Internet Explained

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Table of Content

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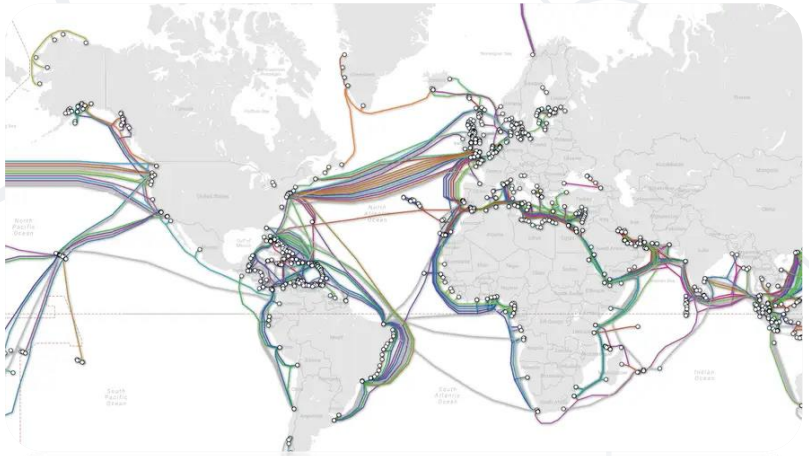
Introduction to Internet

An Introduction to the Internet

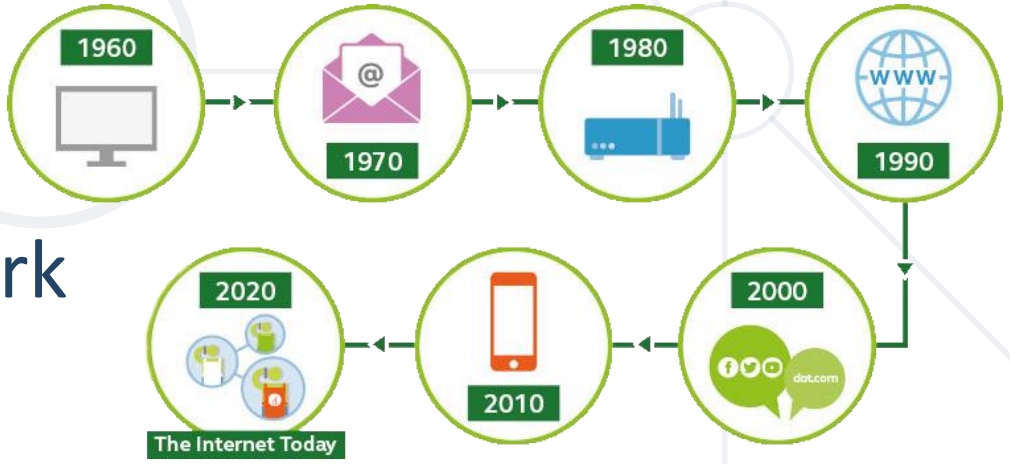
What is the Internet?

- **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

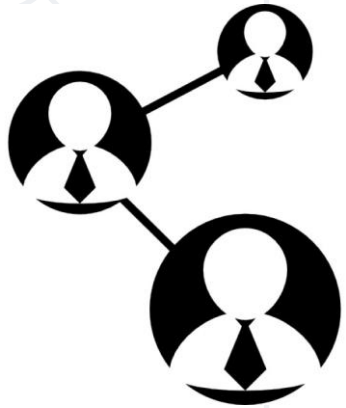


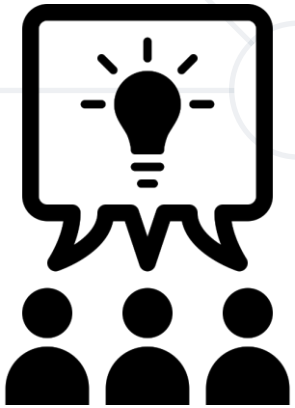
What is a Network?

- **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

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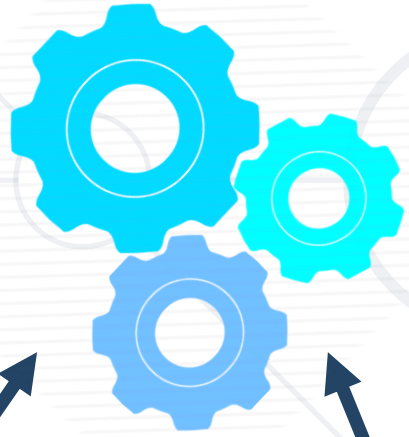
Web Client

