## Network Overview

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UDP</strong></td>
<td>Fast</td>
</tr>
<tr>
<td></td>
<td>Packets are treated individually</td>
</tr>
<tr>
<td></td>
<td>Packets may arrive out of order</td>
</tr>
<tr>
<td></td>
<td>Packets may be lost</td>
</tr>
<tr>
<td></td>
<td>Client &amp; Server must handle resulting problems</td>
</tr>
<tr>
<td></td>
<td>Used by: Games, NFS</td>
</tr>
</tbody>
</table>

| **TCP**  | Handles lost packets |
|          | Handles packet order |
|          | TCP has delays       |
|          | Starting of connection |
|          | Closing of connection |
|          | Resending packets    |
IP Addresses

IP address is currently a 32-bit number

130.191.3.100 (Four 8 bit numbers)

IPv6 uses 128 bit numbers for addresses

105.220.136.100.0.0.0.0.0.18.128.140.10.255.255

69DC:8864:0:0:0:1280:8C0A:FFFF

69DC:8864::1280:8C0A:FFFF

Machines on a network need a unique IP address
What is the difference between
MAC address
IP address
Domain Name System (DNS)

Maps machine names to IP addresses

Internet Corporation for Assigned Names and Numbers (ICANN [http://www.icann.org/](http://www.icann.org/)) oversees assigning TLDs

Unix "host" command

Shows mapping between machine names and IP address

->host rohan.sdsu.edu
rohan.sdsu.edu has address 130.191.3.100

->host 130.191.3.100
100.3.191.130.IN-ADDR.ARPA domain name pointer rohan.sdsu.edu
Ports

TCP/IP supports multiple logical communication channels called ports

Ports are numbered from 0 - 65535

A connection between two machines is uniquely defined by:

- Protocol (TCP or UDP)
- IP address of local machine
- Port number used on the local machine
- IP address of remote machine
- Port number used on the remote machine
How Ports Work

Network

Server

Port Table

22
193
5494

App 1
App 2
App 3

Network

App 1
App 2
App 3
### Some Port Numbers

<table>
<thead>
<tr>
<th>Well known Ports</th>
<th>1-1023</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registered Ports</td>
<td>1024-49151</td>
</tr>
<tr>
<td>Dynamic/Private Ports</td>
<td>49152-65535</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service</th>
<th>Port</th>
</tr>
</thead>
<tbody>
<tr>
<td>echo</td>
<td>7</td>
</tr>
<tr>
<td>discard</td>
<td>9</td>
</tr>
<tr>
<td>ftp</td>
<td>21</td>
</tr>
<tr>
<td>ssh</td>
<td>22</td>
</tr>
<tr>
<td>telnet</td>
<td>23</td>
</tr>
<tr>
<td>smtp</td>
<td>25</td>
</tr>
<tr>
<td>time</td>
<td>37</td>
</tr>
<tr>
<td>http</td>
<td>80</td>
</tr>
<tr>
<td>pop</td>
<td>110</td>
</tr>
<tr>
<td>https</td>
<td>443</td>
</tr>
<tr>
<td>doom</td>
<td>666</td>
</tr>
<tr>
<td>mysql</td>
<td>3306</td>
</tr>
<tr>
<td>postgresql</td>
<td>5432</td>
</tr>
<tr>
<td>gnutella</td>
<td>6346 6347</td>
</tr>
</tbody>
</table>

For a local list of services
file://rohan.sdsu.edu/etc/services

For a complete list see:
http://www.iana.org/assignments/port-numbers

See IANA numbers page [http://www.iana.org/numbers.html](http://www.iana.org/numbers.html) for more information about protocol numbers and assignment of services
What is Telnet?

Protocol
Send text between client & server

Server
Requests login
Sends text to shell to be executed
Returns result of commands

Client
Transfers text between user and server
Telnet & Other Text-based Protocols

rohan 37 -> telnet www.eli.sdsu.edu 80
GET /courses/spring06/cs580/index.html HTTP/1.0 <CR>
<CR>
Note <CR> indicates were you need to hit return

rohan 38->telnet cs.sdsu.edu 110
Trying 130.191.226.116...
Connected to cs.sdsu.edu.
Escape character is '^]'.
+OK QPOP (version 3.1.2) at sciences.sdsu.edu starting.
USER whitney
+OK Password required for whitney.
PASS typeYourPasswordHere
+OK whitney has 116 visible messages (0 hidden) in 640516 octets.
## Simple Date Example - Protocol

<table>
<thead>
<tr>
<th>Client Commands</th>
<th>Server Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;date&quot; ended by line feed</td>
<td>current date ended by line feed</td>
</tr>
<tr>
<td>&quot;date\n&quot;</td>
<td>&quot;January 30, 2007\n&quot;</td>
</tr>
<tr>
<td>&quot;time&quot; ended by line feed</td>
<td>Current time ended by line feed</td>
</tr>
<tr>
<td>&quot;time\n&quot;</td>
<td>&quot;6:58 pm\n&quot;</td>
</tr>
</tbody>
</table>

Server listens for an incoming request

On request
- reads command
- returns response
- closes connection

On client errors - action not specified
Beware

Can only send bytes across network

Client & server maybe different hardware platforms

What is a newline?

