New Features in Java 8

Jaanus Pöial, PhD

Tallinn, Estonia

Estonian Information Technology College

Java 8

- Previous major changes in Java:
  - Java 2 – December 1998 – collections, swing
  - Java 5 – September 2004 – generics, annotations
  - Java 8 – March 2014 – lambda expressions, functional interfaces, streams, default and static methods in interfaces
- Interface may contain method implementations
- Multiple inheritance is possible using interfaces
- Functional notation („lambda expressions“) is possible using functional interfaces

Functional interfaces

- Functional interface has exactly one abstract method – functional method

Example. Comparator – method compare

```
List<Integer> myList = ..... ;
Comparator<Integer> cmp = new Comparator<Integer>() {
      @Override
      public int compare (Integer n1, Integer n2) {
          return (n1>n2?1:(n1<n2?-1:0));
      }
 };
 Collections.sort (myList, cmp);
```

In Java 8:

```
Collections.sort (myList, (n1, n2) -> n1>n2?1:(n1<n2?-1:0));
```

Lambda expressions

- Short way to express contents of functional interfaces

```
param -> expression
(param_1, ... , param_n) -> expression
Class::method
Class::new
...
```

Expression can also be a block (in curly braces)

```
Java.util.function.Function<Double, Double> fn;
fn = x->x*(x-3.)*(x+4)*Math.cos(x);
fn = Math::cos;
```

User defined functional interface

Example:

```
@FunctionalInterface
 interface Talker<X> {
   void talk (X x);
 }

 public static void main (String[] args) {
   Talker<Integer> italk = i -> System.out.println ("int " + i);
   Talker<Double> dtalk = d -> System.out.println ("double " + d);
   italk.talk(45);
   dtalk.talk(Math.PI);
 }
```

Streams

Provide inner iteration for data structures (e.g. Stream for the elements of Collection) – parallel processing possible
Packages involved:

- java.lang – Iterable, ...
- java.util – Optional, Collection, ...
- java.util.stream – Stream, Collector, ...
- java.util.function – Function,Predicate, Consumer, Supplier, BiFunction, ...

Stream methods: map, filter, reduce, forEach, collect, flatMap, allMatch, max, min, distinct, generate, ...

Optional methods: filter, map,flatMap, orElse, ifPresent, ...

Example - outer iteration

```
// Old way (Java 1)
sum = 0;
for (int i = 0; i < myList.size(); i++) {
  if (myList.get(i) > 0) {
    sum += myList.get (i);
  }
}

// little better old way (Java 5)
sum = 0;
for (int elem : myList) {
  if (elem > 0) {
    sum += elem;
  }
}
```

Stream example - Consumer

```
// forEach and anonymous Consumer (ugly)

   sum = 0;
   myList.forEach (new Consumer<Integer>() {
       @Override
       public void accept (Integer elem) {
         if (elem > 0) {
           sum += elem;
         }
       }
     });
```

Stream example - lambda

```
// Java 8 forEach and lambda expression

sum = 0;
myList.forEach (elem -> {
    if (elem > 0) {
      sum += elem;
    }
  });
System.out.println ("SumPos is: " + sum);
```

Stream example – filter and reduce

```
// Java 8 stream, filter, reduce (with lambda expression) - the best

sum = myList.stream()
          .filter (elem -> (elem > 0))
          .reduce (0, (s, e) -> s + e);
```

Stream example – map and optional

```
// multiply each element of the list by 2 and find the first element
//    that is bigger than 3 (null, if there is no such element)

myList.stream()
        .map (e->e*2)
        .filter (e->(e>3))
        .findFirst()
        .orElse (null)
```

Example - user defined map

```
public static void main (String[] args) {
   "Hello World".chars()
              .map (J8example5::myMap)
              .forEach (ch -> System.out.print ((char)ch) );
   System.out.println();
 }

 public static int myMap (int chi) {
   char ch = (char)chi;
   if (Character.isLowerCase(ch))
     return Character.toUpperCase(ch);
   else if (Character.isUpperCase(ch))
     return Character.toLowerCase(ch);
   else
     return ch;
  }
```

```
//  Map as expression

public static void main (String[] args) {
    "Hello World 2015".chars()
                .map (ch ->
                        Character.isLowerCase (ch)?
                            Character.toUpperCase (ch):
                            (Character.isUpperCase (ch)?
                                Character.toLowerCase (ch):
                                ch)
                        )
                .forEach (ch -> System.out.print ((char)ch));
    System.out.println();
  }
```

Adding method implementations to interfaces

- Default methods in interface provide implementation, if it is not provided by the class. Overriding is OK.
- Static methods in interface provide implementation that can be used in default methods (or elsewhere). Overriding is not OK.
- Methods defined in class are always „stronger“ than methods defined in interface.
- If a class implements two (or more) interfaces that have the same method, it is up to the class to decide about implementation of this method (diamond problem).

