Static and Default Methods in Java 8 Interfaces

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Marty is also available for consulting and development support

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Big Idea

• **Static methods in interfaces**
  – Java 7 and earlier
    • No
  – Java 8 and later
    • Yes
  – New rules violate the spirit of interfaces?
    • No (arguably)

• **Concrete (default) methods in interfaces**
  – Java 7 and earlier
    • No
  – Java 8 and later
    • Yes
  – New rules violate the spirit of interfaces?
    • Yes (arguably)

Java 8: Interfaces and Abstract Classes

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<th>Java 7 and Earlier</th>
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<td><strong>Abstract Classes</strong></td>
<td>• Can have concrete methods and abstract methods</td>
<td>(Same as Java 7)</td>
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<td></td>
<td>• Can have static methods</td>
<td></td>
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<td>• Can have instance variables</td>
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<td></td>
<td>• Class can directly extend one</td>
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<tr>
<td><strong>Interfaces</strong></td>
<td>• Can only have abstract methods – no concrete methods</td>
<td>• Can have concrete (default) methods and abstract methods</td>
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<td>• Cannot have static methods</td>
<td>• Can have static methods</td>
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<td></td>
<td>• Cannot have mutable instance variables</td>
<td>• Cannot have mutable instance variables</td>
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<td>• Class can implement any number</td>
<td>• Class can implement any number</td>
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Conclusion: there is little reason to use abstract classes in Java 8. Except for instance variables, Java 8 interfaces can do everything that abstract classes can do, plus are more flexible since classes can implement more than one interface. This means (arguably) that Java 8 has real multiple inheritance.
Static Methods in Interfaces

• Idea
  – Java 7 and earlier prohibited static methods in interfaces. Java 8 now allows this

• Motivation
  – Seems natural to put operations related to the general type in the interface
  – Does not violate the “spirit” of interfaces
    • `Shape.sumAreas(arrayOfShapes);`

• Notes
  – You must use interface name in the method call, even from code within a class that implements the interface
    • `Shape.sumAreas, not sumAreas`
  – The static methods cannot manipulate static variables
    • Java 8 interfaces continue to prohibit mutable fields

Example: Shape
Example from OOP Section

- **Goal**
  - Want to be able to make mixed collections of Circle, Square, etc.

- **Standard solution**
  - Define Shape interface and have Circle, Square, etc. implement it

- **Goal**
  - Want to be able to sum up the areas of an array of mixed Shapes

- **Standard solution**
  - Put abstract getArea method in the interface, define it in the classes
  - Make static method that takes a Shape[] and sums the areas

- **Java 8 twist**
  - Put static method directly in Shape instead of in a utility class as would have been done in Java 7

```java
public interface Shape {
    double getArea(); // All real shapes must define a getArea

    public static double sumAreas(Shape[] shapes) { 
        double sum = 0;
        for(Shape s: shapes) {
            sum = sum + s.getArea();
        }
        return (sum);
    }
}
```
public class Circle implements Shape {
    private double radius;

    public Circle(double radius) {
        this.radius = radius;
    }

    @Override
    public double getArea() {
        return (Math.PI * radius * radius);
    }

    ...
}

Rectangle and Square are similar.

public class ShapeTest {
    public static void main(String[] args) {
        Shape[] shapes = { new Circle(10),       // Area is about 314.159
                          new Rectangle(5, 10),     // Area is 50
                          new Square(10) };          // Area is 100
        System.out.println("Sum of areas: " +
                           Shape.sumAreas(shapes));    // Area is about 464.159
    }
}
Example: Op

Example from First Lambda Section

• **Goal**
  – Want to be able to time various operations without repeating code

• **Java 8 solution**
  – Define functional (1-abstract-method) Op interface
  – Define static method that takes an Op, calls its method, and times it
  – Pass lambdas to the static method
    
    ```java
    TimingUtils.timeOp(() -> someLongOperation(...));
    ```

• **New twist**
  – Put static method directly in Op instead of in a utility class (TimingUtils)
    
    ```java
    Op.timeOp(() -> someLongOperation(...));
    ```
Old Approach: The Op Interface

```java
@FunctionalInterface
public interface Op {
    void runOp();
}
```

Old Approach: The TimingUtils Class

```java
public class TimingUtils {
    private static final double ONE_BILLION = 1_000_000_000;

    public static void timeOp(Op operation) {
        long startTime = System.nanoTime();
        operation.runOp();
        long endTime = System.nanoTime();
        double elapsedSeconds = (endTime - startTime)/ONE_BILLION;
        System.out.printf("  Elapsed time: %.3f seconds.\n", elapsedSeconds);
    }
}
```
Old Approach: Test Code

```java
public class TimingTests {
    public static void main(String[] args) {
        for(int i=3; i<8; i++) {
            int size = (int)Math.pow(10, i);
            System.out.printf("Sorting array of length %,d.%n", size);
            TimingUtils.timeOp(() -> sortArray(size));
        }
    }
}

// Supporting methods like sortArray
```

Second Approach: The Op Interface

```java
@FunctionalInterface
public interface Op {
    static final double ONE_BILLION = 1_000_000_000;

    void runOp();

    static void timeOp(Op operation) {
        long startTime = System.nanoTime();
        operation.runOp();
        long endTime = System.nanoTime();
        double elapsedSeconds = (endTime - startTime)/ONE_BILLION;
        System.out.printf("  Elapsed time: %.3f seconds.%n", elapsedSeconds);
    }
}
```
Second Approach: The TimingUtils Class

• None!

