Internet Explained

SoftUni Team

Technical Trainers

Software University

SoftUni

Software University

https://softuni.bg

Have a Question?

Software University

sli.do

#csharp-web

Table of Content

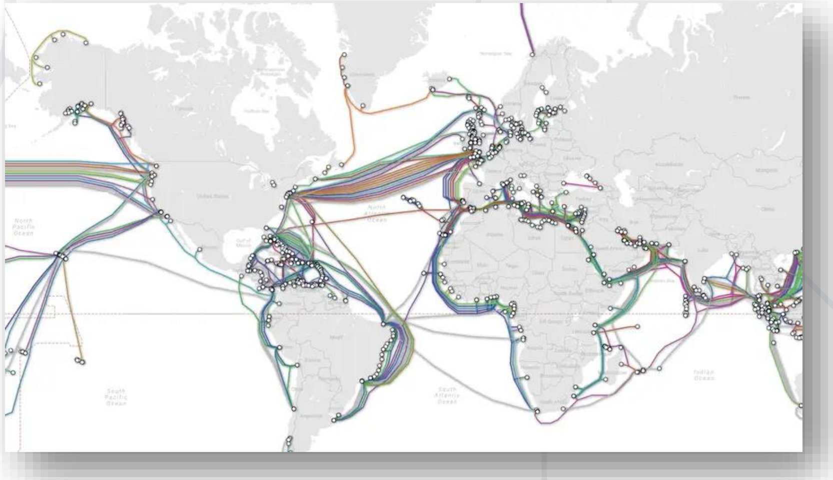
1. Introduction to Internet
2. How does the Internet work?
3. Packets – Sending and Receiving Data
4. Internet Protocol
5. Reliability and TCP
6. The OSI Model
7. Network Hardware
8. The Future of the Internet

Introduction to Internet

An Introduction to the Internet

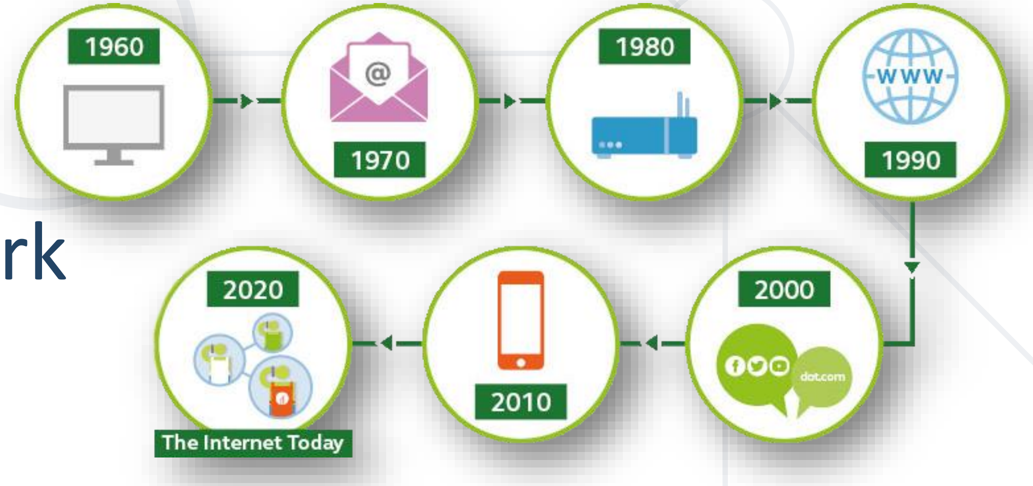
What is the Internet?

- **Vast network** that connects billions of devices together all over the globe
  - Through **fiber optics**, **copper**, **satellites** or **cell phone network**
- We get indirectly **connected** though **ISP**s (**I**nternet **S**ervice **P**roviders)



History – Overview

- Begins with the development of electronic computers in the 1950s
- Packet switching networks were developed in the late 1960
- The internet protocol was developed in the 1970s
- In the 1980s at CERN Tim Berners-Lee created the **World Wide Web** – the first website, linking hypertext documents into an information system, accessible from any node on the network

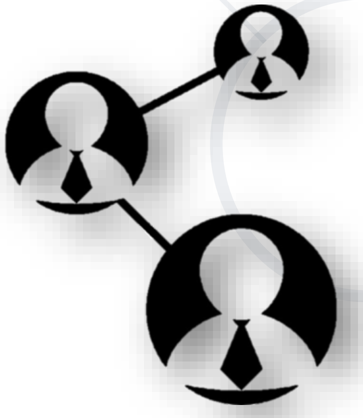


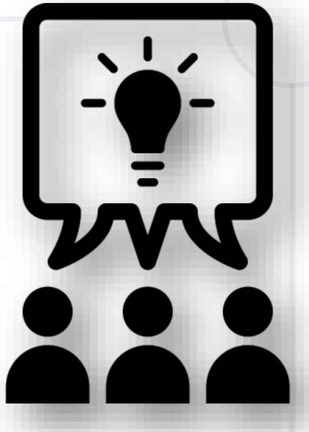
What is a Network?

- **Network** == a group of **two or more devices** that can communicate
- It is comprised of a number of **different computer systems** connected by **physical and/or wireless** connections
- The scale can range from **a single PC sharing** out basic peripherals to **massive data centers** located around the world,
  to the Internet itself

Networks and Internet

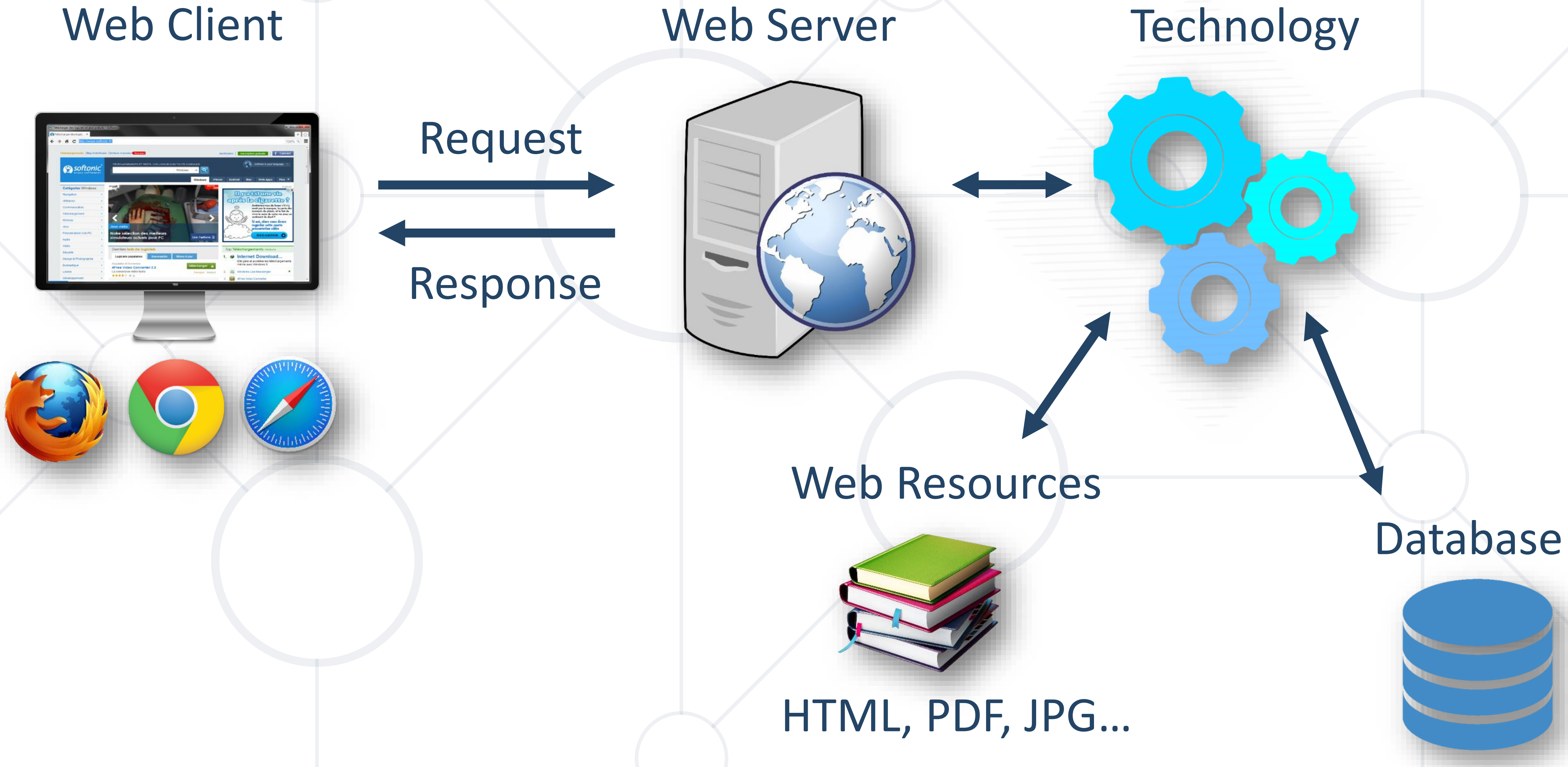
- **The Internet** is made of hundreds of thousands of **networks** and billions of computers and devices connected physically
- These different systems **connect to each other**, **communicate with each other** and **work together** because of standards for how data is sent





How Does the Internet Work?