Example of default and static methods

```
// talk must be overriden, log can be overriden, newlog can be used
@FunctionalInterface
interface Talker<X> {
    void talk (X x);    // compulsory method

    default void log (X x) {     // possible to override
      System.out.println ("logged by log in Talker interface: " + x);
      newlog (x.toString());
    }

    static void newlog (String s) {     // impossible to override, possible to use
      System.out.println ("logged by newlog in Talker interface: " + s);
    }
}
```

```
// Class provides both talk and log
static class MyTalker1<X> implements Talker<X> {
    @Override
    public void talk (X x) {
      System.out.println ("talk from MyTalker1: " + x);
    }

    @Override
    public void log (X x) {
      System.out.println ("logged by log in Mytalker1: " + x);
      System.out.println ("also call to newlog by log in MyTalker1:");
      Talker.newlog (x.toString());  // it is possible to use interface static method in class
    }
  }
```

```
// Class does not provide log
static class MyTalker2<X> implements Talker<X> {
    @Override
    public void talk (X x) {
      System.out.println ("talk from MyTalker2: " + x);
    }
}

// test
public static void main (String[] args) {
    Talker<Integer> italk = i -> System.out.println ("int " + i);
    Talker<Double> dtalk = d -> System.out.println ("double " + d);
    italk.talk(45);             // int 45
    dtalk.talk(Math.PI);   // double pi
    MyTalker1<Integer> myitalk1 = new MyTalker1<Integer>();
    myitalk1.talk (2014); // from class
    myitalk1.log (1022);  // log from class contains static newlog from interface
    MyTalker2<Integer> myitalk2 = new MyTalker2<Integer>();
    myitalk2.talk (2015); // from class
    myitalk2.log (1023);  // from interface contains static newlog
}
```

Example about extending the interface

```
@FunctionalInterface
 interface MyComparable<T> extends Comparable<T> {
   default boolean myEquals (T o2) {
     return this.compareTo (o2) == 0;
   }
 }

 static class MyInt implements MyComparable<MyInt> {
   private int content = 0;
   MyInt (int i) {
     content = i;
   }
   @Override
   public int compareTo (MyInt o) {     // delegation to Integer
     return new Integer(content).compareTo (o.content);
   }
   @Override
   public boolean equals (Object o) { // override equals in class using interface
       return myEquals ((MyInt)o);
   }
 }
```

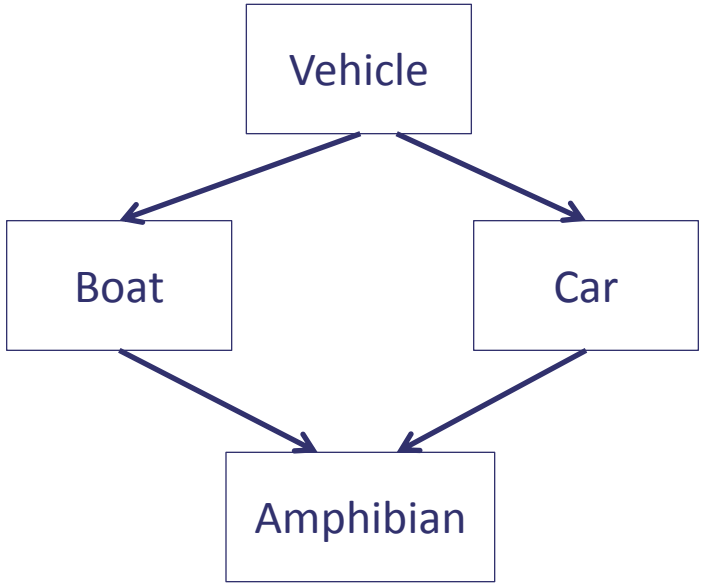
Multiple inheritance using interfaces

- Multiple inheritance – ability to inherit behaviour from several superclasses

Example.

