Internet Explained

SoftUni Team

Technical Trainers

Software University

SoftUni

Software University

https://softuni.bg

Table of Content

Have a Question?

Software University

sli.do

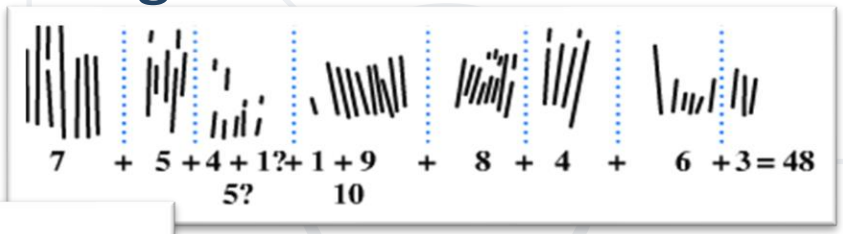
#java-web

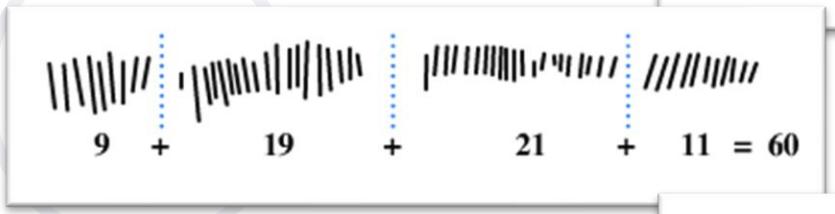
Introduction to Internet

An Introduction to the Internet

Ishango Bone

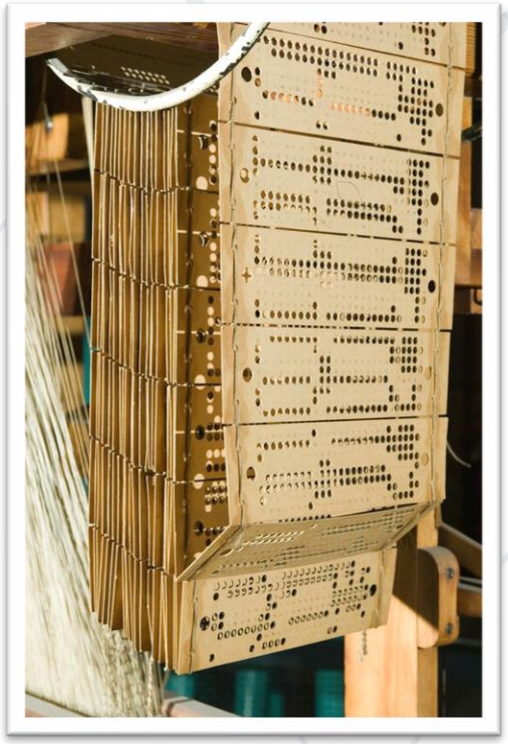
- The Ishango bone is a bone tool and possible mathematical object, dated to the Upper Paleolithic era.
- The etchings on the bone are in three columns with marks asymmetrically grouped into sets, leading hypotheses such as that the implement indicates an understanding of decimals or prime numbers

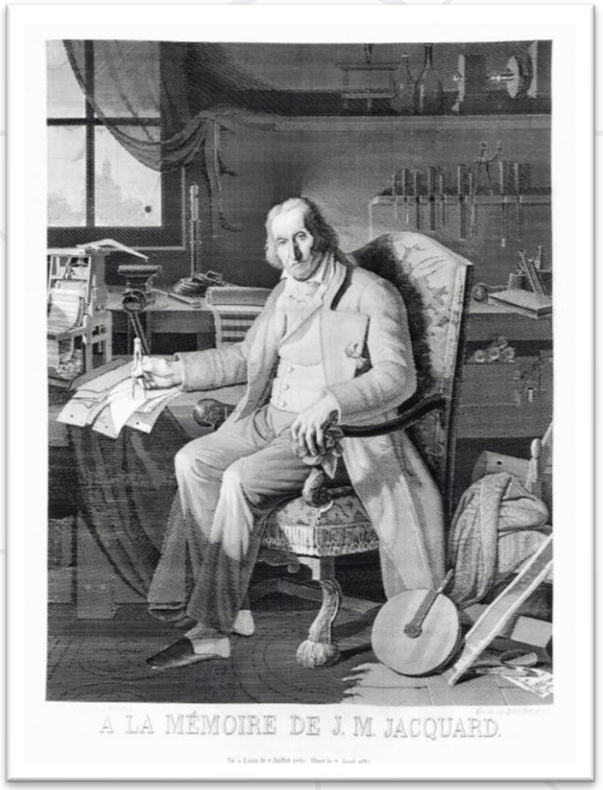




Jacquard machine

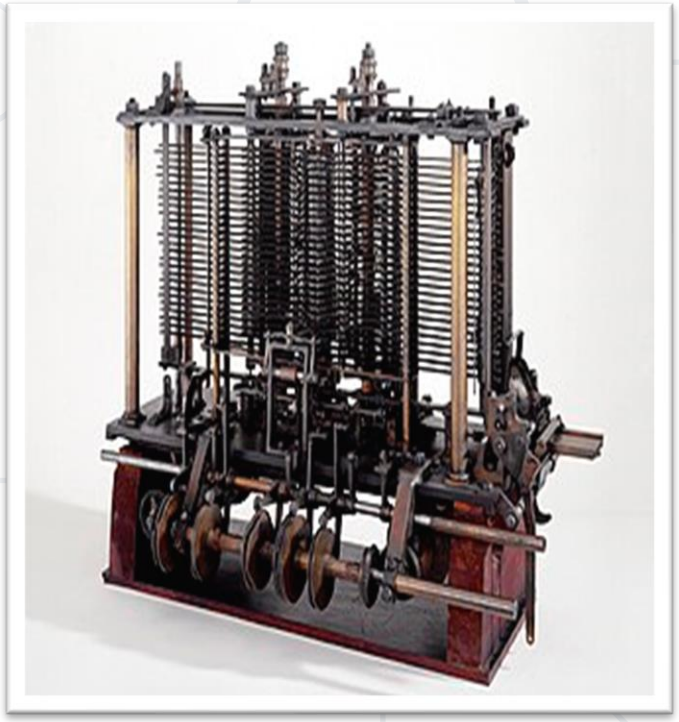
- Joseph-Marie Jacquard, a French weaver and merchant, patented his invention in 1804.
- Machine use of **interchangeable cards**, upon which small holes were punched, which held **instructions** for weaving a pattern

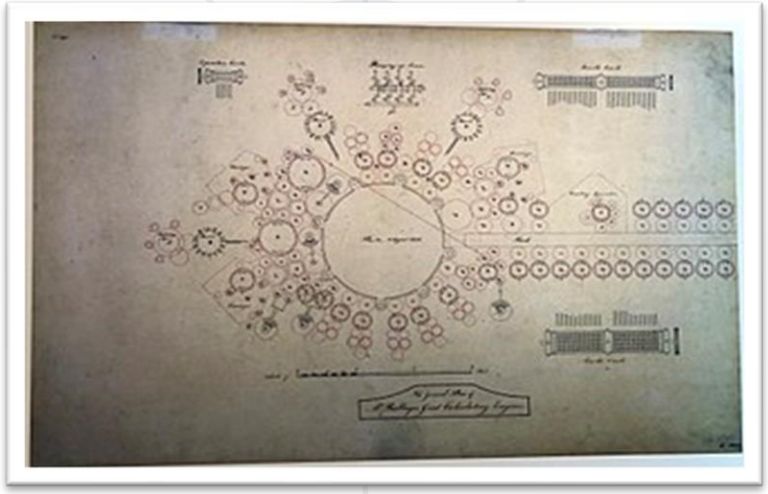


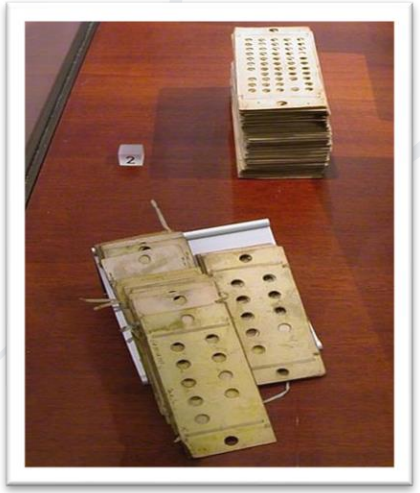


Analytical Engine

- The **Analytical Engine** was a proposed mechanical general-purpose computer designed by English mathematician and computer pioneer Charles Babbage
- The Analytical Engine incorporated an **arithmetic logic unit**, control flow in the form of **conditional** branching and **loops**, and **integrated memory**, making it the first design for a general-purpose computer that could be described in modern terms as Turing-complete

