

CMSC 132: OBJECT-ORIENTED PROGRAMMING II



Threads in Java

Department of Computer Science
University of Maryland, College Park

Problem

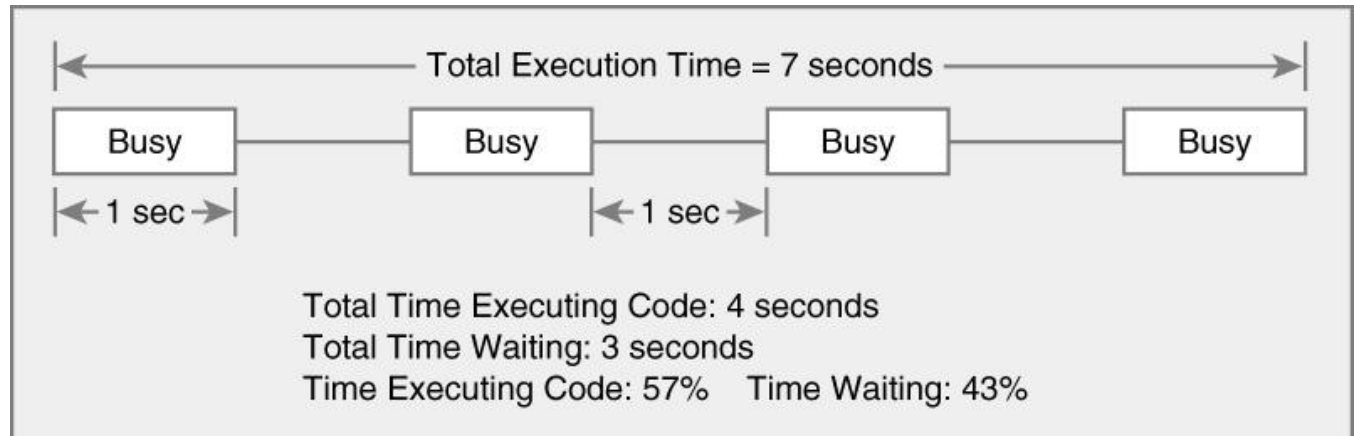
- Multiple tasks for computer
 - Draw & display images on screen
 - Check keyboard & mouse input
 - Send & receive data on network
 - Read & write files to disk
 - Perform useful computation (editor, browser, game)
- How does computer do everything at once?
 - Multitasking
 - Multiprocessing

Multitasking (Time-Sharing)

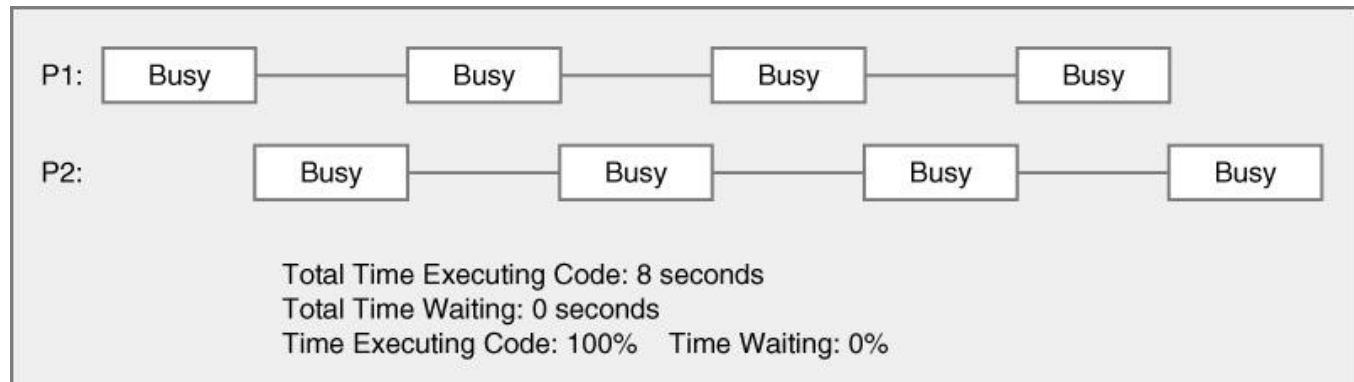
- Approach
 - Computer does some work on a task
 - Computer then quickly switch to next task
 - Tasks managed by operating system (scheduler)
- Computer **seems** to work on tasks concurrently
- Can improve performance by reducing waiting

