

Internet Explained

SoftUni Team

Technical Trainers



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Software University

<https://softuni.bg>

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Have a Question?



sli.do

#java-web



Introduction to Internet

An Introduction to the Internet

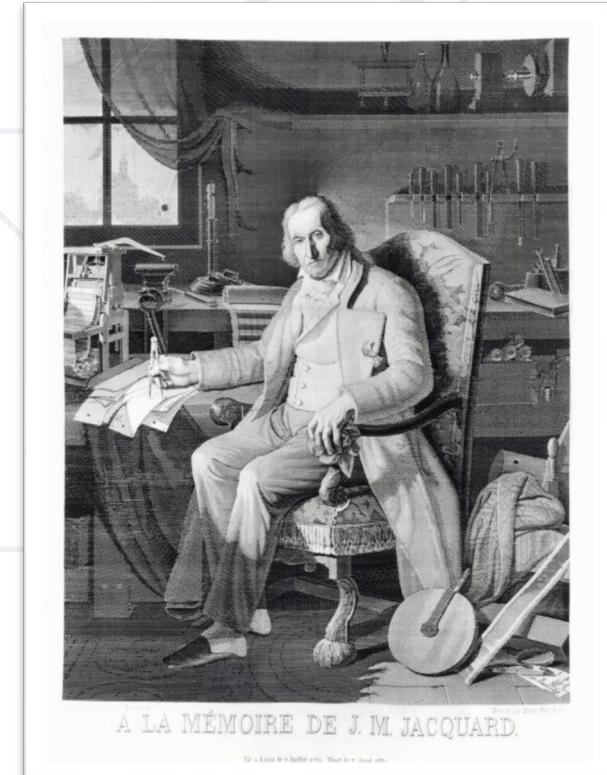
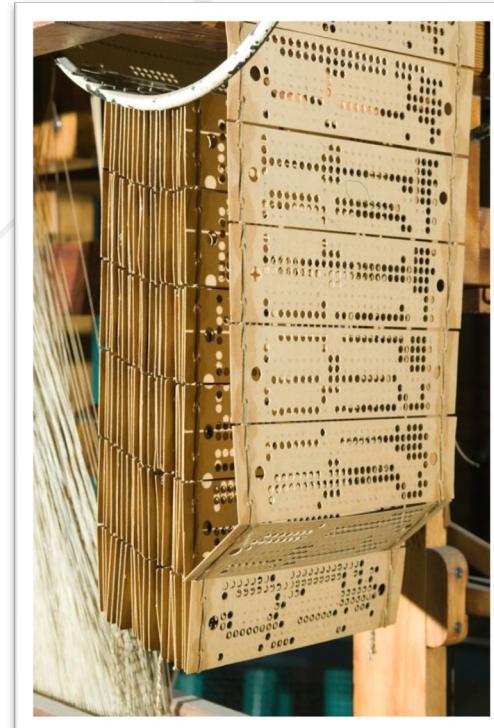
Ishango Bone

- 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



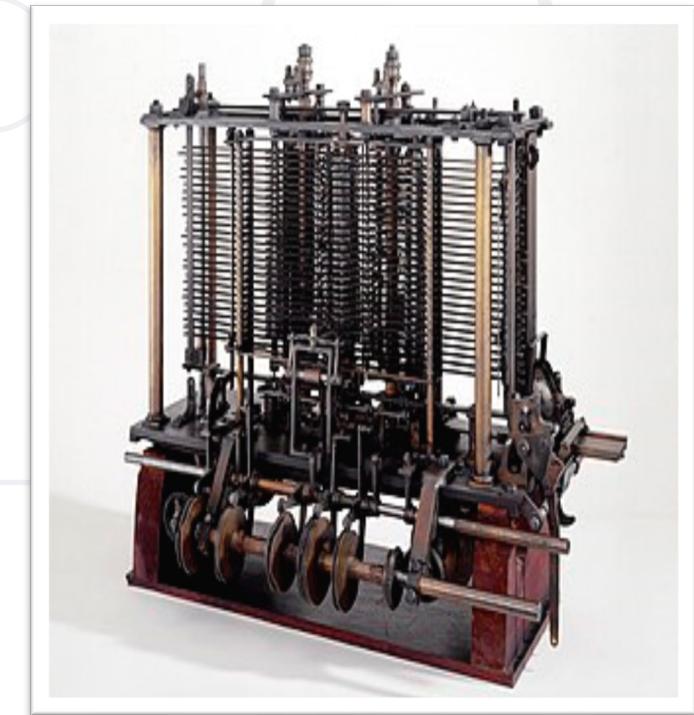
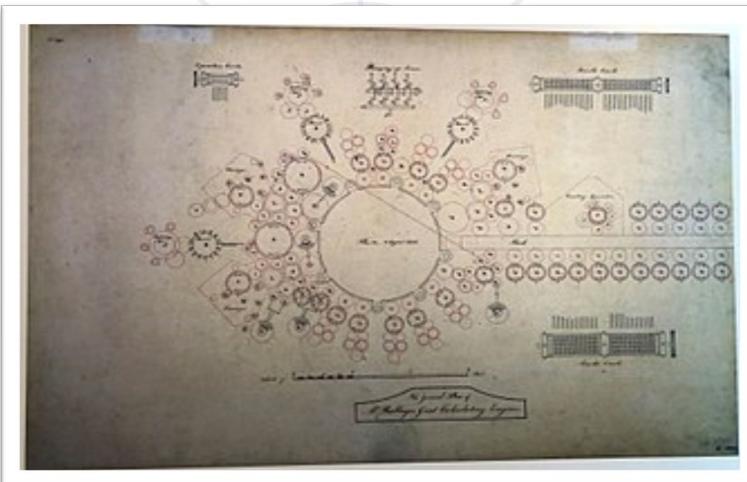
Jacquard machine

