Communication Networks II
Network Applications - Web

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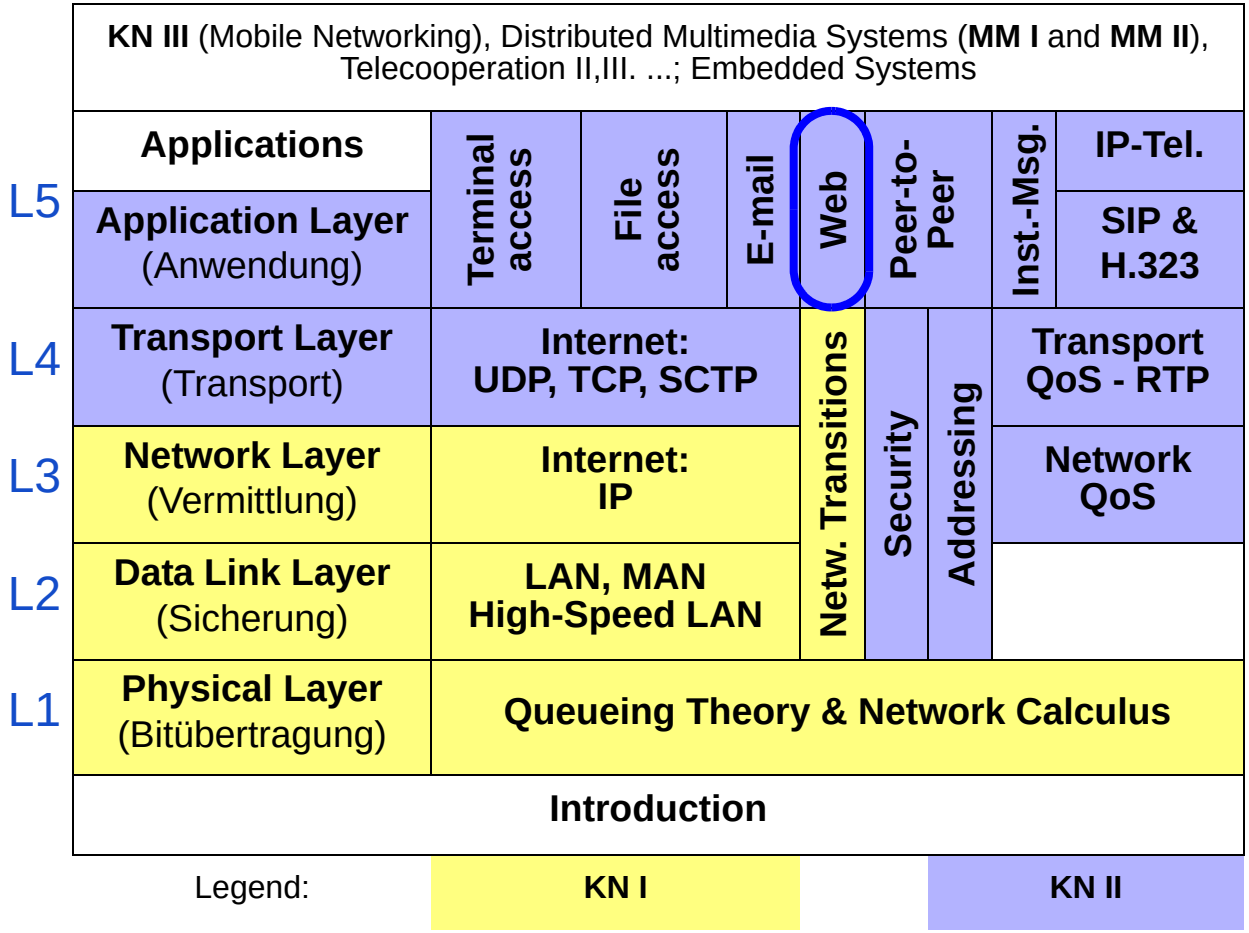
Scope


