Chapter outline

- `ArrayList`
  - basic operations
  - searching for elements
  - wrapper classes

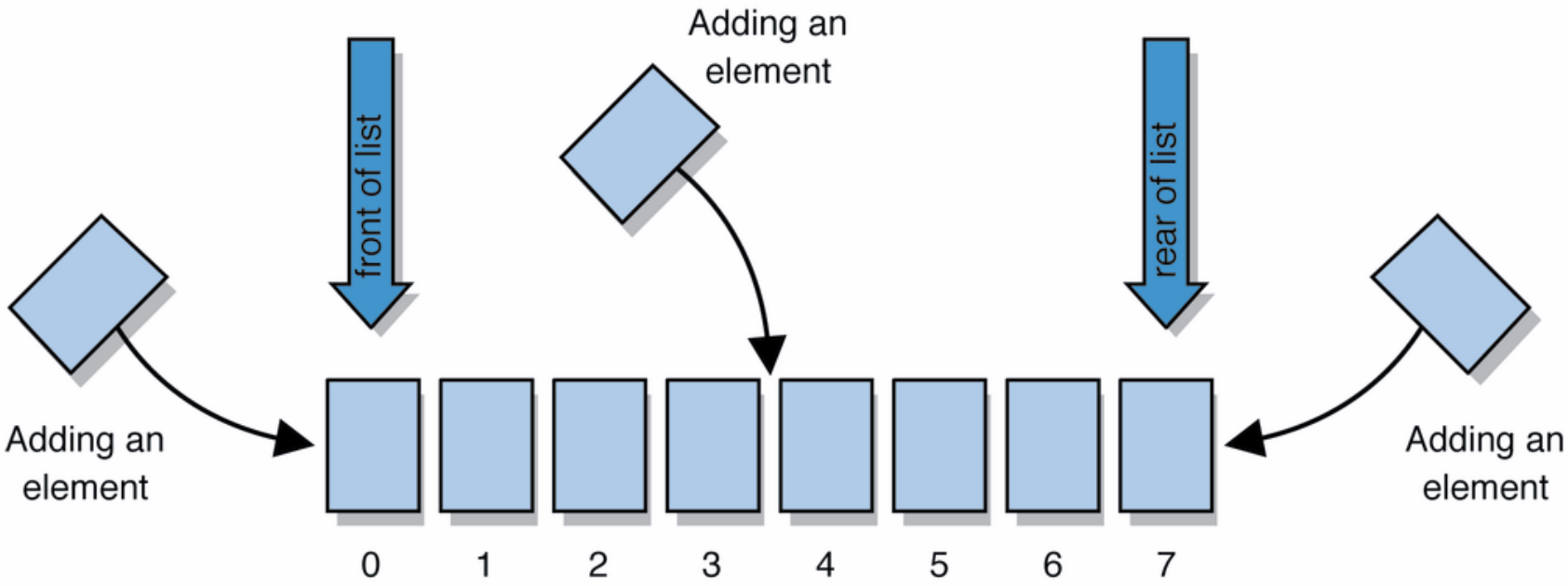
- `Comparable` interface
  - natural ordering and compareTo
  - implementing `Comparable`

