An Introduction to XML and Web Technologies

The HTTP Protocol

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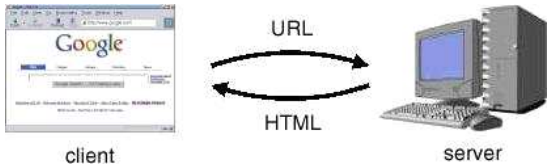
Objectives

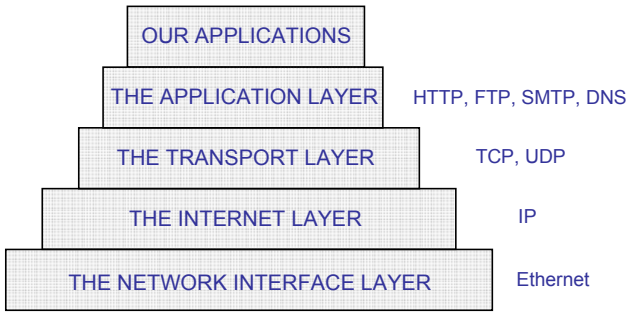
- How the **HTTP** protocol works
- The **SSL** security extension from a programmer's point of view
- How to write servers and clients in **Java**

HTTP



- HTTP: *HyperText Transfer Protocol*
- Client-Server model
- Request-Response pattern

Network Layers



IP

- IP: *Internet Protocol*
- **Unreliable** communication of **limited size data packets** (datagrams)
- **IP addresses** (e.g. 165.193.130.107) identify machines
- Handles **routing** using the underlying physical network (e.g. Ethernet)

TCP

- TCP: *Transmission Control Protocol*
- Layer on top of IP
- Data is transmitted in **streams**
- **Reliability** ensured by retransmitting lost datagrams, reordering, etc.
- **Connection-oriented**
  - establish connection between client and server
  - data streaming in **both directions**
  - close connection
- **Socket**: end point of connection, associated a pair of (IP address, **port number**)

HTTP

- HTTP: *HyperText Transfer Protocol*
- Layer on top of TCP
- Request and response sent using TCP streams

HTTP Requests

```
GET /search?q=Introduction+to+XML+and+Web+Technologies HTTP/1.1
Host: www.google.com
User-Agent: Mozilla/5.0 (X11; U; Linux i686; en-US; rv:1.7.2)
↪ Gecko/20040803
Accept: text/xml,application/xml,application/xhtml+xml,
↪ text/html;q=0.9,text/plain;q=0.8,image/png,*/*;q=0.5
Accept-Language: da,en-us;q=0.8,en;q=0.5,sw;q=0.3
Accept-Encoding: gzip,deflate
Accept-Charset: ISO-8859-1,utf-8;q=0.7,*;q=0.7
Keep-Alive: 300
Connection: keep-alive
Referer: http://www.google.com/
```

- Request line (methods: GET, POST, ...)
- Header lines
- Request body (empty here)

HTTP Responses

```
HTTP/1.1 200 OK
Date: Fri, 17 Sep 2009 07:59:01 GMT
Server: Apache/2.0.50 (Unix) mod_perl/1.99_10 Perl/v5.8.4
↪ mod_ssl/2.0.50 OpenSSL/0.9.7d DAV/2 PHP/4.3.8 mod_bigwig/2.1-3
Last-Modified: Tue, 24 Feb 2009 08:32:26 GMT
ETag: "ec002-afa-fd67ba80"
Accept-Ranges: bytes
Content-Length: 2810
Content-Type: text/html

<!DOCTYPE HTML PUBLIC "-//W3C//DTD HTML 4.01 Transitional//EN">
<html>...</html>
```

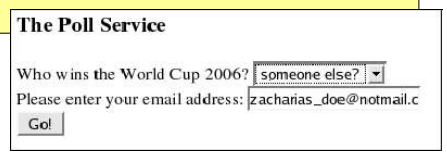
- Status line
- Header lines
- Response body

Status Codes

- 200 OK
- 301 Moved Permanently
- 400 Bad Request
- 401 Unauthorized
- 403 Forbidden
- 404 Not Found
- 500 Internal Server Error
- 503 Service Unavailable
- ...