- 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



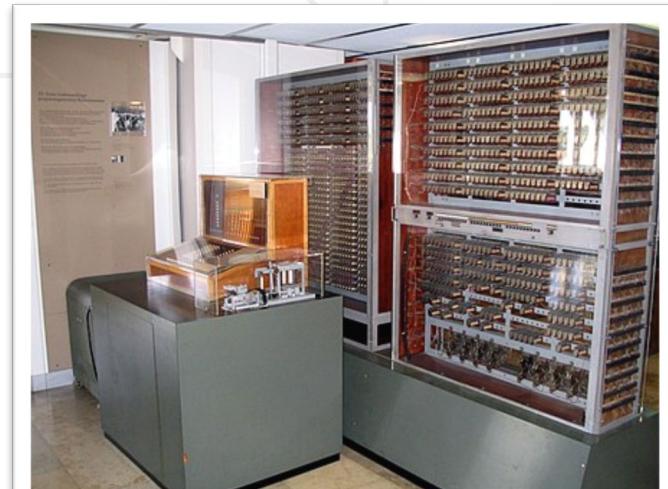
Analytical Engine

- 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



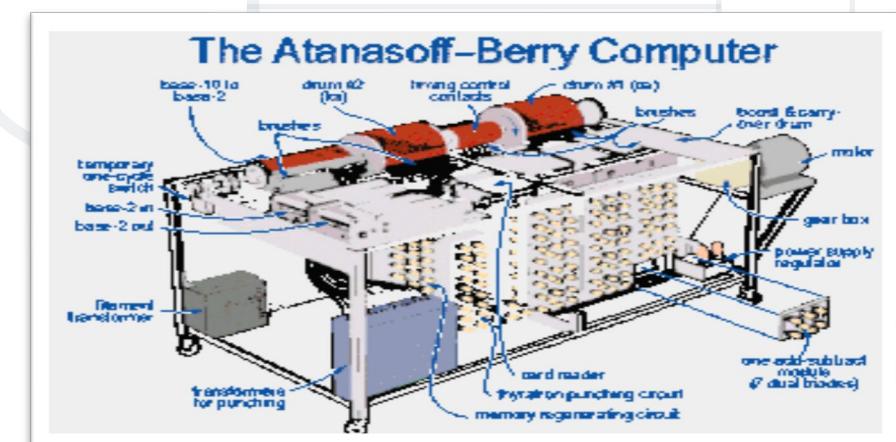
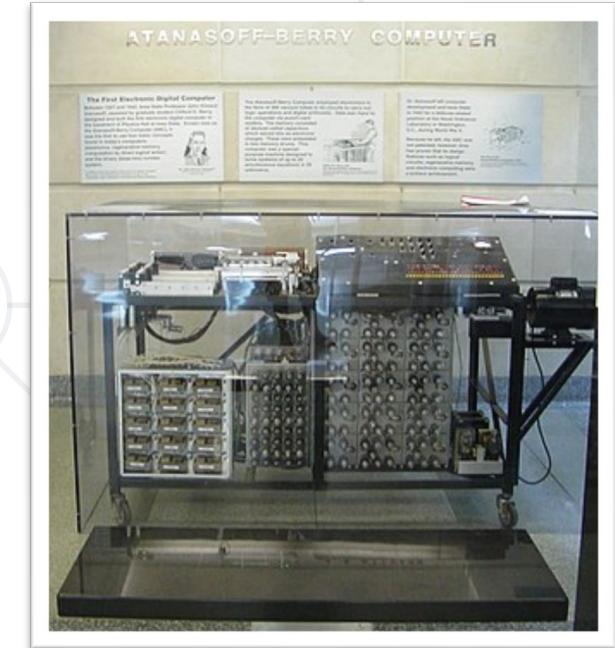
Tabulating machine & Z3

- 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.



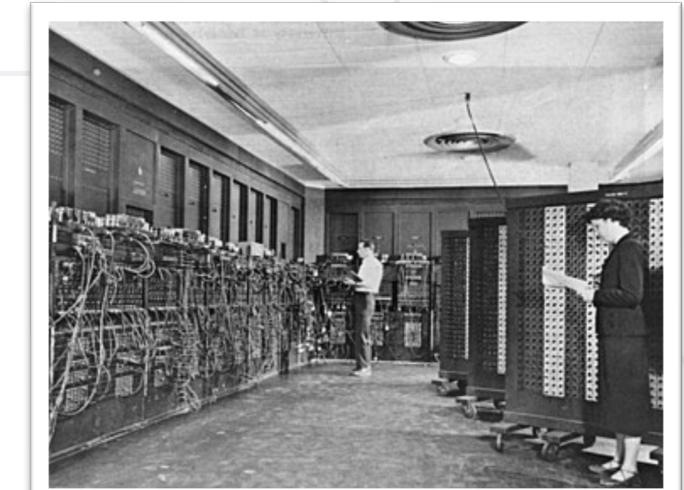
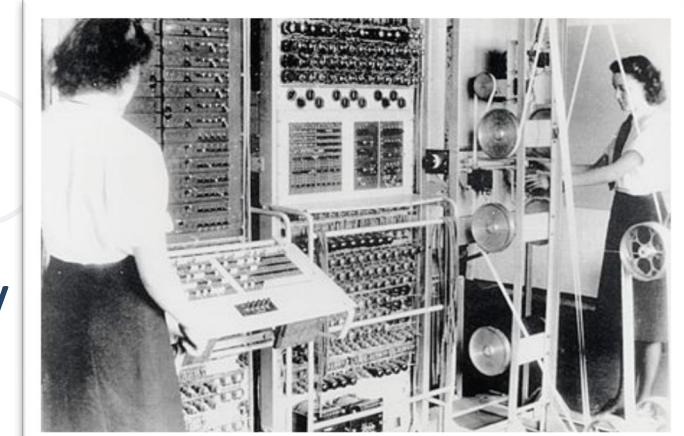
Atanasoff–Berry computer

- 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



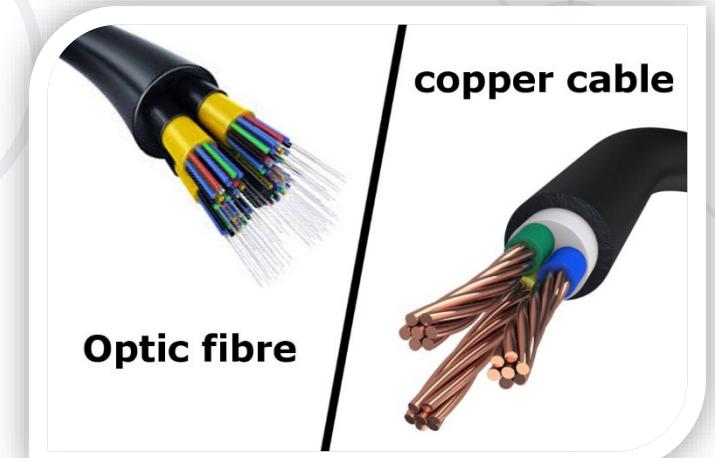
Internet – History

- 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



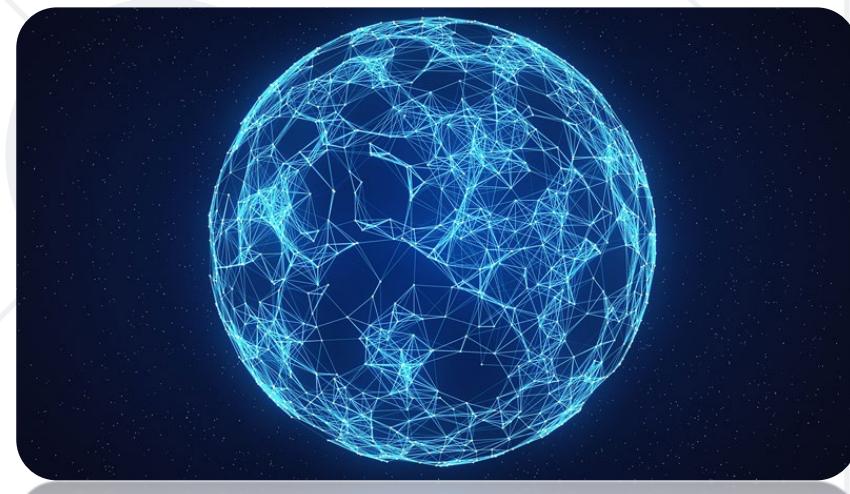
Internet – Introduction (1)

- 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)

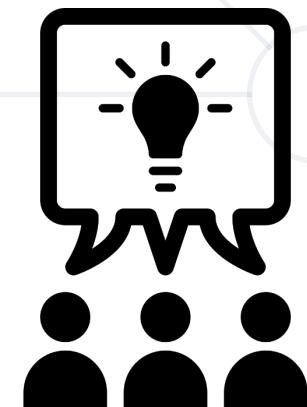
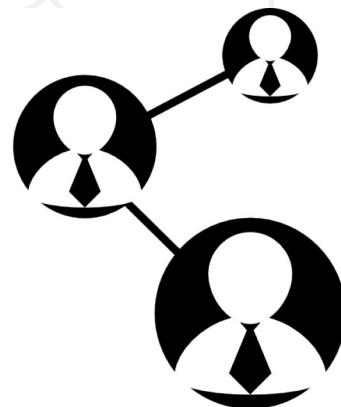
- **ISPs** (Internet Service Providers) have access to such cables
- We get indirectly **connected** to them though ISPs
- The **Internet** is a **network of networks**. It connects billions of devices together all over the globe that are connected to this wire in one form or another



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

- 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





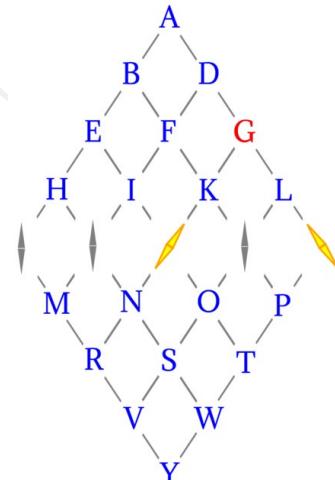
Plain text

The fascinating story of plain text

Cooke and Wheatstone Telegraph



- Invented around 1830s
- 5 needles - five cables
- Not all letters were present
- Easy to use
- ... John Tawell was hanged because of it



Samuel Morse, Friedrich Gerke

International Morse Code

1. The length of a dot is one unit.
2. A dash is three units.
3. The space between parts of the same letter is one unit.
4. The space between letters is three units.
5. The space between words is seven units.