Request

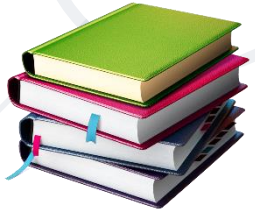
Response

Web Server

Technology



Web Resources

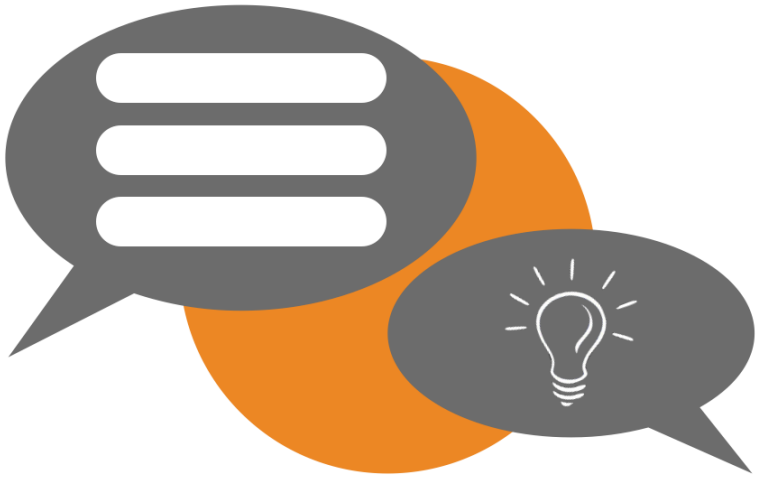


HTML, PDF, JPG…

Database

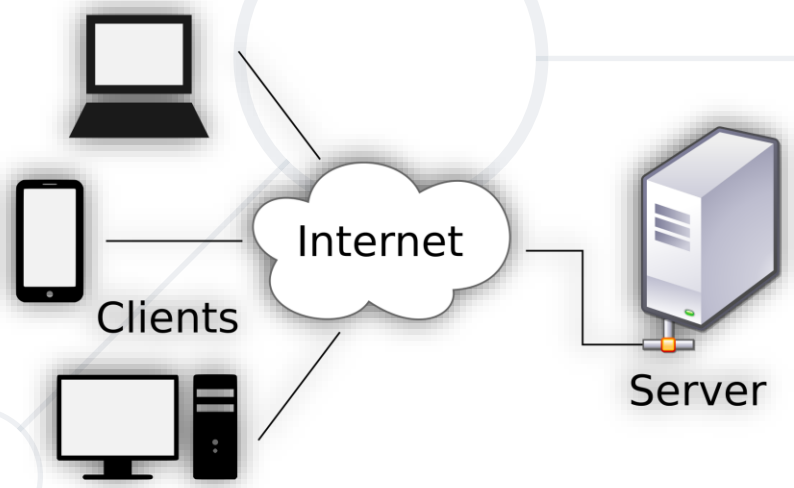
Important Definitions

- 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

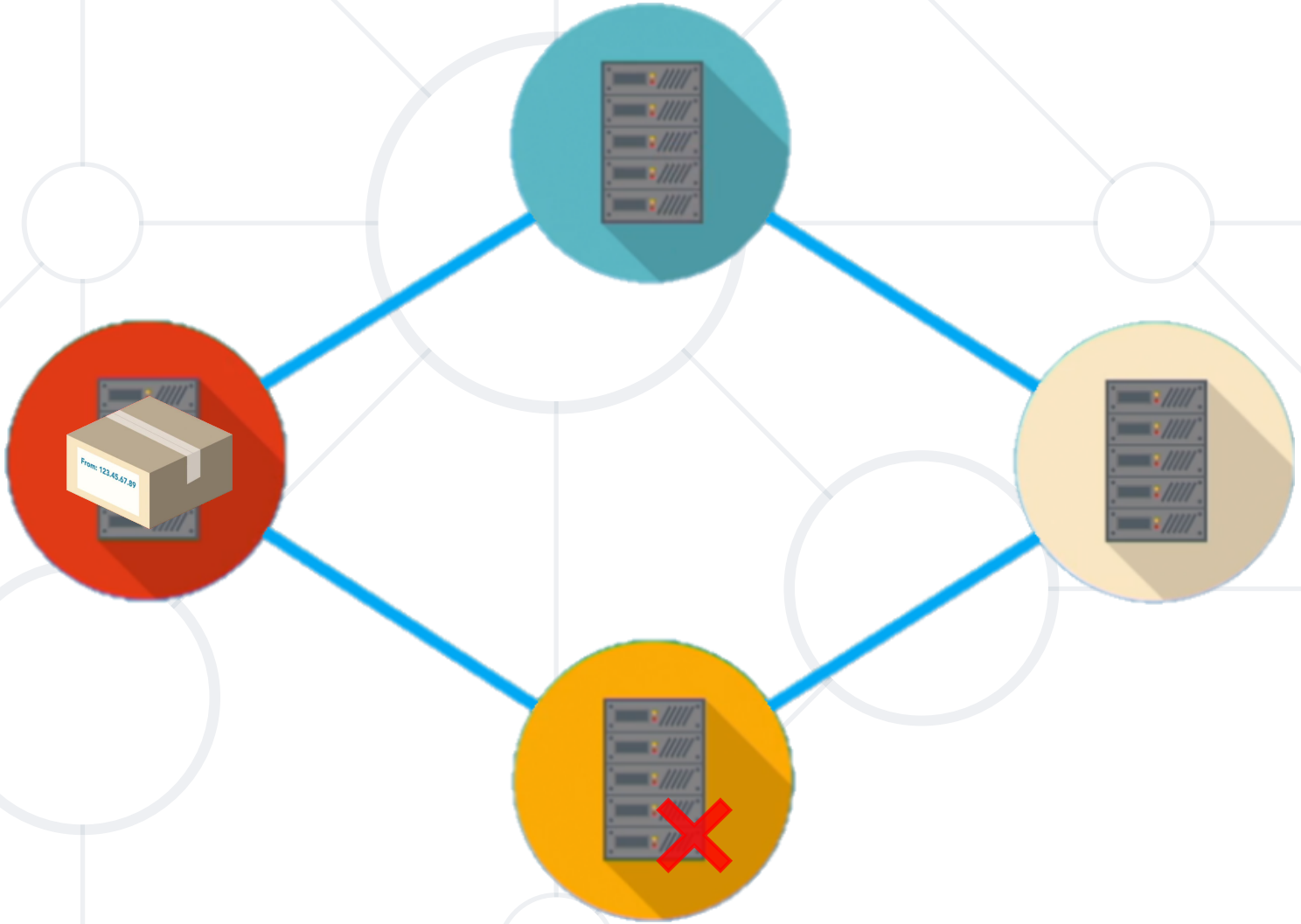
Packets (1)

- 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 (2)

