CSCD 330 Network Programming

Lecture 8
Client-Server Programming Threads
Spring 2018

Reading: Chapter 2, Relevant Links - Threads

Introduction

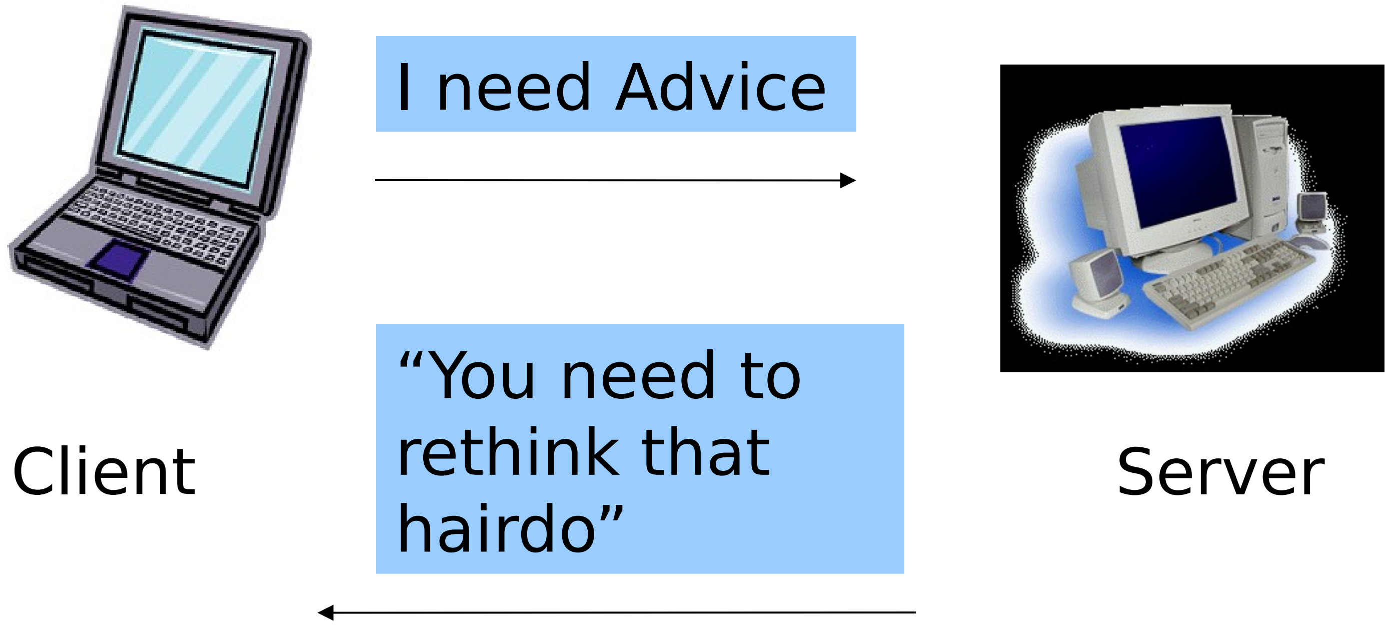
- So far,
- Studied client-server programs with Java
    - Sockets – TCP, UDP is still to do
    - Reading and writing to a socket
    - One client at a time
- Today,
- Study client-server programs
    - Sockets – with threads, allow multiple clients in parallel
    - Also, go over the Input/Output of Sockets

Details of Socket I/O

- New Example
  - DailyAdviceServer
    - Server provides valuable advice to clients
    - You connect as a client and it sends back the “advice of the day”
    - Random selection of advice messages

  - Still one client at a time
  - Review - connection-oriented, what type of socket are we using?

Daily Advice Client/Server



Algorithm for Daily Advice Client

1. Creates a socket to Advice Server
2. Waits for Server to provide excellent advice
3. Reads advice from server
4. Prints advice to screen
5. Quits

Socket I/O - Client

```
import java.io.*;
import java.net.*;

//The client
public class DailyAdviceClient {

  public void go() {
      try {
         Socket s = new Socket("127.0.0.1", 4200);
         InputStreamReader streamReader =
                new  InputStreamReader(s.getInputStream());
         BufferedReader reader =
                new BufferedReader(streamReader);
         String advice = reader.readLine();
         System.out.println ("Today you should: " + advice);
          reader.close ();
      } catch(IOException ex) {
         ex.printStackTrace();
      }
   } // close go
```

What IP is this?