Web Server Work Model



Web Client

Request

Response

Web Server

Technology

Web Resources

HTML, PDF, JPG…

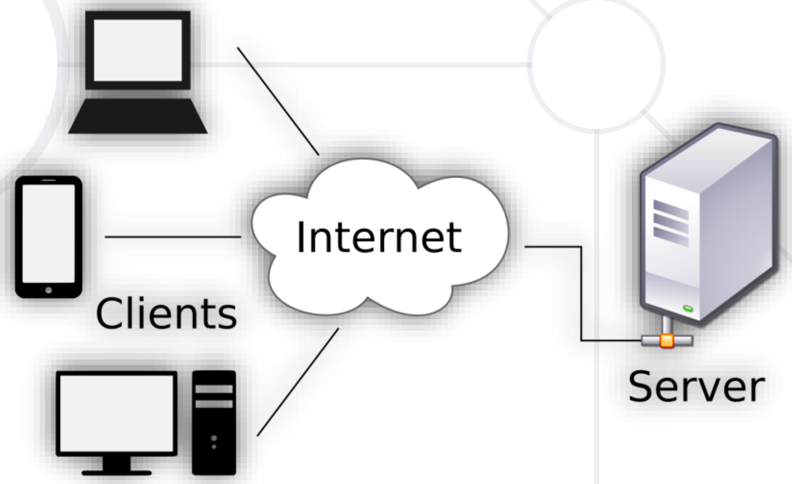
Database

Important Definitions

- To understand how **the Internet works**, first we need to get acquainted with a few definitions
- **What is?**
  - Server and Client
  - Network Protocol
  - Packets
  - TCP vs UDP

Servers and Clients

- All of the machines on the Internet are either **servers** or **clients**
  - **Servers** are the machines that provide services to other machines
  - **Clients** are the machines that are used to connect to those services



Network Protocol

- **Network Protocol** == a set of rules and standards, that allow communication between network devices
- Network protocols include **mechanisms** for devices to **identify** and make **connections** with each other
- Examples for standard network protocols
  - TCP, QUIC, UDP, IP, ARP
  - HTTP, FTP, TFTP, SMTP, SSH

Packets

Sending and Receiving Data

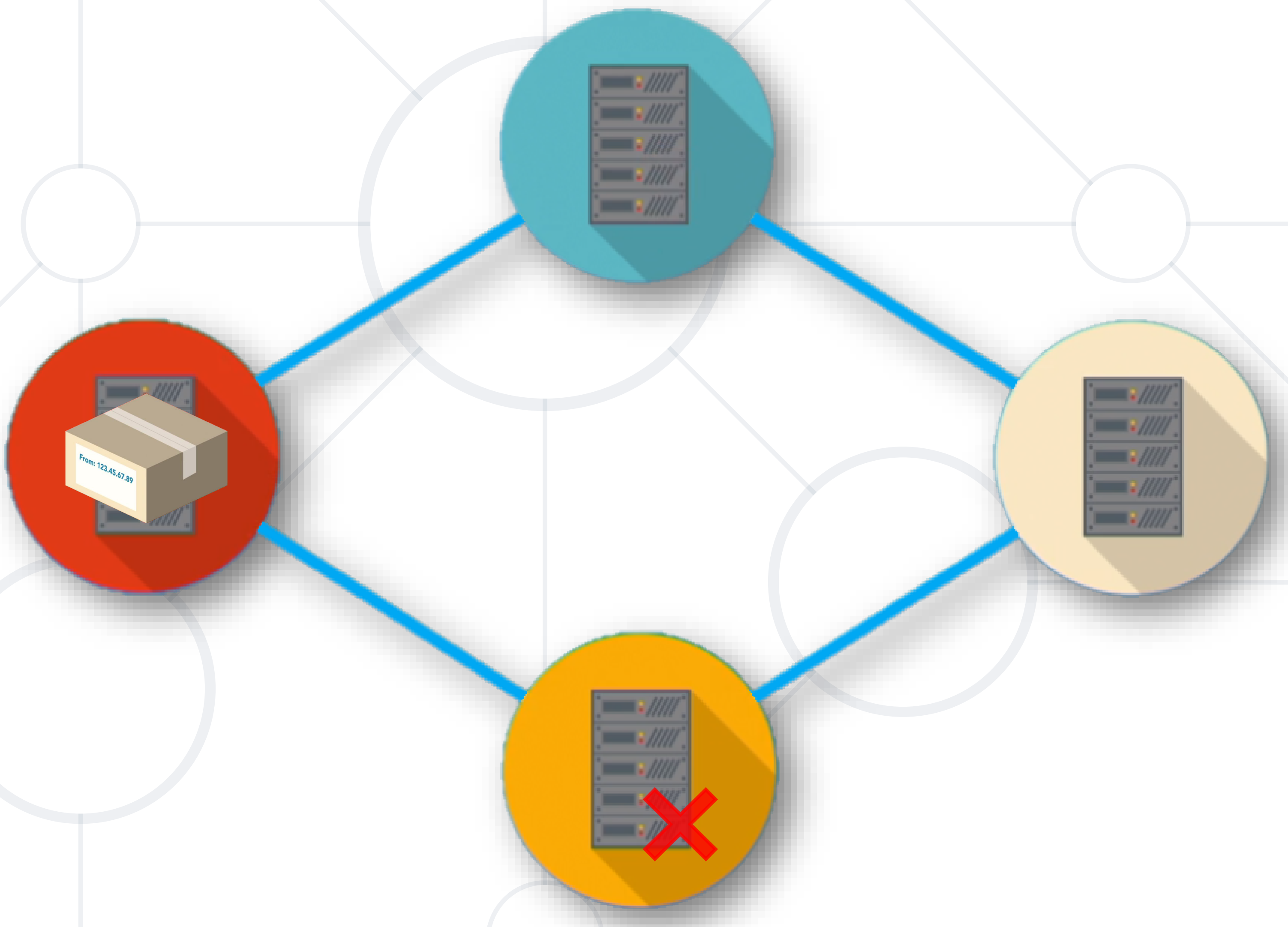
Packets

- Everything that is created on a computer is translated into digital data using **bits**
- Bits need to have a way to be transmitted over the Internet
- Every message, file or stream of data is broken down into small chunks, called **packets**
- When packets are sent on the Internet, they usually travel the network together
- But they might have to take a different route to get to the destination

Packets

- Each packet contains some **important information** inside of it, called a **header**
  - Where it came from
  - Where it is going
  - How long it is
    - This is how the packet is known to be complete
    - All the packets in the message are the same size
  - How many packets there are in the overall message

