CSC 405
Computer Security

Web Security

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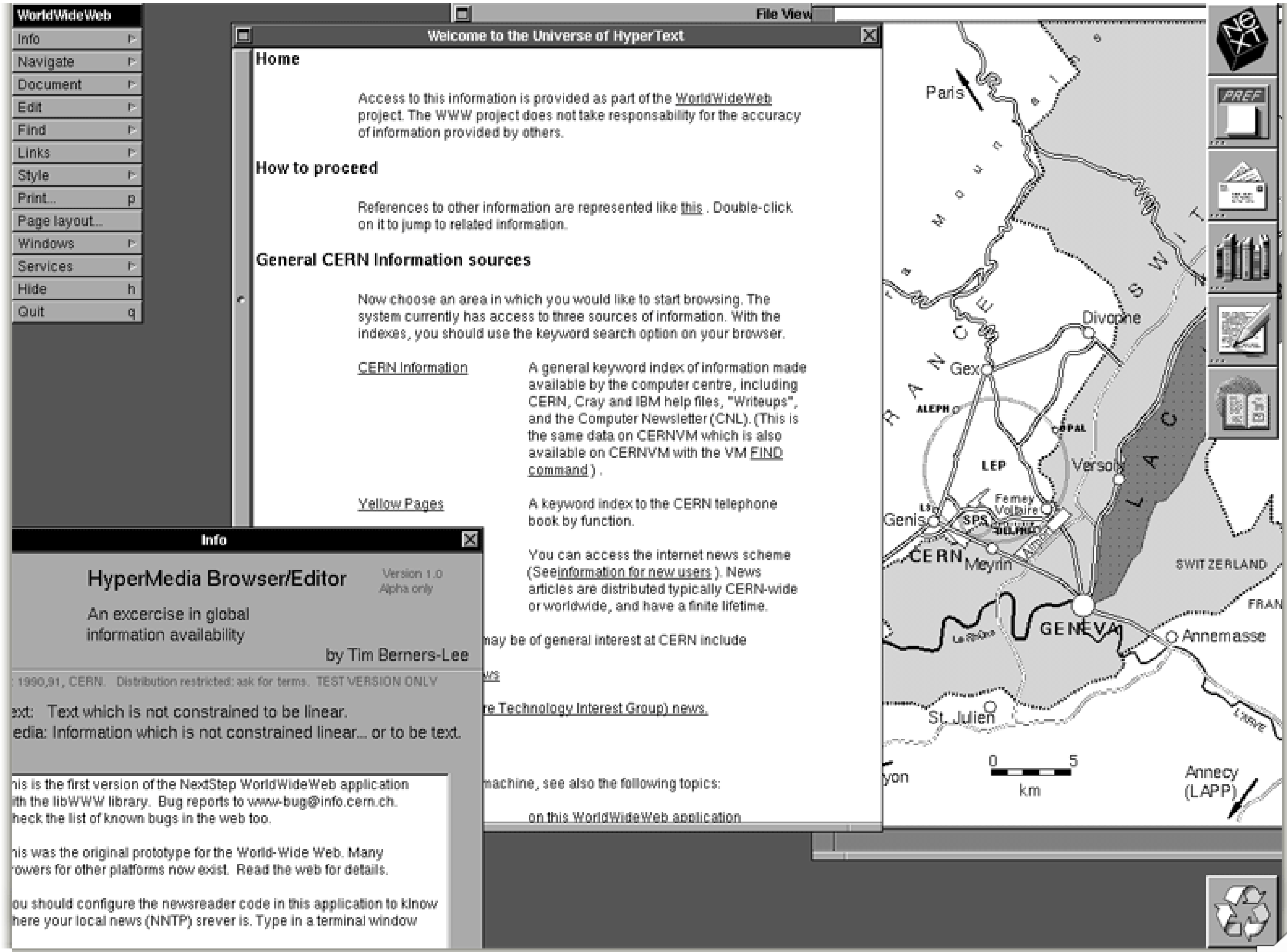
(Derived from slides by Giovanni Vigna and Adam Doupe)



Welcome to the Universe of HyperText

Home

Access to this information is provided as part of the WorldWideWeb project. The WWW project does not take responsability for the accuracy of information provided by others.

