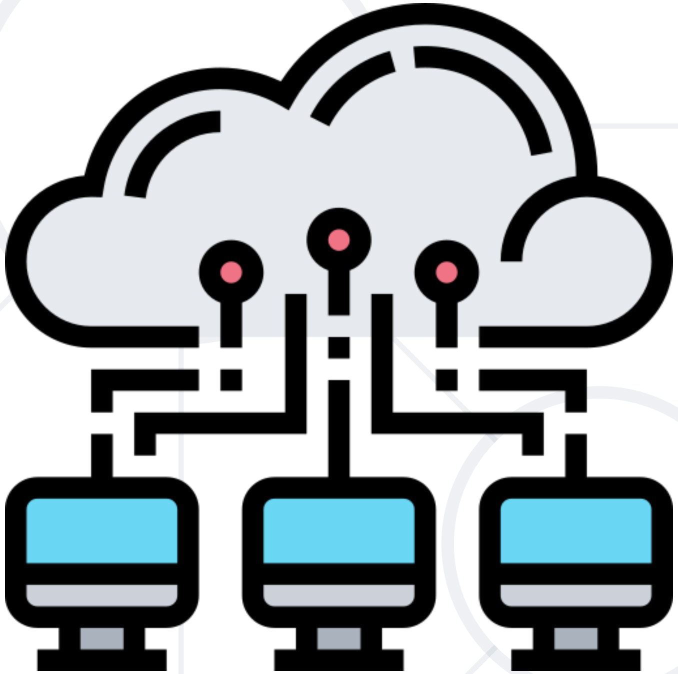
Networks, Internet and Protocols

Network Fundamentals, Network Services



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Have a Question?

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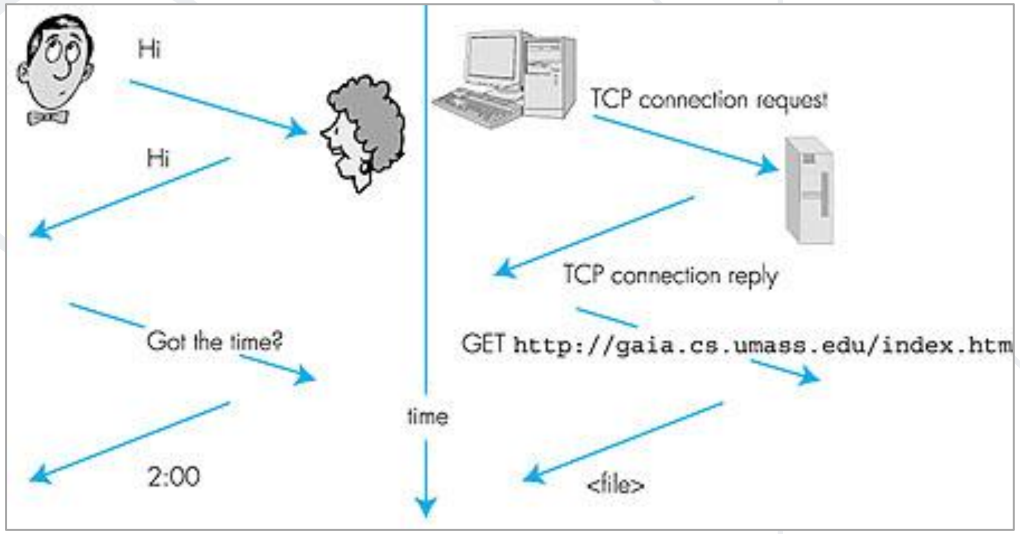
Network Fundamentals

OSI Model, MAC address, IP address, TCP and ports

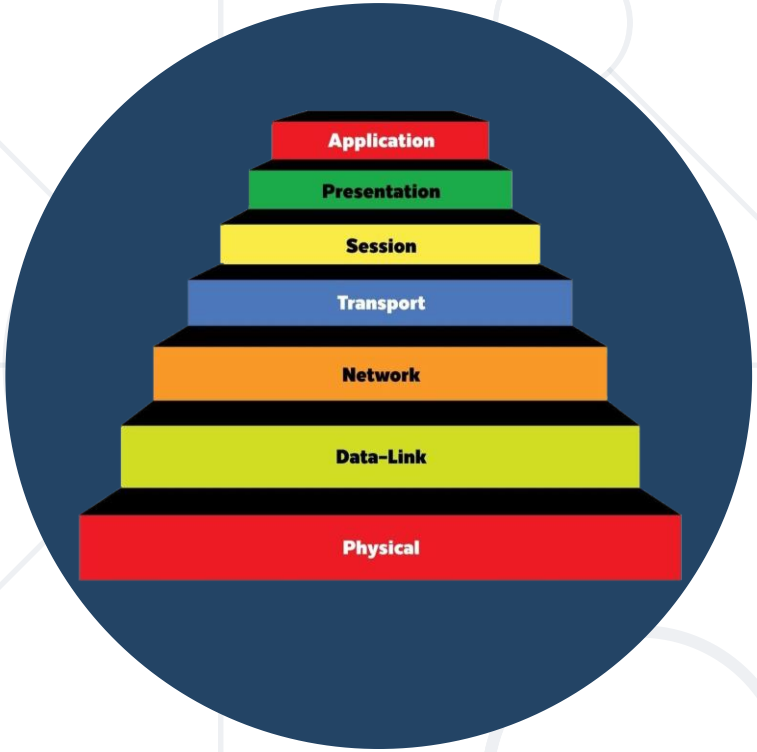
What is a Network Protocol?

- A **set of rules** that determine how data is transmitted between different devices in the same network
- Enable **standardized communication** between devices
- Govern aspects of **data transmission**, **addressing**, **routing**, and **error handling**
- Work in **conjunction** to **facilitate communication**



Layering Models

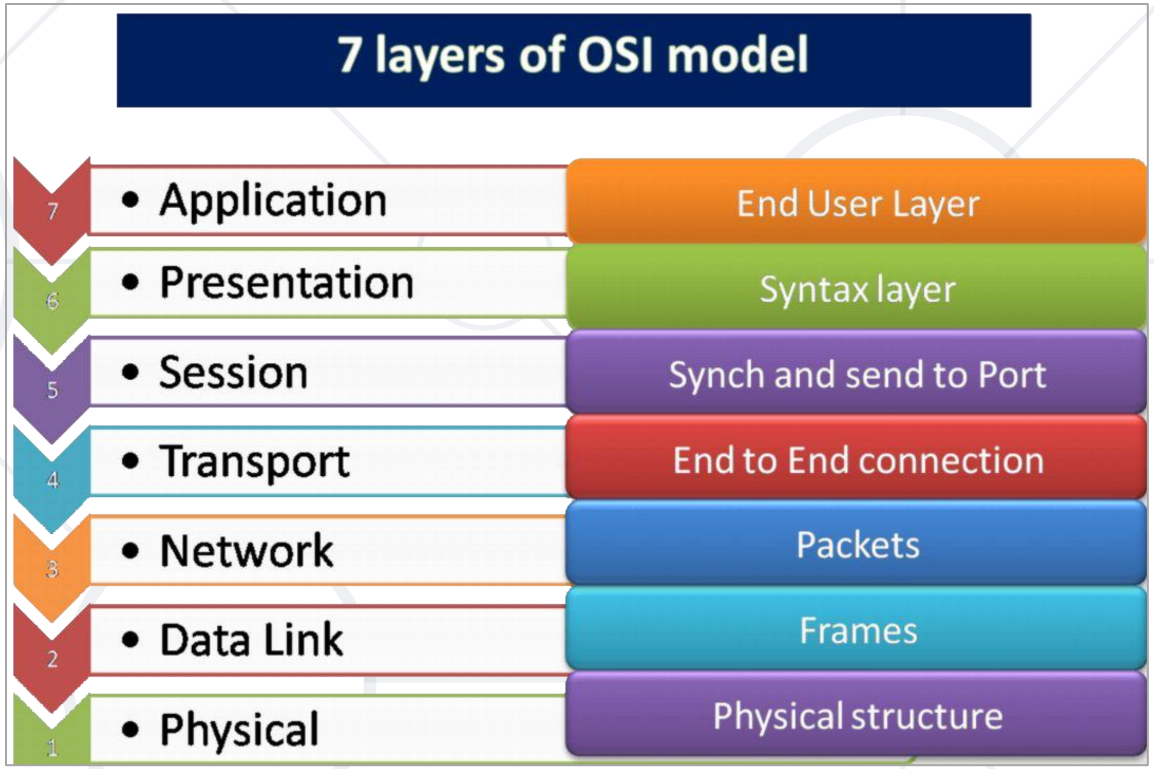
- **Organize** network protocols into a **structured framework**
- Facilitate the understanding, design, and management of **complex networks**
- **Simplifies** network communication and troubleshooting
- Encourages protocol **interoperability** and **modularity**
- **Examples:**
  - **OSI** Model
  - **TCP/IP** Model


Application
Presentation
Session
Transport
Network
Data-Link
Physical

OSI Model

OSI Model Overview

- The **OSI Model** /**Open Systems Interconnection Model**/
- Developed by the International Organization for Standardization (**ISO**) in the **1970s**
- **Framework** for understanding and designing network protocols and communication
- **7 layers**
- **Key concept** - **Each layer adds functionality** to the data transmitted



7 layers of OSI model

7	• Application	End User Layer
6	• Presentation	Syntax layer
5	• Session	Synch and send to Port
4	• Transport	End to End connection
3	• Network	Packets
2	• Data Link	Frames
1	• Physical	Physical structure

OSI Model Layers

- Physical Layer (Layer 1)
  - **Converts digital data** into electrical, radio, or optical signals for transmission
  - **Devices -** Hubs, switches, routers, modems, network interface cards (NICs)
  - **Standards -** Ethernet, Wi-Fi, Bluetooth, USB, DSL
- Data Link Layer (Layer 2)
  - **Manages data transmission** between nodes, error detection / correction
  - **MAC Address** - Unique identifier for network interfaces
  - **Protocols -** Ethernet, Point-to-Point Protocol (PPP), Frame Relay
  - **Devices** - Switches, bridges

