CS305 Lab3
HTTP

Dept. Computer Science and Engineering
Southern University of Science and Technology

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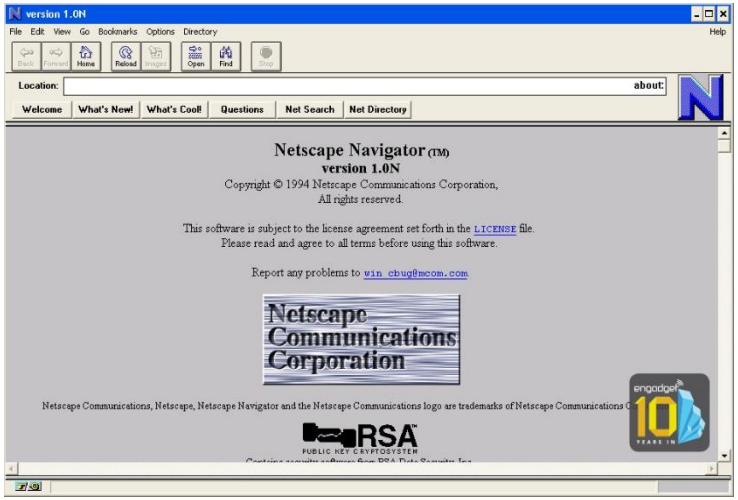
Thanks to HHQ.ZHANG

TOPICS

- Client and Server
- URL and MIME
- Request and Response
- Tools: browser, curl, Wireshark

Web browsers

- A web browser is a program to retrieve and display resources on the Web
  Example: Netscape 1.0N

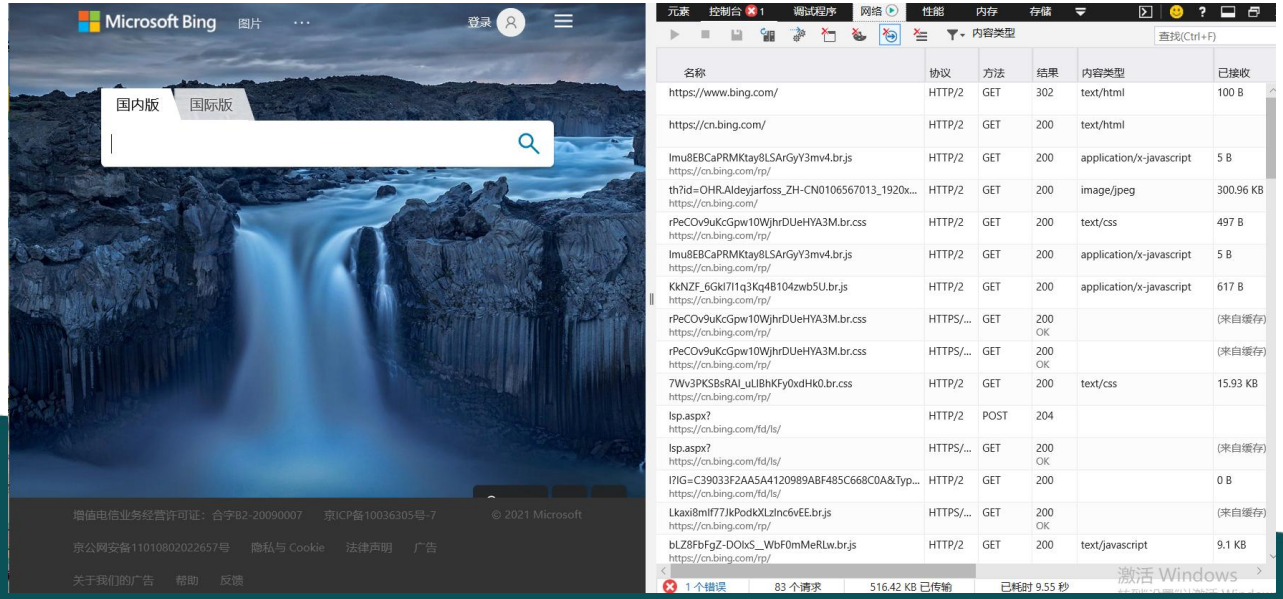


Web browsers and servers

- Popular web browsers: Google Chrome, Apple Safari, Microsoft Internet Explorer & Edge, Mozilla Firefox
  - https://www.w3counter.com/globalstats.php
- A web server receives requests from a web browser and returns the requested resources.
  - Retrieve the resources from file system on server
  - Run a program to generate the resources
- Popular web servers: Microsoft IIS, Apache HTTP server, Nginx
  - https://news.netcraft.com/

Web resources in a web page

- A web page actually consists of several kinds of web resources
  - One or more HTML document
  - Some CSS style sheets
  - Some JavaScript programs
  - Images
  - Objects *(e.g. flash going died)*
  - Font
  - …



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Web resources

- A resource is anything that is important enough to be referenced as a thing in itself.
- A resource has at least one URL as its address. A browser uses the URL to download the resource from a server.
- The web server uses MIME type to specify the data type of a representation of a resource.
  - Examples of resources:
    - The front page of SUSTech web site
    - The logo of SUSTech
    - A directory of resources pertaining to “web design” found by Google.
    - A json record returned by Facebook graph API: https://graph.facebook.com/cocacola