Traveling of the Packets in the Network



216.58.214.46

www.google.com

Internet Protocol

IPv4, IPv6 and DNS

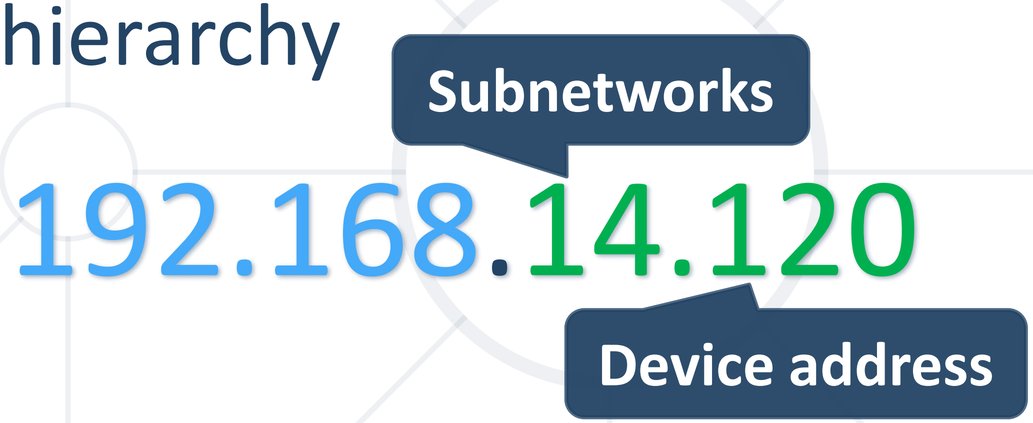
Internet Protocol

- One of the most important protocols used in Internet communication is the **Internet Protocol** (**IP**)
- All the devices on the Internet have **addresses**
- They are called **IP Addresses**
- The IP address is **unique** to each computer or a device at the edge of the network

IP Address:
192.168.10.5
IP Address:
192.168.0.1

IP Address

- An **IP Address** has many parts, organized in a hierarchy



Subnetworks

192.168.14.120

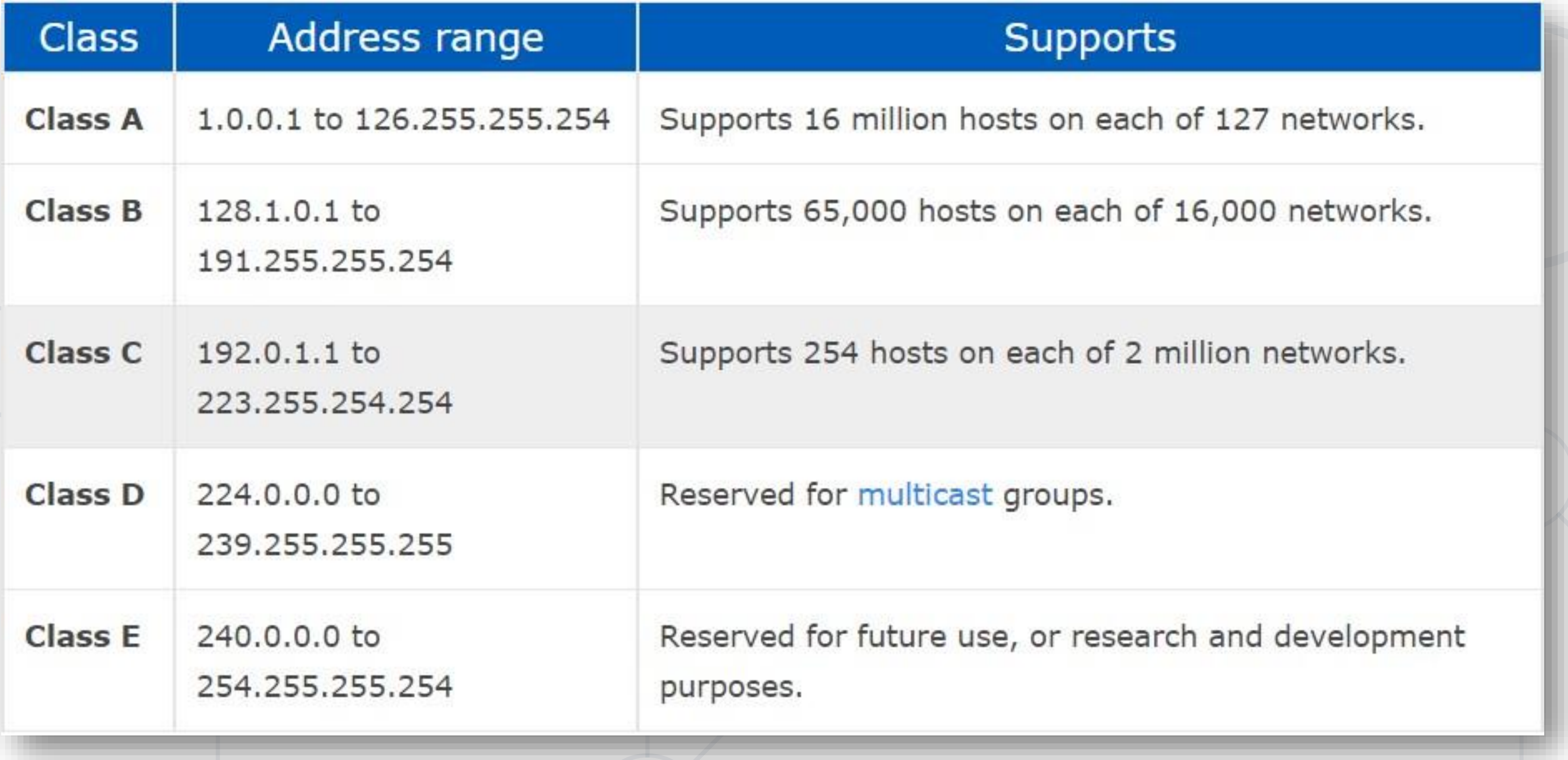
Device address

- This version of IP Addressing is called **IPv4**
  - Provides more than 4 billion **32-bits** unique addresses

IPv4

- **IPv4** == sequence of 4 three-digit numbers, separated by a period
  - Each number can be a number from 0 to 255
  - **IPv4** is not enough for all network devices connected to the internet
- In 1995, a new version of the Internet Protocol was created, it's called **IPv6**

IP Address Classes



Class	Address range	Supports
Class A	1.0.0.1 to 126.255.255.254	Supports 16 million hosts on each of 127 networks.
Class B	128.1.0.1 to 191.255.255.254	Supports 65,000 hosts on each of 16,000 networks.
Class C	192.0.1.1 to 223.255.254.254	Supports 254 hosts on each of 2 million networks.
Class D	224.0.0.0 to 239.255.255.255	Reserved for multicast groups.
Class E	240.0.0.0 to 254.255.255.254	Reserved for future use, or research and development purposes.

What Is CIDR (Classless Inter-Domain Routing)

- Classless Inter-Domain Routing == IP addressing scheme that improves the allocation of IP addresses
- It replaces the old system based on classes A, B and C
- This scheme also helped greatly **extend the life of IPv4** as well as slow the growth of routing tables

IPv4 Private Address Space and Filtering

CIDR	IP address range	Class
10.0.0.0/8	10.0.0.0 – 10.255.255.255	A
172.16.0.0/12	172.16.0.0 – 172.31.255.255	B
192.168.0.0/16	192.168.0.0 – 192.168.255.255	C

IPv6

- **IPv6** uses **128 bits** – 340 undecillion unique addresses
  - That's more than the atoms on the surface of the Earth
- These **128** bits are organized into eight 16-bit sections
- Each 16-bit block is converted to hexadecimal and it's separated with a colon
- Full IPV6 address
  - **3FFE:F200:0234:AB00:0123:4567:8901:ABCD**
- The **leading zeros** in **IPv6** can usually be left out (not recommended)

What is a DNS?

