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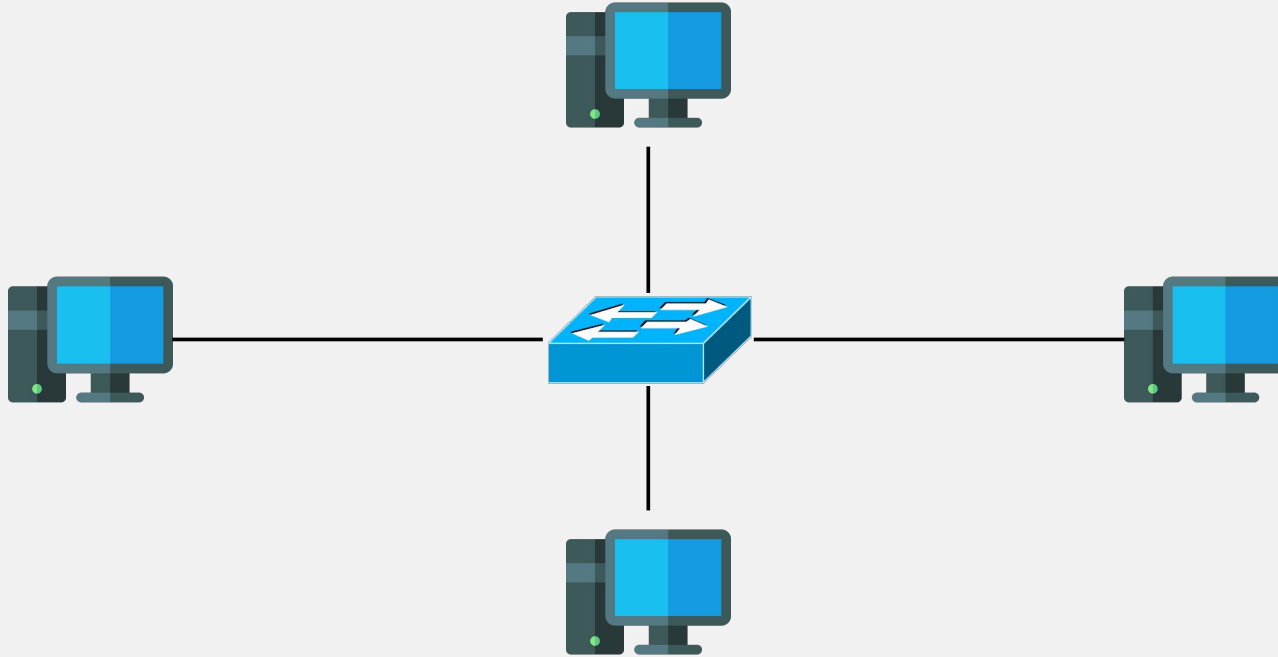
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Informatique
Électronique

Network Security

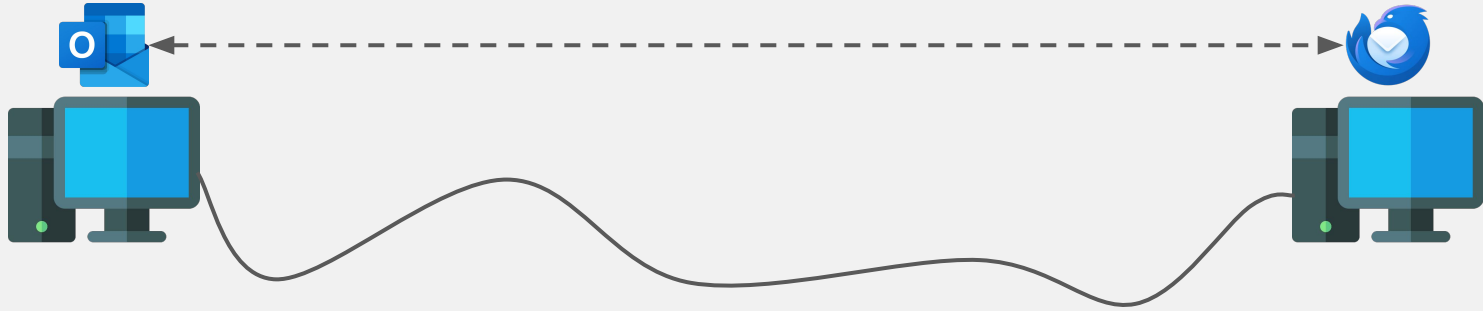
Network Fundamentals Refresher

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2025/2026

Main Goal: Connect Devices



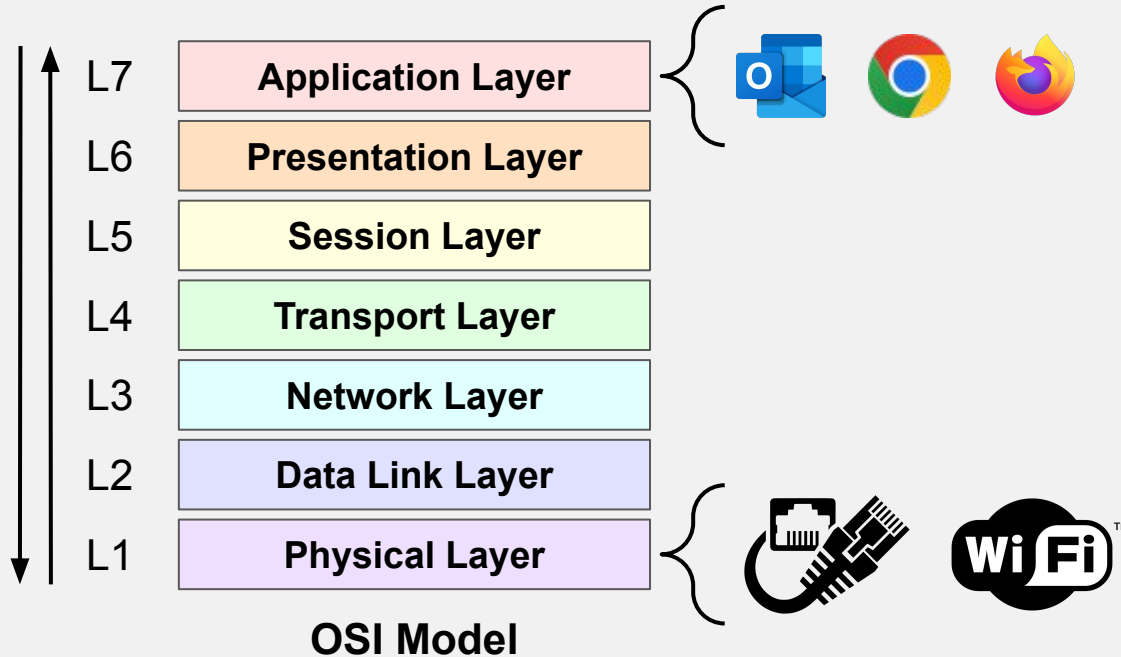
Send and receive messages



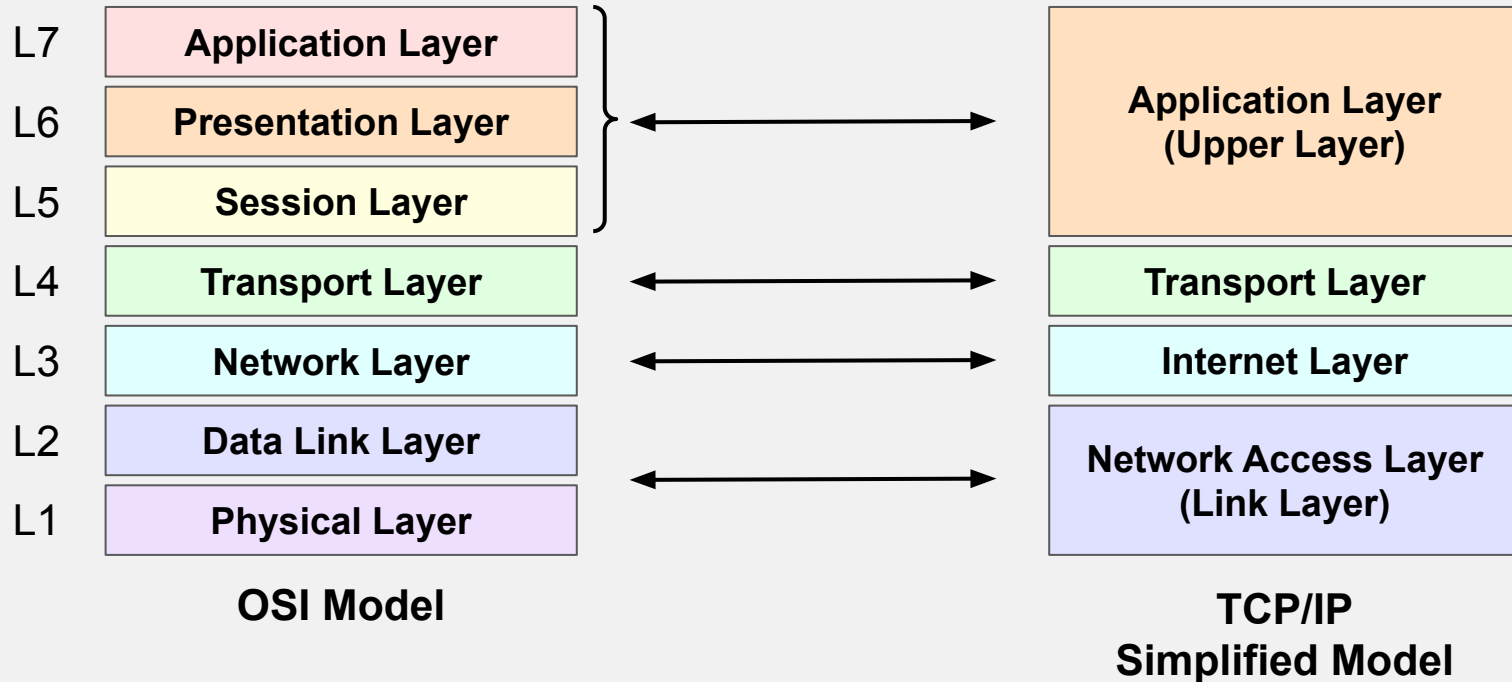
Problem to solve:

- ☐ Devices need to speak the same language.

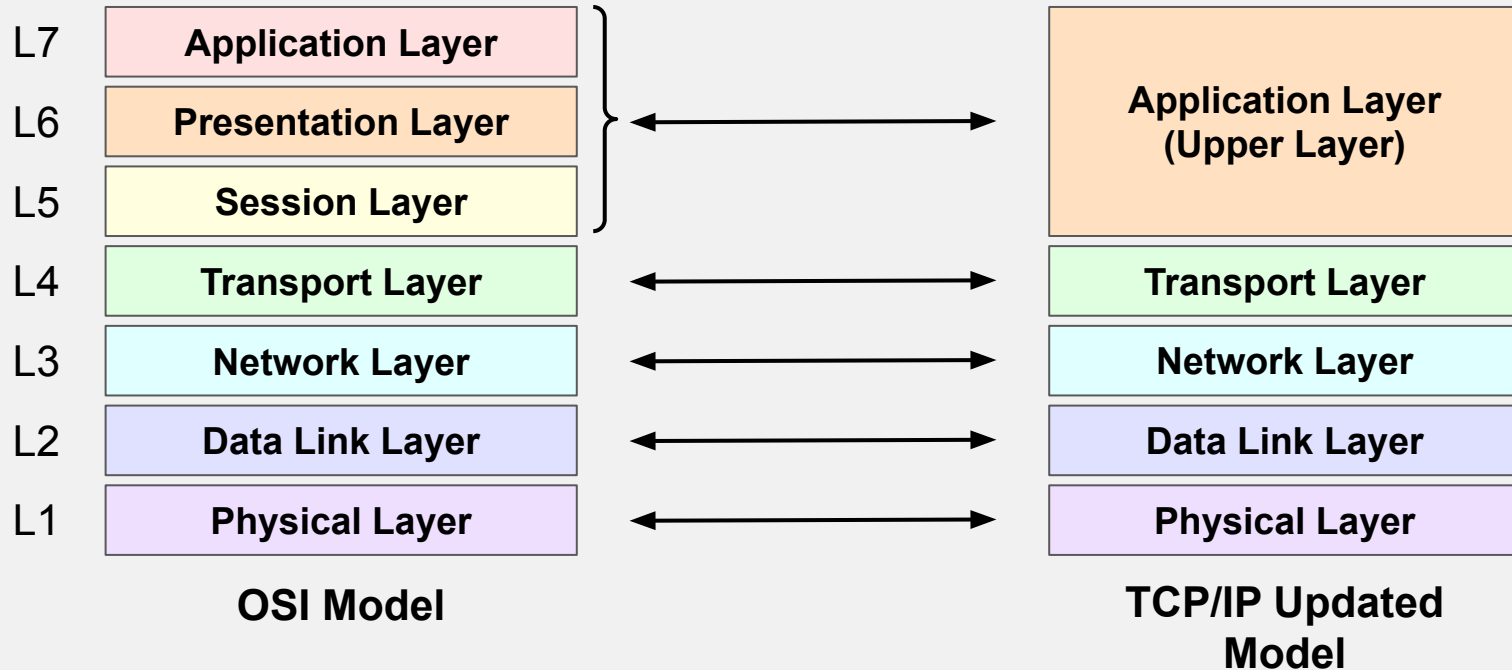
The Famous ISO OSI model



OSI vs TCP/IP Models

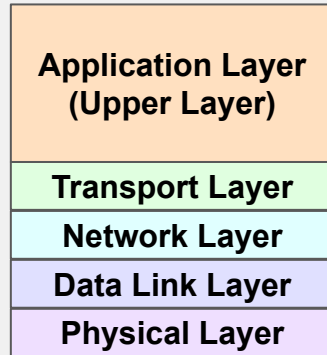
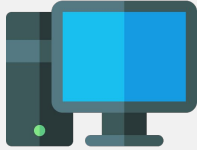


OSI vs TCP/IP Models

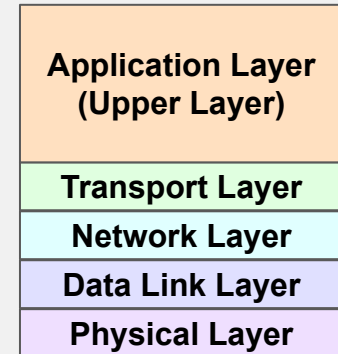
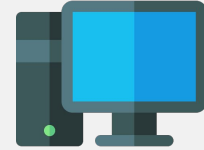


TCP/IP Model

Alice



Bob



Layer Overview

Layer 5: Application

- ☐ Abstraction level: Application-to-Application
- ☐ Addressing method: Application specific addressing (e.g. URLs for HTTP)