Vehicle
- Boat
  - Amphibian
- Car
  - Amphibian

Diamond



```
@FunctionalInterface
 interface Vehicle {

        void makeNoise();

        default void startEngine() {
                System.out.println ("Vehicle engine started");
        }

        default void stopEngine() {
                System.out.println ("Vehicle engine stopped");
        }
}
```

```
@FunctionalInterface
 interface Car extends Vehicle {      // obligation to provide makeNoise

      @Override
      default void stopEngine() {
        System.out.println ("Car engine stopped");
      }

      default void enjoyCar() {
        System.out.println ("I enjoy my car: Car interface default");
      }

      default void drive() {
        System.out.println ("I drive my car: Car interface default");
      }

   // possible to override also startEngine
}
```

```
@FunctionalInterface
interface Boat extends Vehicle {     // obligation to provide makeNoise

  default void enjoyBoat() {
    System.out.println ("I enjoy my boat: Boat interface default");
  }

  default void drive() {
    System.out.println ("I drive my boat: Boat interface default");
  }

  // possible to override also startEngine, stopEngine
}
```

```
static class Amphibian implements Car, Boat {

    @Override
    public void makeNoise() { // my obligation from Vehicle
      System.out.println ("makeNoise: compulsory Vehicle behaviour: from Amphibian class");
    }

    @Override
    public void drive() { // diamond problem solved in Java way
      System.out.println ("I drive my amphibian: from Amphibian class");
    }

    // possible to override also startEngine, stopEngine, enjoyCar, enjoyBoat
}
```

```
public static void main (String[] args) {
   Amphibian a = new Amphibian();
   a.startEngine();    // Vehicle engine started
   a.makeNoise();    // both Car and Boat are kind of Vehicle
   a.drive();             // diamond problem (both Car and Boat provide drive method)
   a.enjoyCar();       // inherited from Car
   a.enjoyBoat();     // inherited from Boat
   a.stopEngine();    // Car is more specific than Vehicle
 }
```

```
Vehicle engine started
makeNoise: compulsory Vehicle behaviour: from Amphibian class
I drive my amphibian: from Amphibian class
I enjoy my car: Car interface default
I enjoy my boat: Boat interface default
Car engine stopped
```

Playing with functions

- Functional interfaces are supported in java.util.function package

```
Function<Double, Double> f = Math::sin;      // assignment context: Class::method
double res = f.apply (Math.PI/2.);           // variable f represents a function
System.out.println (res);

// degrees → radians → sin : g takes degrees as argument and returns sinus
Function<Double, Double> g = ((Function<Double, Double>)Math::sin)
      .compose (Math::toRadians);
System.out.println (g.apply (45.));

((Consumer<String>)System.out::println).accept (String.valueOf (g.apply (45.)));
```

Functions on functions

```
public static <T, U> Function<U, U> proj1 (BiFunction<T, U, U> b, T arg) {
  System.out.println ("(" + b + " in proj1 applied to " + arg);
  return y -> b.apply (arg, y);
}

public static <T, U> Function<T, T> proj2 (BiFunction<T, U, T> b, U arg) {
  System.out.println ("(" + b + " in proj2 applied to " + arg);
  return x -> b.apply (x, arg);
}

public static <T, U> Function<T, U> combine (Function<U, U> f, Function<T, U> g) {
  return x -> f.apply (g.apply (x));
}
```