`www.softuni.bg`

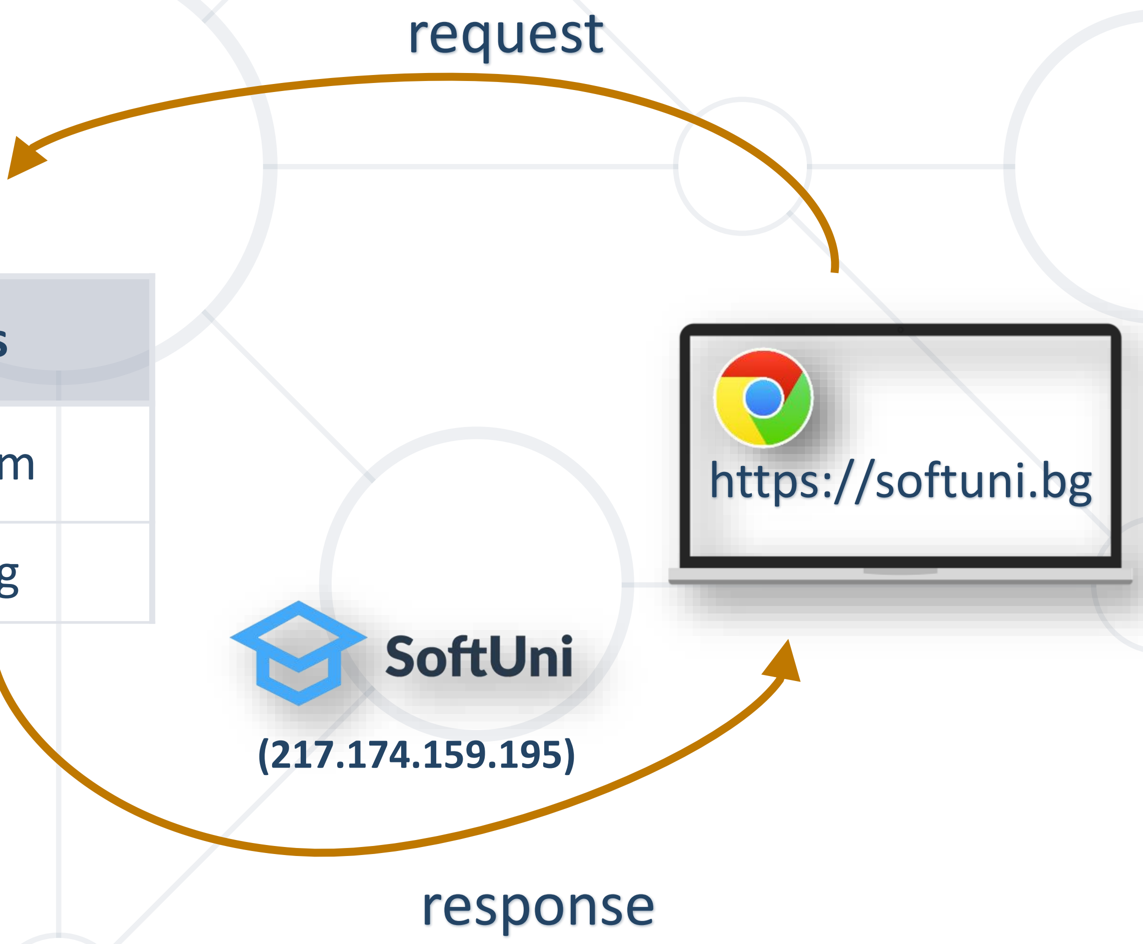
Domain name

- The **domain name** is a human way to access IP addresses for devices and websites around the world
- It is a sequence of phrases that **map** to a giant **Internet-wide database** of **IP addresses**
- When a domain name is entered in the browser, a request is made to something called a **DNS** (**Domain Name Server**)
- This server holds a cache of tons of domain names, and their matching IP addresses

DNS Example

DNS

IP Address	Domains
216.58.214.46	google.com
217.174.159.195	softuni.bg



TCP

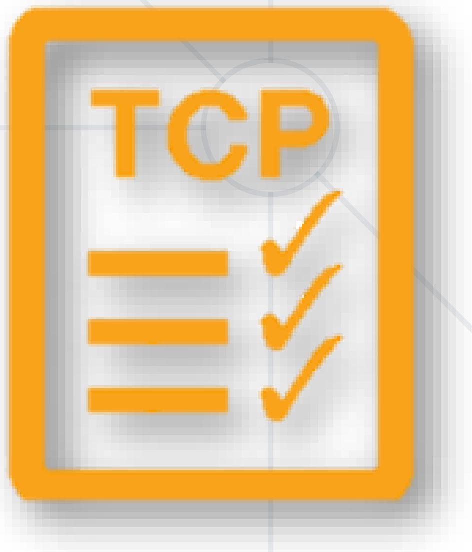
Reliability and TCP

Reliability

- When packets are transmitted from one location to another, they can take different paths
- When they get to the destination, they are unorganized and sometimes not complete
- So the message needs to be audited and reviewed in order to put it together in the right way
- The **Transmission Control Protocol** or **TCP** does exactly that

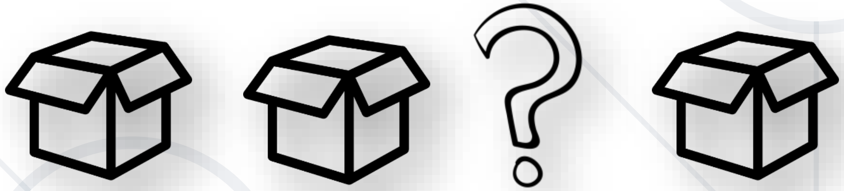
Transmission Control Protocol - TCP

- **TCP** uses a process, where it looks at **all the packets** in a message and **checks them**
- Using the header information in each packet, it knows
  - How many there are
  - How large they should be
  - In which order the packets should be in
- Using this checklist, it is able to rearrange the packets



Transmission Control Protocol - TCP

- If it finds that a packet doesn't match the expected characteristic, it is discarded
- **TCP verifies** that all the packets are
  - In the right order
  - Free of any issues



- After that it **certifies the data** and the packets are **merged** together to recreate the **original** file that was on the sender's device

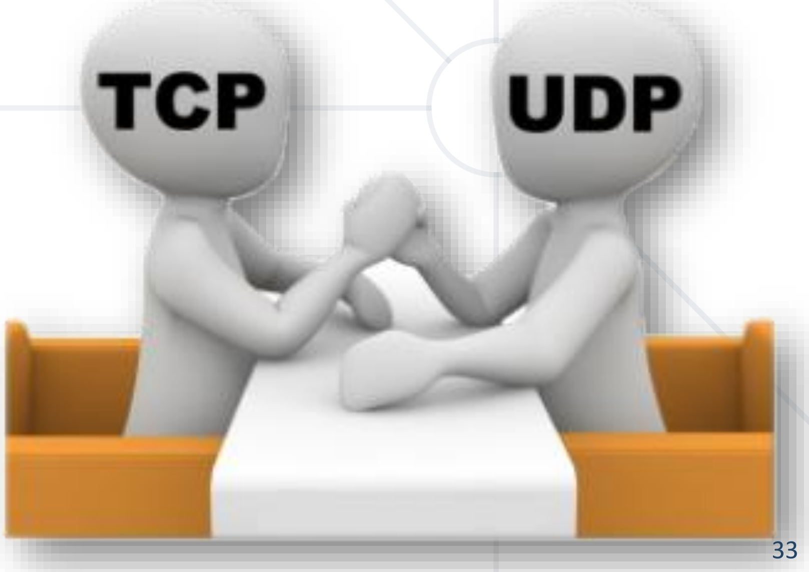
User Datagram Protocol

- UDP does not establish a session and it does not guarantee data delivery
- It is known as the **"fire-and-forget" protocol**
  - It sends data and it doesn't really care if the data is received at the other end

