Using Lambdas to Write Mixins in Java 8

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Who is Heinz Kabutz?

- **Java consultant, teacher, programmer**
  - **Born in Cape Town, South Africa, now lives on Crete**
  - **Created The Java Specialists' Newsletter**
    - **www.javaspecialists.eu**
  - **One of the first Java Champions**
    - **www.javachampions.com**
  - **Unfounder of hottest Unconference JCrete (jcrete.org)**

Functional Interface

Java 8 Lambda Syntax

- **In Java 7, we did this**

```
public void greetConcurrent() {
  new Thread(new Runnable() {
    public void run() { sayHello(); }
  }).start();
}

private void sayHello() { System.out.println("Kalamari!"); }
```

- **With Java 8 Lambdas, we can do this**

```
public void greetConcurrent() {
  new Thread(() -> sayHello()).start();
}
```

Functional Interface

- **Lambdas have to be functional interfaces**
- **Definition: *Functional Interface***
  - **Interface**
  - **Exactly one abstract method**
    - **Methods inherited from Object do not count**

Is this a Functional Interface?

```
@FunctionalInterface
public interface Runnable {
  public abstract void run();
}
```

Yes it is!

```
@FunctionalInterface
public interface Runnable {
  public abstract void run();
}
```

Interface with exactly one abstract method

```
   threadPool.submit(() -> sayHello());
```

Is this a Functional Interface?

```
@FunctionalInterface
public interface ActionListener
    extends EventListener {
  public void actionPerformed(ActionEvent e);
}
```

We first need to look at EventListener

```
~~@FunctionalInterface~~
public interface EventListener {
}
```

EventListener is ***not*** a Functional Interface

Yes it is!

```
~~@FunctionalInterface~~
public interface EventListener {
}

@FunctionalInterface
public interface ActionListener
    extends EventListener {
  public void actionPerformed(ActionEvent e);
}
```

ActionListener Interface has exactly one abstract method

Is this a Functional Interface?

```
@FunctionalInterface
public interface Stringer {
  // force class to implement toString()
  String toString();
}
```

No, it is not!

```
~~@FunctionalInterface~~
public interface Stringer {
  // force class to implement toString()
  String toString();
}
```

Public methods defined inside Object do not count

Which methods can we override? Which would be ignored in the functional interface method count?

Object Refresher

```
public class Object {
  public final Class<?> getClass();
  public int hashCode();
  public boolean equals(Object obj);
  protected Object clone();
  public String toString();
  public final void notify();
  public final void notifyAll();
  public final void wait(long timeout);
  public final void wait(long timeout, int nanos);
  public final void wait();
  protected void finalize();
}
```

Final methods cannot be added to interface

```
public final Class<?> getClass();
public final void notify();
public final void notifyAll();
public final void wait(long timeout);
public final void wait(long timeout, int nanos);
public final void wait();
```

Public non-final methods for functional interfaces

```
public int hashCode();
public boolean equals(Object obj);
public String toString();
```

Protected methods count for functional interfaces

```
protected void finalize();
protected Object clone();
```

Are these Functional Interfaces?

```
@FunctionalInterface
public interface Foo1 {
  boolean equals(Object obj);
}


@FunctionalInterface
public interface Bar1 extends Foo1 {
  int compare(String o1, String o2);
}
```

Using Lambdas to Write Mixins in Java 8

Foo1 is not, but Bar1 is

```
~~@FunctionalInterface~~
public interface Foo1 {
  boolean equals(Object obj);
}
```

equals(Object) is already an implicit member

```
@FunctionalInterface
public interface Bar1 extends Foo1 {
  int compare(String o1, String o2);
}
```

Interface with exactly one abstract method

Is this a Functional Interface?

```
@FunctionalInterface
public interface Comparator<T> {
  public abstract boolean equals(Object obj);
  int compare(T o1, T o2);
}
```

Yes, it is!

equals(Object) is already an implicit member

```
@FunctionalInterface
public interface Comparator<T> {
  public abstract boolean equals(Object obj);
  int compare(T o1, T o2);
}
```

