Objectives

- Collections
- Enumerated types

COLLECTIONS

Collections

- Sometimes called *containers*
- Group multiple elements into a single unit
- Store, retrieve, manipulate, and communicate aggregate data
- Represent data items that form a natural group
  - Poker hand (a collection of cards)
  - Mail folder (a collection of messages)
  - Telephone directory (a mapping of names to phone numbers).
- Examples: `HashMaps, Sets, Lists`

Collections Framework

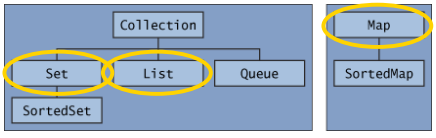
- *Unified architecture* for representing and manipulating collections
- More than arrays
  - More flexible, functionality, dynamic sizing
- `java.util`

Collections Framework

- **Interfaces**
  - Abstract data types that represent collections
  - Collections can be manipulated *independently* of implementation
- **Implementations**
  - Concrete implementations of collection interfaces
  - Reusable data structures
- **Algorithms**
  - Methods that perform useful computations on collections, e.g., searching and sorting
  - Reusable functionality
  - ***Polymorphic***: same method can be used on many different implementations of collection interface

Core Collection Interfaces

- Encapsulate different types of collections



Implementation vs. Interface

Implementation choice only affects performance

- Preferred Style:
  1. Choose an implementation
  2. Assign collection to variable of corresponding **interface** type

```
Interface variable = new Implementation();
```

- Also, methods should accept interfaces, not implementations

Why is this the preferred style?

Implementation vs. Interface

Implementation choice only affects performance

- Preferred Style:
  1. Choose an implementation
  2. Assign collection to variable of corresponding **interface** type
- Why?
  - Program does not depend on a given implementation's methods
  - Programmer can change implementations
    - Performance concerns or behavioral details

GENERICS

Example of the Way It Was

- Before Java 1.5
- Doesn't know what *type* of data is in the List

```
List myIntList = new LinkedList();
myIntList.add(new Integer(0));
…
Integer x = (Integer) myIntList.get(0);
```

Returns an object

- Have to cast object we get out of list
- What if someone put in an object of wrong type previously?

Generic Collection Interfaces

- Added to 1.5
- Declaration of the `Collection` interface:

```
public interface Collection<E> …
```

Type parameter

  - <E> means interface is generic for **e**lement class
- When declare a `Collection`, **specify type** of object it contains
  - Make sure put in, get out appropriate type
  - Allows compiler to verify that object's *type* is correct
    - Reduces errors at runtime
- Example, a hand of cards:

Always declare type

```
List<Card> hand = new List<Card>();
```


`Comparable` Interface

- Also uses Generics

```
public interface Comparable<T>
```

The type it compares

```
int compareTo(T o)
```

Types Allowed with Generics

- Can only contain `Objects`, not primitive types
- Autoboxing and Autounboxing to the rescue!
  - Example: If collecting `ints`, use `Integer`

Comparing: Before & After Generics

- Before Generics

```
List myIntList = new LinkedList();
myIntList.add(new Integer(0));
…
Integer x = (Integer) myIntList.get(0);
```

- After Generics

```
List<Integer> myIntList = new LinkedList<Integer>();
myIntList.add(new Integer(0));
…
Integer x = myIntList.get(0);
```

✓ Improved readability and robustness

LISTS

`List` Interface

- An ordered collection of elements
- Can contain duplicate elements
- Has control over where objects are stored in the list
- `boolean add(<E> o)`
  - Boolean so that List can refuse some elements
    - e.g., refuse adding `null` elements
- `<E> get(int index)`
  - Returns element at the position index
- `int size()`
  - Returns the number of elements in the list
- And more! (`contains`, `remove`, `toArray`, …)

Differences from Python

- No shorthand
  - `list[pos]`

`List` Implementations

- `ArrayList`
  - Resizable array
  - Used most frequently
  - Fast
- `LinkedList`
  - Use if adding elements to beginning of list
  - Use if often delete from middle of list

`cards.Deck.java`

SETS

Set Interface

- No duplicate elements
  - Needs to determine if two elements are "logically" the same (`equals` method)
- Models mathematical set abstraction
- `boolean add(<E> o)`
  - Add to set, only if not already present
- `int size()`
  - Returns the number of elements in the list
- And more! (`contains, remove, toArray, …`)
  - Note: no `get` method -- `get` #3 from the set?

Select Set Implementations

- `HashSet` 
  - Implements set using *hash table*
    - `add, remove`, and `contains` each execute in O(1) time
  - Used more frequently
  - Faster than `TreeSet`
  - No ordering
- `TreeSet`
  - Implements set using a *tree*
    - `add, remove`, and `contains` each execute in O (log n) time
  - Sorts

FindDuplicates Problem

- From the array of command-line arguments, identify the duplicates

```
public static void main(String args[]) {

}
```


FindDuplicates

```
public static void main(String args[]) {
    Set<String> s = new HashSet<String>();
    for (String a : args) {
      if (!s.add(a)) {
           System.out.println(
                "Duplicate detected: " + a);
      }
    }
    System.out.println(s.size() +
       " distinct words detected: " + s);
}
```

Note how much code changes if `s` is a `TreeSet`