Missing packets..
I don't care..
UDP

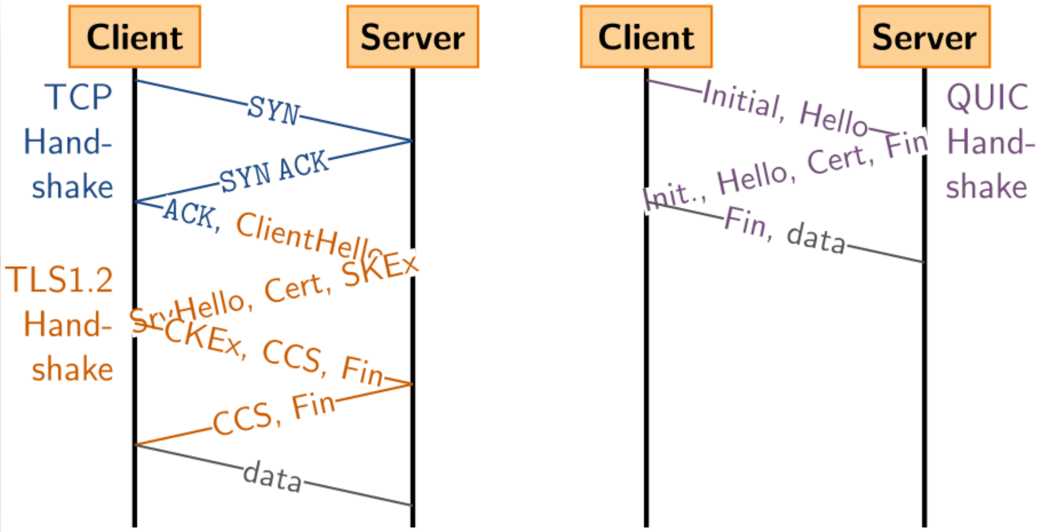
TCP vs UDP

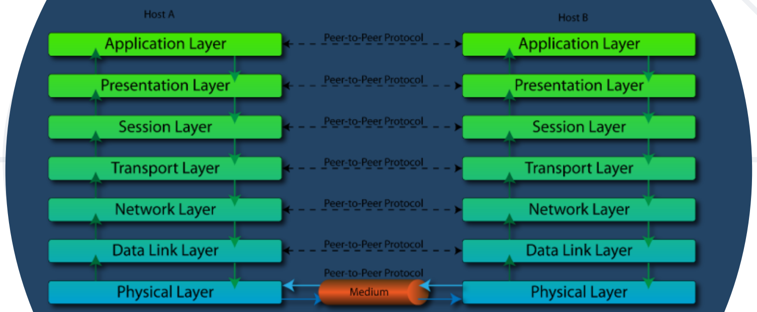
- **TCP** places **reliability** in a higher priority than speed or latency
- For instances where reliability isn't as important, but **speed** is, **UDP** is used
- UDP doesn't do excessive reliability checks, but it can send information at a faster rate
- TCP is the foundation of how a majority of data is transmitted over networks



QUIC Protocol

- **QUIC** == new transport protocol designed for **mobile-heavy** Internet usage
- Uses **UDP** as its basis, not TCP
- Packets are encrypted **individually**
- Exchange of supported protocols is a part of the initial **handshake process**



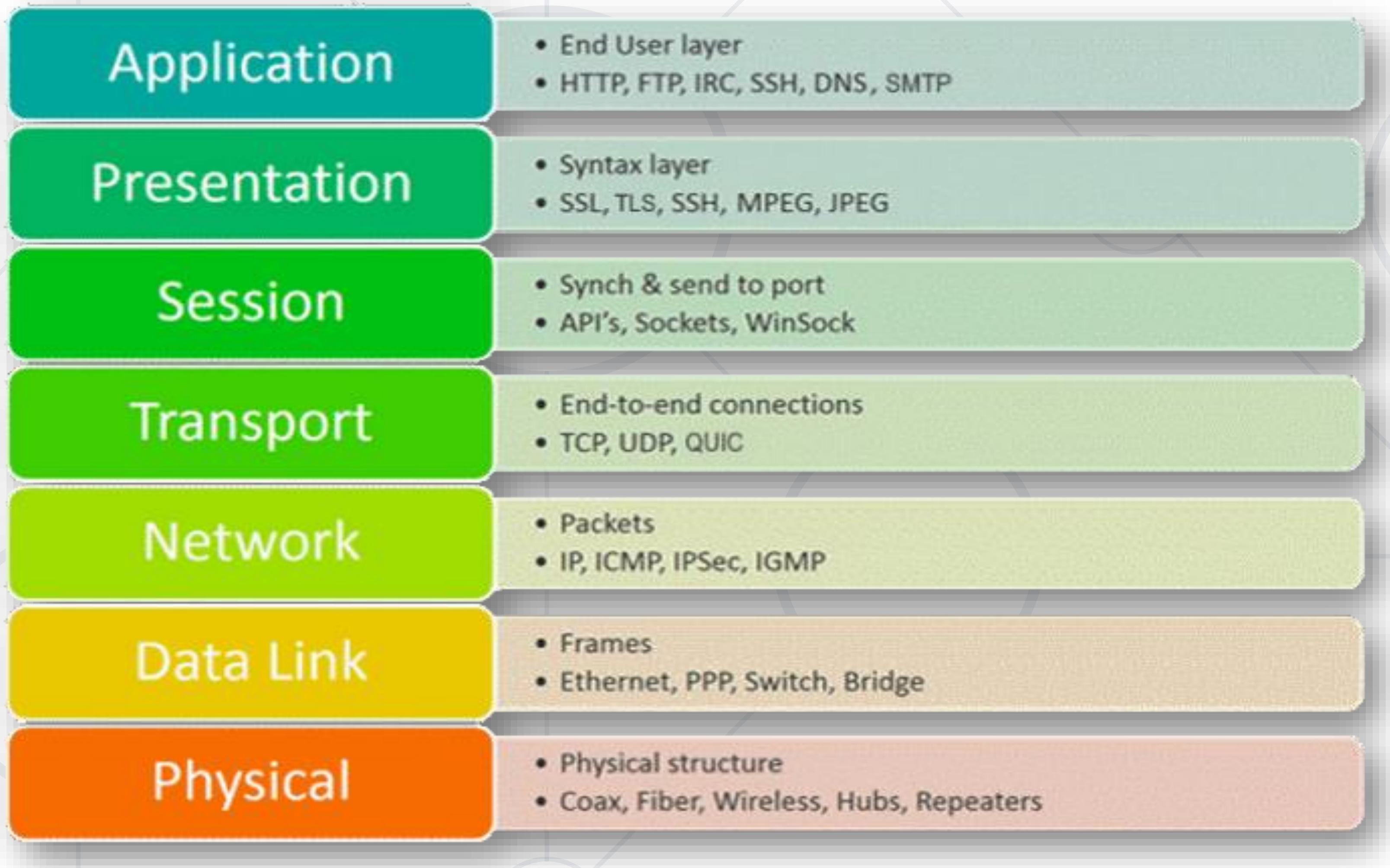


The OSI Model

What is the OSI Model?

- OSI model stands for Open System Interconnect
- It consists of 7 layers
  - Each layer serves the layer above it and in return, is served by the layer below it
- Understanding each layer of the model helps us with
  - Troubleshooting
  - Communicating better with technical and non-technical individuals about any system

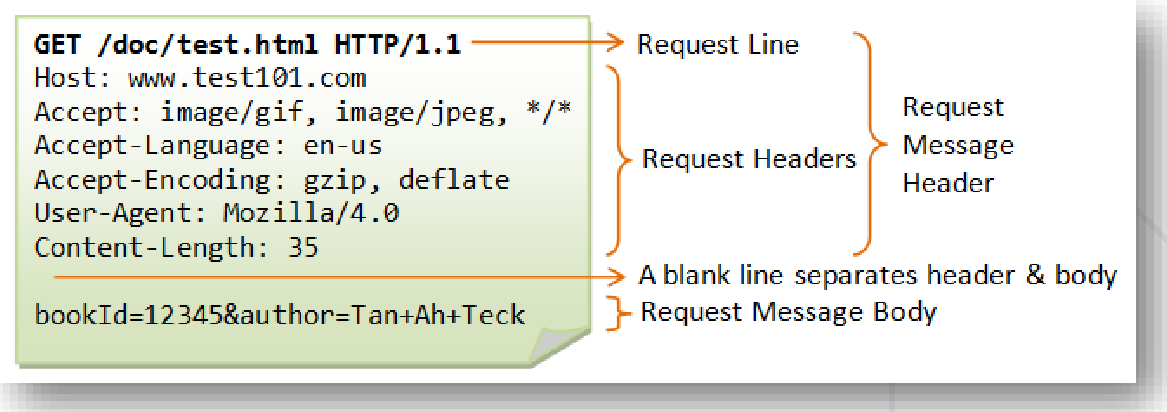
OSI Layers



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

Application Layer – 7

- Only layer that **directly interacts** with the **user**
- Software applications, e.g., **web browsers** and **e-mail clients**, rely directly on its protocols
- Protocol examples
  - DNS, FTP, HTTP, SMTP, POP3, IMAP
- Most **important** layer for **software engineers**



```
GET /doc/test.html HTTP/1.1
Host: www.test101.com
Accept: image/gif, image/jpeg, */*
Accept-Language: en-us
Accept-Encoding: gzip, deflate
User-Agent: Mozilla/4.0
Content-Length: 35

bookId=12345&author=Tan+Ah+Teck
```