A	• -
B	- - - .
C	- - : .
D	- - - .
E	.
F	• - - - :
G	- - - - :
H	• - - -
I	• •
J	• - - - -
K	- - - .
L	- - - - .
M	- - -
N	- - .
O	- - -
P	• - - -
Q	- - - - .
R	- - - .
S	• - -
T	- - -

U	• - -
V	• - - -
W	- - -
X	- - - -
Y	- - - - -
Z	- - - - - .

1	• - - - -
2	• - - - - -
3	• - - - - - -
4	• - - - - - - -
5	• - - - - - - - -
6	• - - - - - - - - -
7	• - - - - - - - - - -
8	• - - - - - - - - - - -
9	• - - - - - - - - - - - -
0	• - - - - - - - - - - - - -

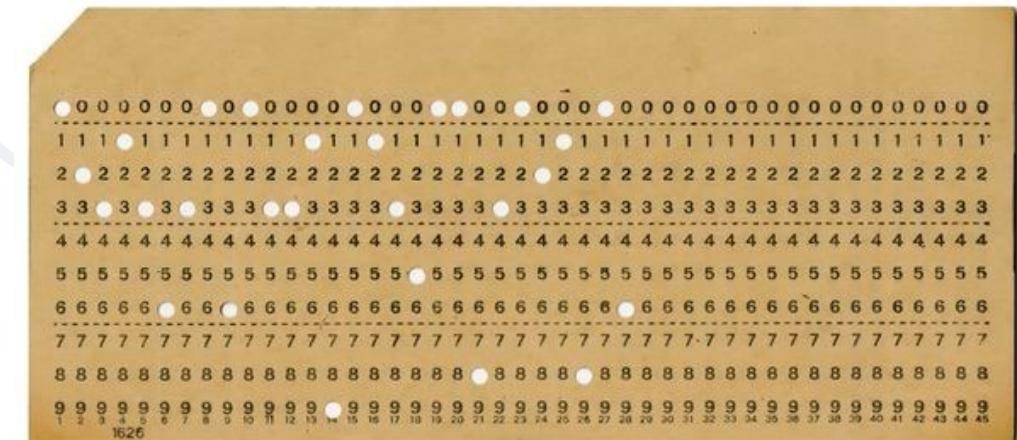
- Agreed as standard 1865
- Used around the world
- Lasted around 100 years



ASCII



- Work began 1961
 - First edition 1963
 - Revision 1967
 - Internet standard 2015



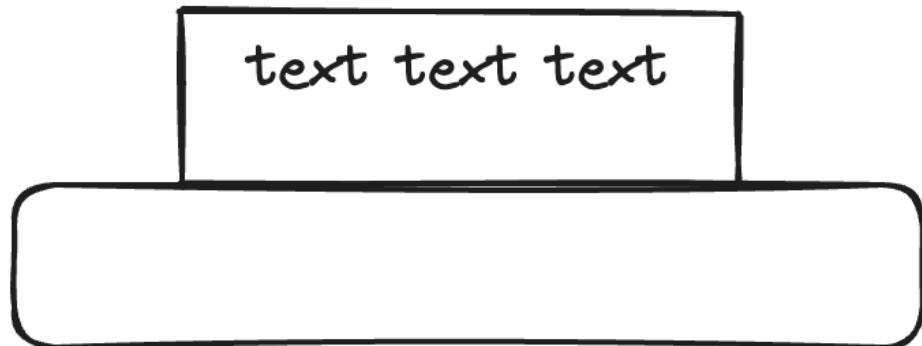
ASCII - control characters

Dec	Hex	Binary	HTML	Char	Description
0	00	00000000	�	NUL	Null
1	01	00000001		SOH	Start of Header
2	02	00000010		STX	Start of Text
3	03	00000011		ETX	End of Text
4	04	00000100		EOT	End of Transmission
5	05	00000101		ENQ	Enquiry
6	06	00000110		ACK	Acknowledge
7	07	00000111		BEL	Bell
8	08	00001000		BS	Backspace
9	09	00001001			HT	Horizontal Tab
10	0A	00001010	
	LF	Line Feed
11	0B	00001011		VT	Vertical Tab
12	0C	00001100		FF	Form Feed
13	0D	00001101		CR	Carriage Return
14	0E	00001110		SO	Shift Out
15	0F	00001111		SI	Shift In
16	10	00010000		DLE	Data Link Escape
17	11	00010001		DC1	Device Control 1
18	12	00010010		DC2	Device Control 2
19	13	00010011		DC3	Device Control 3
20	14	00010100		DC4	Device Control 4
21	15	00010101		NAK	Negative Acknowledge
22	16	00010110		SYN	Synchronize
23	17	00010111		ETB	End of Transmission Block
24	18	00011000		CAN	Cancel
25	19	00011001		EM	End of Medium

- Intended to control the machinery
- Many survive today



ASCII - \r\n



ASCII - string comparisons

Dec	Hex	Binary	HTML	Char	Description
65	41	01000001	A	A	Capital A
66	42	01000010	B	B	Capital B
67	43	01000011	C	C	Capital C
68	44	01000100	D	D	Capital D
69	45	01000101	E	E	Capital E

Dec	Hex	Binary	HTML	Char	Description
97	61	01100001	a	a	Small a
98	62	01100010	b	b	Small b
99	63	01100011	c	c	Small c
100	64	01100100	d	d	Small d
101	65	01100101	e	e	Small e

ASCII - numbers

48	30	00110000	0	0	Zero
49	31	00110001	1	1	One
50	32	00110010	2	2	Two
51	33	00110011	3	3	Three
52	34	00110100	4	4	Four
53	35	00110101	5	5	Five
54	36	00110110	6	6	Six
55	37	00110111	7	7	Seven
56	38	00111000	8	8	Eight
57	39	00111001	9	9	Nine

ASCII - delete

11111111



ASCII - and the rest of the world



Windows-1251, KOI8

Code pages
kohuept

Çäðàñòè, äîêòîðå.



К О Н Ц Е Р Т

203 207 206 195 197 210 212

11001011 11001111 11001110 11000011 11000101 11010010 11010100
01001011 01001111 01001110 01000011 01000101 01010010 01010100

75 79 78 67 69 82 84

K O N C E R T



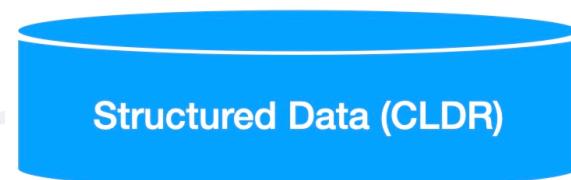
Unicode



The standards body for the internationalization of software and services



Allow easy integration into operating system, applications, services, and more



Language-specific data for sorting, formatting, and processing of dates, times, numbers, currencies, and more