How to proceed

References to other information are represented like this . Double-click on it to jump to related information.

General CERN Information sources

Now choose an area in which you would like to start browsing. The system currently has access to three sources of information. With the indexes, you should use the keyword search option on your browser.

CERN Information	A general keyword index of information made available by the computer centre, including CERN, Cray and IBM help files, "Writeups", and the Computer Newsletter (CNL). (This is the same data on CERNVM which is also available on CERNVM with the VM FIND command) .
Yellow Pages	A keyword index to the CERN telephone book by function.
	You can access the internet news scheme (Seeinformation for new users). News articles are distributed typically CERN-wide or worldwide, and have a finite lifetime.

may be of general interest at CERN include

ws

re Technology Interest Group) news.

machine, see also the following topics:

on this WorldWideWeb application

Info

HyperMedia Browser/Editor

Version 1.0
Alpha only

An excercise in global information availability

by Tim Berners-Lee

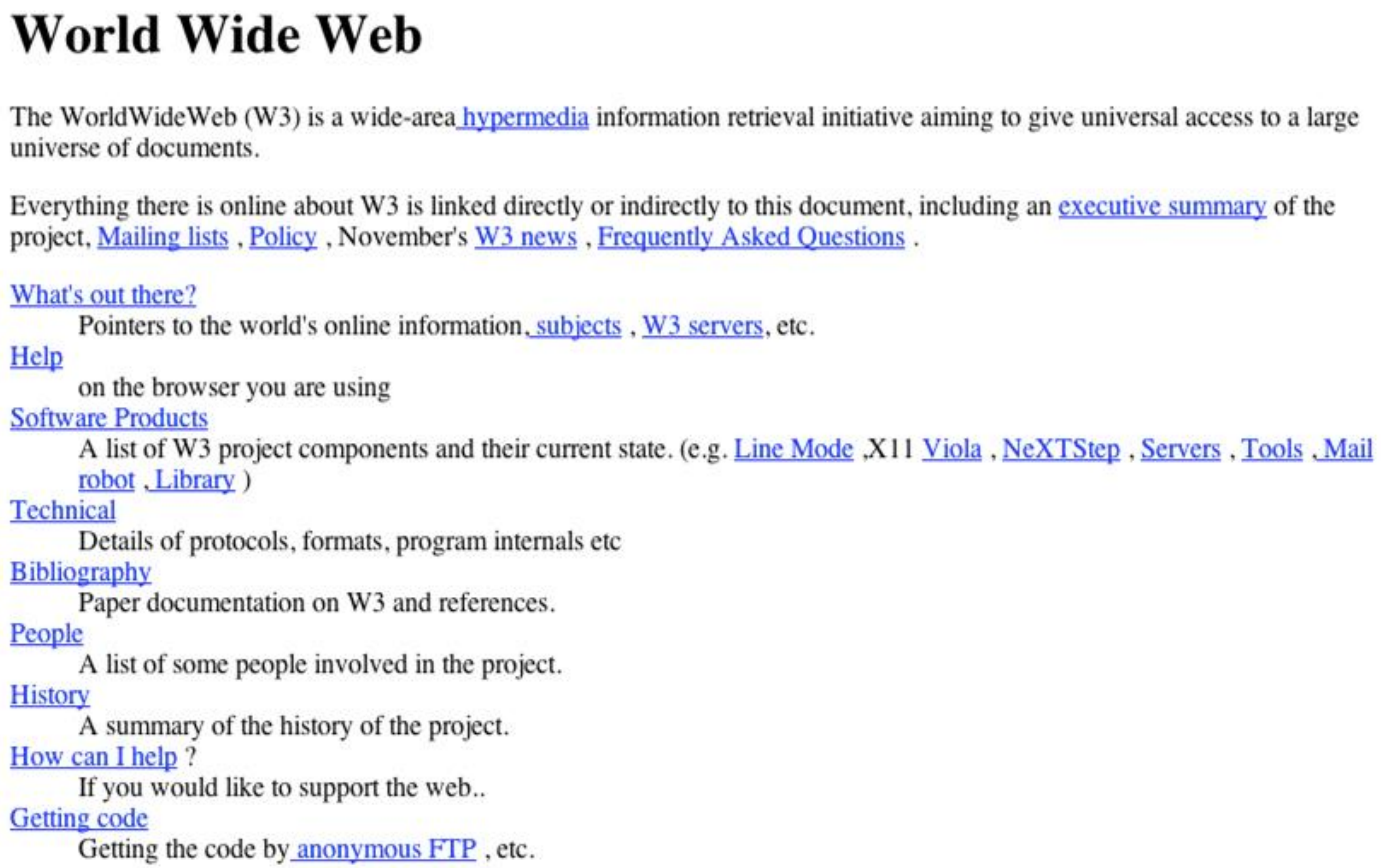
: 1990,91, CERN. Distribution restricted: ask for terms. TEST VERSION ONLY

