Threads

Java Threads

- A thread is computer code being executed.
- More than one thread can be executed virtually simultaneously (actually interleaved).
  - The code for the threads can be the **same**, or different.
  - Each thread has its own state, **sort of**.
  - Threads can **share variables**, and modify the variables they share.
- Programs with > 1 thread are called "concurrent programs".

Timing of Threads

- Threads don't progress in lock-step fashion.
- One may be started and another stopped in an **unpredictable** fashion by the operating system.
- This behavior is called **asynchronous**.

Similar Idea: Processes

- A process is also code in execution.
- Typically processes don't share variables, although limited sharing is possible.
- Multiple processes is common in, e.g. UNIX.
- Processes are "heavy weight", threads are "light weight".
- Weight refers to the cost of switching the processor from one unit's state to another's.

Why are Threads Useful?

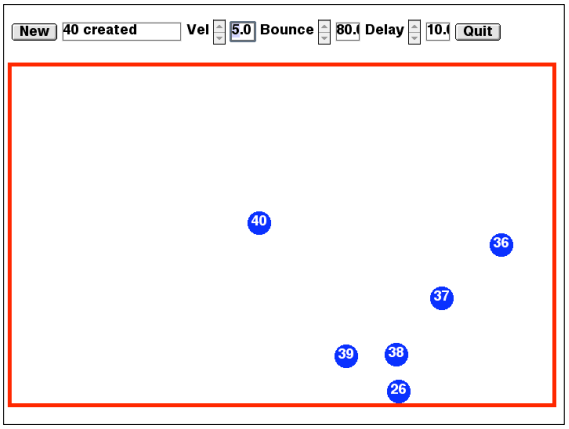
- May wish to have multiple activities going on at once.
- Don't want one activity's waiting (e.g. for an event) to stop the other activities.
- This is only doable with threads (or processes).

Thread Example

- On thread is a **computational** one, that occasionally needs to wait for input from the outside, say from an input stream of characters.
- Another thread may be a **graphical user interface**, responding to mouse events.
- We don't want **waiting** for input to hold up the graphics, or waiting for a click to hold up the computational thread.
- In fact, the click might tell the computational thread to alter its behavior.

Thread Example

- Bouncing Balls Example
- Each ball is run by a separate thread.
- Each thread can, in principal, be **interrupted** and re-started independently of the others.
- If a ball is "clicked" in mid-air, it will suspend, and resume if clicked a second time.



Two Ways to Have Threads in Java

- extends Thread
  - Thread is a *base class* with threading capability.
- implements Runnable
  - Runnable is an interface that requires method
    - void run()
- The latter is preferred, because it does not take away your ability to inherit from another class (multiple inheritance is not allowed in Java).

Using "implements Runnable"

- The class that implements Runnable *still* needs to contain a Thread.
- This Thread is what controls starting and stopping.

Ball "extends Thread" Code

```
/**
 * Ball class represents ball's state information
 */

class Ball extends Thread // Thread implements Runnable
  {
  double x, y;                          // this ball's coordinates
  double deltaX, deltaY;                // this ball' velocities
  String myNumber;                      // ball's number as a string

  public Ball(...) // constructor {}

  /**
   * over-ride run() method in parent class (Thread)
   */

  public void run()
    {
    while( true )
      {
      move();                           // move the ball
      sleep(app.delay);                 // sleep (defined in Thread)
      }
    }
```

Ball "implements Runnable" Code

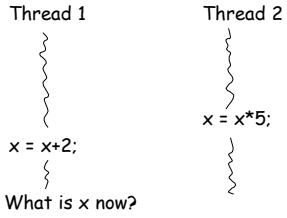
```
class Ball implements Runnable
{
Thread myThread;          // this ball's thread
double x, y;              // this ball's coordinates
double deltaX, deltaY;    // this ball' velocities
String myNumber;          // ball's number as a string

Ball(x, y, number)        // constructor
  {
  ...
  myThread = new Thread(this);     // make thread for Ball
  }

public void run()                  // run method for this Runnable
    {
    while( true )
      {
      move();                      // move the ball
      myThread.sleep(app.delay);   // sleep
      }
    }
...
}
```

Cautions about Threads

- Reasoning about concurrent programs is inherently more difficult than reasoning about sequential ones.
- They can exhibit **non-deterministic** behavior, when variables are shared among threads.

Non-Determinism

Suppose x == 1 initially.



Interesting Methods of Thread

start

```
public void start()
```

Causes this thread to begin execution; the Java Virtual Machine calls the `run` method of this thread.

The result is that *two threads are running concurrently*: the current thread (which returns from the call to the `start` method) and the other thread (which executes its `run` method).

Throws:
`IllegalThreadStateException` - if the thread was already started.

Methods of Thread

currentThread

```
public static Thread currentThread()
```

Returns a reference to the currently executing thread object.

So "executing" is more specific than "running":

"executing" means "has the processor"

"running" means "able to execute"

Methods of Thread

yield

```
public static void yield()
```

Causes the currently executing thread object to pause temporarily and allow other threads to execute.

Methods of Thread

sleep

```
public static void sleep(long millis)
                  throws InterruptedException
```

Causes the currently executing thread to sleep (temporarily cease execution) for the specified number of milliseconds.
The thread does not lose ownership of any monitors.

Parameters:
`millis` - the length of time to sleep in milliseconds.
Throws:
`InterruptedException` - if another thread has interrupted the current thread.
The *interrupted status* of the current thread is cleared when this exception is thrown.

Methods of Thread

interrupt

```
public void interrupt()
```

Interrupts this thread.

First the `checkAccess` method of this thread is invoked,
which may cause a `SecurityException` to be thrown.

Methods of Thread

setPriority

```
public final void setPriority(int newPriority)
```

Changes the priority of this thread.

First the `checkAccess` method of this thread is called with no arguments.
This may result in throwing a `SecurityException`.

Otherwise, the priority of this thread is set to the smaller of the specified `newPriority`
and the maximum permitted priority of the thread's thread group.

Methods of Thread

join

```
public final void join(long millis)
                throws InterruptedException
```

Waits at most `millis` milliseconds for this thread to die.
A timeout of `0` means to wait forever.

Parameters:
`millis` - the time to wait in milliseconds.
Throws:
`InterruptedException` - if another thread has interrupted the current thread.
The *interrupted status* of the current thread is cleared when this exception is thrown.

Runnable

java.lang

Interface Runnable

Known Implementing Classes:
Thread, TimerTask

The `Runnable` interface should be implemented by any class whose instances are intended to be executed by a thread. The class must define a method of no arguments called `run`.

This interface is designed to provide a common protocol for objects that wish to execute code while they are active. For example, `Runnable` is implemented by class `Thread`.
Being active simply means that a thread has been started and has not yet been stopped.

In addition, `Runnable` provides the means for a class to be active while not subclassing `Thread`.
A class that implements `Runnable` can run without subclassing `Thread` by instantiating a `Thread` instance and passing itself in as the target. In most cases, the `Runnable` interface should be used if you are only planning to override the `run()` method and no other `Thread` methods.
This is important because classes should not be subclassed unless the programmer intends on modifying or enhancing the fundamental behavior of the class.