ArrayList

reading: 10.1

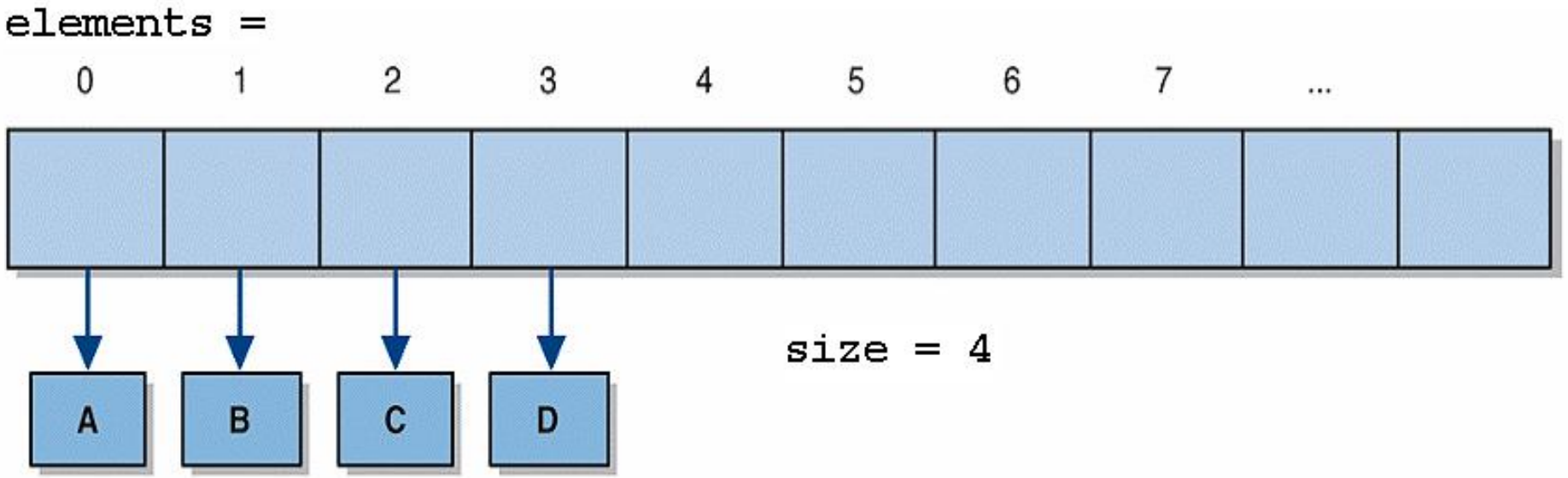
Lists

- **list**: an ordered sequence of elements, each accessible by a 0-based index
  - one of the most basic collections of data



The `ArrayList` class

- Class `ArrayList<E>` implements the notion of a list using a partially-filled array
  - when you want to use `ArrayList`, remember to `import java.util.*;`



`ArrayList` features

- think of it as an auto-resizing array that can hold any type of object, with many convenient methods

- maintains most of the benefits of arrays, such as fast random access

- frees us from some tedious operations on arrays, such as sliding elements and resizing

- can call `toString` on an `ArrayList` to print its elements
  - `[1, 2.65, Marty Stepp, Hello]`

Generic classes

- **generic class**: A type in Java that is written to accept another type as part of itself.
  - Generic ("parameterized") classes were added to Java to improve the type safety of Java's collections.
    - A parameterized type has one or more other types' names written between < and > .
  - `ArrayList<E>` is a generic class.
    - The `<E>` is a placeholder in which you write the type of elements you want to store in the `ArrayList`.
  - Example:

```
ArrayList<String> words = new ArrayList<String>();
```

    - Now the methods of `words` will manipulate and return `String`s.

`ArrayList` vs. array

- array

```
String[] names = new String[5];
names[0] = "Jennifer";
String name = names[0];
```

- `ArrayList`

```
ArrayList<String> namesList = new ArrayList<String>();
namesList.add("Jennifer");
String name = namesList.get(0);
```

Adding elements

- Elements are added dynamically to the list:

```
ArrayList<String> list = new ArrayList<String>();
System.out.println("list = " + list);
list.add("Tool");
System.out.println("list = " + list);
list.add("Phish");
System.out.println("list = " + list);
list.add("Pink Floyd");
System.out.println("list = " + list);
```

- Output:

```
list = []
list = [Tool]
list = [Tool, Phish]
list = [Tool, Phish, Pink Floyd]
```

Removing elements

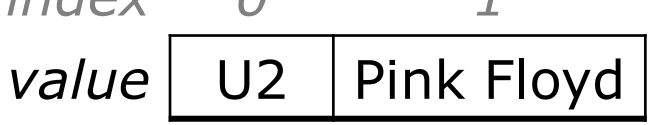
- Elements can also be removed by index:

```
System.out.println("before remove list = " + list);
list.remove(0);
list.remove(1);
System.out.println("after remove list = " + list);
```

- Output:

```
before remove list = [Tool, U2, Phish, Pink Floyd]
after remove list = [U2, Pink Floyd]
```

  - Notice that as each element is removed, the others shift downward in position to fill t
  - Therefore, the



Searching for elements

- You can search the list for particular elements:

```
if (list.contains("Phish")) {
    int index = list.indexOf("Phish");
    System.out.println(index + " " + list.get(index));
}
if (list.contains("Madonna")) {
    System.out.println("Madonna is in the list");
} else {
    System.out.println("Madonna is not found.");
}
```

- Output:

```
2 Phish
Madonna is not found.
```

  - `contains` tells you whether an element is in the list or not, and `indexOf` tells you at which index you can find it.