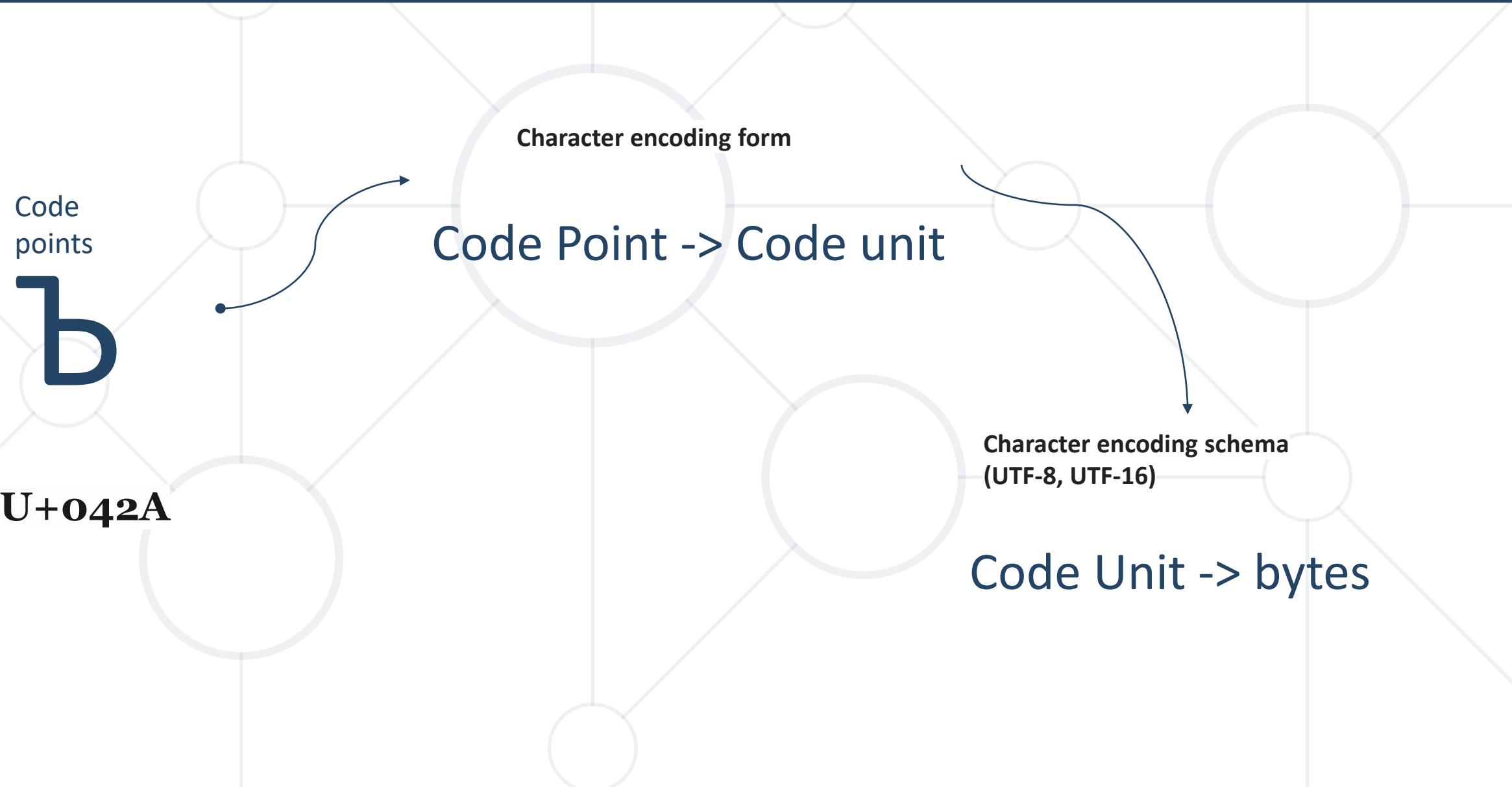


Provide character/emoji properties and behavior to ensure correct and consistent use across all platforms



Encoding of nearly 150,000 characters covering the world's languages (and emoji!)

Everyone in the world should be able to use their own language on phones and computers.



UTF-16



UTF-8

	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
00	3C	68	74	6D	6C	3E	0A	3C	62	6F	64	79	3E	0A	20	20	<html> <body>
10	20	D0	97	D0	B4	D1	80	D0	B0	D0	B2	D0	B5	D0	B9	D1	Здравейт
20	82	D0	B5	21	0A	3C	2F	62	6F	64	79	3E	0A	3C	2F	68	! </body> </h
30	74	6D	6C	3E	□												tml>■

Code point ↔ UTF-8 conversion

First code point	Last code point	Byte 1	Byte 2	Byte 3	Byte 4
U+0000	U+007F	0xxxxxxx			
U+0080	U+07FF	110xxxxx	10xxxxxx		
U+0800	U+FFFF	1110xxxx	10xxxxxx	10xxxxxx	
U+10000	[b]U+10FFFF	11110xxx	10xxxxxx	10xxxxxx	10xxxxxx

<html>

<body>

Здравейте!

</body>

</html>



How Does the Internet Work?

Web Server Work Model

Web Client



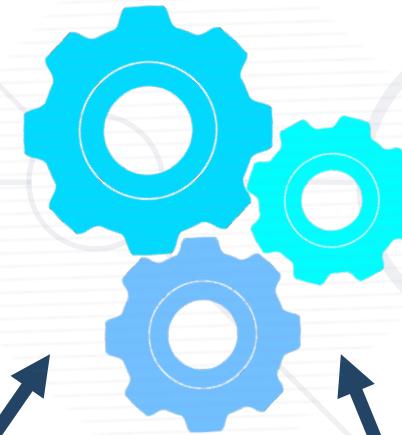
Request

Response

Web Server



Technology



Web Resources



HTML, PDF, JPG...