OSI Model Layers (2)

- Network Layer (Layer 3)
  - **Routing algorithms -** Shortest Path First (SPF), Distance Vector (DV), Link State (LS)
  - **Devices -** Routers, Layer 3 switches
  - **Protocols -** Internet Protocol (IP), Internet Control Message Protocol (ICMP), Ipsec

- Transport Layer (Layer 4)
  - **Error checking**, flow control, congestion control, multiplexing
  - **TCP -** Ensures data is received in order, guarantees delivery using ACKs and retransmissions
  - **UDP -** Fast, best-effort delivery without connection setup or error recovery

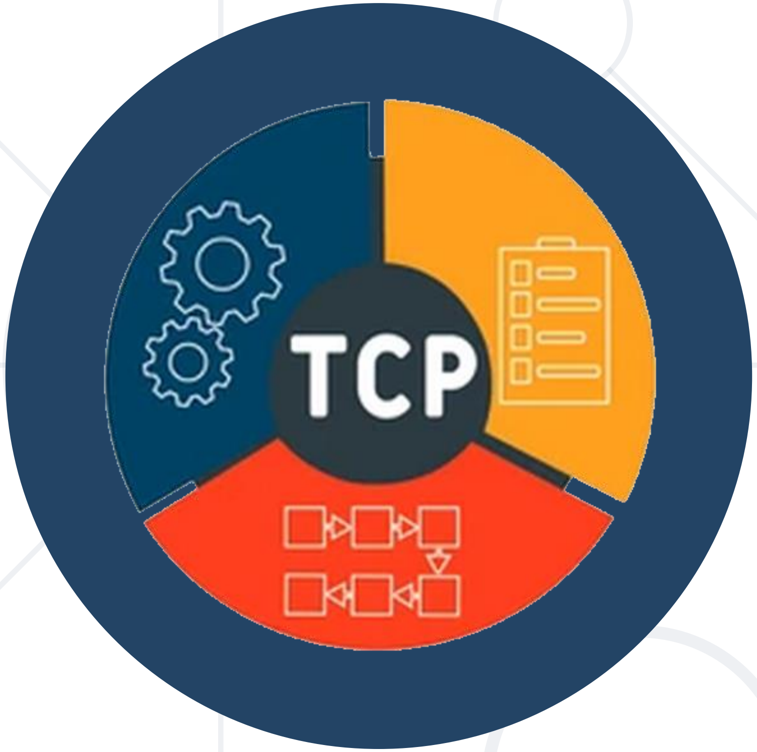
OSI Model Layers (3)

- Session Layer (Layer 5)
  - **Functions -** Dialog control, token management, synchronization
  - **Protocols -** Remote Procedure Call (RPC), Session Initiation Protocol (SIP), Network File System (NFS)

- Presentation Layer (Layer 6)
  - **Functions -** Data representation, encryption, decryption, compression, decompression
  - **Standards -** Secure Sockets Layer (SSL), Transport Layer Security (TLS), ASCII, Unicode, JPEG, MPEG

OSI Model Layers (4)

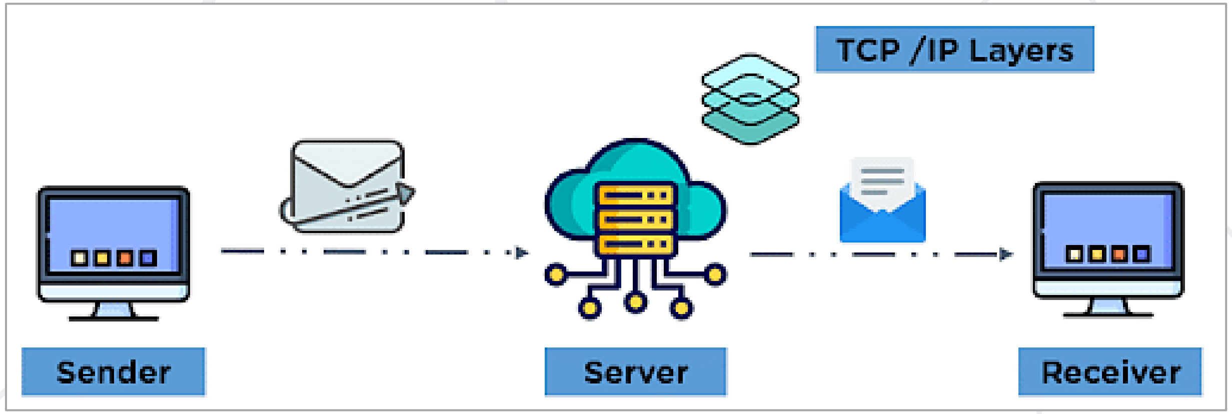
- Application Layer (Layer 7)
  - **User interface** for networked applications
  - **Protocols**
    - Hypertext Transfer Protocol (**HTTP**)
    - File Transfer Protocol (**FTP**)
    - Simple Mail Transfer Protocol (**SMTP**)
    - Domain Name System (**DNS**)
    - Telnet
    - Secure Shell (**SSH**)



TCP/IP Model

TCP/IP Model

- Transmission Control Protocol / Internet Protocol Model
- **Developed** by the Department of Defense (**DoD**) in the **1970s** as part of the ARPANET project, the precursor to the modern internet
- 4 layers - **Simplified version** with fewer layers
- Designed with a **focus on robustness, resilience,** and **scalability**



TCP/IP Layers

- Link Layer
  - Combines the **functionalities of OSI Physical and Data Link layers**
  - Transmission and reception of data packets over a physical medium
  - Management of data link connections
- Internet Layer
  - **Corresponds to the OSI Network Layer**
  - Handling the logical addressing and routing of data packets

TCP/IP Layers

- **Transport Layer**
  - Closely **resembles the OSI Transport Layer**
- **Application Layer**
  - **Merges** the functionalities of **OSI Session, Presentation, and Application layers**

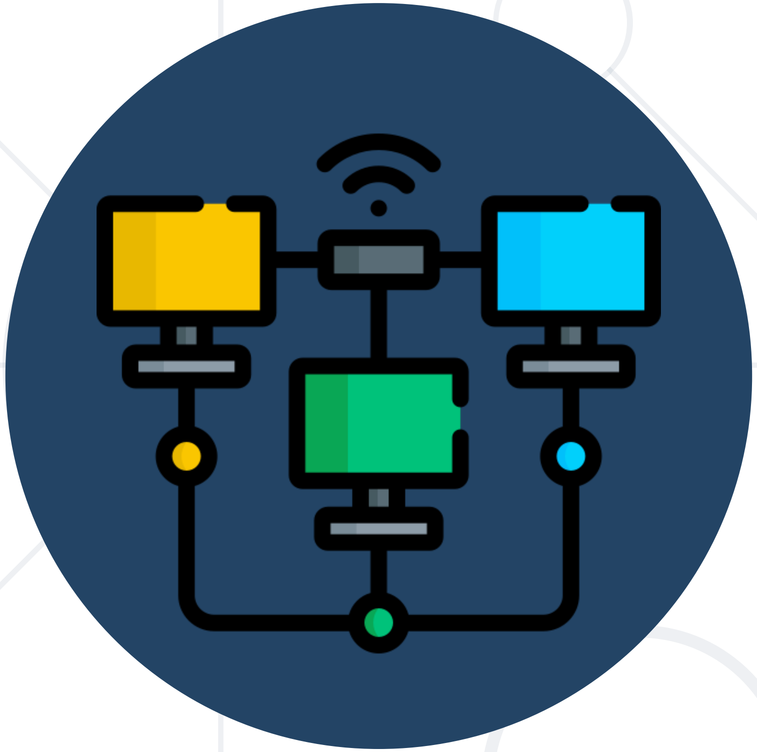
Mac, IP

MAC Address

- **Media Access Control (MAC) address** is a unique hardware identifier assigned to network interface cards (NICs)
- **Facilitate communication** at the Data Link Layer (Layer 2) in the OSI Model and the Link Layer in the TCP/IP Model
- **Format**
  - 48-bit (6-byte) or 64-bit (8-byte) hexadecimal number
  - Typically represented as six pairs of hexadecimal digits separated by colons or hyphens (e.g., 01:23:45:67:89:AB)
- **Generally hardcoded** by the manufacturer
- Can be manually changed in some cases

IP Address

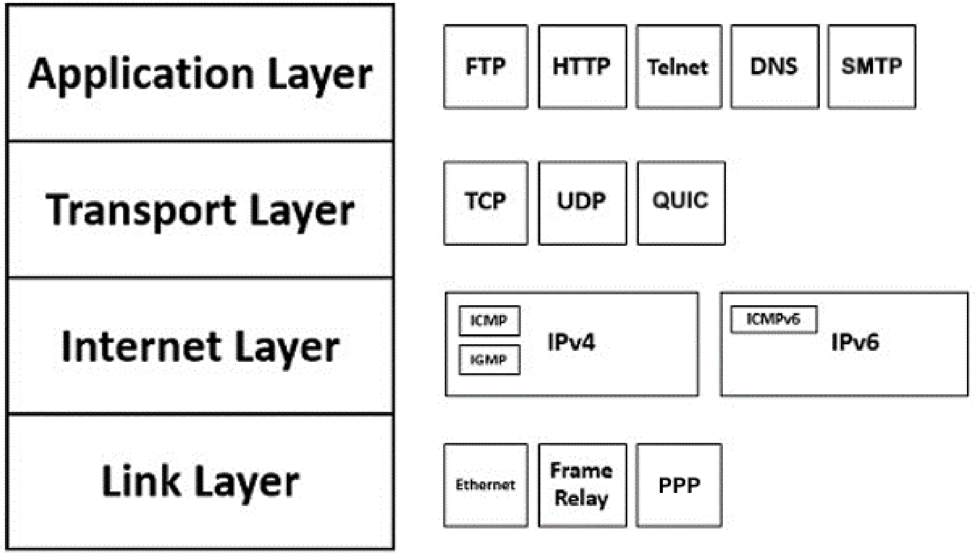
- **Internet Protocol (IP) address** - numerical identifier assigned to devices in a network for routing and addressing purposes
- Facilitate the **identification and location** of devices on a network
- Used at the Network Layer (Layer 3) in the OSI Model and the Internet Layer in the TCP/IP Model
- Types:
  - **IPv4:** 32-bit addresses, four decimal numbers separated by periods
  - **IPv6:** 128-bit addresses
- Assigned **statically (manually)** or **dynamically (using DHCP)**