KN III (Mobile Networking), Distributed Multimedia Systems (MM I and MM II), Telecooperation II,III. ...; Embedded Systems
Applications
Application Layer (Anwendung)
Terminal access
File access
E-mail
Web
Peer-to-Peer
Inst.-Msg.
IP-Tel.
SIP & H.323
L5
Transport Layer (Transport)
Internet: UDP, TCP, SCTP
Netw. Transitions
Security
Addressing
Transport QoS - RTP
L4
Network Layer (Vermittlung)
Internet: IP
Network QoS
L3
Data Link Layer (Sicherung)
LAN, MAN High-Speed LAN
L2
Physical Layer (Bitübertragung)
Queueing Theory & Network Calculus
L1
Introduction
Legend:
KN I
KN II

Overview

1. The “Web”: Introduction

   1.1 History
   1.2 WWW Architecture

2. Client - Server Communication: HTTP

   2.1 HTTP Request
   2.2 HTTP Response
   2.3 Examples for HTTP Requests

3. HTTP: From initial V. 1.0 to actual Versions

4. Document Structure

5. Future Evolution: Semantic Web

Goal

- overview with focus on communications

Non goal

- in detail e.g. xml, web engineering, etc. (see related lectures)

1. The “Web”: Introduction

Original problem:

- **to present complicated experiments including diagrams and pictures**
  - to groups at different locations

Solution: World Wide Web (WWW, W3, „The Web“):

- **framework for hyperlink documents**
- **large collection of documents distributed all over the internet**
  - see also http://www.w3.org

1.1 History

Overall

- 1989 (March) Tim Berners-Lee (CERN, Geneva) publishes his first ideas
- 1993 (start) approx. 50 web-servers
- 1993 (Feb.) Mosaic distributes first version as shareware
- 1994 CERN and MIT found W3 Organization (W3O)
  Inria joins the developing W3 Consortium (W3C)
  objective: to promote the WWW
  (see also http://www.w3.org)
- 1995 (Nov.) html defined as HTML 2.0. in RFC 1866
  (ftp://ds.internic.net/rfc/rfc1866.txt)
- 1996 HTML 3.2 consensus for 1996
- 1998 HTML 4.0 and very few variations
- today XHTML 1.0 (often vendor specific pages)
- semantic web to add knowledge to nodes (as metadata)

Further Background

Netscape (History & Background)

- 1952 — Silicon Graphics (SGI) founded by Jim Clark
- 1993 — Mark Andreesen develops Mosaic as a “front end” at the US National Center for Supercomputer Applications
- 1994 (April) — J.Clark leaves Silicon Graphics; Netscape Communic. founded by J.Clark & M.Andreesen
- 1996 — Netscape Browser market share: approx. 70%
- 1998 — available free of charge
- 1999 — taken over by AOL
- today — mayor player togehter with Mozilla (but, less than in the past)

Sun Microsystems

- approx. 1994 — Java as a Plug-in (Applet) defines additional functionality
- today — the most important companies have Java under license within this area

Microsoft

- since 1996 — Internet Explorer (as part of the operating system)
- today — spreading increasingly among endusers

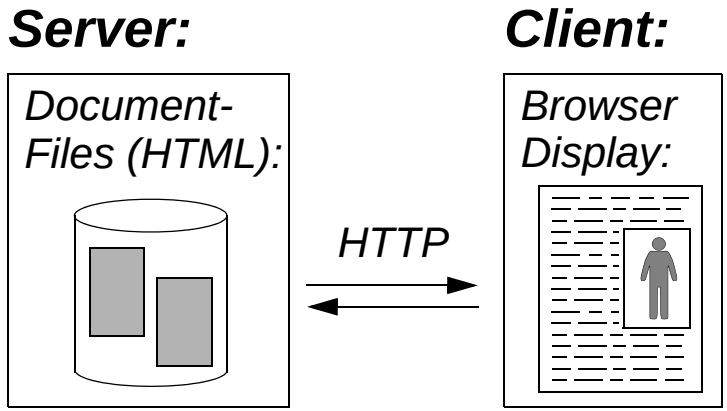
Mozilla

- since 1998 — open source project (originally based on Netscape code)
- today — code used by / feed back into Netscape, starting to be one of the leading browsers and email clients (see Thunderbird)

1.2 WWW Architecture

Paradigm

- **client-server architecture**
- **server**
  - stores documents
  - document written in „Hypertext Markup Language“ HTML
- **clients**
  - access documents
  - display them
  - integrate various media
  - through the browser itself



Communication is done via a specific protocol

- **"Hypertext Transfer Protocol“ HTTP**
- **HTTP uses TCP/IP**

Web Browser

Client uses browser to:

- **communicate with the server**
- **display documents**

Steps to display a document:

1. **retrieve document from the server**
2. **interpret the contents**
3. **generate local layout**
4. **display "layout"**

Most prevalent browsers:

- Microsoft Internet Explorer
- Netscape Navigator
- Microsoft Internet Explorer
- Opera
- Mozilla
- Mosaic
- Lynx (based on text)
- ...