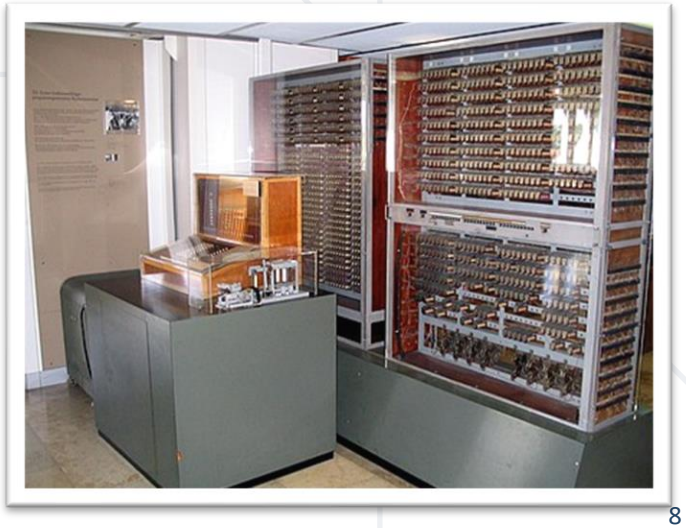






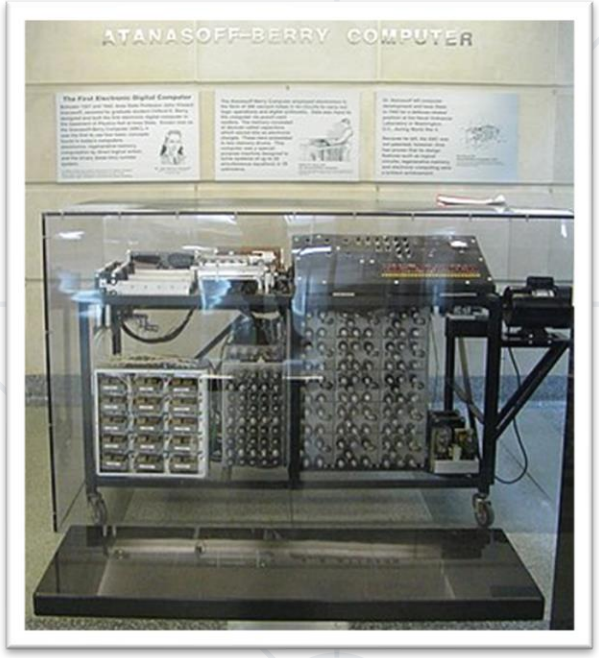
Tabulating machine & Z3

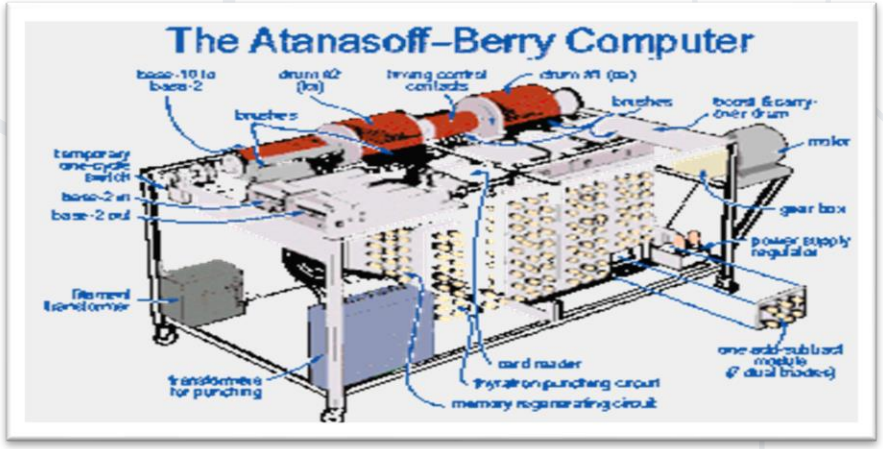
- The **Tabulating machine** was an electromechanical machine designed to assist in summarizing information stored on punched cards.
- Invented by Herman Hollerith
- Later models were widely used for business applications such as accounting and inventory control
- The **Z3** was a German electromechanical computer designed by Konrad Zuse in 1935, and completed in 1941. It was the world's first working programmable, fully automatic digital computer.



Atanasoff–Berry computer

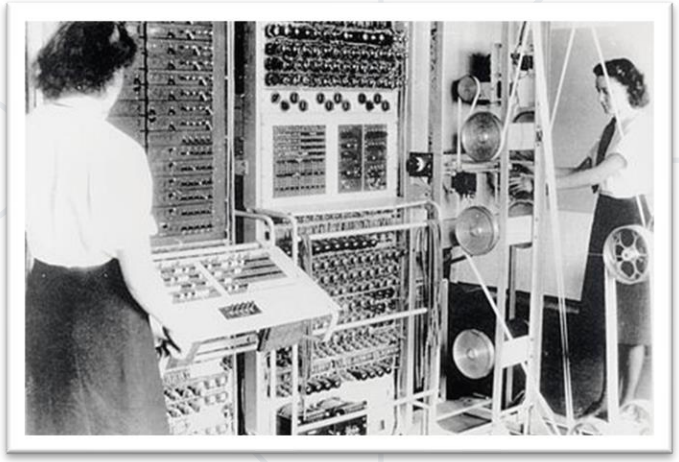
- The **Atanasoff–Berry computer** (ABC) was the first automatic electronic digital computer.
- The ABC would be considered the first electronic ALU (**Arithmetic Logic Unit**) - which is integrated into every modern processor's design.
- Its unique contribution was to make computing faster by being the first to use **vacuum tubes** to do the arithmetic calculations

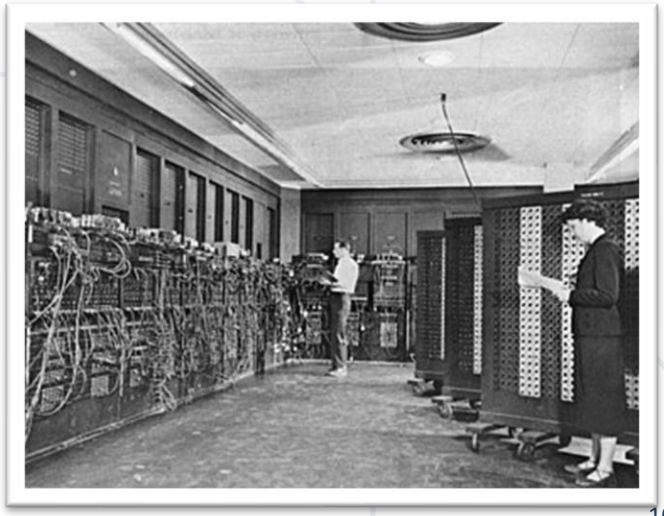




Colossus & ENIAC

- Colossus was a set of computers developed by British codebreakers in the years 1943–1945 to **help** in the **cryptanalysis** of the Lorenz cipher.
- Colossus used thermionic valves (vacuum tubes) to perform Boolean and counting operations.
- Colossus is thus regarded as the world's first programmable, electronic, digital computer, although it was programmed by switches and plugs and not by a stored program.
- ENIAC (Electronic Numerical Integrator and Computer) was the first programmable, electronic, general-purpose digital computer. It was Turing-complete and able to solve "a large class of numerical problems" through reprogramming.
- Was designed and primarily used to **calculate artillery firing** tables for the United States Army's Ballistic Research Laboratory



