CS3101-3 Programming Language – Java

Fall 2004

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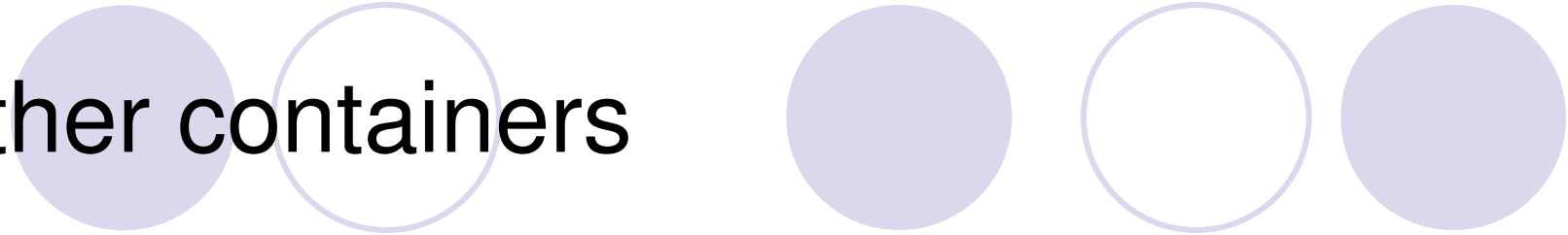
Containers

- Hold a group of objects
- Significantly increase your programming power
- All perform bound checking
- array: efficient, can hold primitives
- Collection: a group of individual elements
  - List, Set
- Map: a group of key-value object pairs
  - HashMap
- Misleading: sometimes the whole container libraries are also called collection classes

array

- Most efficient way to do random access
- Size is fixed and cannot be changed for the lifetime
- If run out of space, have to create a new one and copy everything
- Advantage: can hold primitives

Other containers



- Can only take object
- Have to “wrap” primitives
  - int -> Integer, double-> Double
- Have to cast or unwrap on retrieval
- Slow, error prone, tedious….
- Fixed by JDK1.5, hopefully
- Advantage: automatic expanding

Arrays class

- In java.util, a “wrapper” class for array
- A set of static utility methods
  - fill(): fill an array with a value
  - equals(): compare two arrays for equality
  - sort(): sort an array
  - binarySearch(): find one element in a sorted array
- All these methods overload for all primitive types and Object

Arrays.sort()

- Sorts the objects into ascending order, according to their *natural ordering*
- This sort is guaranteed to be *stable*: equal elements will not be reordered as a result of the sort
- You can specify a range. The range to be sorted extends from index fromIndex, inclusive, to index toIndex, exclusive.
- The objects need to **comparable** or there is a special **comparator**

Arrays.sort() cont.

- sort(array), sort(array, fromIndex, toIndex)
- All elements in the array must implement the *Comparable* interface

- sort(array, comparator)
- sort(array, fromIndex, toIndex, comparator)
- All elements in the array must be *mutually comparable* by the specified comparator

Comparable interface

- With a single method compareTo()
- Takes another Object as argument
- And returns:
  - Negative value if *this* is less than argument
  - Zero value if *this* is equal to argument
  - positive value if *this* is greater than argument

Comparator interface

- Two methods: compare(), equals()
- Only need to implement compare()
- Takes two Object as argument: compare(Object o1, Object o2)
- And returns
  - Negative value if o1 is less than o2
  - Zero value if o1 is equal to o2
  - positive value if o1 is greater than o2

Sort example: WorkerTest.java

Array.binarySearch()

