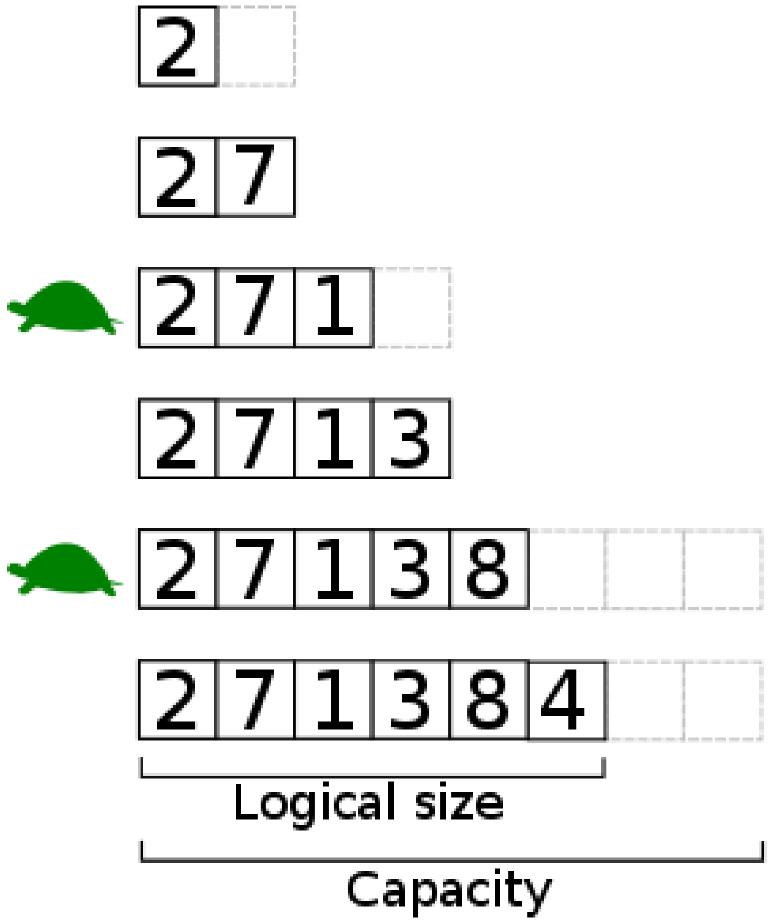
Dynamically sized arrays



"SLINKY" SPRINGS to FAME

Given an initial shove, "Slinky" eerily and deliberately flip-flops end over end down a flight of steps. It is simply a spring, but it does stunts that made R. P. James, Philadelphia engineer, think of converting it into a toy.

"Slinky" goes places when, with a flick of the wrist, it leaps out into space like a striking serpent. Much of its action depends on the ingenuity of its handler.

Produced in one small plant in Philadelphia, 100,000 of the springs sold so rapidly that the promoter had to subcontract to other plants in a number of cities.

The flat-coiled strip of Swedish blue steel assumes shapes in almost unending patterns. Mr. James got his toy idea when he saw the spring roll off a workbench and do funny antics on the floor.

Inert, "Slinky" (below) is a handful of spring before wriggling into its giddy gyrations for child or grownup.

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Overview

- The Java Library
  - Many handy classes and methods
  - Importing a package
- Dynamically sized arrays
  - Java `ArrayList`
  - Wrapper classes for primitive types

The problem with arrays

- Normal Java arrays:
  - Can hold primitive types
  - Can hold reference types
  - Must declare size when we create

```
int        n = StdIn.readInt();
Charge [] a = new Charge[n];
```

```
int        n = StdIn.readInt();
double [] x = new double[n];
double [] y = new double[n];
```

- What if we need to add another element?
- What if we want to remove an element?
- What if we don't know how big to create?

Java library

- Java library
  - Tons of useful classes you can use
  - Only the most important are automatically available without excessive typing:
    - Things like `String`, `System.out`, etc.
- Today:
  - Look at one particular class: `ArrayList`
  - Provides dynamically sized arrays