Layer 4: Transport

- ☐ Abstraction level: End-to-End
- ☐ Addressing method: Port

Layer 3: Network

- ☐ Abstraction level: Device-to-Device
- ☐ Addressing method: IP addresses

Layer 2: Transport

- ☐ Abstraction level: Hop-to-Hop
- ☐ Addressing method: MAC addresses

Layer 1: Transport

- ☐ Abstraction level: Physical transmission
- ☐ Addressing method: -

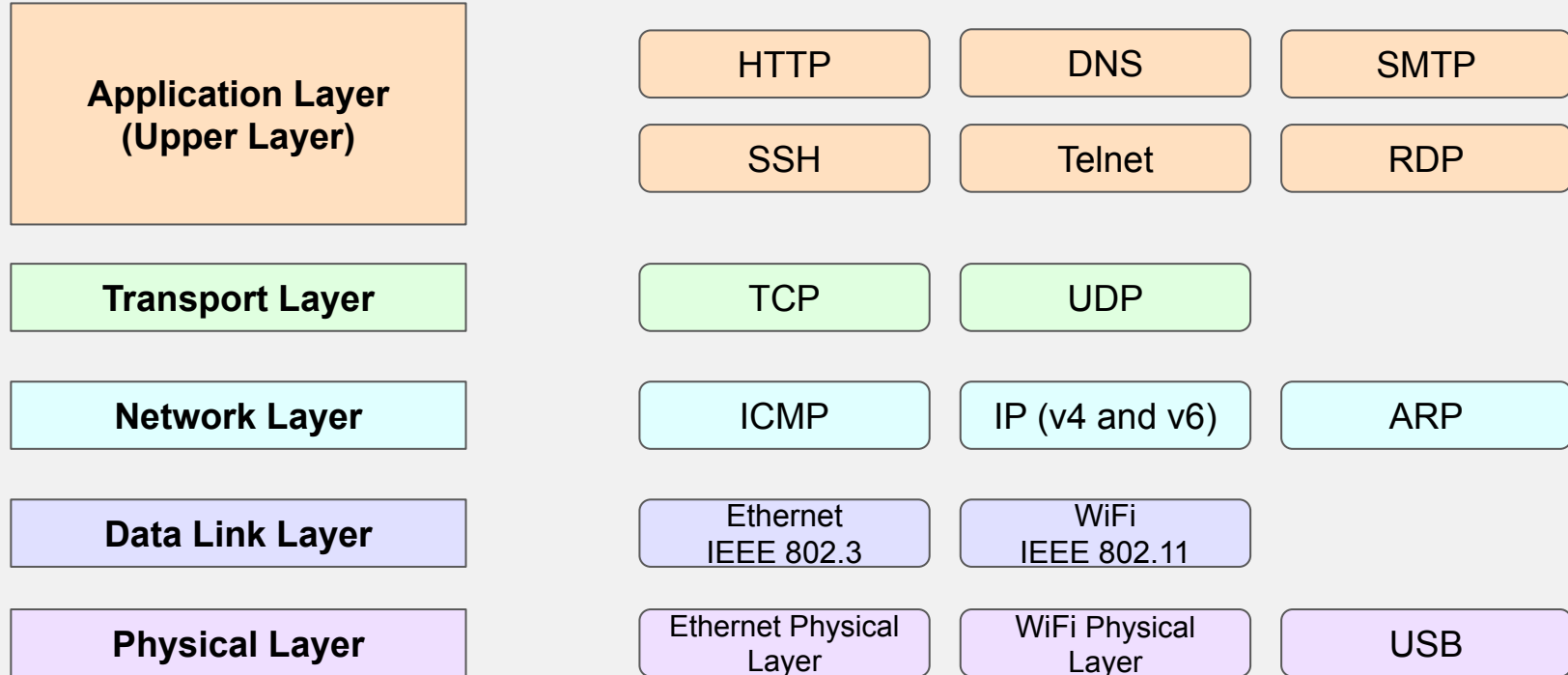
Some Definitions

Protocol: Communication between **same-layer entities**

- Define **syntax** and **semantics**
- E.g. TCP



Some protocols



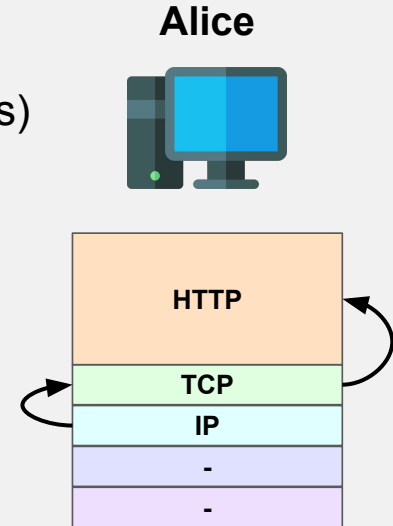
Some Definitions

Service: Communication between **adjacent layers**

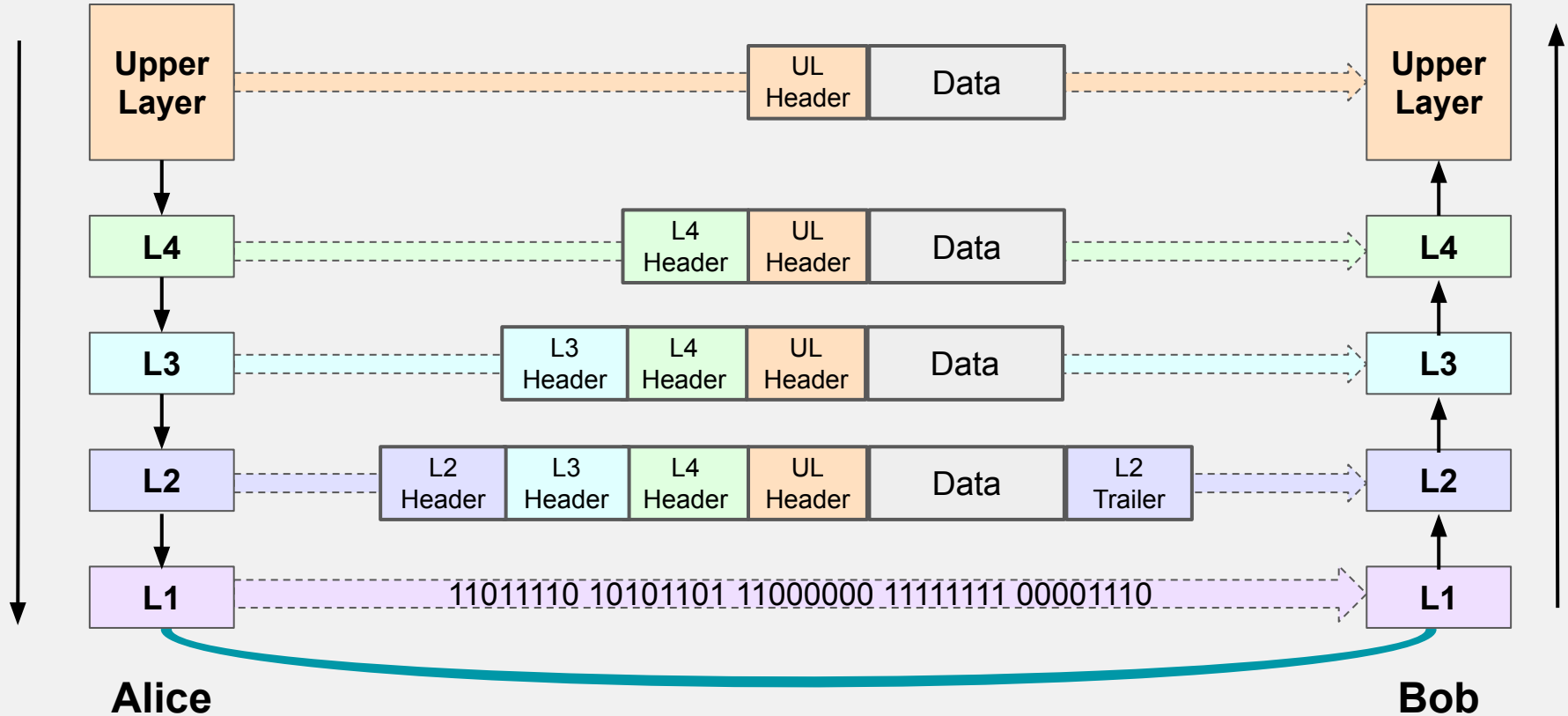
- Define interface between layers

In this example the following services can be identified:

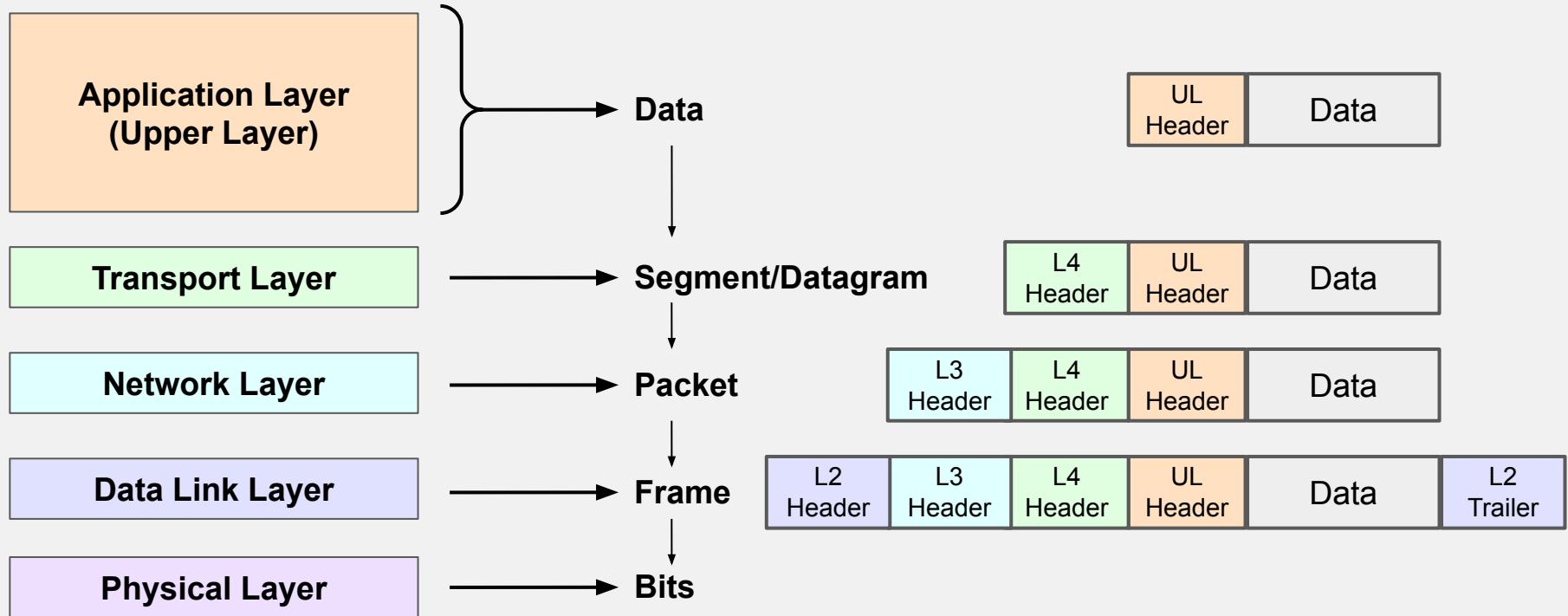
- IP provides a service for TCP (routing data between devices)
- TCP provides a service for HTTP (connexion reliability)