Socket I/O - Client

```
//Main method

public static void main(String[] args) {
      DailyAdviceClient client = new DailyAdviceClient();
      client.go();
   }
}
```

Socket I/O - Client

- Input
- InputStreamReader acts like a bridge between low-level byte stream, getInputStream() and high-level character stream like BufferedReader

```
InputStreamReader streamReader =
    new InputStreamReader(s.getInputStream());
```

  - Converts bytes to characters
  - Then .....

Details of Socket I/O - Client

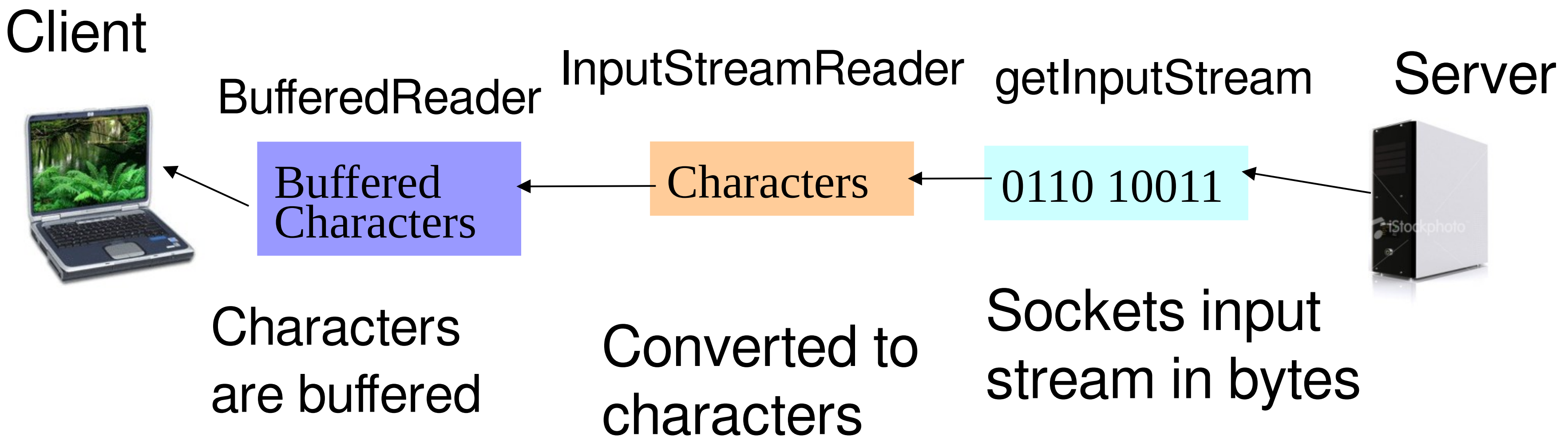
- Input Continued ...
- We chain high-level character stream like BufferedReader to the InputStreamReader to read **buffered characters**

```
BufferedReader reader =
        new BufferedReader(streamReader);
String advice = reader.readLine();
```

- Chaining of input streams from server to client looks like ...

Details of Socket I/O - Client

Chain of input from server to client



Why do you want to use a Buffered Reader class?

Buffered Readers are Efficient

- Reason to use buffered reader
  - More efficient I/O
  - Each time you read a character, must access the disk
  - Buffered reader gets several characters at once
  - Stores them in a buffer then writes to disk

Explains I/O performance

http://www.kegel.com/java/wp-javaio.html

Socket I/O - Server

```
import java.io.*;
import java.net.*;

public class DailyAdviceServer {

 String[] adviceList = {"Take smaller bites", "Go for the tight
   jeans. No they do NOT make you look fat.", "One word:
   inappropriate", "Just for today, be honest. Tell your boss what
   you *really* think", "You might want to rethink that haircut."};

 public static void main(String[] args) {
   DailyAdviceServer server = new DailyAdviceServer();
   server.go(); // Main Server code in this routine
   }
```

Socket I/O - Server

What is this number?