Address of web resource

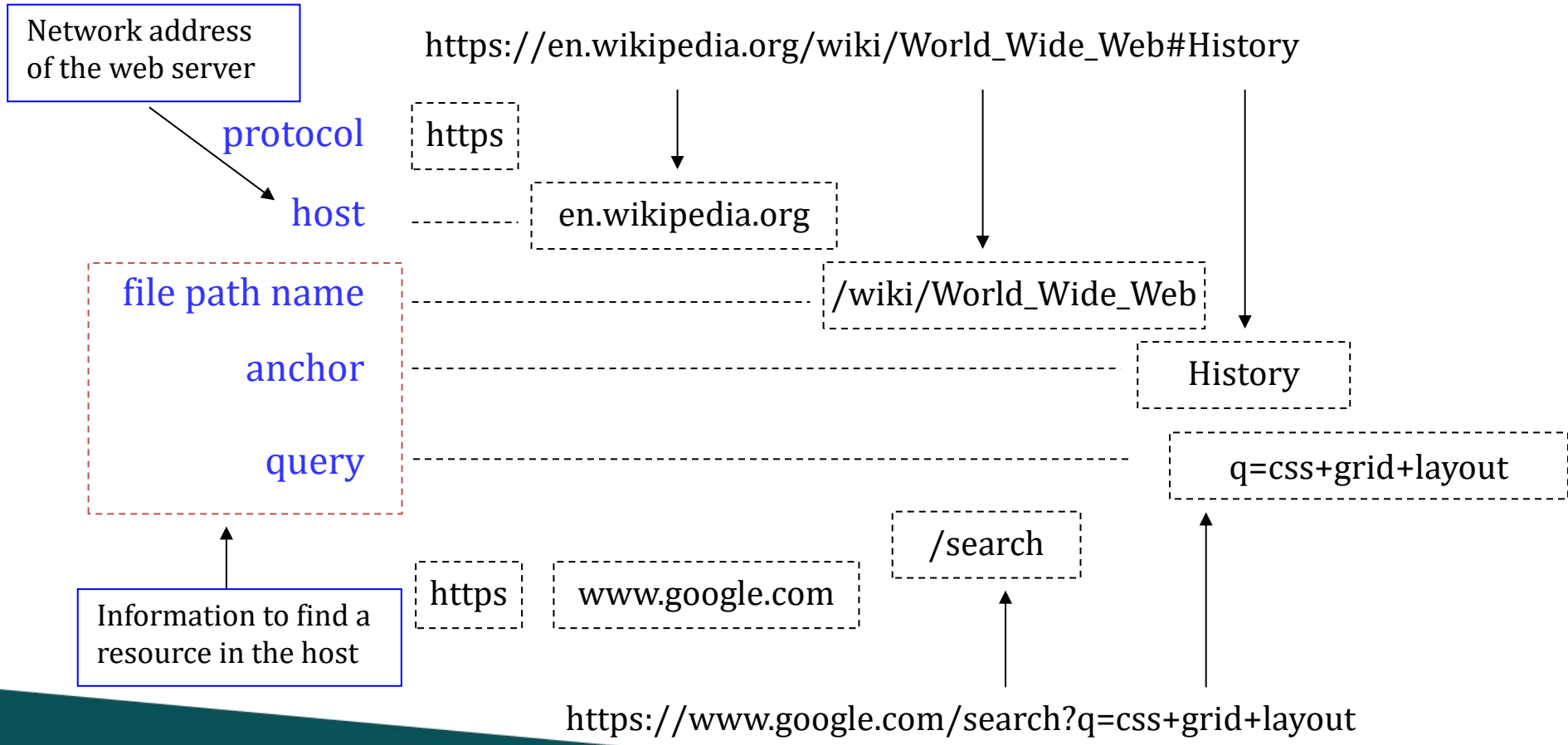
- Each web resource has a **URL** (Universal Resource Locator) as an address. It includes
  - protocol – how to communicate with the server
  - address of a web server – where to find the resource
  - additional info for the server to find the resource – which resource in the server
- Given a URL, a browser has enough info to construct a request to retrieve the resource

Syntax of URL

protocol://host/filepathname?query#anchor

- Protocol is either 'http' or 'https'
- Host is usually a domain name of a web server
- File path name identifies a resource in the server
- Query is form data submitted to a server-side script. The format is name1=value1&name2=value2
- Anchor refers to an element with the id in an html or xml file.
- Notice that separator characters in blue must be encoded if they are used as ordinary text in URL.

Inside a URL ...


Network address of the web server
https://en.wikipedia.org/wiki/World_Wide_Web#History
protocol
https
host
en.wikipedia.org
file path name
/wiki/World_Wide_Web
anchor
History
query
q=css+grid+layout
/search
Information to find a resource in the host
https
www.google.com
https://www.google.com/search?q=css+grid+layout

Encode characters in URL

- In general, characters other than letters and numbers should be encoded in URL.
  - Space may be written as '+' or '%20'
  - Other printable character in ASCII should be written in hexadecimal. e.g, 1/2 is encoded as '1%2F2'
  - Non-ascii characters, e.g, Chinese, should be written as UTF-8 in hexadecimal. e.g.中文 is encoded as '%E4%B8%AD%E6%96%87'

Python urllib

```
C:\Users\Administrator>python
Python 3.8.6rc1 (tags/v3.8.6rc1:08bd63d, Sep  7 2020,
Type "help", "copyright", "credits" or "license" for m
>>> import urllib.parse
>>> urllib.parse.quote('foo=bar')
'foo%3Dbar'
>>> urllib.parse.unquote('foo%3Dbar')
'foo=bar'
>>> obj = {'name':'Tonny','age':20}
>>> urllib.parse.urlencode(obj)
'name=Tonny&age=20'
>>> urllib.parse.parse_qs('name=Tonny&age=20')
{'name': ['Tonny'], 'age': ['20']}
>>>
```

Reference: https://docs.python.org/3/library/urllib.parse.html

Data type of web resource

- There are various types of web resources
  - E.g. text, image, audio, video, data
- There are different formats to encode a certain type
  - E.g. an image can be in GIF, JPEG or PNG
  - Some formats are defined by W3C, e.g. HTML, CSS, XML (general data), PNG (bitmap image), SVG (vector graphics)
  - Others are de-facto standards defined by the industry, e.g. GIF, JPEG, SWF (flash movie), JavaScript
- These formats are identified by a standard called **MIME type** (Multipurpose Internet Mail Extensions)
- Most browsers support these formats, and can display them correctly.

Common MIME types

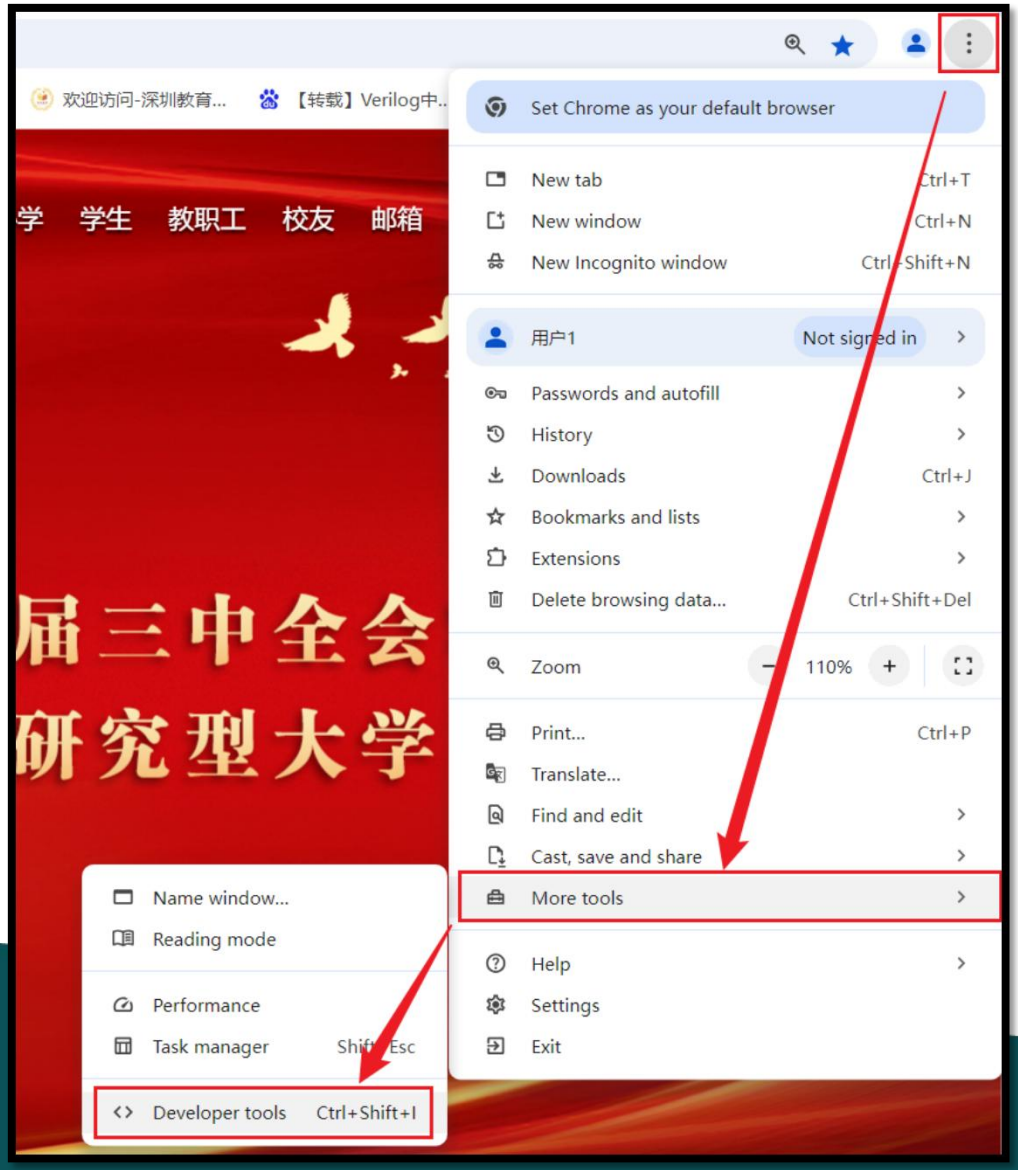
Category	MIME type	File extension
Text	text/html	HTML (.html)
	text/css	CSS (.css)
Image	image/gif	GIF (.gif)
	image/jpeg	JPEG (.jpg, .jpe, .jpg)
	image/png	PNG (.png) Portable Network Graphics
	image/svg+xml	SVG (.svg) Scalable Vector Graphics
Audio	audio/mpeg	Mp3 audio (.mp3)
Video	video/mpeg	Video (.mpg, .mpv2, .mp2, .mpa, .mpe, .mpeg)
Application	Application/ octet-stream	Arbitrary binary data (.exe, .lha, .lzh, .bin, .class, .dms, *)
	application/json	JSON data
	application/javascript	JavaScript source (.js)
	application/msword	WORD file (.doc, .dot)
	application/x-www-form-urlencoded	HTML form submission

