CS11 – Java

Fall 2014-2015

Lecture 5

Today's Topics

- Introduction to Java threads
- Swing and threading
- Lab 5 Hints

Java Threads

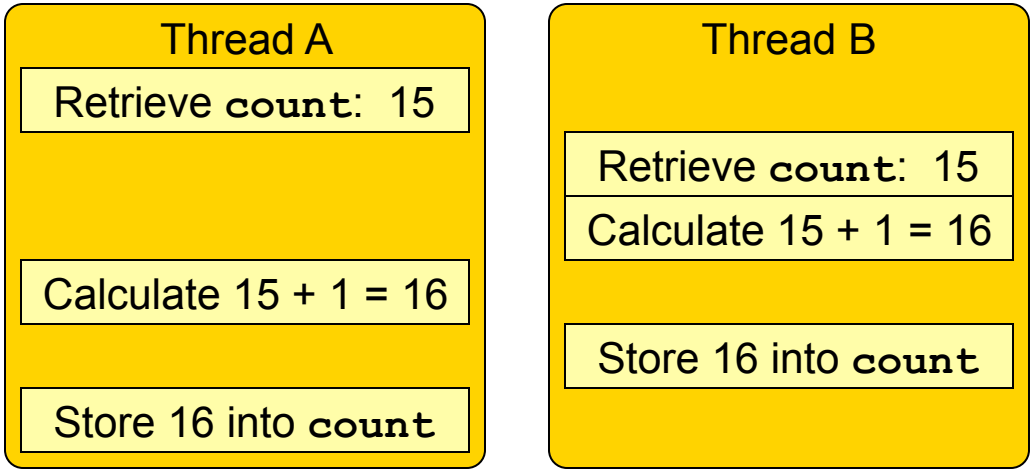
- A “thread of execution” is a single, sequential flow of execution through your program
  - Threads have a beginning and an end
  - A thread does only one thing at a time
- All programs have at least one thread of execution
  - The “main thread” runs your **`main()`** method
- Multi-threaded programs have several threads of execution
  - They can do multiple things “at the same time”

Standard Java Threads

- The Java VM uses multiple threads
  - The main thread runs your program
  - The garbage-collector may use a thread
  - Java AWT/Swing starts its own thread
    - For event-dispatching
  - Some Java library classes use threads internally
- You can start your own threads too
  - This week's lab doesn't need them (phew!)

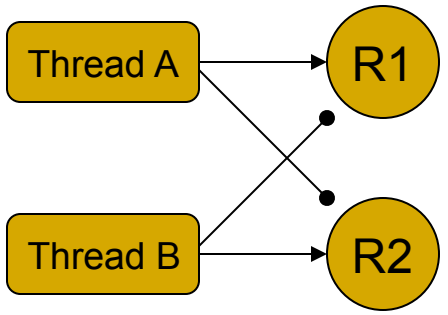
Threads and Resources

- A thread can have local resources; only used by the thread
- Threads can also share resources between each other
  - This can lead to many problems
- One big problem: interleaved access
  - Example: **`count`** is a shared variable. Assume **`count`** = 15.
  - Two threads executing **`count = count + 1;`**



Locking Shared Resources

- Shared resources must be manipulated atomically
  - Only allow one thread to access shared resource at a time
  - Shared resources can be locked by a thread
- If threads can lock multiple shared resources, deadlock can occur
  - Thread A locks resource R1
  - Thread B locks resource R2
  - Thread A tries to lock resource R2…
  - Thread B tries to lock resource R1…
  - Locking order is the issue here.



Swing and Thread-Safety

- Swing has its own thread for event handling
  - the event dispatcher thread
- …but, Swing components *aren't* thread-safe!
- To be thread-safe in Swing:
  - Once a Swing component has been made visible, only interact with it from event dispatcher thread.
- Initializing a Swing UI from another thread is fine (it hasn't been made visible yet)
  - e.g. usually done from the main thread

Long-Running Tasks and Swing

- Very common to have UIs performing long-running tasks
  - e.g. web browsers frequently have large files to download when displaying a web page, etc.
- Problem:
  - If long-running operation is performed on the event-dispatch thread, can't process events!
  - There is only one event-dispatch thread. If it's tied up with work, the UI will *freeze* until work is done.

Long-Running Tasks and Swing (2)

- Swing provides a solution to this issue:
  - **`javax.swing.SwingWorker`**
- Can dispatch a long-running task on a worker thread, in the background
  - Task won't tie up the event-dispatch thread
  - User can still interact with the user interface while the task is being completed
- When task is finished, SwingWorker's results are made available on event-dispatch thread
  - Can update user interface with results of task

`SwingWorker` Details

- **`SwingWorker`** is an abstract class
  - Must be subclassed to perform specific tasks
- Several important methods:
  - **`protected Object doInBackground()`**
    - Implement this method to perform the long-running task
    - This method is never called on the event-dispatch thread
    - (uses a small thread-pool of worker threads)
  - **`protected void done()`**
    - This method is always called on event-dispatch thread!
    - Implement this method to update your Swing GUI with results of long-running task

