1922
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UNIVERSIDAD DE LAS FUERZAS ARMADAS
INNOVACIÓN PARA LA EXCELENCIA

Department of Computer Sciences

Computer Networks

NCR: 14575

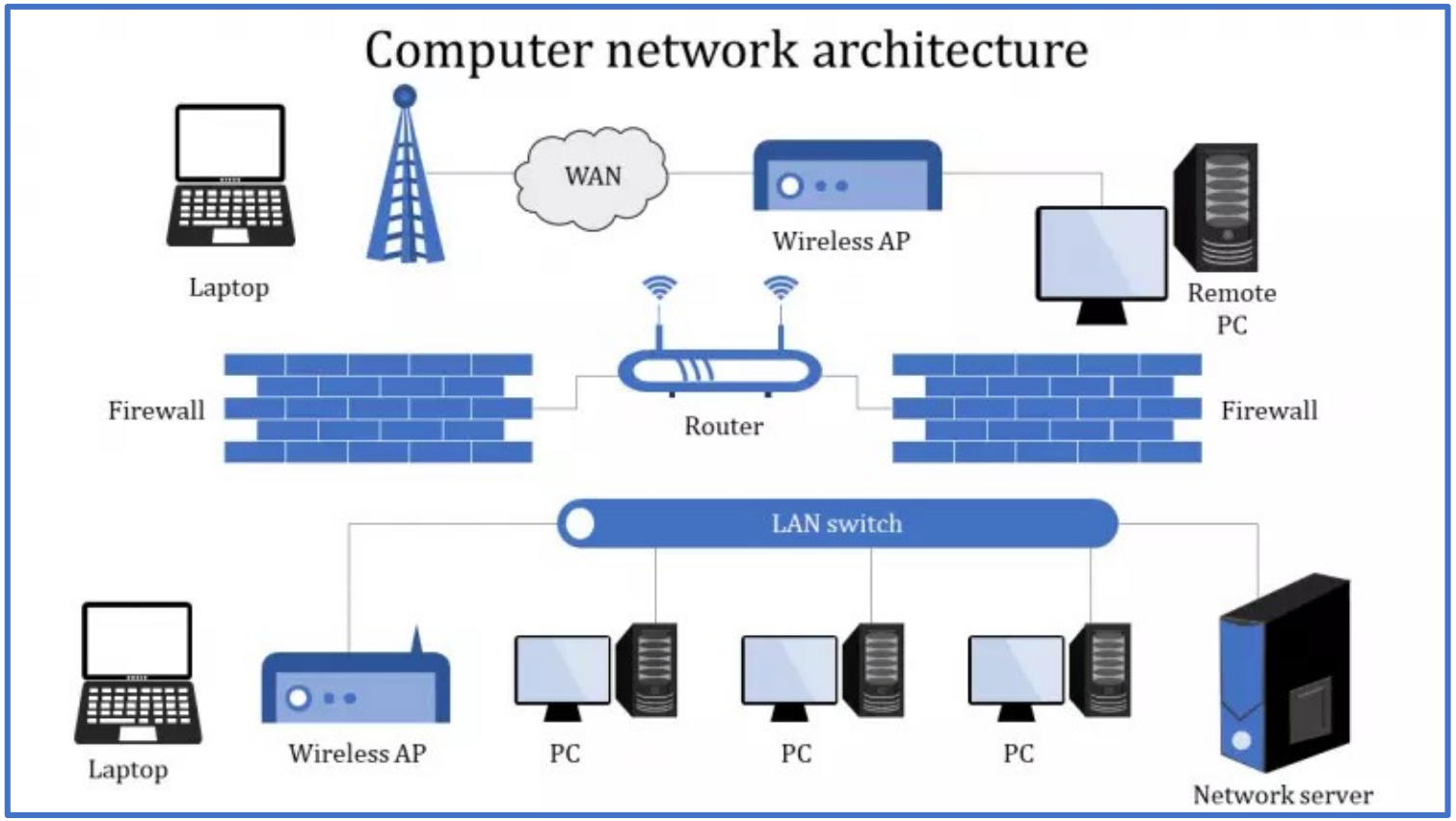
Profesor: Walter Fuertes Díaz, PhD.

