BIRZEIT UNIVERSITY

Event-Driven Programming

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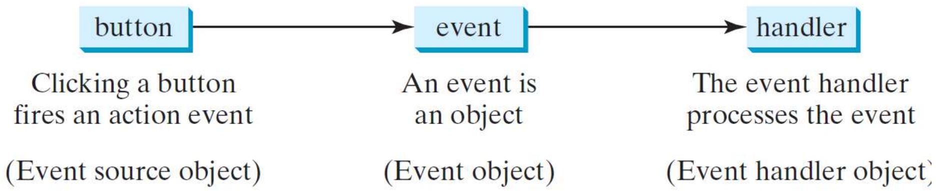
Procedural vs. Event-Driven Programming

- ***Procedural programming*** is executed in procedural order.
- In ***event-driven programming***, code is executed upon activation of events.

Handling GUI Events

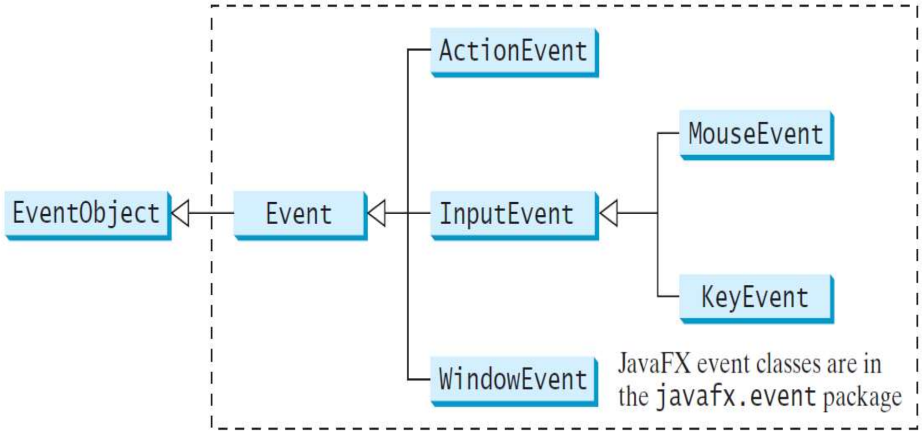
- ❖ **Source object** (e.g., button)
- ❖ **Listener object** contains a method for processing the event.



Events

- ❖ An ***event*** can be defined as a type of signal to the program that something has happened.
- ❖ The event is generated by external user actions such as mouse movements, mouse clicks, or keystrokes.