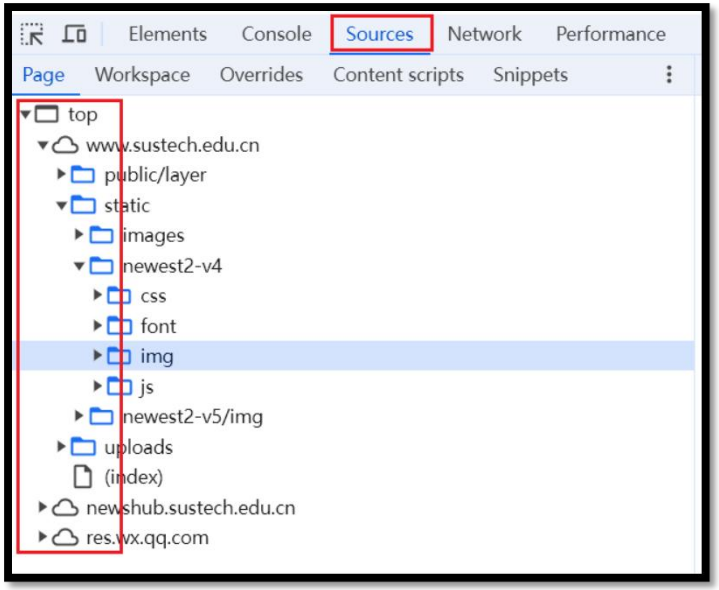
Reference: https://www.rfc-editor.org/rfc/rfc1521.html
https://www.rfc-editor.org/rfc/rfc1522.html

Practice 3.1

- Check the sources of a web page. For example, the home page of SUSTech.
- Browse all files on this page.
  - Tips: Expand and view all folded folders.
- Find the MIME types of all files. You can do this practice manually or use a Python program to help you complete it.
  - Tips: analyze the suffix of each file.

How to check sources in Chrome



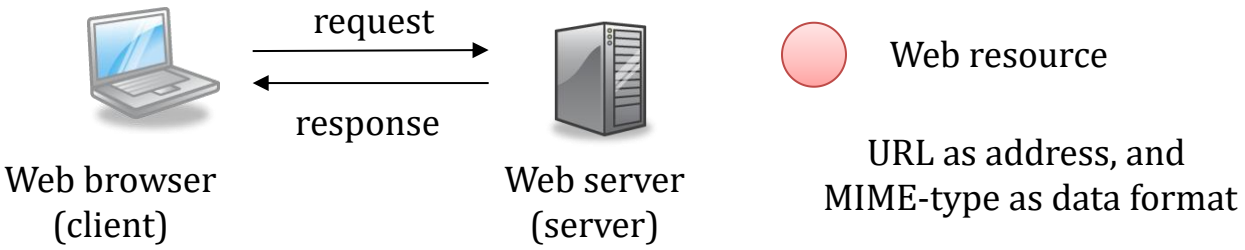


HTTP operation

- Each HTTP transaction consists of one request and one response.
  - A client sends a request for a resource to the server. Then the server returns a response containing a representation of the resource to the client.
- HTTP/1.0 requires a new TCP connection for each HTTP transaction.
  - the server closes the connection after sending the response.
- HTTP/1.1 can transfer several web resources in a TCP connection.

Basic retrieval

- To retrieve a static file in server
  - A browser sends a request to GET a resource at a URL
  - The server receives the request, maps the URL to a file in its file system, e.g. http://example.com/home.html -> c:\inetpub\home.html
  - The server infers the MIME-type from the file extension, e.g. *.html -> text/html, *.gif -> image/gif
  - The server constructs and returns the response



Example: Basic retrieval

HTTP request

GET **/home.html** HTTP/1.1
Host: example.com
User-Agent: Mozilla/5.0 ... Chrome/57.0

example.com

HTTP/1.1 200 OK
Date: Fri, 18 Sep 2020 08:00:29 GMT
Server: nginx/1.10.3
Content-Type: text/html; charset=utf-8

<html>... </html>

HTTP response

Simple HTTP retrieval of the page http://example.com/home.html.

Notice how the URL of the resource is specified in the request, and how the data type is stated in the response.