Interface with exactly one abstract method

And what about this?

```
@FunctionalInterface
public interface CloneableFoo {
  int m();
  Object clone();
}
```

No, it is not!

```
~~@FunctionalInterface~~
public interface CloneableFoo {
  int m();
  Object clone();
}
```

clone() is not public in Object

Is this a Functional Interface?

```
@FunctionalInterface
public interface MouseListener
    extends EventListener {
  public void mouseClicked(MouseEvent e);
  public void mousePressed(MouseEvent e);
  public void mouseReleased(MouseEvent e);
  public void mouseEntered(MouseEvent e);
  public void mouseExited(MouseEvent e);
}
```

No, it is not!

MouseListener has five abstract methods

```
~~@FunctionalInterface~~
public interface MouseListener
    extends EventListener {
  public void mouseClicked(MouseEvent e);
  public void mousePressed(MouseEvent e);
  public void mouseReleased(MouseEvent e);
  public void mouseEntered(MouseEvent e);
  public void mouseExited(MouseEvent e);
}
```

Fundamental Functional Interfaces

Fundamental Functional Interfaces

- Java 8 contains some standard functional interfaces
  - Supplier<T>
  - Consumer<T>
  - Predicate<T>
  - Function<T, R>
  - UnaryOperator<T>
  - BinaryOperator<T>

Supplier<T>

- Use whenever you want to supply an instance of a T
  - Can delay object creation, for example:

```
public void foo() {
  logger.fine("ms since 1970: " + System.currentTimeMillis());
}

public void bar() {
  logger.fine(() -> "ms since 1970: " + System.currentTimeMillis());
}
```

```
public void fine(Supplier<String> msgSupplier) {
    log(Level.FINE, msgSupplier);
}
```

Consumer<T>

- **Provide an action to be performed on an object**

```
Collection<String> names =
        Arrays.asList("Kirk", "Andrea", "Szonya", "Anna");
names.forEach(new Consumer<String>() {
    public void accept(String s) {
        System.out.println(s.toUpperCase());
    }
});
```

```
names.forEach(s -> System.out.println(s.toUpperCase()));
```

```
names.stream().map(String::toUpperCase).forEach(System.out::println);
```

Predicate<T>

- **A boolean-valued property of an object**

```
Collection<String> names =
        Arrays.asList("Heinz", "Helene", "Maxi",
                "Connie", "Bangie", "Efi");
names.removeIf(new Predicate<String>() {
    public boolean test(String s) {
        return s.contains("i");
    }
});
```

```
names.removeIf(s -> s.contains("i"));
```

Function<T, R>

- **Transforming a T to an R**

```
Collection<String> names =
       Arrays.asList("Heinz", "Helene", "Maxi",
              "Connie", "Bangie", "Efi");
names.stream().map(new Function<String, Integer>() {
    public Integer apply(String s) {
        return s == null ? 0 : s.length();
    }
});
```

```
names.stream().map(s -> s == null ? 0 : s.length());
```

UnaryOperator<T>

- **Transforming a T - similar to Function<T, R>**

```
List<String> names =
        Arrays.asList("Heinz", "Helene", "Maxi",
                "Connie", "Bangie", "Efi");
names.replaceAll(new UnaryOperator<String>() {
    public String apply(String s) {
        return s.toUpperCase();
    }
});
```

```
names.replaceAll(s -> s.toUpperCase());
```

```
names.replaceAll(String::toUpperCase);
```

Mixins Using Java 8 Lambdas

Mixins using Java 8 Lambdas

- **State of the Lambda has this misleading example**

```
public interface ActionListener {
    void actionPerformed(ActionEvent e);
}

button.addActionListener(new ActionListener() {
  public void actionPerformed(ActionEvent e) {
    ui.dazzle(e.getModifiers());
  }
});
```

- **With Java 8 Lambdas, this becomes**

```
button.addActionListener(e -> ui.dazzle(e.getModifiers()));
```