Web Server

Server

- is contacted by client
- provides information back to client

Basic steps (performed in loop):

- accepts TCP connection from client
- gets name of file requested
- retrieves the file
- sends file as reply to the client
- releases TCP connection

More features in modern web servers, e.g.:

- caching
- multi-threaded, multi-processor, multi-tier, server-farm, ...
- generating data to be returned (from database, ...)

Uniform Resource Locator (URL)

URL is the „address“of a page

Format: <SCHEME>:<SCHEME-SPECIFIC-PART>

```
http://<host>:<port>/<path>?<searchpart>
ftp://<user>:<password>@<host>:<cwd1>..<cwdN>/<name>;type=<ty..
                                                    ..pecode>
mailto:<rfc822-addr-spec>
nntp://<host>:<port>/<newsgroup-name>/<article-number>
telnet://<user>:<password>@<host>:<port>
file://<host>/path
```

Typical URL consists of three parts:

- **protocol for accessing the page (http, ftp, mailto, ...)**
- **the name of the host administrating the page**
- **the local name of the page on the host**

	Name	Used for	Example
Examples	http	Hypertext	http://www.kom.tu-darmstadt.de/
	ftp	FTP	ftp://ftp.ibr.cs.tu-bs.de/README
	file	Local file	file:///home/imartino/.signature
	mailto	Sending email	mailto: imartino@kom.tu-darmstadt.de
	telnet	Remote login	telnet://www.w3.org:80

2. Client - Server Communication: HTTP

Communication sequence:

- **client**
  - connects to the server using TCP
  - usually uses Port 80
  - client places a request
- **server**
  - accepts TCP connection from client
  - gets name of file requested and retrieves the file
  - sends file as reply to the client
- **the TCP connection is closed (by server)**

HTTP - the document transfer protocol

- **„HyperText Transfer Protocol“**
- **defines permissible requests and replies**
- **request:**
  - simple ASCII message
  - (command plus parameters)
- **reply:**
  - document (and any data) within a MIME message format, e.g,
    - (MIME = Multipurpose Internet Mail Extensions)

Client - Server Communication: HTTP (2)

HTTP / 1.0: (RFC 1945)

- **used by:**
  - CERN, NCSA, APACHE server
- **permits hypermedia access to resources**
  - provided by various applications
  - including those supported by SMTP, NNTP, FTP, Gopher, WAIS
- **task(s)**
  - to access and transfer multimedia contents
  - to transfer messages in a MIME-like format

Communication scheme:

- **open, operation, close**
- **request:**
- **response:**

Stateless:

- each request is processed individually
- TCP connection is setup and released after request has been processed
- connections are of short duration only

2.1 HTTP Request

Full request:

- **request line:**

  ```
  Method SP(space)  Request-URL SP HTTP-Version CRLF
  ```

  Example

  ```
  GET  http://www.w3.org HTTP/1.0
  ```

- **plus**
  - general header (date, MIME version)

    and/or
  - request header (authorization, from, ..)

    and/or
  - entity header (allow, content type, expires,...)
  - CRLF
  - entity body

HTTP Requests

Each request begins with a method that has to be executed

Method	Description
GET	Request to read a web page
HEAD	Request to read the header of a web page
PUT	Request to store a web page on the server
POST	Attach data to a resource (e.g. news or forms)
DELETE	Delete a web page
LINK	Connect two existing resources
UNLINK	Cancel a connection between two resources

Method

- **in HTTP v1.0**
  - GET, HEAD and POST are the ones mainly used

Parameters

- **optional**
- **request header fields can be inserted in the lines following each respective parameter**

2.2 HTTP Response

Full response:

- **status line:**

  `HTTP version SP Status-Code SP Reason-Parameter CRLF`

  Example

  `...  200  OK`

- **plus**
  - general header (date, MIME version)

    and/or
  - response header (location, server, WWW authentications)

    and/or
  - entity header (allow, content type, expires,...)
  - CRLF
  - entity body

HTTP Response: HTTP v1.0 Status Codes

1xx: Reserved for future use.