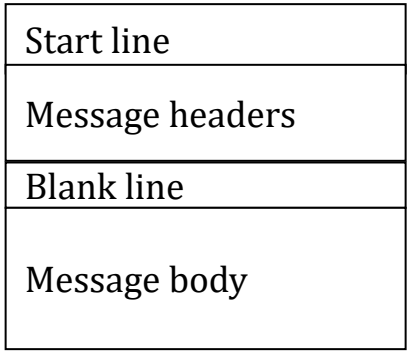
Basic HTTP request and response

- A basic **request** contains
  - Method GET to retrieve a resource
  - URL (or part of URL) – address of the resource
  - Other headers, e.g. name of user-agent

- A basic **response** contains
  - Status code
  - A representation of the resource
  - its MIME-type and encoding (for text resource) in Content-type header
  - Other headers, e.g. name of server

HTTP message structure(1)

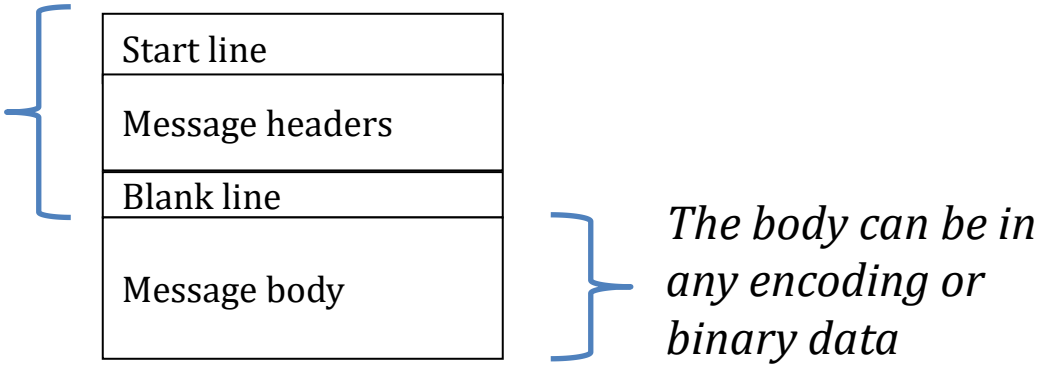
- **HTTP requests and responses have similar structure**
  - **Start line** – URL requested, any error
  - Headers – additional info
  - **Blank line**
  - Body – representation of the resource
- **Start line** and **blank line** are **required**.
- Headers and body are **optional**.



HTTP message structure(2)

- Start line and headers must be in US-ASCII
  - i.e. Chinese characters must be encoded
- Message body can be text in any encoding or binary data
  - The header Content-Type defines the data type
  - The header Content-Length defines the size (in bytes)

Each line ends with CR LF (ASCII 13 and 10), and can only contain US-ASCII characters.



Request Line

- The request line has three parts:
  - Method name: GET, POST, HEAD, etc
  - (partial) URL of the resource
  - Version of HTTP: HTTP/1.0 or HTTP/1.1

```
GET /test.html HTTP/1.0
```

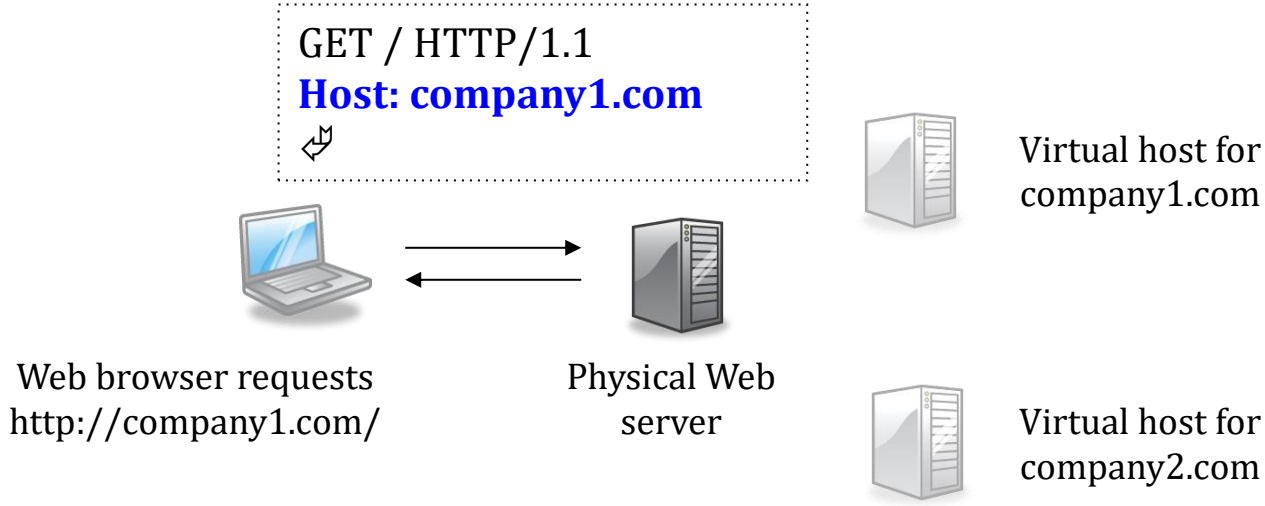
```
GET http://www.example.com/test.html HTTP/1.0
```

```
GET /search?hl=en&q=HTTP+headers&btnG=Google+Search HTTP/1.1
```

```
POST /accounts/ServiceLoginAuth?service=mail HTTP/1.1
```

Host:

- Compulsory header in HTTP/1.1
- Specifies the host of the requested URL
  - Useful for multi-homed web servers. Several web sites (with different host names) may be using the same IP address.



Example: HTTP requests

To retrieve the web page
http://www.example.com/test.html
The web browser constructs a HTTP request and sends it to the web server at www.example.com.

```
GET /test.html HTTP/1.1↵
Host: www.example.com↵
↵
```

```
GET /test.html HTTP/1.0↵
↵
```

```
GET http://www.example.com/test.html HTTP/1.1↵
Host: www.example.com↵
↵
```

Status line

- The status line has three parts:
  - HTTP version
  - Response status code
    - 200 – success
    - 404 – file not found
    - 500 – server error
  - English reason phrase, which describes the status code
- HTTP defines five classes of status code
  - 1xx – informational message
  - 2xx - success of some kind
  - 3xx – redirects the client to another URL
  - 4xx – an error on the client's part
  - 5xx – an error on the server's part

HTTP/1.1 200 OK

HTTP/1.1 404 Not found

Here you go.
Go away.
you screwed up.
I screwed up.

Common codes for success and error

Status code	Meaning
200 OK	The server successfully carried out the action that the client requested. For GET request, the response body contains a representation of the requested resource.
204 No content	The server successfully carried out the action, but declined to return any representation. In Ajax, this usually means the browser should not refresh the user interface.
400 Bad request	Generic client-side error. Probably a request format error.
404 Not found	The server cannot find the resource at the requested URL.
500 Internal server error	Generic server-side error. Probably a server-side program run-time error.
503 Service unavailable	The web server is not available, probably because of overloading or maintenance.

https://developer.mozilla.org/en-US/docs/Web/HTTP/Status

Example: HTTP responses

After receiving the request for
http://www.example.com/test.html
The web server will return a response containing the page, or an error message if it cannot find the page.

```
HTTP/1.1 200 OK↵
Content-Type: text/html↵
Content-Length: 2300↵
↵
<html>… content of test.html …</html>
```

```
HTTP/1.1 404 Not found↵
Content-Type: text/html↵
Content-Length: 1024↵
↵
<html>… error message …</html>
```

Content-Type:

- Indicates the data type (MIME) and character encoding of the message body in requests and responses
  - Omitted if empty body
  - Content-Type: application/octet-stream if server cannot decide

HTTP request to login mail.com

```
POST /accounts/auth?service=mail HTTP/1.1
Host: www.mail.com
Content-Type: application/x-www-form-urlencoded
Content-Length: 194

...&email=username&passwd=password&...
```

Notice how character encoding is specified.