- **But most AWT Listeners *not* functional interfaces**

Pre-Lambda Event Listeners

```
salaryIncreaser.addFocusListener(new FocusAdapter() {
  public void focusGained(FocusEvent e) {
    System.out.println("Almost there!");
  }
});
salaryIncreaser.addKeyListener(new KeyAdapter() {
  public void keyPressed(KeyEvent e) {
    e.consume();
    System.out.println("Not quite!");
  }
});
salaryIncreaser.addMouseListener(new MouseAdapter() {
  public void mouseEntered(MouseEvent e) {
    shuffleSalaryButton();
  }
});
```

This is What We Want

```
salaryIncreaser.addFocusGainedListener(
  e -> System.out.println("Almost there!")
);

salaryIncreaser.addKeyPressedListener(
  e -> {
    e.consume();
    System.out.println("Not quite!");
  }
);

salaryIncreaser.addMouseEnteredListener(
  e -> shuffleSalaryButton()
);
```

How do we get there?

Focus/Mouse/KeyListeners are *not* Functional Interfaces

- **They have several abstract methods**

```
public interface FocusListener {
  /**
   * Invoked when a component gains the keyboard focus.
   */
  void focusGained(FocusEvent e);

  /**
   * Invoked when a component loses the keyboard focus.
   */
  void focusLost(FocusEvent e);
}
```

FocusAdapter

- **In previous example, we MouseAdapter, FocusAdapter and KeyAdapter**

```
public abstract class FocusAdapter
    implements FocusListener {
  public void focusGained(FocusEvent e) {}
  public void focusLost(FocusEvent e) {}
}
```

FocusEventProducerMixin

```java
public interface FocusEventProducerMixin {
  void addFocusListener(FocusListener l);

  default void addFocusGainedListener(Consumer<FocusEvent> c) {
    addFocusListener(new FocusAdapter() {
      public void focusGained(FocusEvent e) { c.accept(e); }
    });
  }

  default void addFocusLostListener(Consumer<FocusEvent> c) {
    addFocusListener(new FocusAdapter() {
      public void focusLost(FocusEvent e) { c.accept(e); }
    });
  }
}
```

What Just Happened?

- We defined an interface with default methods
  - Both addFocusGainedListener() and addFocusLostListener() call the abstract method addFocusListener() in the interface
  - It is a Functional Interface, but that does not matter in this case
- Let’s see how we can “mixin” this interface into an existing class JButton

JButtonLambda Mixin Magic

- **JButton contains method addFocusListener**
- **We subclass it and implement Mixin interface**
  - **We could even leave out the constructors and just have**

```
public class JButtonLambda extends JButton
    implements FocusEventProducerMixin { }
```