Multitasking Can Aid Performance

- Single task



- Two tasks



Multiprocessing (Multithreading)

- Approach
 - Multiple processing units (**multiprocessor**)
 - Computer works on several tasks in parallel
 - Performance can be improved



**Dual-core
AMD
Athlon X2**



**32
processor
Pentium
Xeon**



**4096
processor
Cray X1**



**Beowulf computer
cluster (Borg, 52-
node cluster used
by McGill University
Image/Info from
Wikipedia)**

Perform Multiple Tasks Using Processes

- Process
 - Definition → executable program loaded in memory
 - Has own address space
 - Variables & data structures (in memory)
 - Each process may execute a different program
 - Communicate via operating system, files, network
 - May contain multiple threads

Perform Multiple Tasks Using Threads

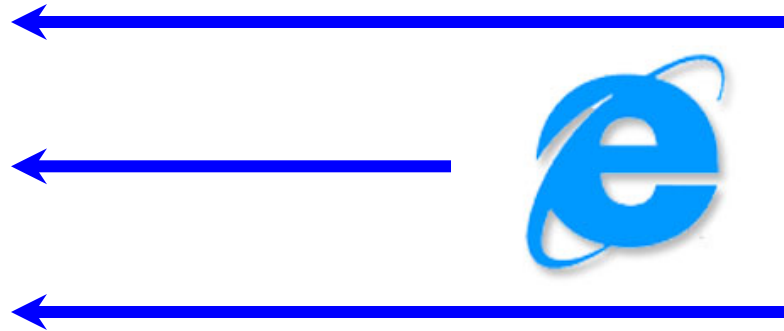
- Thread
 - Definition → sequentially executed stream of instructions
 - Has own **execution context**
 - Program counter, call stack (local variables)
 - Communicate via shared access to data
 - Also known as “lightweight process”
 - Let’s see how memory is organized for a threaded environment
 - Diagram
 - <http://blog.codecentric.de/wp-content/uploads/2009/12/java-memory-architecture.jpg>

Motivation for Multithreading

- Captures logical structure of problem
 - May have concurrent interacting components
 - Can handle each component using separate thread
 - **Simplifies programming for problem**
- Example



**Web Server uses
threads to handle ...**



**Multiple simultaneous
web browser requests**

Motivation for Multithreading

- Better utilize hardware resources
 - When a thread is delayed, compute other threads
 - Given extra hardware, compute threads in parallel
 - Reduce overall execution time
- Example



**Multiple simultaneous
web browser requests...**

**Handled faster by
multiple web servers**

Programming with Threads

- **Concurrent programming**
 - Writing programs divided into independent tasks
 - Tasks may be executed in parallel on multiprocessors
- **Multithreading**
 - Executing program with multiple threads in parallel
 - Special form of multiprocessing

Creating Threads in Java

- Two approaches to create threads
 - Extending Thread class (**NOT RECOMMENDED**)
 - Runnable interface approach (**PREFERRED**)
- Approach 1: Extending Thread class
 - We overload the Thread class run() method
 - The run() methods defines the actual task the thread performs
 - Example

```
public class MyT extends Thread {  
    public void run( ) {  
        ...                // work for thread  
    }  
}  
  
MyT t = new MyT( ) ; // create thread  
t.start( );          // begin running thread  
...                  // thread executing in parallel
```
- **Example:** message, messageThreadExtends packages