ext: Text which is not constrained to be linear.
edia: Information which is not constrained linear... or to be text.

his is the first version of the NextStep WorldWideWeb application ith the libWWW library. Bug reports to www-bug@info.cern.ch. heck the list of known bugs in the web too.

his was the original prototype for the World-Wide Web. Many rowers for other platforms now exist. Read the web for details.

ou should configure the newsreader code in this application to know here your local news (NNTP) srever is. Type in a terminal window



World Wide Web

The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an executive summary of the project, Mailing lists , Policy , November's W3 news , Frequently Asked Questions .

What's out there?
: Pointers to the world's online information, subjects , W3 servers, etc.

Help
: on the browser you are using

Software Products
: A list of W3 project components and their current state. (e.g. Line Mode ,X11 Viola , NeXTStep , Servers , Tools , Mail robot , Library)

Technical
: Details of protocols, formats, program internals etc

Bibliography
: Paper documentation on W3 and references.

People
: A list of some people involved in the project.

History
: A summary of the history of the project.

How can I help ?
: If you would like to support the web..

Getting code
: Getting the code by anonymous FTP , etc.

Sir Tim Berners-Lee

ACM Turing Award 2016

Birth of the Web

- Created by Tim Berners-Lee while he was working at CERN
  - First CERN proposal in 1989
  - Finished first website end of 1990

- Weaving the Web: The Original Design and Ultimate Destiny of the World Wide Web, Tim Berners-Lee

Design

- Originally envisioned as a way to share research results and information at CERN
- Combined multiple emerging technologies
  - Hypertext
  - Internet (TCP/IP)
- Idea grew into “universal access to a large universe of documents”

Three Central Questions

- How to name a resource?
- How to request and serve a resource?
- How to create hypertext?

Three Central Technologies

- How to name a resource?
  - Uniform Resource Identifier (URI/URL)
- How to request and serve a resource?
  - Hypertext Transfer Protocol (HTTP)
- How to create hypertext?
  - Hypertext Markup Language (HTML)

Uniform Resource Identifier

- Essential metadata to reach/find a resource
- Answers the following questions:
  - Which server has it?
  - How do I ask?
  - How can the server locate the resource?
- Latest definition in RFC 3986 (January 2005)

URI – Syntax

```
<scheme>:<authority>/<path>?<query>#<fragment>
```

URI – Syntax

```
<scheme>:<authority>/<path>?<query>#<fragment>
```

- scheme
  - The protocol to use to request the resource
- authority
  - The entity that controls the interpretation of the rest of the URI
  - Usually a server name
    - <username>@<host>:<port>
- path
  - Usually a hierarchical pathname composed of “/” separated strings
- query
  - Used to pass non-hierarchical data
- fragment
  - Used to identify a subsection or subresource of the resource

