Web security: web basics

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[1] slides from Myrto Arapinis

Web applications

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- online banking,
- online shopping,
- social networking,
- entertainment,
- education,
- news,
- ...

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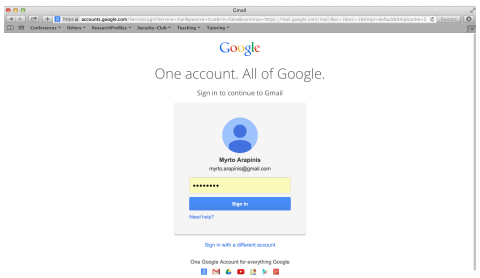
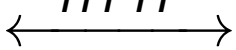
and has brought new classes of security and privacy concerns

Web applications



Client
(HTML, JavaScript)



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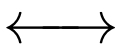
Server
(PHP)



Database
(SQL)

URLs

A web browser identifies a website with a uniform resource locator (URL).

`Protocol://host:port/path?arg1=val1&arg2=val2#statement`

This naming scheme allows referring to content on distant computers in a simple and consistent manner:

- `Protocol:` protocol to access the resource (`http`, `https`, `ftp`, ...)
- `host:` domain or IP address of the server storing the resource
- `FilePath:` path to the resource on the host
- Resources can be static (`file.html`) or dynamic (`do.php`)
- URLs for dynamic content usually include arguments to pass to the process (`arg1`, `arg2`)

HTTP requests

GET request

```
GET / HTTP/1.1
Host:  www.inf.ed.ac.uk
User-Agent:  Mozilla/5.0
             (X11; Ubuntu; Linux x86_64; rv:29.0)
             Gecko/20100101 Firefox/29.0
Accept:  text/html,application/xhtml+xml,
         application/xml;q=0.9,*/*;q=0.8
Accept-Language:  en-US,en;q=0.5
Accept-Encoding:  gzip, deflate
Referer:  https://www.google.com
Connection:  keep-alive
```

- After establishing a TCP connection to the web server, the browser sends HTTP requests to that server
- HTTP requests begin with a request line (`GET` or `POST` command)
- An HTTP request consist of the headers section, and the message body

HTTP responses

```
HTTP/1.1 200 OK
Server:  Apache
Cache-control:  private
Set-Cookie:  JSESSIONID=B7E2479EC28064DF84DF4E3DBEE9C7DF;
             Path=/
Content-Type:  text/html;charset=UTF-8
Date:  Wed, 18 Mar 2015 22:36:30 GMT
Connection:  keep-alive
Set-Cookie:  NSC_xxx.fe.bd.vl-xd=ffffffffc3a035...423660; path=/
Content-Encoding:  gzip
Content-Length:  4162

<!DOCTYPE html PUBLIC "-//W3C//DTD XHTML 1.0
    Strict//EN" "http://www.w3.org/TR/xhtml1/DTD/
    xhtml1-strict.dtd">
<html xmlns="http://www.w3.org/1999/xhtml"
    xml:lang="en" lang="en">
<head>
<title> Informatics home | School of Informatics </title>
...
```

Hypertext Markup Language (HTML)

- The main body of a web page is encoded using HTML.
- HTML provides a structural description of a document using special tags: `<header></header>`, `<body></body>`, `<div></div>`, `<a></a>`
- HTML includes a mechanism called forms to allow users to provide input to a website in the form of variables represented by name-value pairs.
- Forms can submit data either using the `GET` (name-value pairs encoded in the URL) or the `POST` method (name-value pairs encoded in the message body).

```
<form method="POST" action="login.php">
   FirstUsername: <input type="text" name="username">
   Password: <input type="password" name="password">
   <input type="submit" value="submit">
</form>
```