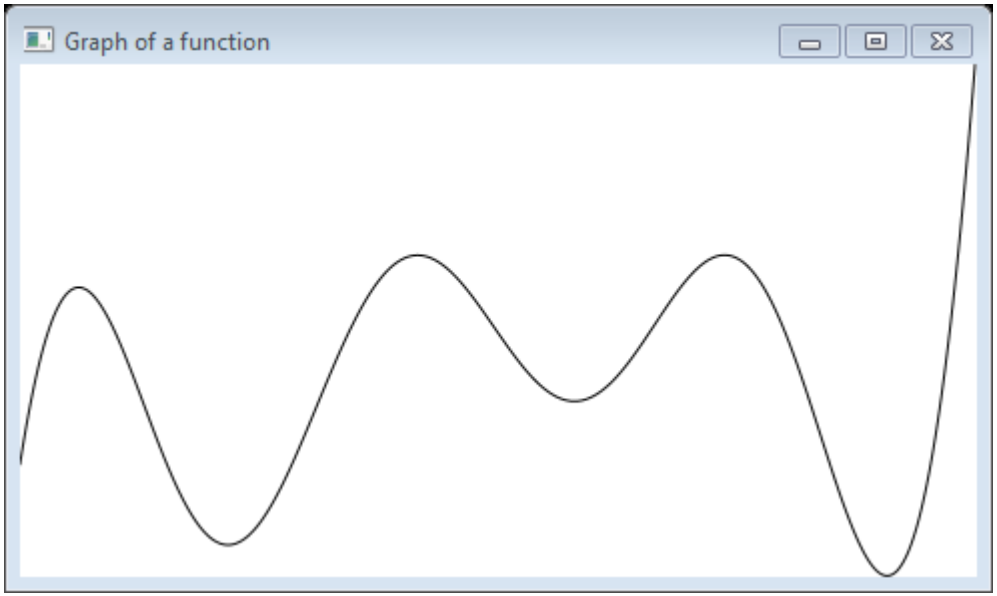
```
public static int minus (int a1, int a2) {
   System.out.println ("("+a1+"-"+a2+") ");
   return a1-a2;
 }

   BiFunction<Integer, Integer, Integer> p = J8example9::minus;
   Function<Integer, Integer> p1 = proj1 (p, 2);      // p1(x) = 2 - x
   System.out.println (p1.apply (8));                 // 2 – 8 = -6
   Function<Integer, Integer> p2 = proj2 (p, 1);      // p2(x) = x - 1
   System.out.println (p2.apply (9));                  // 9 – 1 = 8
   System.out.println (combine (p1, p2).apply (4));
                                                      //  ([2-x][x-1])(4) = [2-x]([x-1](4)) = [2-x](3) = 2-3 = -1
```

```
public static <T, U, V> Function<T, V> sCombine
                (BiFunction<T, U, V> f, Function<T, U> g) {
   return x -> f.apply (x, g.apply (x));
}

public static <T, U, V> BiFunction<T, U, V> sBiCombine
                (BiFunction<T, U, V> f, BiFunction<T, U, U> g) {
   return (x,  y) -> f.apply (x, g.apply (x, y));
}

   BiFunction<Integer, Integer, Integer> p = J8example9::minus;
   BiFunction<Integer, Integer, Integer> q = Math::max;
   Function<Integer, Integer> p1 = proj1 (p, 2);              // p1(x) = 2 - x
   System.out.println (sCombine (p, p1).apply (11));       // [x – [2-x] ](11) = 11-(2-11) = 20
   System.out.println (sBiCombine (p, q).apply (17, 29)); // [x – max(x,y)](17,29) = 17-29 = -12
   //  sBiCombine (J8example9::sBiCombine, J8example9::sBiCombine).apply (17, 29);
   // does not compile
```

Java FX became a part of Java 8

- Example – drawing a graph of a function

  Class DrawFunction



```
@Override
public void start (Stage myStage) {    // compulsory method for Java FX  Application
    Function<Double, Double> fn = x->x*(x-3.)*(x+4)*Math.cos(x);
    double from = -5.;
    double to = 5.;
    Pane myPane = new Pane();
    Scene myScene = new Scene (myPane, 319, 159);
    myStage.setScene (myScene);
    myStage.setTitle ("Graph of a function");
    ObservableList<Node> nodes = myPane.getChildren();
    drawFunction (fn, from, to, myScene.getWidth(), myScene.getHeight(), nodes);
    myScene.widthProperty().addListener (
      (obsv, oldv, newv) -> {
        drawFunction (fn, from, to, myScene.getWidth(), myScene.getHeight(), nodes);
    });
    myScene.heightProperty().addListener (
       (obsv, oldv, newv) -> {
        drawFunction (fn, from, to, myScene.getWidth(), myScene.getHeight(), nodes);
    });
    myStage.show();
}
```

```
public static void drawFunction (Function<Double,Double> f,
   double start, double end, double w, double h, ObservableList<Node> nl) {
      int iw = (int)w;
      Double[] points = new Double[2*iw];
      double fmax = Double.MIN_VALUE;
      double fmin = Double.MAX_VALUE;
      for (int i=0; i < iw; i++) {
         double arg = start + ((double)i)*(end-start)/w;
         double value = f.apply (arg);
         points[2*i] = (double)i;
         points[2*i+1] = value; // to be scaled later
         if (value > fmax) fmax = value;
         if (value < fmin) fmin = value;
      }
      for (int i=0; i < iw; i++) {
         double value = points[2*i+1];
         points[2*i+1] = (fmax-value)*h/(fmax-fmin); // scaling
      }
      Polyline graph = new Polyline();
      graph.getPoints().addAll (points);
      nl.clear();
      nl.add (graph);
}
```

Exercises

Instructions are given during the lectures