What does this do?

```
public void go() {
      try {
        ServerSocket serverSock = new ServerSocket (4200);

        while(true) {
          Socket sock = serverSock.accept();

        PrintWriter writer =
                new PrintWriter(sock.getOutputStream());
          String advice = getAdvice(); // select advice string, next slide

          writer.println(advice);
          writer.close();  // need THIS or flush() or never writes...

          System.out.println(advice); // Writes to screen too
         }
      } catch(IOException ex) {
        ex.printStackTrace();
      }
    } // close go
```

Socket I/O - Server

```
private String getAdvice() {
    int random = (int) (Math.random() * adviceList.length);
    return adviceList[random];
    }



}
```

Socket I/O - Server

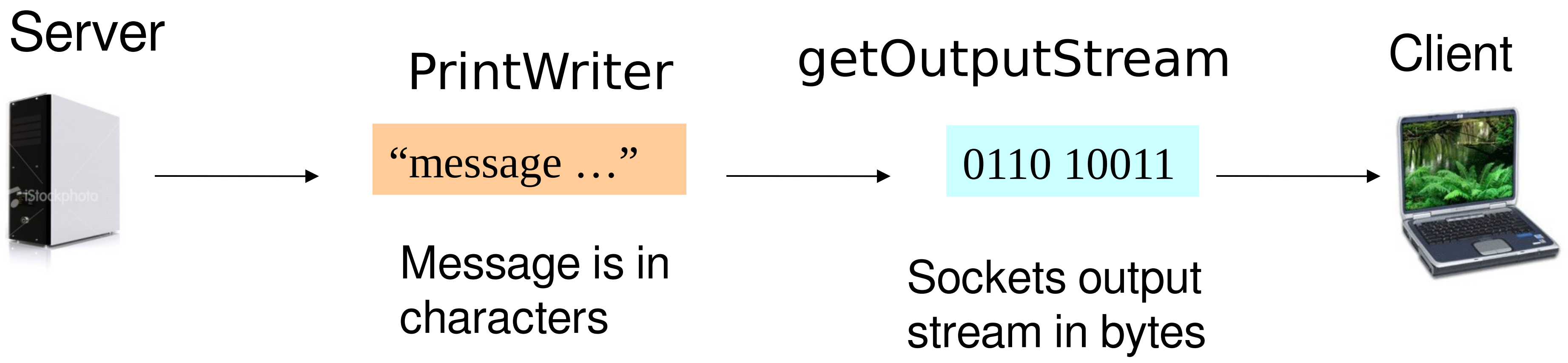
Output

- Create a PrintWriter object gets chained to low-level socket output getOutputStream
- PrintWriter acts like its own bridge between character data and the bytes it gets from the Socket’s low-level output stream
- Can then write strings to the socket connection

```
PrintWriter writer =
            new PrintWriter(sock.getOutputStream());
String advice = getAdvice();
writer.println (advice);   //adds a newline to string
```

Socket I/O - Server

Chain of output from server to client



Demo Time

Run the Great Advice of the Day program !

Run: DailyAdviceClient.java
DailyAdviceServer.java

Threads in Java

Threads in Java

What is a thread?

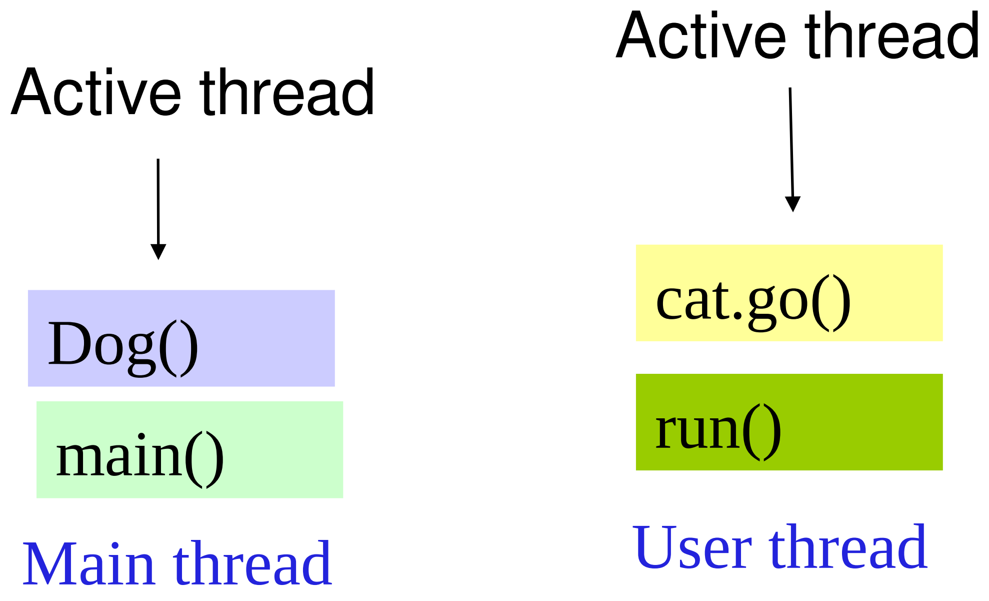
- Separate thread of execution
- Called from an existing program
- A java class, Thread represents a thread in Java
- **Has a separate stack !!!**
- Allows you to run separate processes from main thread
- Can do concurrency