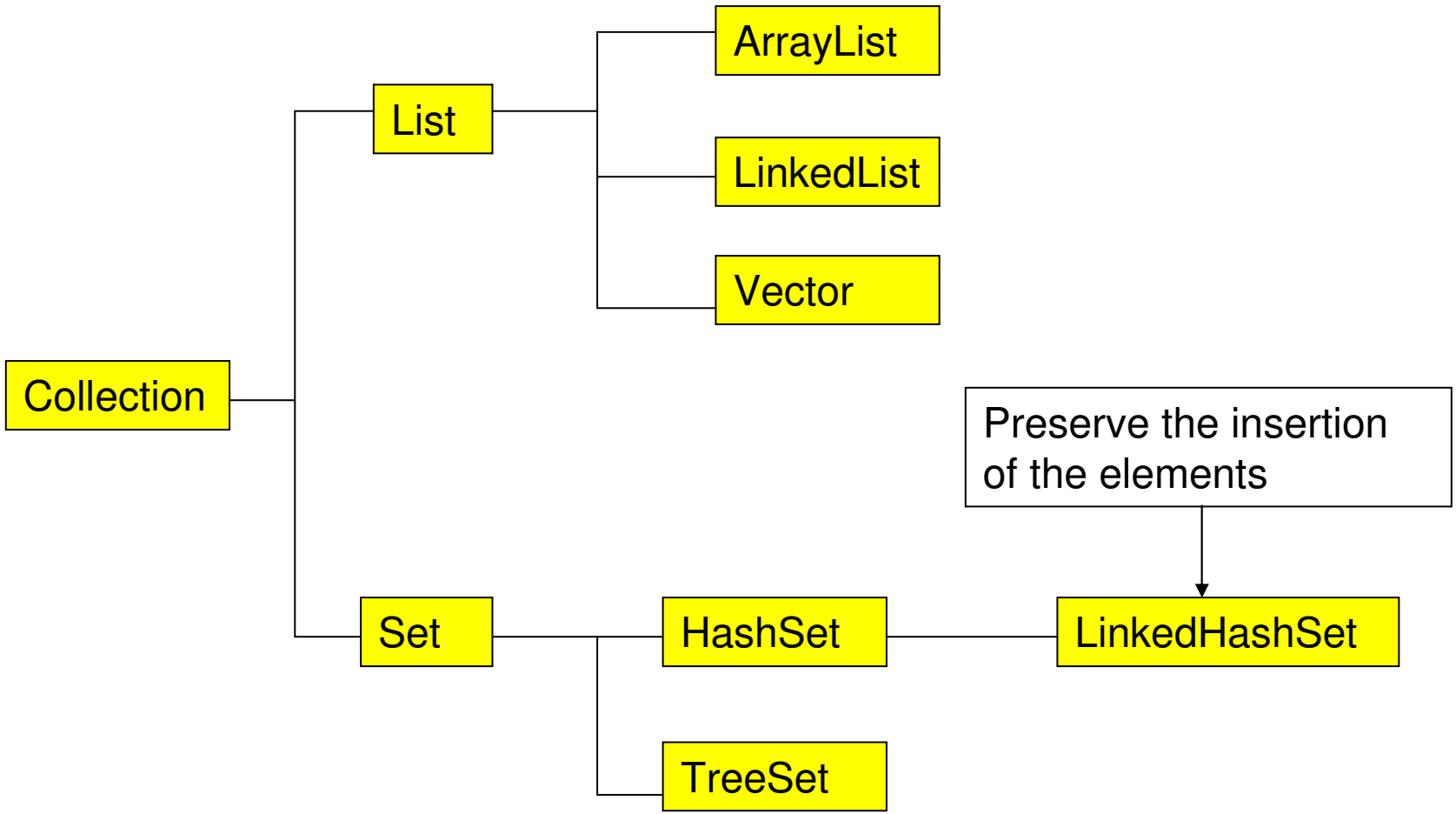
- Only usable on sorted array!
  - Otherwise, result unpredictable
- If there are multiple elements equal to the specified object, there is no guarantee which one will be found.
- Return:
  - Location if find the key (positive number)
  - (-(*insertion point*) - 1) if not find key (negative)