- 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

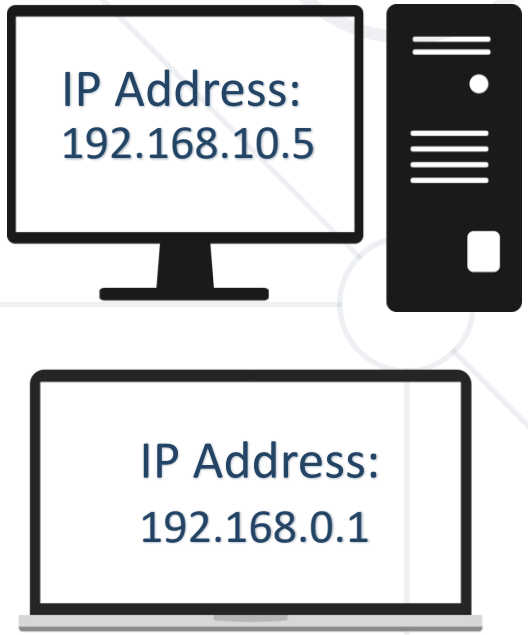


Internet Protocol

IPv4, IPv6 and DNS

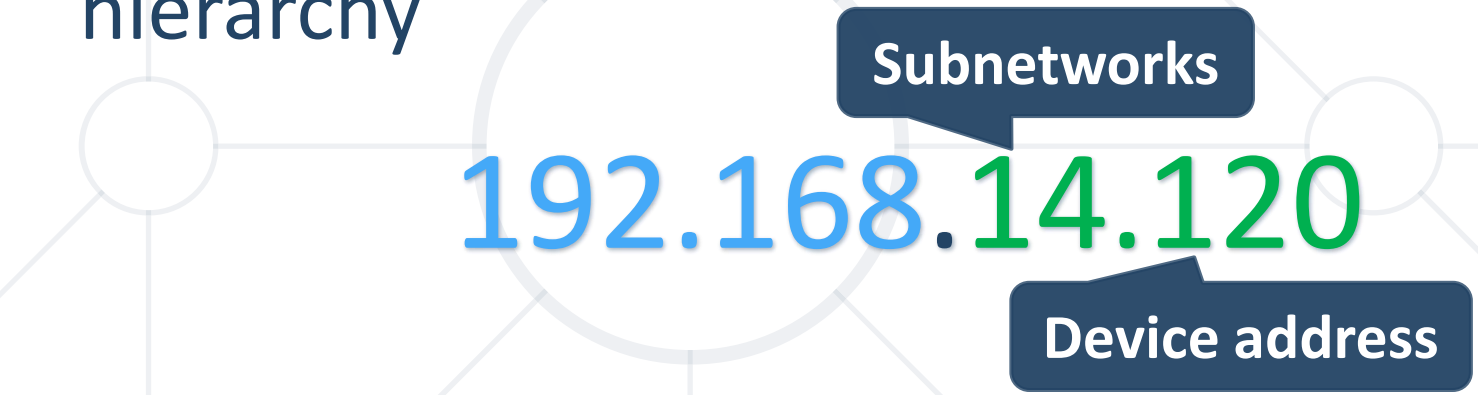
Internet Protocol

- 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

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



- 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

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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)

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- 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

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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)

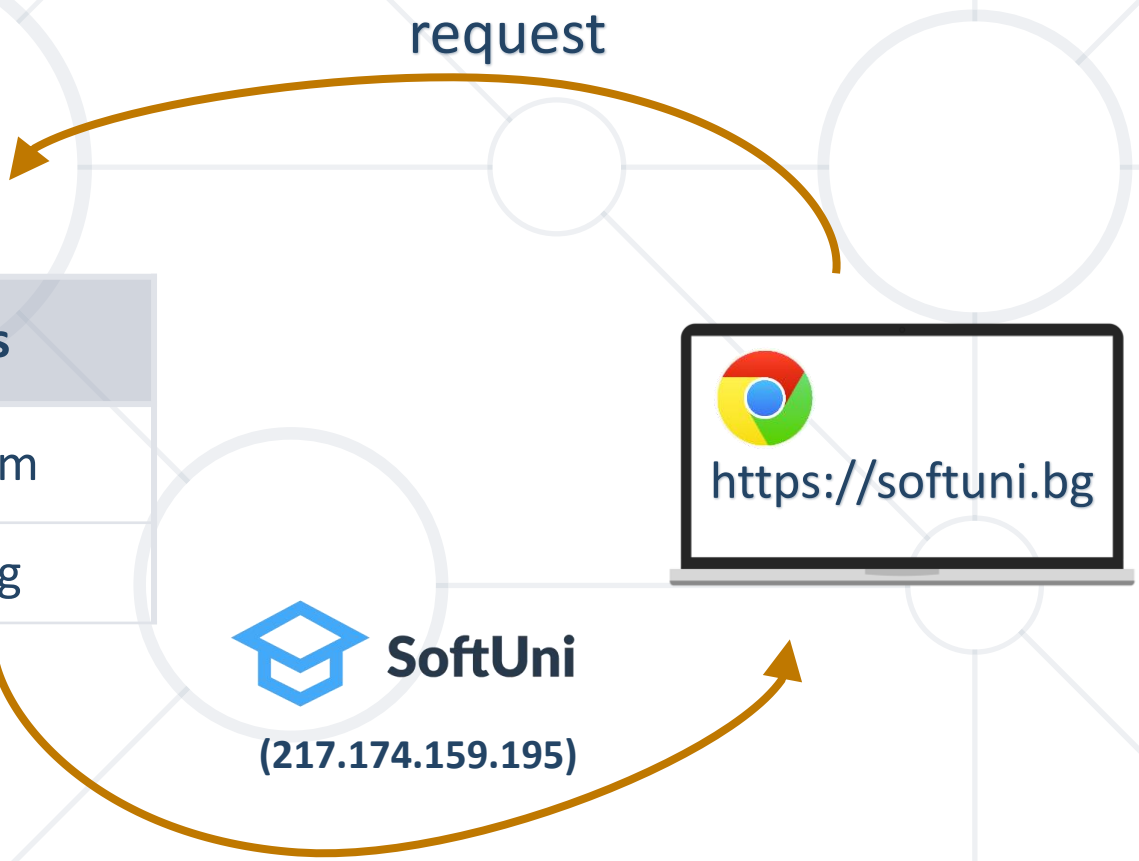
What is a DNS?

`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

IP Address	Domains
216.58.214.46	google.com
217.174.159.195	softuni.bg



Reliability and TCP

Reliability

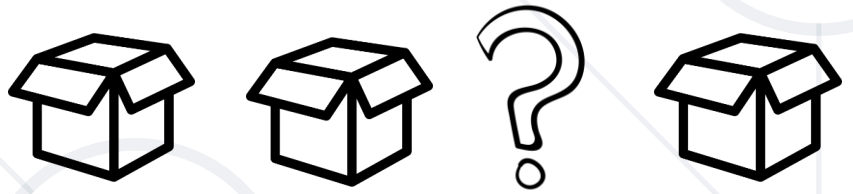
- When packets are transmitted from one location to another, they can take different paths
- When they get to the destination, they are unorganized and sometimes not complete
- So the message needs to be audited and reviewed in order to put it together in the right way
- The **Transmission Control Protocol**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

Transmission Control Protocol - TCP (1)

- **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 (2)