Event Classes



EventObject

Event

ActionEvent

InputEvent

MouseEvent

KeyEvent

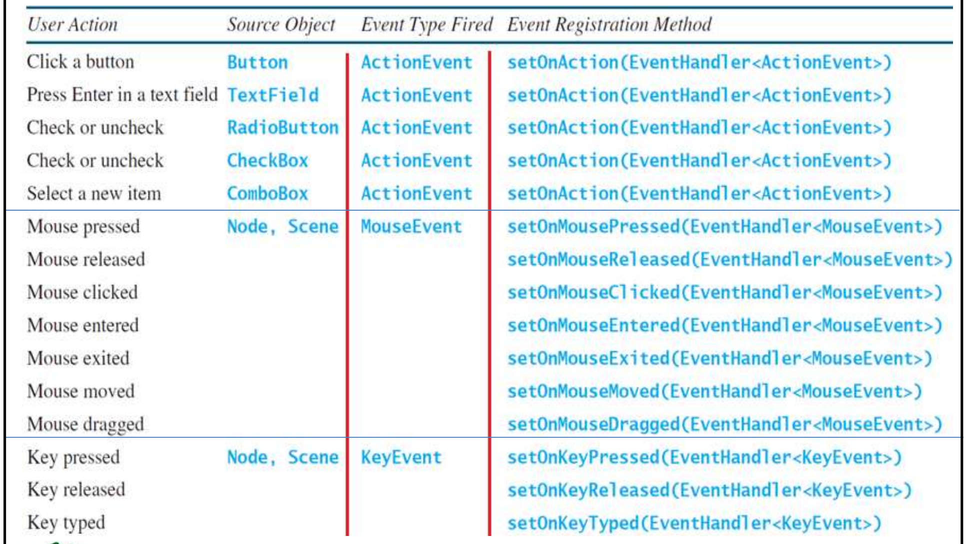
WindowEvent

JavaFX event classes are in the javafx.event package

Event Information

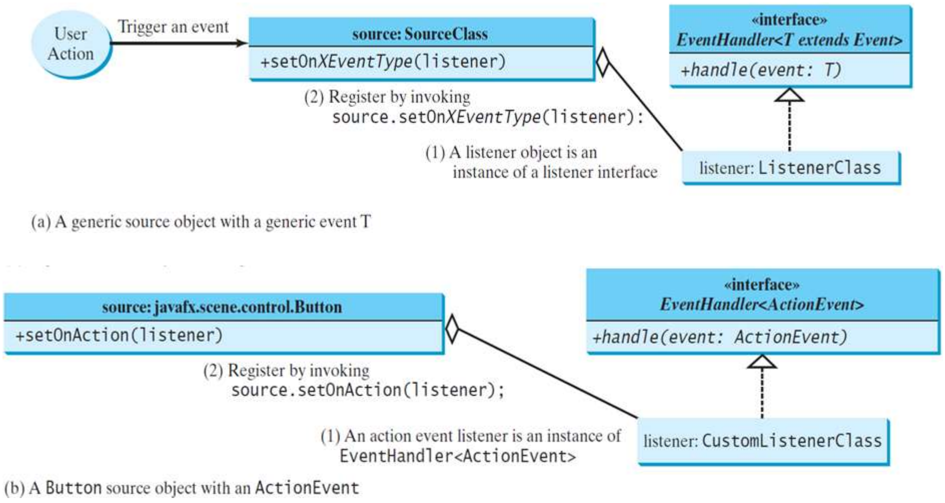
- An event object contains whatever properties are pertinent to the event.
- You can identify the source object of the event using the **getSource()** instance method in the **EventObject** class.
- The subclasses of **EventObject** deal with special types of events, such as button actions, window events, component events, mouse movements, and keystrokes.

Selected User Actions and Handlers



User Action	Source Object	Event Type Fired	Event Registration Method
Click a button	Button	ActionEvent	setOnAction(EventHandler<ActionEvent>)
Press Enter in a text field	TextField	ActionEvent	setOnAction(EventHandler<ActionEvent>)
Check or uncheck	RadioButton	ActionEvent	setOnAction(EventHandler<ActionEvent>)
Check or uncheck	CheckBox	ActionEvent	setOnAction(EventHandler<ActionEvent>)
Select a new item	ComboBox	ActionEvent	setOnAction(EventHandler<ActionEvent>)
Mouse pressed	Node, Scene	MouseEvent	setOnMousePressed(EventHandler<MouseEvent>)
Mouse released			setOnMouseReleased(EventHandler<MouseEvent>)
Mouse clicked			setOnMouseClicked(EventHandler<MouseEvent>)
Mouse entered			setOnMouseEntered(EventHandler<MouseEvent>)
Mouse exited			setOnMouseExited(EventHandler<MouseEvent>)
Mouse moved			setOnMouseMoved(EventHandler<MouseEvent>)
Mouse dragged			setOnMouseDragged(EventHandler<MouseEvent>)
Key pressed	Node, Scene	KeyEvent	setOnKeyPressed(EventHandler<KeyEvent>)
Key released			setOnKeyReleased(EventHandler<KeyEvent>)
Key typed			setOnKeyTyped(EventHandler<KeyEvent>)

The Delegation Model


User Action
Trigger an event
source: SourceClass
+setOnXEventType(listener)
«interface»
EventHandler<T extends Event>
+handle(event: T)
(2) Register by invoking
source.setOnXEventType(listener);
(1) A listener object is an instance of a listener interface
listener: ListenerClass
(a) A generic source object with a generic event T
source: javafx.scene.control.Button
+setOnAction(listener)
«interface»
EventHandler<ActionEvent>
+handle(event: ActionEvent)
(2) Register by invoking
source.setOnAction(listener);
(1) An action event listener is an instance of
EventHandler<ActionEvent>
listener: CustomListenerClass
(b) A Button source object with an ActionEvent

