SWEN20003
Object Oriented Software Development

Collections and Maps

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The Road So Far

- Java Foundations
  - A Quick Tour of Java
- Object Oriented Programming Foundations
  - Classes and Objects
  - Arrays and Strings
  - Input and Output
  - *Software Tools and Bagel*
  - Inheritance and Polymorphism
  - Interfaces and Polymorphism
- Advanced Object Oriented Programming and Software Design
  - Modelling Classes and Relationships
  - Generics

Previous Lecture Generics

Learning Outcomes:

- Understand **generic** classes in Java
- Use **generically typed** classes
- Define **generically typed** classes

Previous Lecture Generics - Recap

We looked at how the type parameter `T` was used in the Java `Comparable Interface`.

```
public interface Comparable<T> {

    public int compareTo(T other);

}
```

```
public class Robot implements Comparable<Robot> {...}
public class Book implements Comparable<Book> {...}
public class Dog implements Comparable<Dog> {...}
```

Previous Lecture Generics - Recap

We looked at how to use the `ArrayList` class.

```
import java.util.ArrayList;
public class PrintCircleRadius {
    public static void main(String[] args) {
        ArrayList<Circle> circles = new ArrayList<Circle>();
        circles.add(new Circle(0.0, 0.0, 5));
        circles.add(new Circle(0.0, 0.0, 10));
        circles.add(new Circle(0.0, 0.0, 7));
        printRadius(circles);
    }
    private static void printRadius(ArrayList<Circle> circles){
        int index = 0;
        for(Circle c: circles) {
            System.out.println("Radius at index " + index +
            " = " +  c.getRadius());
            index++;
        }
    }
}
```

Lecture Objectives

After this lecture you will be able to:

- Choose appropriate data structures storing, retrieving and manipulating objects (data)
- Use the Java Collections Framework
- Use the Java Maps Framework

Collections and Maps

Understanding how to store data (a collection of objects) for later retrieval and manipulation is an essential when writing programs.

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Java provides two *frameworks* to support this.

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Understanding how to store data (a collection of objects) for later retrieval and manipulation is an essential when writing programs.

Java provides two *frameworks* to support this.

Keyword

Collections: A framework that permits storing, accessing and manipulating *lists* (an ordered collection).

Keyword

Maps: A framework that permits storing, accessing and manipulating *key-value pairs*.

Back to ArrayList

Last lecture we looked at the `ArrayList` as a generic class.

`ArrayList` is a class in the Java Collections framework that can be used for storing, retrieving and manipulating a group of objects.

In this lecture we will take a closer look at how we can use the `ArrayList` class for more sophisticated data manipulations.

Using the ArrayList Class for storing

```
import java.util.ArrayList;
public class PrintCircleRadius {
    public static void main(String[] args) {
        ArrayList<Circle> circles = new ArrayList<Circle>();
        circles.add(new Circle(0.0, 0.0, 5));
        circles.add(new Circle(0.0, 0.0, 10));
        circles.add(new Circle(0.0, 0.0, 7));
        printRadius(circles);
    }
    private static void printRadius(ArrayList<Circle> circles){
        int index = 0;
        for(Circle c: circles) {
            System.out.println("Radius at index " + index +
                               " = " +  c.getRadius());
            index++;
        }
    }
}
```

retrieve use for each loop

Using the `ArrayList` Class for storing

What would the program print?

```
Radius of circle: at index 0 = 5.0
Radius of circle: at index 1 = 10.0
Radius of circle: at index 2 = 7.0
```

Using the `ArrayList` Class for storing

`ArrayList` can be used for storing different types of objects, provided they inherit the same base class - therefore not quite different types of objects theoretically.

Why is this useful?

Common behaviour across objects can be executed seamlessly - see next example.