- 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



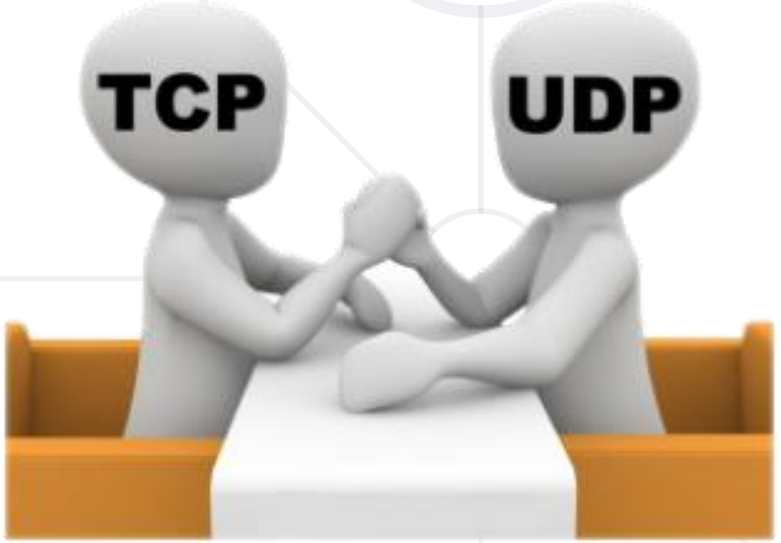
- After that it **certifies the data** and the packets are **merged** together to recreate the **original** file that was on the sender's device

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

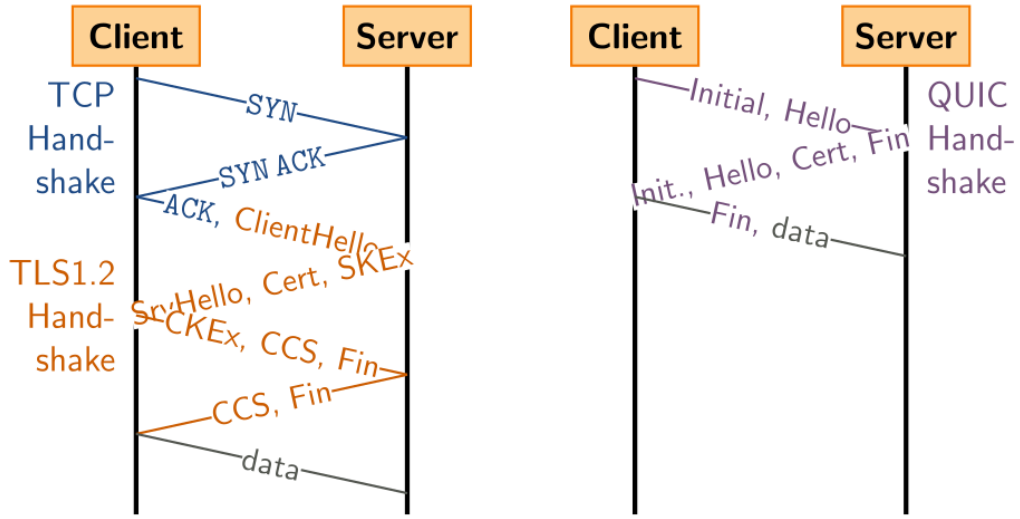
TCP vs UDP

- **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**

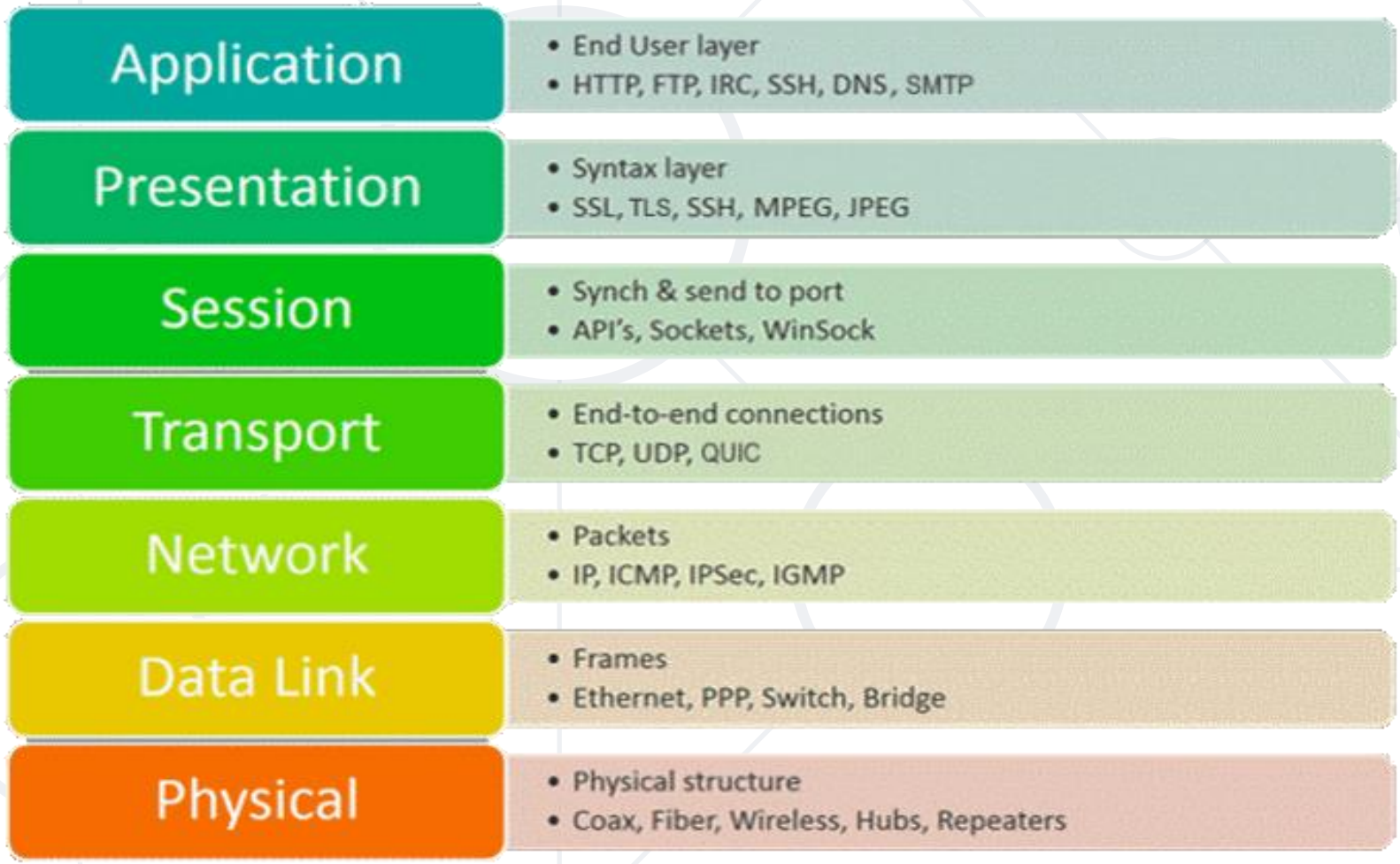


The OSI Model

What is the OSI Model?