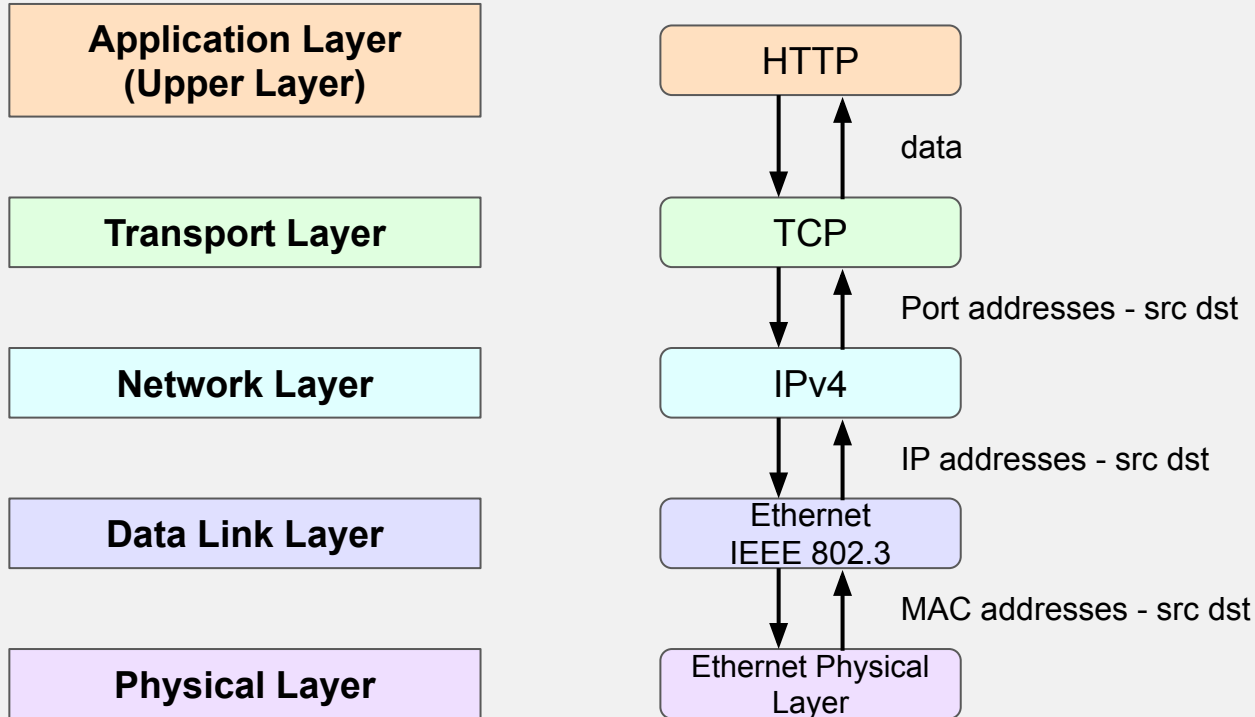
Encapsulation / Decapsulation



Protocol Data Unit: PDU



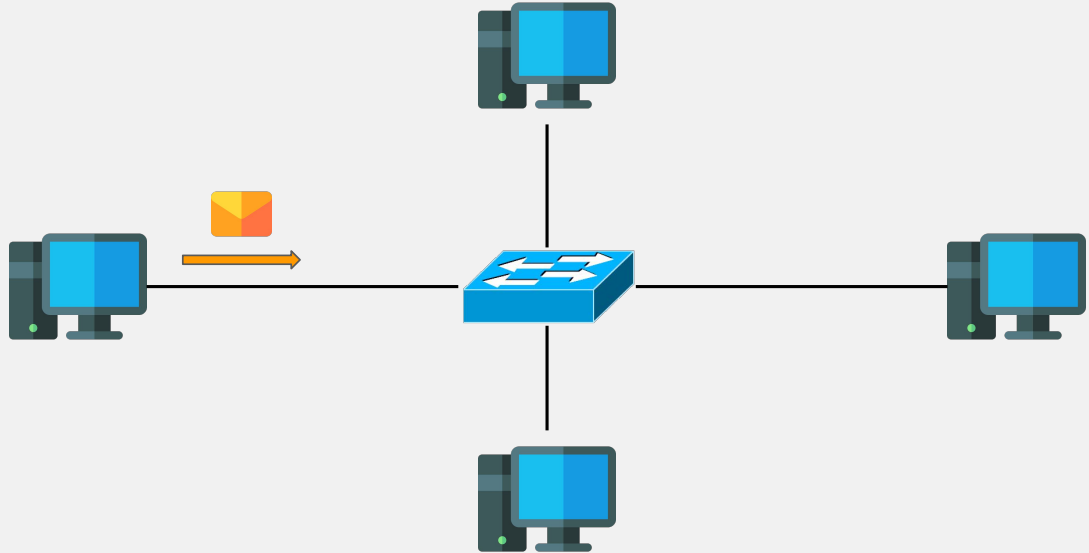
Top-down communication



Connecting Devices

Problems to solve:

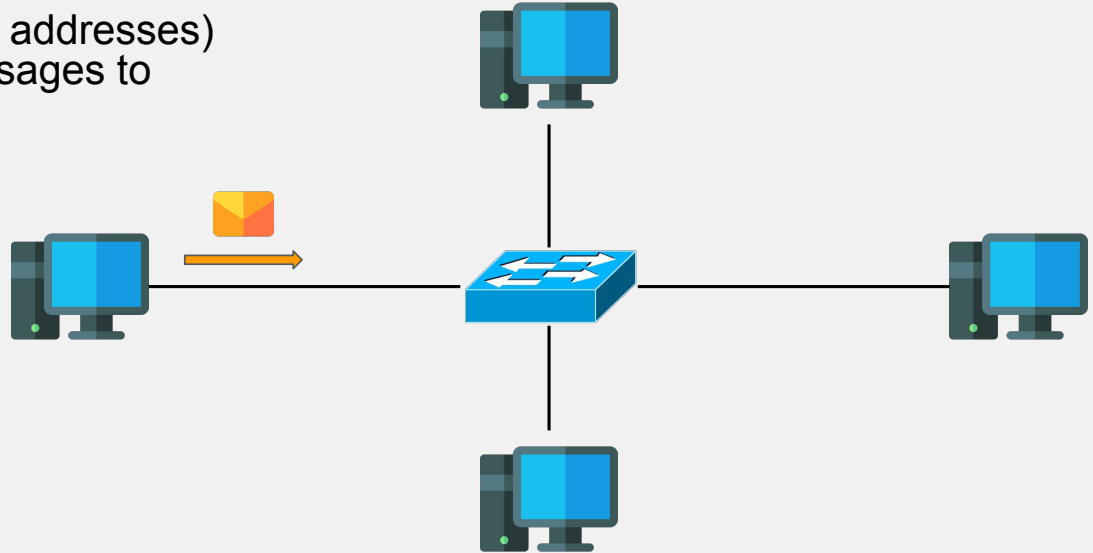
- ☐ How to send a message?
- ☐ How to route a message?



In a Local Network (LAN)

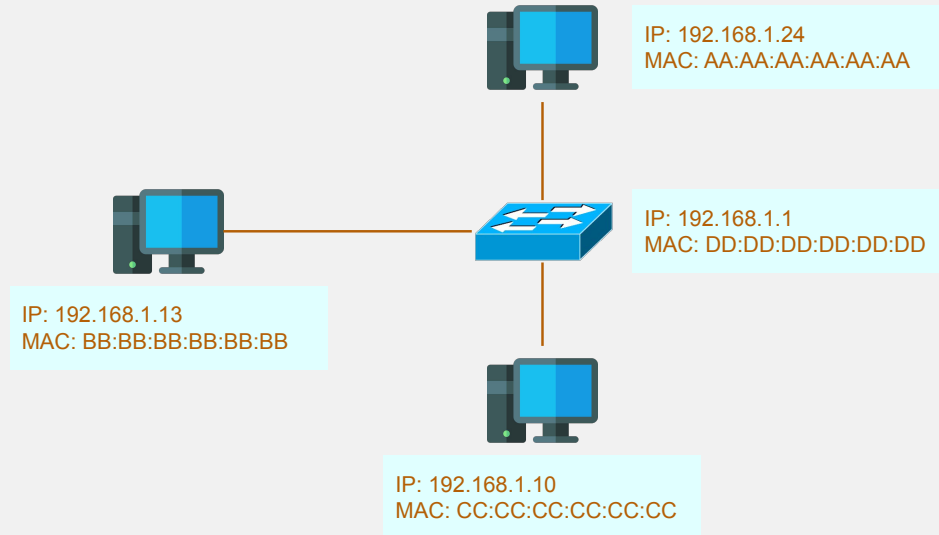
In a local network:

- Layer 1 and 2 are required (MAC addresses)
- Devices can broadcast ARP messages to discover MAC addresses.



