§19.1: Multi-threading

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CMPT166
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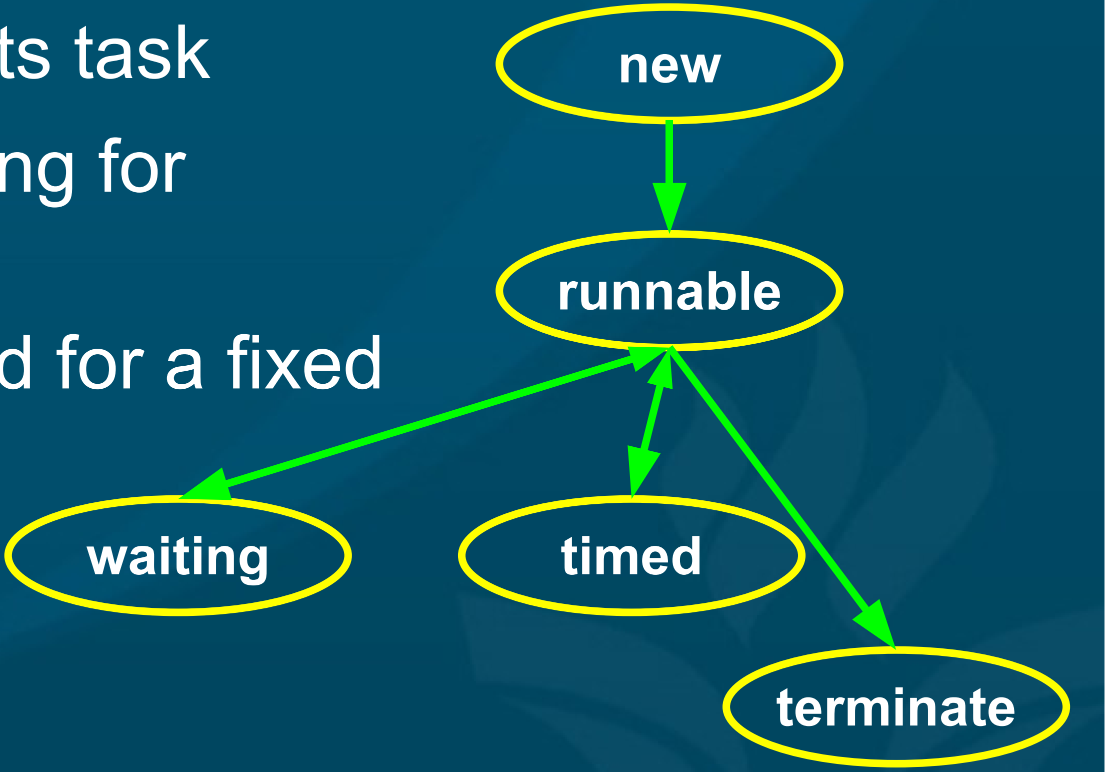
Multithreading

- Concurrency is running multiple tasks at the same time
  - Downloading a file, watching a movie, checking email
  - One server talking to multiple clients
- Threads are individual tasks (objects) that may run concurrently
  - Executor (master) thread starts and coordinates worker threads
- Multithreading is built-in to Java ≥1.5

Thread state diagram

- Threads can be in one of four states:
  - New: not yet initialized
  - Runnable: executing its task
  - Waiting: blocked waiting for another thread
  - Timed waiting: blocked for a fixed time
  - Terminated



Task scheduling

- The API allows a program to create multiple threads
- But how many threads can run simultaneously depends on how many physical processors you have
  - e.g., dual-core, quad-core SMP
- The scheduler assigns runnable threads to processors
  - Done by the operating system, not the Java VM
  - If more threads than processors, scheduler may preempt running threads to allow others to run
  - Each thread has a priority (“nice” value)
    - Lower priority threads might get starved

Creating a thread object in Java 1.5

- Class design:
  - Each thread is a separate object
  - Executor (master thread) is another object
    - Created from main()
- The thread objects should implement the interface Runnable (java.lang):
  - Define (override) the method: public void run()
  - Can use utility methods in class Thread (java.lang)
    - Thread.sleep(100); // timed wait for 100ms

Multithreading keeps GUI responsive

- If an event handler (ActionListener) takes a long time to run, the whole GUI is blocked waiting for it
  - Window doesn't even close!
- For long-running callbacks, spawn a separate thread
- Inner (nested) class has access to all the private instance variables: widgets, graphics context, etc.

```
public void ActionPerformed() {
    Packer packerThread = new Packer();      // new thread
    packerThread.start();
}
private class Packer extends Thread { ...
```

Example: PrintTask

```
import java.util.Random;
class PrintTask implements Runnable {
    private int sleepTime;
    private String name;
    private static Random gen = new Random();
    public PrintTask( String name ) {
        this.name = name;
        this.sleepTime = gen.nextInt( 5000 );
    }
    public void run() {
        System.out.println( name + “: good night!” );
        Thread.sleep( sleepTime );
        System.out.println( name  + “: good morning!” );
    }
}
```

Managing threads in Java 1.5

- The executor object implements interface ExecutorService (java.util.concurrent):
  - Defines method: public void execute()
- The class Executors (java.util.concurrent) provides static methods to create executors:
    - Executors.newFixedThreadPool(3);
  - Creates a new ExecutorService object that can run up to three threads simultaneously
  - If more than three threads are to be executed, the ExecutorService object queues them up

Example: RunnableTester

```
import java.util.concurrent.*;
public class RunnableTester {
    public static void main( String args[] ) {
        PrintTask task1 = new PrintTask( “Thread 1” );
        PrintTask task2 = new PrintTask( “Thread 2” );
        ExecutorService master =
          Executors.newFixedThreadPool( 3 );
        master.execute( task1 );
        master.execute( task2 );
        master.shutdown();
    }
}
```

- Master fires up worker threads, then quits
- Worker threads continue running afterward