understanding hashCode( )

The whole point of hashing is speed: hashing allows the lookup to happen quickly.



Sample : SlowMap.java ⟷ Sample : SimpleHashMap.java

9.10.3 Overriding hashCode( )

The most important factor is, regardless of when **hashCode( )** is called, it produces the same value for a particular object.

For a **hashCode( )** to be effective, it must be fast and meaningful.

A good **hashCode( )** should result in an even distribution of values.

Sample : CountedString.java

9.11 Choosing an implementation

There are really only four container components: **Map**, **List**, Queue and **Set**, and only two or three implementations of each interface.

Each different implementation has its own features, strengths, and weaknesses.

1. If you want to do many insertions and removals in the middle of a list, a **LinkedList** is the appropriate choice. If not, an **ArrayList** is typically faster.

2. The performance of **HashSet** is generally superior to **TreeSet** for all operations. The only reason **TreeSet** exists is that it maintains its elements in sorted order.

3. when you're using a **Map** your first choice should be **HashMap**, and only if you need a constantly sorted **Map** will you need **TreeMap**.

There's no need to use the legacy classes **Vector**, **Hashtable** and **Stack** in new code.