End-of-file indicates connection is closed
Sample Java Client

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

class DateClient {
    String server;
    int port;

    public DateClient(String serverAddress, int port) {
        server = serverAddress;
        this.port = port;
    }

    public String date() {
        return send("date\n");
    }

    public String time() {
        return send("time\n");
    }
}
```
Java Client Continued

```java
private String send(String text) {
    try {
        Socket connection = new Socket(server, port);
        OutputStream rawOut = connection.getOutputStream();
        PrintStream out = new PrintStream(new BufferedOutputStream(rawOut));
        InputStream rawIn = connection.getInputStream();
        BufferedReader in = new BufferedReader(new InputStreamReader(rawIn));
        out.print(text);
        out.flush();
        String answer = in.readLine();
        out.close();
        in.close();
        return answer;
    } catch (IOException e) {
        return "Error in connecting to server";
    }
}
```
Running the Client

System.out.println("hi");
DateClient client = new DateClient("127.0.0.1", 4444);
System.out.println( client.date());
System.out.println( client.time());
Issue - Avoid Small Packets

OutputStream rawOut = connection.getOutputStream();
PrintStream out = new PrintStream(new BufferedOutputStream(rawOut));
Issue - Actually Send the request

out.flush();
Issue - Client will not work on all platforms

String answer = in.readLine();
Don't Do this

String answer = in.readLine();
Issue - Close the connection when done

out.close();
in.close();
Issue - Testing

How does one test the client?
Issue - Background material

Java
Streams
Read Chapter 4

Sockets
Read Chapter 10

Java Network Programming, Harold 3rd Ed
require 'socket'

class DateClient
  def initialize(serverAddress, port)
    @server = serverAddress
    @port = port
  end

  def date()
    send("date\n")
  end

  def time()
    send("time\n")
  end

  private
  def send(text)
    connection = TCPSocket.new(@server, @port)
    connection.send(text, 0)
    answer = connection.gets("\n")
    connection.close
    answer
  end
end

client = DateClient.new("127.0.0.1", 4444)
puts client.date
puts client.time
Issues - Using Standard IO Methods

def send(text)
    connection = TCPSocket.new(@server, @port)
    connection.print(text)
    connection.flush
    answer = connection.gets("\n")
    connection.close
    answer
end
Ruby Background

Sockets

Read IPSocket & TCPSocket in Appendix A

IO

Chapter 10 Basic Input & Output
Class IO documentation (pp 503-515)

Programming Ruby, Thomas, 2'ed
Server

Basic Algorithm

while (true) {
    Wait for an incoming request;
    Perform whatever actions are requested;
}

Basic Server Issues

How to wait for an incoming request?
How to know when there is a request?
What happens when there are multiple requests?
How do clients know how to contact server?
How to parse client request?
How do we know when the server has the entire request?
public class DateServer {
    private static Logger log = Logger.getLogger("dateLogger");

    public static void main(String args[]) throws IOException {
        ProgramProperties flags = new ProgramProperties(args);
        int port = flags.getInt("port", 8765);
        new DateServer().run(port);
    }

    public void run(int port) throws IOException {
        ServerSocket input = new ServerSocket(port);
        log.info("Server running on port " + input.getLocalPort());

        while (true) {
            Socket client = input.accept();
            log.info("Request from " + client.getInetAddress());
            processRequest(
                client.getInputStream(),
                client.getOutputStream());
            client.close();
        }
    }
}
Java Date Server Continued

void processRequest(InputStream in, OutputStream out) throws IOException {

    BufferedReader parsedInput =
            new BufferedReader(new InputStreamReader(in));

    boolean autoflushOn = true;
    PrintWriter parsedOutput = new PrintWriter(out, autoflushOn);

    String inputLine = parsedInput.readLine();

    if (inputLine.startsWith("date")) {
        Date now = new Date();
        parsedOutput.println(now.toString());
    }
}

This server needs work
Starting the Server

rohan 16-> java -jar DateServer.jar
Feb 19, 2004 10:56:59 AM DateServer run
INFO: Server running on port 8765
require 'socket'

class DateServer
  def initialize(port)
    @port = port
  end

  def run()
    server = TCPServer.new( @port )
    puts("start " + @port.to_s) 
    while (session = server.accept)
      Thread.new(session) do |connection|
        process_request_on(connection)
        connection.close
      end
    end
  end
end

private
  def process_request_on(socket)
    request = canonical_form( socket.gets("\n") )
    now = Time.now
    answer = case request
    when 'time'
      now.strftime("%X")
    when 'date'
      now.strftime("%x")
    else
      "Invalid request"
    end
    socket.send(answer + "\n",0)
  end

  def canonical_form(string)
    string.lstrip.rstrip.downcase
  end
end
Issue - Date Format

What format does the server use for time and date?

Clients need to know so can parse them