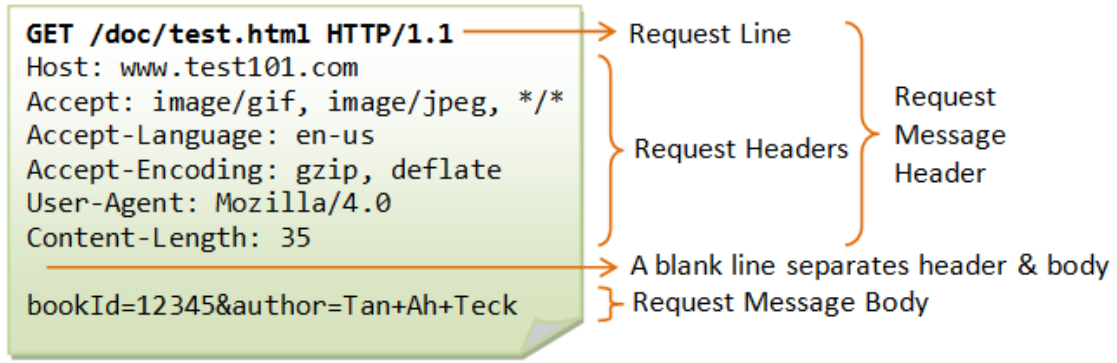
- **OSI** model stands for **O**pen **S**ystem **I**nterconnect
- It consists of **7 layers**
  - Each layer serves the layer above it and in return, is served by the layer below it
- Understanding each layer of the model helps us with
  - **Troubleshooting**
  - **Communicating** better with technical 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