HTML Forms

```
<h3>The Poll Service</h3>
<form action="http://freewig.brics.dk/users/laudrup/soccer.jsp"
      method="post">
Who wins the World Cup 2006?
<select name="bet">
<option value="br">Brazil!</option>
<option selected value="dk">Denmark!</option>
<option value="other country">someone else?</option>
</select><br>
Please enter your email address:
<input type="text" name="email"><br>
<input type="submit" name="send" value="Go!">
</form>
```



Encoding of Form Data

Name	*Value*
bet	other country
email	zacharias_doe@notmail.com
send	Go!

- Encoding to query string (URL encoding):

```
bet=other+country&email=zacharias_doe%40no
↪ tmail.com&send=Go%21
```

- GET: place query string in request URI
  `http://.../soccer.jsp?bet=other+country...`
- POST: place query string in request body

GET vs. POST?

- *The client should not be held responsible for the consequences of a GET request*
  - useful for **retrieving** data, not for submitting orders to an online shop
- Limits on request URI length
- POST allows other encodings (e.g. for file upload)
- Cachability

Authentication

- Restricting access to authorized users
- Common techniques:
  - IP-address
  - Form (with username/password fields)
  - HTTP Basic
  - HTTP Digest

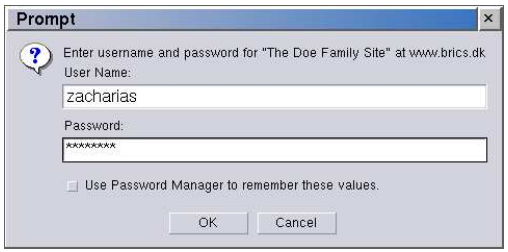
HTTP Basic Authentication

- *Challenge:*

```
HTTP/1.1 401 Authorization Required
WWW-Authenticate: Basic realm="The Doe Family Site"
```

- *Response:*

```
Authorization: Basic emFjaGFyaWFzOmFwcGxlcGllCg==
```



Advanced Features in HTTP

- Cache control
- Range requests
- Persistent connections, pipelining
- ...

Cache Control

- Caches used in clients, servers, and network (proxy servers, content delivery networks)
- `Cache-Control:`
  - `no-store` never cache this message
  - `no-cache` may cache but need revalidation
  - `public` may cache
  - `private` intended for single user
  - `max-age` set expiration
  - `must-revalidate` require revalidation
- HTTP/1.0:

```
Expires: Thu, 01 Jan 1970 00:00:00 GMT
Pragma: no-cache
```


Range Requests

- `Range: bytes=387-`
- 206 Partial Content

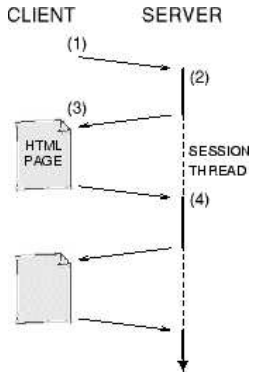
Persistent Connections

- Multiple request-response pairs on a single TCP connection
  - `Content-Length` (now important!)
  - `Connection: close` (persistent by default in HTTP/1.1)
  - `Connection: keep-alive` (compatibility)
  - `Keep-Alive: 300` (control timeout, compatibility)
- Pipelining
  - send multiple requests before receiving the responses
  - fewer TCP/IP packets
  - only for idempotent requests (e.g. GET)
  - supported by newer browsers

Limitations of HTTP

- **Stateless**, no built-in support for tracking clients (session management)
- No built-in **security** mechanisms

Session Management



Techniques

- URL rewriting
- Hidden form fields
- Cookies
- SSL sessions

Cookies

- Extension of HTTP that allows servers to **store data on the clients**
  - limited size and number
  - may be disabled by the client
- `Set-Cookie: sessionid=21A9A8089C305319; path=/`
- `Cookie: sessionid=21A9A8089C305319`

Security

Desirable properties:

- confidentiality
- integrity
- authenticity

} SSL/TLS

- non-repudiation

SSL

- SSL: *Secure Sockets Layer*
- TLS: *Transport Layer Security* (newer version)
- Layer between HTTP and TCP, accessed by `https://...`
- Based on public-key cryptography
  - private key + public key
  - certificate (usually for server authentication only)

Web Programming with Java

Why Java?