2xx: Success.

- **200:** OK.
- **201:** Created.
- **202:** Accepted.
- **204:** No Content.

3xx: Reroute

- **301:** Permanently moved to a different location.
- **302:** Temporarily moved to a different location.
- **304:** Not modified.

4xx: Client error.

- **400:** Wrong syntax.
- **401:** Unauthorized access.
- **403:** Forbidden access.
- **404:** Document not found.

5xx: Server error.

- **500:** Internal server error.
- **501:** Function not implemented.
- **502:** Bad Gateway.
- **503:** Service not available (temporarily).

2.3 Examples for HTTP Requests

Example university

TELNET BONGO 80

```
Trying 130.83.139.185...
Connected to bongo.kom.tu-darmstadt.de.
Escape character is '^]'.
```

GET /PEOPLE/RST-ENGLISCH.HTML HTTP/1.0
IF-MODIFIED-SINCE: WED, 22 MAY 1997 12:00:00 GMT
(BLANK LINE)

```
HTTP 304 Not modified
Date: Wed, 22 May 2002 16:32:39 GMT
Server: NCSA/1.5.1
Last-modified: Tue, 14 May 2002 09:12:46 GMT
Content-type: text/html
Content-length: 2602

Connection closed by foreign host.
```

Examples for HTTP Requests (2)

Example w3.org (with syntax error, where?)

```
$ TELNET WWW.W3.ORG 80
   Trying 18.23.0.23...
   Connected to www.w3.org.
   Escape character is '^]'.
GET HTTP://WWW.W3.ORG HTTP/1.0
.. BLANK LINE WITH <CRLF>
   HTTP/1.1 302 Moved Temporarily
   Date: Sat, 24 Jan 1998 12:43:10 GMT
   Server: Apache/1.2.5
   Location: http://www.w3.org/WWW
   Connection: close
   Content-Type: text/html
   <HTML><HEAD><TITLE>302 Moved Temporarily</TITLE></
   HEAD><BODY>
   <H1>Moved Temporarily</H1>
   The document has moved <A HREF="http://www.w3.org/
   WWW">here</A>.<P>
   </BODY></HTML>
   Connection closed by foreign host.
```

Examples for HTTP Requests (3)

```
$ TELNET WWW.W3.ORG 80
   Trying 18.23.0.23...
   Connected to www.w3.org.
   Escape character is '^]'.
GET HTTP://WWW.W3.ORG/ HTTP/1.0
.. BLANK LINE WITH <CRLF>
   Server: Apache/1.2.5
   Last-Modified: Sat, 09 Aug 1997 17:25:46 GMT
   ETag: "2d1d66-3ab-33eca81a"
   Content-Length: 939
   Accept-Ranges: bytes
   Connection: close
   Content-Type: text/html; charset=ISO-8859-1
   <!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML//EN">
   <HTML>
    <HEAD>
    <TITLE>
   .. and so on
```

Examples for HTTP Requests (4)

```
<HTML>
 <HEAD>
 <TITLE>
.. and so on
<P class=policyfooter>
<SMALL><A href="./Consortium/Legal/ipr-
notice.html#Copyright">Copyright</A>
 &copy;  1997 <A href="http://www.w3.org">W3C</A>
(<A href="http://www.lcs.mit.edu">MIT</A>,
<A href="http://www.inria.fr/">INRIA</A>,
<A href="http://www.keio.ac.jp/">Keio</A> ), All Rights Reserved.
W3C
<A href="./Consortium/Legal/ipr-notice.html#Legal
Disclaimer">liability,</A>
<A href="./Consortium/Legal/ipr-notice.html#W3C
Trademarks">trademark</A>,
<A href="./Consortium/Legal/copyright-documents.html">document
use </A>and
<A href="./Consortium/Legal/copyright-software.html">software
licensing
</A>rules apply. Your interactions with this site are in
accordance with
our <A href="./Consortium/Legal/privacy-
statement.html#Public">public</A>
and <A href="./Consortium/Legal/privacy-
statement.html#Members">Member</A>
privacy statements.</SMALL>
</BODY></HTML>
Connection closed by foreign host.
```

