

Core Java

Collection framework

Queue interface

- Represents utility data structures (like Stack, Queue, ...) data structure.
- Implementations: LinkedList, ArrayDeque, PriorityQueue.
- Can be accessed using iterator, but no random access.
- Methods
 - `boolean add(E e)` - throw `IllegalStateException` if full.
 - `E remove()` - throw `NoSuchElementException` if empty
 - `E element()` - throw `NoSuchElementException` if empty
 - `boolean offer(E e)` - return false if full.
 - `E poll()` - returns null if empty
 - `E peek()` - returns null if empty
- In queue, addition and deletion is done from the different ends (rear and front).

Deque interface

- Represents double ended queue data structure i.e. add/delete can be done from both the ends.
- Two sets of methods
 - Throwing exception on failure: `addFirst()`, `addLast()`, `removeFirst()`, `removeLast()`, `getFirst()`, `getLast()`.
 - Returning special value on failure: `offerFirst()`, `offerLast()`, `pollFirst()`, `pollLast()`, `peekFirst()`, `peekLast()`.
- Can used as Queue as well as Stack.
- Methods
 - `boolean offerFirst(E e)`
 - `E pollFirst()`
 - `E peekFirst()`
 - `boolean offerLast(E e)`
 - `E pollLast()`
 - `E peekLast()`

ArrayDeque class

- Internally `ArrayDeque` is dynamically growable array.
- Elements are allocated contiguously in memory.

LinkedList class

- Internally `LinkedList` is doubly linked list.

PriorityQueue class

- Internally PriorityQueue is a "binary heap" data structure.
- Elements with highest priority is deleted first (NOT FIFO).
- Elements should have natural ordering or need to provide comparator.

Set interface

- Collection of unique elements (NO duplicates allowed).
- Implementations: HashSet, LinkedHashSet, TreeSet.
- Elements can be accessed using an Iterator.
- Abstract methods (same as Collection interface)
 - add() returns false if element is duplicate

HashSet class

- Non-ordered set (elements stored in any order)
- Elements must implement equals() and hashCode()
- Fast execution

LinkedHashSet class

- Ordered set (preserves order of insertion)
- Elements must implement equals() and hashCode()
- Slower than HashSet

SortedSet interface

- Use natural ordering or Comparator to keep elements in sorted order
- Methods
 - E first()
 - E last()
 - SortedSet headSet(E toElement)
 - SortedSet subSet(E fromElement, E toElement)
 - SortedSet tailSet(E fromElement)

NavigableSet interface

- Sorted set with additional methods for navigation
- Methods
 - E higher(E e)
 - E lower(E e)
 - E pollFirst()
 - E pollLast()
 - NavigableSet descendingSet()
 - Iterator descendingIterator()

TreeSet class

- Sorted navigable set (stores elements in sorted order)

- Elements must implement Comparable or provide Comparator
- Slower than HashSet and LinkedHashSet
- It is recommended to have consistent implementation for Comparable (Natural ordering) and equals() method i.e. equality and comparison should be done on same fields.
- If need to sort on other fields, use Comparator.

```
class Book implements Comparable<Book> {
    private String isbn;
    private String name;
    // ...
    public int hashCode() {
        return isbn.hashCode();
    }
    public boolean equals(Object obj) {
        if(!(obj instanceof Book))
            return false;
        Book other=(Book)obj;
        if(this.isbn.equals(other.isbn))
            return true;
        return false;
    }
    public int compareTo(Book other) {
        return this.isbn.compareTo(other.isbn);
    }
}
```

```
// Store in sorted order by name
set = new TreeSet<Book>((b1,b2) -> b1.getName().compareTo(b2.getName()));
```

```
// Store in sorted order by isbn (Natural ordering)
set = new TreeSet<Book>();
```

HashTable Data structure

- Hashtable stores data in key-value pairs so that for the given key, value can be searched in fastest possible time.
- Internally hash-table is a table(array), in which each slot(index) has a bucket(collection). Key-value entries are stored in the buckets depending on hash code of the "key".
- Load factor = Number of entries / Number of buckets.
- Examples
 - Key=pincode, Value=city/area
 - Key=Employee, Value=Manager
 - Key=Department, Value=list of Employees

hashCode() method

- Object class has hashCode() method, that returns a unique number for each object (by converting its address into a number).
- To use any hash-based data structure hashCode() and equals() method must be implemented.
- If two distinct objects yield same hashCode(), it is referred as collision. More collisions reduce performance.
- Most common technique is to multiply field values with prime numbers to get uniform distribution and lesser collisions.
- hashCode() overriding rules
 - hash code should be calculated on the fields that decides equality of the object.
 - hashCode() should return same hash code each time unless object state is modified.
 - If two objects are equal (by equals()), then their hash code must be same.
 - If two objects are not equal (by equals()), then their hash code may be same (but reduce performance).