Creating Threads in Java

- Approach 2: Runnable Interface

- Define a class (worker) that implements the Runnable interface

```
public interface Runnable {  
    public void run(); // work done by thread  
}
```

- Create thread to execute the run() method

- Alternative 1: Create thread object and pass worker object to Thread constructor
- Alternative 2: Hand worker object to an executor

- Example

```
public class Worker implements Runnable {  
    public void run( ) { // work for thread }  
}
```

```
Thread t = new Thread(new Worker( )); // create thread  
t.start(); // begin running thread  
... // thread executing in parallel
```

- **Example:** message, messageThreadRunnable packages

Why Extending Thread Approach Not Recommended?

- Not a big problem for getting started
 - But a bad habit for industrial strength development
- Methods of worker and Thread class intermixed
- Hard to migrate to more efficient approaches
 - Thread Pools

Thread Class

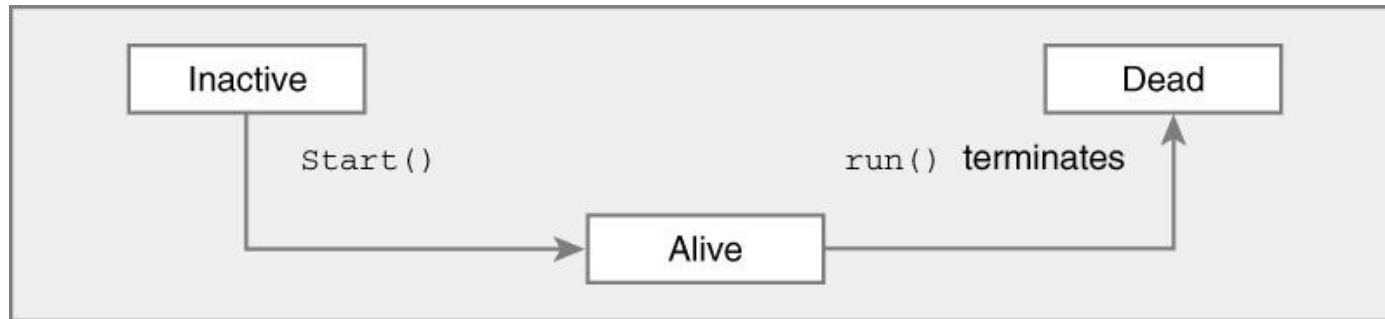
```
public class Thread extends Object implements Runnable {  
    public Thread();  
    public Thread(String name); // Thread name  
    public Thread(Runnable R);  
    public Thread(Runnable R, String name);  
  
    public void run(); // if no R, work for thread  
    public void start(); // thread gets in line so it eventually it can run  
    ...  
}
```

More Thread Class Methods

```
public class Thread extends Object {  
    ...  
    public static Thread currentThread()  
    public String getName()  
    public void interrupt() // alternative to stop (deprecated)  
    public boolean isAlive()  
    public void join()  
    public void setDaemon()  
    public void setName()  
    public void setPriority()  
    public static void sleep()  
    public static void yield()  
}
```