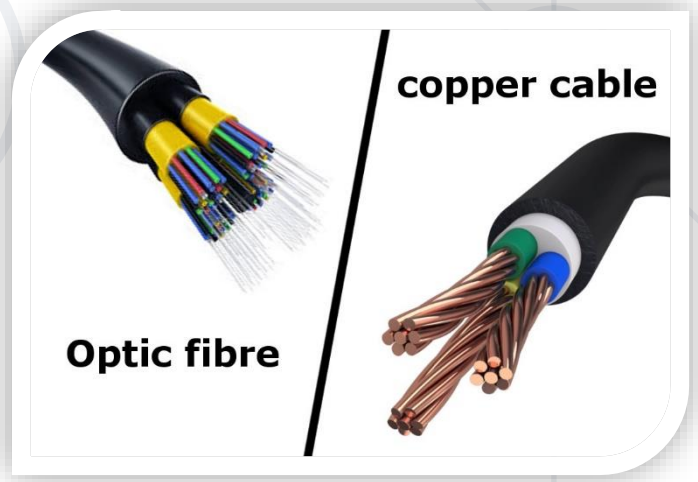


Internet – History

- 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

Internet – Introduction (1)

- So, what is **the Internet?**
  - A simple answer to that question is a **wire**. A wire, which is buried into the ground or even in the ocean
  - That wire can be **fiber optics**, **copper** or occasionally beamed to **satellites** or through **cell phone network**



Internet – Introduction (2)

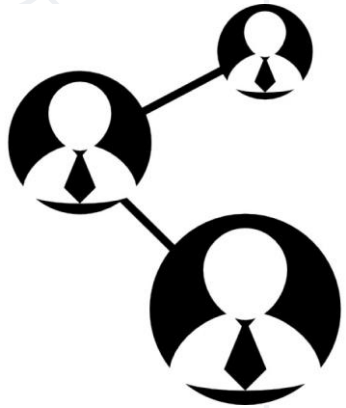
- **ISPs** (**I**nternet **S**ervice **P**roviders) have access to such cables
- We get indirectly **connected** to them though ISPs
- The **Internet** is a **network of networks**. It connects billions of devices together all over the globe that are connected to this wire in one form or another

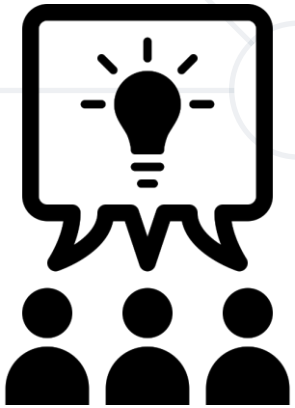
What is a Network?

- **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

Software University

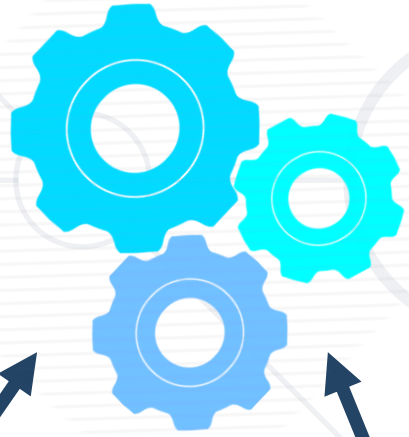
Web Client

Request

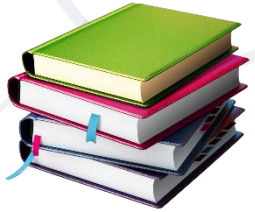
Response

Web Server

Technology



Web Resources

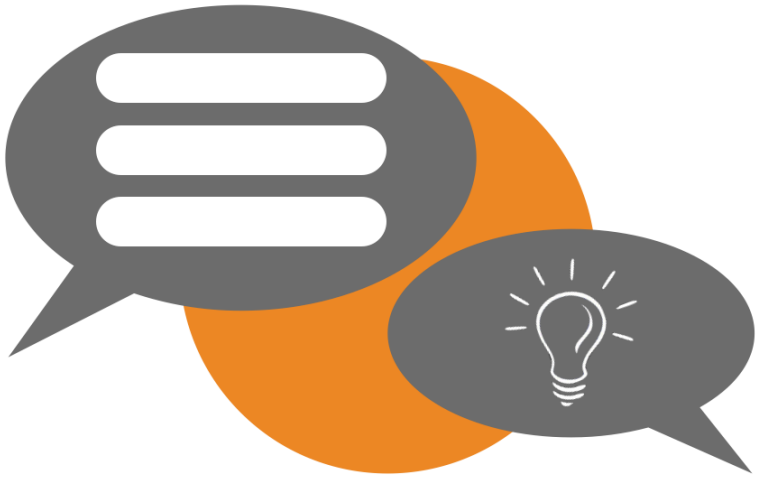


HTML, PDF, JPG…

Database

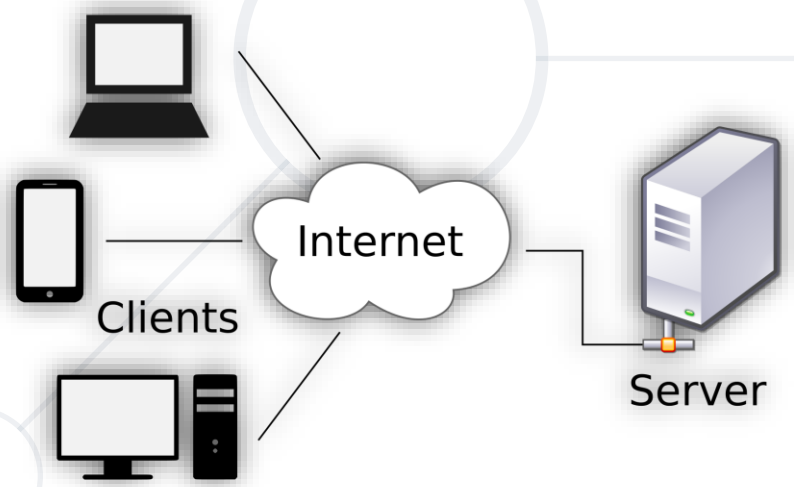
Important Definitions

- 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
- Example for standard network protocols:
  - TCP, UDP, IP, ARP
  - HTTP, FTP, TFTP, SMPT, SSH