3. HTTP: From initial V. 1.0 to actual Versions

Problems in HTTP / 1.0

- **limited to only ONE URL per TCP connection**
- **disconnect**
  - causes loss of any congestion control
  - may congest low bandwidth links
    - problems with flow control during connect and disconnect in TCP
- **server administrates a large amount of connections in close-wait state**
- **HTTP 1.0 uses**
  - more time for waiting
  - than for actual data transfer

HTTP characteristics / 1.1 (RFC 2086) and follow-on

- **implemented in JIGSAW, APACHE 1.2b, ...**
- **persistent connection**
- **cache characteristic**
- **new request methods**
- **range request**

HTTP v1.1: Methods

Method	Description
OPTIONS	Inquires about available communication options.
GET	Request to read a web page.
HEAD	Request to read the headers of a web page.
PUT	Request to store a web page on the server.
POST	Attach data to a resource (e.g. news).
PATCH	Like PUT, transferring varieties.
COPY	Copies a resource to a different location.
MOVE	Moves a resource to a different location.
DELETE	Deletes a web page.
LINK	Connects two existing resources.
UNLINK	Closes connection between two resources.
TRACE	Returns the request received from the server.
WRAPPED	Permits HTTP requests to be summarized.

HTTP Methods

HTTP permits an extendable amount of methods to display the purpose of a request:

- **GET:** **reads the data identified by the requested URL**

- **HEAD:** **reads any data header (containing information about data)**
- **PUT:** **stores any data at a URL**
- **POST:** **attaches data to a location specified by a URL**
- **DELETE:** **deletes data specified by a URL**
- **LINK:** **connects two resources**
- **UNLINK:** **closes existing connections**
- **.....**

RANGE:

- **requests one or more subranges of an entity**
  - instead of the complete entity

Persistent vs. Non-Persistent Connections

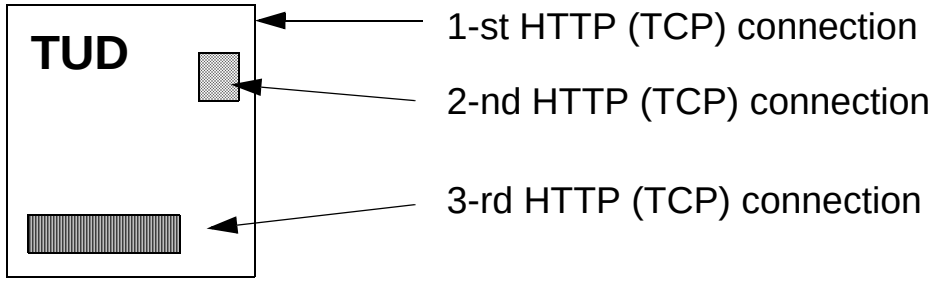
Performed steps in general:

1. **user**
   - selection of object (clicking)
2. **browser**
   - determines URL
3. **DNS (Domain Name System)**
   - request to get IP address
4. **browser**
   - establishes TCP connection to IP address / port 80
5. **browser**
   - sends request (GET /...)
6. **server**
   - returns requested file
7. **browser (or server)**
   - closing TCP connection
8. **browser**
   - displays content
   - perhaps after interpretation of file and requesting of further files

Persistent vs. Non-Persistent Connections (2)

With non-persistent connection:

- **a separate TCP connection is established for every single URL requested**
  - TCP connection is closed after object is sent
  - hence, one request-respnse pair per TCP connection



Problems:

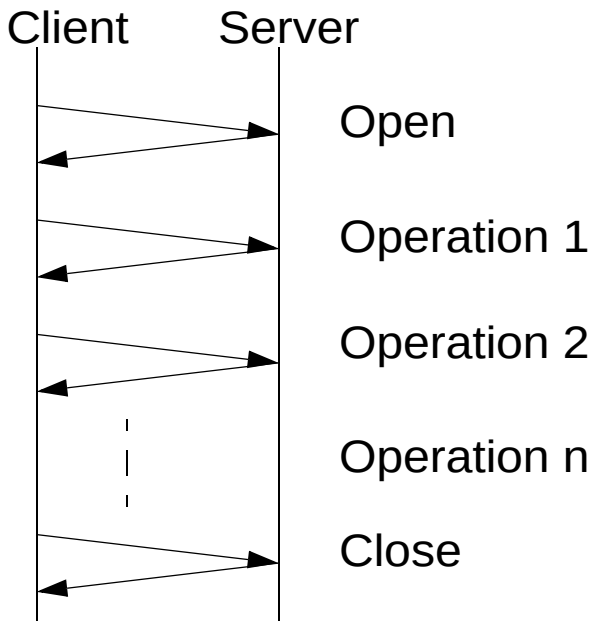
- **large resource demands on HTTP server**
- **causes congestion in the Internet**
  - (slow-start, RTT determination,...)

Persistent vs. Non-Persistent Connections (3)

Persistent connections:

- **establishing a single TCP connection**
  - to get multiple URLs from the same server
  - open, operations, close
- **are standard with each HTTP 1.1 connection**

Persistent vs. Non-Persistent Connections (4)



persistent connections have many benefits:

- **administrative overhead for TCP is reduced (CPU & memory)**
- **HTTP requests and responses can be sent on one connection representing a pipeline:**
  - pipelines permit client to send several requests without waiting for responses
- **network congestion is reduced**
  - because number of packets necessary to connect and disconnect is smaller

Caching in HTTP

The objective of caching in HTTP 1.1 is:

- **to reduce the amount of accesses onto one and the same page, thereby**
  - avoiding repeated transmissions of the same data requests
    - reducing the access time (expiration mechanism)
  - avoiding repeated transmission of the same data, full responses
    - reducing the required net bandwidth (validation mechanism)

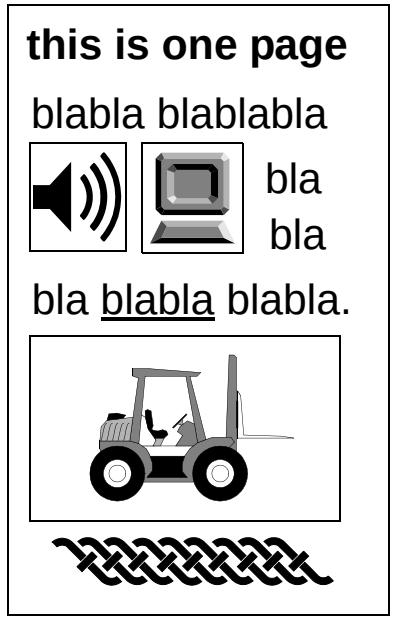
Cache control directives

- **restrictions with regard to**
  - what is supposed to be cached (server)
  - what is supposed to be stored in a cache (server / user agent)
- **modifications of expiration mechanism**
  - server / user agent
- **cache revalidation and reload control**
  - user agent

4. Document Structure

WWW documents („pages“) may consist of:

- **text**
- **icons**
- **drawings**
- **cards**
- **pictures**
- **audio clips**
- **video clips**



All media may contain links to other pages.

Media may be displayed

- **directly over the browser itself or**
- **over an external „viewer“ (e.g. MPEG viewer)**

Documents: Internal Representation

Page presentation in HTML:

- **„Hypertext Markup Language“**
  - uses the SGML standard
  - defines “markup tags”
  - syntax and semantics
- **browser**
  - can interpret tags
  - can convert these into page layouts

HTML file:

```
<HTML>
<HEAD>My Page</HEAD>
<BODY>
This is my own Web page.
<P><B>Ain’t it nice?</B>
<P>Here’s my picture:
<IMG SRC=“myself.jpg“>
<P>That’s all for now!
</BODY>
</HTML>
```

important HTML tags:

<HEAD>...</HEAD>	**page header**
<B>...</B>	**text in bold print**
<P>	**new paragraph**
<IMG SRC=“...“>	**inserted image**
<A HREF=“...“>...</A>	**link to another document**

Documents: Defining Hyperlinks

Tag <A> defines links:

- **format: <A HREF="uniform resource locator"> item can be activated </A>**
- **example:**
  - HTML:

    „click <A HREF= "http://www.fh-koeln.de/fb/fb-nt"> here</A> for Fb. NT."
  - layout:

    „click here for Fb. NT."
  - user entry:
    click here loads the document „www.fh-koeln.de/fb/fb-nt"

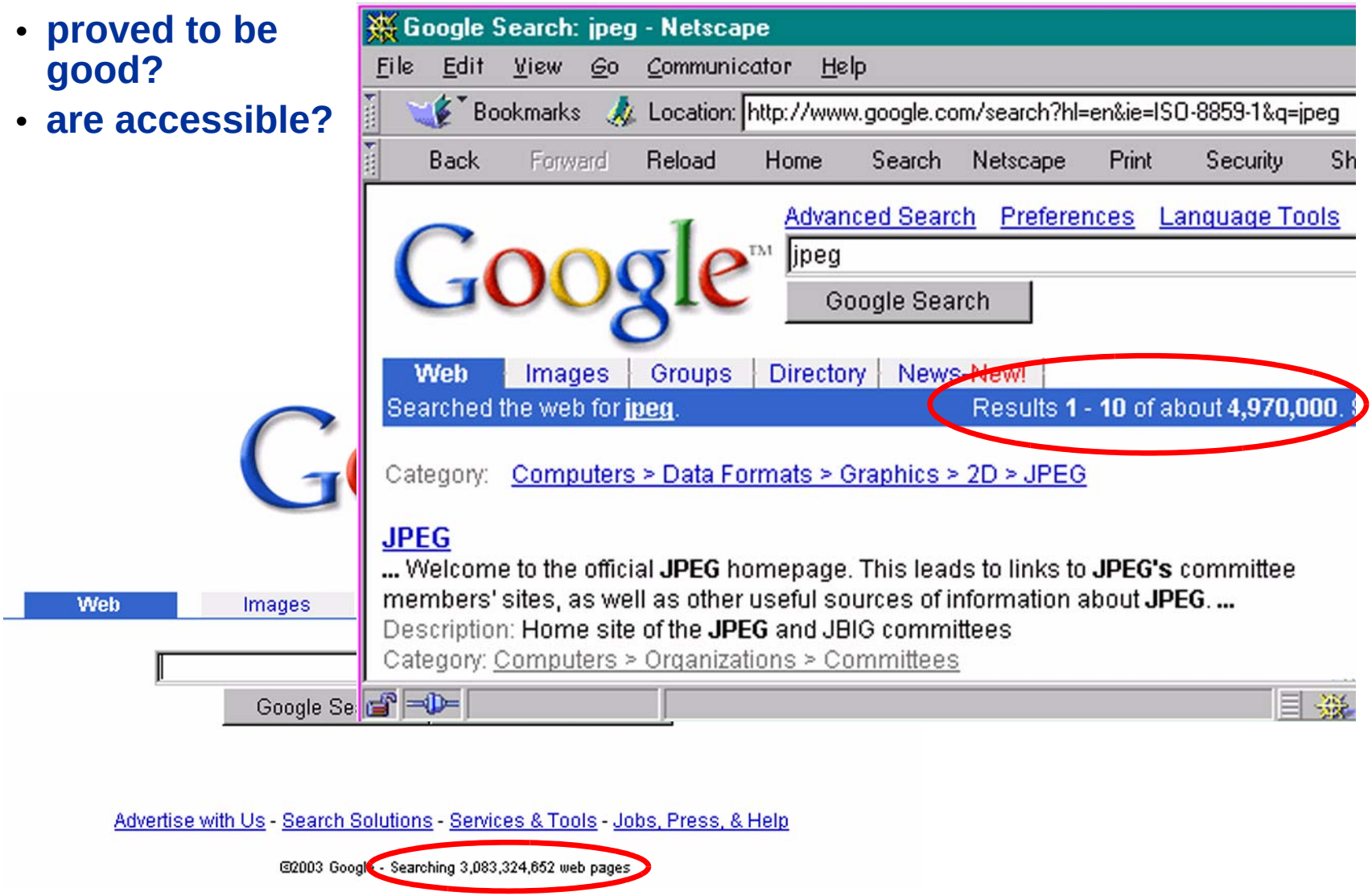
HTML: Differences Between Various Previous Versions