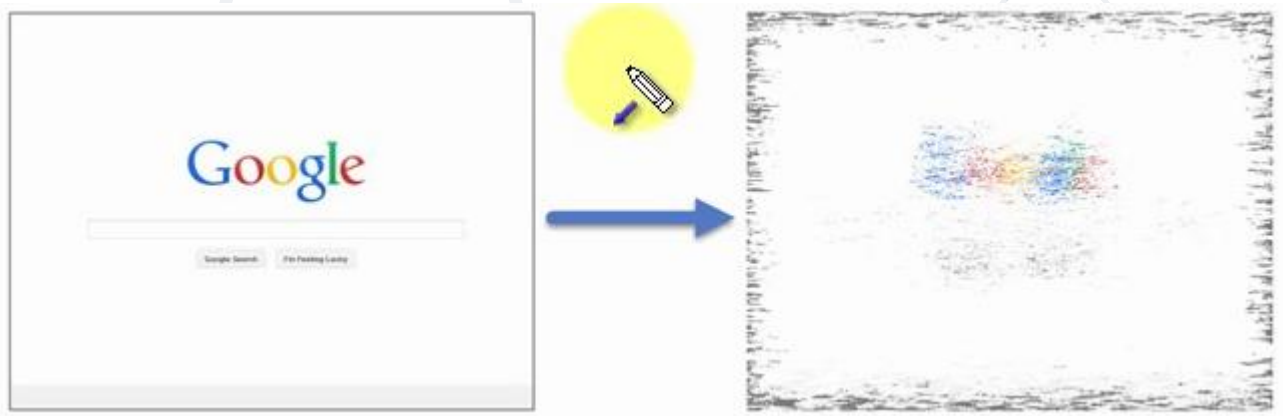
Application Layer – 7

- 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**



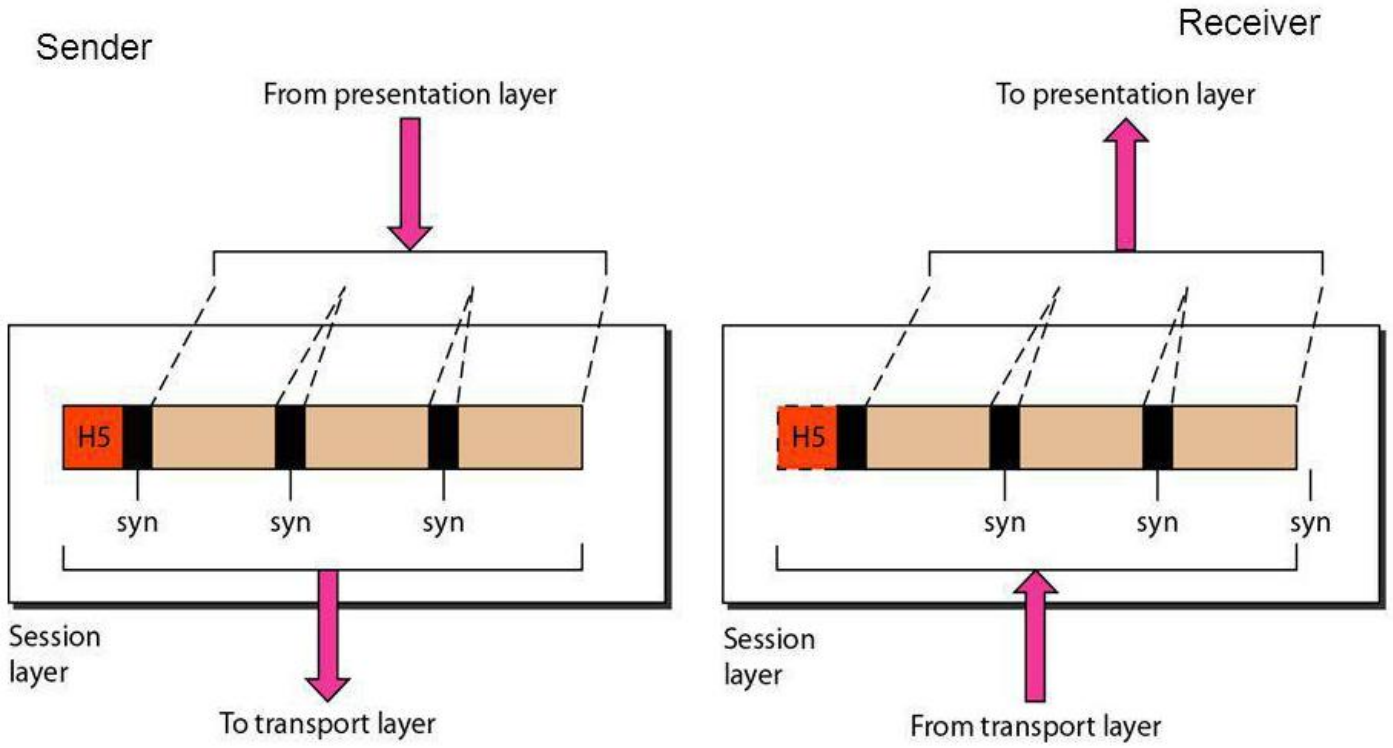
Presentation Layer – 6

- 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

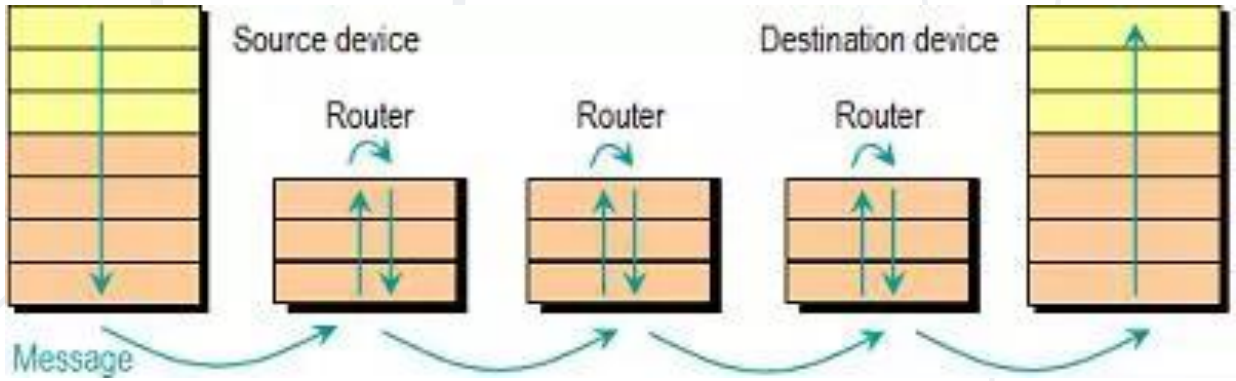


Transport Layer – 4

- 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

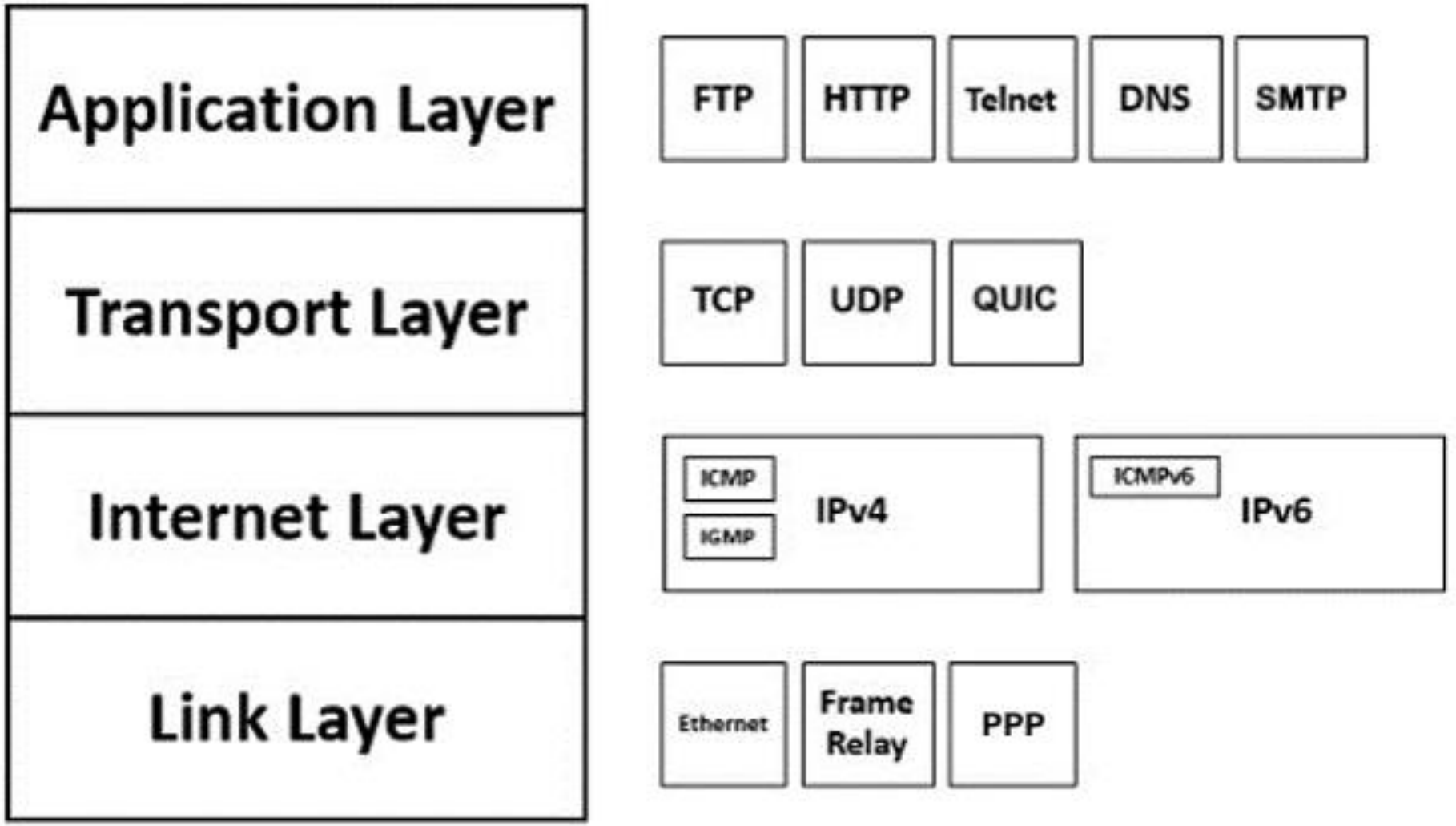
- Provides **node-to-node data transfer**
- The data transferred is split into packets – **frames**
- It **detects** and possibly **corrects** errors that may occur in the **physical layer**