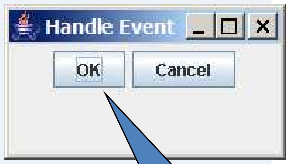
The Delegation Model: Example

```
class OKHandlerClass implements EventHandler<ActionEvent> {
  public void handle(ActionEvent e) {
      System.out.println("OK button clicked");
  }
}
```

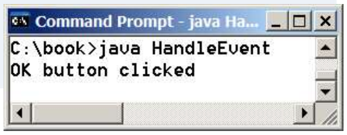
```
Button btOK = new Button("OK");

OKHandlerClass handler = new OKHandlerClass();

btOK.setOnAction(handler);
```

```
public class HandleEvent extends Application {
  public void start(Stage primaryStage) {
    …
    OKHandlerClass handler1 = new OKHandlerClass();
    btOK.setOnAction(handler1);
    CancelHandlerClass handler2 = new CancelHandlerClass();
    btCancel.setOnAction(handler2);
    …
    primaryStage.show(); // Display the stage
  }
}

class OKHandlerClass implements EventHandler<ActionEvent> {
  @Override
  public void handle(ActionEvent e) {
    System.out.println("OK button clicked");
  }
}
```

1. Start from the start method to create a window and display it



2. Click OK

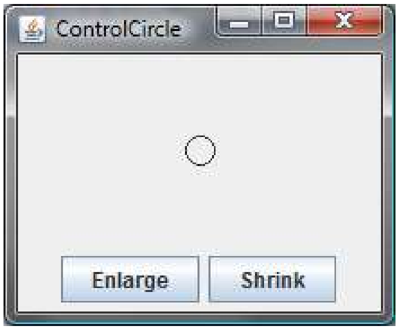


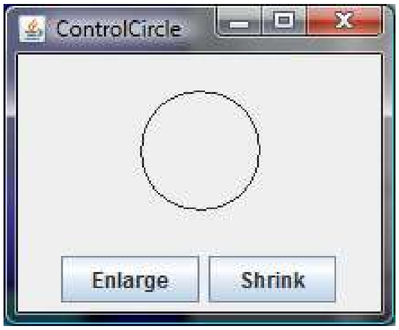
```
C:\book>java HandleEvent
OK button clicked
```

3. The JVM invokes the listener's handle method

Example: ControlCircle

- Now let us consider to write a program that uses two buttons to control the size of a circle.





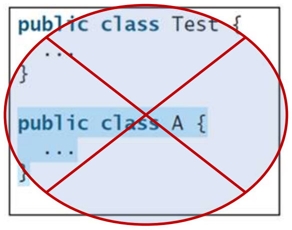
Inner Class Listeners

- A listener class is designed specifically to create a listener object for a GUI component (e.g., a **button**).
- It will **not be shared** by other applications.
- So, it is appropriate to define the listener class inside the frame class as an **inner class**.

Inner Classes

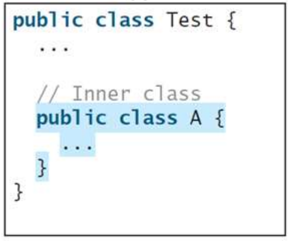
- **Inner class**: A class is a member of another class.
- **Advantages**: In some applications, you can use an inner class to make programs **simple**:
  - An inner class can reference the data and methods defined in the outer class in which it nests, so you do not need to pass the reference of the outer class to the constructor of the inner class.

Inner Classes cont.



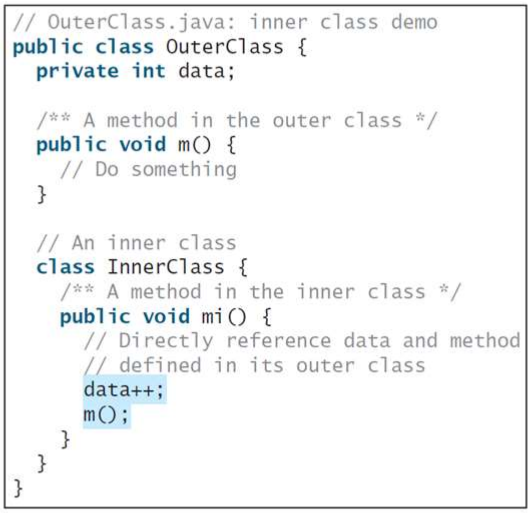
```
public class Test {
  ...
}

public class A {
  ...
}
```