ArrayList methods

Method name	Description
`add(`*value*`)`	adds the given value to the end of the list
`add(`*index*`, `*value*`)`	inserts the given value before the given index
`clear()`	removes all elements
`contains(`*value*`)`	returns `true` if the given element is in the list
`get(`*index*`)`	returns the value at the given index
`indexOf(`*value*`)`	returns the first index at which the given element appears in the list (or -1 if not found)
`lastIndexOf(`*value*`)`	returns the last index at which the given element appears in the list (or -1 if not found)
`remove(`*index*`)`	removes value at given index, sliding others back
`size()`	returns the number of elements in the list

ArrayList and for loop

- Recall the enhanced for loop syntax from Chapter 7:

```
for (<type> <name> : <collection>) {
    <statement(s)>;
}
```

- This syntax can be used to examine an `ArrayList`:

```
int sum = 0;
for (String s : list) {
    sum += s.length();
}
System.out.println("Total of lengths = " + sum);
```

Wrapper classes

- `ArrayList`s only contain objects, and primitive values are not objects.
  - e.g. `ArrayList<int>` is not legal

- If you want to store primitives in an `ArrayList`, you must declare it using a "wrapper" class as its type.

Primitive type	Wrapper class
`int`	`Integer`
`double`	`Double`
`char`	`Character`
`boolean`	`Boolean`

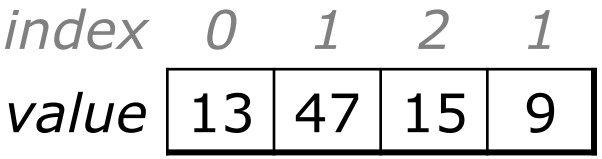
  - example:

```
ArrayList<Integer> list = new ArrayList<Integer>();
```

Wrapper example

- The following list stores `int` values:

```
ArrayList<Integer> list = new ArrayList<Integer
list.add(13);
list.add(47);
list.add(15);
list.add(9);
int sum = 0;
for (int n : list) {
    sum += n;
}
System.out.println("list = " + list);
System.out.println("sum = " + sum);
```



- Output:

```
list = [13, 47, 15, 9]
sum = 84
```

  - Though you must say `Integer` when declaring the list, you can refer to the elements as type `int` afterward.
  - Java automatically converts between the two using techniques known as **boxing** and **unboxing**.

Comparable interface

reading: 10.2

Natural ordering

- Many types have a notion of a **natural ordering** that describes whether one value of that type is "less than" or "greater than" another:
  - `int`, `double`: numeric value
  - `String`: lexical (alphabetical) order

- Not all types have a natural ordering:
  - `Point`: How would they be ordered? By y? By x? Distance from origin?
  - `ArrayList`: What makes one list "less than" another?

Uses of natural ordering

- An `ArrayList` of orderable values can be sorted using the `Collections.sort` method:

```
ArrayList<String> words = new ArrayList<String>();
words.add("four");
words.add("score");
words.add("and");
words.add("seven");
words.add("years");
words.add("ago");

// show list before and after sorting
System.out.println("before sort, words = " + words);
Collections.sort(words);
System.out.println("after sort, words = " + words);
```

- Output:

```
before sort, words = [four, score, and, seven, years, ago]
after sort, words = [ago, and, four, score, seven, years]
```

Comparable interface

- The natural ordering of a class is specified through the `compareTo` method of the `Comparable` interface:

```
public interface Comparable<T> {
    public int compareTo(T other);
}
```

- Classes such as `String` and `Integer` implement `Comparable`.
- `compareTo` returns an integer that is < 0, > 0, or 0:

Relationship	Primitive comparison	Object comparison
less than	`if (x < y) {`	`if (x.compareTo(y) < 0) {`
less than or equal	`if (x <= y) {`	`if (x.compareTo(y) <= 0) {`
equal	`if (x == y) {`	`if (x.compareTo(y) == 0) {`
not equal	`if (x != y) {`	`if (x.compareTo(y) != 0) {`
greater than	`if (x > y) {`	`if (x.compareTo(y) > 0) {`
greater or equal	`if (x >= y) {`	`if (x.compareTo(y) >= 0) {`

Implementing Comparable

- You can define a natural ordering for your own class by making it implement the `Comparable` interface.
  - `Comparable` is a generic interface, `Comparable<T>`
  - When implementing it, you must write your class's name in `<>` after the word `Comparable`.
  - Example:
    ```
    public class Point implements Comparable<Point>
    ```
  - You must also write a method `compareTo` that compares the current object (the implicit parameter) to a given other object.
  - Example:
    ```
    public int compareTo(Point p) {
        ...
    }
    ```

Comparable implementation

- The following `CalendarDate` class implements `Comparable`:

```
public class CalendarDate implements Comparable<CalendarDate> {
    private int month;
    private int day;

    public CalendarDate(int month, int day) {
        this.month = month;
        this.day = day;
    }

    // Compares two dates by month and then by day.
    public int compareTo(CalendarDate other) {
        if (month != other.month) {
            return month - other.month;
        } else {
            return day - other.day;
        }
    }

    public int getMonth() {
        return month;
    }

    public int getDay() {
        return day;
    }

    public String toString() {
        return month + "/" + day;
    }
}
```