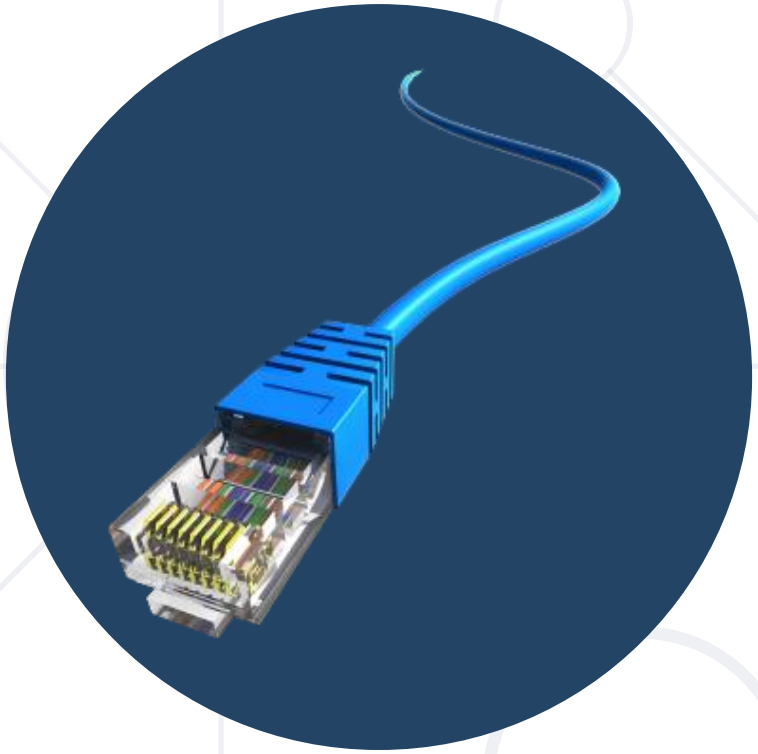
- Divides into two sublayers
  - **Medium Access Control (MAC)** layer – controlling how devices in a network gain access to a medium and permission to transmit data
  - **Logical Link Control (LLC)** layer – identifying and encapsulating network layer protocols, controls error checking and frame synchronization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

TCP/IP Protocol Suite





Network Hardware

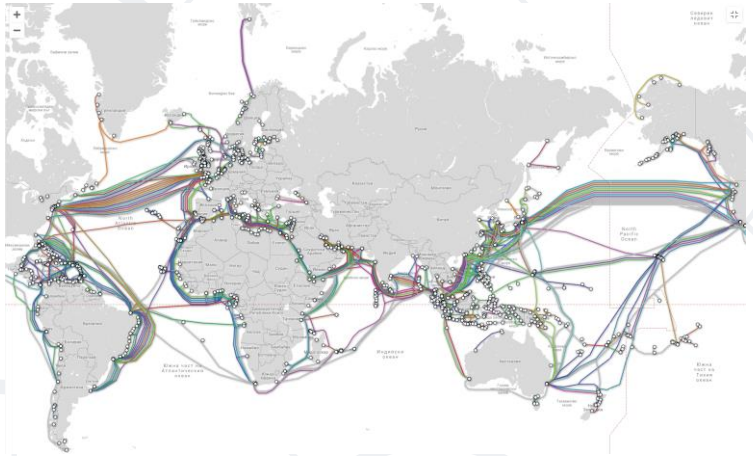
Basic Hardware Components

Network Hardware

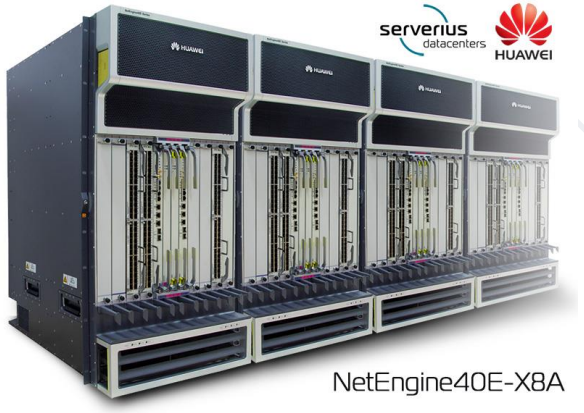
- Basic Hardware Components
  - Cables
  - Routers
  - Repeaters, Hubs and Switches
  - Bridges
  - Gateways
  - Network Interface Cards

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

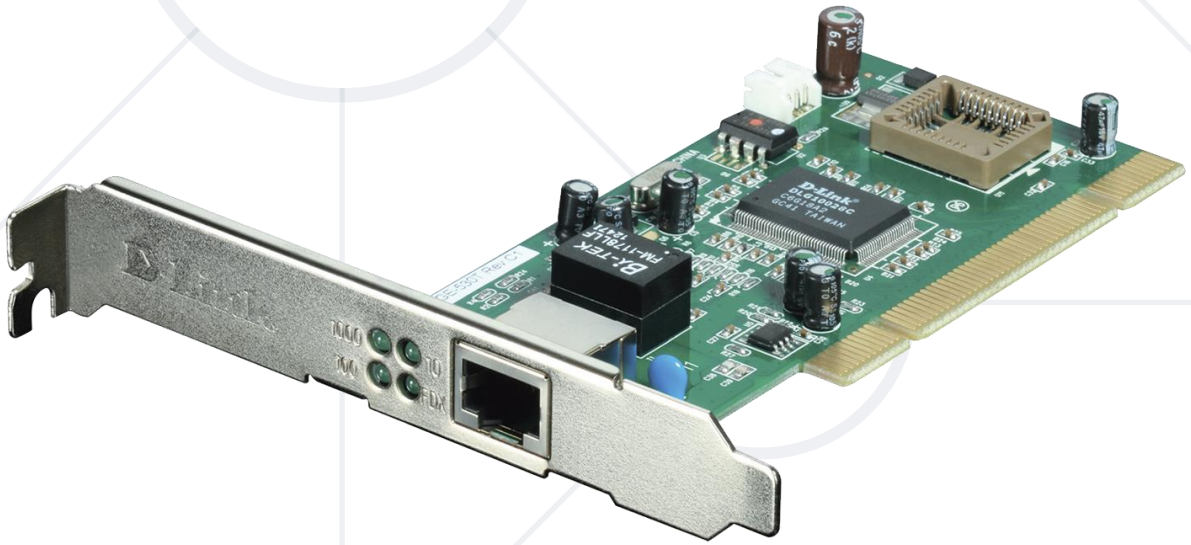
- **Repeaters**, **hubs** and **switches connect** network **devices** together so that they can function as a single segment
  - **Repeater** – **receives** a **signal** and regenerates it before re-transmitting, so that it can travel longer distances
  - **Hub** – multiport **repeater** (operates on 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

