

# CSE1500 Web Technology Notes

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## 1 DISCLAIMER

Most of the notes here are a summarization of the provided lectures and lecture notes. When in doubt, always refer to the original sources.

## 2 HTTP

### 2.1 Status Codes

**1xx informational response** Indicates that the request was received and understood.

**2xx success** The action requested by the client was received, understood and accepted.

**3xx redirection** Indicates the client must take additional action to complete the request. Many of these status codes are used in URL redirection.

**4xx client errors** For errors that seem to have been caused by the client.

**5xx server errors** The server failed to fulfil a request. Except when responding to a HEAD request, the server *should* include an entity containing an explanation of the error situation, and indicate whether it is a temporary or permanent condition. Likewise, user agents should display any included entity to the user.

### 2.2 Common Headers

Header	Description
<b>Content-Type</b>	Entity Type
<b>Content-Length</b>	Length/size of the message
<b>Content-Encoding</b>	Data transformations applied to the entity
Content-Location	Alternative location of the entity
Content-Range	Range defines the pieces sent for partial entities
<b>Content-MD5</b>	Checksum of the content
<b>Expires</b>	Date at which the entity will become stale
<b>Last-Modified</b>	Most recent creation/modification date of the entry
Allow	The legal request methods for the entity
<b>Connection &amp; Upgrade</b>	Protocol Update

### 2.2.1 Content-Type

- MIME<sub>Multipurpose Internet Mail Extensions</sub> types determine the clients' reaction to data.
- A standard MIME Pattern looks like `[primary object type]/[subtype]`  
Every MIME has a primary object type and a subtype.
- Examples:
  - text/plain
  - text/html
  - image/jpeg
  - application/pdf

### 2.2.2 Content-Length

- Indicates the *size* of the entity body
- Necessary to detect premature message truncation due to extenuating circumstances
- Used to discover where one HTTP message ends and the next begins for **persistent connections**, which reuse a TCP connection for multiple HTTP request/response messages

### 2.2.3 Content-MD5 (RFC 1321)

- HTTP messages are sent via TCP (this'll change in HTTP/3)

- However, as the internet is decentralize, different servers implement the protocol differently, which causes bugs
- To counter this, sender generates a 128-bit MD5 checksum of the content to detect unintended modifications. This procedure is called **sanity check**.
- Has been removed from HTTP/1.1 specification (2014), however; this simple technique is still in use

#### 2.2.4 Expires

- Contains the date/time after which the response is considered stale/invalid.
- Invalid dates, like the value 0, represent a date in the past and mean that the resource is already expired.
- Web caches have several advantages:
  1. Reduces redundant data transfer
  2. Reduces network bottlenecks
  3. Reduces demand on origin servers
  4. Reduces distance delay
- **Cache-Control** is a header that overrules **Expires**. While **Expires** indicates a resource's expiration date in absolute terms (a specific date/time), **Cache-Control** indicates it in relative terms (seconds since being sent). This is an advantage because the server doesn't have to "reassign" a specific date/time for expiration repeatedly.

#### 2.2.5 Last-Modified

- Contains the date on which the resource was last **altered**
- No indication about the amount of changes
- Often used with **If-Modified-Since** for cache revalidation requests so that the origin server only returns the documents if it has been modified since the given date

### 2.2.6 Connection & Upgrade

- When using HTTP/1.1 the client always initiates the connection
- Within this boundary there are ways to simulate a **server-side push** of data:

**Polling:** client regularly sends HTTP requests to receive updates  
– Wastes bandwidth

**Long Polling:** client sends an HTTP request and the server holds it open until new data arrives  
– Difficult to implement  
– Not widely used

- This header is used to switch protocols to circumvent these restrictions and make server-side push more efficient with protocols such as WebSocket through the following procedures:
  1. Client and server have to agree to the protocol upgrade.
  2. Client initiates the upgrade with two request headers:  
`Connection:Upgrade`  
`Upgrade:[protocols]`
  3. Server responds with a 101 **Switching Protocols** status if such upgrade is possible.
  4. Once established, both the client and the server can push data.