- **With our new JButtonLambda, we can now call**

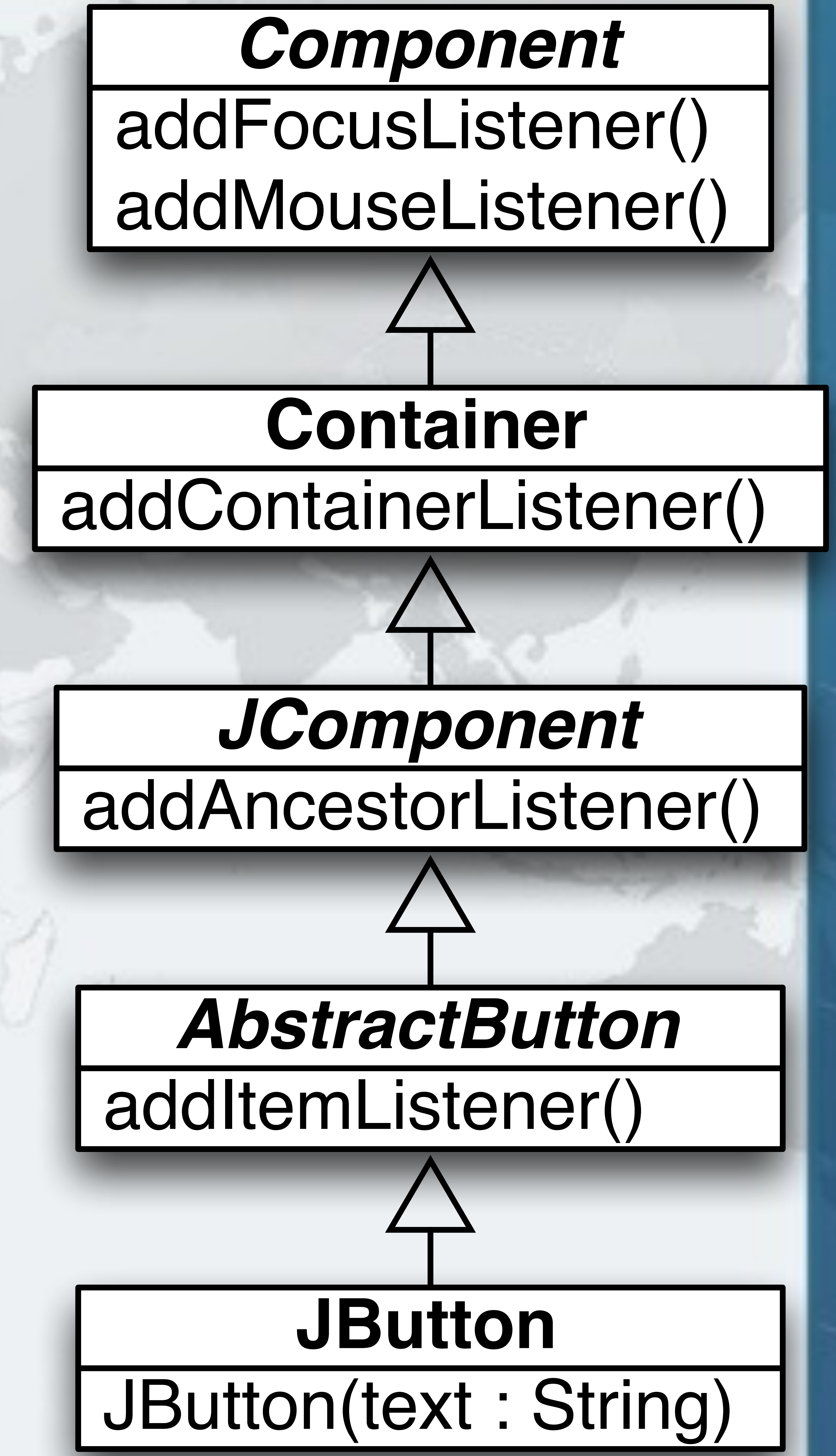
```
salaryIncreaser.addFocusGainedListener(
  e -> System.out.println("Almost there!")
);
```

JButtonLambda

```
public class JButtonLambda extends JButton
    implements FocusEventProducerMixin {
  public JButtonLambda() { }

  public JButtonLambda(Icon icon) { super(icon); }

  public JButtonLambda(String text) { super(text); }

  public JButtonLambda(Action a) { super(a); }

  public JButtonLambda(String text, Icon icon) {
    super(text, icon);
  }
}
```

Combining Different Mixins

- **Each class in the hierarchy adds new addXXXListener() methods**
  - **Here are just some of them**
- **We can define a JComponent mixin that contains all the addXXXListener and other mixins in the classes above**



JComponent Mixin

```
public interface JComponentEventProducerMixin extends
        AncestorEventProducerMixin,
        ComponentEventProducerMixin,
        ContainerEventProducerMixin,
        FocusEventProducerMixin,
        HierarchyEventProducerMixin,
        InputMethodEventProducerMixin,
        KeyEventProducerMixin,
        MouseEventProducerMixin,
        MouseMotionEventProducerMixin {
  void addHierarchyListener(HierarchyListener l);
  void addMouseWheelListener(MouseWheelListener l);
  void addPropertyChangeListener(PropertyChangeListener l);
  void addVetoableChangeListener(VetoableChangeListener l);
}
```