URI – Syntax

```
<scheme>:<authority>/<path>?<query>#<fragment>
```

Examples:

```
foo://example.com:8042/over/there?test=bar#nose

ftp://ftp.ietf.org/rfc/rfc1808.txt

mailto:akaprav@ncsu.edu

https://example.com/test/example:1.html?/alex
```

URI – Reserved Characters

:	&
/	‘
?	(
#	)
[	*
]	+
@	,
!	;
$	=

URI – Percent Encoding

- Must be used to encode anything that is **not** of the following:
  Alpha `[a-zA-Z]`
  Digit `[0-9]`
  `-`
  `.`
  `_`
  `~`

URI – Percent Encoding

- Encode a byte outside the range with percent sign (%) followed by hexadecimal representation of byte
  - & -> %26
  - % -> %25
  - <space> -> %20
  - …
- Let’s fix our previous example:
  - `https://example.com/test/example:1.html?/alex`
  - `https://example.com/test/example%3A1.html?%2Falex`

URI – Absolute vs. Relative

- URI can specify the absolute location of the resource
  - `https://example.com/test/help.html`
- Or the URI can specify a location relative to the current resource
  - //example.com/example/demo.html
    - Relative to the current network-path (scheme)
  - /test/help.html
    - Relative to the current authority
  - ../../people.html
    - Relative to the current authority and path
- Context important in all cases
  - http://localhost:8080/test

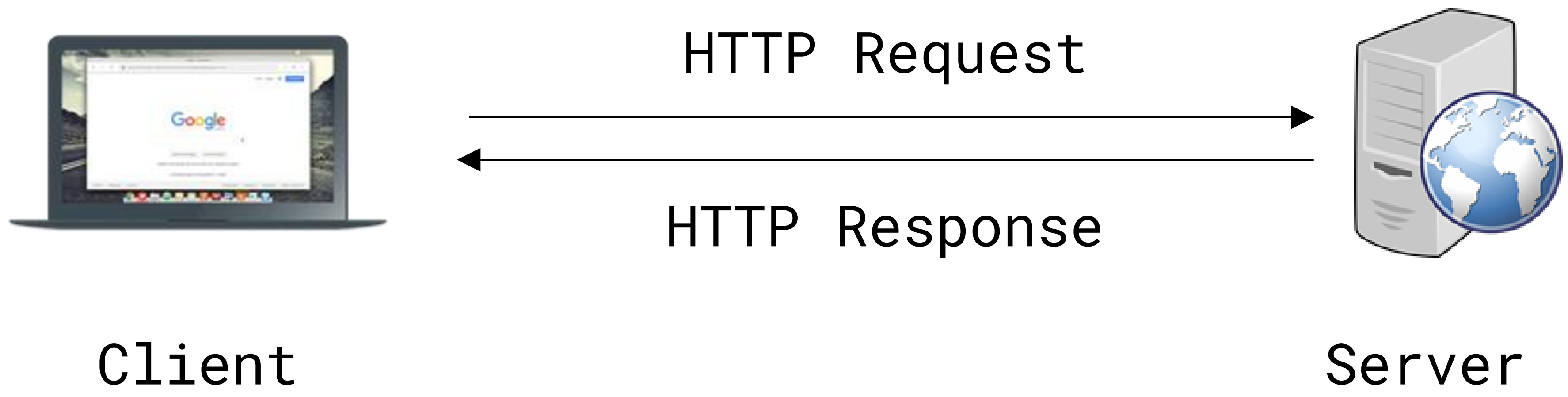
Hypertext Transport Protocol

- Protocol for how a web client can request a resource from a web server
- Based on TCP, uses port 80 by default
- Version 1.0
  - Defined in RFC 1945 (May 1996)
- Version 1.1
  - Defined in RFC 2616 (June 1999)
- Version 2.0
  - Based on SPDY, still under discussion