## 2.3 Common Methods

Method	Definition
<b>GET</b>	Get a document from the Web server
<b>HEAD</b>	Get the header of a document from the Web server
<b>POST</b>	Send data from the client to the server for processing
<b>PUT</b>	Save the body of the request on the server
<b>TRACE</b>	Trace the message through the proxy servers to the server
<b>OPTIONS</b>	Determine what methods can operate on a server
<b>DELETE</b>	Remove a document from a Web server

## 2.4 Telnet

### 2.4.1 Properties

1. Interactive text-oriented communication with a server

2. Uses TCP to communicate with server
3. Won't work with HTTPS
4. Connections are not encrypted

### 2.4.2 Commands

1. Connecting to a server and requesting headers:

```
$ telnet www.reddit.com 80
HEAD /r/TUDeft HTTP/1.1
Host: www.reddit.com
Connection: close
```

This gives a 301 Moved Permanently error because reddit uses HTTPS for security reasons.

Full message:

```
HTTP/1.1 301 Moved Permanently
Retry-After: 0
Location: https://www.reddit.com/r/TUDeft
Content-Length: 0
Accept-Ranges: bytes
Date: Tue, 14 Dec 2021 00:04:13 GMT
Via: 1.1 varnish
Connection: close
Cache-Control: private, max-age=3600
Strict-Transport-Security: max-age=31536000; includeSubdomains
X-Content-Type-Options: nosniff
X-Frame-Options: SAMEORIGIN
X-XSS-Protection: 1; mode=block
Server: snooserv
X-Clacks-Overhead: GNU Terry Pratchett
```

Therefore, we need a different tool for HTTPS.

## 2.5 OpenSSL

### 2.5.1 Properties

1. Its `s_client` component works just like telnet, though it's a bit less interactive

2. Uses SSL+TLS for secure connection
3. Supports HTTPS
4. Connections are encrypted and secure

### 2.5.2 Commands

1. Command-line args:

**-crlf** Translates a LF<sub>Line Feed</sub> (11th ASCII character) into CR+LF  
**-connect** Connects to a SSL HTTP server.

2. Connecting to a server and requesting headers:

```
$ openssl s_client -crlf -connect www.reddit.com:443
HEAD /r/TUDeft HTTP/1.1
Host: www.reddit.com
Connection: close
```

Output:

```
HTTP/1.1 200 OK
Connection: close
Cache-control: private, s-maxage=0, max-age=0, must-revalidate, no-store
Content-Type: text/html; charset=utf-8
Accept-Ranges: bytes
Date: Tue, 14 Dec 2021 00:21:09 GMT
Via: 1.1 varnish
Vary: Accept-Encoding
Set-Cookie: loid=0000000000hjgnftu8.2.1639441268721.Z0FBQUFBQmh0LU4wem9QRHBnYUhhVQ1
Set-Cookie: session_tracker=ibekfgdqdfkmfrhhcd.0.1639441269865.Z0FBQUFBQmh0LU4xeDh
Set-Cookie: token_v2=eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJleHAiOjE2Mzk0NDQ3NDgs
Set-Cookie: csv=2; Max-Age=63072000; Domain=.reddit.com; Path=/; Secure; SameSite=
Set-Cookie: edgebucket=MdiF5bpSjBeHhPKevt; Domain=reddit.com; Max-Age=63071999; Pa
Strict-Transport-Security: max-age=31536000; includeSubdomains
X-Content-Type-Options: nosniff
X-Frame-Options: SAMEORIGIN
X-XSS-Protection: 1; mode=block
Server: snooserv
X-Clacks-Overhead: GNU Terry Pratchett
```

## 2.6 URL

- Uniform Resource Locators offer a standardized way to point to a resource on the Internet
- Not restricted to HTTP, URLs support different schemes/protocols such as HTTP, HTTPS, mailto, file, ftp etc.