Map interface

- Collection of key-value entries (Duplicate "keys" not allowed).
- Implementations: HashMap, LinkedHashMap, TreeMap, Hashtable, ...
- The data can be accessed as set of keys, collection of values, and/or set of key-value entries.
- Map.Entry<K,V> is nested interface of Map<K,V>.
 - K getKey()
 - V getValue()
 - V setValue(V value)
- Abstract methods

```
* boolean isEmpty()
* int size()
* V put(K key, V value)
* V get(Object key)
* Set<K> keySet()
* Collection<V> values()
* Set<Map.Entry<K,V>> entrySet()
* boolean containsValue(Object value)
* boolean containsKey(Object key)
* V remove(Object key)
* void clear()
* void putAll(Map<? extends K,? extends V> map)
```

- Maps not considered as true collection, because it is not inherited from Collection interface.

HashMap class

- Non-ordered map (entries stored in any order -- as per hash code of key)
- Keys must implement equals() and hashCode()
- Fast execution
- Mostly used Map implementation

LinkedHashMap class

- Ordered map (preserves order of insertion)
- Keys must implement equals() and hashCode()
- Slower than HashSet
- Since Java 1.4

TreeMap class

- Sorted navigable map (stores entries in sorted order of key)
- Keys must implement Comparable or provide Comparator
- Slower than HashMap and LinkedHashMap
- Internally based on Red-Black tree.
- Doesn't allow null key (allows null value though).

Hashtable class

- Similar to HashMap class.
- Legacy collection class (since Java 1.0), modified for collection framework (Map interface).
- Synchronized collection -- Thread safe but slower performance
- Inherited from java.util.Dictionary abstract class (it is Obsolete).

Anonymous Inner class

- Creates a new class inherited from the given class/interface and its object is created.
- If in static context, behaves like static member class. If in non-static context, behaves like non-static member class.
- Along with Outer class members, it can also access (effectively) final local variables of the enclosing method.

```
// (named) local class
class EmpnoComparator implements Comparator<Employee> {
    public int compare(Employee e1, Employee e2) {
        return e1.getEmpno() - e2.getEmpno();
    }
}
Arrays.sort(arr, new EmpnoComparator());    // anonymous obj of local class
```

```
// Anonymous inner class
Comparator<Employee> cmp = new Comparator<Employee>() {
    public int compare(Employee e1, Employee e2) {
        return e1.getEmpno() - e2.getEmpno();
    }
};
Arrays.sort(arr, cmp);
```

```
// Anonymous object of Anonymous inner class.
Arrays.sort(arr, new Comparator<Employee>() {
    public int compare(Employee e1, Employee e2) {
        return e1.getEmpno() - e2.getEmpno();
    }
});
```

Java 8 Interfaces

- Before Java 8
 - Interfaces are used to design specification/standards. It contains only declarations – public abstract.

```
interface Geometry {
    /*public static final*/ double PI = 3.14;
    /*public abstract*/ int calcRectArea(int length, int breadth);
    /*public abstract*/ int calcRectPeri(int length, int breadth);
}
```

- As interfaces doesn't contain method implementations, multiple interface inheritance is supported (no ambiguity error).
 - Interfaces are immutable. One should not modify interface once published.
- Java 8 added many new features in interfaces in order to support functional programming in Java. Many of these features also contradicts earlier Java/OOP concepts.

Default methods

- Java 8 allows default methods in interfaces. If method is not overridden, its default implementation in interface is considered.
- This allows adding new functionalities into existing interfaces without breaking old implementations e.g. Collection, Comparator, ...

```
interface Emp {
    double getSal();
    default double calcIncentives() {
        return 0.0;
    }
}
class Manager implements Emp {
    // ...
    // calcIncentives() is overridden
    double calcIncentives() {
        return getSal() * 0.2;
    }
}
```

```
class Clerk implements Emp {
    // ...
    // calcIncentives() is not overridden -- so method of interface is
    considered
}
```

```
new Manager().calcIncentives(); // return sal * 0.2
new Clerk().calcIncentives(); // return 0.0
```

- However default methods will lead to ambiguity errors as well, if same default method is available from multiple interfaces. Error: Duplicate method while declaring class.
- Superclass same method get higher priority. But super-interfaces same method will lead to error.
 - Super-class wins! Super-interfaces clash!!

```
interface Displayable {
    default void show() {
        System.out.println("Displayable.show() called");
    }
}
interface Printable {
    default void show() {
        System.out.println("Printable.show() called");
    }
}
class FirstClass implements Displayable, Printable { // compiler error:
    duplicate method
    // ...
}
class Main {
    public static void main(String[] args) {
        FirstClass obj = new FirstClass();
        obj.show();
    }
}
```

```
interface Displayable {
    default void show() {
        System.out.println("Displayable.show() called");
    }
}
interface Printable {
    default void show() {
        System.out.println("Printable.show() called");
    }
}
class Superclass {
    public void show() {
```

```

        System.out.println("Superclass.show() called");
    }
}
class SecondClass extends Superclass implements Displayable, Printable {
    // ...
}
class Main {
    public static void main(String[] args) {
        SecondClass obj = new SecondClass();
        obj.show(); // Superclass.show() called
    }
}