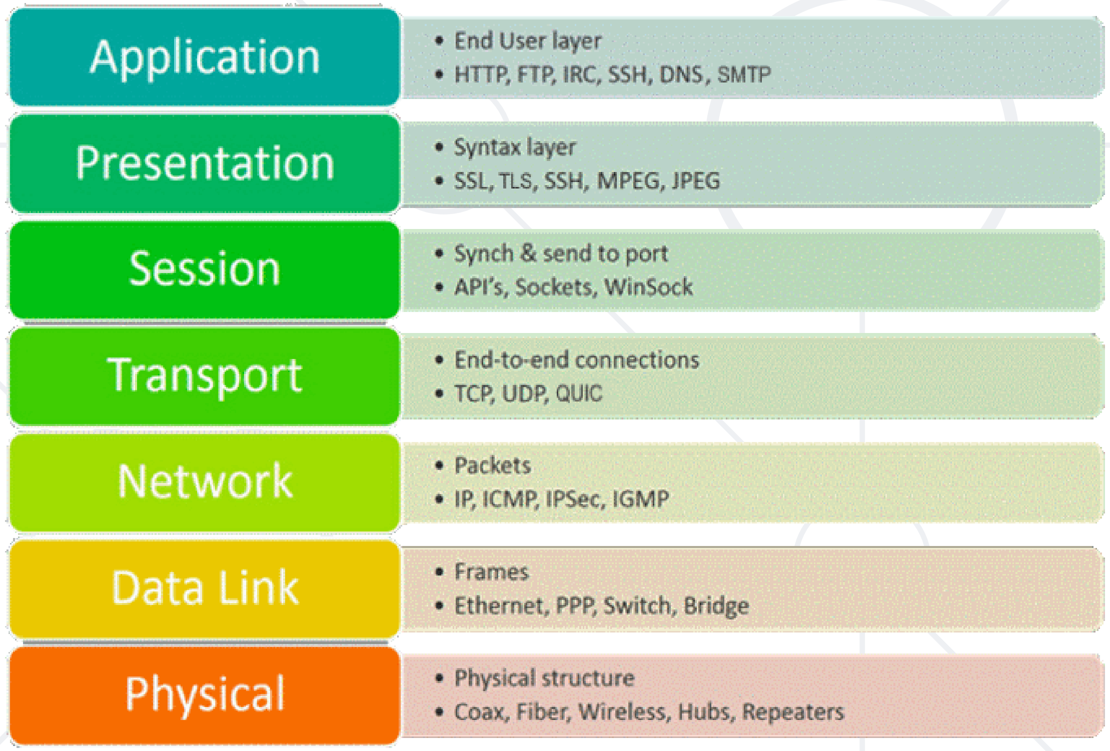
Networking Summary

Networking and Internet Protocols Summary

- Communication in Internet uses **networking protocols**
  - The OSI model defines 7 layers of networking protocols
  - The TCP/IP protocol suite



Application Layer	FTP, HTTP, Telnet, DNS, SMTP
Transport Layer	TCP, UDP, QUIC
Internet Layer	ICMP, IGMP, IPv4 ICMPv6, IPv6
Link Layer	Ethernet, Frame Relay, PPP

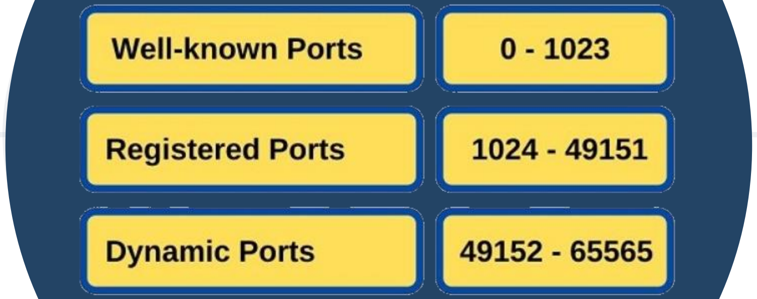


Application	• End User layer • HTTP, FTP, IRC, SSH, DNS, SMTP
Presentation	• Syntax layer • SSL, TLS, SSH, MPEG, JPEG
Session	• Synch & send to port • API's, Sockets, WinSock
Transport	• End-to-end connections • TCP, UDP, QUIC
Network	• Packets • IP, ICMP, IPSec, IGMP
Data Link	• Frames • Ethernet, PPP, Switch, Bridge
Physical	• Physical structure • Coax, Fiber, Wireless, Hubs, Repeaters

Key Network Protocols

- **IP (Internet Protocol):** Handles addressing and communication between devices
- **TCP (Transmission Control Protocol):** Complements IP, focuses on the reliable transport of data packets; uses ports to distinguish connections
- **UDP (User Datagram Protocol):** Similar to TCP, connectionless, faster, has no error checking; uses ports for communication
- **ICMP (Internet Control Message Protocol):** Used by networking devices, e.g. routers for error reporting and diagnostics
- **QUIC (Quick UDP Internet Connections):** Developed by Google, TCP alternative, combines features of TCP and UDP to reduce latency and improve security; often used with HTTP

* Brief list of commonly encountered protocols



Well-known Ports	0 - 1023
Registered Ports	1024 - 49151
Dynamic Ports	49152 - 65565

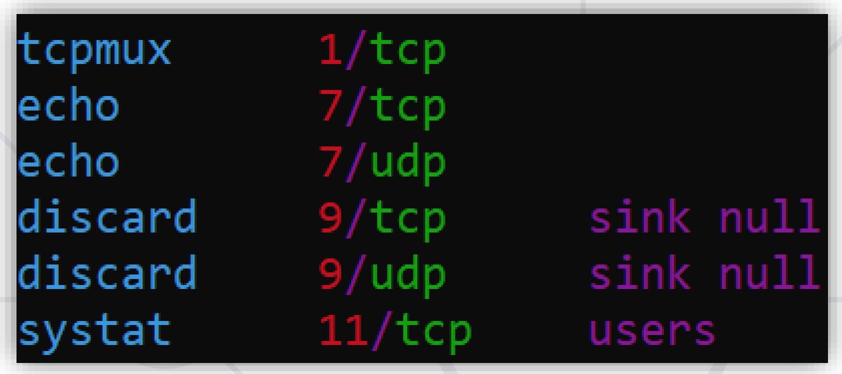
Ports

Ports Overview

- **Numerical identifiers** used to distinguish specific processes or services running on a device within a network
- Facilitate end-to-end communication between applications on different devices
- **Types of Ports**
  - **TCP ports -** Used for connection-oriented communication, ensuring reliability and data integrity
  - **UDP ports -** Used for connectionless communication, providing faster data transmission with minimal overhead

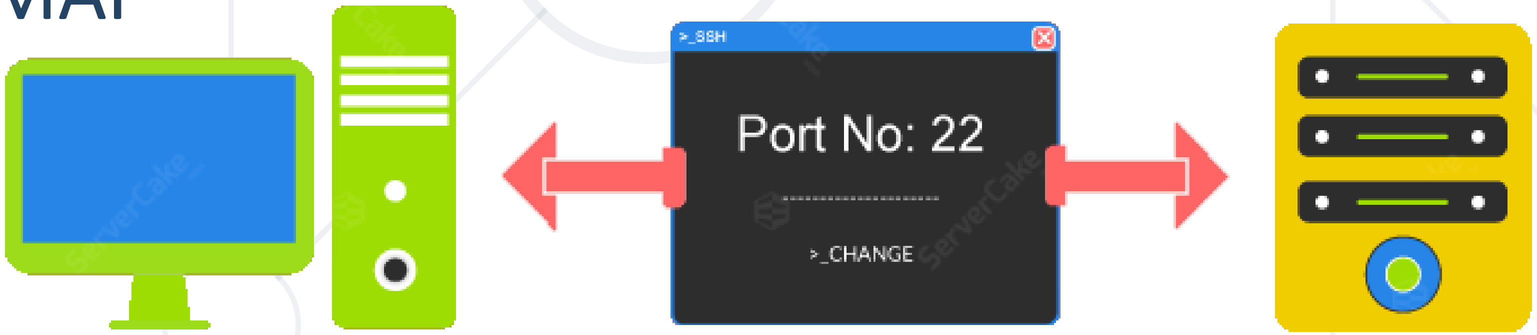
Port Numbers

- Used to **identify** a network service
- Network services registry in `/etc/services`
- Some of them are:
  - **22** – SSH, **53** – DNS, **80** – HTTP, **110** – POP3, **123** – NTP , **143** – IMAP



```
tcpmux        1/tcp
echo          7/tcp
echo          7/udp
discard       9/tcp        sink null
discard       9/udp        sink null
systat        11/tcp       users
```

Ports	Port Numbers
Well-known (or system) ports	**0 – 1023**
Registered (or user) ports	**1024 – 49151**
Dynamic (and / or private) ports	**49152 – 65535**