(a)



```
public class Test {
  ...

  // Inner class
  public class A {
    ...
  }
}
```

(b)



```
// OuterClass.java: inner class demo
public class OuterClass {
  private int data;

  /** A method in the outer class */
  public void m() {
    // Do something
  }

  // An inner class
  class InnerClass {
    /** A method in the inner class */
    public void mi() {
      // Directly reference data and method
      // defined in its outer class
      data++;
      m();
    }
  }
}
```

(c)

Inner Classes cont.

- ❖ An inner class supports the work of its containing outer class and is compiled into a class named:

  ***OuterClassName$InnerClassName*.class**

  - ▪ For example, the inner class **InnerClass** in **OuterClass** is compiled into:

    ***OuterClass$InnerClass*.class**

Inner Classes cont.

- ❖ An inner class can be declared **public**, **protected**, or **private** subject to the same visibility rules applied to a member of the class.
- ❖ An inner class can be declared **static**:
  - ▪ A **static** inner class can be accessed using the outer class name.
  - ▪ A **static** inner class cannot access non-static members of the outer class.

Anonymous Inner Classes

- An *anonymous inner class* is an inner class without a name.
- An anonymous inner class **must** always extend a

superclass or implement an **interface**, **but** it cannot have an explicit **extends** or **implements** clause.

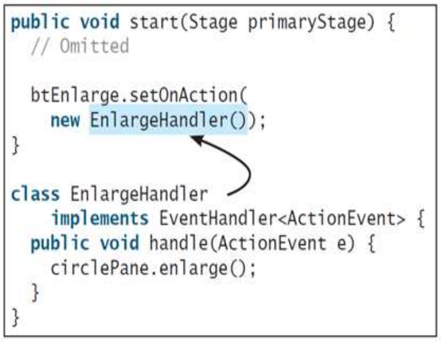
- An anonymous inner class **must** implement all the abstract methods in the superclass or in the interface.
- An anonymous inner class always uses the no-arg constructor from its superclass to create an instance. If an anonymous inner class implements an interface, the constructor is **Object()**.
- An anonymous inner class is compiled into a class named **OuterClassName$*n*.class .** For example, if the outer class Test has two anonymous inner classes, these two classes are compiled into **Test$1.class** and **Test$2.class**

Anonymous Inner Classes cont.

- Inner class listeners can be shortened using anonymous inner classes.
- It combines declaring an inner class and creating an instance of the class in one step.
- An anonymous inner class is declared as follows:

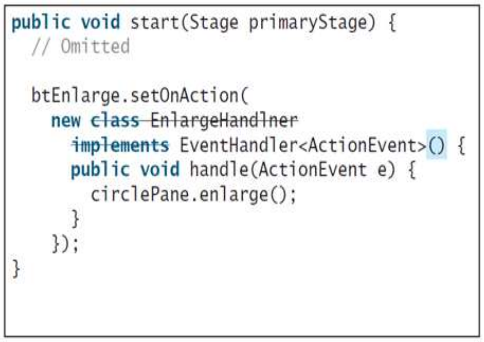
```
new SuperClassName/InterfaceName() {
  // Implement or override methods in superclass or interface
  // Other methods if necessary
}
```

Anonymous Inner Classes cont.



```
public void start(Stage primaryStage) {
  // Omitted

  btEnlarge.setOnAction(
    new EnlargeHandler());
}

class EnlargeHandler
    implements EventHandler<ActionEvent> {
  public void handle(ActionEvent e) {
    circlePane.enlarge();
  }
}
```

(a) Inner class EnlargeListener

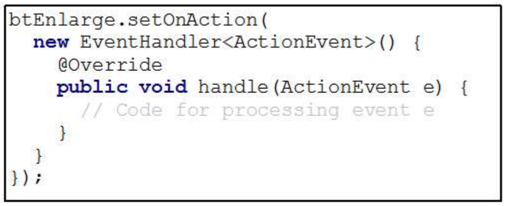


```
public void start(Stage primaryStage) {
  // Omitted

  btEnlarge.setOnAction(
    new ~~class EnlargeHandlner~~
      ~~implements~~ EventHandler<ActionEvent>() {
      public void handle(ActionEvent e) {
        circlePane.enlarge();
      }
    });
}
```