AbstractButton Mixin

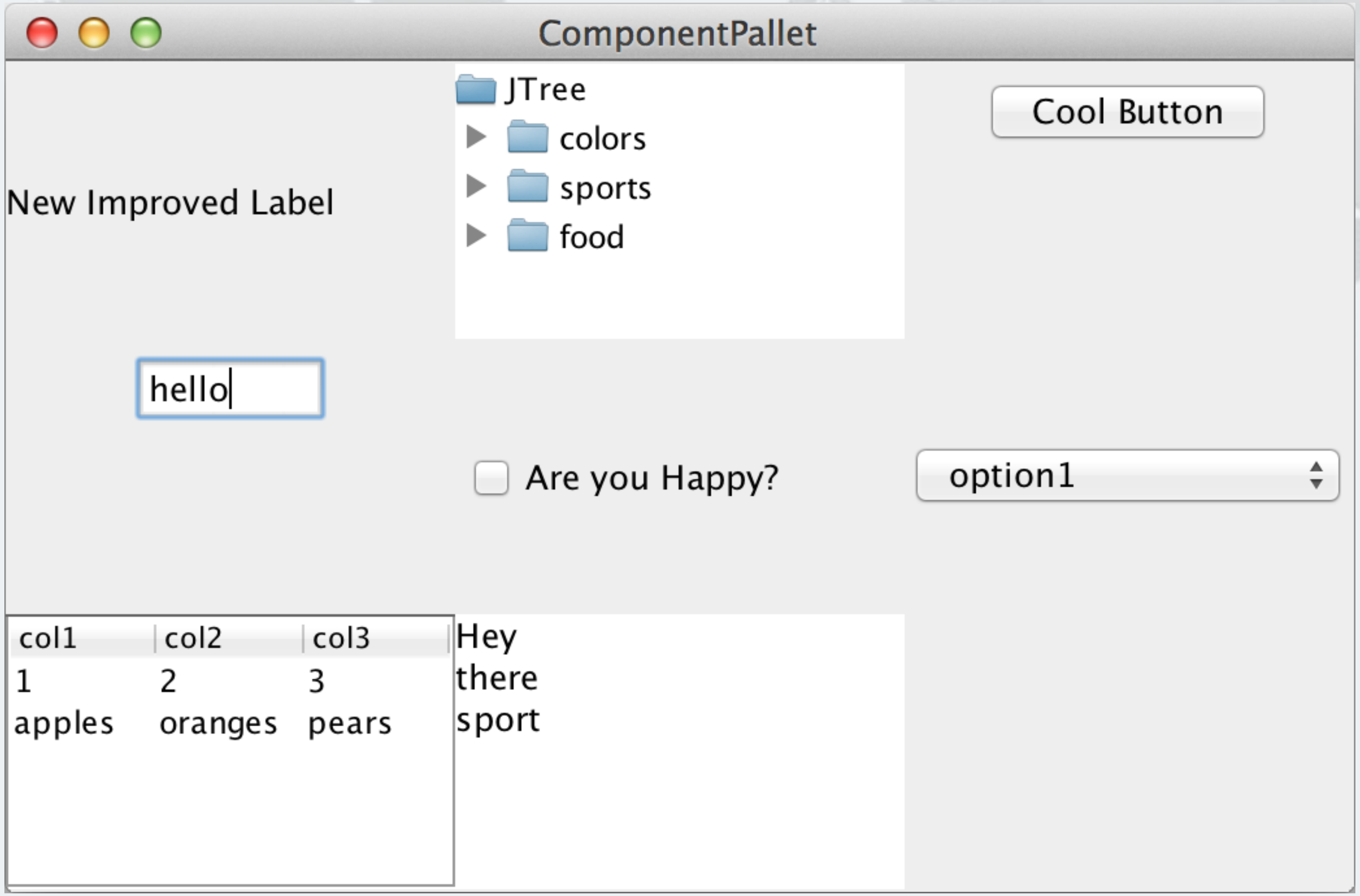
```
public interface AbstractButtonEventProducerMixin {
  void addActionListener(ActionListener l);
  void addItemListener(ItemListener l);
  void addChangeListener(ChangeListener l);
}
```

We need this so that we have a common super-interface that we can cast all types of abstract buttons to.