HTTP response

```
HTTP/1.1 200 OK
Content-Type: text/html; charset=UTF-8
Content-Length: 12800

<html>...</html>
```

Content-Length:

- Indicates the size (in bytes) of the message body in requests and responses
  - Content-length header is sent before the message body
  - Difficult to determine message size if the response is generated dynamically by a program
  - A solution: chunked-transfer encoding (to be discussed)

HTTP request to login mail.com

```
POST /accounts/auth?service=mail HTTP/1.1
Host: www.mail.com
Content-Type: application/x-www-form-urlencoded
Content-Length: 194

...&email=username&passwd=password&...
```

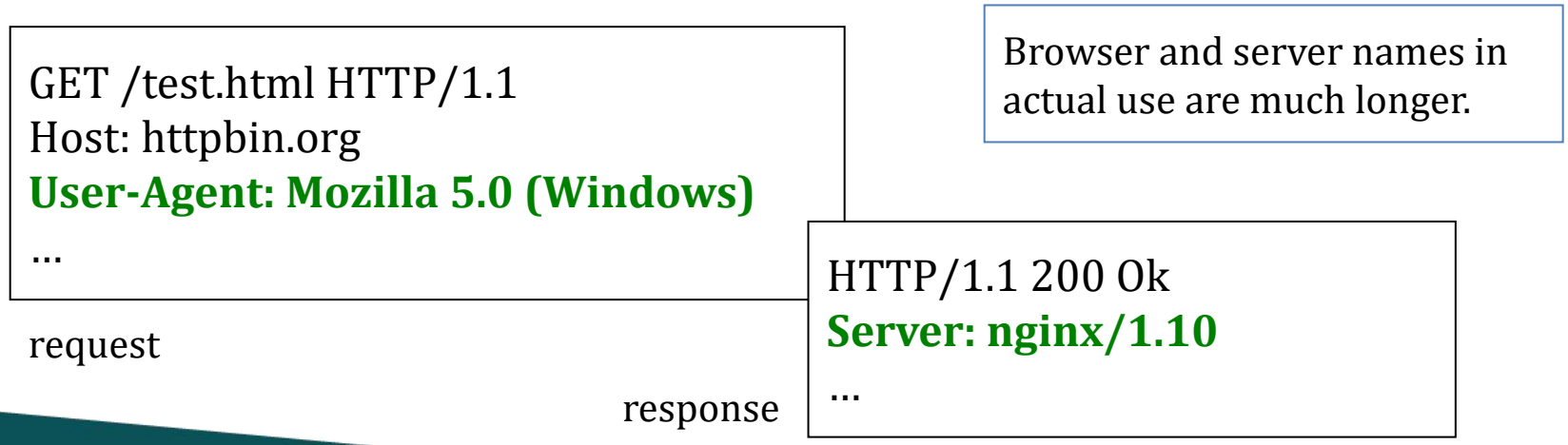
HTTP response

```
HTTP/1.1 200 OK
Content-Type: text/html; charset=UTF-8
Content-Length: 12800

<html>...</html>
```

User-Agent: & Server:

- Indicate which web browser generates the request and which web server generates the response
  - May be used for collecting statistics about web browser market share
  - A server may generate browser specific response



Common headers

Header	Request	Response
Host:	Domain name of requested URL	
User-agent:	Which web browser?	
Server:		Which web server?
Referer:	From which web page does the browser obtain this URL?	
Content-type:	Type of content in the body	
Content-length:	Length of the body in bytes	

Methods in HTTP/1.0

- HTTP methods are operations on resources
- HTTP/1.0 supports three methods
  - GET – to retrieve a representation of a resource
  - HEAD – to retrieve only the metadata of a resource
  - POST – to submit some data to a resource (program) in web server for processing

GET method

- **GET** retrieves a representation of a resource
  - Usually empty body in request message
  - Browsers mainly use this method to retrieve web resources
  - Usually a read-only operation

```
GET /a.txt HTTP/1.1
Host: example.com
```

request

```
HTTP/1.1 200 OK
Content-Type: text/plain
Content-Length: 5

Hello
```

response

HEAD method

- **HEAD** is similar to **GET**, but the response only contains headers and an empty body
- Useful to check the characteristics of a resource without retrieving it, e.g.
  - What is its size?
  - Is the resource still available?

```
HEAD/a.txt HTTP/1.1
Host: example.com
```

request

```
HTTP/1.1 200 OK
Content-Type: text/plain
Content-Length: 5
```

response

POST method

- **POST** submits some data to a resource for processing
  - The resource is usually a server-side program
  - The data are usually encoded in the body of the POST request
  - Usually invokes some server-side action

```
POST /accounts/auth?service=mail HTTP/1.1
Host: www.mail.com
Content-Type: application/x-www-form-urlencoded
Content-Length: 194

...&email=username&passwd=password&...
```

HTTP request to login mail.com

Observation

- The **GET** request in form submission can be …
  - saved in bookmark
  - saved in browser history (possible security problem!)
  - used in a hyperlink <a href="..">. When users click the link, the browser sends the same GET request as in submitting the HTML form.

```
GET /login.php?user=philip&passwd=12345 HTTP/1.1
Host: example.com
```

Request for
http://example.com/login.php?user=philip&passwd=12345

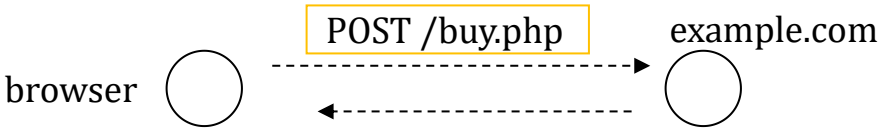
Side-effect

- **GET** and **HEAD** have no side-effect
  - read-only operations in web servers
  - A browser may repeat sending these requests without user confirmation
  - May repeat a **GET** request in case of network error
- **POST** may have side-effect
  - May cause some actions in the server (e.g. adding a record, sending an email, placing an order)
  - A browser must confirm with users before resending such requests

Also try : https://www.w3school.com.cn/tiy/t.asp?f=html_form_submit

Example: resubmit a POST request

- In this example, a purchase request is sent as a POST (because it has side-effect).
- The server returns the transaction result in the response
- If the user refreshes the result page, the browser would need to send the POST request twice.
  - What would happen?



POST /buy.php HTTP/1.1
Host: example.com
Content-Type: application/x-www-form-urlencoded
Content-Length: 194

...&productID=554433&quantity=1&...