- platform independence
- safe runtime model
- multi-threading
- sandboxing
- Unicode
- serialization, dynamic class loading
- powerful standard libraries
  - `java.net`
  - `java.nio.channels`
  - `javax.net.ssl`

TCP/IP: DomainName2IPNumbers

```
import java.net.*;

public class DomainName2IPNumbers {
  public static void main(String[] args) {
    try {
      InetAddress[] a = InetAddress.getAllByName(args[0]);
      for (int i = 0; i<a.length; i++)
        System.out.println(a[i].getHostAddress());
    } catch (UnknownHostException e) {
      System.out.println("Unknown host!");
    }
  }
}
```

```
java DomainName2IPNumbers www.google.com

66.102.9.104
66.102.9.99
```


TCP/IP: SimpleServer (1/2)

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

public class SimpleServer {
  public static void main(String[] args) {
    try {
      ServerSocket ss =
        new ServerSocket(Integer.parseInt(args[0]));
      while (true) {
        Socket con = ss.accept();
        InputStreamReader in =
          new InputStreamReader(con.getInputStream());
```


TCP/IP: SimpleServer (2/2)

```
        StringBuffer msg = new StringBuffer();
        int c;
        while ((c = in.read())!=0)
          msg.append((char)c);
        PrintWriter out =
          new PrintWriter(con.getOutputStream());
        out.print("Simon says: "+msg);
        out.flush();
        con.close();
      }
    } catch (IOException e) {
      e.printStackTrace();
    }
  }
}
```

TCP/IP: SimpleClient (1/2)

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

public class SimpleClient {
  public static void main(String[] args) {
    try {
      Socket con =
        new Socket(args[0], Integer.parseInt(args[1]));
      PrintStream out =
        new PrintStream(con.getOutputStream());
      out.print(args[2]);
      out.write(0);
      out.flush();
```


TCP/IP: SimpleClient (2/2)

```
      InputStreamReader in =
        new InputStreamReader(con.getInputStream());
      int c;
      while ((c = in.read())!=-1)
        System.out.print((char)c);
      con.close();
    } catch (IOException e) {
      e.printStackTrace();
    }
  }
}
```

```
java SimpleServer 1234
```

```
java SimpleClient localhost 1234 "Hello World"

Simon says: Hello World
```


Non-Blocking I/O

- Support for **concurrent connections** and **buffering**
- Packages: `java.nio.channels`, `java.nio`
- Central classes:
  - `ServerSocketChannel`, `SocketChannel`
  - `Selector`
  - `ByteBuffer`
- See example in the book...

HTTP in Java

Two approaches:

1. Use the TCP/IP features in Java “manually”
2. Use the HTTP features

HTTP: ImFeelingLucky2 (1/2)

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

public class ImFeelingLucky2 {
  public static void main(String[] args) {
    try {
      String req = "http://www.google.com/search?"+
         "q="+URLEncoder.encode(args[0], "UTF8")+"&"+
         "btnI="+URLEncoder.encode("I'm Feeling Lucky", "UTF8");
      HttpURLConnection con =
        (HttpURLConnection) (new URL(req)).openConnection();
      con.setRequestProperty("User-Agent", "IXWT");
      con.setInstanceFollowRedirects(false);
```


HTTP: ImFeelingLucky2 (2/2)

```
      String loc = con.getHeaderField("Location");
      System.out.print("The prophet spoke thus: ");
      if (loc!=null)
        System.out.println("Direct your browser to "+loc+
          " and you shall find great happiness in life.");
      else
        System.out.println("I am sorry - my crystal ball is blank.");
    } catch (IOException e) {
      e.printStackTrace();
    }
  }
}
```

```
java ImFeelingLucky2 W3C

The prophet spoke thus: Direct your browser to
http://www.w3.org/ and you shall find great
happiness in life.
```


SSL in Java (JSSE)

- `javax.net.ssl`, `java.security.cert`
- `SSLServerSocketFactory`, `SSLServerSocket`
- `SSLSocketFactory`, `SSLSocket`
- `SSLSession`, `Certificate`, `HttpsURLConnection`
- `keytool`
- `java -Djavax.net.ssl.trustStore=...`
  `-Djavax.net.ssl.trustStorePassword=...`
  `...`

- See example in the book...

A Web Server in 145 Lines of Code

- Listens for HTTP requests on a port
- Parses the requests
- Returns files from the server's file system

[DEMO]

- Source code in the book...

Summary

- Communication protocols:
  - IP
  - TCP
  - HTTP
  - SSL
- Programming Web servers and clients with Java

Essential Online Resources

- HTTP/1.1:
  `http://www.w3.org/Protocols/rfc2616/rfc2616.html`
- Java API (`java.net` and others):
  `http://java.sun.com/j2se/1.5.0/docs/api/`