Threads

- What does it mean to have more than one stack?
  - Gives appearance of having multiple things happen at once
  - Execution is actually moving back and forth between stacks
  - It might look like this …

Threads

- Main gets started, invokes Dog method
- Thread is started, cat
- Execution switches between main and user thread



Java Thread Class

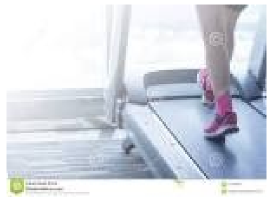
- The Thread class has three primary methods that are used to control a thread:

  - public void start()
  - public void run()
  - public final void stop()

- The start() method prepares a thread to be run;
- The run() method actually performs the work of the thread;
- The stop() method halts the thread

The thread dies when the run() method terminates or when the thread's stop() method is invoked.

Java Thread Class



- Running Threads
- You never call run() explicitly.
- It is called automatically by the runtime as necessary once you've called start()
- There are also methods to suspend and resume threads, to put threads to sleep, wake them up, and to yield control to other threads
    - These will be covered later in another lecture

Creating Java Threads

Two ways to create threads in Java

1. Extend the Thread Class

    Declare new class as subclass of Thread, then override run() method with code you want executed by Thread

    Example: Compute Prime numbers via thread

```
class PrimeThread extends Thread {
        public void run() {
            // compute primes...
         }
 }
```

    To start this thread, instantiate it, then call start ()

    Run method is executed when thread is started

```
PrimeThread p = new PrimeThread();
p.start();
```

Creating Java Threads

Two ways to create threads in Java

2. Create a Thread via Runnable Interface

Another way to create a thread is by using the Runnable interface. This way any object that implements the Runnable interface can be run in a thread.

For example:

```
class Primes implements Runnable {
        public void run() {
            // compute primes...
        }
  }
```

To start this thread, instantiate the thread, **pass it a runnable job,** then call start ()

Run method executed when thread started

```
Primes p = new Primes();
Thread myprime = new thread (p);
myprime.start();
```

Threads in Java

- In choosing the two ways to implement threads,
- Advice is to implement Runnable not Extend Thread class, why?
  - **Answer,**
  - If thread class is to be subclass of some other class, it can’t extend from the Thread class
  - Java does not allow a class to inherit from more than one class … no multiple inheritance
  - Advice is to use Runnable interface to implement threads

Recall …. Java Interface

- Interface looks like a class but it is not a class
- Interface can have methods and variables just like a class but methods declared in interface are by default **abstract**
- Only method signature, no body

Threads in Java

- What are the Advantages of Thread?
  - Multithreading has several advantages over Multiprocessing
  - Threads are **lightweight** compared to processes
  - Threads share same address space and can share both data and code
  - Context switching between threads is less expensive
  - Cost of thread intercommunication relatively low
  - Threads allow different tasks to be performed concurrently

Example Threads via Runnable

- Thread uses the run() method of the runnable interface. Example below

```
public class MyRunnable implements Runnable {
   public void run () {
    go ();
   }

   public void go () {
       doMore ();
   }

   public void doMore ();
      System.out.println (“Top o’ the stack”);
  }
}
```

Runnable has **one method**, run()

This is where you put the **job** the thread is supposed to run, this example, its go ()

Example Threads via Runnable

- Example Continued

Pass the Runnable instance to thread constructor

```
class ThreadTester {
  public static void main (String[] args) {
    Runnable threadJob = new MyRunnable ();
    Thread myThread = new Thread(threadJob);

    myThread.start();

    System.out.println ("back in Main");
  }
}
```

Start the new thread

Run: MyRunnable.java

Thread States

Thread t =
new Thread (r);

t.start();

Running!