Packets

Sending and Receiving Information

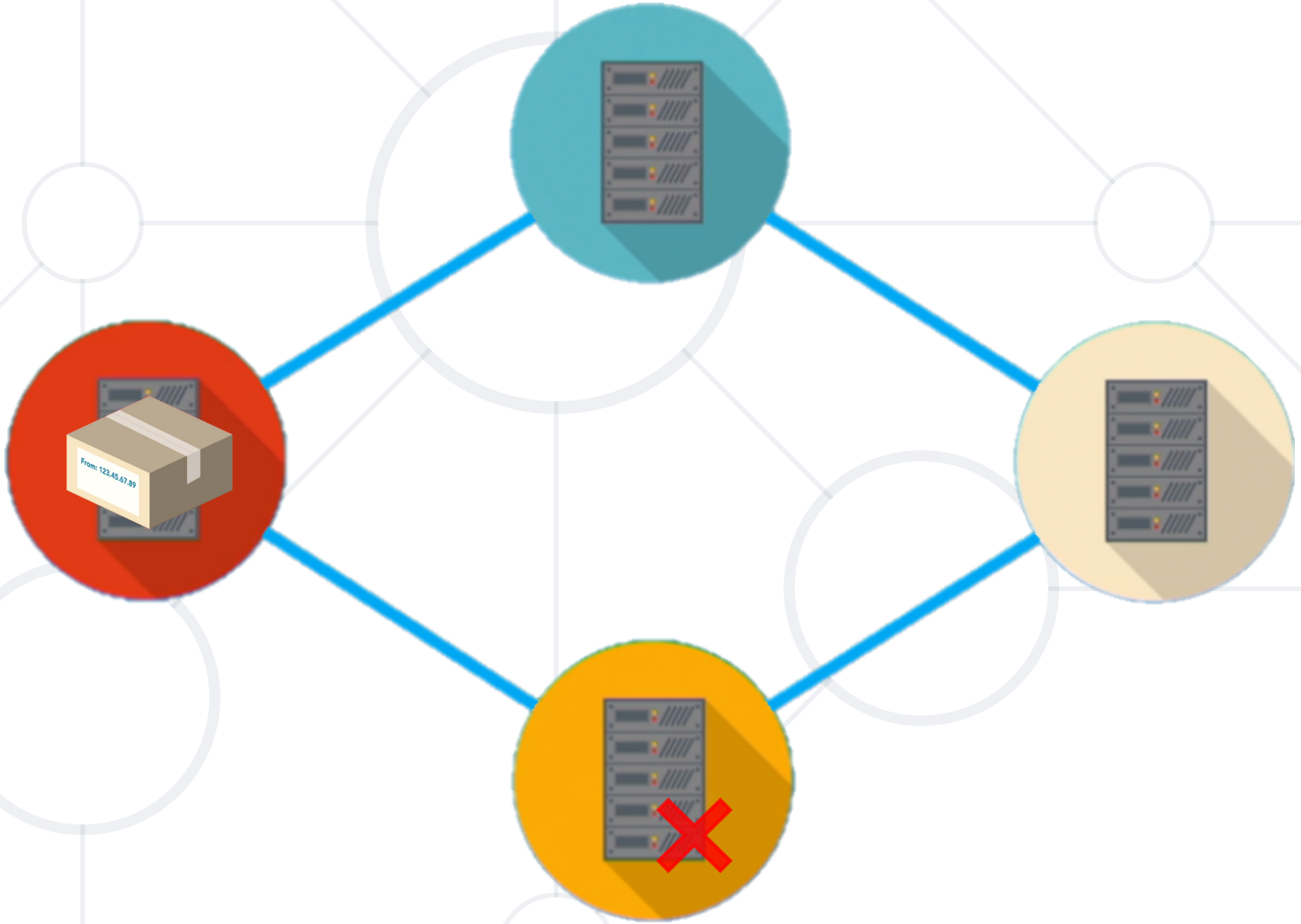
Packets (1)

- Everything that is created on a computer is translated into digital information using **bits**
- Bits need to have a way to be transmitted over the internet
- Every message, file or stream of information 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 **the header**:
  - Where it came from
  - Where is it 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 On the Packets in the Network

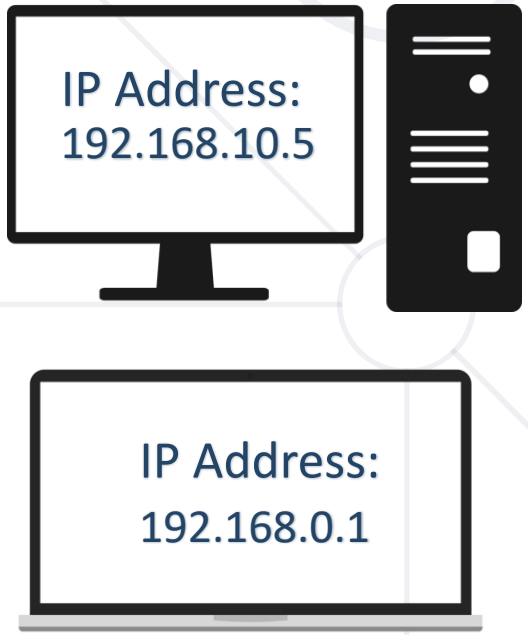


Internet Protocol

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



IPv4

- **IPv4** is a sequence of four, 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

- 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

IP address classes

```
Class A
  0.  0.  0.  0 = 00000000.00000000.00000000.00000000
127.255.255.255 = 01111111.11111111.11111111.11111111
                  0nnnnnnn.HHHHHHHH.HHHHHHHH.HHHHHHHH

Class B
128.  0.  0.  0 = 10000000.00000000.00000000.00000000
191.255.255.255 = 10111111.11111111.11111111.11111111
                  10nnnnnn.nnnnnnnn.HHHHHHHH.HHHHHHHH

Class C
192.  0.  0.  0 = 11000000.00000000.00000000.00000000
223.255.255.255 = 11011111.11111111.11111111.11111111
                  110nnnnn.nnnnnnnn.nnnnnnnn.HHHHHHHH

Class D
224.  0.  0.  0 = 11100000.00000000.00000000.00000000
239.255.255.255 = 11101111.11111111.11111111.11111111
                  1110XXXX.XXXXXXXX.XXXXXXXX.XXXXXXXX

Class E
240.  0.  0.  0 = 11110000.00000000.00000000.00000000
255.255.255.255 = 11111111.11111111.11111111.11111111
                  1111XXXX.XXXXXXXX.XXXXXXXX.XXXXXXXX
```

What Is CIDR (Classless Inter-Domain Routing)

Software University

- Classless Inter-Domain Routing, is an 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

Software University

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
- This is a full IPV6 address:
  - **3FFE:F200:0234:AB00:0123:4567:8901:ABCD**
- The **leading zeros** in **IPv6** can usually be left out

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

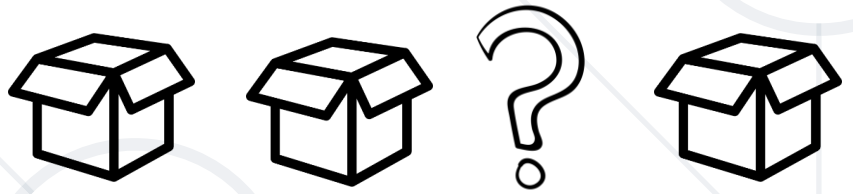
- When packets are transmitted from one location to another, they can take different paths
- When they get to the destination, they are unorganized and sometimes not complete
- So the message needs to be audited and reviewed in order to put it together in the right way
- The **Transmission Control Protocol**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

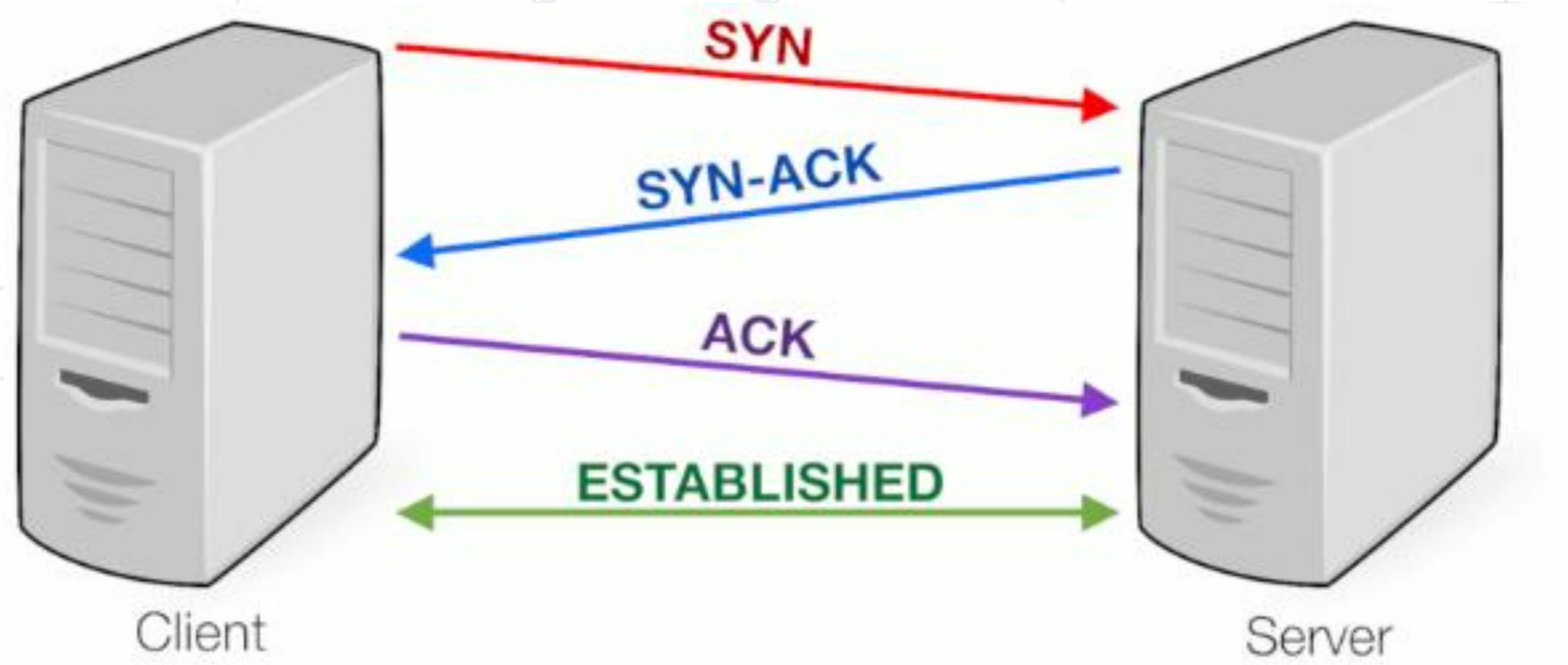
Transmission Control Protocol - TCP (2)

