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- ▶ To understand programming of clients that connect to servers via TCP
- ▶ To understand the basics of programming of servers that accept TCP connections
- ▶ To practice programming of application-level internet connections (HTTP)
- ▶ Knowledge from this lecture will be needed at a lab but not necessarily at the project
  - ▶ But it is important also for practicing Java code writing and Java documentation lookup

# TCP connections

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**Application**  
**(HTTP, FTP, Telnet)**

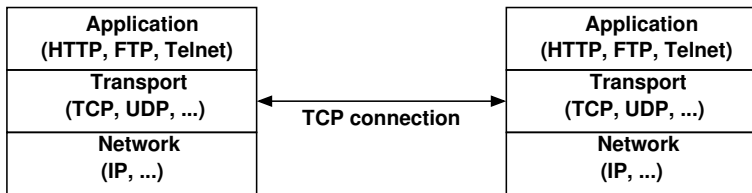
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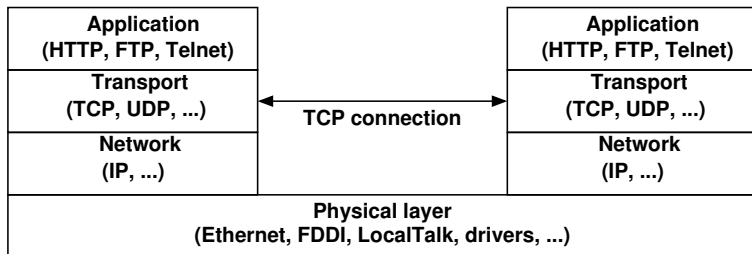
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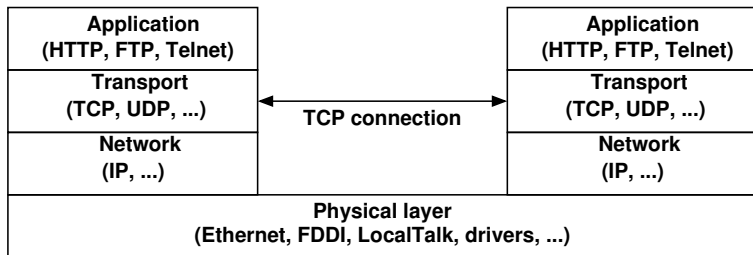
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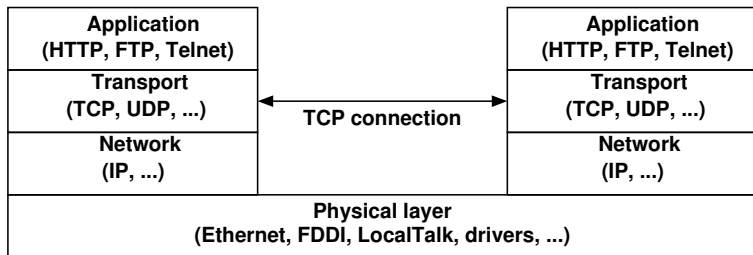


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- ▶ A client connects to a server on another machine. That server "listens to" a specific port on that machine.

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  - ▶ one stream to talk to the server: `OutputStream getOutputStream()`
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- ▶ When you are done with the socket you call `close()` on the streams and the socket (in that order) to free network resources on the machine



# Connect to an Echo port

This program sends some text to an echo port (7) and prints the response on the screen.

Start the program with `java TextToEcho www.nada.kth.se "some message"`

```
import java.io.*;
import java.net.*;
public class TextToEcho {
    public static void main(String argv[])
        throws IOException, UnknownHostException {
        Socket conn = new Socket(argv[0], 7);
        PrintWriter talk =
            new PrintWriter(new OutputStreamWriter(conn.getOutputStream()));
        Reader listen = new InputStreamReader(conn.getInputStream());
        talk.print(argv[1]);
        talk.flush(); /* we make sure that the chars reach the server */
        char buffer[] = new char[80];
        int n = listen.read(buffer, 0, 80);
        System.out.println("The server said: " + new String(buffer, 0, n));
        talk.close(); listen.close(); conn.close();
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- ▶ The echo server sends back immediately whatever it got
- ▶ In other protocols (e.g. HTTP) the server waits until it has at least one line to send before it starts responding

# HTTP request

Here is a program that makes a HTTP request and prints the result.

```
java HttpAccess www.nada.kth.se index.html | more
```

```
import java.io.*; import java.net.*;
public class HttpAccess {
    public static void main(String argv[])
        throws IOException, UnknownHostException {
        Socket conn = new Socket(argv[0], 80);
        PrintWriter talk =
            new PrintWriter(new OutputStreamWriter(conn.getOutputStream()));
        talk.println("GET /" + argv[1] + " HTTP/1.0"); /* HTTP command */
        talk.println("Host: " + argv[0]); /* HTTP header(s) */
        talk.println(); /* empty line, no content after */
        talk.flush(); /* PrintWriter println() is not autoflush! */
        BufferedReader listen =
            new BufferedReader(new InputStreamReader(conn.getInputStream()));
        String line;
        while ( (line = listen.readLine()) != null)
            System.out.println(line);
        talk.close(); listen.close(); conn.close();
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```

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- ▶ Alternatives to client-server: remote procedure call (RPC), Web Services

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  - ▶ Communication with the client takes place on the input stream and output stream of the returned `Socket`
  - ▶ `accept()` blocks until a request from a client comes!
- ▶ `close()` your server socket when you are done.
  - ▶ Rarely happens. Servers usually call `accept()` in an endless loop