### 2.6.1 Syntax

`<scheme>://<user>:<password>@<host>:<port>/<path>;<params>?<query>#<frag>`

`<scheme>` determines the protocol to use when connecting to the server

`<user>:<password>` is the username and/or password to access a protected resource

`<host>` is the domain name or IP address of the server

`<port>` is the port on which the server is expecting requests

`<path>` is the local path to the resource

`<params>` are additional input parameters applications may require

`<query>` are parameters passed to gateway resources (e.g. a search engine)  
Common convention: `name1=value1&name2=value2...`

`<frag>` the name of a piece of a resource (i.e. a part of a page), only used by the client. For example, with this tag the middle of a webpage may be shown by default. However, the client will always retrieve the entire page

### 2.6.2 Design Restrictions

1. No invisible/non-printing characters
2. Initially restricted to ASCII<sub>American Standard Code for Information Interchange</sub> characters, biased towards English speakers
  - Added Later: character encoding e.g. whitespace -> %20
  - Punycode (RFC 3492) is used to **uniquely** and **reversibly** transform a Unicode string into an ASCII string. Introduces a potential security issue in *mixed* scripts.



### 2.6.3 Weaknesses

1. URLs point to a location instead of a Web resource. When the location of a website changes, the old URL won't work anymore.

## 2.7 Authentication

HTTP is an **anonymous**, **stateless** request/response protocol. The same request, sent by different clients, is treated in exactly the same manner. Now, there are different identification methods such as:

1. HTTP headers
2. Client IP address tracking
3. Fat URLs
  - Track users through the generation of unique URLs
    - (a) First time a user visits a resource within a Website, a **unique ID** is generated by the server
    - (b) Server redirects client to the fat URL (URL + unique ID)
    - (c) Server **rewrites the HTML** when a HTTP request with a fat URL is received (by adding ID to all hyperlinks)
    - (d) As a result, independent HTTP requests are tied into a single session.
  - Issues:
    - Fat URLs are ugly
    - They cannot be shared
    - They break web caching mechanisms
    - Extra server load through HTML page rewrites
    - The ID is lost when the user navigates away from the website
4. User login (HTTP Basic Authentication)
  - Server explicitly asks the user for authentication (401 Login Required)
  - HTTP has a **built-in mechanism** to support username/password based authentication via **WWW-Authenticate** and **Authorization** headers
    - Username and passwords are joined together by a colon and converted to **base-64 encoding**

- Base-64 ensures that only HTTP compatible characters are entered into a message.
- HTTP is **stateless**: Once logged in, the client sends the login information with each request.
- Issues:
  - (a) Username and password can be decoded trivially, the data is not encrypted. HTTPS solves this issue by encrypting sent data.
  - (b) Users tend to reuse login/password combinations

## 2.8 Security

- Secure HTTP should provide:
  - Server Authentication** Client is sure to talk to the right server
  - Client authentication** Server is sure to talk to the right client
  - Integrity** Client and server are sure that their data is intact
  - Encryption** The data is sufficiently encrypted
  - Efficiency** Providing security should be a reasonable endeavour
- HTTPS is the most popular, secure form of HTTP
  - URL Scheme is **https://** instead of **http://**
  - Request and response data are encrypted before being sent across the network via SSL<sub>Secure Sockets Layers</sub>. Client and server *negotiate* the cryptographic protocol to use.
  - TRIVIA: To use HTTPS on your website, you need a TLS certificate from a CA<sub>Certificate Authority</sub>. Let's Encrypt provides this service free of charge.

## 3 HTML5

### 3.1 Overview

- HTML 5 is a set of related technologies that together enable rich web content
- Successor to XHTML and HTML 4.01

### 3.1.1 Features

**Core HTML5** marks up content

**CSS** controls the appearance of marked-up content

**JavaScript** manipulates the contents of HTML documents & responds to user interactions

Not all browsers support all features.

## 4 JavaScript

### 4.1 What is JavaScript?

- JavaScript is an interpreted programming language designed to implement complex, interactive features on web pages. However, JS is also used in other areas such as micro-controllers.
- JavaScript adheres to the ECMAScript standard.
- JavaScript is a dynamic language, meaning you can't enforce a certain *type* on a variable. All variables can hold any type.