Using the ArrayList Class for storing

```
public abstract class Shape {
    public abstract double getArea();
}
public class Circle extends Shape {
    private double radius = 0.0;
    // Code for constructors, getter and setter go here
    @Override
    public double getArea() {
        return Math.PI*radius*radius;
    }
}
public class Square extends Shape {
    private double length = 0.0;
    // Code for constructors, getter and setter go here
    @Override
    public double getArea() {
        return length*length;
    }
}
```

Using the ArrayList Class for storing

```
import java.util.ArrayList;

public class ComputeAreaShapes {
    public static void main(String[] args) {
        ArrayList<Shape> shapes = new ArrayList<Shape>();
        shapes.add(new Circle(0.0, 0.0, 5));
        shapes.add(new Circle(0.0, 0.0, 10));
        shapes.add(new Square(0.0, 0.0, 7));
        printArea(shapes);
    }

    private static void printArea(ArrayList<Shape> shapes) {
        int index = 0;
        for(Shape s: shapes) {
            System.out.println("Area of shape: at index " +
                               index++ + " = " + s.getArea());
        }
    }
}
```

Using the `ArrayList` Class for storing

What would the program print?

```
Area of shape: at index 0 = 78.53981633974483
Area of shape: at index 1 = 314.1592653589793
Area of shape: at index 2 = 49.0
```

Using the `ArrayList` Class for sorting

Elements of an `ArrayList` can be easily sorted if:

Using the `ArrayList` Class for sorting

Elements of an `ArrayList` can be easily sorted if:

The stored element class implements the `Comaparable<T>` interface!

The `compareTo()` method of the class must provide a comparison (returning an integer) which will be used to decide how the elements are sorted.

Using the ArrayList Class for sorting

```
public class CircleT  implements Comparable<CircleT>{
    private double radius = 0.0;

    public double getRadius() {
        return radius;
    }
    public void setRadius(double radius) {
        this.radius = radius;
    }
    public CircleT(double centreX, double centreY, int radius) {
        this.radius = radius;
    }

    @Override
    public int compareTo(CircleT c) {
        if (radius > c.getRadius())
            return 1;
        else if (radius < c.getRadius())
            return -1;
        else
            return 0;
    }
}
```

if "<" change to return 1

⇒ sort in descending order

Using the ArrayList Class for sorting

```
import java.util.ArrayList;
import java.util.Collections;

public class PrintCircleRadiusSorted {
    public static void main(String[] args) {
        ArrayList<CircleT> circles = new ArrayList<CircleT>();
        circles.add(new CircleT(0.0, 0.0, 5));
        circles.add(new CircleT(0.0, 0.0, 10));
        circles.add(new CircleT(0.0, 0.0, 7));
        printRadius(circles);
        Collections.sort(circles);
        System.out.println("****************************");
        printRadius(circles);
    }

    private static void printRadius(ArrayList<CircleT> circles){
        int index = 0;
        for(CircleT c: circles) {
            System.out.println("Radius of circle: at index " +
                        index++ + " = " + c.getRadius());
        }
    }
}
```

give circle Arraylist

Using the ArrayList Class for sorting

What would the program print?

```
Radius of circle: at index 0 = 5.0
Radius of circle: at index 1 = 10.0
Radius of circle: at index 2 = 7.0
**************************
Radius of circle: at index 0 = 5.0
Radius of circle: at index 1 = 7.0
Radius of circle: at index 2 = 10.0
```

Using the ArrayList Class for sorting

```
import java.util.*;
class Movie implements Comparable<Movie>
{
    private double rating;
    private String name;
    private int year;
    public Movie(String name, double rating, int year)
    {
        this.name = name;
        this.rating = rating;
        this.year = year;
    }
    public int compareTo(Movie m)
    {
        return this.year - m.year;
    }
    // Getters and setters go here - not shown
}
```

Using the ArrayList Class for sorting

```
import java.util.ArrayList;
import java.util.Collections;
public class MovieSorter {
    public static void main(String[] args) {
        ArrayList<Movie> list = new ArrayList<Movie>();
        list.add(new Movie("Force Awakens", 8.3, 2015));
        list.add(new Movie("Star Wars", 8.7, 1977));
        list.add(new Movie("Empire Strikes Back", 8.8, 1980));
        list.add(new Movie("Return of the Jedi", 8.4, 1983));
        Collections.sort(list);
        printList(list);
    }

    public static void printList(ArrayList<Movie> list) {
        for (Movie movie: list)
            System.out.println(movie.getRating() + " " +
                movie.getName() + " " +    movie.getYear());
    }
}
```

Using the `ArrayList` Class for sorting

What would the program print?

Using the ArrayList Class for sorting

What would the program print?

```
8.7 Star Wars 1977
8.8 Empire Strikes Back 1980
8.4 Return of the Jedi 1983
8.3 Force Awakens 2015
```

Now, what if we want to sort the movies by rating or name - not year?