Request Line

Request Headers

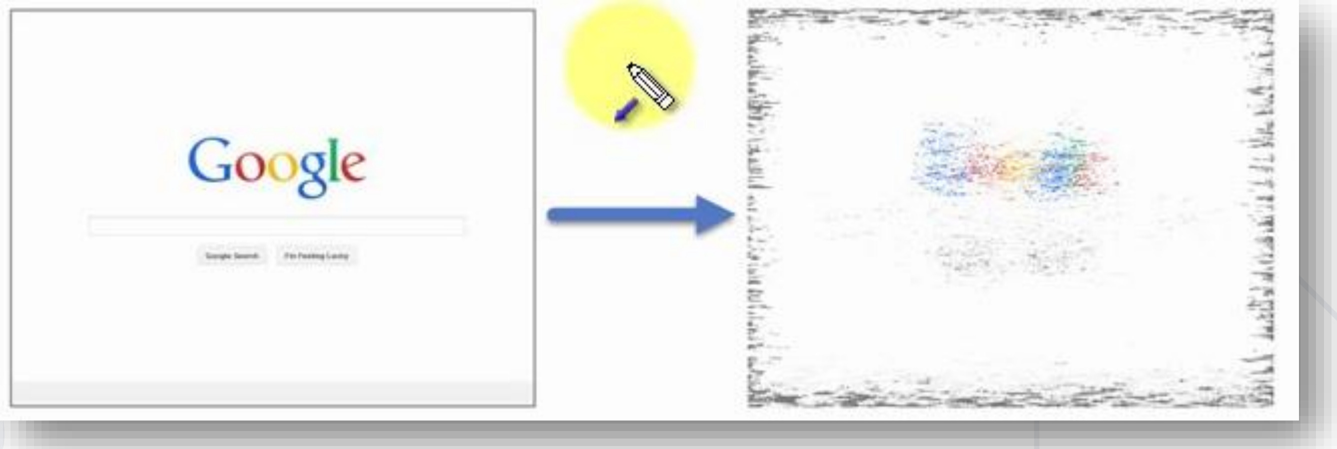
Request Message Header

A blank line separates header & body

Request Message Body

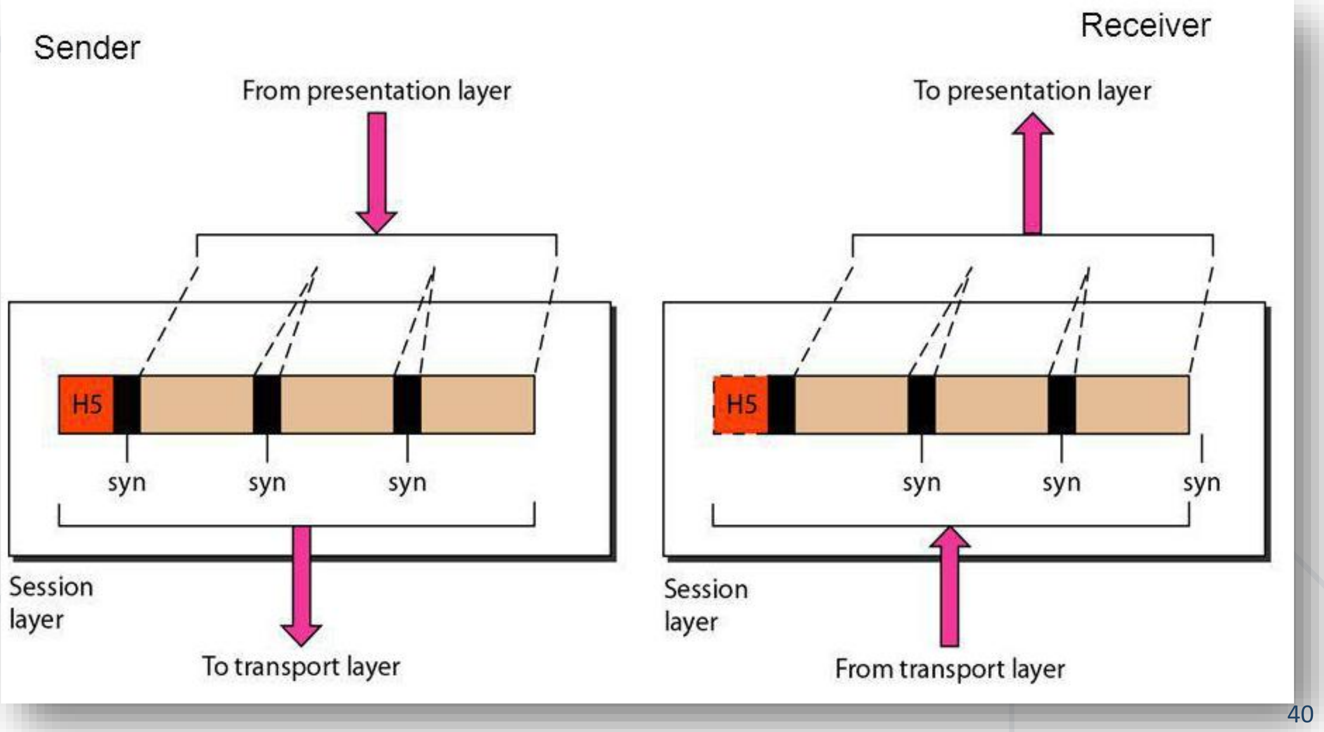
Presentation Layer – 6

- This layer is a part of the operating system (OS)
- **Converts** incoming and outgoing **data** from one presentation format to another
- Responsible for **translation**, **encryption**, and **compression** of **data**
- Protocol examples
  - SSL, TSL



Session Layer – 5

- Controls the **dialogues** (connections) between computers
- Establishes, manages and terminates **connections** between the local and remote application
- Its services include **authentication** and **reconnection** after an interruption
- Protocol examples
  - RPC, PPTP

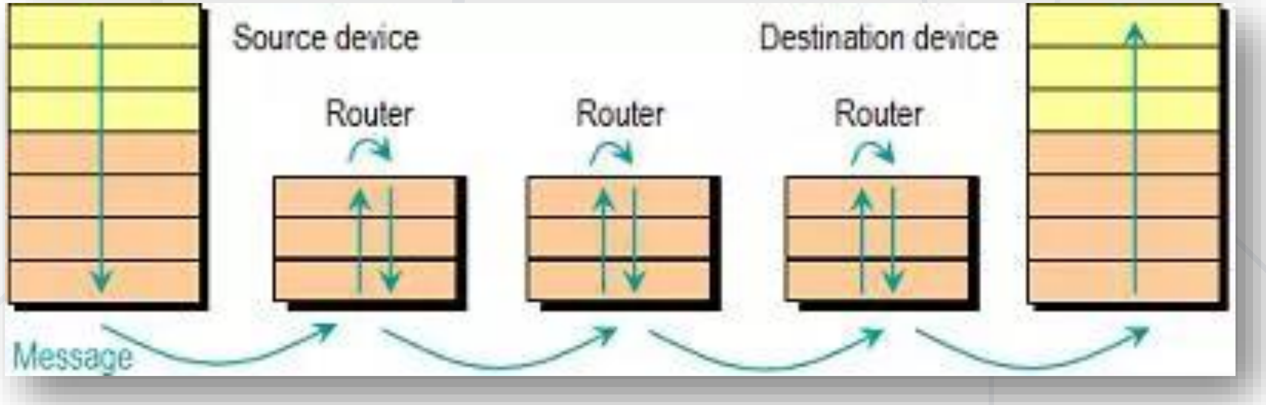


Transport Layer – 4

- Responsible for **end-to-end communication** over a network
- Transfers data, splitting it into pieces (**segments**)
- Provides logical communication between application processes
- Responsible for the management of error correction, providing quality and reliability to the end user
- Important concept for web devs – **port number**
- Protocol examples – **TCP**, **QUIC**, **UDP**