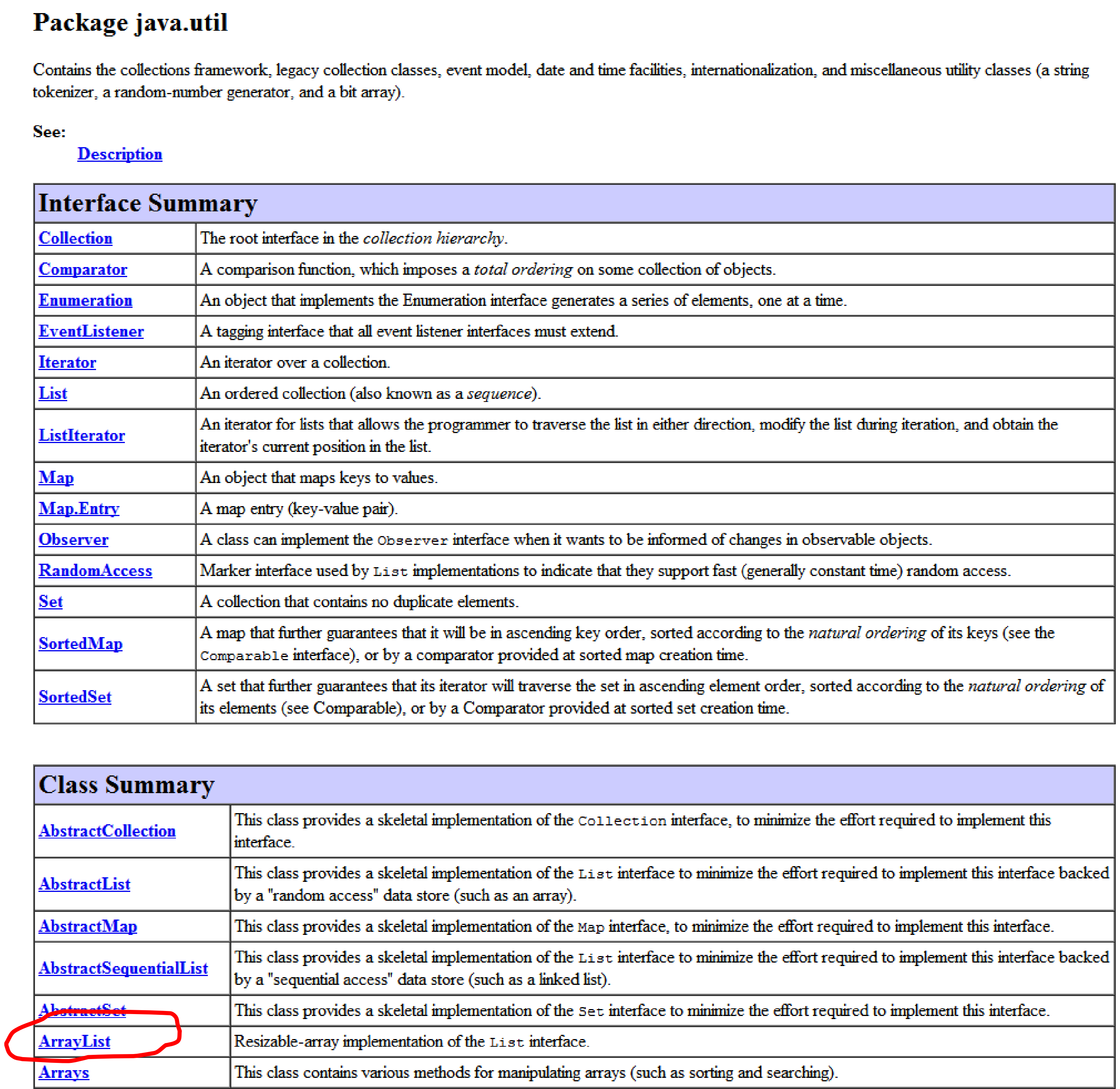
Java packages

- Packages
  - A collection of classes under one *namespace*
    - Avoids problems if multiple classes have same name
  - Common stuff in `java.lang` package

```
// Two ways to declare a String
String s = "hello world!";
java.lang.String s2 = "hello world!";
```

The `String` class lives in a package called `java.lang`, qualifying it is optional for this package

  - `ArrayList` is in a the `java.util` package
    - Add line outside of class: `import java.util.ArrayList;`



Package java.util

Contains the collections framework, legacy collection classes, event model, date and time facilities, internationalization, and miscellaneous utility classes (a string tokenizer, a random-number generator, and a bit array).