How can we do that?

Using the `ArrayList` Class for sorting

What would the program print?

```
8.7 Star Wars 1977
8.8 Empire Strikes Back 1980
8.4 Return of the Jedi 1983
8.3 Force Awakens 2015
```

Now, what if we want to sort the movies by rating or name - not year?

How can we do that?

Good news is java `Comparator` and `Collections.sort()` can still help you!

interface

Using the ArrayList Class for sorting

```
import java.util.Comparator;
class RatingComparator implements Comparator<Movie>
{
    public int compare(Movie m1, Movie m2)
    {
        if (m1.getRating() < m2.getRating()) return -1;
        if (m1.getRating() > m2.getRating()) return 1;
        else return 0;
    }
}

import java.util.Comparator;
public class NameComparator implements Comparator<Movie> {
    public int compare(Movie m1, Movie m2) {
        return m1.getName().compareTo(m2.getName());
    }
}
```

compareTo

only one parameter

Using the ArrayList Class for sorting

```
// import statements
public class MovieSorter {
    public static void main(String[] args) {
        // Code to add movies to the arraylist - same as pervious example
        Collections.sort(list);
        printList(list);
        System.out.println("*****************************");
        Collections.sort(list,new RatingComparator());
        printList(list);
        System.out.println("*****************************");
        Collections.sort(list,new NameComparator());
        printList(list);
    }
    public static void printList(ArrayList<Movie> list) {
        for (Movie movie: list)
            System.out.println(movie.getRating() + " " +
                movie.getName() + " " +    movie.getYear());
    }
}
```

new comparator based on rating

Using the `ArrayList` Class for sorting

What would the program print?

Using the ArrayList Class for sorting

What would the program print?

```
8.7 Star Wars 1977
8.8 Empire Strikes Back 1980
8.4 Return of the Jedi 1983
8.3 Force Awakens 2015
**********************************
8.3 Force Awakens 2015
8.4 Return of the Jedi 1983
8.7 Star Wars 1977
8.8 Empire Strikes Back 1980
**********************************
8.8 Empire Strikes Back 1980
8.3 Force Awakens 2015
8.4 Return of the Jedi 1983
8.7 Star Wars 1977
```

⇒ write a separate class

Using the `ArrayList` Class for sorting

In the previous example, we developed new comparator class for each comparison.

Was it necessary? Is that a bit of an overkill?

Is there a different solution?

Using the `ArrayList` Class for sorting

In the previous example, we developed new comparator class for each comparison.

Was it necessary? Is that a bit of an overkill?

Is there a different solution?

Anonymous Inner Class is the solution.

Keyword

Anonymous Inner Class: A class created "on the fly", without a new file, or class name for which only a single object is created.

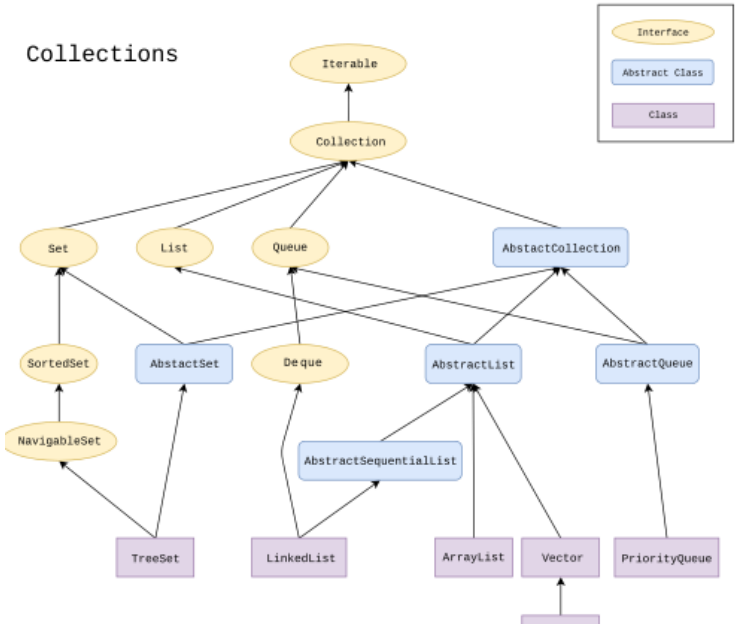
Using the ArrayList Class for sorting

```
public class MovieSorterAnnonymous {
    public static void main(String[] args) {
    // Same code as the previous example
        Collections.sort(list, new Comparator<Movie>(){
            @Override
            public int compare(Movie m1, Movie m2){
                if (m1.getRating() < m2.getRating()) return -1;
                if (m1.getRating() > m2.getRating()) return 1;
                else return 0;
            }});
        printList(list);

        Collections.sort(list, new Comparator<Movie>(){
            @Override
            public int compare(Movie m1, Movie m2) {
                return m1.getName().compareTo(m2.getName());
            }});
        printList(list);
    }
}
```