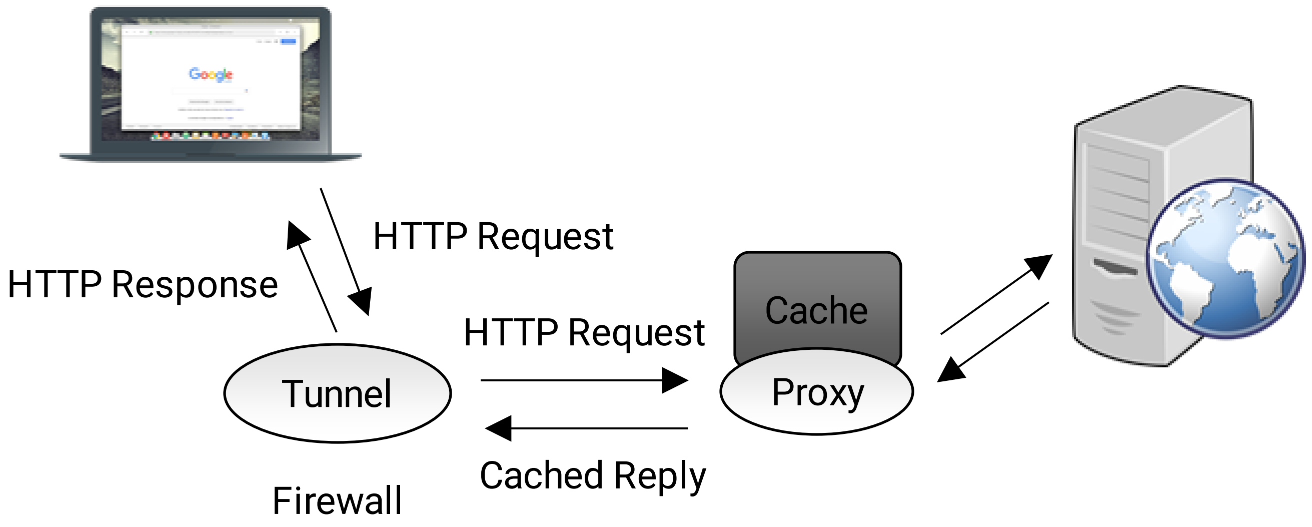
HTTP – Overview

- Client
  - Opens TCP connection to the server
  - Sends request to the server
- Server
  - Listens for incoming TCP connections
  - Reads request
  - Sends response