search example: compareExp.java

Collection: hold one item at each location

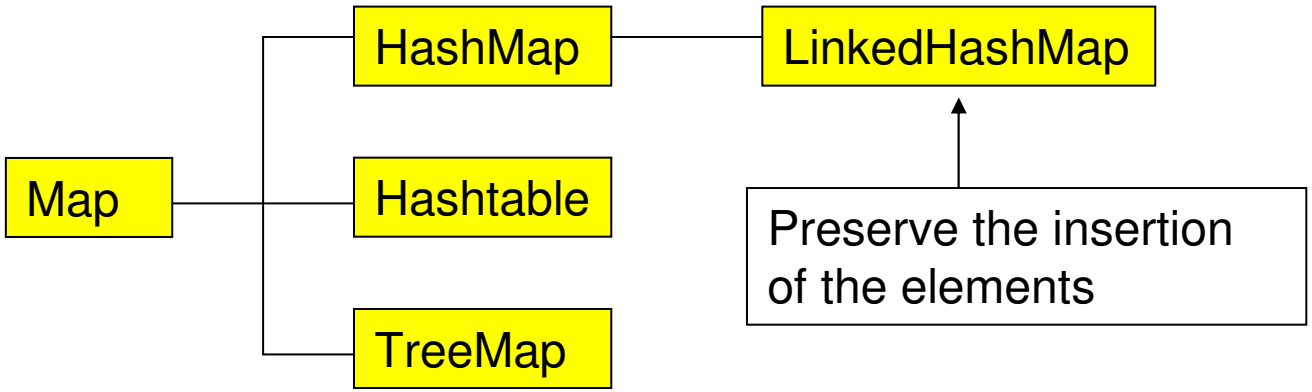
List: items in order

Set: no duplicates, no ordering



Map: key-value pairs, fast retrieval

no duplicate keys, no ordering



Disadvantages of container

- Cannot hold primitives
  - Have to wrap it
- Lose type information when put object into container
  - Everything is just Object type once in container
- Have to do cast when get it out
  - You need to remember what's inside
- Java do run time type check
  - ClassCastException

ArrayList

- An array that automatically expand itself
- Put objects using add()
- Get out using get(int index)
  - Need to cast type
- Method size() to get the number of objects
  - Similar to .length attribute of array
- Example: CatsAndDogs.java

Iterator object

- Access method regardless of the underlying structure
- Generic programming
  - Can change underlying structure easily
- “light-weight” object
  - Cheap to create
- Can move in only one direction

Iterator constraints

- Container.**iterator**() returns you an Iterator, which is ready to return the first element in the sequence on your first call to **next**()
- Get the next object in the sequence with **next**()
- Set there are more objects in the sequence with **hasNext**()
- Remove the last element returned by the iterator with **remove**()
- Example: revisit CatsAndDogs.java

ArrayList vs. LinkedList

- ArrayList
  - Rapid random access
  - Slow when inserting or removing in the middle
- LinkedList
  - Optimal sequential access
  - Fast insertion and deletion from the middle
  - addFirst(), addLast(), getFirst(), removeFirst()
  - Easy to be used as queue, stack

Set interface

- Each element add to the Set must be unique, otherwise won't add.
- Objects added to Set must define equals() to establish object uniqueness
- Not maintain order

Set

- HashSet
  - Fast lookup time by hashing function
- TreeSet
  - Ordered Set backed by a tree (red-black tree)
  - Can extract ordered sequence
- LinkedHashSet
  - Has the lookup speed of a HashSet
  - Maintain the insertion order by linked list

Set example

- revisit CatsAndDogs.java

Map interface

- Key-value associative array
- Look up object using another object
  - Array use index
- put(Object key, Object value)
- Object get(Object key)
- containsKey(), containsValue()

Map

- HashMap
  - Based on a hash table
  - Constant time for insertion and locating pairs
  - Most commonly used
- LinkedHashMap
  - Like HashMap
  - When iterate through, get pairs in insertion order
- TreeMap
  - Based on red-black tree, can viewed in order
  - Need to implement Comparable or Comparator

Map example

- MapExample.java

I/O

- Difficult task
- Too many sources and sinks to cover
  - File
  - Console
  - Network
- Many format
  - Binary-oriented
  - Unicode
  - Zipped

Java I/O: lowest level abstraction

- InputStream/OutputStream class
  - Byte-oriented
  - read() return the byte got read
  - write(int b) writes one byte out
- Can obtain from console, file, or socket
- Handle them in essentially the same way
- Write your code to work with Streams and won't care if it's talking to a file or a system on the other side of the world