Second Approach: Test Code

```java
public class TimingTests {
    public static void main(String[] args) {
        for(int i=3; i<8; i++) {
            int size = (int)Math.pow(10, i);
            System.out.printf("Sorting array of length %,d.%n", size);
            Op.timeOp(() -> sortArray(size));
        }
    }

    // Supporting methods like sortArray
}
```
Default Methods in Interfaces

Default (Concrete) Methods in Interfaces

• Idea
  – Java 7 and earlier prohibited concrete methods in interfaces. Java 8 now allows this.

• Motivation
  – Java needed to add methods like stream and forEach to List.
  – No problem for built-in classes: Java could update the definition of the List interface and all built-in classes that implemented List (ArrayList, etc.)
  – Big problem for custom (user-defined) classes that implemented List: they would fail in Java 8. Would very seriously violate the rule that new Java versions do not break existing code.

• Note
  – Some people argue that this breaks the spirit of interfaces, and interfaces are now more like abstract classes. Perhaps (but arguable), but it was a useful trick, and default methods in interfaces are useful in your code as well.
Updating the Op Interface

• **Make method to combine two Ops**
  - To produce single Op that runs the code of two other Ops

• **Natural place to put it is in Op itself**
  
  ```java
  Op op1 = () -> someCode(...);
  Op op2 = () -> someOtherCode(...);
  Op op3 = op1.combinedOp(op2);
  Op.timeOp(op3);
  ```

• **Requires a default method**
  
  ```java
  public interface Op {
    ...
    default Op combinedOp(...) { ... }
  }
  ```

Third Approach: The Op Interface

```java
@FunctionalInterface
public interface Op {
  void runOp();

  static void timeOp(Op operation) {
    // Unchanged from last example
  }

  default Op combinedOp(Op secondOp) {
    return (() -> { runOp();
                    secondOp.runOp(); });
  }
}
```
Third Approach: Test Code

```java
public static void main(String[] args) {
    for(int i=3; i<8; i++) {
        int size = (int)Math.pow(10, i);
        Op sortArray = () -> sortArray(size);
        Op wasteTime = () -> wasteTime(size);
        Op doBoth = sortArray.combinedOp(wasteTime);
        System.out.printf("Sorting array of length %d%n", size);
        Op.timeOp(sortArray);
        System.out.printf("Wasting time (%d repeats).%n", size);
        Op.timeOp(wasteTime);
        System.out.printf("Doing both (%d repeats).%n", size);
        Op.timeOp(doBoth);
    }
}
// Supporting methods like sortArray and wasteTime
```
Source Code for Builtin Function Interface

```java
@FunctionalInterface
public interface Function<T, R> {

    R apply(T t);

    default <V> Function<V,R> compose(Function<...> before) {
        ...
    }

    default <V> Function<T, V> andThen(...) { ... }

    static <T> Function<T, T> identity() {
        return t -> t;
    }
}
```

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### No Conflicts: Java 7

- **Interfaces Int1 and Int2 specify someMethod**
  
  ```java
  public interface Int1 { int someMethod(); }
  public interface Int2 { int someMethod(); }
  ```

- **Class ParentClass defines someMethod**
  
  ```java
  public class ParentClass {
      public int someMethod() { return(3); }
  }
  ```

- **Examples**
  
  ```java
  public class SomeClass implements Int1, Int2 {
      ...
  }
  ```

  - No conflict: SomeClass must define someMethod, and by doing so, satisfies both interfaces

  ```java
  public class ChildClass extends ParentClass implements Int1 {
      ...
  }
  ```

  - No conflict: the child class inherits someMethod from ParentClass, and interface is satisfied

### Potential Conflicts: Java 8

- **Interfaces Int1 and Int2 define someMethod**
  
  ```java
  public interface Int1 { default int someMethod() { return(5); } }
  public interface Int2 { default int someMethod() { return(7); } }
  ```

- **Class ParentClass defines someMethod**
  
  ```java
  public class ParentClass {
      public int someMethod() { return(3); }
  }
  ```

- **Examples**
  
  ```java
  public class SomeClass implements Int1, Int2 {
      ...
  }
  ```

  - Potential conflict: whose definition of someMethod wins, the one from Int1 or the one from Int2?

  ```java
  public class ChildClass extends ParentClass implements Int1 {
      ...
  }
  ```

  - Potential conflict: whose definition of someMethod wins, the one from ParentClass or the one from Int1?
Resolving Conflicts

• Classes win over interfaces
  public class ChildClass extends ParentClass implements Int1
  – Conflict resolved: the version of someMethod from ParentClass wins over the version from Int1
  – This rule also means that interfaces cannot provide default implementations for methods from Object (e.g., toString)
  • The methods from the interface could never be used, so Java prohibits you from even writing them

• Conflicting interfaces: you must redefine
  public class SomeClass implements Int1, Int2
  – The conflict cannot be resolved automatically, and SomeClass must give a new definition of someMethod
  – But, this new method can refer to one of the existing methods with Interface1.super.someMethod(…) or Interface2.super.someMethod

Wrap-Up
Summary

• **Static methods**
  – Use for methods that apply to instances of that interface
    • Shape.sumAreas(Shape[] shapes)
    • Op.timeOp(Op opToTime)

• **Default methods**
  – Use to add behavior to existing interfaces without breaking classes that already implement the interface
  – Use for operations that are called on instances of your interface type
  – Resolving conflicts
    • Classes win over interfaces
    • If two interfaces conflict, class must reimplement the method
      – But the new method can refer to old method by using InterfaceName.super.methodName

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