Database



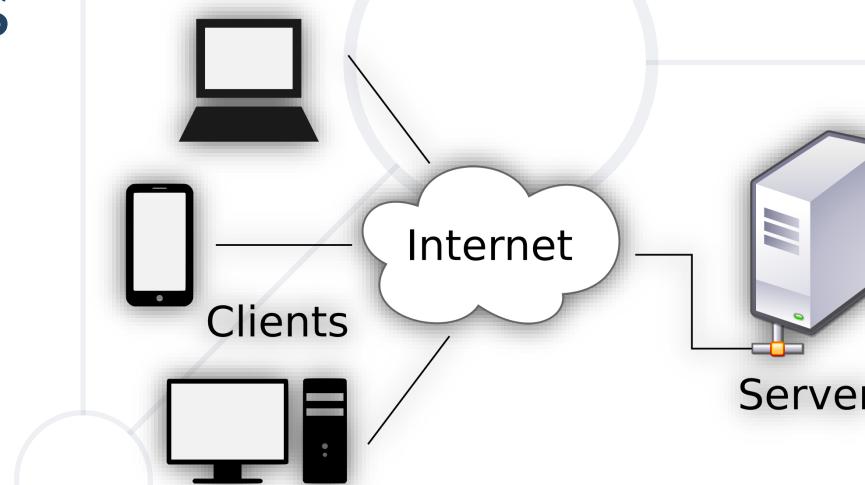
Important Definitions

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

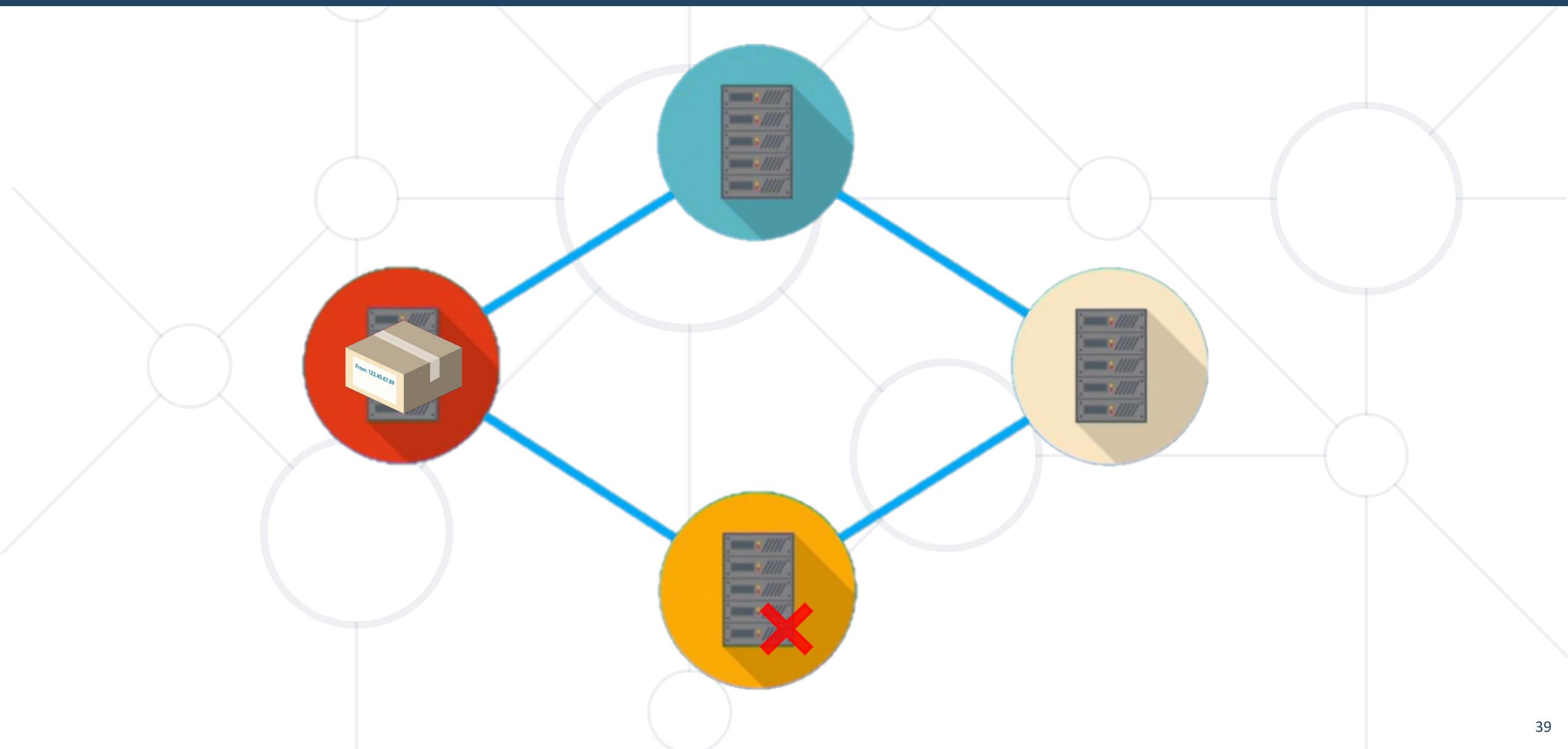


Packets (2)

- 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





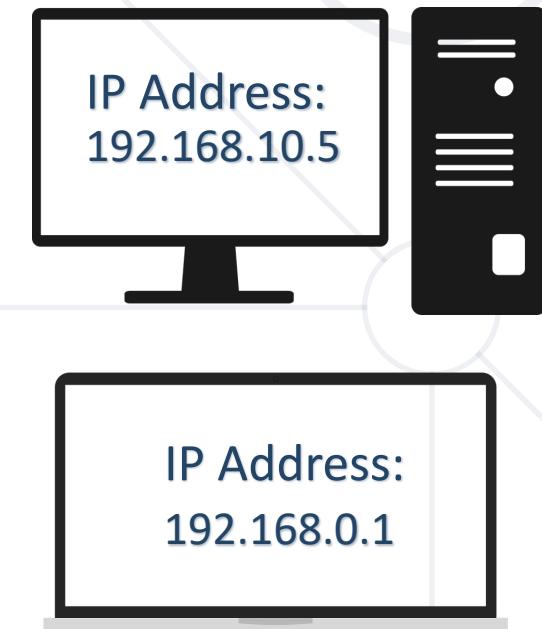
216.58.214.46
www.google.com

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



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



192.168.14.120

Subnetworks

Device address

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

IP address classes

Class A

$0. 0. 0. 0 = 0000000.0000000.0000000.0000000$
 $127.255.255.255 = 01111111.11111111.11111111.11111111$
 0nnnnnnn.HHHHHHHH.HHHHHHHH.HHHHHHHH

Class B

$128. 0. 0. 0 = 1000000.0000000.0000000.0000000$
 $191.255.255.255 = 10111111.11111111.11111111.11111111$
 10nnnnnn.nnnnnnnn.HHHHHHHH.HHHHHHHH

Class C

$192. 0. 0. 0 = 1100000.0000000.0000000.0000000$
 $223.255.255.255 = 11011111.11111111.11111111.11111111$
 110nnnnn.nnnnnnnn.nnnnnnnn.HHHHHHHH

Class D

$224. 0. 0. 0 = 1110000.0000000.0000000.0000000$
 $239.255.255.255 = 11101111.11111111.11111111.11111111$
 1110XXXX.XXXXXXXX.XXXXXXXX.XXXXXXXX

Class E

$240. 0. 0. 0 = 1111000.0000000.0000000.0000000$
 $255.255.255.255 = 11111111.11111111.11111111.11111111$
 1111XXXX.XXXXXXXX.XXXXXXXX.XXXXXXXX

What Is CIDR (Classless Inter-Domain Routing)

- 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

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?