Web Fundamentals

WWW, Domains, DNS, URL

WWW

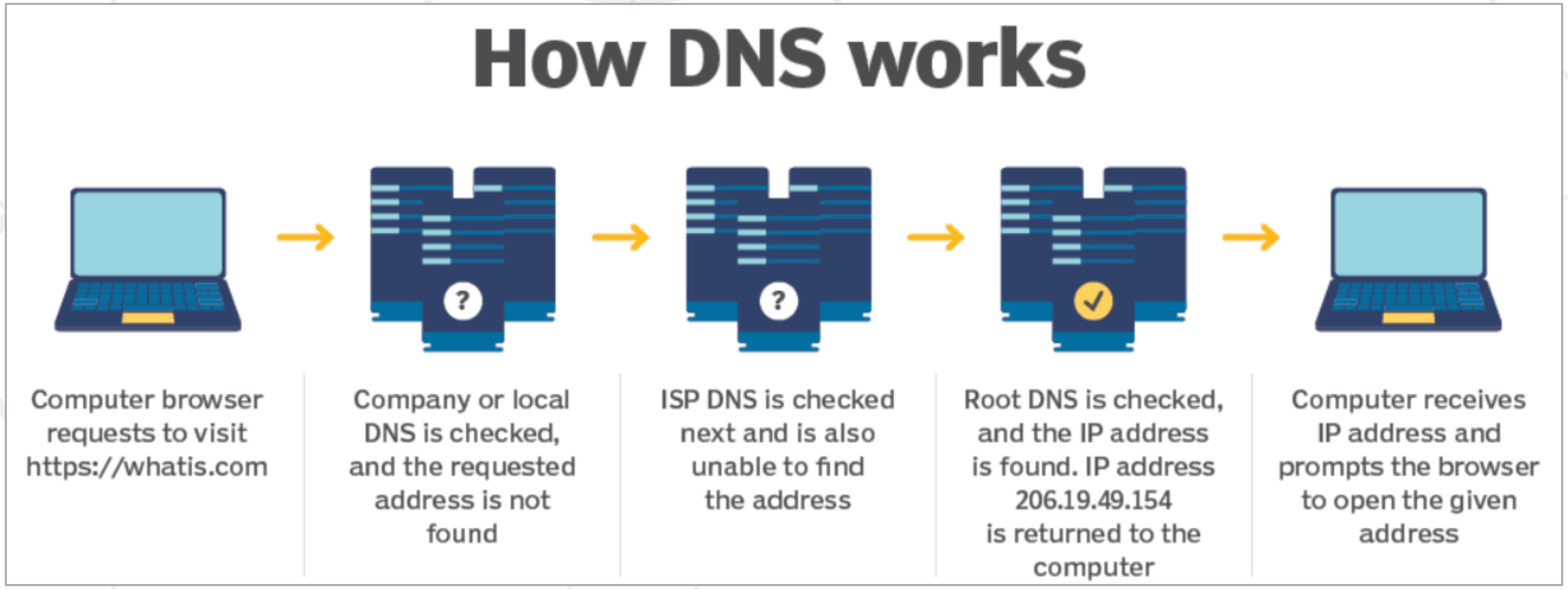
- A **global**, **interconnected system** of documents, images, and other resources, accessed through the internet using web browsers
- Invented by Sir Tim Berners-Lee in 1989 at CERN
- How the **Web Works**
  - **Hyperlinks -** Connect resources across the web, allowing users to navigate between them
  - **Web Servers -** Host and serve resources, making them accessible to web browsers
  - **Web Browsers -** Retrieve and display resources, allowing users to interact with the web

Domain Names

- A **unique**, human-readable **name** that **identifies a website**
- **Simplify navigation** and accessibility to websites, making it easier to remember and share
- **Structure**
  - **Top-Level Domains (TLDs)** - domain extensions, e.g., .com, .org, .net, .us, .uk, .de
  - **Second-Level Domains (SLDs)** - website's name, e.g., "example" in example.com
  - **Subdomains** - additional sections of a website, e.g., "blog" in blog.example.com

Domain Name System (DNS)

- A hierarchical, distributed database that **translates domain names into IP addresses**
- Facilitates the resolution of human-readable domain names to machine-readable IP addresses



How DNS works

Computer browser requests to visit https://whatis.com

Company or local DNS is checked, and the requested address is not found

ISP DNS is checked next and is also unable to find the address

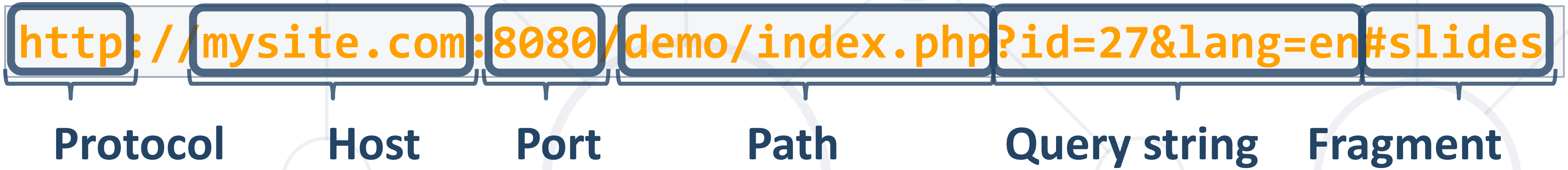
Root DNS is checked, and the IP address is found. IP address 206.19.49.154 is returned to the computer

Computer receives IP address and prompts the browser to open the given address

What is a URL?

- A **URL**, short for a **uniform resource locator** is a web address pointing to a specific website, a web page, or a document on the internet.
- **Structure-wise**, a URL consists of multiple **elements**
  - Communication protocol
  - Subdomain
  - Domain name
  - Domain extension
  - Path to the resource
  - Parameters, etc.

Uniform Resource Locator (URL) Example



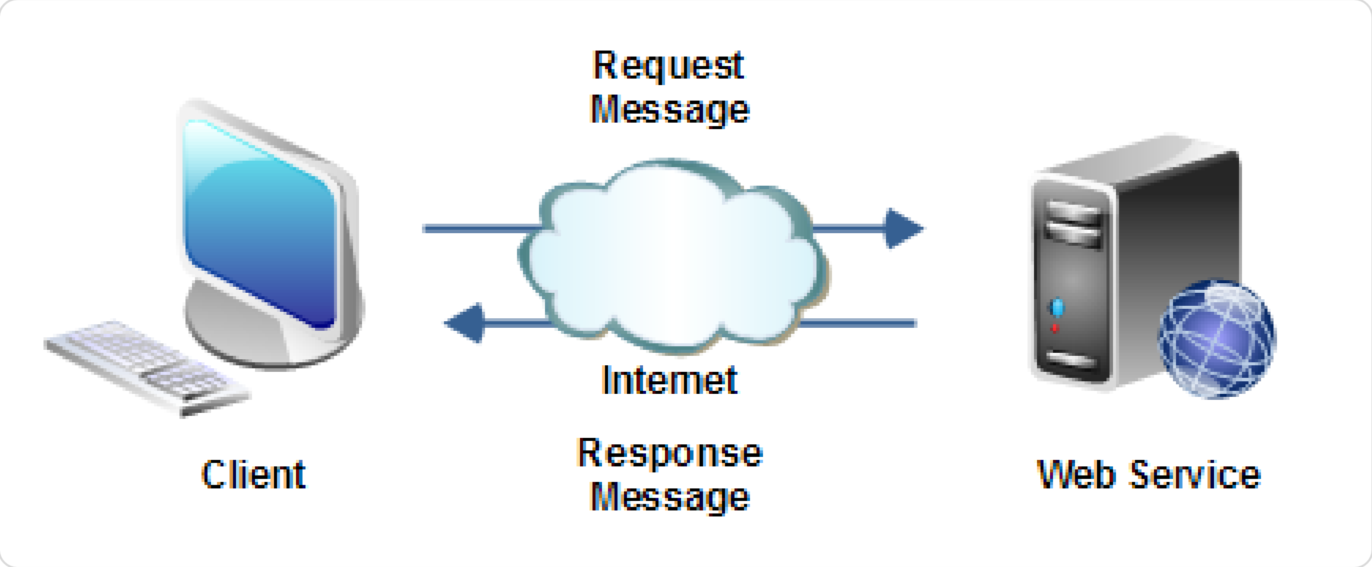
`http://mysite.com:8080/demo/index.php?id=27&lang=en#slides`

Protocol Host Port Path Query string Fragment

- **Network protocol** (`http`, `ftp`, `https`…) – HTTP in most cases
- **Host, Domain** or **IP** address (`softuni.org`, `gmail.com`, `127.0.0.1`, `web`)
- **Port** (the default port is **80**) – integer in the range [0…65535]
- **Path** (`/forum`, `/path/index.php`)
- **Query string** (`?id=27&lang=en`)
- **Fragment** (`#slides`) – navigate to some section in the page

What is Web Service?

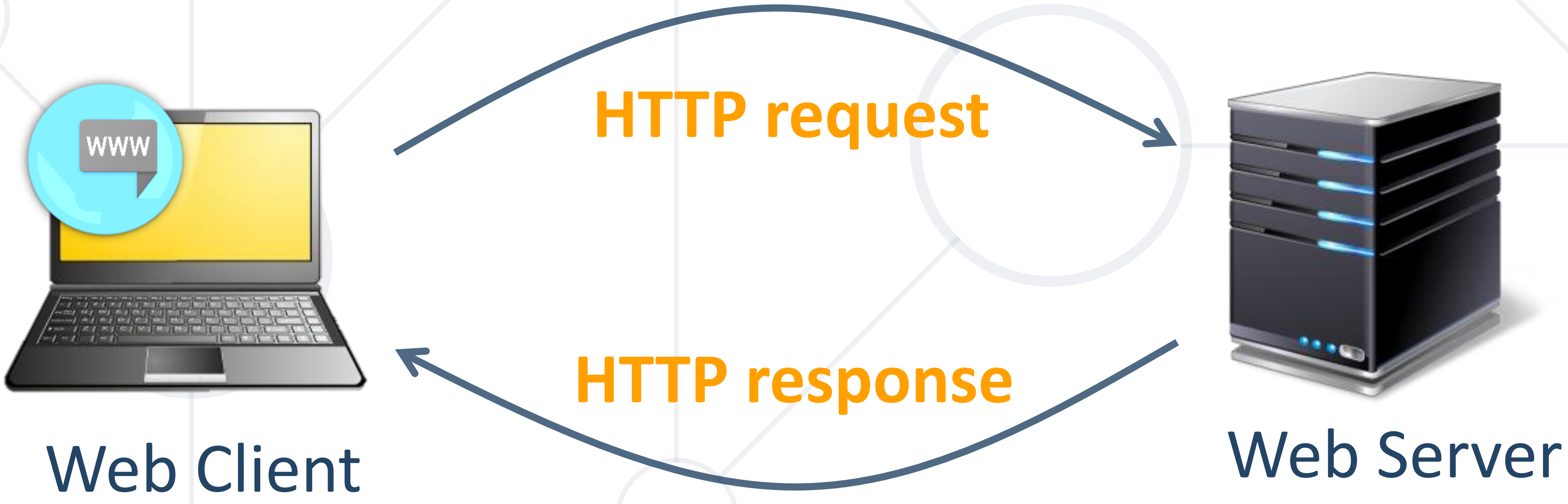
- **Web services** implement **communication** between software **systems** or **components** of over the **network**
  - Using standard **protocols**, such as HTTP, JSON and XML
  - Exchanging **messages**, holding data and operations