	HTML 1.0	HTML 2.0	HTML 3.0	HTML 4.0
Active maps and images		X	X	X
Equations			X	X
Forms		X	X	X
Hyperlinks	X	X	X	X
Images	X	X	X	X
Listen	X	X	X	X
Toolbars			X	X
Tables			X	X
Objects (Generalization of the IMG tag)				X
Formula				X

5. Future Evolution: Semantic Web

NON-semantic Web Today: e.g. which of the nearly 5 million sites

- **are relevant?**
- **proved to be good?**
- **are accessible?**



Future Evolution: Semantic Web (2)

"The Semantic Web
provides a common framework that allows data to be SHARED AND REUSED across application, enterprise, and community boundaries. It is a collaborative effort led by W3C with participation from a large number of researchers and industrial partners. It is based on the Resource Description Framework (RDF), which integrates a variety of applications using XML for syntax and URIs for naming.

`http://www.w3.org/2001/sw/  http://www.semanticweb.org/`

"The Semantic Web is an extension of the current web in which information is given WELL-DEFINED MEANING, better enabling computers and people TO WORK IN COOPERATION."

`Tim Berners-Lee, James Hendler, Ora Lassila, The Semantic Web, Scientific American, May 2001 see e.g. http://www.scientificamerican.com/2001/0501issue/0501berners-lee.html`

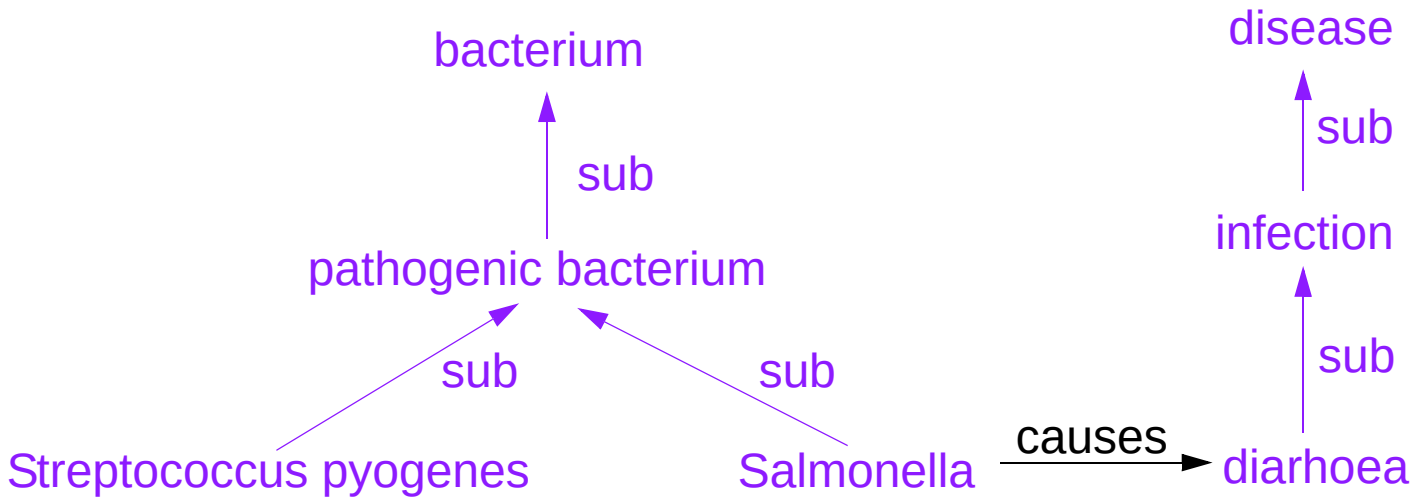
Metadata & Ontologies

Metadata = data about data

- **due to a metadata scheme**
- **orthogonal attributes**
- **clear vocabulary for entries**

Ontology =
a specification of a conceptualization,
i.e. a shared conceptualization of a knowledge domain (Gruber)

- **concepts, instances as thematic entities of the knowledge domain**
- **relations as semantic interconnections between concepts**
  - superconcepts-subconcepts, domain relations
  - moreover: axioms, attributes, inference



Bird's Eye View