(b) Anonymous inner class

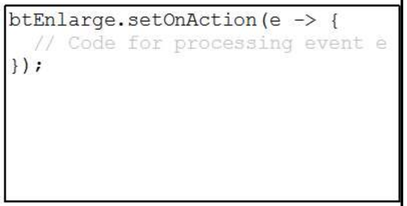
Simplifying Event Handling Using Lambda Expressions

- ❖ ***Lambda expression*** is a new feature in **Java 8**.
- ❖ Lambda expressions can be viewed as an anonymous method with a concise syntax.
- ❖ For example, the following code in (a) can be greatly simplified using a lambda expression in (b) in three lines:



```
btEnlarge.setOnAction(
  new EventHandler<ActionEvent>() {
    @Override
    public void handle(ActionEvent e) {
      // Code for processing event e
    }
  }
});
```

(a) Anonymous inner class event handler



```
btEnlarge.setOnAction(e -> {
  // Code for processing event e
});
```

(b) Lambda expression event handler

Basic Syntax for a Lambda Expression

- The basic syntax for a lambda expression is either:

(type1 param1, type2 param2, ...) -> expression

or

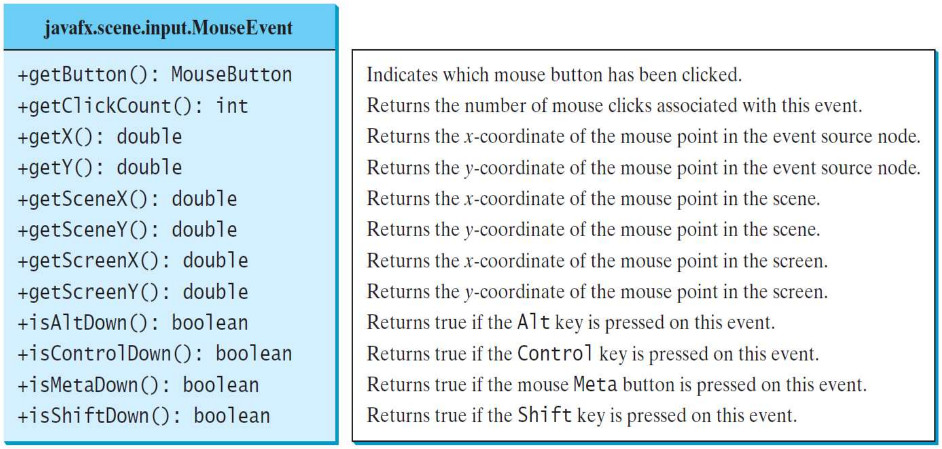
(type1 param1, type2 param2, ...) -> { statements; }

- The data type for a parameter may be explicitly declared or implicitly inferred by the compiler.
- The parentheses can be omitted if there is only one parameter without an explicit data type.

Single Abstract Method Interface (SAM)

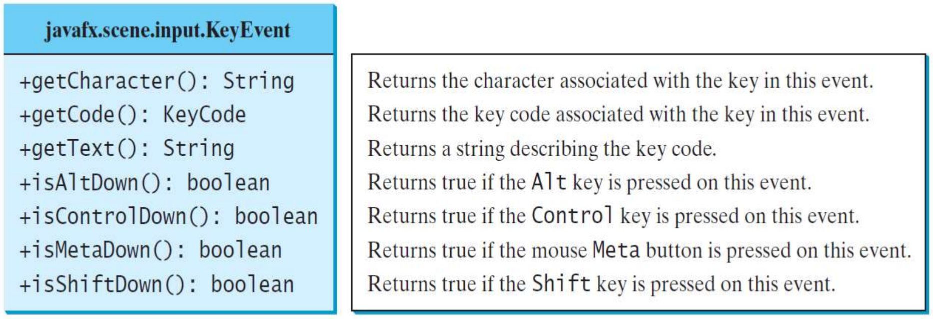
- For the compiler to understand lambda expressions, the interface **must** contain exactly one abstract method.
- The statements in the lambda expression is all for that method.
- If it contains multiple methods, the compiler will not be able to compile the lambda expression.
- Such an interface is known as a ***functional interface***, or a ***Single Abstract Method*** **(SAM)** interface.