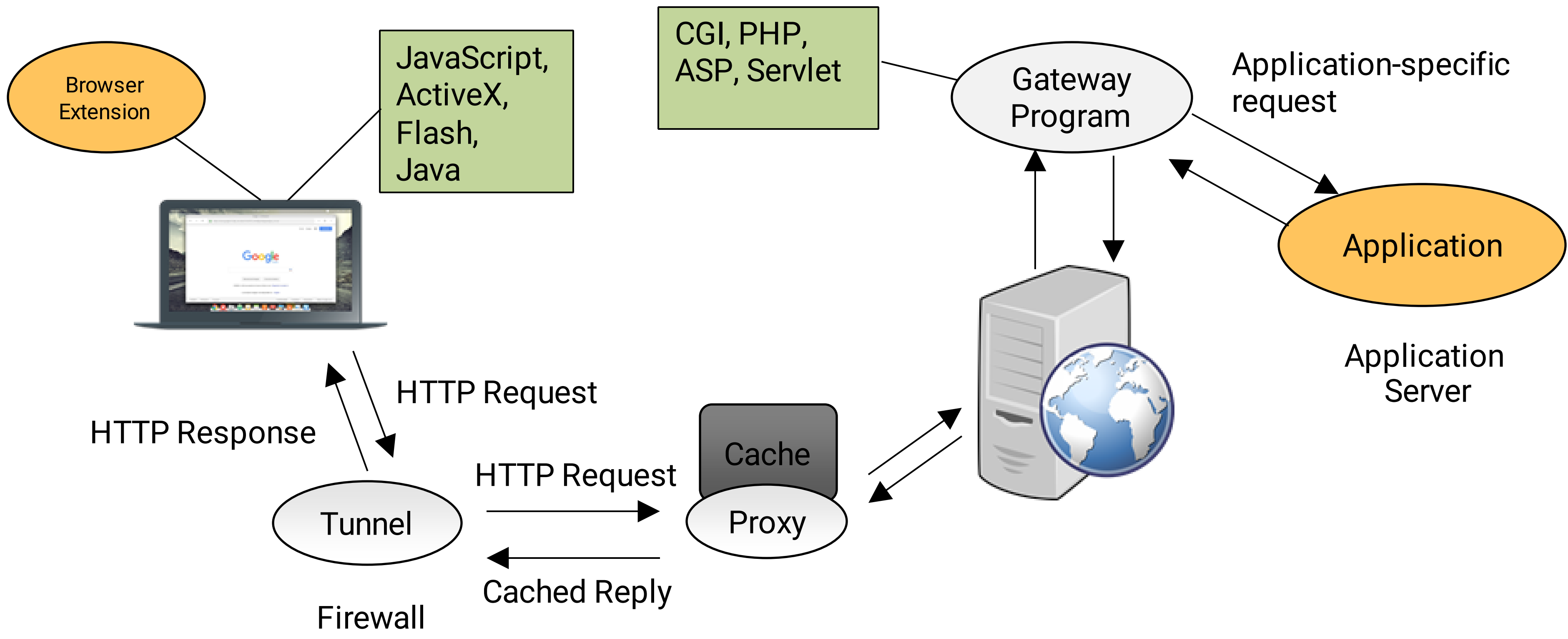
Architecture



Architecture



Architecture



Requests

- An HTTP request consists of:
  - method
  - resource (derived from the URI)
  - protocol version
  - client information
  - body (optional)

Requests – Syntax

- Start line, followed by headers, followed by body
  - Each line separated by CRLF
- Headers separated by body via empty line (just CRLF)

Requests – Methods

- The method that the client wants applied to the resource
- Common methods
  - GET – Request transfer of the entity referred to by the URI
  - POST – Ask the server to process the included body as “data” associated with the resource identified by the URI
  - PUT – Request that the enclosed entity be stored under the supplied URI
  - HEAD – Identical to GET except server **must not** return a body

Requests – Methods

- OPTIONS – Request information about the communication options available on the request/response chain identified by the URL
- DELETE – Request that the server delete the resource identified by the URI
- TRACE – used to invoke a remote, application-layer loop-back of the request message and the server should reflect the message received back to the client as the body of the response
- CONNECT – used with proxies
- …
  - A webserver can define arbitrary extension methods

Requests – Example

```
GET / HTTP/1.1
User-Agent: curl/7.37.1
Host: www.google.com
Accept: */*
```

Modern Requests

```
GET / HTTP/1.1
Host: www.google.com
Accept-Encoding: deflate, gzip
Accept:
text/html,application/xhtml+xml,applic
ation/xml;q=0.9,image/webp,*/*;q=0.8
User-Agent: Mozilla/5.0 (Macintosh;
Intel Mac OS X 10_10_1)
AppleWebKit/537.36 (KHTML, like Gecko)
Chrome/39.0.2171.95 Safari/537.36
```

Responses

- An HTTP response consists of:
  - protocol version
  - status code
  - short reason
  - headers
  - body

Responses – Syntax

- Status line, followed by headers, followed by body
  - Each line separated by CRLF
- Headers separated by body via empty line (just CRLF)
- Almost the same overall structure as request

Responses – Status Codes

- 1XX – Informational: request received, continuing to process
- 2XX – Successful: request received, understood, and accepted
- 3XX – Redirection: user agent needs to take further action to fulfill the request
- 4XX – Client error: request cannot be fulfilled or error in request
- 5XX – Server error: the server is aware that it has erred or is incapable of performing the request