JButton using JComponent Mixins

```
public class JButtonLambda extends JButton
        implements JComponentEventProducerMixin,
                   AbstractButtonEventProducerMixin {
    public JButtonLambda() {
    }
    // and other constructors
}
```

ComponentPallet Demo



col1	col2	col3
1	2	3
apples	oranges	pears

Hey
there
sport

Facade Pattern For Listeners

Facade Pattern for Listeners

- **Another approach is facades for each listener**

```
public interface FocusListeners {
  static FocusListener forFocusGainedListener(
      Consumer<FocusEvent> c) {
    return new FocusAdapter() {
      public void focusGained(FocusEvent e) {c.accept(e);}
    };
  }
  static FocusListener forFocusLostListener(
      Consumer<FocusEvent> c) {
    return new FocusAdapter() {
      public void focusLost(FocusEvent e) { c.accept(e); }
    };
  }
}
```

Facade Pattern for Listeners

```
salaryIncreaser.addFocusListener(
  FocusListeners.forFocusGainedListener(
    e -> System.out.println("Almost there!")));

salaryIncreaser.addKeyListener(
  KeyListeners.forKeyPressedListener(
    e -> {
      e.consume();
      System.out.println("Not quite!");
    }));

salaryIncreaser.addMouseListener(
  MouseListeners.forMouseEntered(
    e -> shuffleSalaryButton()));
```

Method Call Stacks

Bonus material (if we have time)

Method Call Stacks

- **Anonymous inner classes use synthetic static methods to access private members**

```
private void showStack() {
    Thread.dumpStack();
}

private void anonymousClassCallStack() {
    Runnable runnable = new Runnable() {
        public void run() {
            showStack();
        }
    };
    runnable.run();
}
```

Method Call Stacks

- **Output of run**

```
java.lang.Exception: Stack trace
    at java.lang.Thread.dumpStack(Thread.java:1329)
    at MethodCallStack.showStack(MethodCallStack.java:3)
    at MethodCallStack.access$000(MethodCallStack.java:1)
    at MethodCallStack$1.run(MethodCallStack.java:9)
    at MethodCallStack.anonymousClassCallStack(MethodCallStack.java:12)
```

- **Synthetic method in MethodCallStack.class**

```
static void MethodCallStack.access$000(MethodCallStack)
```

Method Call Stacks

- **Lambdas have more direct access to outer class**

```
public void lambdaCallStack() {
    Runnable runnable = () -> showStack();
    runnable.run();
}
```

```
java.lang.Exception: Stack trace
    at java.lang.Thread.dumpStack(Thread.java:1329)
    at MethodCallStack.showStack(MethodCallStack.java:3)
    at MethodCallStack.lambda$lambdaCallStack$0(MethodCallStack.java:16)
    at MethodCallStack$$Lambda$1/455659002.run(Unknown Source)
    at MethodCallStack.lambdaCallStack(MethodCallStack.java:17)
```

- **Synthetic λ method in MethodCallStack.class**

```
private void MethodCallStack.lambda$lambdaCallStack$0()
```

Conclusion

Mixins in GitHub

- Code with more details available here
  - https://github.com/kabutz/javaspecialists-awt-event-mixins
    - (http://tinyurl.com/jmixins)

Lambdas, Static and Default Methods

- Java 8 released in March 2014
- Practical use of language will produce idioms
- Mixin idea can be applied in other contexts too
  – e.g. Adding functionality to Enums
- Java 8 will probably take another year to be used
  – Some of my customers are still using Java 1.4
    • One even has modules with Java 1.1

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