HTTP Protocol – Basics

HTTP Basics

- **HTTP** (**H**yper**T**ext **T**ransfer **P**rotocol)
  - **Text-based** client-server protocol for the Internet
  - For transferring **Web resources** (HTML files, images, styles, etc.)
  - **Request-response** based



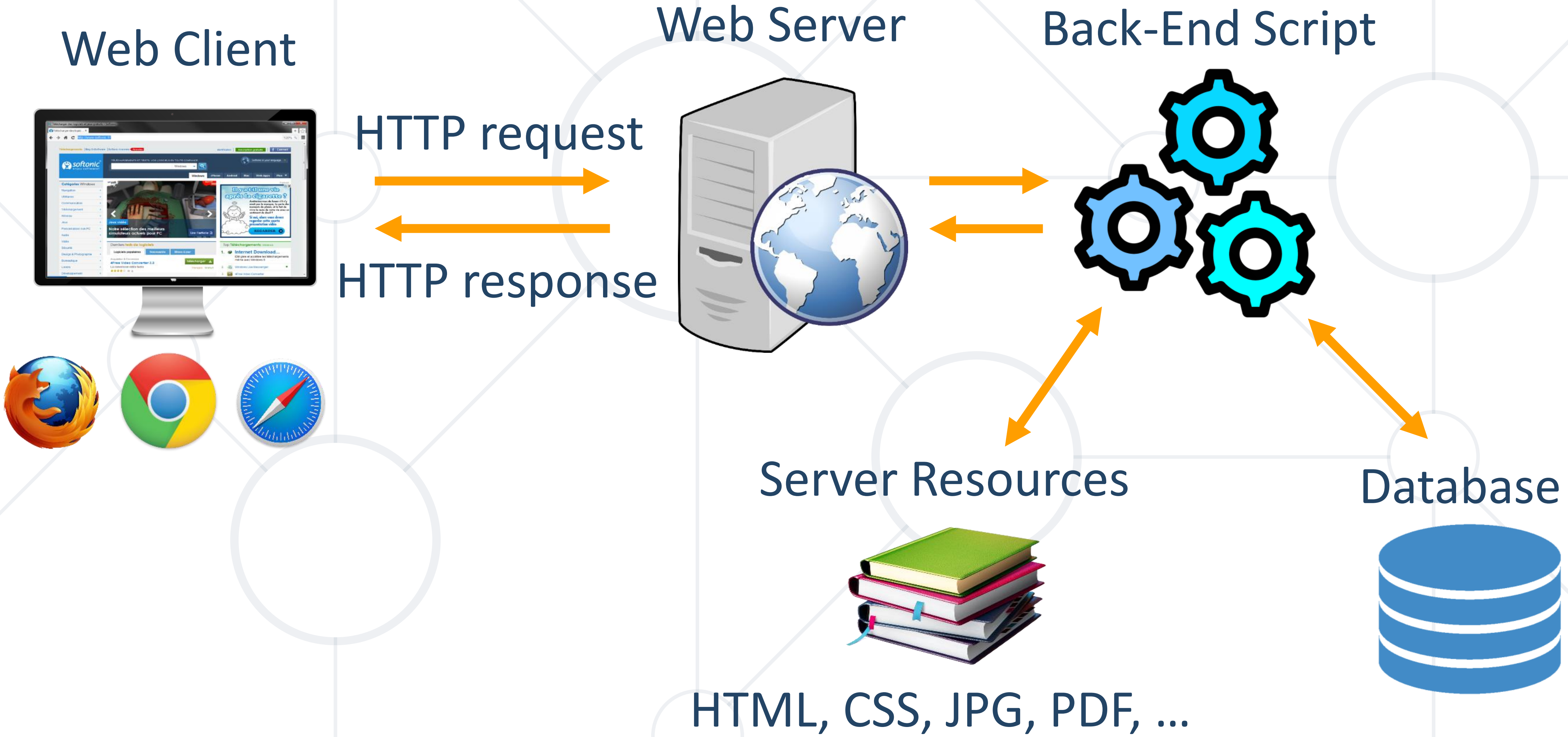
HTTP request

HTTP response

Web Client

Web Server

Web Server Work Model



Web Client

HTTP request

HTTP response

Web Server

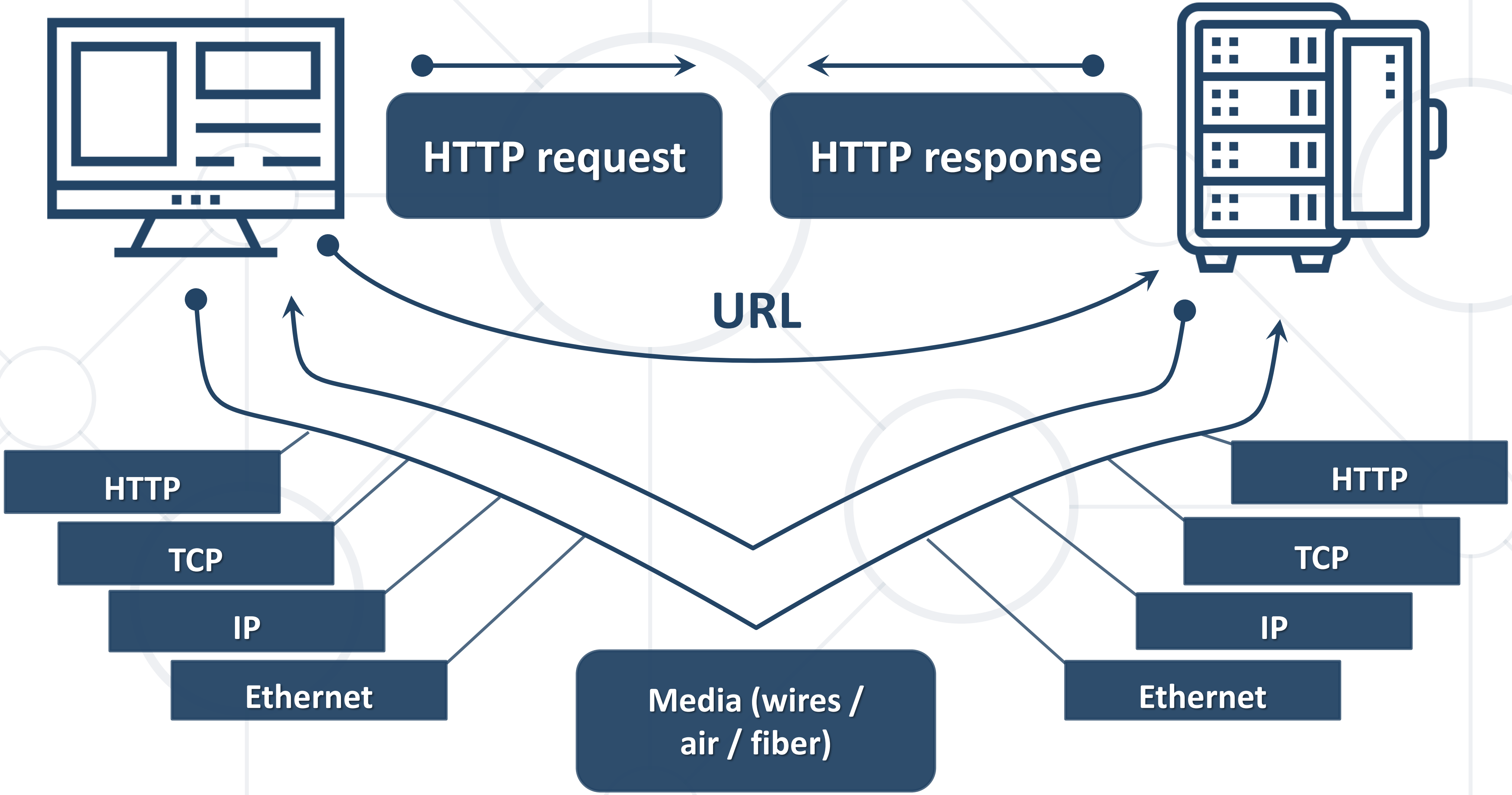
Back-End Script

Server Resources

HTML, CSS, JPG, PDF, …

Database

Network Layers and HTTP



HTTP request

HTTP response

URL

HTTP

TCP

IP

Ethernet

Media (wires / air / fiber)

HTTP

TCP

IP

Ethernet

HTTP Request Methods

- **HTTP request methods** specify the desired **action** to be performed on the requested resource (identified by URL)

Method	Description
GET	Retrieve a resource
POST	Create / store a resource
PUT	Update (replace) a resource
DELETE	Delete (remove) a resource
PATCH	Update resource partially (modify)
HEAD	Retrieve the resource's headers