Responses – Status Codes

- "200"   ; OK
- "201"   ; Created
- "202"   ; Accepted
- "204"   ; No Content
- “301"   ; Moved Permanently
- "307"   ; Temporary Redirect

Responses – Status Codes

- `"400"    ; Bad Request`
- `"401"    ; Unauthorized`
- `"403"    ; Forbidden`
- `"404"    ; Not Found`
- `"500"    ; Internal Server Error`
- `"501"    ; Not Implemented`
- `"502"    ; Bad Gateway`
- `"503"    ; Service Unavailable`

Requests – Example

```
GET / HTTP/1.1
User-Agent: curl/7.37.1
Host: www.google.com
Accept: */*
```

Responses – Example

```
HTTP/1.1 200 OK
Date: Tue, 13 Jan 2015 03:57:26 GMT
Expires: -1
Cache-Control: private, max-age=0
Content-Type: text/html; charset=ISO-8859-1
Set-Cookie: …
Server: gws
X-XSS-Protection: 1; mode=block
X-Frame-Options: SAMEORIGIN
Alternate-Protocol: 80:quic,p=0.02
Accept-Ranges: none
Vary: Accept-Encoding
Transfer-Encoding: chunked

<!doctype html><html itemscope=""
itemtype="http://schema.org/WebPage" lang="en"><head><meta
content="Search the world's information, including webpages,
images, videos and more. Go …
```

HTTP Authentication

- Based on a simple *challenge-response* scheme
- The *challenge* is returned by the server as part of a 401 (unauthorized) reply message and specifies the authentication schema to be used
- An authentication request refers to a *realm*, that is, a set of resources on the server
- The client must include an Authorization header field with the required (valid) credentials

HTTP Basic Authentication

- The server replies to an unauthorized request with a 401 message containing the header field

```
WWW-Authenticate: Basic realm="ReservedDocs"
```

- The client retries the access including in the header a field containing a cookie composed of base64 encoded (RFC 2045) username and password

```
Authorization: Basic QWxhZGRpbjpvcGVuIHNlc2FtZQ==
```

- Can you crack the username/password?

HTTP 1.1 Authentication

- Defines an additional authentication scheme based on cryptographic digests (RFC 2617)
  - Server sends a nonce as challenge
  - Client sends request with digest of the username, the password, the given nonce value, the HTTP method, and the requested URL
- To authenticate the users the web server has to have access to clear-text user passwords

Monitoring and Modifying HTTP Traffic

- HTTP traffic can be analyzed in different ways
  - Sniffers can be used to collect traffic
  - Servers can be configured to create extensive logs
  - Browsers can be used to analyze the content received from a server
  - Client-side/server-side proxies can be used to analyze the traffic without having to modify the target environment
- Client-side proxies are especially effective in performing vulnerability analysis because they allow one to examine and modify each request and reply
  - Firefox extensions: LiveHTTPHeaders, Tamper Data
  - Burp Proxy
    - This is a professional-grade tool that I use

Hypertext Markup Language

- A simple data format used to create hypertext documents that are portable from one platform to another
- Based on Standard Generalized Markup Language (SGML) (ISO 8879:1986)
- HTML 2.0
  - Proposed in RFC 1866 (November 1995)
- HTML 3.2
  - Proposed as World Wide Web Consortium (W3C) recommendation (January 1997)
- HTML 4.01
  - Proposed as W3C recommendation (December 1999)
- XHTML 1.0
  - Attempt by W3C to reformulate HTML into Extensible Markup Language (XML) (January 2000)
- HTML 5.0
  - Proposed as W3C recommendation (October 2014)
- HTML 5.1
  - Under development