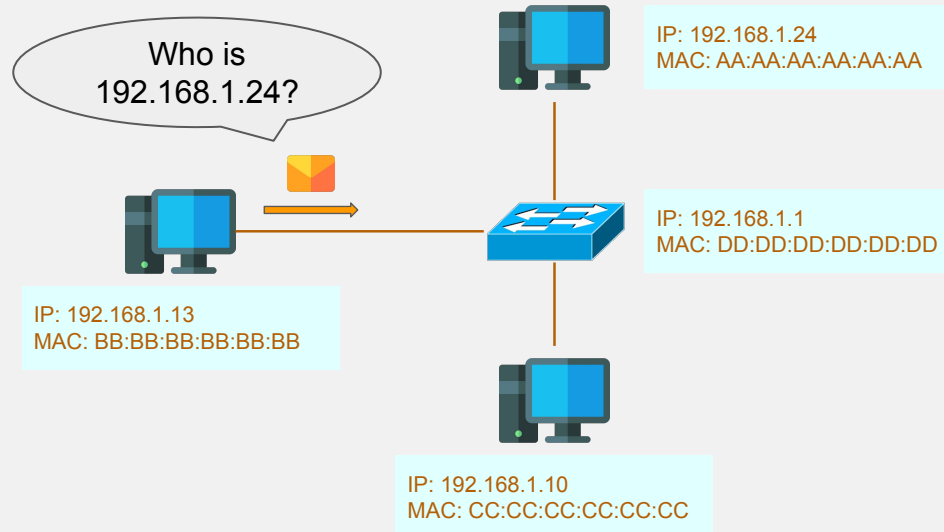
ARP: Routing in the LAN

- ❑ **ARP:** Address Resolution Protocol
- ❑ Used to get the MAC address associated to an IP address.



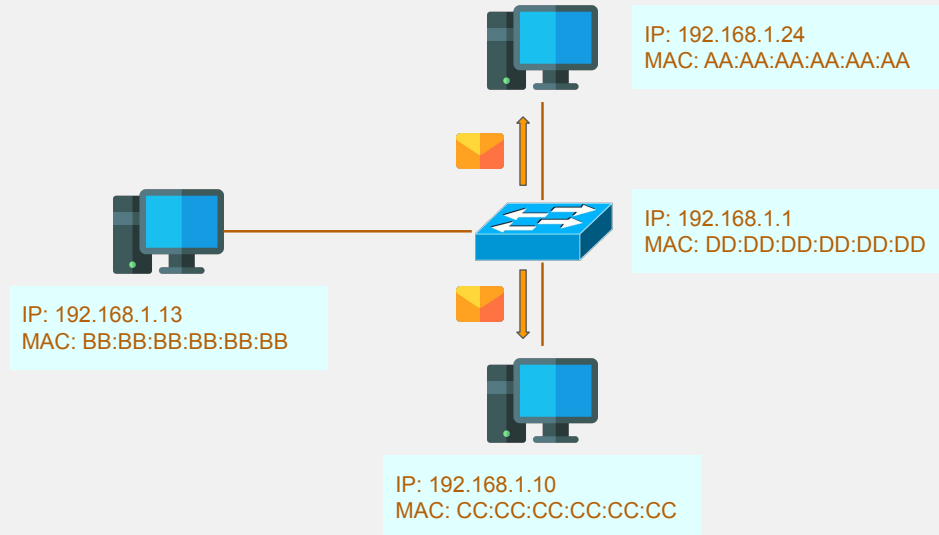
ARP Broadcast

- ❑ **ARP:** Address Resolution Protocol
- ❑ Used to get the MAC address associated to an IP address.



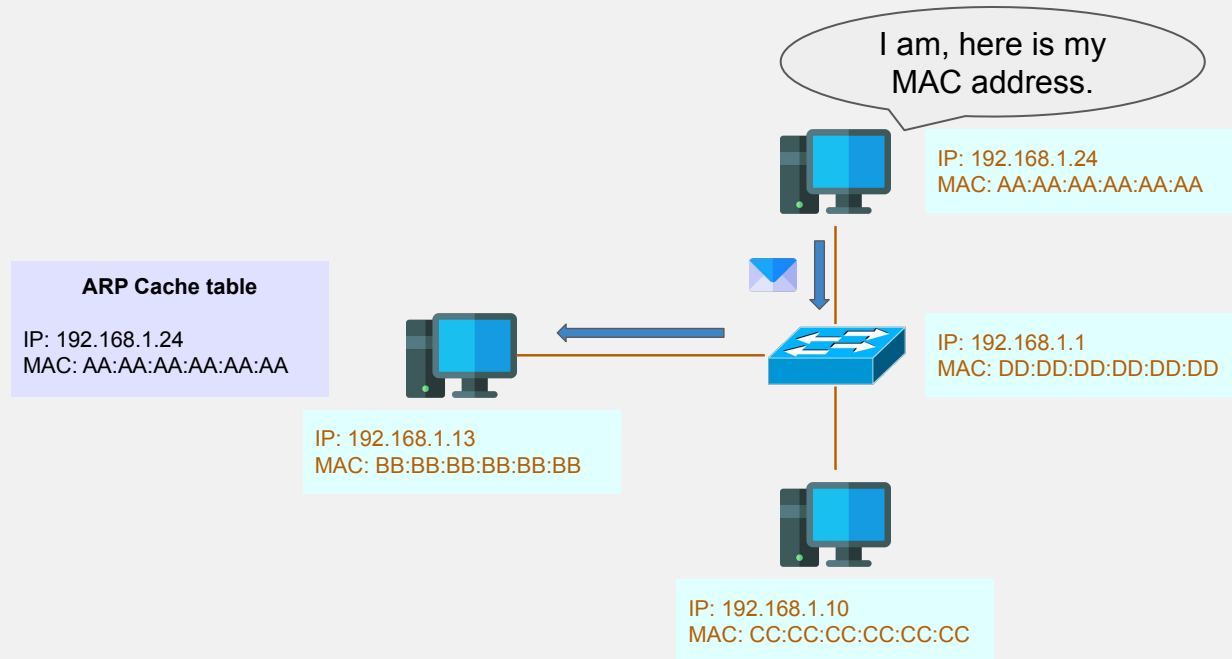
ARP Broadcast

- ❑ **ARP:** Address Resolution Protocol
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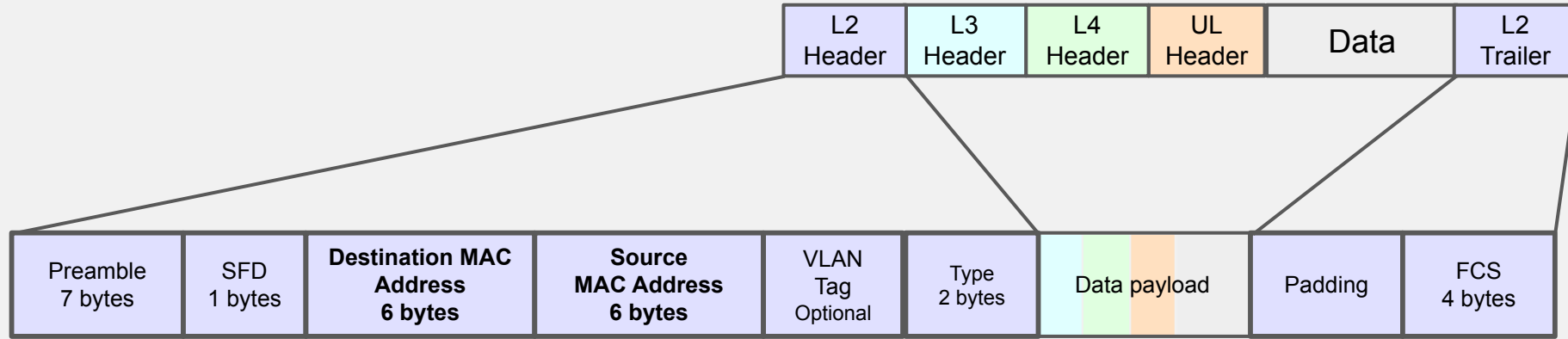


ARP Response

- ❑ **ARP:** Address Resolution Protocol
- ❑ Used to get the MAC address associated to an IP address.