CRUD == the four main functions of persistent storage

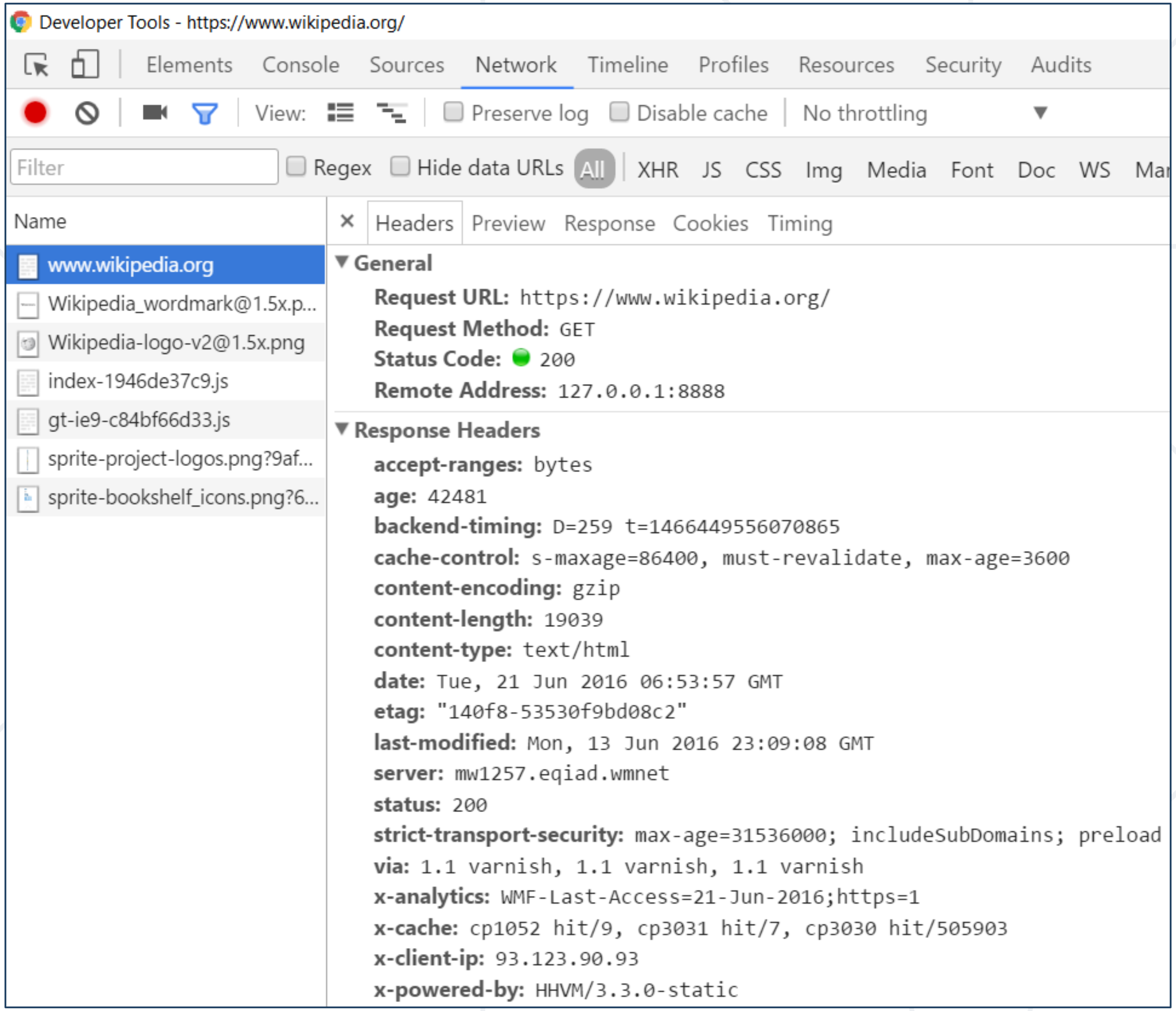
Other Methods
CONNECT
OPTIONS
TRACE

HTTP Response Status Codes

Status Code	Action	Description	
200	OK	Successfully retrieved resource	Success
201	Created	A new resource was created	
204	No Content	Request has nothing to return	
301 / 302	Moved	Moved to another location (redirect)	Redirect
400	Bad Request	Invalid request / syntax error	Error
401 / 403	Unauthorized	Authentication failed / access denied	
404	Not Found	Invalid resource requested	
409	Conflict	Conflict detected, e.g. duplicated email	
500 / 503	Server Error	Internal server error / service unavailable	

HTTP Dev Tools

HTTP Developer Tools: Network Inspector



- www.wikipedia.org
- Wikipedia_wordmark@1.5x.p...
- Wikipedia-logo-v2@1.5x.png
- index-1946de37c9.js
- gt-ie9-c84bf66d33.js
- sprite-project-logos.png?9af...
- sprite-bookshelf_icons.png?6...

▼ General

Request URL: `https://www.wikipedia.org/`
Request Method: GET
Status Code: ● 200
Remote Address: 127.0.0.1:8888

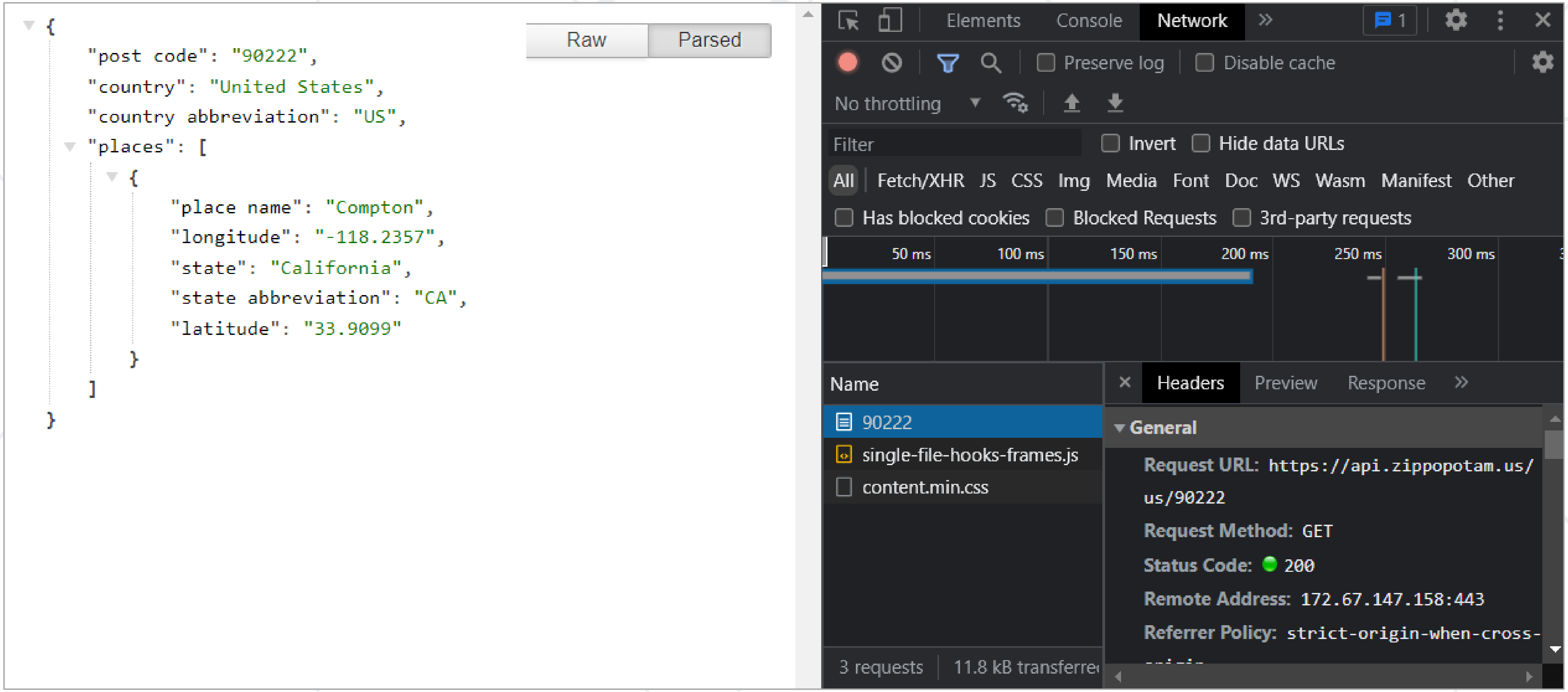
▼ Response Headers

accept-ranges: bytes
age: 42481
backend-timing: D=259 t=1466449556070865
cache-control: s-maxage=86400, must-revalidate, max-age=3600
content-encoding: gzip
content-length: 19039
content-type: text/html
date: Tue, 21 Jun 2016 06:53:57 GMT
etag: "140f8-53530f9bd08c2"
last-modified: Mon, 13 Jun 2016 23:09:08 GMT
server: mw1257.eqiad.wmnet
status: 200
strict-transport-security: max-age=31536000; includeSubDomains; preload
via: 1.1 varnish, 1.1 varnish, 1.1 varnish
x-analytics: WMF-Last-Access=21-Jun-2016;https=1
x-cache: cp1052 hit/9, cp3031 hit/7, cp3030 hit/505903
x-client-ip: 93.123.90.93
x-powered-by: HHVM/3.3.0-static

- Chrome Developer Tools
  - Press **[F12]** in Chrome
  - Open the [Network] tab
  - Inspect the HTTP traffic

Requests Demo

- https://api.zippopotam.us/us/90222



```
{
    "post code": "90222",
    "country": "United States",
    "country abbreviation": "US",
    "places": [
        {
            "place name": "Compton",
            "longitude": "-118.2357",
            "state": "California",
            "state abbreviation": "CA",
            "latitude": "33.9099"
        }
    ]
}
```