See:
    Description

Interface Summary	
Collection	The root interface in the *collection hierarchy*.
Comparator	A comparison function, which imposes a *total ordering* on some collection of objects.
Enumeration	An object that implements the Enumeration interface generates a series of elements, one at a time.
EventListener	A tagging interface that all event listener interfaces must extend.
Iterator	An iterator over a collection.
List	An ordered collection (also known as a *sequence*).
ListIterator	An iterator for lists that allows the programmer to traverse the list in either direction, modify the list during iteration, and obtain the iterator's current position in the list.
Map	An object that maps keys to values.
Map.Entry	A map entry (key-value pair).
Observer	A class can implement the `Observer` interface when it wants to be informed of changes in observable objects.
RandomAccess	Marker interface used by `List` implementations to indicate that they support fast (generally constant time) random access.
Set	A collection that contains no duplicate elements.
SortedMap	A map that further guarantees that it will be in ascending key order, sorted according to the *natural ordering* of its keys (see the `Comparable` interface), or by a comparator provided at sorted map creation time.
SortedSet	A set that further guarantees that its iterator will traverse the set in ascending element order, sorted according to the *natural ordering* of its elements (see Comparable), or by a Comparator provided at sorted set creation time.

Class Summary	
AbstractCollection	This class provides a skeletal implementation of the `Collection` interface, to minimize the effort required to implement this interface.
AbstractList	This class provides a skeletal implementation of the `List` interface to minimize the effort required to implement this interface backed by a "random access" data store (such as an array).
AbstractMap	This class provides a skeletal implementation of the `Map` interface, to minimize the effort required to implement this interface.
AbstractSequentialList	This class provides a skeletal implementation of the `List` interface to minimize the effort required to implement this interface backed by a "sequential access" data store (such as a linked list).
AbstractSet	This class provides a skeletal implementation of the `Set` interface to minimize the effort required to implement this interface.
ArrayList	Resizable-array implementation of the `List` interface.
Arrays	This class contains various methods for manipulating arrays (such as sorting and searching).

Reversing lines in a file

- Goal: Print lines from `StdIn` in reverse order
- Problem: Don't know how many things to expect

```
Alabama
Alaska
Arizona
Arkansas
California
Colorado
Connecticut
Delaware
Florida
...
```

`states.txt`

```
java ReverseLines < states.txt
Wyoming
Wisconsin
West Virginia
Washington
Virginia
Vermont
Utah
Texas
...
```

Reversing lines in a file

"I want to type `ArrayList` instead of `java.util.ArrayList` everywhere."

"I want an empty `ArrayList` and I promise to only put `String` objects in it."

"Please add this `String` to my `ArrayList`."

```java
import java.util.ArrayList;

public class ReverseLines
{
   public static void main(String[] args)
   {
      ArrayList<String> lines = new ArrayList<String>();

      while (!StdIn.isEmpty())
         lines.add(StdIn.readLine());
      for (int i = lines.size() - 1; i >= 0; i--)
         System.out.println(lines.get(i));
   }
}
```

"How many things are in my list?"

"Please return the ith element of the array."

Reversing lines in a file

```
java ReverseLines < states.txt
Exception in thread "main" java.lang.IndexOutOfBoundsException: Index: 50, Size: 50
        at java.util.ArrayList.RangeCheck(ArrayList.java:547)
        at java.util.ArrayList.get(ArrayList.java:322)
        at ReverseLines.main(ReverseLines.java:14)
```

```java
import java.util.ArrayList;

public class ReverseLines
{
   public static void main(String[] args)
   {
      ArrayList<String> lines = new ArrayList<String>();

      while (!StdIn.isEmpty())
         lines.add(StdIn.readLine());
      for (int i = lines.size(); i > 0; i--)
         System.out.println(lines.get(i));
   }
}
```

Just like normal arrays, `ArrayList` objects use 0-based indexing.
The index to the `get()` instance method must be in `[0, size() - 1]`.

Reversing numbers in a file

- Goal: Reverse doubles read from StdIn
- Problem: We don't know how many numbers

```
1.0 1.5
2.1 2.7 3.0
3.9
5.5
6.7
8.8
9.99
10.553
22.5
33.74
```

nums.txt

```
java ReverseNums < nums.txt
33.74
22.5
10.553
9.99
8.8
6.7
5.5
3.9
...
```

Reversing numbers in a file: failure

- Goal: Reverse doubles read from StdIn
- Problem: We don't know how many numbers

This will not work! Java generics like ArrayList only take reference data types, not primitive types like double.

```java
import java.util.ArrayList;

public class ReverseNums
{
   public static void main(String[] args)
   {
      ArrayList<double> nums = new ArrayList<double>();

      while (!StdIn.isEmpty())
         nums.add(StdIn.readDouble());

      for (int i = nums.size() - 1; i >= 0; i--)
         System.out.println(nums.get(i));
   }
}
```