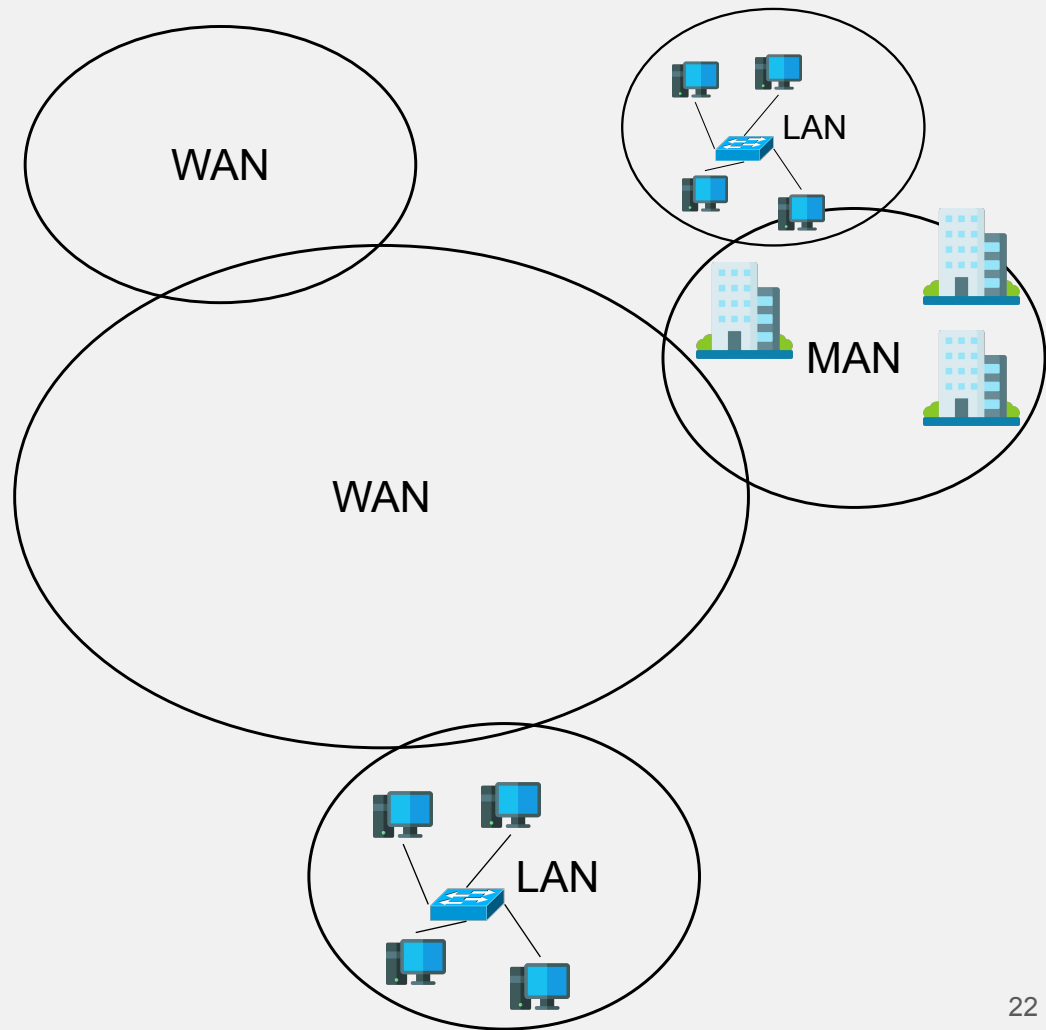
Frame Header/Trailer: Ethernet example



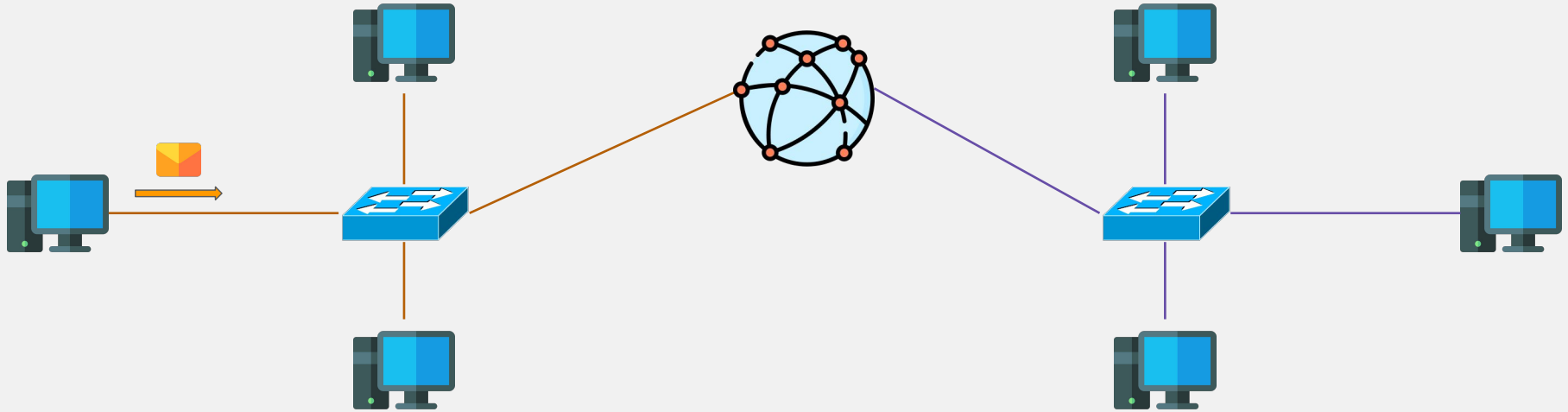
- ☐ SFD (Start Frame Delimiter)
- ☐ **Source** and **destination MAC addresses** for device specific identification.
- ☐ Optional VLAN tags for logical segmentation (more on this later).
- ☐ FCS (Frame Check Sequence) in the trailer, used to detect transmission errors.

Types of Network

- ☐ **LAN:** Local Area Network
 - ☐ Up to ~1 km.
 - ☐ Home, Office, Building, etc...
- ☐ **MAN:** Metropolitan Area Network
 - ☐ Up to ~50 km.
 - ☐ Within one city
- ☐ **WAN:** Wide Area Network
 - ☐ Above 50 km.
 - ☐ Within countries



Routing outside the LAN: Layer 3



Internet Protocol version 4 (IPv4)

- IPv4 still performs most of the routing on the internet
 - Designed in the 70s
 - Was redefined, fixed, over the years.
 - IPSec for security.
 - NAT for intranet and to resolve address shortage.
 - ...
- Was here to be the main protocol for the Internet layer.
 - Many to one to Many.
 - Maximize interoperability
 - Minimize number of service interfaces

IPv4 Structure

An **IPv4 address** consists of two parts:

- **Network part:** identifies the network.
- **Host part:** identifies a device within that network.

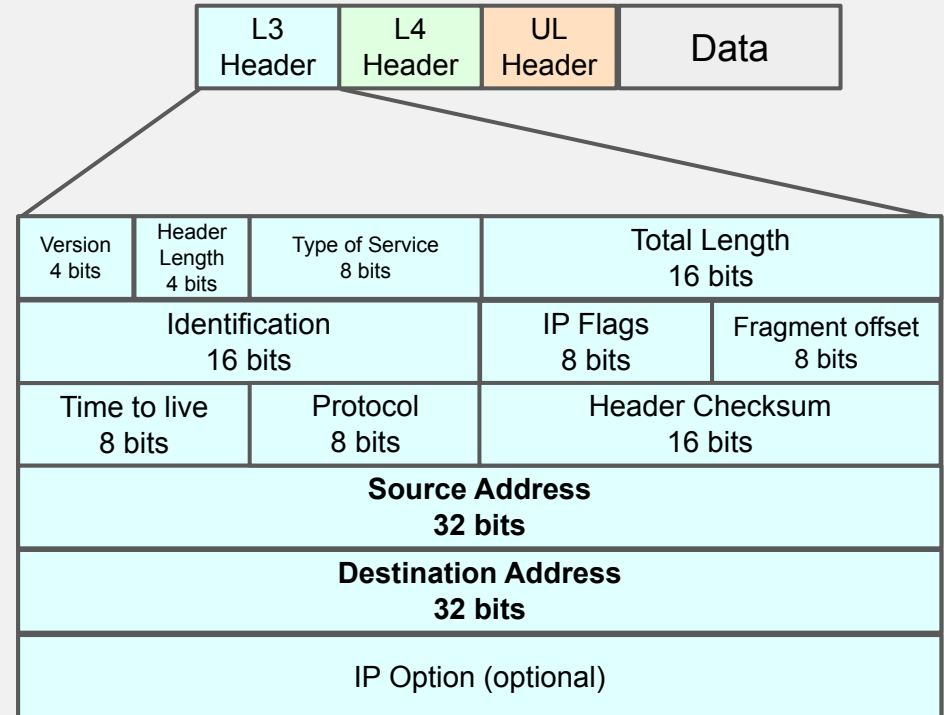
The **subnet mask** specifies which bits belong to the network and which to the host.

