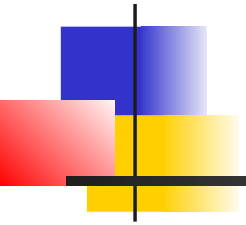


Threads in Swing

Using threads for long running tasks.

3 Kinds of Threads

In a Swing app:

- initial thread starts the application
- Event Dispatcher Thread
  - handles all UI events, updates Swing UI
- Worker Threads (Background Threads)
  - perform long running tasks

Why Bother with Threads?

- Prevent UI from *Freezing* while work is being done
  - connecting to database
  - downloading something
- Avoid *Thread Interference* and memory inconsistency
  - Like in Homework 4

"main" method - the wrong way

- your "main" class runs in the initial thread (any thread)
- this code starts Swing UI on the same thread.

```
public class PurseApp {
   public static void main(String[] args) {
        Purse purse = new Purse( 10 );
        // dependency injection
        PurseUI ui = new PurseUI( purse );
        ui.setVisible(true);
   }
```

Use SwingUtilities to launch UI

- Oracle says you should both create and launch the UI on the *Event Dispatcher thread*.

Use `SwingUtilities.invokeLater( runnable );`

```
public class PurseApp {
   public static void main(String[] args) {
      SwingUtilities.invokeLater(
        new Runnable( ) {
          public void run() {
             // create and start Swing UI
          }
        }
      );
}
```

SwingUtilities Example

- Create PurseUI inside the Runnable task, because the UI will create Swing components.
- purse is final so it can be accessed in anonymous class

```
public static void main(String[] args) {
   final int capacity = 10;
   final Purse purse = new Purse( capacity );
   SwingUtilities.invokeLater(
     new Runnable( ) {
       public void run() {
          // Must CREATE PurseUI inside Runnable
          PurseUI pui = new PurseUI( purse );
          pui.setVisible(true);
       }
     }
   );
```

SwingUtilities

SwingUtilities

invokeLater(Runnable): void

invokeAndWait(Runnable): void

isEventdispatcherThread(): bool

many more methods

Rules for Event Dispatcher Thread

To prevent UI from freezing and to prevent memory inconsistency:

1) operations on UI components should be done *only* in the Event Dispatcher thread
2) time-consuming operations should never be done on the Event Dispatcher thread

Note that all UI events (button press, state change) invoke event handlers on the event dispatcher thread.

Example: Fibonacci

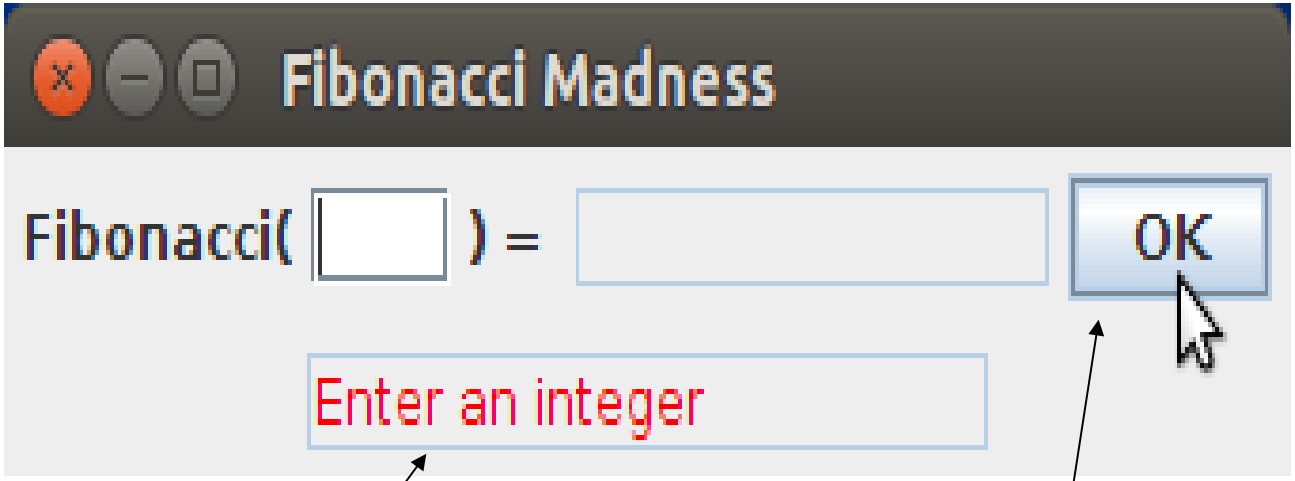
- as an example of a slow operation, let's compute Fibonacci numbers by recursion.
- fib(0) = 1, fib(1) = 1, fib(n) = fib(n-1) + fib(n-2)

```
public class Fibonacci {

    // this method could be static
    public long fibonacci(int n) {
        if (n < 0) return 0;
        if (n <= 1) return 1;
        return fibonacci(n-2) + fibonacci(n-1);
    }

    //TODO: test this code
}
```

UI for Fibonacci



Status or error message.