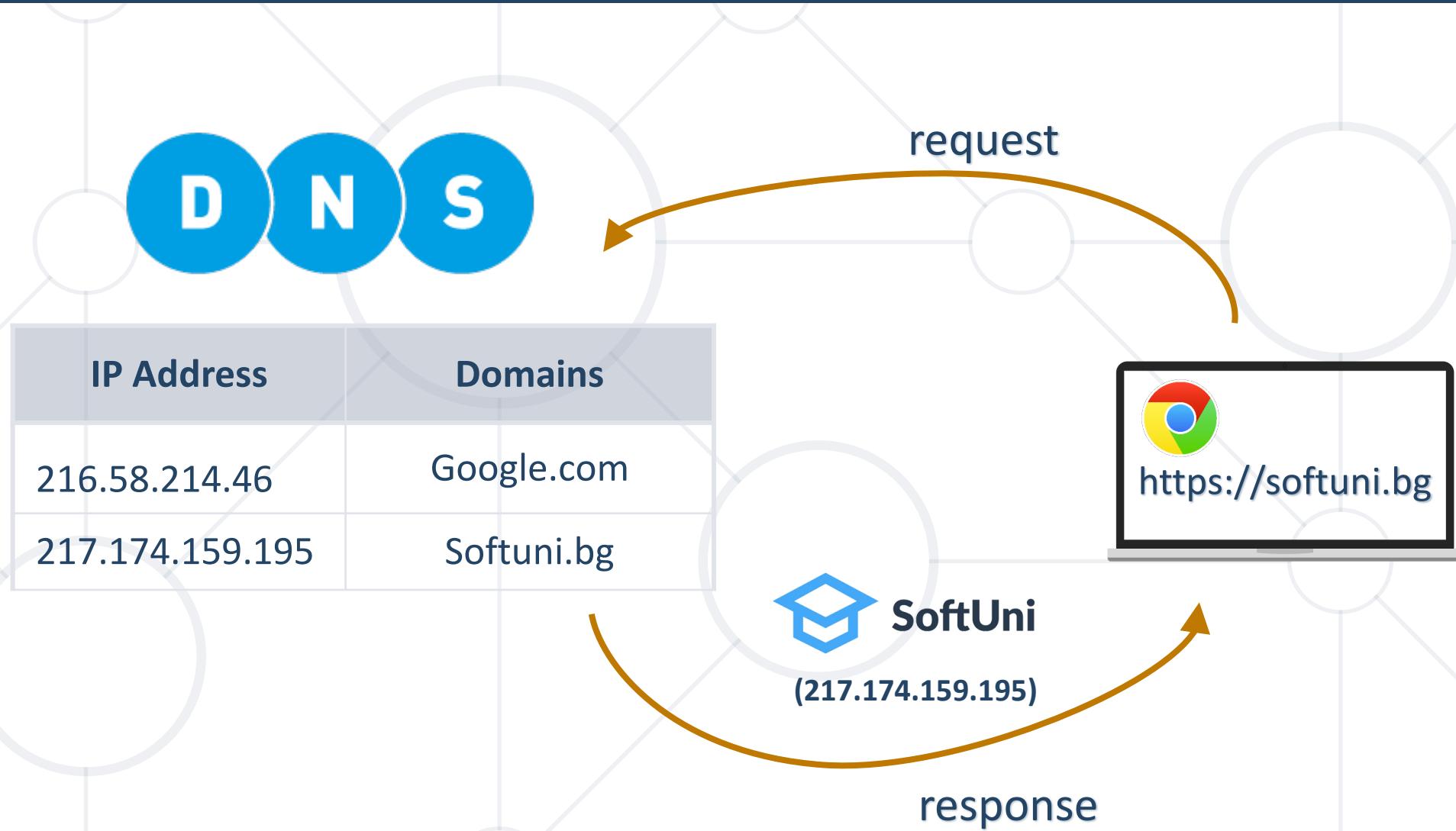
www.softuni.bg

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





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 (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

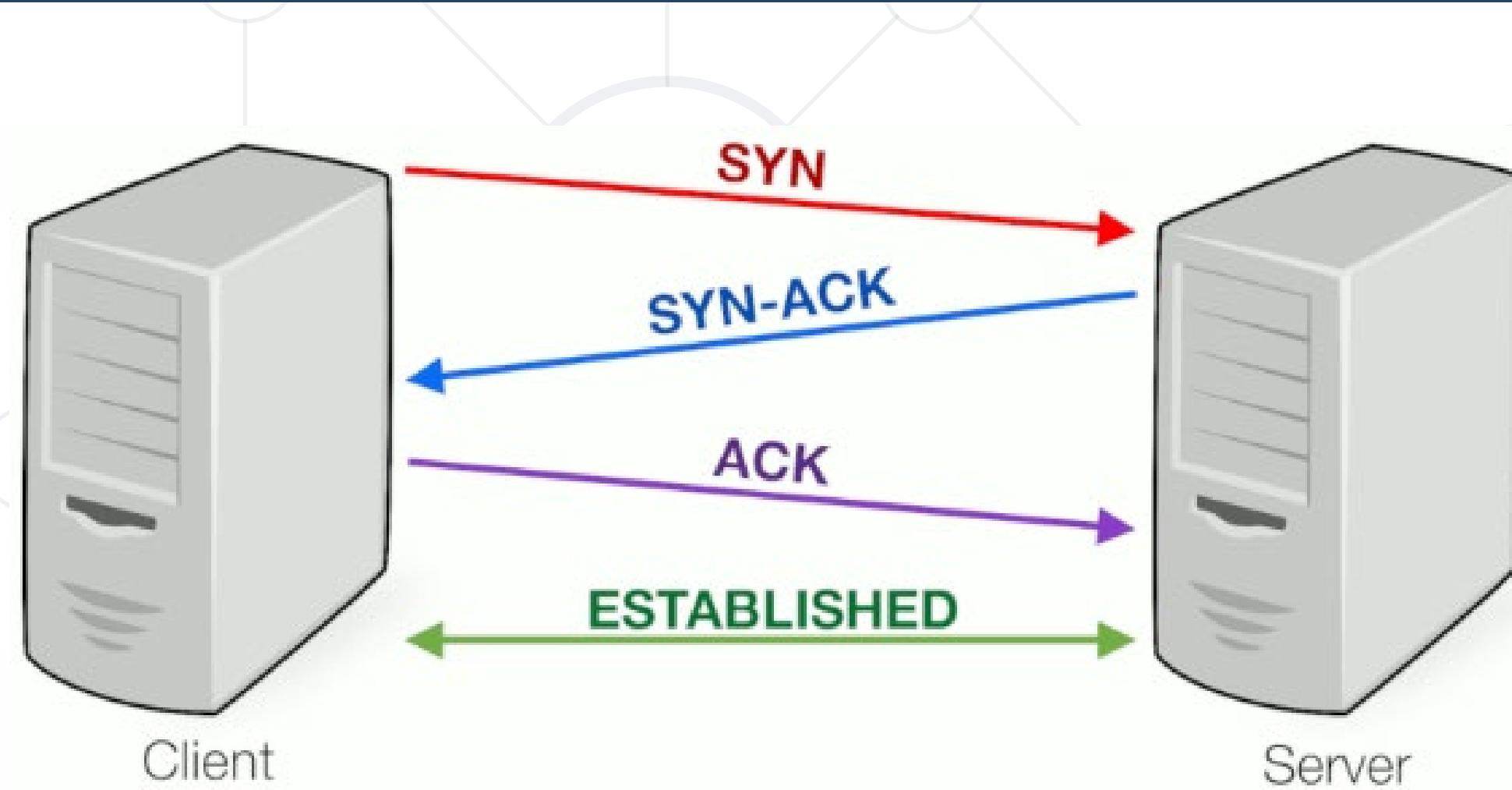


Transmission Control Protocol - TCP (2)

- 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

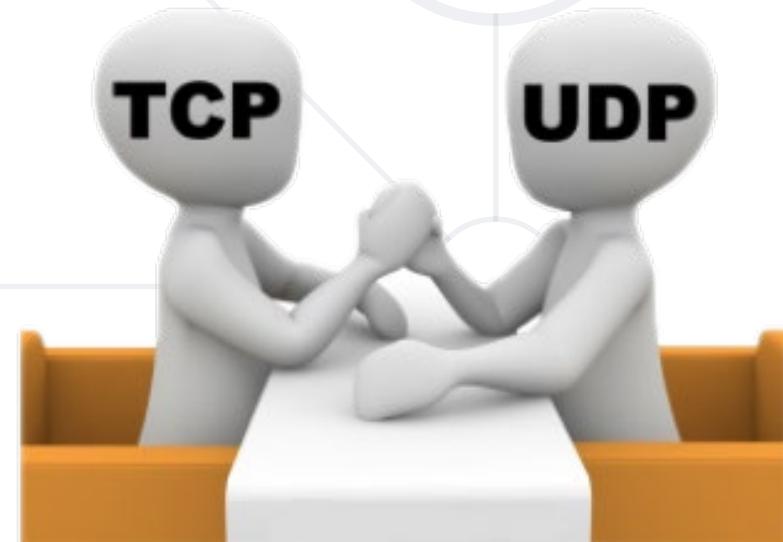


Transmission Control Protocol - TCP (3)



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



Missing packets..



I don't care..