Creating Threads in Java

- Note
 - Thread eventually starts executing **only if start() is called**



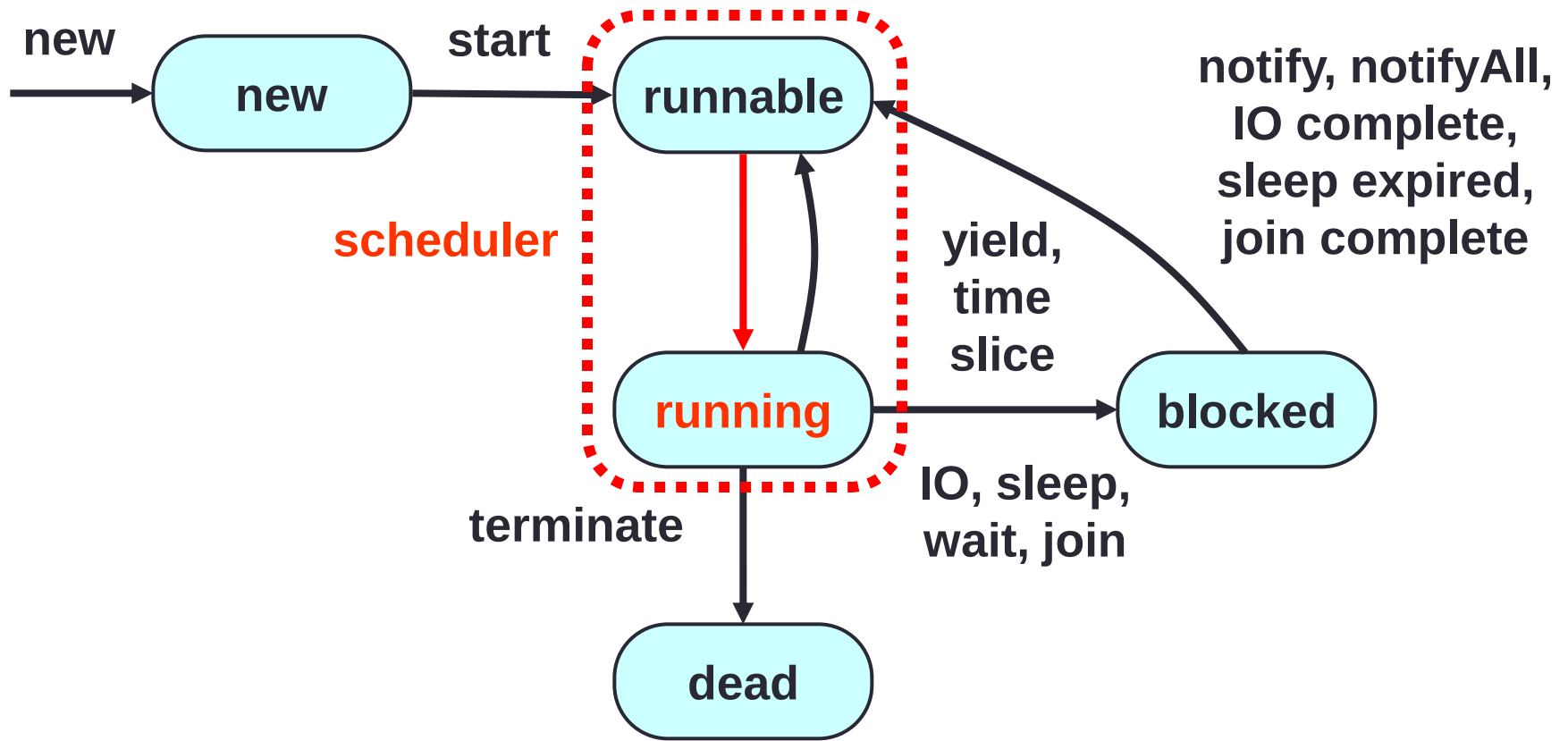
- Runnable is interface
 - So it can be implemented by any class
 - Required for multithreading in applets
- **Do not call the run method directly**

Threads – Thread States

- Java thread can be in one of these states
 - **New** → thread allocated & waiting for start()
 - **Runnable** → thread can begin execution
 - **Running** → thread currently executing
 - **Blocked** → thread waiting for event (I/O, etc.)
 - **Dead** → thread finished
- Transitions between states caused by
 - Invoking methods in class Thread
 - new(), start(), yield(), sleep(), wait(), notify()...
 - Other (external) events
 - Scheduler, I/O, returning from run()...
- In Java states defined by Thread.State
 - <http://docs.oracle.com/javase/6/docs/api/java/lang/Thread.State.html>

Threads – Thread States

- State diagram



Running is a logical state → indicates runnable thread is actually running