HTTP/1.1 200 Ok
Content-Type: text/html
Content-Length: 5000

<html>...
Thanks for your purchase! ...</html>

Confirmation when resubmitting request

- Because GET causes no action in the server, it should make no difference to repeat or skip a GET request
  - The browser may resubmit a GET request
- POST may have side-effect. If the browser resubmits a POST request, the server may perform some action twice.
  - The browser must confirm with users before resubmitting a POST request
  - *Users may be confused by the resend warning … Solution: Post/Redirect/Get pattern*

Comparison: GET and POST

	GET	POST
Typical usage	Read-only query like Google search, Google Charts	Request that triggers action on server side. E.g. place an order, login, save a file
Side-effect?	Read-only operations in servers. Browsers can resubmit requests without confirmation	May cause write operations in servers. Browsers must confirm with users.
Form data in URL?	Yes. The query URL can be saved in bookmark and hyperlinks.	No
Support file upload	No	Yes

cURL: Utility for URL

- cURL is a computer software project providing a library and command-line tool for transferring data using various protocols.
  Download: **https://curl.haxx.se/download.html**
- Example:

```
$ curl http://httpbin.org/headers
{
  "headers": {
    "Accept": "*/*",
    "Host": "httpbin.org",
    "User-Agent": "curl/7.55.1"
    "X-Amzn-Trace-Id": "Root=1-5f646cba-4f1892177757747d3883a5ed"
  }
}
```

cURL: Inspect HTTP transaction

$ curl http://httpbin.org/headers --HEAD -v

> HEAD /headers HTTP/1.1

> Host: httpbin.org

> User-Agent: curl/7.55.1

> Accept: */*

...

< HTTP/1.1 200 OK

< Date: Mon, 27 Feb 2023 03:12:42 GMT

< Content-Type: application/json

< Content-Length: 173

< Connection: keep-alive

< Server: gunicorn/19.9.0

< Access-Control-Allow-Origin: *

< Access-Control-Allow-Credentials: true

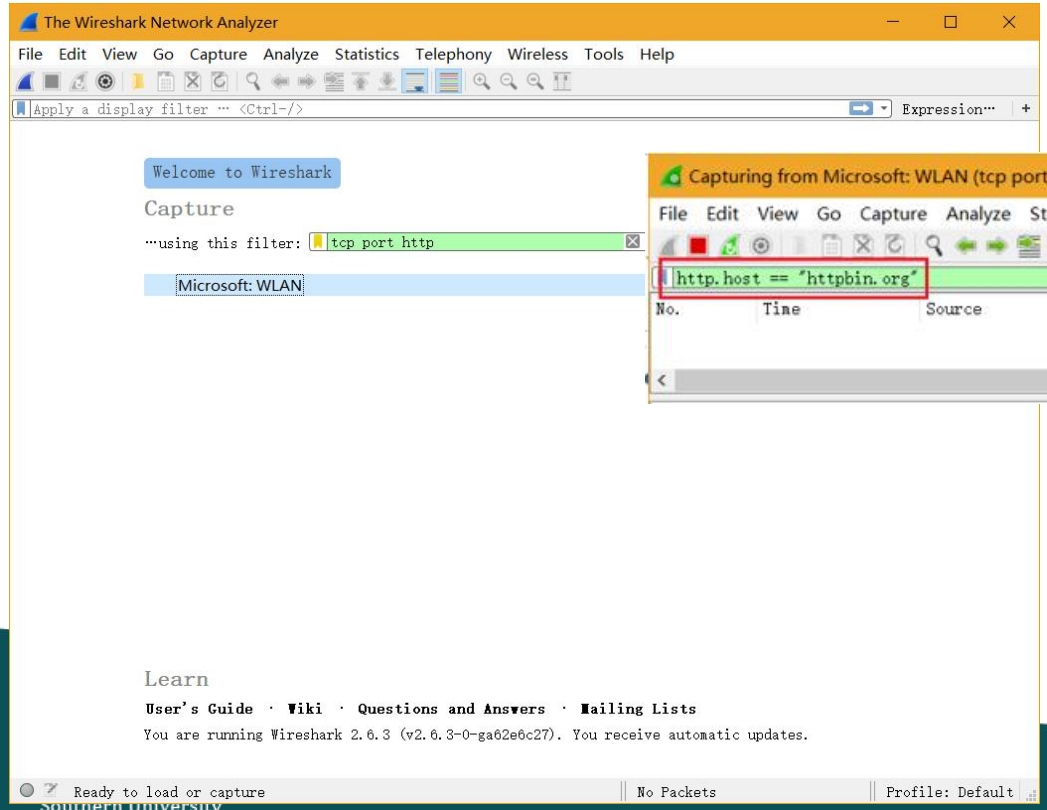
cURL: Inspect GET request

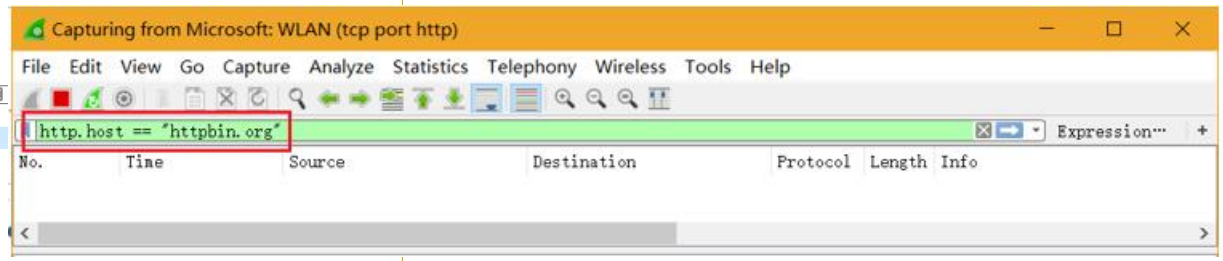
```
$ curl http://httpbin.org/get
{
  "args": {},
  "headers": {
    "Accept": "*/*",
    "Host": "httpbin.org",
    "User-Agent": "curl/7.55.1",
    "X-Amzn-Trace-Id": "Root=1-66e27c81-4db22d705748a91e3268b84f"
  },
  "origin": "116.7.234.239",
  "url": "http://httpbin.org/get"
}
```

```
$ curl http://httpbin.org/get?date=2024-09-23
{
  "args": {
    "date": "2024-09-23"
  },
  "headers": {
    "Accept": "*/*",
    "Host": "httpbin.org",
    "User-Agent": "curl/7.55.1",
    "X-Amzn-Trace-Id": "Root=1-66e27c35-2d53b44016a2a77d103c0139"
  },
  "origin": "116.7.234.239",
  "url": "http://httpbin.org/get?date=2024-09-23"
}
```