Unicode

- Internationalization-friendly text representation
- Reader = InputStream for Unicode
- Write = OutputStream for Unicode
- Can build Reader from InputStream or sometimes get directly from source
  - Same for Writer
- Reader r = InputStreamReader(istream);

Stream from file

- Create from String

```
FileInputStream fin = new
    FileInputStream("data.txt")
```

- Or create a File object first

```
File f = new File("data.txt");
FileInputStream fin = new FileInputStream(f);
```

- Note: can also create Files from directory

```
File f = new File("/home/kewang");
File[] dirListing = f.listFiles();
```

Higher-level features

- Buffered
  - Higher performance through buffers
  - Allows readline() for Readers
- Pushback
  - Can “unread” a byte or character
  - InputStream, Reader

Read console input

```
import java.io.*;

BufferedReader console = new BufferedReader (new
        InputStreamReader(System.in));
System.out.println("What's your name?");
String name = "";
try{
        name = console.readLine();
}catch(IOException e) {}
System.out.println("My name is: "+name);
```

Read a binary file

```
try{
        File f = new File("myfile.jpg");
        int filesize = (int)f.length(); // get the file size
        byte[] data = new byte[filesize];
        //a stream to read the file
        DataInputStream in = new DataInputStream(new
                FileInputStream(f));
        in.readFully(data); //read file contents in array
        in.close();          //remember to close it
}
catch(IOException e){}
```

Read from text file

```
try{
        BufferedReader in = new BufferedReader(new
                FileReader(filename));
        String line="";
        while( (line=in.readLine())!=null ) { //read the file line by
line
                …. // process the read in line
        }
        in.close();
}
catch(IOException e){}
```

Write text to file

```
try{
        File f = new File(filename);
        PrintWriter out = new PrintWriter(new FileWriter(f));
        out.println("my filename is: "+filename);
        out.close();
}catch(IOException e){}
```

System.out just refers to the standard output stream

println(), print() can be used with any Writer.

StringTokenizer class

- Extract tokens from a string
- StringTokenizer(String s, String delim)
  - s: the input string from which tokens are read
  - delim: the delimiter character (any one in it is a delimiter)
  - Default delimiter is " \t\n\r"
- boolean hasMoreTokens()
  - Return true if more token exists
- String nextToken()
  - Return the next token

StringTokenizer cont.

```
String line = is.readLine();

//suppose readback a line: Mike|15.5|40
StringTokenizer st =new StringTokenizer(line, "|");

String name = st.nextToken();
double rate = Double.parseDouble(st.nextToken());
int hours = Integer.parseInt(st.nextToken());
```

Serialization

- An important feature of Java
- Convert an object into a stream of byte, and can later deserialize it into a copy of the original object
- Takes care of reassembling objects
- Need to cast type when read back
- Any object as long as it ***implements Serializable interface***
  - No method inside

Serialization cont.

```
Employee e = new Employee();
try{
        //Serialize the object
        ObjectOutputStream oos = new ObjectOutputStream( new
FileOutputStream(filename));
        oos.writeObject(e);
        oos.close();

        //read back the object
        ObjectInputStream ois = new ObjectInputStream( new
FileInputStream(filename));
        Employee e2 = (Employee)ois.readObject();
        ois.close();

}catch(IOExceptione e){}
 catch(ClassNotFoundException e){} //readObject can throw this

//the class must implement the Serializable interface
class Employee implements Serializable{… …}
```

Java networking

- Java.net.
- Create a socket with the internet address and port of the destination
  - Socket s = new Socket("www.columbia.edu", 80);
- Grab the associated streams
  - InputStream is = s.getInputStream();
  - OutputStream os = s.getOutputStream();
- Rock!
  - Build higher level things on the streams

ServerSocket

- Construct with the port number on which it should listen
  - ServerSocket servsock = new ServerSocket(1234);
- Socket conn=servsock.accept()
  - Will block until a client connects
  - Connection is then encapsulated in **conn**
  - Normally put in a loop to wait for next connection

Still too difficult?

- URL class
- Need to grab file from the web?
  - URL u = new URL("http://www.foo.com/a/b/c/d.txt");
  - InputStream is = u.openStream();
- Done!
- Much easier than C socket
- Also support ftp://, file://, https://