Thread created but not started

Thread ready to run, runnable state
Waiting to be selected for execution

Thread selected to run and is the currently running thread

Once thread is runnable, can go back and forth between running, runnable and blocked

Threads

- The JVM thread scheduler is responsible for deciding who gets to run next
- You, have little control over the decision

- Threads can be Blocked !!!
  - Thread might be blocked for many reasons
  - Examples
    - Executing code to read from socket input stream, but no data to read
    - Executing code told thread to sleep
    - Tried to call a method but object was “locked”

Scheduling Threads

- Don’t base your program’s correctness on the scheduler working in a particular way
  - Can’t control it or even predict the scheduler behavior
    - Implementations are different with different JVM’s
    - We will compile and run example code several times to see this
    - Results will differ even on the same machine

Multiple Clients

- Original Problem
  - Need to handle multiple requests for service from a given server
  - Without threads
    - One client at a time, process each until done
  - With threads
    - Many clients, process one, move on and process another etc.

Threads and multiple clients

- Same problem, **DailyAdvice Server**
- Now,
  - Add threads so we can service multiple clients at once
  - Everyone will have the benefit of having great advice to start their day

Socket I/O - Server

```
import java.io.*;
import java.net.*;

public class DailyAdviceServer {

 String[] adviceList = {"Take smaller bites", "Go for the tight
   jeans. No they do NOT make you look fat.", "One word:
   inappropriate", "Just for today, be honest. Tell your boss what
   you *really* think", "You might want to rethink that haircut."};

 public static void main(String[] args) {
   DailyAdviceServer server = new DailyAdviceServer();
   server.go(); // Main Server code in this routine
   }
```

```
public void go() {
      try {
        ServerSocket serverSock = new ServerSocket(4200);

        while(true) {
          AdviceRequest request =
                  new AdviceRequest (serverSock.accept());
         Thread thread = new Thread (request);
          thread.start ();
         }
      } catch(IOException ex) {
        ex.printStackTrace();
      }

   } // close go
```

AdviceRequest is our Runnable object

Pass an extension of Runnable to thread constructor

```
final class AdviceRequest implements Runnable {
     Socket socket;

   public AdviceRequest (Socket socket) throws Exception {
        this.socket = socket;
   }
// Implement the run method of the Runnable interface
  public void run() {
    try {
           processRequest ();
    } catch (Exception e) {
           System.out.println (e);
    }
 }

  private void processRequest () throws Exception {
        // Attach a PrintWriter to socket's output stream
          PrintWriter writer =
                    new PrintWriter(this.socket.getOutputStream());
            String advice = getAdvice();
            writer.println(advice);
            writer.close();  // must have THIS or flush() or it never writes...

            System.out.println(advice);
}
```

AdviceRequest implements the Runnable interface
One method - run ()

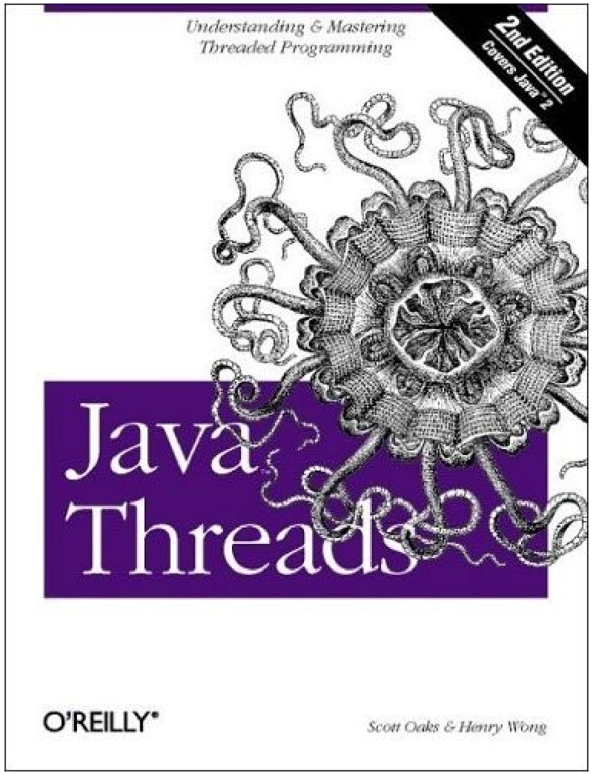
Inside run, processRequest does all the work is the "job" to be run

Gets output stream and sends advice to one client

Summary

- Brief coverage of sockets with threads
- Should be enough for you to get started
  - This example will be available to download
  - Code is on the main class page
- We will be implementing .....
  - A multi-threaded Web Server!!!!
- Also, practice client-server in the lab
- Can read references in RelevantLinks for more information

Reference: http://www.java-success.com/java-beginner-multithreading-interview-questions-and-answers/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Scott Oaks & Henry Wong