Example:

- IP: 192.168.1.10
- Mask: 255.255.255.0 (or /24)
- Network: 192.168.1.0
Host range: 192.168.1.1 to 192.168.1.254
- Broadcast: 192.168.1.255

Packet Header: IPv4 example

- **Source and destination *IPv4* addresses.**
- Upper-layer protocol identification (TCP, UDP, ICMP...).
- Checksum to verify header validity.

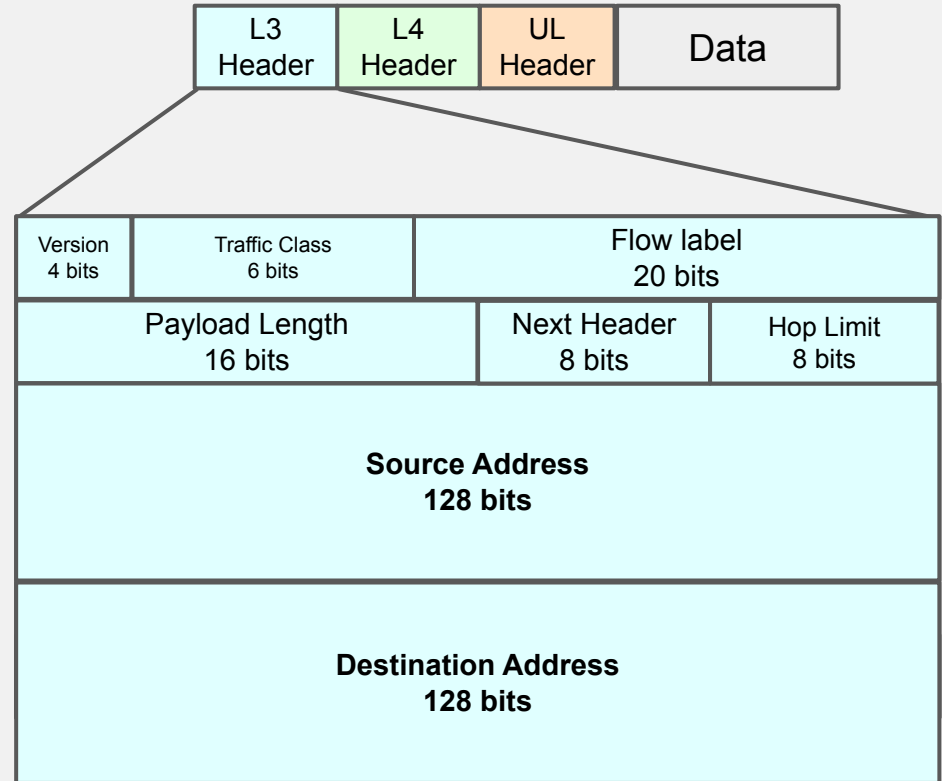


Internet Protocol version 6 (IPv6)

- ❑ Developed in the 90s to address IPv4 limitations.
 - ❑ Built-in improvements rather than incremental fixes.
 - ❑ IPSec support is native, part of the base specification.
 - ❑ No need for NAT thanks to a vastly larger address space.
 - ❑ 2^{32} addresses maximum for IPv4 against 2^{128} for IPv6.
- ❑ Simplified packet header for more efficient routing.
- ❑ Better support for mobile devices and IoT.
- ❑ Aimed to be the new main protocol for the Internet layer.
- ❑ Designed to maintain interoperability while enabling future scalability.
- ❑ Adoption is progressing, but still slow in some regions due to legacy infrastructure and transition costs.

Packet Header: IPv6 example

- **Source and destination *IPv6* addresses.**
- Upper-layer protocol identification (TCP, UDP, ICMP...).
- No checksum anymore. We rely on the Data Link Layer to provide sufficient protection.



IPv6 Structure

IPv6 uses a **prefix length** instead of a subnet mask.

The prefix length defines the number of bits representing the network.

Example:

- IPv6: 2001:db8:abcd:0012::1/64
- /64 means the first 64 bits are the network identifier.
- The remaining 64 bits are used for host addresses.

Now for the connection

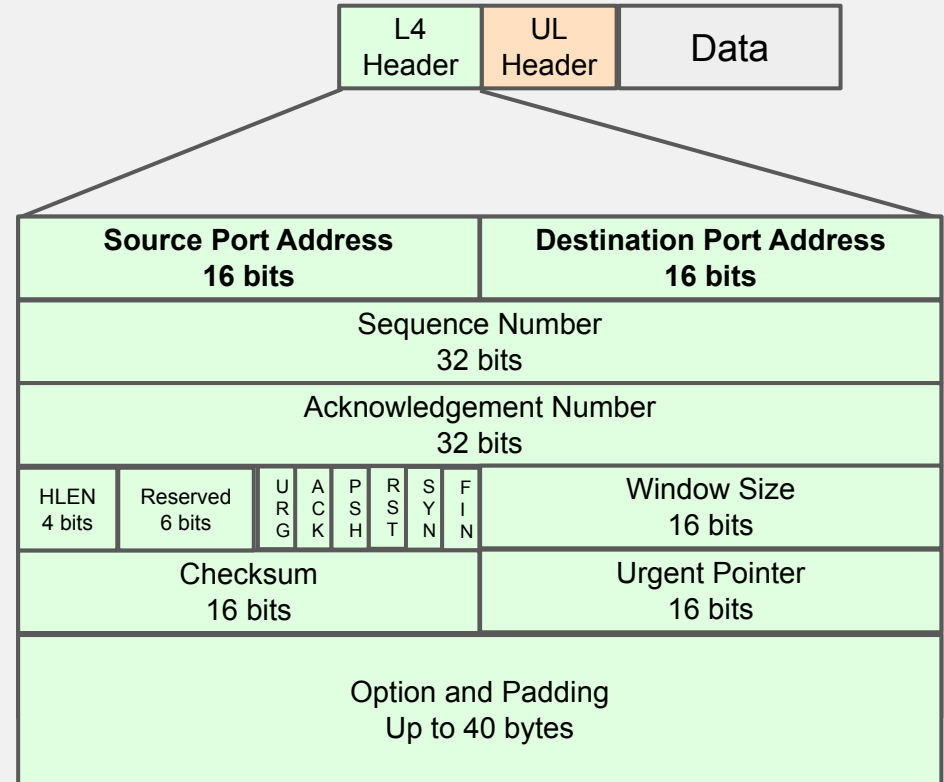
With addresses, devices can talk to each other.

Now choosing the layer 4 protocol:

- ☐ TCP
 - ☐ Reliable but slow, perfect for HTTP
- ☐ UDP
 - ☐ Fast but no reliability
 - ☐ Perfect for video streaming

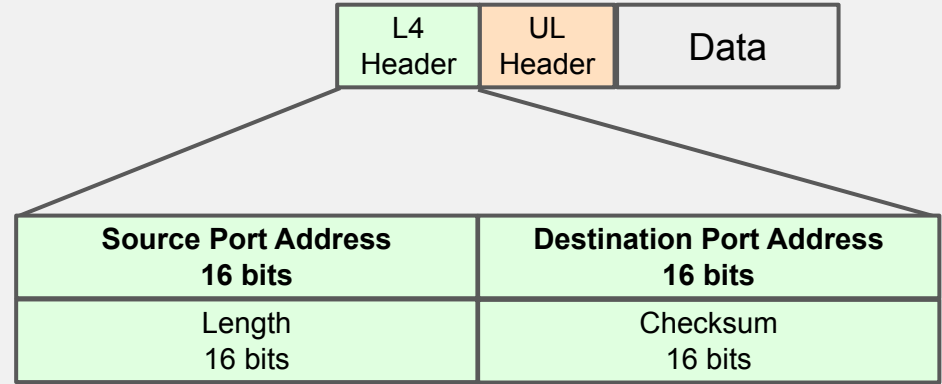
Segment Header: TCP example

- Application identification through **source** and **destination ports**.
- Reliability via sequence and acknowledgment (ACK) numbers.
- Flow control through the window size.
- Integrity with the checksum.
- Additional functions (SYN, FIN, RST, etc.) that handle connection establishment, termination, or reset.