TODO:
add ActionListener

Frozen UI

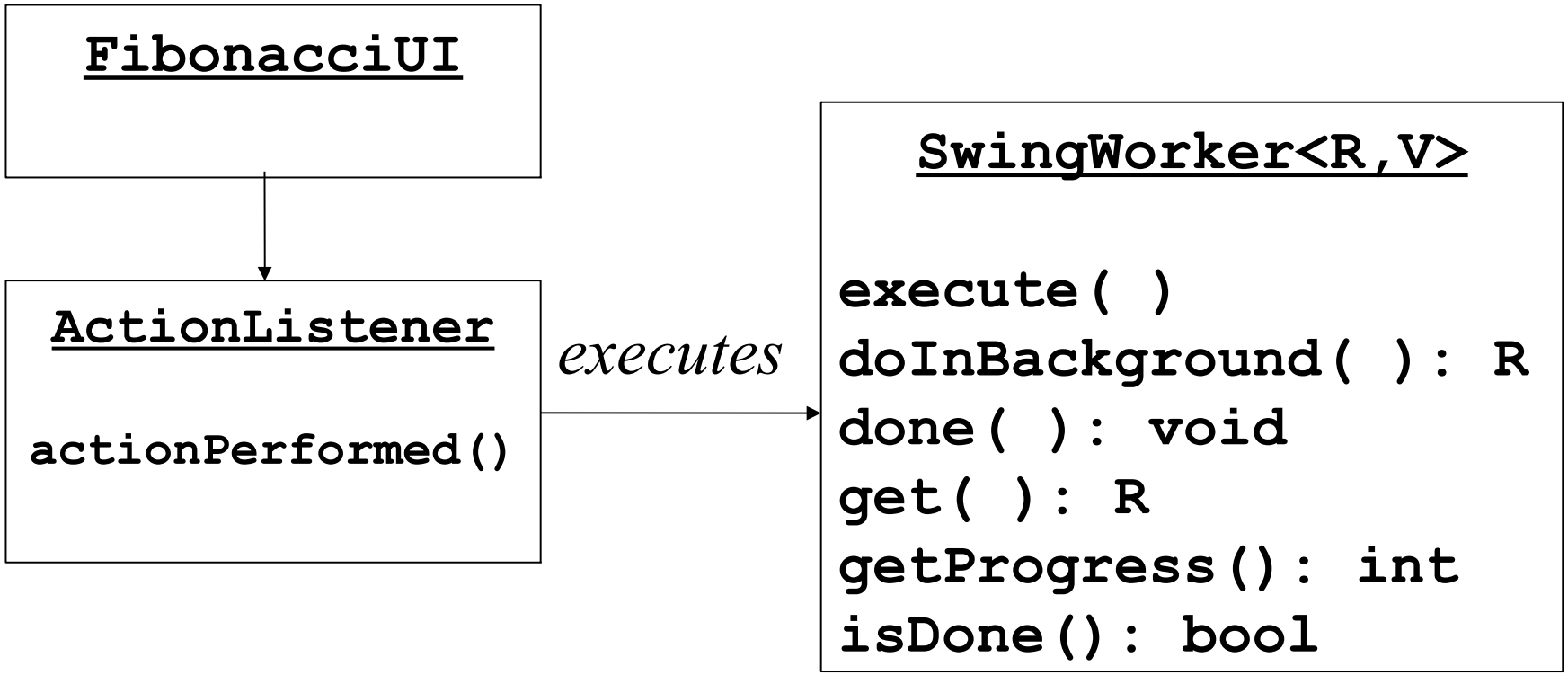
UI freezes (unresponsive) if you use try to compute large fibonacci numbers on the event dispatcher thread.

```
// ActionListener method for fibonacci UI
public void actionPerformed(ActionEvent evt) {
    String value = inputField.getText().trim();
    if (value.isEmpty()) return;
    int n = Integer.parseInt( value );
    setMessage( "working" );
    long result = Fibonacci.fibonacci( n );
    outputField.setText( Long.toString(result) );
    setMessage( "" );
}
```

SwingWorker

SwingWorker runs a task in a background thread.

SwingWorker communicates result to Event Dispatcher Thread.



How to Use SwingWorker

1) Create a subclass of SwingWorker for your task.

2) Override 2 methods:

`doInBackground( )` - do work on a background thread.