MouseEvent



javafx.scene.input.MouseEvent	
+getButton(): MouseButton	Indicates which mouse button has been clicked.
+getClickCount(): int	Returns the number of mouse clicks associated with this event.
+getX(): double	Returns the *x*-coordinate of the mouse point in the event source node.
+getY(): double	Returns the *y*-coordinate of the mouse point in the event source node.
+getSceneX(): double	Returns the *x*-coordinate of the mouse point in the scene.
+getSceneY(): double	Returns the *y*-coordinate of the mouse point in the scene.
+getScreenX(): double	Returns the *x*-coordinate of the mouse point in the screen.
+getScreenY(): double	Returns the *y*-coordinate of the mouse point in the screen.
+isAltDown(): boolean	Returns true if the `Alt` key is pressed on this event.
+isControlDown(): boolean	Returns true if the `Control` key is pressed on this event.
+isMetaDown(): boolean	Returns true if the mouse `Meta` button is pressed on this event.
+isShiftDown(): boolean	Returns true if the `Shift` key is pressed on this event.

The KeyEvent Class

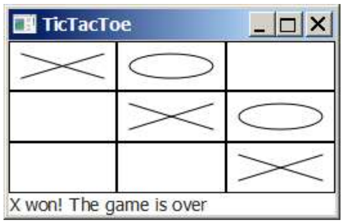


javafx.scene.input.KeyEvent	
+getCharacter(): String	Returns the character associated with the key in this event.
+getCode(): KeyCode	Returns the key code associated with the key in this event.
+getText(): String	Returns a string describing the key code.
+isAltDown(): boolean	Returns true if the `Alt` key is pressed on this event.
+isControlDown(): boolean	Returns true if the `Control` key is pressed on this event.
+isMetaDown(): boolean	Returns true if the mouse `Meta` button is pressed on this event.
+isShiftDown(): boolean	Returns true if the `Shift` key is pressed on this event.

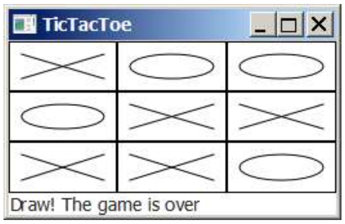
The KeyCode Constants

Constant	*Description*	*Constant*	*Description*
HOME	The Home key	CONTROL	The Control key
END	The End key	SHIFT	The Shift key
PAGE_UP	The Page Up key	BACK_SPACE	The Backspace key
PAGE_DOWN	The Page Down key	CAPS	The Caps Lock key
UP	The up-arrow key	NUM_LOCK	The Num Lock key
DOWN	The down-arrow key	ENTER	The Enter key
LEFT	The left-arrow key	UNDEFINED	The keyCode unknown
RIGHT	The right-arrow key	F1 to F12	The function keys from F1 to F12
ESCAPE	The Esc key	0 to 9	The number keys from 0 to 9
TAB	The Tab key	A to Z	The letter keys from A to Z

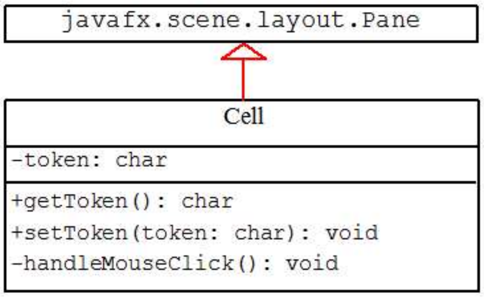
Case Study: TicTacToe



X won! The game is over



Draw! The game is over



javafx.scene.layout.Pane

Cell

-token: char

+getToken(): char
+setToken(token: char): void
-handleMouseClick(): void

Token used in the cell (default: ' ').

Returns the token in the cell.

Sets a new token in the cell.

Handles a mouse click event.