```

- A class can invoke methods of super interfaces using InterfaceName.super.

```

interface Displayable {
    default void show() {
        System.out.println("Displayable.show() called");
    }
}
interface Printable {
    default void show() {
        System.out.println("Printable.show() called");
    }
}
class FourthClass implements Displayable, Printable {
    @Override
    public void show() {
        System.out.println("FourthClass.show() called");
        Displayable.super.show();
        Printable.super.show();
    }
}
class Main {
    public static void main(String[] args) {
        FourthClass obj = new FourthClass();
        obj.show(); // calls FourthClass method
    }
}

```

Static methods

- Before Java 8, interfaces allowed public static final fields.
- Java 8 also allows the static methods in interfaces.
- They act as helper methods and thus eliminates need of helper classes like Collections, ...

```

interface Emp {
    double getSal();
    public static double calcTotalSalary(Emp[] a) {

```



```

        double total = 0.0;
        for(int i=0; i<a.length; i++)
            total += a[i].getSal();
        return total;
    }
}

```

Functional Interface

- If interface contains exactly one abstract method (SAM), it is said to be functional interface.
- It may contain additional default & static methods. E.g. Comparator, Runnable, ...
- @FunctionalInterface annotation does compile time check, whether interface contains single abstract method. If not, raise compile time error.

```

@FunctionalInterface // okay
interface Foo {
    void foo(); // SAM
}

```

```

@FunctionalInterface // okay
interface FooBar1 {
    void foo(); // SAM
    default void bar() {
        /*... */
    }
}

```

```

@FunctionalInterface // NO -- error
interface FooBar2 {
    void foo(); // AM
    void bar(); // AM
}

```

```

@FunctionalInterface // NO -- error
interface FooBar3 {
    default void foo() {
        /*... */
    }
    default void bar() {
        /*... */
    }
}

```

```

@FunctionalInterface    // okay
interface FooBar4 {
    void foo(); // SAM
    public static void bar() {
        /*... */
    }
}

```

- Functional interfaces forms foundation for Java lambda expressions and method references.

Built-in functional interfaces

- New set of functional interfaces given in java.util.function package.
 - `Predicate<T>`: test: T -> boolean
 - `Function<T,R>`: apply: T -> R
 - `BiFunction<T,U,R>`: apply: (T,U) -> R
 - `UnaryOperator<T>`: apply: T -> T
 - `BinaryOperator<T>`: apply: (T,T) -> T
 - `Consumer<T>`: accept: T -> void
 - `Supplier<T>`: get: () -> T
- For efficiency primitive type functional interfaces are also supported e.g. `IntPredicate`, `IntConsumer`, `IntSupplier`, `IntToDoubleFunction`, `ToIntFunction`, `ToIntBiFunction`, `IntUnaryOperator`, `IntBinaryOperator`.

Lambda expressions

- Traditionally Java uses anonymous inner classes to compact the code. For each inner class separate .class file is created.
- However code is complex to read and un-efficient to execute.
- Lambda expression is short-hand way of implementing functional interface.
- Its argument types may or may not be given. The types will be inferred.
- Lambda expression can be single liner (expression not statement) or multi-liner block { ... }.

```

// Anonymous inner class
Arrays.sort(arr, new Comparator<Emp>() {
    public int compare(Emp e1, Emp e2) {
        int diff = e1.getEmpno() - e2.getEmpno();
        return diff;
    }
});

```

```

// Lambda expression -- multi-liner
Arrays.sort(arr, (Emp e1, Emp e2) -> {
    int diff = e1.getEmpno() - e2.getEmpno();
    return diff;
});

```

```
// Lambda expression -- multi-liner -- Argument types inferred
Arrays.sort(arr, (e1, e2) -> {
    int diff = e1.getEmpno() - e2.getEmpno();
    return diff;
});
```

```
// Lambda expression -- single-liner -- with block { ... }
Arrays.sort(arr, (e1, e2) -> {
    return e1.getEmpno() - e2.getEmpno();
});
```

```
// Lambda expression -- single-liner
Arrays.sort(arr, (e1,e2) -> e1.getEmpno() - e2.getEmpno());
```

- Practically lambda expressions are used to pass as argument to various functions.
- Lambda expression enable developers to write concise code (single liners recommended).