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



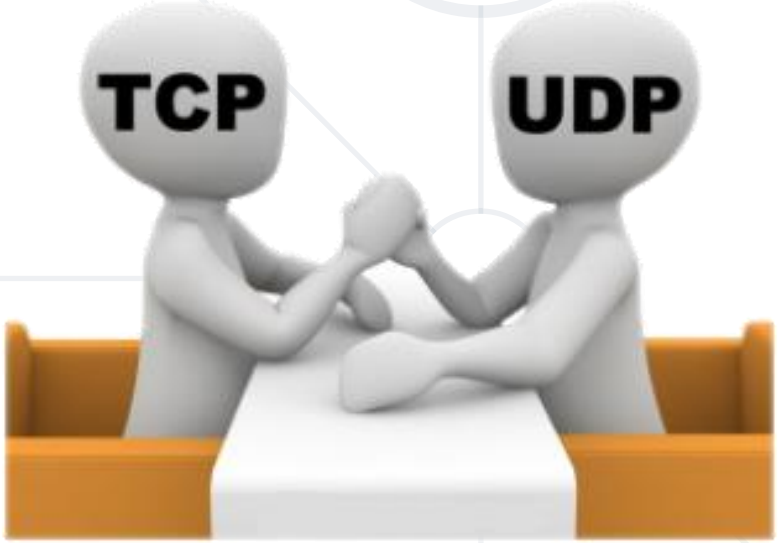
- After that it **certifies the data** and the packets are **merged** together to recreate the **original** file that was on the sender's device

Transmission Control Protocol - TCP (3)



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, there is another protocol called **UDP** or **User Datagram Protocol**
- 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



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

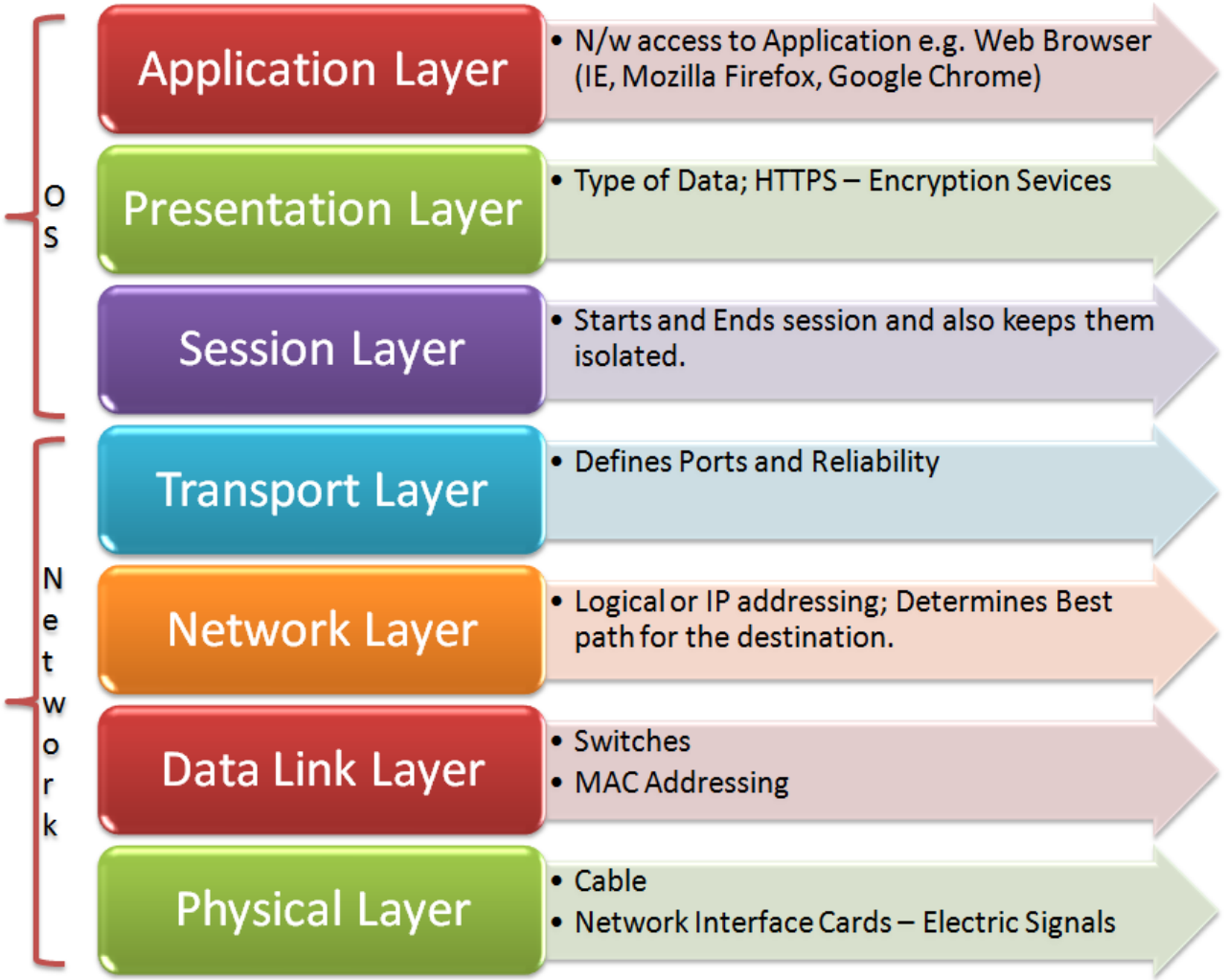
The OSI Model

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

- OSI Model consists of 7 layers:



Example Protocols

HTTP, DNS, FTP, SMTP

TLS, SSL, compression

NetBIOS, PPTP, Sockets

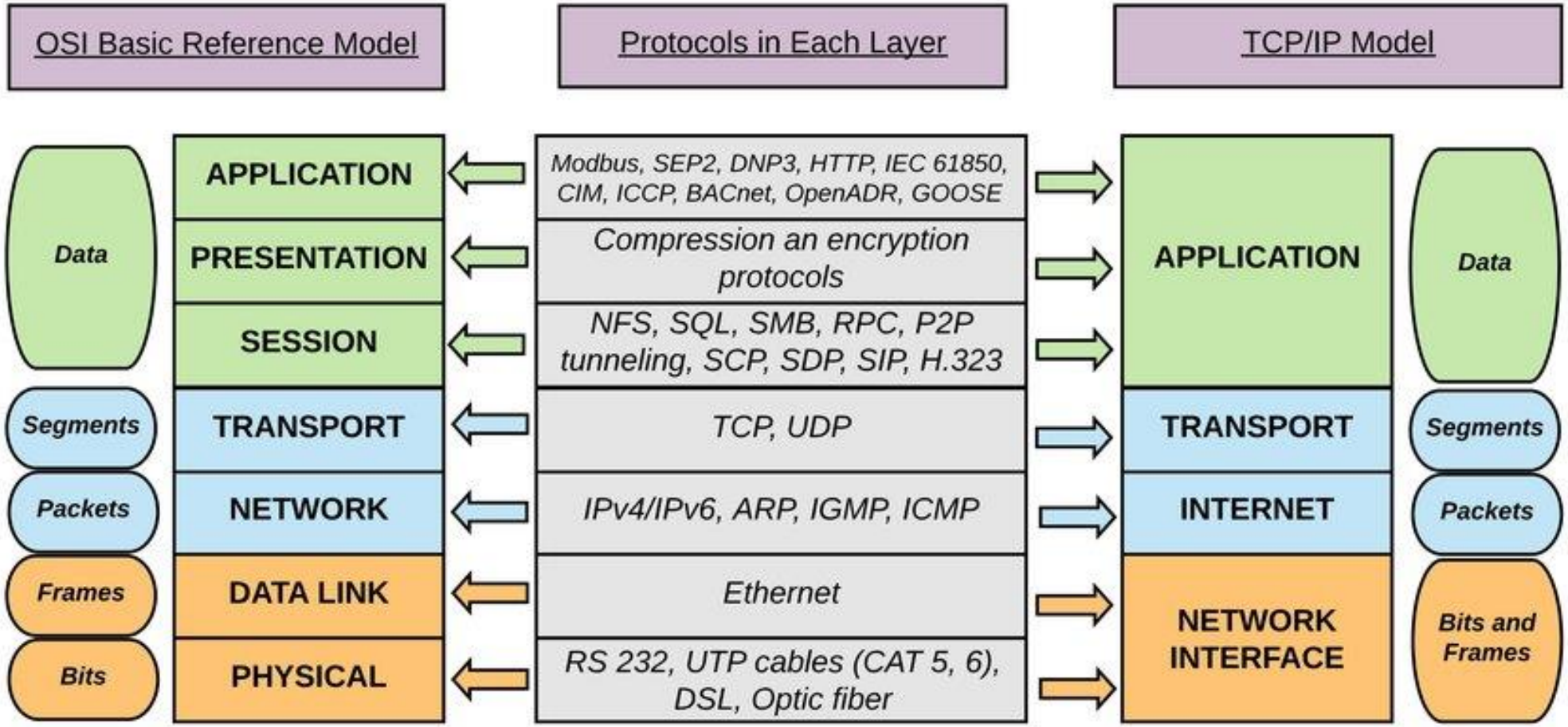
TCP, UDP

IP, IPsec

ATM, Ethernet, MAC, LLC

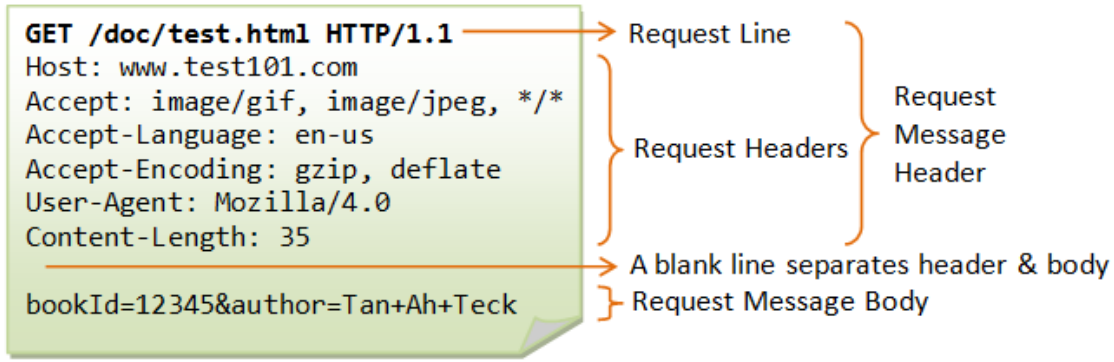
USB, Bluetooth, 802.11a/b/g/n

TCP/IP model mapping to OSI



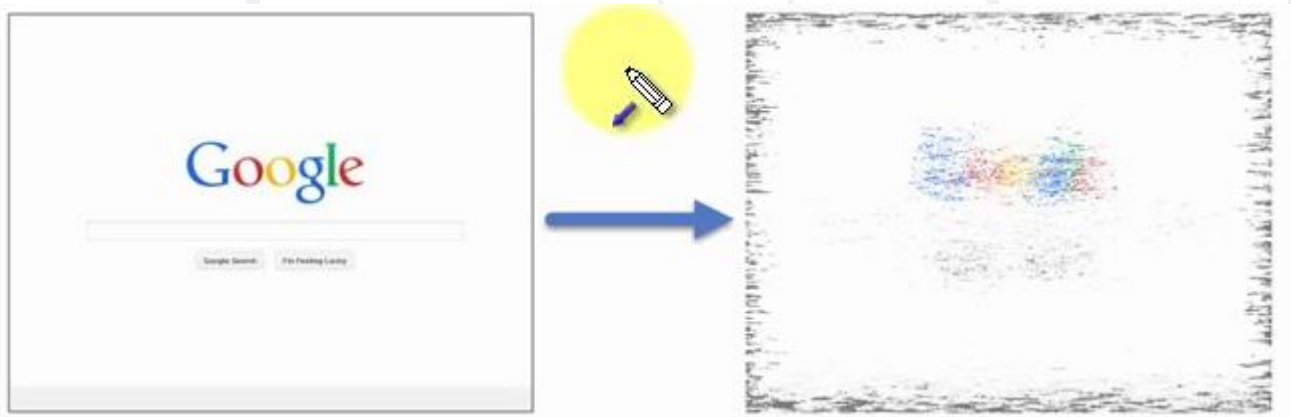
Application Layer – 7

- Enables different applications like the browser to use the network and present it to the End User
- Protocol examples:
  - **Domain Name System (DNS)**
  - **File Transfer Protocol (FTP)**
  - **HyperText Transfer Protocol (HTTP)**
  - **Simple Mail Transfer Protocol (SMTP)**



Presentation Layer – 6

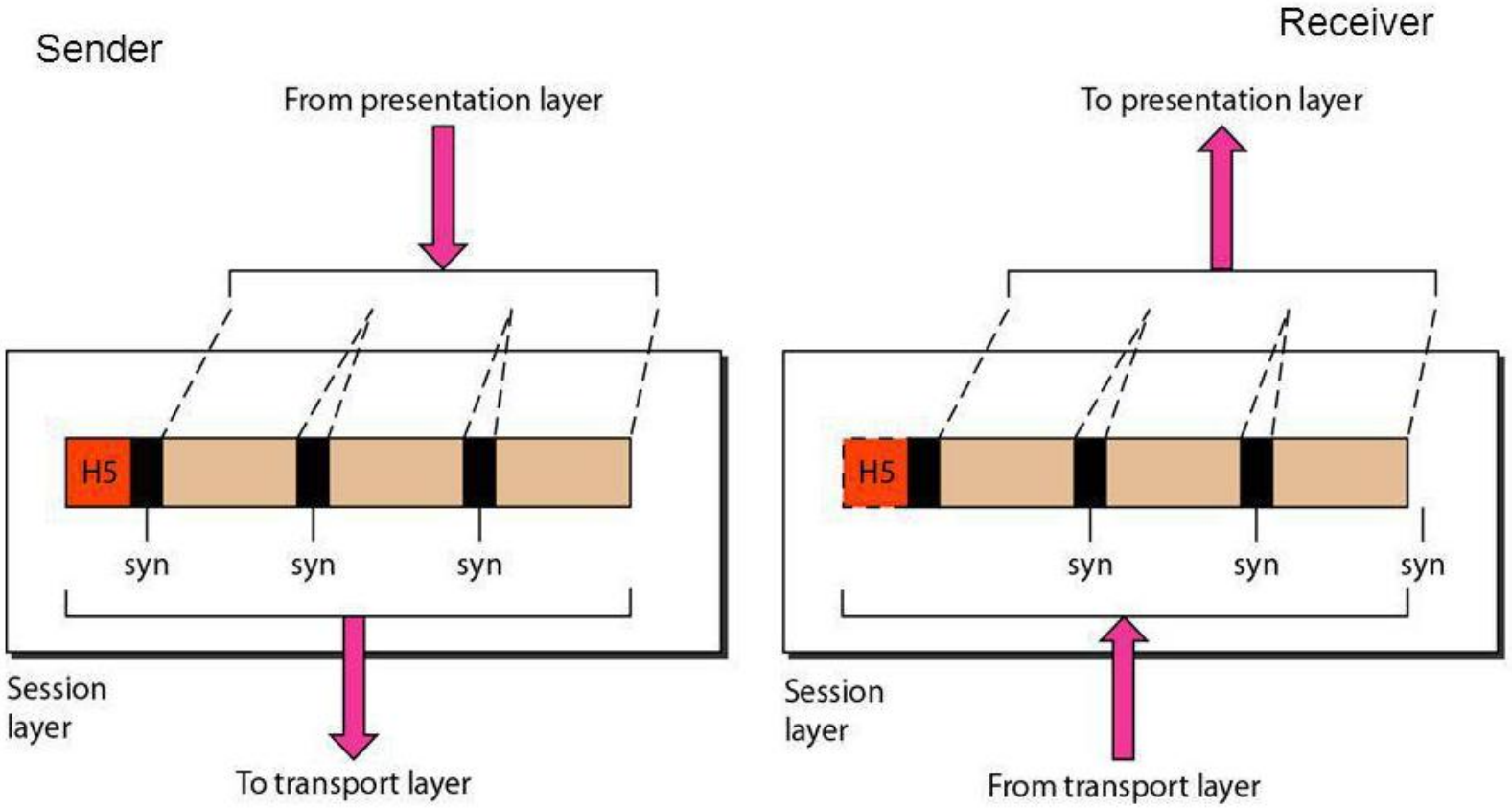
- This layer is a part of an operating system (OS)
- **Converts** incoming and outgoing **data** from one presentation format to another