only in this class

Collections Hierarchy



Common Operations - Collections

Length `int size()`

Common Operations - Collections

Length `int size()` → how many elements inside (memory sometimes not clean up) when remove elements

Presence `boolean contains(Object element)`

Only works when `element` defines `equals(Object element)`

Common Operations - Collections

Length `int size()`

Presence `boolean contains(Object element)`
Only works when `element` defines `equals(Object element)`

Add `boolean add(E element)`

Common Operations - Collections

Length	`int size()`
Presence	`boolean contains(Object element)` Only works when `element` defines `equals(Object element)`
Add	`boolean add(E element)`
Remove	`boolean remove(Object element)` → check equals (object element).

Common Operations - Collections

Length `int size()`

Presence `boolean contains(Object element)`

Only works when `element` defines `equals(Object element)`

Add `boolean add(E element)`

Remove `boolean remove(Object element)`

Iterating `Iterator<E> iterator()`

→ insert an element what happens to the element at present at the particular index

⇒ get pushed down

Common Operations - Collections

Length	`int size()`
Presence	`boolean contains(Object element)` Only works when `element` defines `equals(Object element)`
Add	`boolean add(E element)`
Remove	`boolean remove(Object element)`
Iterating	`Iterator<E> iterator()`
Iterating	`for (T t : Collection<T>)`
Retrieval	`Object get(int index)` Supported only at `AbstractList` level and below.

Most Useful?

Each of these have their useful applications, but personally...

- `ArrayList`: like arrays, but better

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- `ArrayList`: like arrays, but better
- `HashSet`: ensures elements are unique - no duplicates (override the same).
- `PriorityQueue`: allows you to *order* elements in non-trivial ways

Most Useful?

Each of these have their useful applications, but personally...

- `ArrayList`: like arrays, but better
- `HashSet`: ensures elements are unique - no duplicates
- `PriorityQueue`: allows you to *order* elements in non-trivial ways
- `TreeSet`: Fast lookup/search of unique elements

Most Useful?

Each of these have their useful applications, but personally...

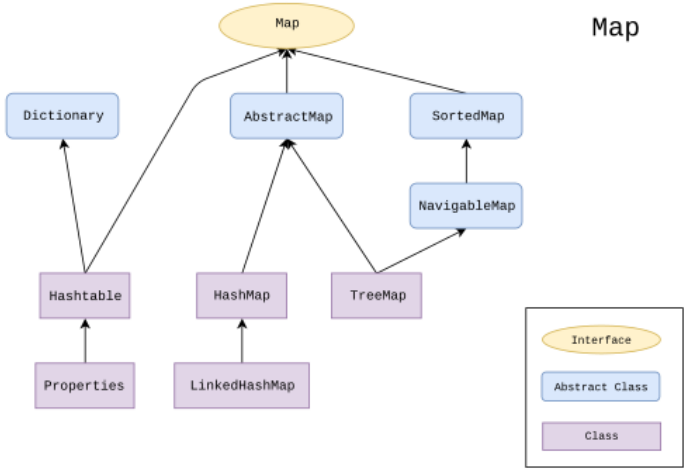
- `ArrayList`: like arrays, but better
- `HashSet`: ensures elements are unique - no duplicates
- `PriorityQueue`: allows you to *order* elements in non-trivial ways
- `TreeSet`: Fast lookup/search of unique elements

Maps

Keyword

Maps: A framework that permits storing, accessing and manipulating *key-value pairs.*

Maps Hierarchy



Source: https://en.wikipedia.org/wiki/Java_collections_framework [Note: Not UML]