Name:
- 90222
- single-file-hooks-frames.js
- content.min.css

3 requests | 11.8 kB transferre

General

Request URL: https://api.zippopotam.us/us/90222

Request Method: GET

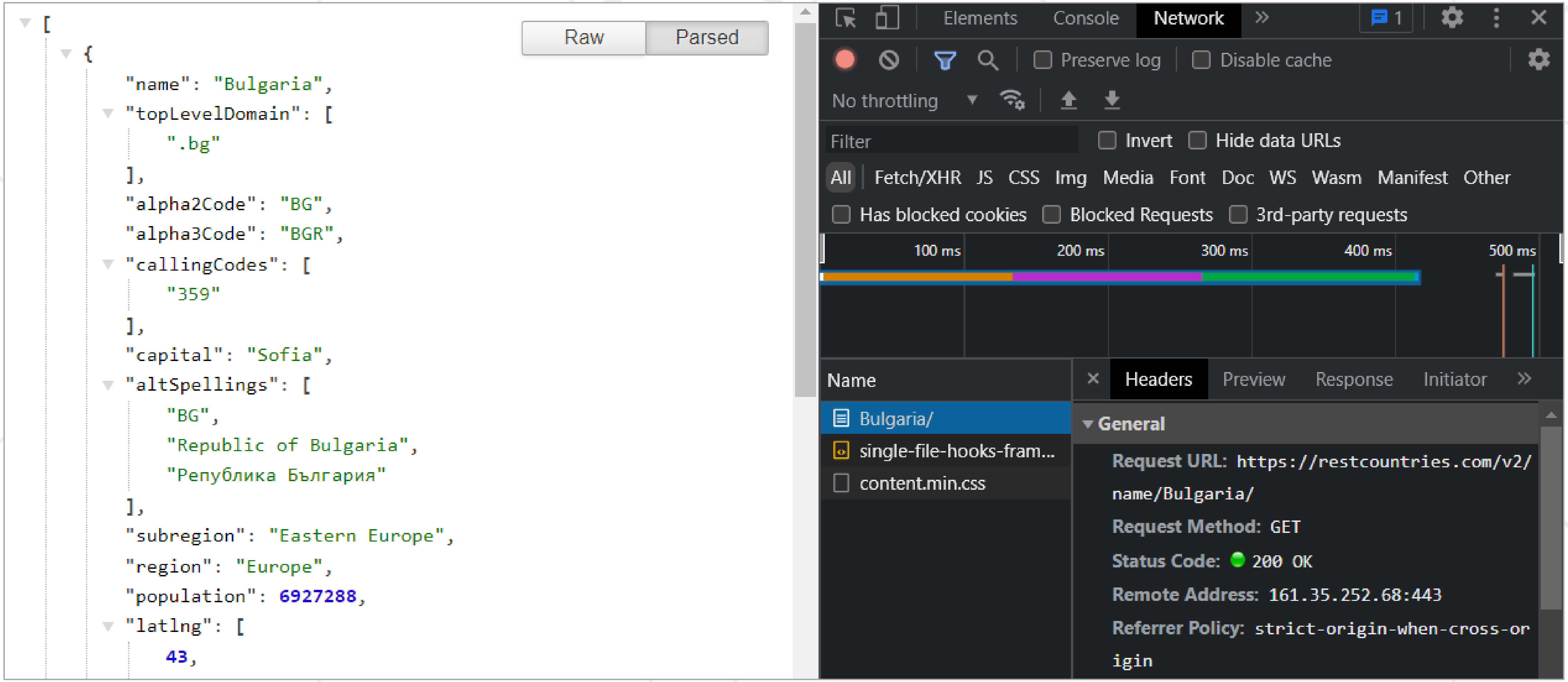
Status Code: ● 200

Remote Address: 172.67.147.158:443

Referrer Policy: strict-origin-when-cross-origin

Requests Demo (2)

- https://restcountries.com/v2/name/Bulgaria



```
[
  {
    "name": "Bulgaria",
    "topLevelDomain": [
      ".bg"
    ],
    "alpha2Code": "BG",
    "alpha3Code": "BGR",
    "callingCodes": [
      "359"
    ],
    "capital": "Sofia",
    "altSpellings": [
      "BG",
      "Republic of Bulgaria",
      "Република България"
    ],
    "subregion": "Eastern Europe",
    "region": "Europe",
    "population": 6927288,
    "latlng": [
      43,
```

Request URL: https://restcountries.com/v2/name/Bulgaria/

Request Method: GET

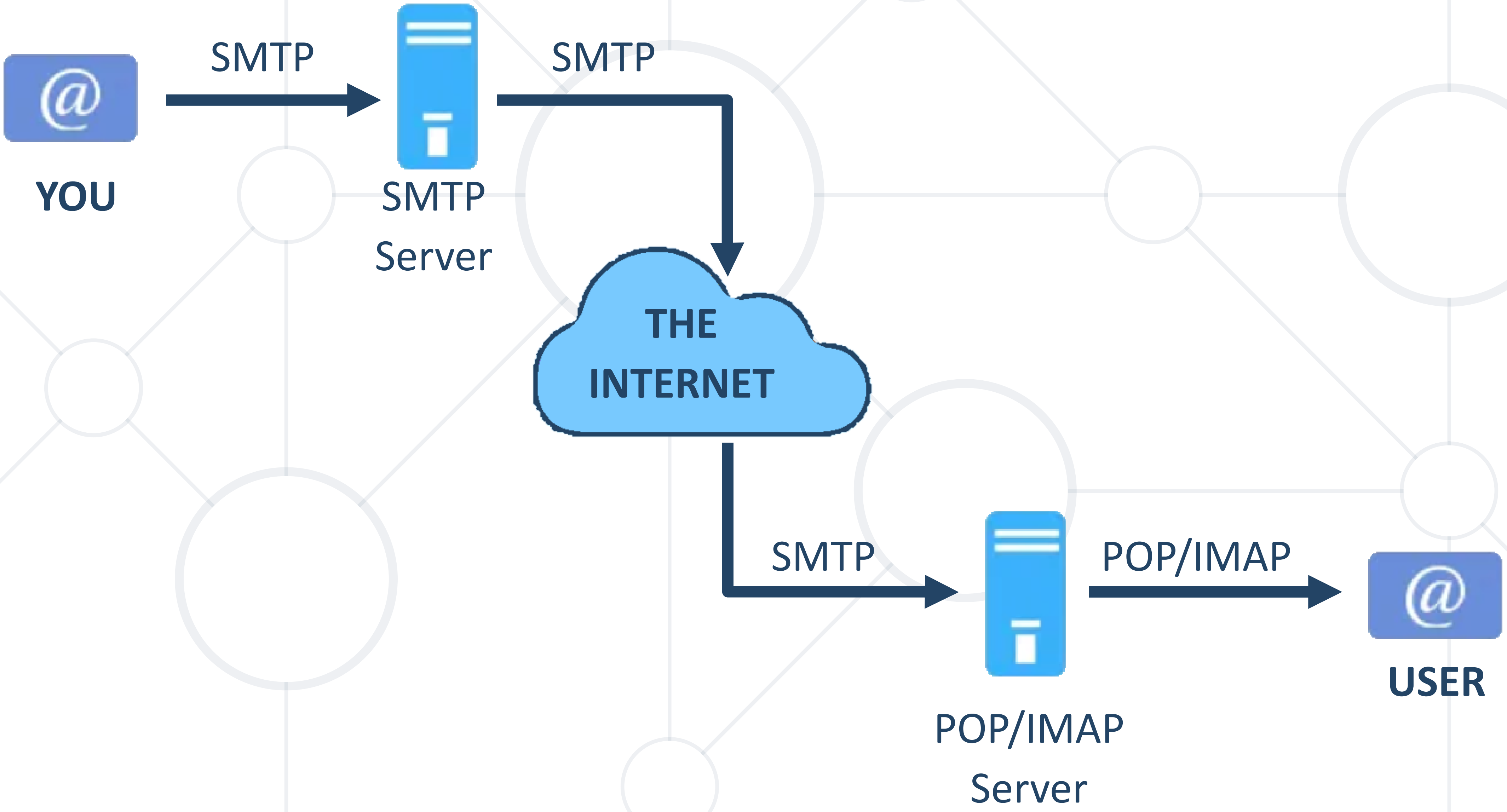
Status Code: ● 200 OK

Remote Address: 161.35.252.68:443

Referrer Policy: strict-origin-when-cross-origin

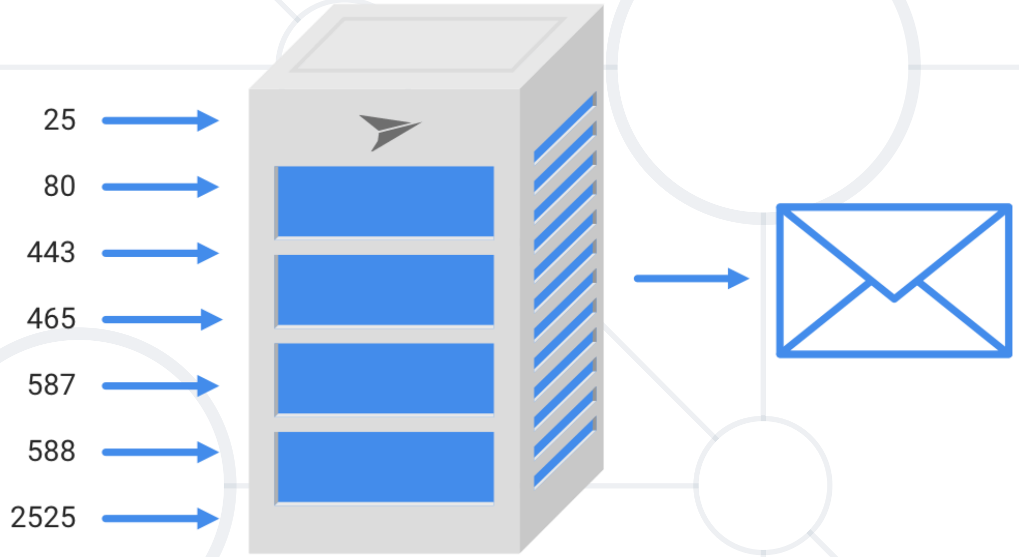
Email

How does Email work?