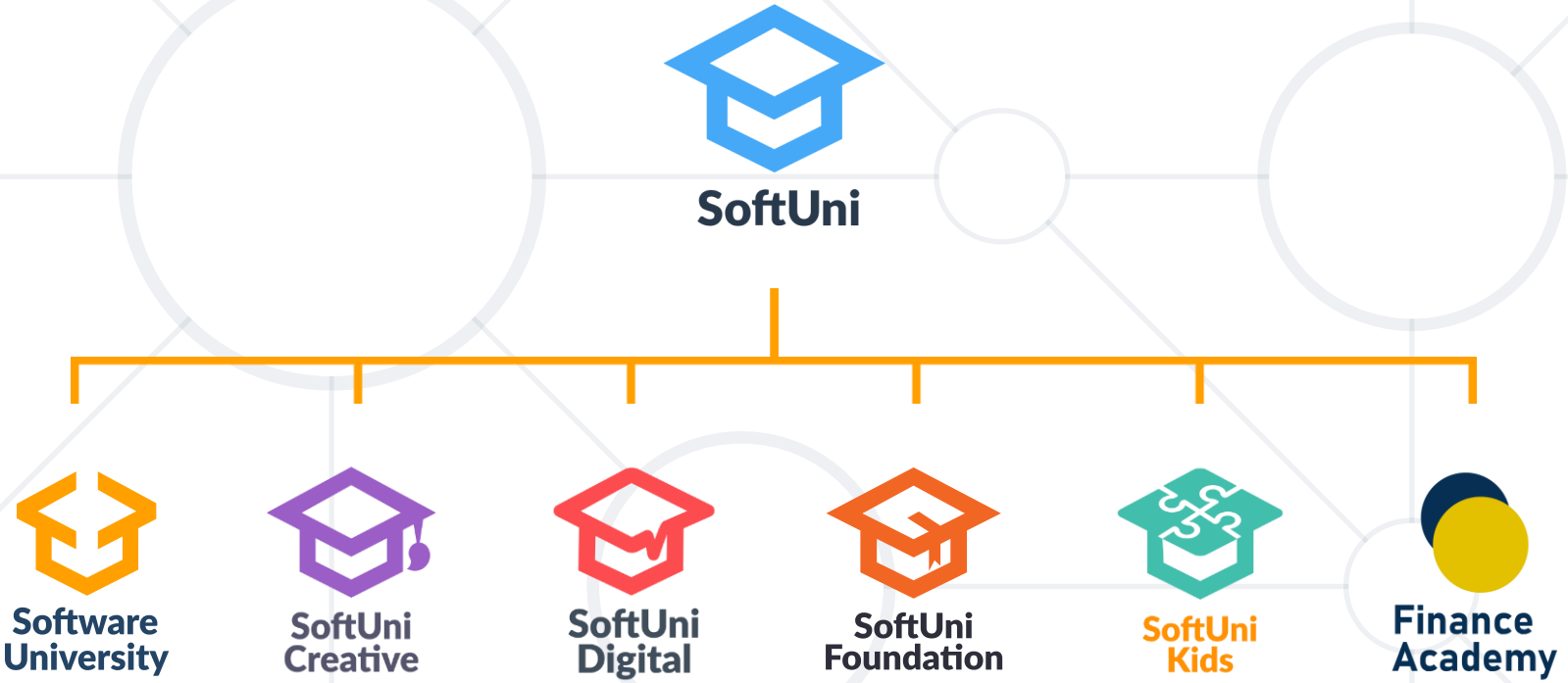
The Future of the Internet

- 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

Questions?



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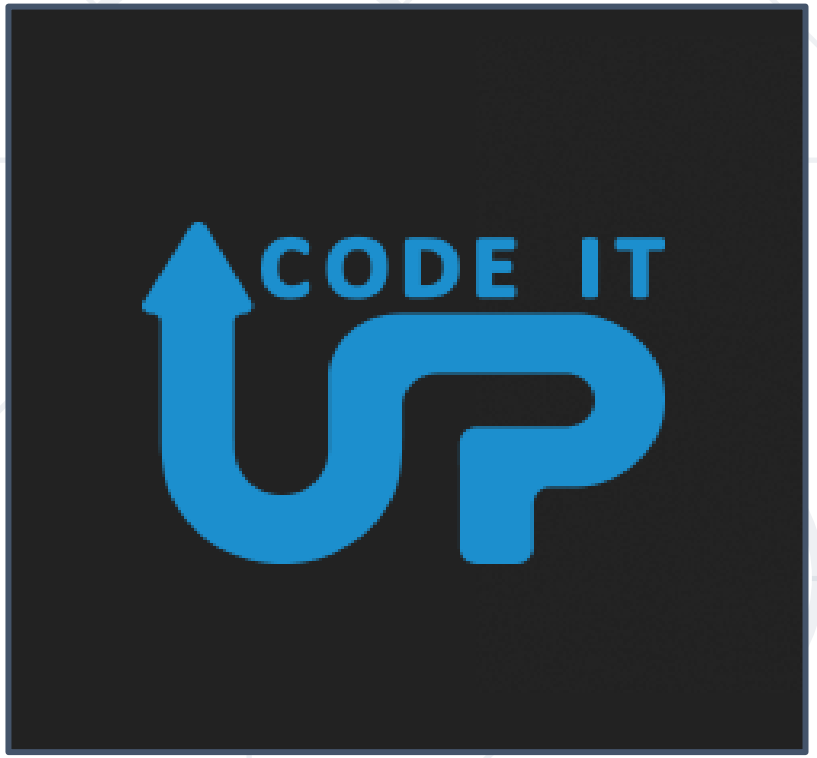

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