`SwingWorker<T,V>` Details

- **`SwingWorker`** is also a generic class
  - Can (and should) specify type parameters
- Type **`T`** specifies what **`doInBackground()`** returns
  - **`protected T doInBackground()`**
- If your **`doInBackground()`** implementation doesn't return anything:
  - Just set **`T`** to **`Object`**, and return **`null`**

`SwingWorker<T,V>` Details (2)

- Type `V` represents *intermediate state*
  - Some tasks generate intermediate results that need to be represented in the user interface
    - (Many tasks do not, so not every `SwingWorker` subclass uses this functionality)
  - In these cases, task's `doInBackground()` calls:
    - `protected void publish(V[] chunks)`
    - Whenever intermediate state must be published, this can be called
  - Calling `publish()` causes this method to be called on the event-dispatcher thread:
    - `protected void process(List<V> chunks)`

`SwingWorker<T,V>` Details (3)

- As before, if your **`SwingWorker`** task doesn't publish intermediate state:
  - Just set **`V`** to **`Object`**, and don't use **`publish()`** method

Shutting Down a GUI Application

- In Java AWT, closing a **`Frame`** just hides the window
  - If you don't do something special, application keeps running
  - Have to register a **`WindowListener`** impl to exit application when window closes
- In Swing, **`JFrame`** gives you options

```
JFrame f = new JFrame("My App!");
f.setDefaultCloseOperation(JFrame.EXIT_ON_CLOSE);
```

  - Default is **`HIDE_ON_CLOSE`**; like AWT Frame

Arrays in Java

- In Java, arrays are also objects
  - Some different syntax though!
- Example:

```
int[] myInts = new int[10];  // Allocate the array.
for (int i = 0; i < myInts.length; i++) {
  myInts[i] = 100 * i;       // Store stuff in it.
}
```

  - In Java, *all* arrays are dynamically allocated
  - Elements are accessed with brackets (like C/C++)
  - Arrays expose a **`length`** field, indicating their size
  - **`length`** is read-only (of course)

Array Variables

- Array-types have brackets after *type*, not after variable name
  - **`String[] names;`** vs. **`String names[];`**
  - Latter form is supported, but is discouraged.
- Can declare array-variables without assigning
  - **`boolean[] flags; // Array of boolean values`**
  - **`float[] weights; // Array of floats`**
- Must initialize them before using
  - Can allocate new array with **`new type[size];`**
    - ***`size`*** can be zero! Called an "empty array."
  - Can assign an existing array to the variable
    - (Java arrays are basically objects with additional syntax)
  - Can set to **`null`** too!

More Array Initialization

- Can also assign specific values to arrays

```
String[] colorNames = {
  "puce", "mauve", "fuchsia", "chartreuse", "umber"
};
// colorNames.length == 5
```

  - Syntactic sugar for the initialization operations
  - Can still reassign and reinitialize such arrays
    - **`colorNames`** is a reference to an array of **`String`** objects

Arrays of Objects

- Arrays of objects initially contain **`null`** values
  - Array initialization does not initialize object-references
  - Must do that in a separate step
- Example:

```
// Allocate an array of 20 point-references
Point2d[] points = new Point2d[20];

// Make a new Point2d object for each elem
for (int i = 0; i < points.length; i++)
  points[i] = new Point2d();
```

Arrays of Arrays

- Arrays can contain other arrays

```
int[][] nums2d;  // Array of arrays of ints.
```

- First the array-of-arrays is allocated:

```
nums2d = new int[20][];
```

  - Each element of **`nums2d`** is of type **`int[]`**.

- Next, each inner array is allocated

```
for (int i = 0; i < nums2d.length; i++)
  nums2d[i] = new int[50];
```

- When array is square, Java has a shortcut

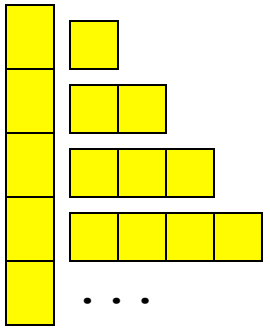
```
int[][] nums2d = new int[20][50];  // Same thing!
```

More Arrays of Arrays

- Inner arrays can be different sizes, if need be

```
int[][] reducedMatrix;
reducedMatrix = new int[20][];
for (int i = 1; i <= 20; i++)
  reducedMatrix[i - 1] = new int[i];
```

  - Can't do this with the shortcut syntax



- Can also specify nested initial values

```
double[][] weights = {
  {3.1,2.6}, {1.5,4.4,-3.6}, null, {6.2}
};
```

Copying Arrays

- Use **`System.arraycopy()`** to copy one array to another efficiently
- Can use **`clone()`** method to duplicate array
  - Result's type is **`Object`**; must cast to proper type

```
int[] nums = new int[35];
...
int[] numsCopy = (int[]) nums.clone();
```

  - Copy is shallow – only top-level array is copied!
    - If array of objects, the objects are not cloned
    - If array of arrays, subarrays are not cloned either

Next Week

- Java Sockets API
- **`String`** processing