SMTP and IMAP/POP

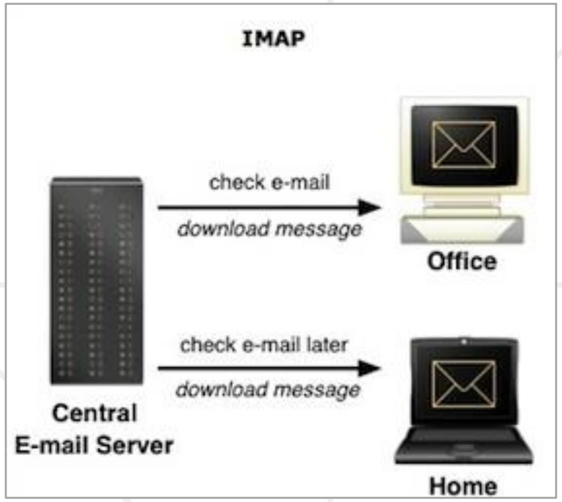
- SMTP (Simple Mail Transfer Protocol)
- Sending and receiving email messages between servers
- Ensures message is delivered to the correct server / format readable by the recipient's email client
- SMTPS (secure SMTP) uses additional SSL or TLS cryptographic protocol for increased security

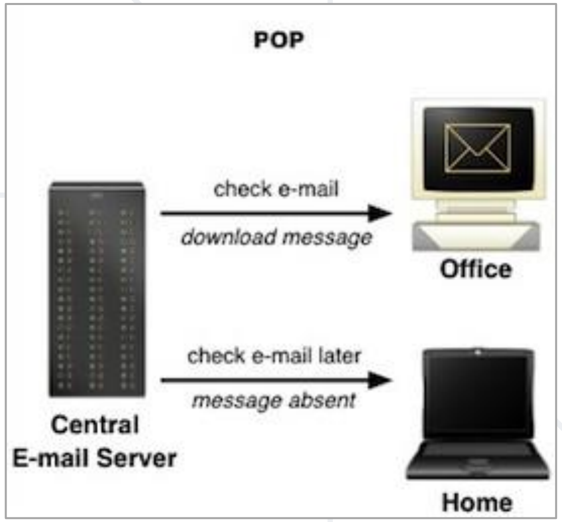


SMTP
TLS/SSL

IMAP/POP

- **IMAP (Internet Message Access Protocol)**
  - Retrieving email messages from servers
  - Allows management of email messages on the server from different devices /**sync and delete**/
  - More popular and flexible
- **POP (Post Office Protocol)**
  - Once downloaded to a client, the message is removed from the server /**download and delete**/
  - Difficult to access email messages from different devices or locations



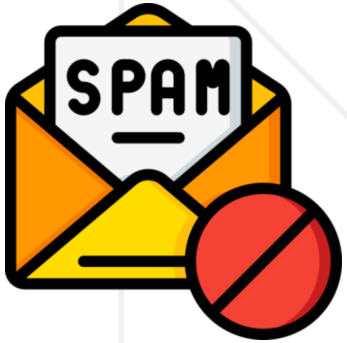


Email Forwarding

- **Redirect** incoming emails to another email address
- Useful for managing multiple email accounts
  - **Server-based forwarding** - Servers configured to automatically forward incoming messages to another email address
  - **Client-based forwarding** - setting up email forwarding using email client settings
  - **Email filters** - setting up filters to forward messages that match specific criteria

Spam Filters

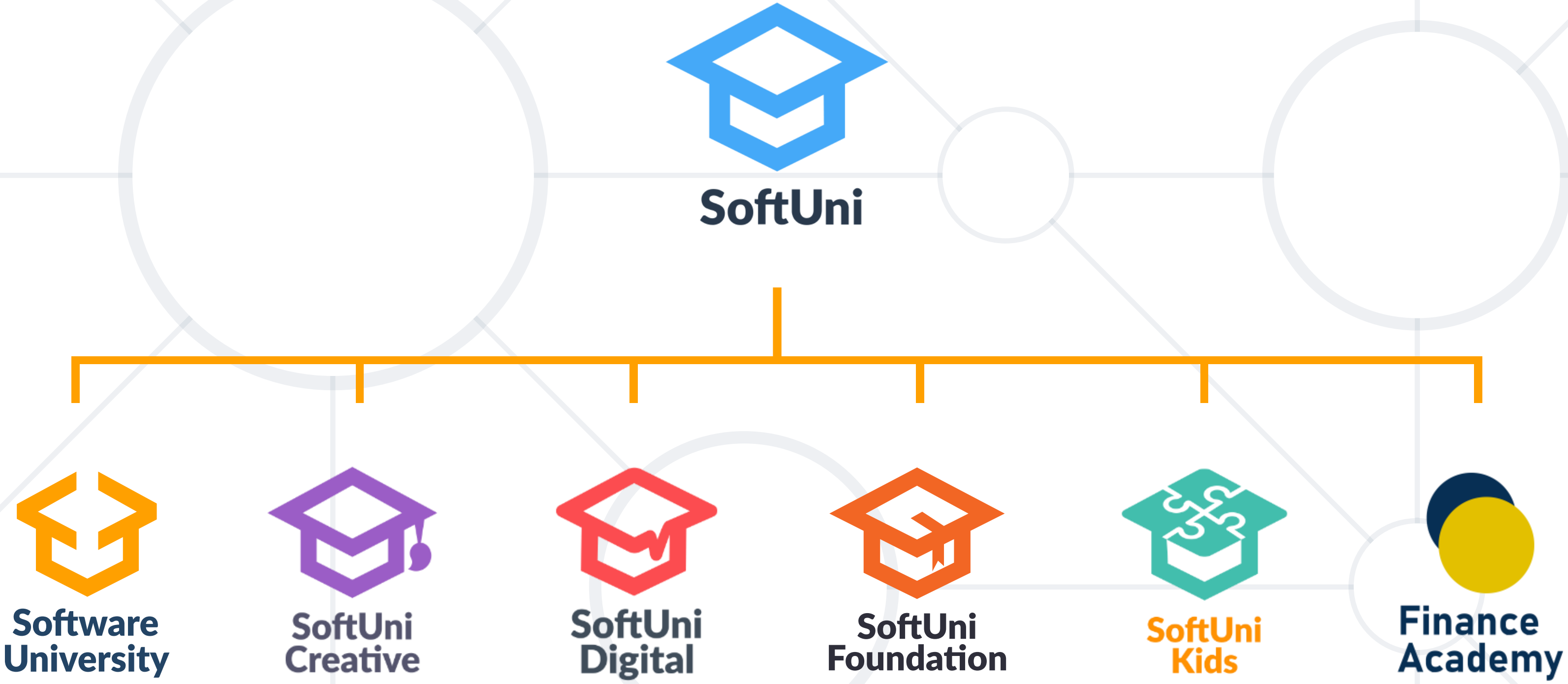
- **Detect** and **filter** out unwanted or harmful email messages
- **Rule-based** filtering and **Machine learning-based** filtering
- Some filtering is usually conducted automatically by an SMTP
- **Reject**, **redirect**, or **quarantine** an email depending on the contents
- **Customizable** for individual needs and preferences
- Setting up rules to **block/allow** emails from specific senders or domains



Summary

- Basic **networking concepts**
- **Layer Models:** OSI Model, TCP/IP
- **MAC address, IP address, Ports**
- **Domains** and **DNS, WWW**
- **HTTP** requests - **GET, POST**
- Browser **Dev Tools** - Web Debugging
- How does an Email work? **SMPT/IMAP**

Questions?



SoftUni

Software University

SoftUni Creative

SoftUni Digital

SoftUni Foundation

SoftUni Kids

Finance Academy

SoftUni Diamond Partners

SUPER HOSTING .BG

Coca-Cola HBC Bulgaria

POKERSTARS
POKER | CASINO | SPORTS
a Flutter International brand

INDEAVR
Serving the high achievers

AMBITIONED

DRAFT KINGS

SOFTWARE GROUP

createX

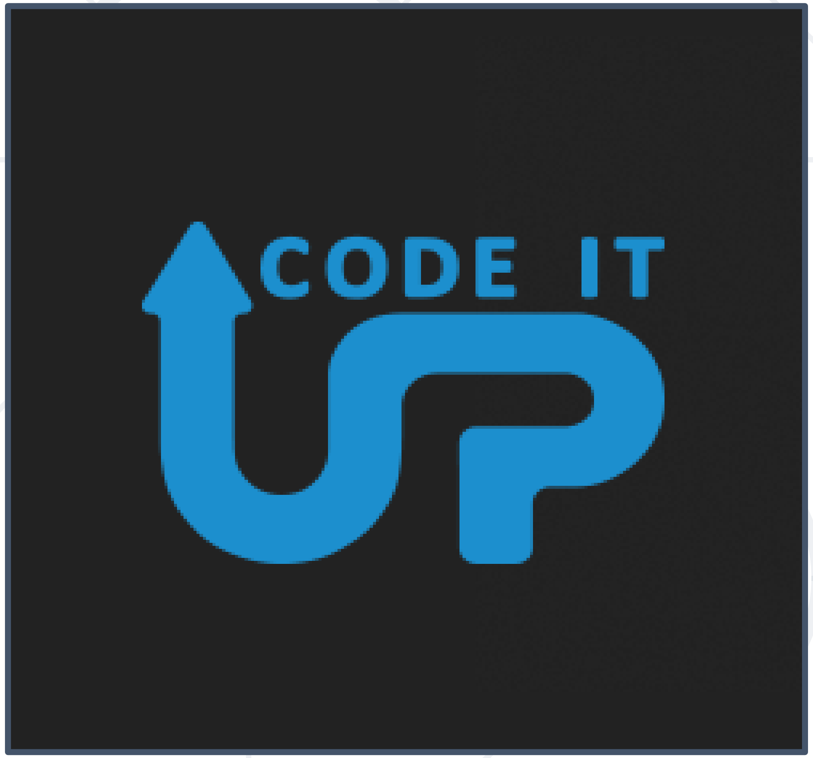
Postbank
Решения за твоето утре

BOSCH

DXC TECHNOLOGY

SmartIT

Educational Partners



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