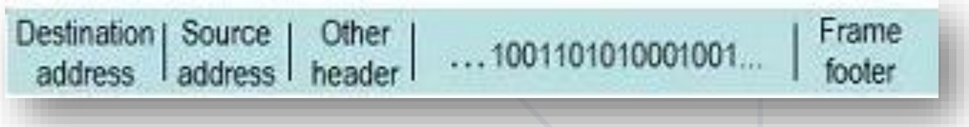
Network Layer – 3

- Transfers **packets** from one node to another
- Responds to service requests from the transport layer and issues service requests to the data link layer
- Protocol examples
  - **IP**, **IPv6**, **IPSec**, **ICMP**, **IGMP**
- Important concept for web devs – **IP address**



Data Link Layer – 2

- Provides **node-to-node data transfer**
- The data transferred is split into packets – **frames**
- It **detects** and possibly **corrects** errors that may occur in the **physical layer**



Destination address	Source address	Other header	...1001101010001001...	Frame footer

- Divides into two sublayers
  - **Medium Access Control (MAC)** layer – controlling how devices in a network gain access to a medium and permission to transmit data
  - **Logical Link Control (LLC)** layer – identifying and encapsulating network layer protocols, controls error checking and frame synchronization
- Example protocols – **ATM**, **Ethernet**, **MAC**

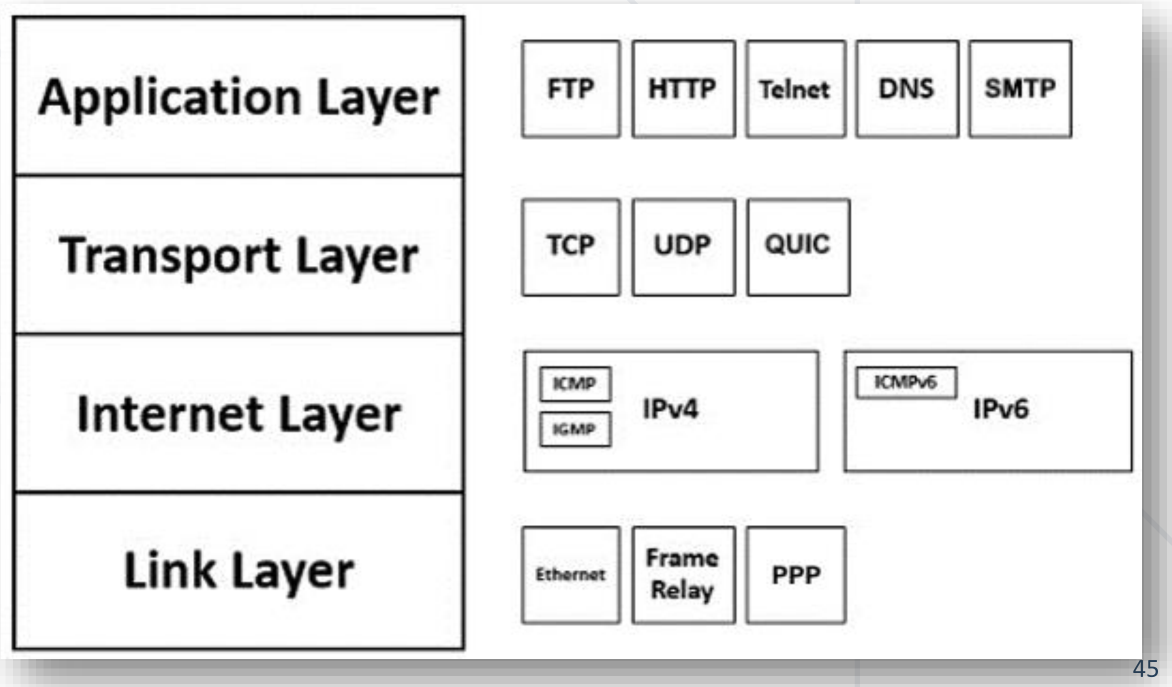
Physical Layer – 1

- It is responsible for the physical connection between two or more parties
- Converts the **binary** from the upper layers into **signals**, **transmits** them over local media (electrical, light, or radio signals)
- Examples
  - **Ethernet**
  - **USB**
  - **Bluetooth**
  - **802.11a/b/g/n**

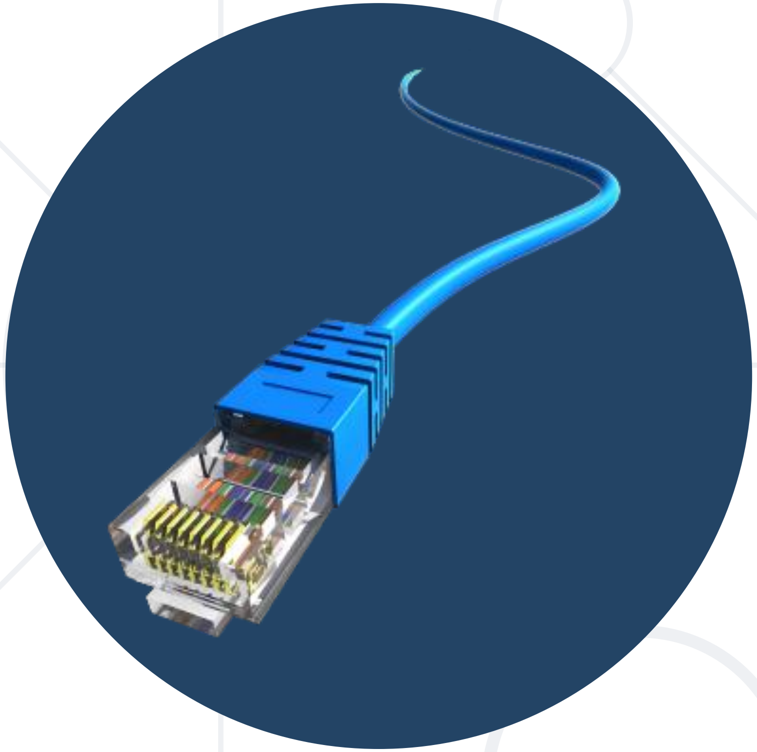
...10011010100010011110101...

TCP/IP Protocol Suite

- The **7-layer OSI model** is too complicated, it's designed for **network engineers** and communication experts
- In **software development** a simplified networking models exists, called the "**The TCP/IP protocol suite**" with **4** layers
  - **Link** – combines physical media and data link protocols
  - **Internet** – transmits packets between 2 hosts
  - **Transport** – provides communication between 2 endpoints
  - **Application** – defines the way apps talk to each other



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



Network Hardware

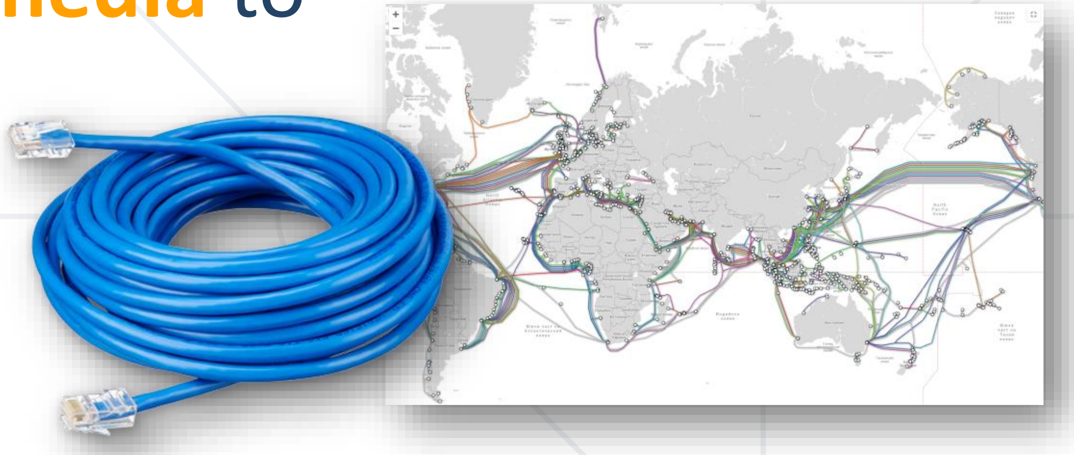
Basic Hardware Components

Network Hardware

- Basic Hardware Components
  - Cables
  - Routers
  - Repeaters, Hubs and Switches
  - Bridges
  - Gateways
  - Network Interface Cards