### 4.2 Scripting

- Scripts can be applied to the context of a website in two ways: Server-side scripting and client-side scripting.

**Server-side scripting** refers to scripts that run on the web server. Only the results of the scripts are returned to the client.

- Advantage: The results are returned in plain HTML, so the computational power of the client platform is irrelevant.
- Disadvantage: As all computations are conducted on the server, this may result in an increasing server load.

**Client-side scripting** sends the script itself (and relevant data if necessary) to the client, who executes the code themselves.

- Advantage: The only job of the server is to send the script and data to the client to be processed, which reduces server load.

- Disadvantage: The performance of the web application is dependent on the client, as they do the hard work by executing the script.
- The lecturer recommends the `<script>` tag to be put to the bottom of the `<body>`, however; apparently there are more modern ways.

### 4.3 Functional Programming

- JS allows functions to be treated as data, in other words it supports functional programming by treating functions as first-class citizens.
  - TRIVIA: The first chapter of SICP is an amazing introduction to functional programming, you may skim over it if you have the time.

#### 4.3.1 Function as data: an example

- Let's observe this following code (which you can find at the official lecture notes):

---

```
1 function toPrint(x) {  
2   console.log(x);  
3 }  
4  
5 function my_func(x, y) {  
6   y(x);  
7 }  
8  
9 my_func(5, toPrint);
```

---

RESULTS:

```
5  
undefined
```

This is a perfect example of functional programming.

- As you can see, `my_func` takes two arguments `x` and `y` and *applies* `y` to `x`. It is implicitly assumed that `y` is a function: using another data type would result in a `TypeError`.

- The first result is produced by applying `y`, in our case `toPrint`, to `x`. `console.log(x)` prints the value of `x`, 5.
- The second result is the value `my_func` returns, in our case it doesn't have a return value. So `undefined` is printed.

## 4.4 Scoping, hoisting and this

### 4.4.1 Scoping

- It is not always possible to access to a variable everywhere inside the code. For example, in Java you can't access a `private` value outside of you class, that's why we have `getters` and `setters`. They're only visible in the **scope** of your class. Thankfully, scoping is not as complicated in JavaScript.
- JavaScript has very few scopes: `local`, `global` and `block` (introduced with ES6).

**Local/function scope** is the scope of the function. Variables declared inside a function cannot be accessed elsewhere. Local variables only exist in the context of the function. Each function creates a new scope.<sup>source</sup>

**Global scope** includes the whole program. A variable declared outside of the function becomes global. It's globally accessible.

**Block scope** is provided by the `let` and `const` keywords (both of which also introduced with ES6). Blocks are delineated with curly braces `{ }`. So, a variable declared this way:

---

```

1 {
2     let x = 2;
3 }
```

---

CANNOT be accessed outside of the curly braces. However, variables declared with `var` cannot have block scope. So:

---

```

1 {
2     var x = 2;
3 }
```

---

CAN be accessed outside of the curly braces if they do not belong to a function.

- Here's a table of every scope in ES6 JavaScript<sup>source</sup>:

Where/how	Scope
<code>var</code> declared within a function	local
<code>var</code> declared outside of a function	global
<code>let</code> (ES6)	block
<code>const</code> (ES6)	block
variable declaration without <code>var/let/const</code>	global

#### 4.4.2 Hoisting

**Hoisting** allows functions to be safely used in code *before* they are declared.

Variables can also be hoisted, however; JS does not hoist initializations  
Take a look at the following code:

---

```

1  // Returns undefined from hoisted var declaration (not 6)
2  console.log(num);
3
4  // Declaration and initialization
5  var num = 6;
6
7  // Returns 6 after the line with initialization is executed.
8  console.log(num);

```

---

- This rule applies for function expressions as well. If you define a variable as a function, the expression won't be hoisted.
- Variable/function *declarations* are hoisted:

---

```

1  f();
2  console.log(x); // 5
3  console.log(y); // 3
4  function f() { // function declaration
5      x = 5; // global scope
6      y = 3; // global scope
7  }

```

---