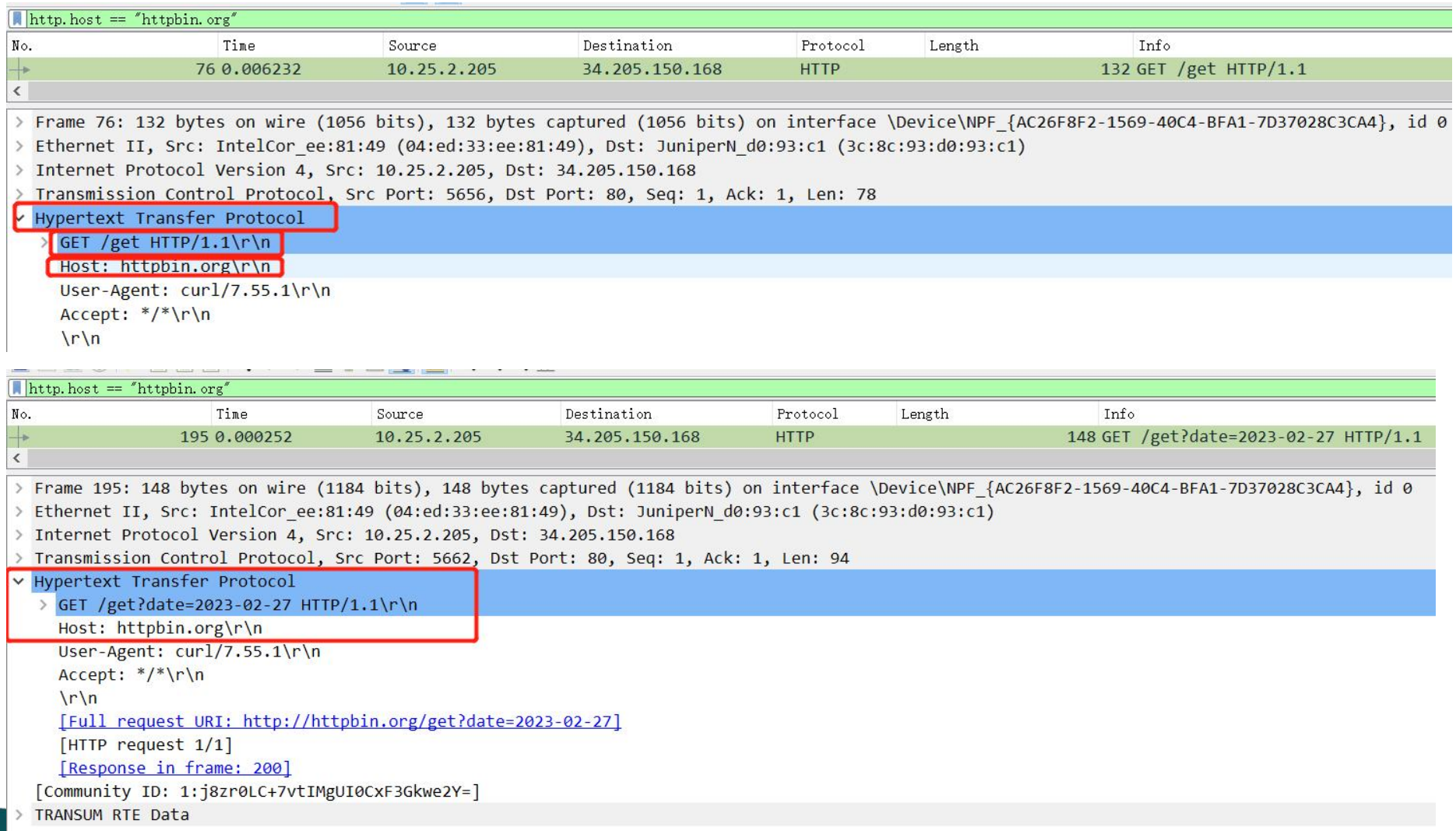
Wireshark: Capture HTTP Request

- Wireshark is a free and open source packet analyzer. It is used for network troubleshooting, analysis, software and communications protocol development, and education.





Tips: When using http.host == "***" as a display filter, only HTTP request packet will be showed, as here "host" represents a specified field, instead of a network endpoint.