HTML – Overview

- Basic idea is to “markup” document with tags, which add meaning to raw text
- Start tag:
  - `<foo>`
- Followed by text
- End tag:
  - `</foo>`
- Self-closing tag:
  - `<bar />`
- Void tags (have no end tag):
  - `<img>`

HTML – Tags

- Tag are hierarchical

HTML – Tags

```
<html>
  <head>
    <title>Example</title>
  </head>
  <body>
    <p>I am the example text</p>
  </body>
</html>
```

HTML – Tags

- <html>
  - <head>
    - <title>
      - Example
  - <body>
    - <p>
      - I am the example text

HTML – Tags

- Tags can have “attributes” that provide metadata about the tag
- Attributes live inside the start tag after the tag name
- Four different syntax
  - <foo bar>
    - `foo` is the tag name and `bar` is an attribute
  - `<foo bar=baz>`
    - The attribute `bar` has the value `baz`
  - `<foo bar='baz'>`
  - `<foo bar="baz">`
- Multiple attributes are separated by spaces
  - `<foo bar='baz' disabled required="true">`

HTML – Hyperlink

- **a**nchor tag is used to create a hyperlink
- `href` attribute is used provide the URI
- Text inside the **a**nchor tag is the text of the hyperlink

- `<a href="http://google.com">Example</a>`

[Example](http://google.com)

HTML – Basic HTML 5 Page

```
<!DOCTYPE html>
<html>
  <head>
    <meta charset="UTF-8">
    <title>CSC 405</title>
  </head>

  <body>
    <a href="http://example.com/">Text</a>
  </body>
</html>
```

HTML – Browsers

- User agent is responsible for parsing and interpreting the HTML and displaying it to the user

HTML – Character References

- How to include HTML special characters as text/data?
  `< > ' " & =`
  - Encode the character reference
  - Also referred to in HTML < 5.0 as “entity reference” or “entity encoding”
- Three types, each starts with & and ends with `;`
  - Named character reference
    - `&<predefined_name>;`
  - Decimal numeric character reference
    - `&#<decimal_unicode_code_point>;`
  - Hexadecimal numeric character reference
    - `&#x<hexadecimal_unicode_code_point>;`
- Note: This will be the root of a significant number of vulnerabilities and is critical to understand

HTML – Character References Example

- The ampersand (&) is used to start a character reference, so it must be encoded as a character reference
- `&amp;`
- `&#38;`
- `&#x26;`
- `&#x00026;`

HTML – Character References Example

- é
- `&eacute;`
- `&#233;`
- `&#xe9;`

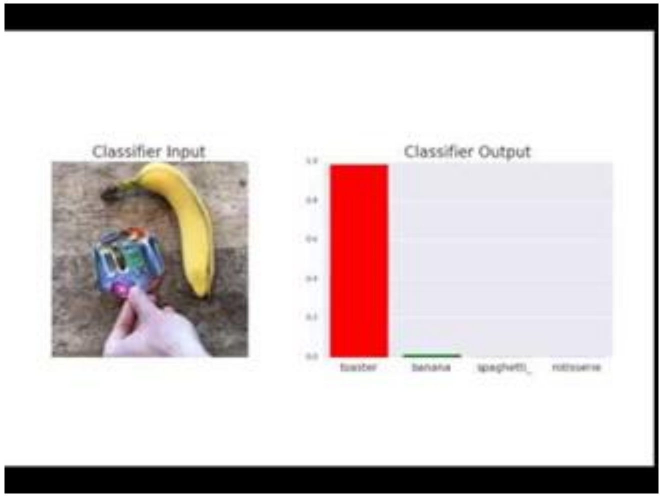
HTML – Character References Example

- Why must '<' be encoded as a character reference?
- &lt;
- `&#60;`
- `&#x30;`
- `&#x00030;`

Your Security Zen

Adversarial Patch

An image-independent patch that is extremely salient to a neural network. This patch can then be placed anywhere within the field of view of the classifier, and causes the classifier to output a targeted class.



Source: https://arxiv.org/pdf/1712.09665.pdf