- Example:
  - From clear text to encrypted (or compressed) text
  - Back to clear text

Session Layer – 5

- This layer sets up coordinates and terminates conversations
- Its services include authentication and reconnection after an interruption
- e.g.: Sockets

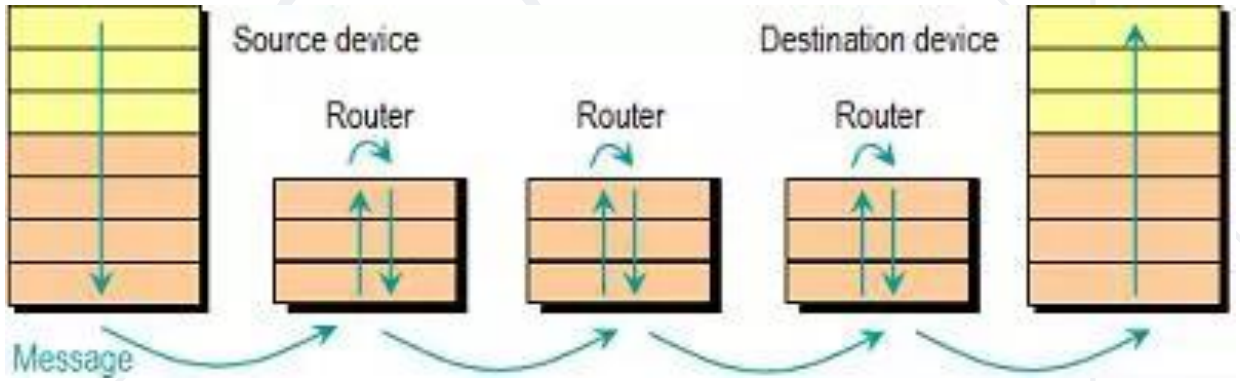


Transport Layer – 4

- Responsible for end-to-end communication over a network
- Provides logical communication between application processes
- Responsible for the management of error correction, providing quality and reliability to the end user
- Protocol examples:
  - **Transmission Control Protocol (TCP)**
  - **User Datagram Protocol (UDP)**

Network Layer – 3

- Provides the functional and procedural means of transferring 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:
  - **Internet Protocol (IP)**
  - **IPSec (IP + Auth)**



Data Link Layer – 2 (1)

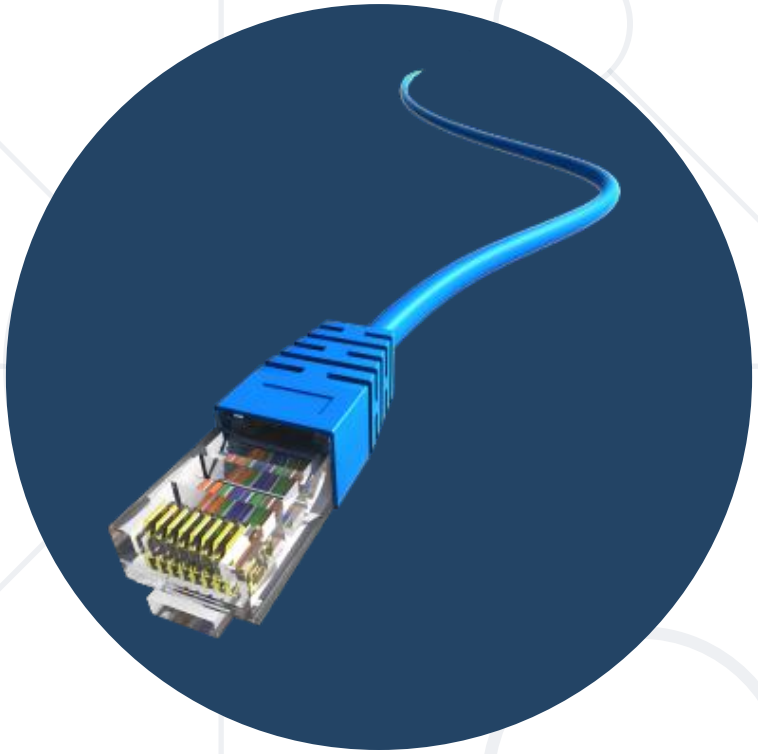
- Provides node-to-node data transfer
- It **detects** and possibly **corrects** errors that may occur in the **physical layer**
- Divides into two sublayers:
  - **Medium access control (MAC)** layer - controlling how devices in a network gain access to a medium and permission to transmit data
  - **Logical link control (LLC)** layer – identifying and encapsulating network layer protocols, controls error checking and frame synchronization

Data Link Layer – 2 (2)

- Protocol examples:
  - **Asynchronous Transfer Mode (ATM)**
  - **Ethernet**
  - **MAC**

Physical Layer – 1

- The things you can actually physically touch
- 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**



Network Hardware

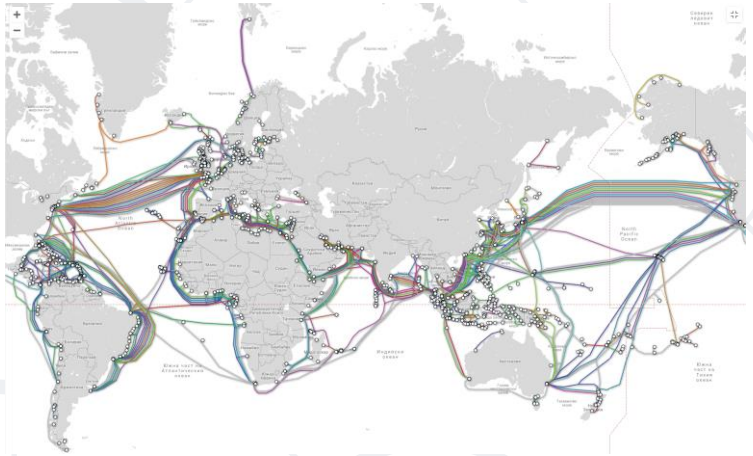
Basic Hardware Components

Network Hardware

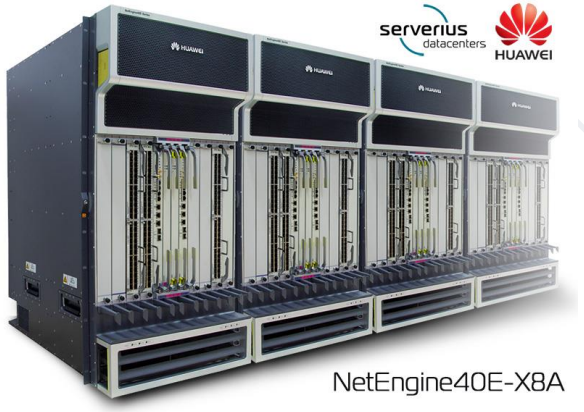
- Basic Hardware Components
  - Cables
  - Routers
  - Repeaters, Hubs and Switches
  - Bridges
  - Gateways
  - Network Interface Cards