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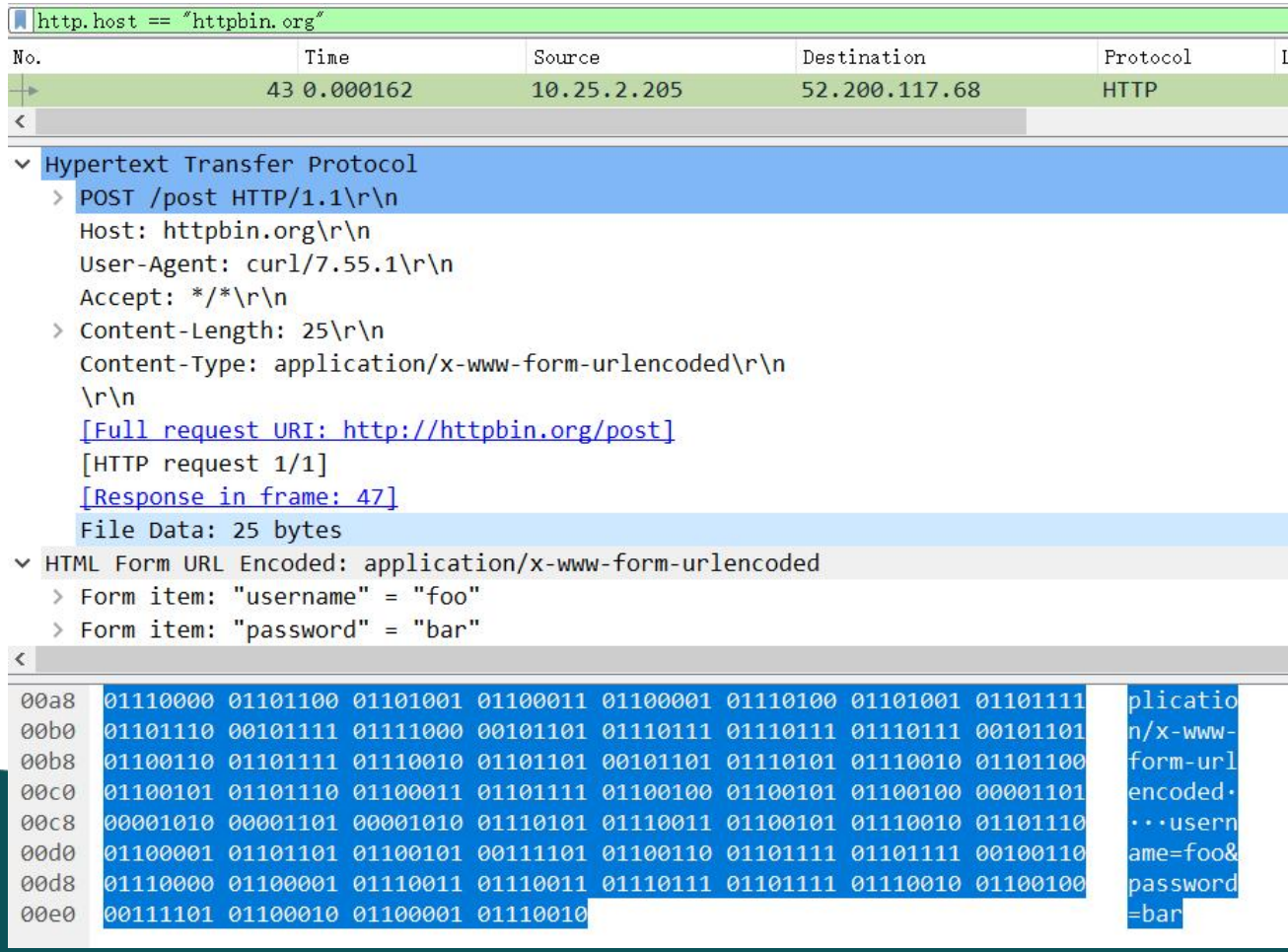
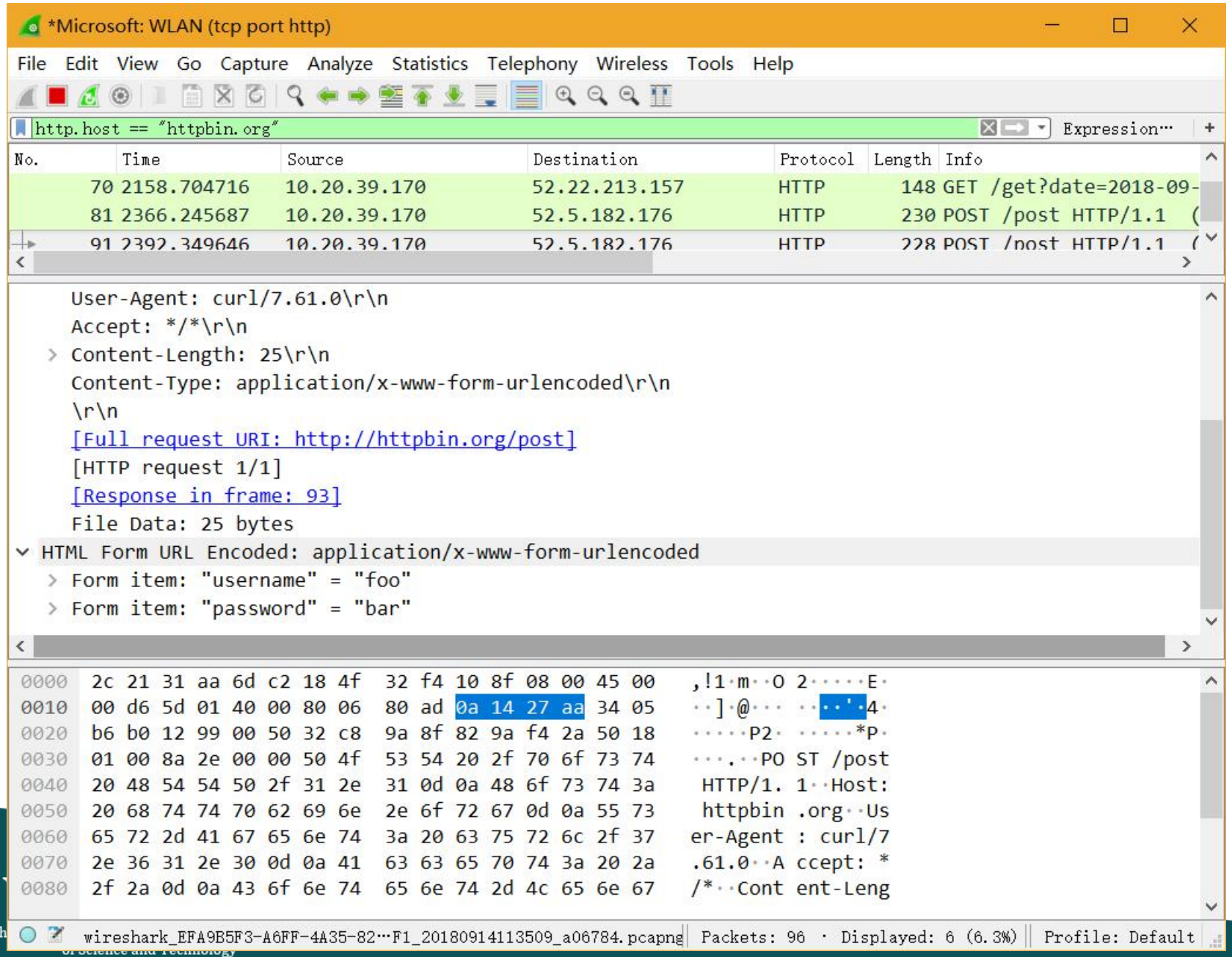
cURL: Inspect POST request

$ curl -d "username=foo&password=bar" -X POST http://httpbin.org/post

```
{
  "args": {},
  "data": "",
  "files": {},
  "form": {
    "password": "bar",
    "username": "foo"
  },
  "headers": {
    ...
}
```




*Microsoft: WLAN (tcp port http)
File Edit View Go Capture Analyze Statistics Telephony Wireless Tools Help
http.host == "httpbin.org"
Expression…
No. Time Source Destination Protocol Length Info
70 2158.704716 10.20.39.170 52.22.213.157 HTTP 148 GET /get?date=2018-09-
81 2366.245687 10.20.39.170 52.5.182.176 HTTP 230 POST /post HTTP/1.1
91 2392.349646 10.20.39.170 52.5.182.176 HTTP 228 POST /post HTTP/1.1
User-Agent: curl/7.61.0\r\n
Accept: */*\r\n
Content-Length: 25\r\n
Content-Type: application/x-www-form-urlencoded\r\n
\r\n
[Full request URI: http://httpbin.org/post]
[HTTP request 1/1]
[Response in frame: 93]
File Data: 25 bytes
HTML Form URL Encoded: application/x-www-form-urlencoded
Form item: "username" = "foo"
Form item: "password" = "bar"
0000 2c 21 31 aa 6d c2 18 4f 32 f4 10 8f 08 00 45 00 ,!1·m··O 2·····E·
0010 00 d6 5d 01 40 00 80 06 80 ad 0a 14 27 aa 34 05 ··]·@··· ····'·4·
0020 b6 b0 12 99 00 50 32 c8 9a 8f 82 9a f4 2a 50 18 ·····P2· ·····*P·
0030 01 00 8a 2e 00 00 50 4f 53 54 20 2f 70 6f 73 74 ····.··PO ST /post
0040 20 48 54 54 50 2f 31 2e 31 0d 0a 48 6f 73 74 3a HTTP/1. 1··Host:
0050 20 68 74 74 70 62 69 6e 2e 6f 72 67 0d 0a 55 73 httpbin .org··Us
0060 65 72 2d 41 67 65 6e 74 3a 20 63 75 72 6c 2f 37 er-Agent : curl/7
0070 2e 36 31 2e 30 0d 0a 41 63 63 65 70 74 3a 20 2a .61.0··A ccept: *
0080 2f 2a 0d 0a 43 6f 6e 74 65 6e 74 2d 4c 65 6e 67 /*··Cont ent-Leng
wireshark_EFA9B5F3-A6FF-4A35-82…F1_20180914113509_a06784.pcapng
Packets: 96 · Displayed: 6 (6.3%)
Profile: Default

Practice 3.2

- Try to use following URLs to invoke several http sessions:
  - http://www.sustech.edu.cn
  - https://www.sustech.edu.cn
  - http://sustech.edu.cn
  - https://sustech.edu.cn
  - http://sina.com.cn
  - http://www.sina.com.cn
  - https://www.sina.com.cn

  Use curl or Wireshark to find:

  1) the status code of the http responses, and explain the meanings.

  2) the port number of the server.