# A simple echo server

This program starts an echo server. Start with: `java SimpleEchoServer port`

```
import java.io.*; import java.net.*;
public class SimpleEchoServer {
    public static void main(String argv[])
        throws IOException {
        ServerSocket server =
            new ServerSocket (Integer.valueOf(argv[0]).intValue());
        while (true) {
            Socket conn = server.accept();
            System.out.println(
                new java.util.Date() + " " + conn.getInetAddress());
            InputStream in = conn.getInputStream();
            OutputStream out= conn.getOutputStream();
            byte[] buffer= new byte[8192];
            while((int n= in.read(buffer, 0, 8192))!=-1)
                out.write(buffer, 0, n);
            in.close(); out.close(); conn.close();
        }
    }
}
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If a client connects to our echo server and sends crap for 20 minutes, all other clients will have to wait 20 minutes before they can get a response. To avoid that, most servers process requests concurrently in separate processes, or lightweight processes (threads)



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Advanced servers use thread pools.

Instead of being destroyed at the end of the client request, the thread is put “on hold” in a pool, and reused when another request comes

# Multithreaded Echo Server

```
import java.io.*;
import java.net.*;
public class EchoServer implements Runnable {
    Socket conn; /* member variable, for run() */
    public EchoServer(Socket s){ conn = s; }
    public static void main(String argv[]) throws IOException {
        /* run is a member method, must create object to call it */
        ServerSocket server =
            new ServerSocket(Integer.valueOf(argv[0]).intValue());
        while(true) new Thread(new EchoServer(server.accept())).start();
    }
    public void run() {
        try { /* run does not throw any exceptions */
            InputStream in = conn.getInputStream();
            OutputStream out = conn.getOutputStream();
            byte[] buffer = new byte[8192];
            int n;
            while((n = in.read(buffer, 0, 8192))!=-1)
                out.write(buffer, 0, n);
            in.close(); out.close(); conn.close();
        }
        catch(IOException e) { e.printStackTrace(); } } }
```

# A simple HTTP server

This program starts a HTTP server which sends back whatever is sent to it.

Start with: `java SimpleHttpServer port.`

Access with a browser: `http://localhost:port/someFile?someParam=someValue`

```
import java.io.*; import java.net.*;
public class SimpleHttpServer {
    public static void main(String argv[]) throws IOException {
        ServerSocket server =
            new ServerSocket(Integer.valueOf(argv[0]).intValue());
        while(true) {
            Socket con = server.accept();
            BufferedReader listen =
                new BufferedReader(new InputStreamReader(con.getInputStream()));
            PrintWriter talk =
                new PrintWriter(new OutputStreamWriter(con.getOutputStream()));
            talk.println("HTTP/1.1 200"); /* HTTP command */
            talk.println("Content-type: text/plain"); /* HTTP header(s) */
            talk.println(); /* empty line, as requested */
            String line; /* HTTP response content starts: */
            while((line=listen.readLine()).length()>0)
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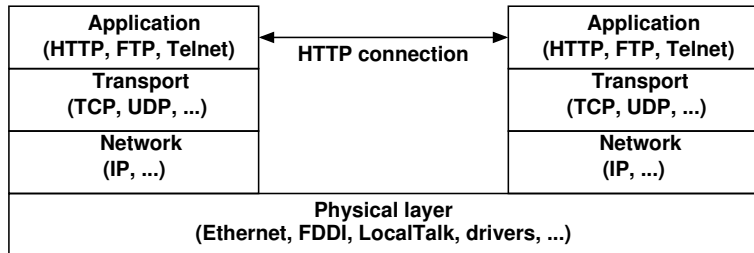
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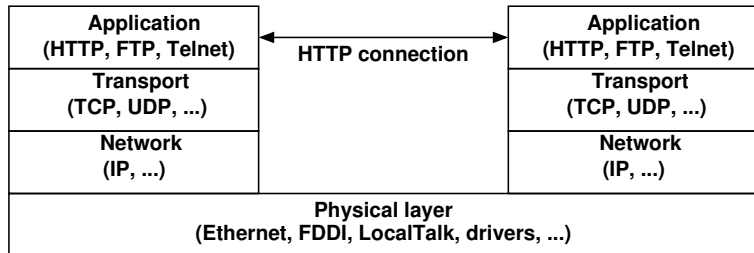
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At the server side, instead of speaking the HTTP protocol, we can use a ready-made and optimized server (like Apache) and simply program how to treat a request (e.g. via CGI, next time)

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  - ▶ `getHeaderField(String name)` provides info on any response header
  - ▶ `getContent()` or `getInputStream()` give you the response itself (i.e. the file you requested in the case of a HTTP connection)

Remember to close any stream that you request from the connection

# HTTP access with URLConnection

This program makes a HTTP request and prints data about the result, and the result itself.

```
java URLAccess http://www.nada.kth.se/index.html
```

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

public class URLAccess {
    public static void main(String argv[]) throws IOException {
        URLConnection con = new URL(argv[0]).openConnection();
        con.connect();
        System.out.println("type: " + con.getContentType());
        System.out.println("length: " + con.getContentLength());
        if(con instanceof HttpURLConnection)
            System.out.println("method: "
                + ((HttpURLConnection)con).getRequestMethod());
        BufferedReader content =
            new BufferedReader(new InputStreamReader(con.getInputStream()));
        String line;
        while((line = content.readLine()) != null)
            System.out.println(line);
        content.close();
    }
}
```

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Most notably `HttpURLConnection`