UDP





The OSI Model

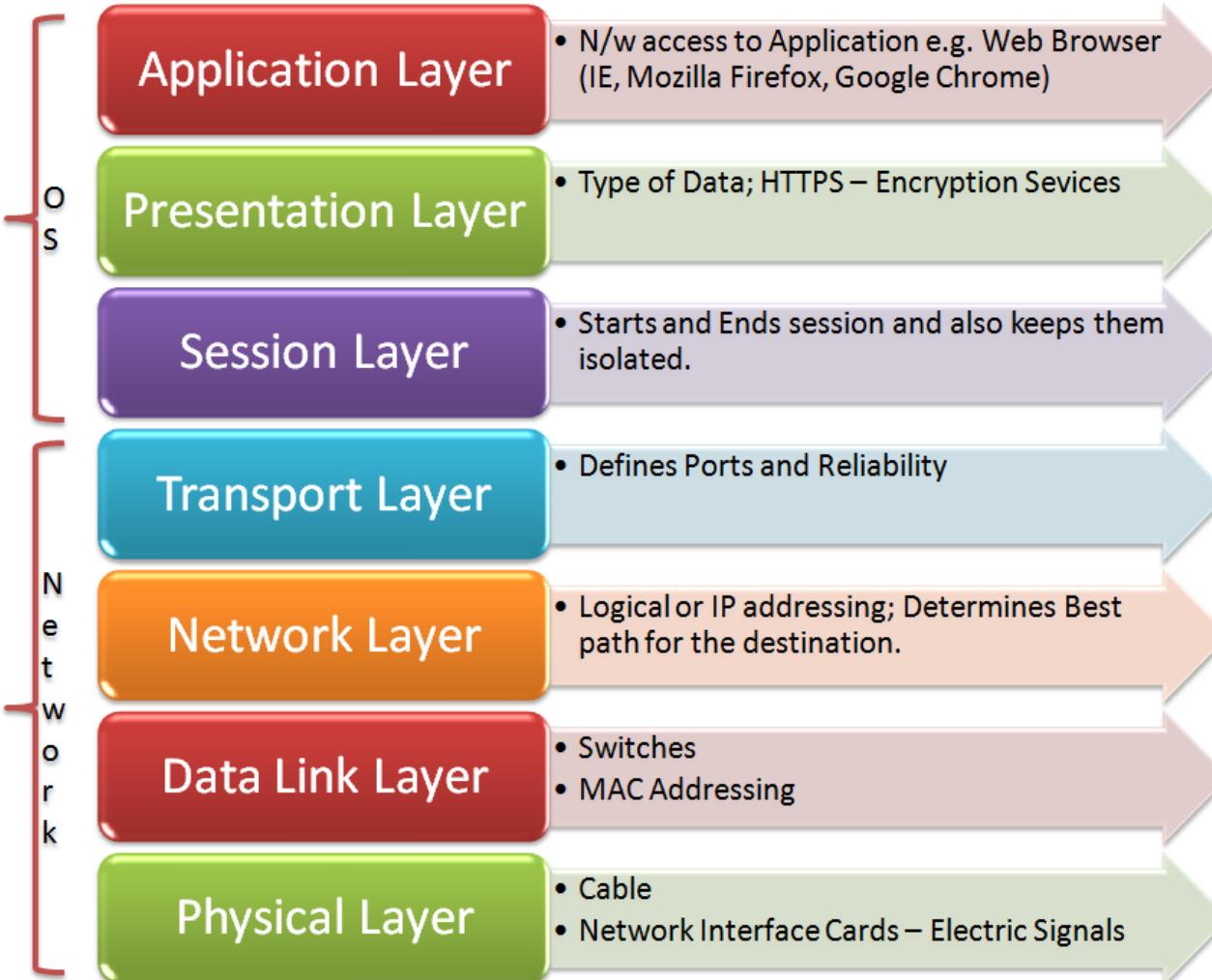
What is the OSI Model?

- **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

- OSI Model consists of 7 layers:



Example Protocols

HTTP, DNS, FTP, SMTP

TLS, SSL, compression

NetBIOS, PPTP, Sockets

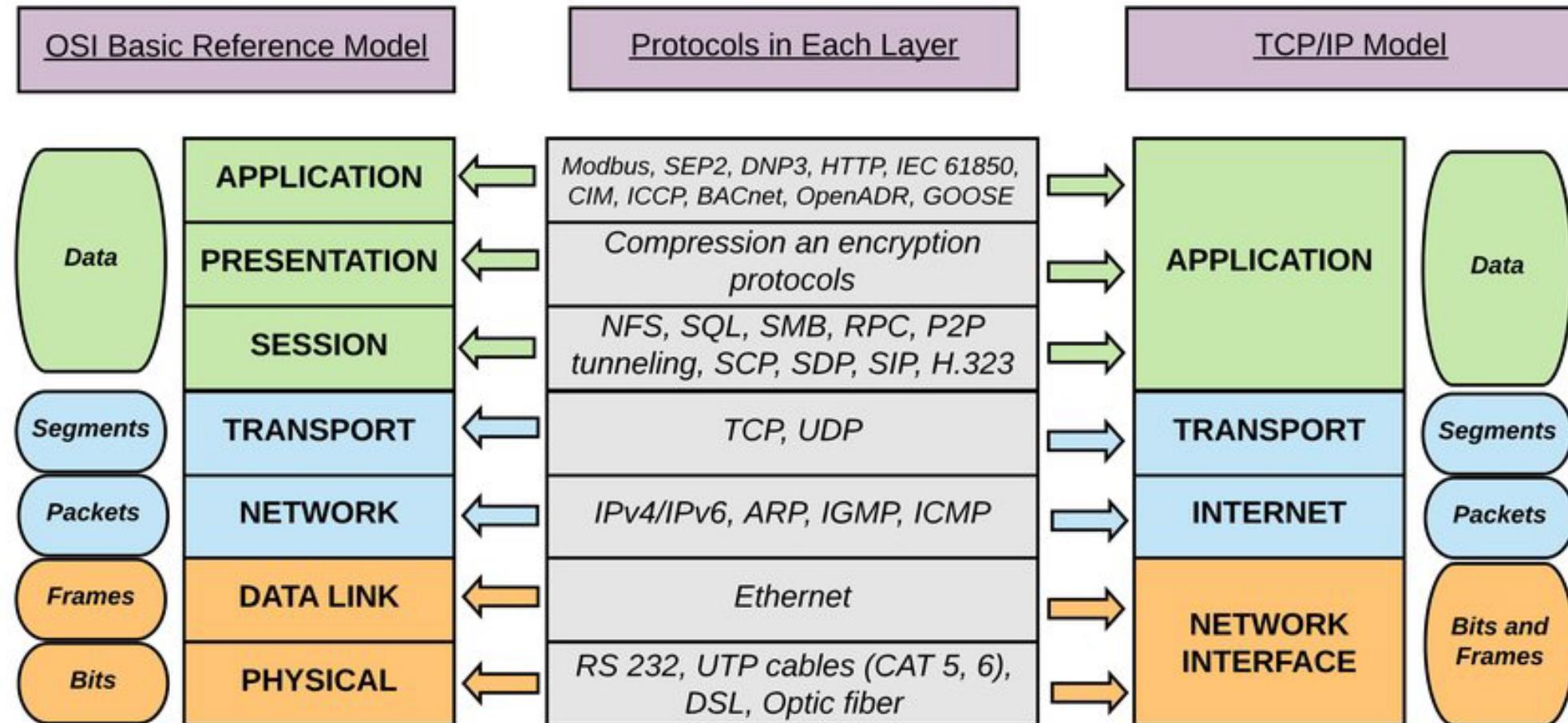
TCP, UDP

IP, IPsec

ATM, Ethernet, MAC, LLC

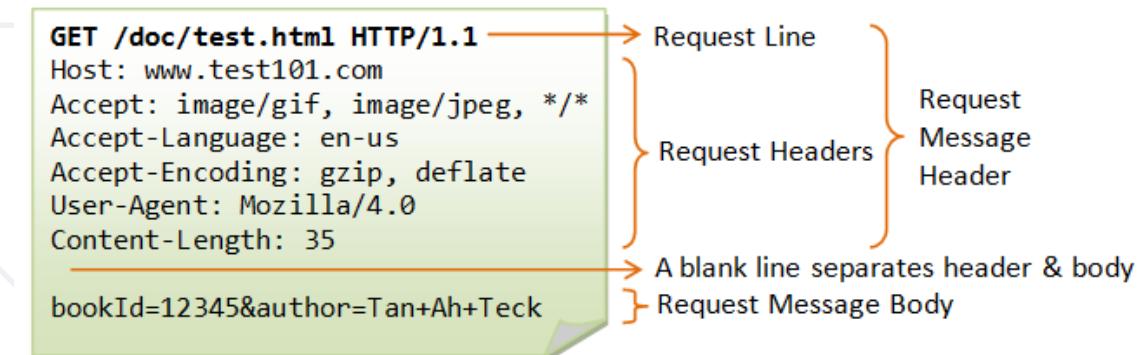
USB, Bluetooth, 802.11a/b/g/n

TCP/IP model mapping to OSI



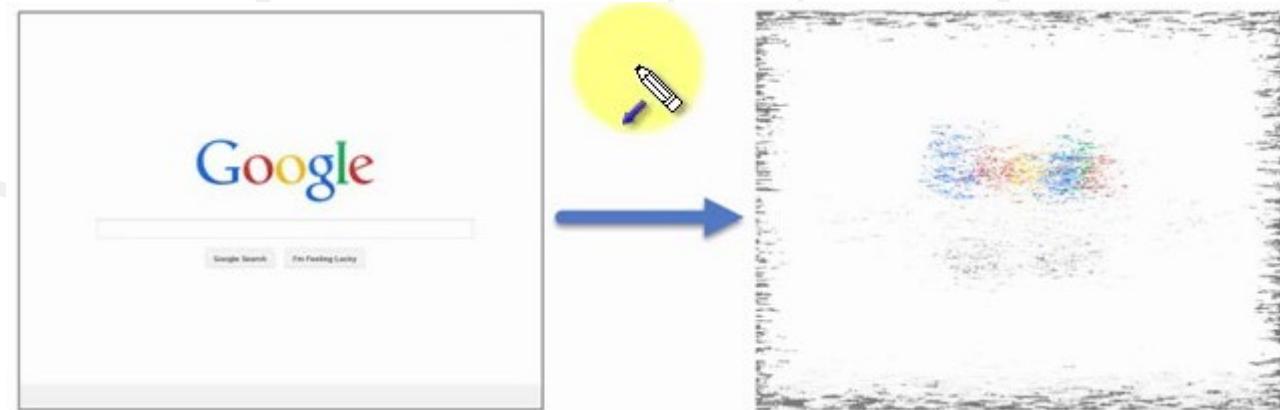
Application Layer – 7

- 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)**



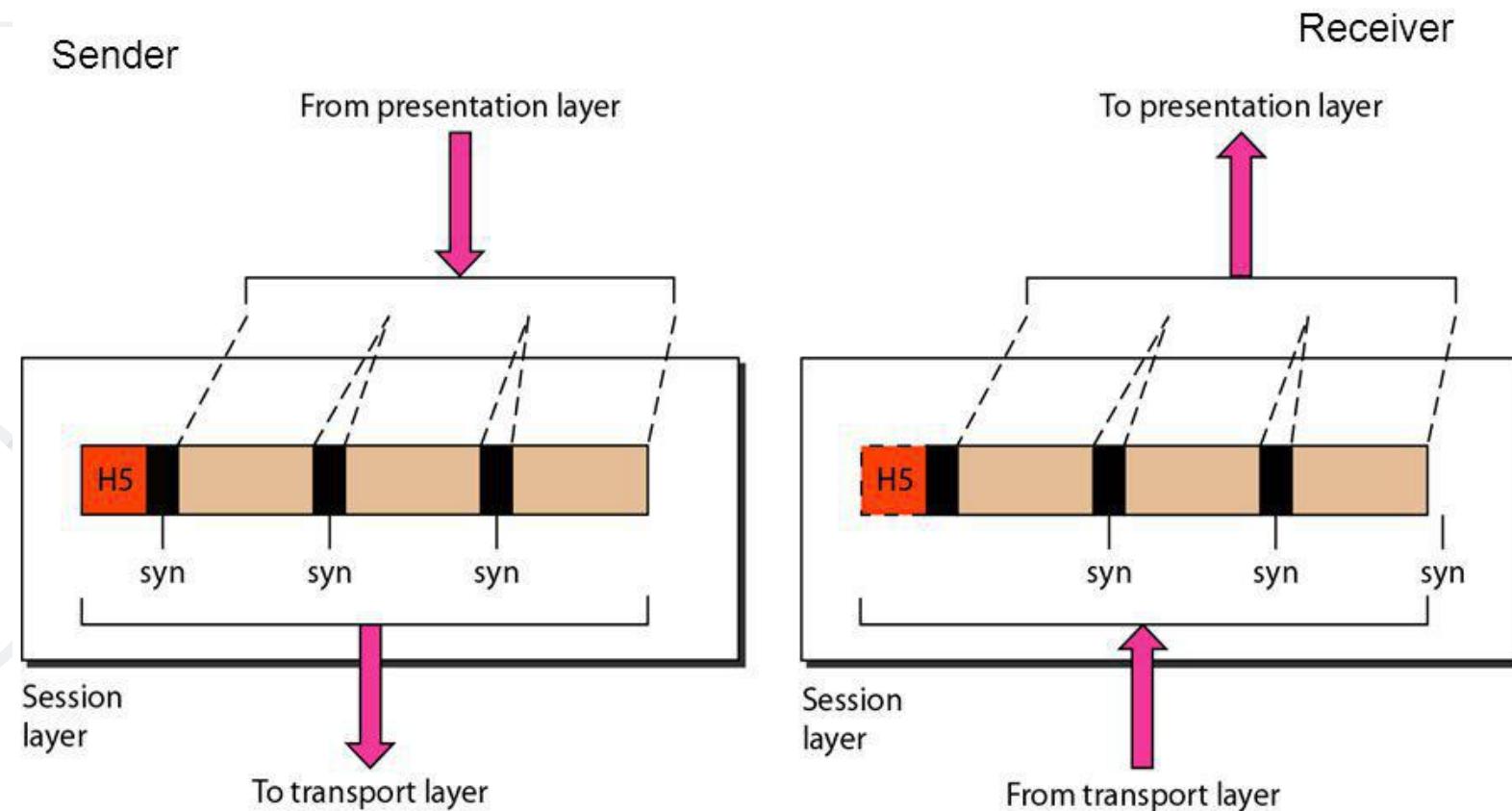
Presentation Layer – 6

- 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

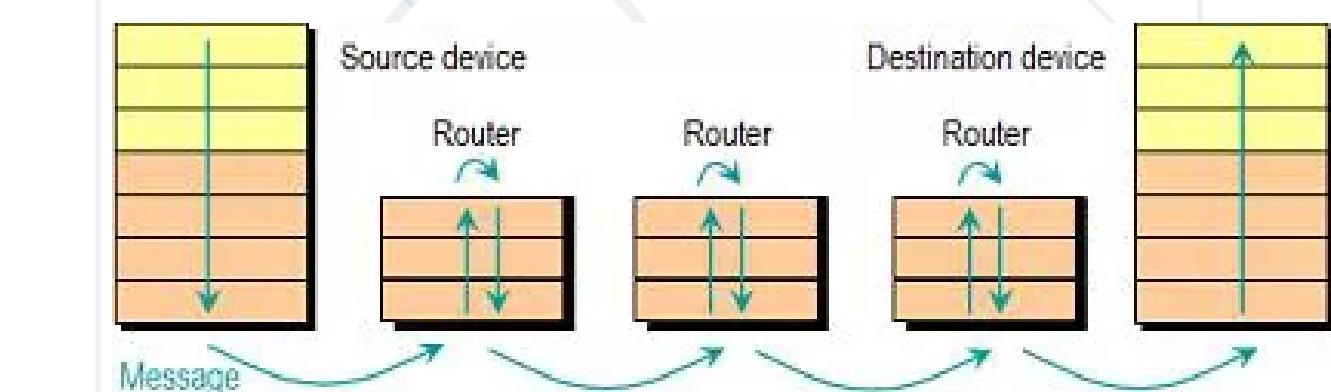


Transport Layer – 4

- 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**



Summary

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



Questions?



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