Dynamic content

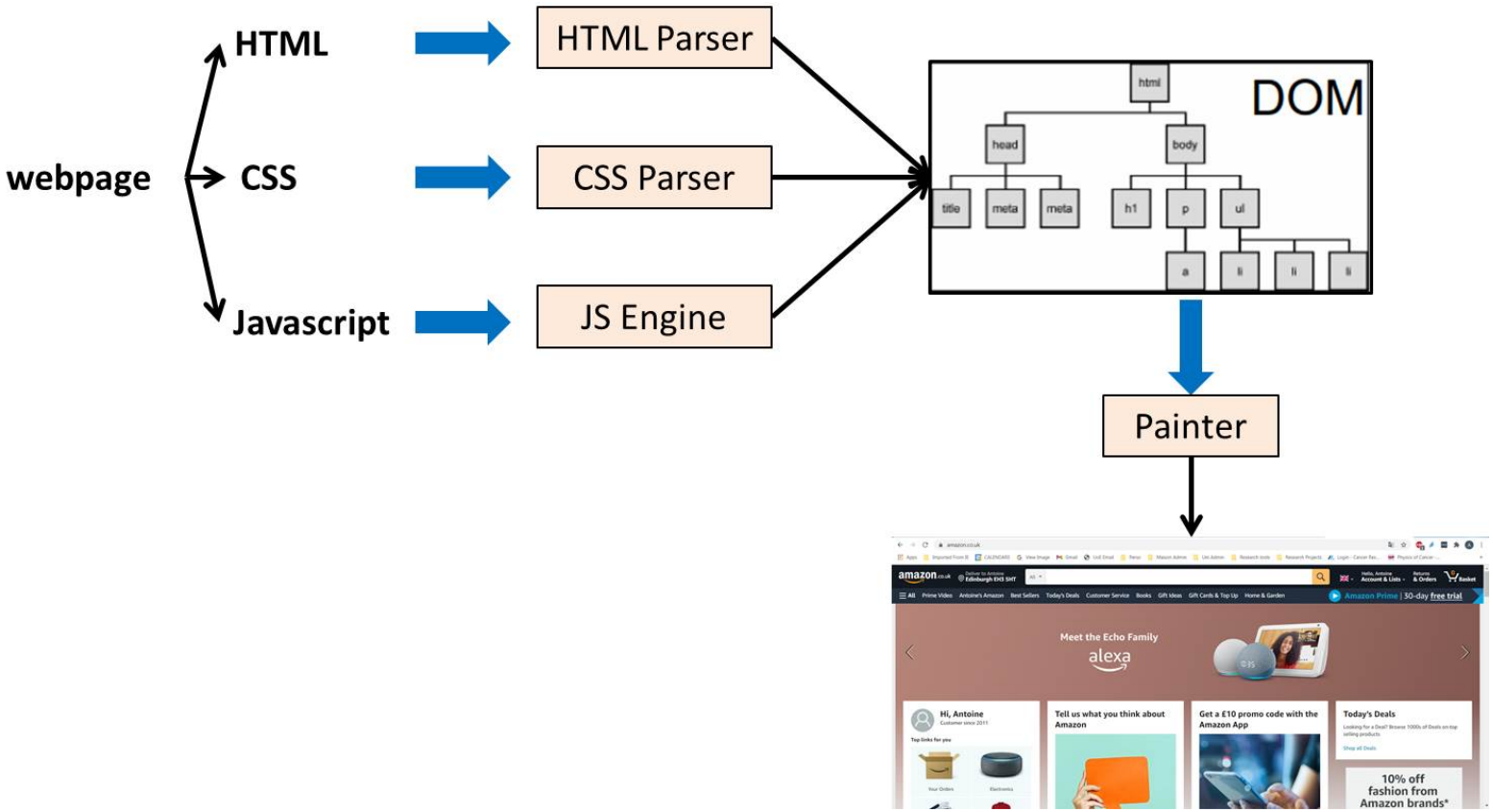
- Pages with dynamic content can change after their delivery to the client browser, eg. in response to user interaction or other conditions.
- To provide dynamic content, scripting languages such as Javascript were introduced.
- To indicate to a browser that Javascript is being used, we use `<script>` and `</script>` tags:
  - Javascript allows programmers to define functions
  - Javascript includes several standard programming constructs such as `for`, `while`, `if/then/else`, ...
  - Javascript also handles events, eg. user clicks on a link, user hovers mouse pointer over a portion of the page

Javascript - example

```
<html>
  <body>
    <p id="p1">Hello World!</p>

    <script>
      document.getElementById("p1").innerHTML =
                                          "New text!";
    </script>
  </body>
</html>
```

Webpage rendering



- The Document Object Model (DOM) is a means to represent and access the content of a page.
- Scripts can alter/manipulate the content of a page by accessing/updating the DOM of the page.

How is state managed in HTTP sessions

HTTP is stateless: when a client sends a request, the server sends back a response but the server does not hold any information from previous requests

The problem: in most web applications a client has to access various pages before completing a specific task and the client state should be kept along with those pages. How does the server know if two requests come from the same browser?
Example: the server doesn't require a user to log in at each HTTP request

The idea: insert a token into the page when it is requested and get that token passed back with the next request

Two main approaches to maintain a session between a web client and a web server

- use hidden fields
- use cookies

Hidden fields (1)

The principle

Include an HTML form with a hidden field containing a session ID in all the HTML pages sent to the client. This hidden field will be returned back to the server in the request.

Example: the web server can send a hidden HTML form field along with a unique session ID as follows:

```
<input type="hidden" name="sessionid" value="12345">
```

When the form is submitted, the specified name and value are automatically included in the GET or POST data.

