Outline

- Client/Server communication via Sockets (Java)
- Multi-threading
- Client/Server Example
Client/Server Communication via Sockets

** This is important for PS1 and P1
Socket communication

- A communication mechanism between networked computers
- An end-point of communication that is identified by an IP address and port number

1. Same Address-Space
   - Global variables, Procedure calls, ...

2. Same Computer but Different Address-Spaces
   - Files, Signals, Shared Memory...

3. Networked Computers
   - Socket Communication
   - Remote Invocation
Communication via Sockets

• Sockets provide a communication mechanism between networked computers.

• A Socket is an end-point of communication that is identified by an IP address and port number.

• A client sends requests to a server using a client socket.

• A server receives clients’ requests via a listening socket.
Communication via Sockets

Person A
(A's home)

Person B
(Guest)

Person B
knocks the
door

Person A
Is Listening

Person A
Opens door

Person B
Enters
Communication via Sockets

Person A (A’s home)

Person B (Guest)

Person A is Listening

Person B knocks the door

Person B enters

Person A opens door

A “binds” to his home

B sends a request to communicate

A accepts the request

B is now “connected” with A
Communication via Sockets

Server A is listening to requests

Client B sends a request to communicate with the server

Client B is now connected with Server A

Server A accepts requests

A binds to:
(1) IP address
(2) Port number
Communication via Sockets

Listening Socket

Service Socket

Server
socket → bind → listen → accept → read → write → close

Client
socket → connect → write → read → close

Synchronization point

Communication
Socket Communication Recipe

1. Server instantiates a ServerSocket object (usually passing a port number). This socket is referred to as the listening socket.

2. Server invokes the accept() method that awaits incoming client connections.

3. Client instantiates Socket object (passing an address to connect to). This socket is referred to as a client socket.

4. On the server side, accept() returns a new socket referred to as a service socket on which the client reads/writes.
Input & Output Streams
Transport Protocols

- Socket: endpoint to read and write data
- Each Socket has a network protocol
- Two types of protocols used for communicating data/packets over the internet:
  - TCP:
    - Transmission Control Protocol
    - Connection Oriented (handshake)
  - UDP:
    - User Datagram Protocol
    - “Connectionless”
TCP Protocol

Communication mechanism:

• Server opens a TCP server socket $SS$ at a known port $sp$
• Server waits to receive a request (using accept call)
• Client opens a TCP socket $CS$ at a random port $cx$
• $CS$ initiates a connection initiation message to ServerIP and port $sp$
• Server socket $SS$ allocates a new socket $NSS$ on random port $nsp$ for the client
• $CS$ can send data to $NSS$
Multi-Threading
Multi-Threading

- A class intended to execute as a thread must implement the `Runnable` interface
  
  ```java
  public class Service implements Runnable
  ```

- **STEP 1**: Implement the method `run()`
  
  ```java
  public void run() {
  // thread's logic goes here
  }
  ```

- **STEP 2**: Instantiate a Thread object
  
  ```java
  Thread t = new Thread(new Service())
  ```

- **STEP 5**: Invoke `start()` on the new thread
  
  ```java
  t.start() // invokes the run() method
  ```
Java Socket Programming
(References)
## ServerSocket Methods

<table>
<thead>
<tr>
<th>SN</th>
<th>Methods with Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><code>public ServerSocket(int port)</code></td>
</tr>
<tr>
<td></td>
<td>Attempts to create a server socket bound to the specified port. An exception occurs if the port is already bound by another application.</td>
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<tr>
<td>2</td>
<td><code>public ServerSocket()</code></td>
</tr>
<tr>
<td></td>
<td>Creates an unbound server socket. When using this constructor, use the bind() method when you are ready to bind the server socket.</td>
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<tr>
<td>3</td>
<td><code>public Socket accept()</code></td>
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<td></td>
<td>Waits for an incoming client. This method blocks until either a client connects to the server on the specified port or the socket times out, assuming that the time-out value has been set using the setSoTimeout() method. Otherwise, this method blocks indefinitely.</td>
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<tr>
<td>4</td>
<td><code>public void bind(SocketAddress host)</code></td>
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<tr>
<td></td>
<td>Binds the socket to the specified server and port in the SocketAddress object. Use this method if you instantiated the ServerSocket using the no-argument constructor.</td>
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<tr>
<td>5</td>
<td><code>public SocketAddress getLocalSocketAddress()</code></td>
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<tr>
<td></td>
<td>Returns the address of the endpoint this socket is bound to, or null if it not bound yet.</td>
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## Socket Methods

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| 1  | **public Socket(String host, int port)**  
This method attempts to connect to the specified server at the specified port. If this constructor does not throw an exception, the connection is successful and the client is connected to the server. |
| 2  | **public Socket()**  
Creates an unconnected socket. Use the connect() method to connect this socket to a server. |
| 3  | **public void connect(SocketAddress host)**  
This method connects the socket to the specified host. This method is needed only when you instantiated the Socket using the no-argument constructor. |
| 4  | **public InputStream getInputStream()**  
Returns the input stream of the socket. The input stream is connected to the output stream of the remote socket. |
| 5  | **public OutputStream getOutputStream()**  
Returns the output stream of the socket. The output stream is connected to the input stream of the remote socket. |
| 6  | **public SocketAddress getLocalSocketAddress()**  
Returns the address of the endpoint this socket is bound to, or null if it is not bound yet. |
| 7  | **public void close()** Closes the socket, which makes this Socket object no longer capable of connecting again to any server |
Client/Server Example