SwingWorker creates the background thread itself.

`done( )` - communicate the result to UI. This method runs on event dispatcher thread.

3) Use (don't override) to give updates to observers:

`publish( V stuff )` - publish intermediate results

`setProgress( int )` - set progress (0 - 100). This value is returned by getProgress().

How to Return a Result

`SwingWorker<R,V>`

`R` = type of the Result.

`R doInBackground( )` background task returns result.
(SwingWorker superclass remembers it.)

`get( )` - get the result in the UI or other thread.

```
worker.execute( );

// wait for worker to finish, then do...

R result = swingworker.get( );
```

Fibonacci Worker

R = result type = Long,

V = type of intermediate results = Void for "nothing"

```
class FibonacciWorker
              extends SwingWorker<Long,Void> {
    private int n; // or get from outer scope
    Long result;
    public FibonacciWorker(int n) { this.n = n; }

    @Override
    protected Long doInBackground() throws … {
        result = Fibonnaci.fibonacci(n);
        return result;
    }
```

Getting Result of Fibonacci Worker

`SwingWorker.done()` is invoked when doInBackground finishes. done() is run in the *Event Dispatcher Thread*.

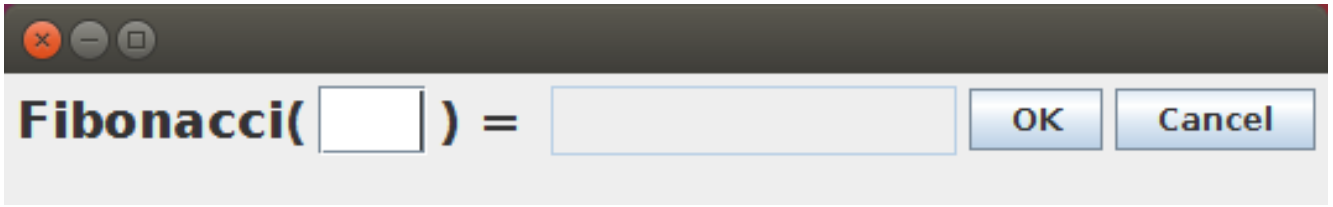
Use `done()` method to:

a) update the UI directly, or

b) notify observer that result is ready

```
@Override
protected void done( ) {
    outputfield.setText(result.toString());
    setMessage(""); // clear status msg
}
```

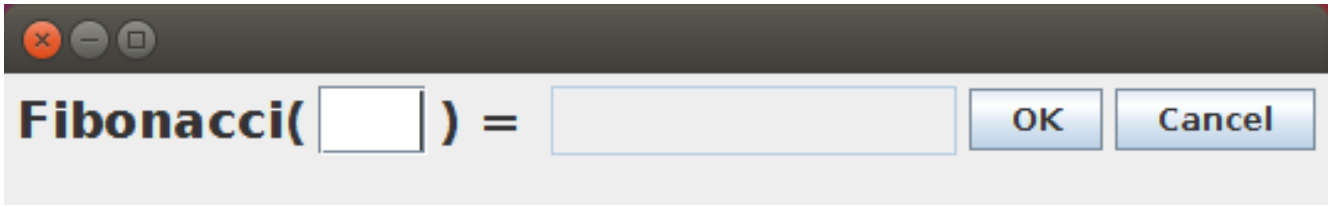
Running a SwingWorker



Call the `execute()` method.

```
public void okButtonHandler(ActionEvent evt) {
    //TODO add try-catch for invalid input
    int n = Integer.parseInt(input.getText());
    worker = new FibonacciWorker(n);
    worker.execute( );
}
```

Demo: add "Cancel" button



What if user presses "Cancel" button?

Call the method `swingWorker.cancel()`.

In done(), need to check whether task was cancelled!

More About SwingWorker

1) Can invoke task only one time.
   Create a new instance each time you need to run task.

2) Can "cancel" a SwingWorker, but requires cooperation of the task. Task should check isCancelled() and catch InterruptedException. See *Java Tutorial*.

3) Status methods:

```
getProgress( )
isDone( )
isCancelled( )
```

Other Ways to Use Threads

SwingWorker is for the special that you want to background threads that communicate with a Swing U.I.

For other cases, see:

1) javax.swing.TimerTask - run a task at given time

2) java.util.TimerTask - run a task at a given time, or a periodic task

2) Executor and ExecutorService - manage a thread pool

3) Future - return a result later

References

The Java Tutorial:
https://docs.oracle.com/javase/tutorial

Concurrency in Swing

https://docs.oracle.com/javase/tutorial/uiswing/concurrency/index.html

Concurrency (general)

https://docs.oracle.com/javase/tutorial/essential/concurrency/index.html