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

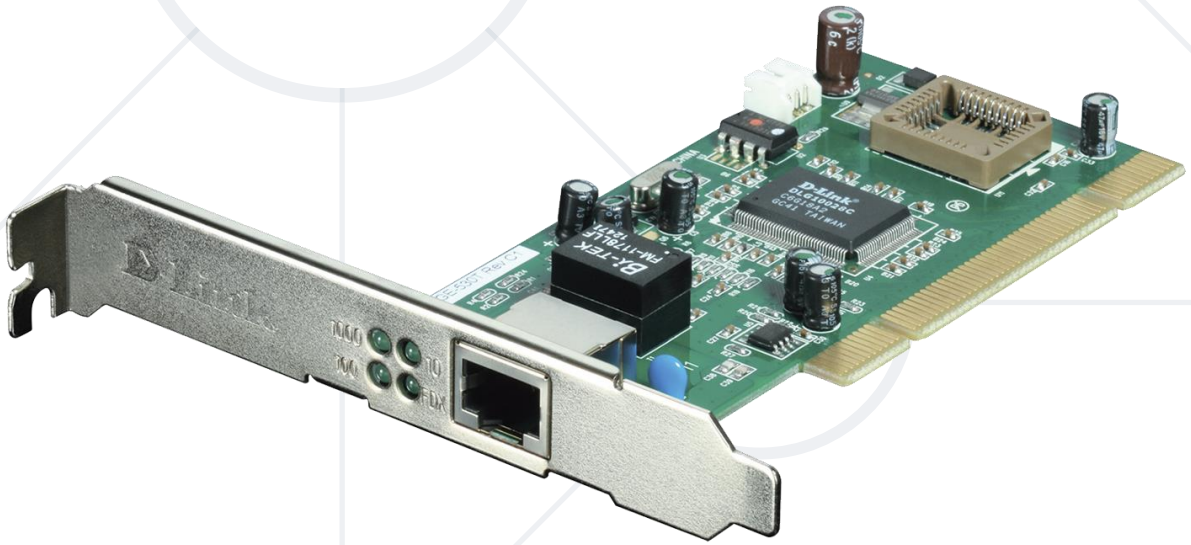
- **Repeaters**, **hubs** and **switches connect** network **devices** together so that they can function as a single segment
  - Repeater – **receives** a **signal** and regenerates it before re-transmitting, so that it can travel longer distances
  - Hub – multiport **repeater** (operates on level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

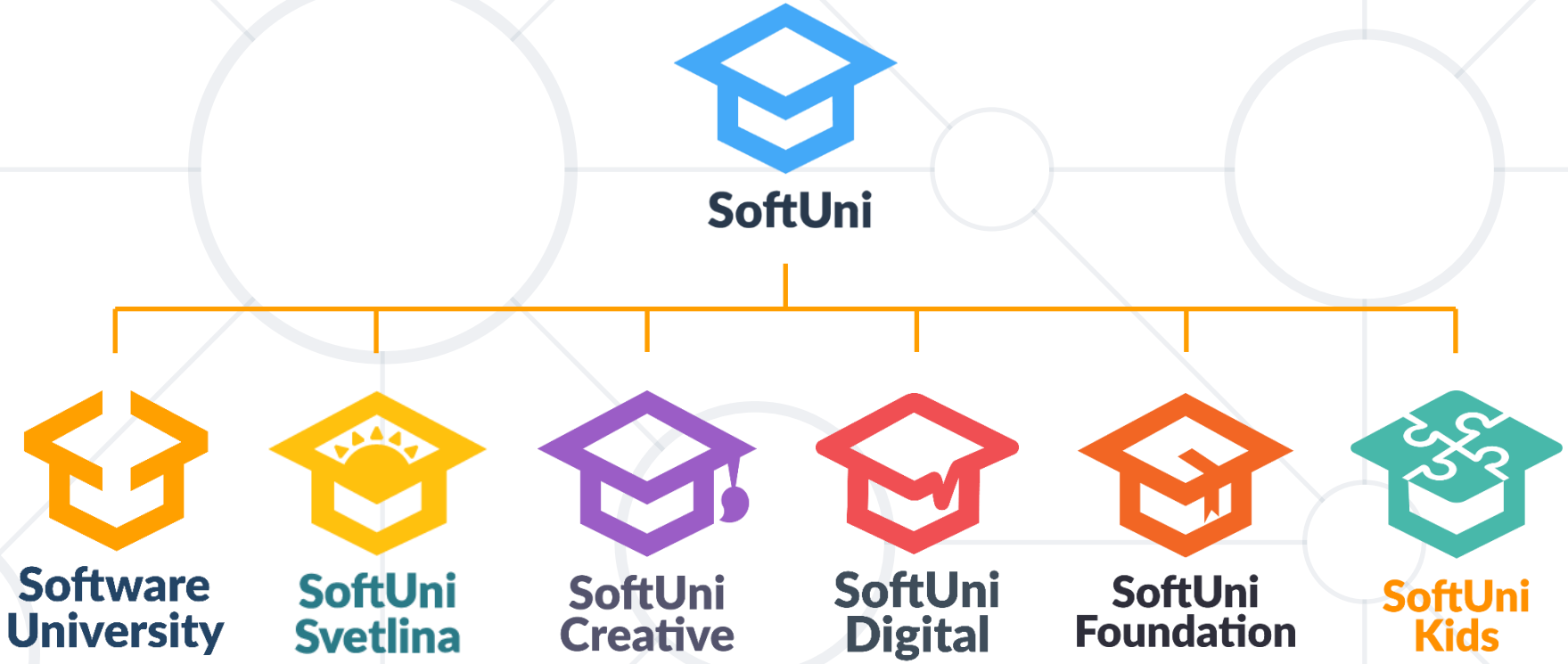
The Future of the Internet

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

Questions?

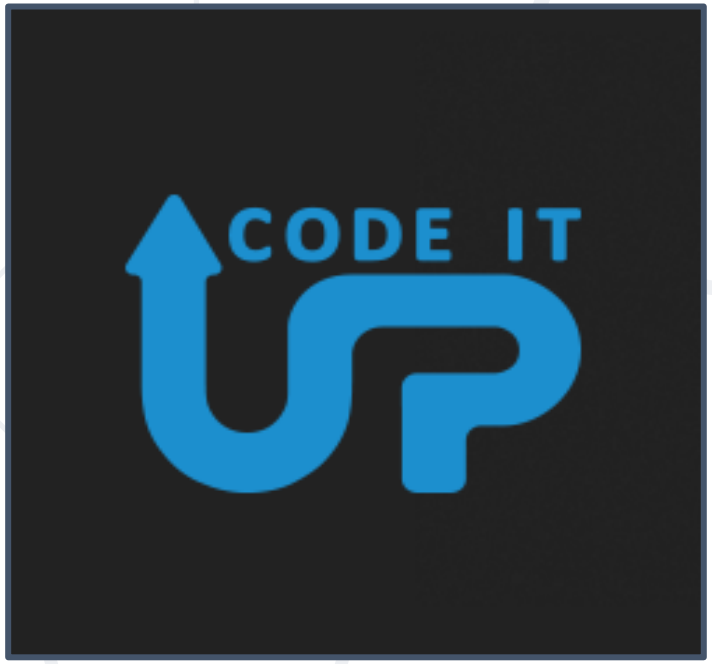


SoftUni Diamond Partners

Software University

Educational Partners

Software University



VIRTUAL RACING SCHOOL

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

- This course (slides, examples, demos, exercises, homework, documents, videos and other assets) is **copyrighted content**
- Unauthorized copy, reproduction or use is illegal
- © SoftUni – https://about.softuni.bg/
- © Software University – https://softuni.bg