Segment Header: UDP example

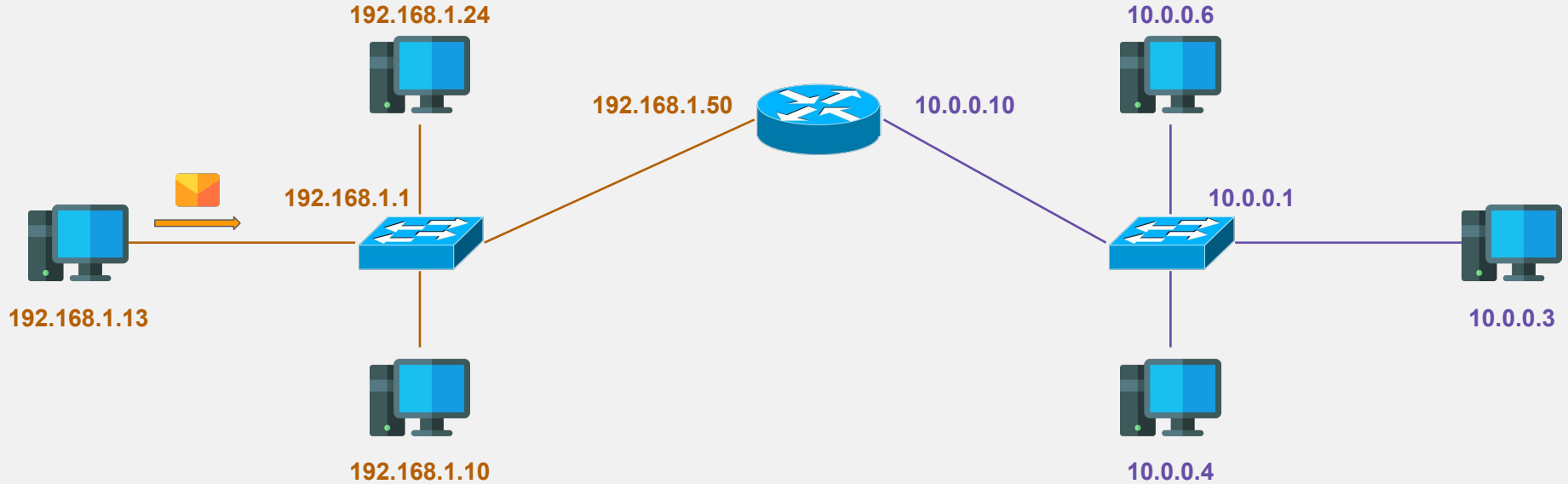
- Application identification through **source** and **destination ports**.
- An additional layer with IP addresses is added when used with IPv4 or IPv6, for checksum calculation.



Common Network Devices and Servers

- ❑ **Switch:** Forwards network traffic between devices within the same local network.
- ❑ **Router:** Connects different networks together and directs network traffic between them.
- ❑ **Gateway:** Serves as the access point that connects a local network to another network.
Most of the time a router.
- ❑ **DNS (Domain Name System):** Translate a Domain Name to its IP address.
- ❑ **DHCP (Dynamic Host Configuration Protocol):** Gives an IP address to a device in the network.

Routing outside the LAN



NETWORK COMMUNICATION PROTOCOLS MAP

OSI MODEL

Layer 7: Application Layer

- Defines interface to user processes for communication and data transfer in network
- Provides standardized services such as virtual terminal, file and job transfer and operation

Layer 6: Presentation Layer

- Masks the differences of data formats between dissimilar systems
- Specifies architecture-independent data transfer format
- Encodes and decodes data; Encrypts and decrypts data; Compresses and decompresses data

Layer 5: Session Layer

- Manages user sessions and dialogues
- Controls establishment and termination of logical links between users
- Reports upper layer errors

Layer 4: Transport Layer

- Manages end-to-end message delivery in network
- Provides reliable and sequential packet delivery through error recovery and flow control mechanisms
- Provides connectionless oriented packet delivery

Layer 3: Network Layer

- Determines how data are transferred among network devices
- Routes packets according to unique network addresses
- Provides flow and congestion control to prevent network resource depletion

Layer 2: Data Link Layer

- Defines procedures for operating the communication link
- Provides framing and sequencing
- Detects and corrects received frame errors

Layer 1: Physical Layer

- Defines physical means of sending data over network devices
- Interfaces between network medium and devices
- Defines optical, electrical and mechanical characteristics

TCP/IP

UNIX HP/IBM

Novell

Microsoft

SAN

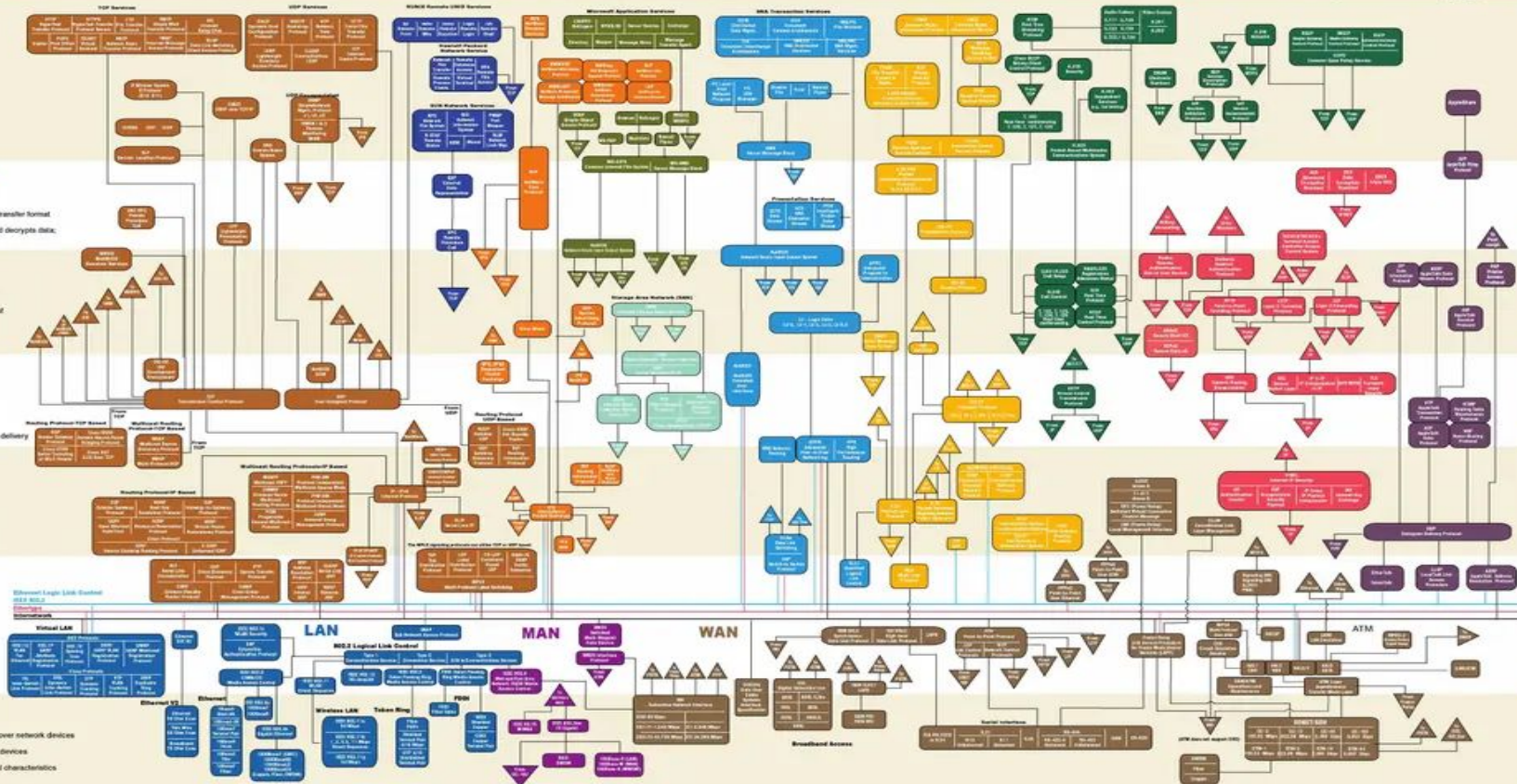
IBM

ISO

VoIP

VPN/Security

Apple



icon