Common Operations - Maps

Length `int size()`

Common Operations - Maps

Length `int size()`

Presence `boolean containKey(Object key)`

Presence `boolean containValue(Object value)`

Add/Replace `boolean put(K key, V value)`

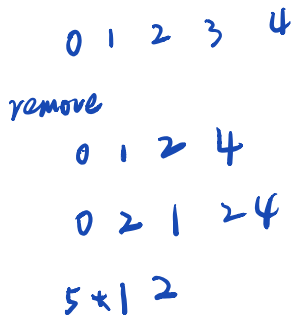
> based on equals method

if key exist, will replace.

if key not exist, will add

Common Operations - Maps

Length	`int size()`
Presence	`boolean containKey(Object key)`
Presence	`boolean containValue(Object value)`
Add/Replace	`boolean put(K key, V value)`
Remove	`boolean remove(Object key)`



Common Operations - Maps

Length	`int size()`
Presence	`boolean containKey(Object key)`
Presence	`boolean containValue(Object value)`
Add/Replace	`boolean put(K key, V value)`
Remove	`boolean remove(Object key)`
Iterating	`Set<K> keySet()`

Common Operations - Maps

Length	`int size()`
Presence	`boolean containKey(Object key)`
Presence	`boolean containValue(Object value)`
Add/Replace	`boolean put(K key, V value)`
Remove	`boolean remove(Object key)`
Iterating	`Set<K> keySet()`
Iterating	`Set<Map.Entry<K,V>> entrySet()`
Retrieval	`V get(Object key)`

containsKey

containsValue

get all keys & value

→ get based on key

Using HashMap

A generic class that takes two types: `K` (the key) and `V` (the value)

```
import java.util.HashMap;

public static void main(String[] args) {
    HashMap<String,Book> library = new HashMap<>();

    Book b1 = new Book("J.R.R. Tolkien", "The Lord of the Rings", 1178);
    Book b2 = new Book("George R. R. Martin", "A Game of Thrones", 694);

    library.put(b1.author, b1);
    library.put(b2.author, b2);

    for(String author : library.keySet()) {
        Book b = library.get(author);
        System.out.format("%s, %s, %d\n", b.getAuthor(),
            b.getTitle(), b.getNumPages());
    }
}
```

optional to put <String, Book>

to iterate, need to get keySet

get based on author

Assess Yourself

If you were to create a digital phonebook using a `HashMap`, what would the `key` and `value` types be?

Assess Yourself

If you were to create a digital phonebook using a `HashMap`, what would the `key` and `value` types be?

```
HashMap<String,Integer> phonebook = new HashMap<>();
```

for phonebook, name phone

Assess Yourself

If you were to create a system to link a pet's ID to it's owner, what would the `key` and `value` types be?

key petID Integer
value owner Person

Assess Yourself

If you were to create a system to link a pet's ID to it's owner, what would the `key` and `value` types be?

```
HashMap<Integer,Person> petTracker = new HashMap<>();
```

Assess Yourself

Write a class called `Tracker`, which accepts two type parameters. The first type must be subclass of `Person`, and the second type a subclass of `Locator`.

A `Person` object could be a `Hiker`, `Diver`, or `Pilot`.

A `Locator` object could be `GPS`, `Infrared`, or `IP`.

The `Tracker` class maintains a list of `TwoTypePair` objects, with the elements of the `TwoTypePair` being a `Person` and a `Locator`.

Generics in the Collections and Maps

If we didn't have generic classes, how would you implement a list, a map, etc.?

Generics in the Collections and Maps

If we didn't have generic classes, how would you implement a list, a map, etc.?

- Define everything as `Object`
- Rewrite your code for any type you might use it with

Generics in the Collections and Maps

If we didn't have generic classes, how would you implement a list, a map, etc.?

- Define everything as `Object`
- Rewrite your code for any type you might use it with

Generics give us **flexibility**; code once, reuse the code for **any** type. They also allow objects to keep their **type** (i.e. not be `Objects`), **and**, allows the compiler to detect errors, thereby prevent run-time errors if code is properly designed.

Lecture Objectives

After this lecture you will be able to:

- Choose appropriate data structures storing, retrieving and manipulating objects (data)
- Use Java Collections Framework
- Use Java Maps Framework