Hidden fields (2)

Disadvantages of this approach

- it requires careful and tedious programming effort, as all the pages have to be dynamically generated to include this hidden field
- session ends as soon as the browser is closed

Advantage of this approach

All browsers support HTML forms

Cookies (1)

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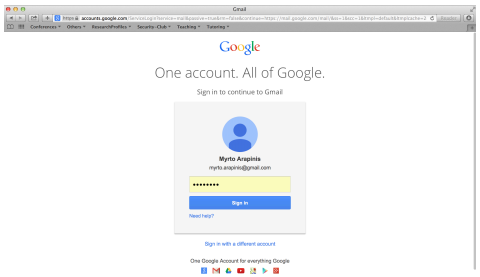
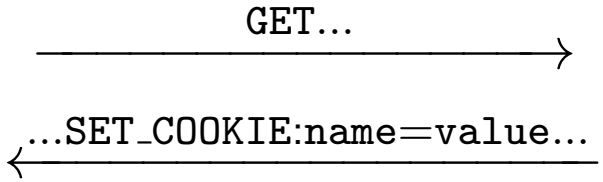
Main limitation

Users may disable cookies in their browser

Cookies (2)

Cookies are set on the client's system when the server uses the `Set-Cookie` field in the HTTP header of its response:





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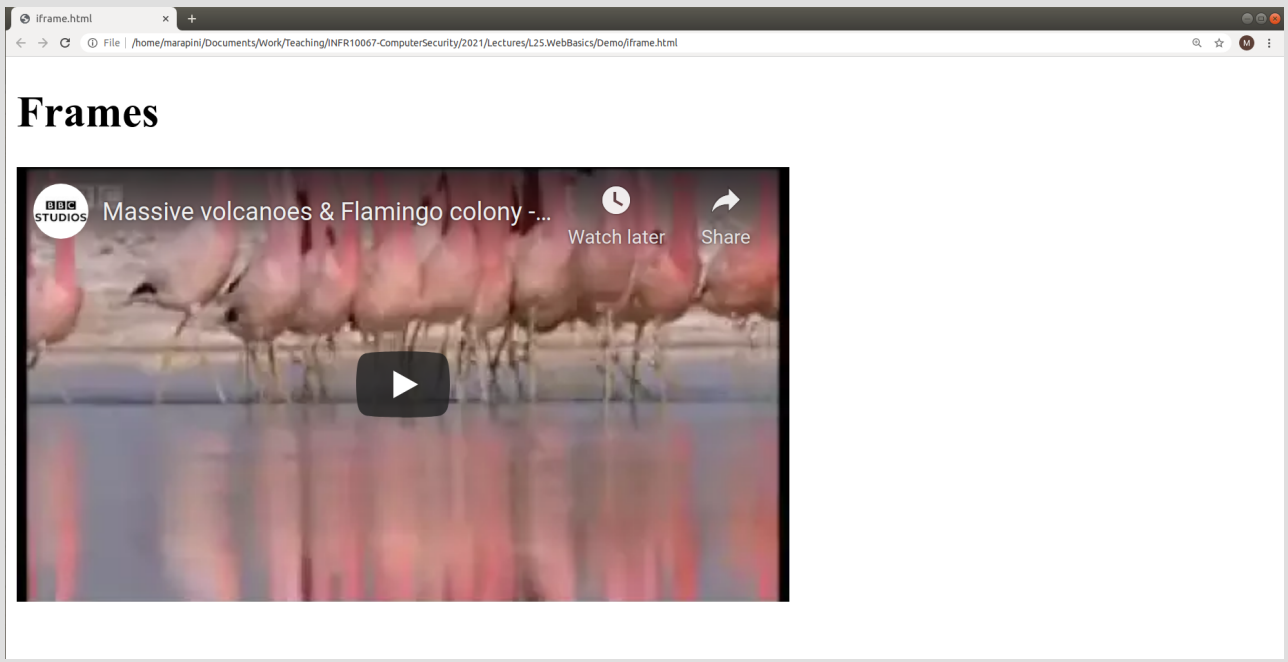
A cookie has several attributes:

```
Set-Cookie:  name=value[; expires=date]
        [; domain=dom][; path=p][; Secure][; HttpOnly]
  expires : (when to be deleted)
  domain : (when to send)  } scope
  path : (when to send)    }
  Secure : (only over SSL)
  HttpOnly : (only over HTTP)
```

Frames

- Embed an “inner” webpage within an “outer” webpage
- `<iframe src="URL"></iframe>`
- The outer webpage specifies the size and position of the inner webpage within the outer webpage

```
<iframe width="560" height="315"
src="https://www.youtube.com/embed/owsfdh4gxyc"
frameborder="0" allowfullscreen></iframe>
```



Web security: security goals

Security goals

Web applications should provide the same security guarantees as those required for standalone applications

1. visiting `evil.com` should not infect my computer with malware, or read and write files
   Defenses: Javascript sandboxed, avoid bugs in browser code, privilege separation, *etc*

2. visiting `evil.com` should not compromise my sessions with `gmail.com`
   Defenses: same-origin policy – each website is isolated from all other websites

3. sensitive data stored about `gmail.com` should be protected

Threat model

Web attacker

- controls `evil.com`
- has valid SSL/TLS certificates for `evil.com`
- victim user visits `evil.com`

Network attacker

- controls the whole network: can intercept, craft, send messages

A Web attacker is weaker than a Network attacker