Using primitive wrapper classes: success

- Goal: Reverse doubles read from StdIn
- Problem: We don't know how many numbers

Double class wraps a primitive double data type into an object so we can put it into the ArrayList.

```java
import java.util.ArrayList;

public class ReverseNums
{
   public static void main(String[] args)
   {
      ArrayList<Double> nums = new ArrayList<Double>();

      while (!StdIn.isEmpty())
         nums.add(StdIn.readDouble());

      for (int i = nums.size() - 1; i >= 0; i--)
         System.out.println(nums.get(i));
   }
}
```

Java primitive wrapper classes

- Wrapper classes
  - Provide a way to use primitives with generics like `ArrayList`
  - Usually primitive type capitalized
  - Stick to primitives unless you actually need a wrapper
    - Less overhead

Primitive type	Wrapper class
byte	Byte
short	Short
int	Integer
long	Long
float	Float
double	Double
char	Character
boolean	Boolean

Autoboxing

- Autoboxing
  - Java 5.0 converts to/from wrapper classes as needed

This works even though `StdIn.readDouble()` returns a primitive double but the `ArrayList` requires a Double object.

```
ArrayList<Double> nums = new ArrayList<Double>();

while (!StdIn.isEmpty())
   nums.add(StdIn.readDouble());

for (int i = nums.size() - 1; i >= 0; i--)
   System.out.println(nums.get(i));
```

Adding and removing

- Adding an element
  - Method: `add(Object o)`
    - Appends the specified object to the end of the list
    - Size of list will increase by one after calling
- Removing an element by index
  - Method: `remove(int index)`
    - Removes element at the specified position in the list
    - Shifts subsequent elements to the left (subtracts one from their indices)
    - Size of list will decrease by one after calling

Removing (cont'd)

- Removing a specific element
  - Method: `remove(Object o)`
    - Removes the first occurrence of the specified element from the list if present
    - Returns true if the list contained the element
    - Shifts subsequent elements to the left (subtracts one from their indices)
    - Size of list will decrease by one if element found
- Removing all elements
  - Method: `clear()`

ArrayListExample

```java
import java.util.ArrayList;
public class ArrayListExample
{
   public static void main(String[] args)
   {
      ArrayList<String> names = new ArrayList<String>();
      names.add("alice");
      names.add("bob");
      names.add("bob");
      names.add("carol");
      System.out.println(names);

      names.remove(2);
      System.out.println(names);

      names.remove("bob");
      System.out.println(names);
      names.remove("bob");
      System.out.println(names);

      names.clear();
      System.out.println(names);
   }
}
```

```
[alice, bob, bob, carol]


[alice, bob, carol]


[alice, carol]

[alice, carol]


[]
```

Removing in a loop: failure

```
import java.util.ArrayList;
public class ArrayListRemoveLoop
{
   public static void main(String[] args)
   {
      ArrayList<String> names = new ArrayList<String>();
      names.add("alice");
      names.add("bob");
      names.add("bob");
      names.add("carol");
      System.out.println(names);

      for (int i = 0; i < names.size(); i++)
      {
         if (names.get(i).equals("bob"))
            names.remove(i);
      }
      System.out.println(names);
   }
}
```

```
[alice, bob, bob, carol]

[alice, bob, carol]
```

This doesn't work since when we remove the first "bob", the list is shortened by one inside the loop. We end up skipping over the second "bob".

Removing in a loop: success

```java
import java.util.ArrayList;
public class ArrayListRemoveLoop
{
   public static void main(String[] args)
   {
      ArrayList<String> names = new ArrayList<String>();
      names.add("alice");
      names.add("bob");
      names.add("bob");
      names.add("carol");
      System.out.println(names);

      for (int i = names.size() - 1; i >= 0; i--)
      {
         if (names.get(i).equals("bob"))
            names.remove(i);
      }
      System.out.println(names);
   }
}
```

Going backwards through the list fixes the bug. Removing something in the loop doesn't affect what elements we'll see as we move earlier in the list.

```
[alice, bob, bob, carol]

[alice, carol]
```

Summary

- Java `ArrayList`
  - Like an array but extra-powerful
  - Has no fixed sized
  - Add/remove elements dynamically as needed
  - Contains objects of a specified reference type
  - Cannot hold primitive types (e.g. `double`, `int`)
    - Wrapper objects used instead (e.g. `Double`, `Integer`)
  - Be careful when you add/remove in a loop!