Cables and Routers

- Network cables – the **transmission media** to transfer data from one device to another



- Router – **connecting device** that transfers data packets between different computer networks (operates on level 3 of OSI)

Repeaters, Hubs and Switches

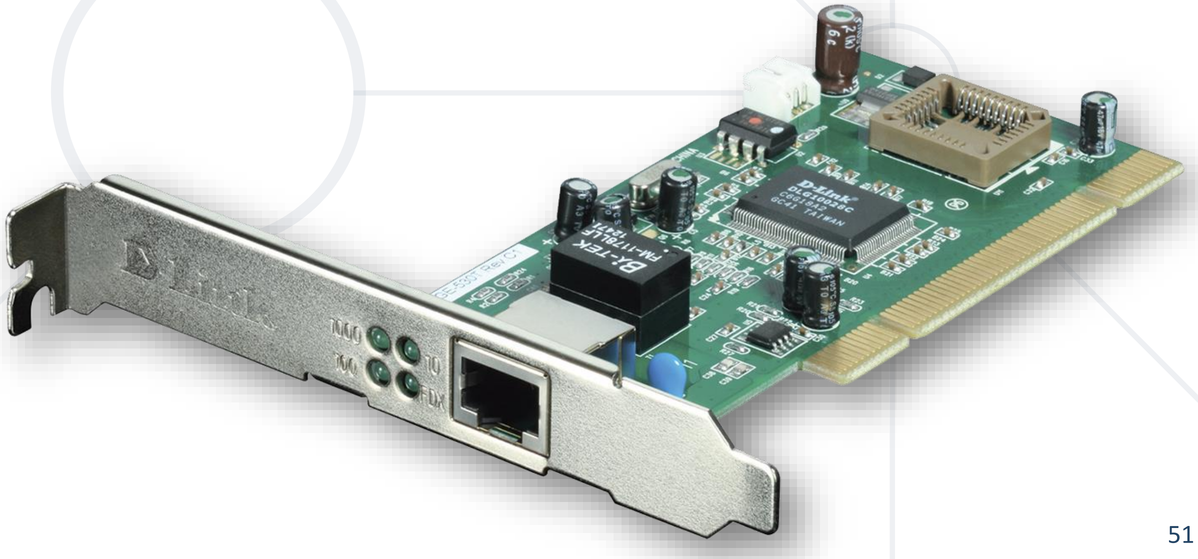
- **Repeaters**, **hubs** and **switches connect** network **devices** together so that they can function as a single segment
  - **Repeater** – **receives** a **signal** and regenerates it before re-transmitting, so that it can travel longer distances
  - **Hub** – multiport **repeater** (operates on level 1 of the OSI model)
  - **Switch** – **receives data** from a port, uses packet switching to resolve the destination device and forwards the data to the particular destination (operates on level 2 of the OSI model)

Bridges and Gateways

- **Bridge**
  - Connects two separate but **similar** Ethernet network segments
  - Forwards packets from the source network to the destined network (operates on level 2 of OSI)
- **Gateway**
  - Connects networks that work upon **different** protocols
  - The entry and the exit point of a network (controls the access to other networks)
  - Level 4, 5, 6 or 7 of the OSI model (same as Firewalls)

Network Interface Cards – NIC

- **NIC** – a computer component that connects it to the network
- There are two types of network cards
  - Internal
  - External



The Future of the Internet

The Future of the Internet

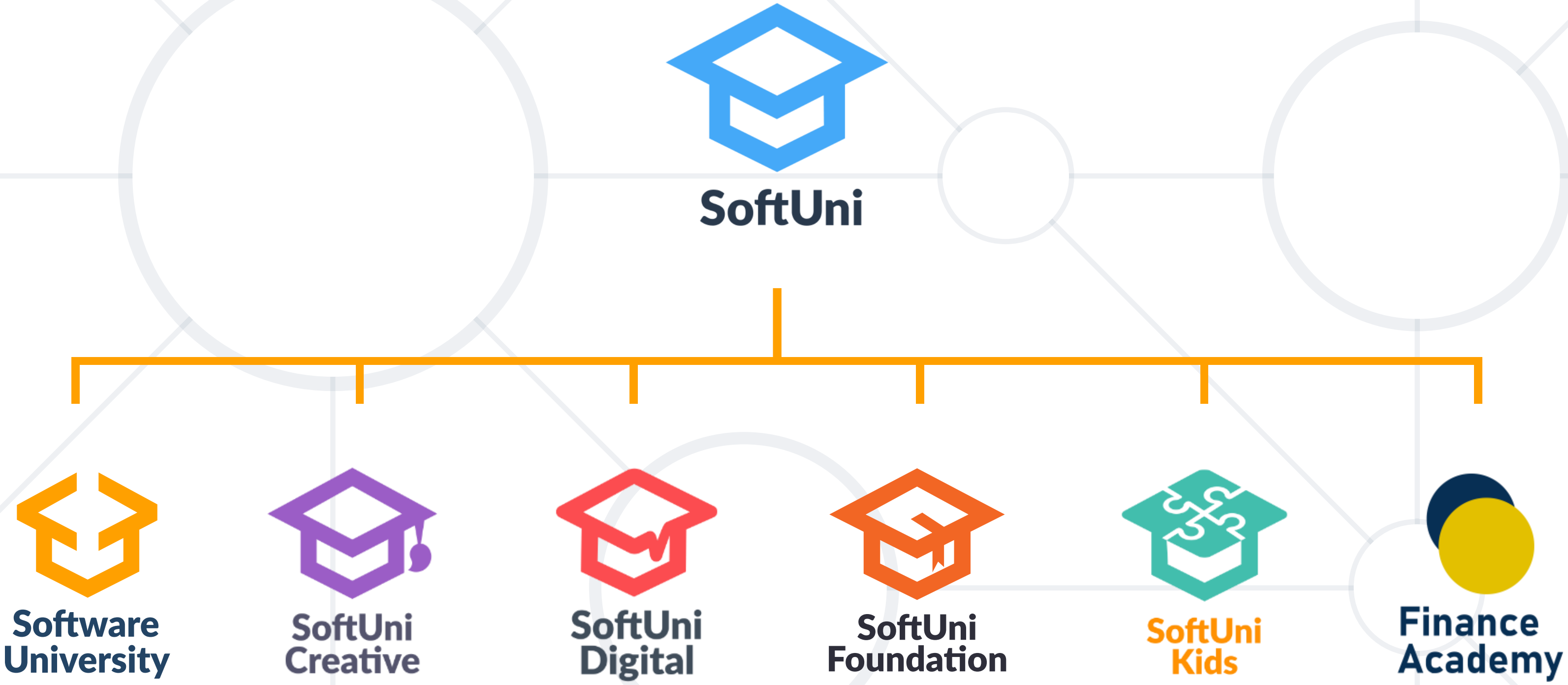
- A typical modern home consists of: PC, Laptop, Tablet, Phones, TV, Security Camera, Air Conditioner, Smart Watch, Printer, Music Player, Light, etc.
- The "**Internet of Things**" will expand
  - Healthcare, agriculture, wearables, manufacturing
  - Smart homes, cars and cities (pollution, parking, energy)
  - In 2030 there will be **50 billion devices** connected to the Internet of Things

Summary

- Internet and Definitions of Internet
- Sending and Receiving Data
- OSI model
  - Layers
- Network Hardware
- The Future of the Internet

Software University

Questions?



SoftUni

Software University

SoftUni Creative

SoftUni Digital

SoftUni Foundation

SoftUni Kids

Finance Academy

SoftUni Diamond Partners

SmartIT

Coca-Cola HBC Bulgaria

SOFTWARE GROUP

DXC TECHNOLOGY

createX

Postbank

Решения за твоето утре

SUPER HOSTING .BG

DRAFT KINGS

VIVACOM

INDEAVR

Serving the high achievers

AMBITIONED

PHAR VISION

Trainings @ Software University (SoftUni)

- Software University – High-Quality Education, Profession and Job for Software Developers
  - softuni.bg, about.softuni.bg
- Software University Foundation
  - softuni.foundation
- Software University @ Facebook
  - facebook.com/SoftwareUniversity
- Software University Forums
  - forum.softuni.bg

License