First Unit

- **INTRODUCING COMPUTER NETWORKS**
  - **Computer Network Features**
  - **Benefits of computer networks**
  - **General model of a communication system**
  - **ISO/OSI Model**
  - **Transmission Modes in Computer Networks**
  - **Network Types: LAN/PAN/WLAN/WAN/MAN**
  - **Computer network topologies**
  - **Computer network components**
  - **Network Devices**
  - **Transmission media**
  - **The Basics of Structured Cabling Systems**
  - **TCP/IP Model**
  - **IP Addressing, Binary Arithmetic**
  - **Subneting**

Introducing Computer Networks

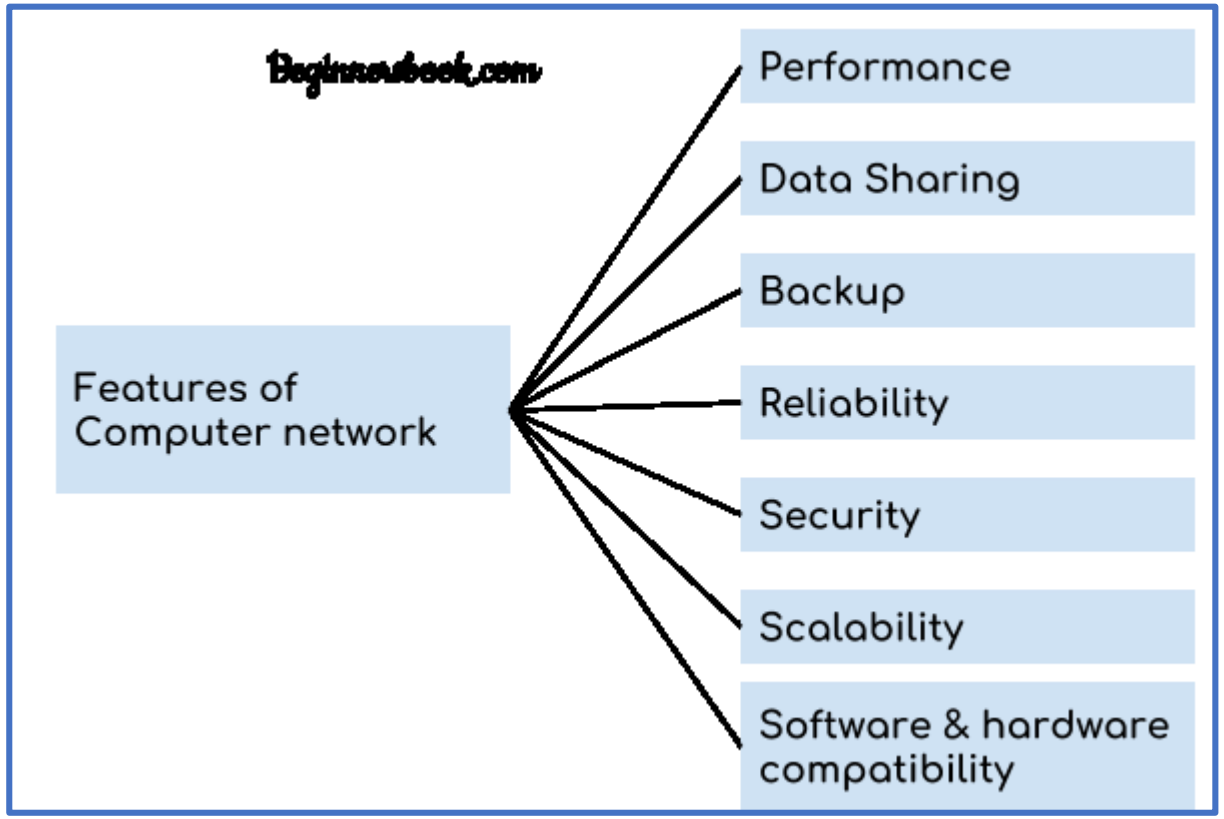
- A computer network **is a group of devices connected** with each other through a **transmission medium** such as wires, cables, electromagnetic spectrum etc. These devices can be computers, printers, scanners, fax machines etc.
- The purpose of having computer network **is to send and receive data stored in other devices over the network**. These devices are often referred as nodes.
- A **computer network architecture** is a design in which all computers in a network are organized. A architecture defines how the computers should get connected to get the maximum advantages of a computer network such as better response time, security, scalability etc.



Source: Beginners-Book, Computer network tutorial, https://beginnersbook.com/2019/03/introduction-to-computer-network/

Computer Network Features

- **Performance**: It is measured in terms of response time. The response time of sending and receiving data from one **node** to another should be minimal.
- **Data Sharing**: One of the reason why we use a computer network is to share the **data between different systems connected** with each other through a transmission media.
- **Backup**: A computer network must have a central server that keeps the backup of all the data that is to be shared over a network so that in case of a failure it should be able to recover the data faster.
- **Reliability**: There should not be any failure in the network or if it occurs the recovery from a failure should be fast



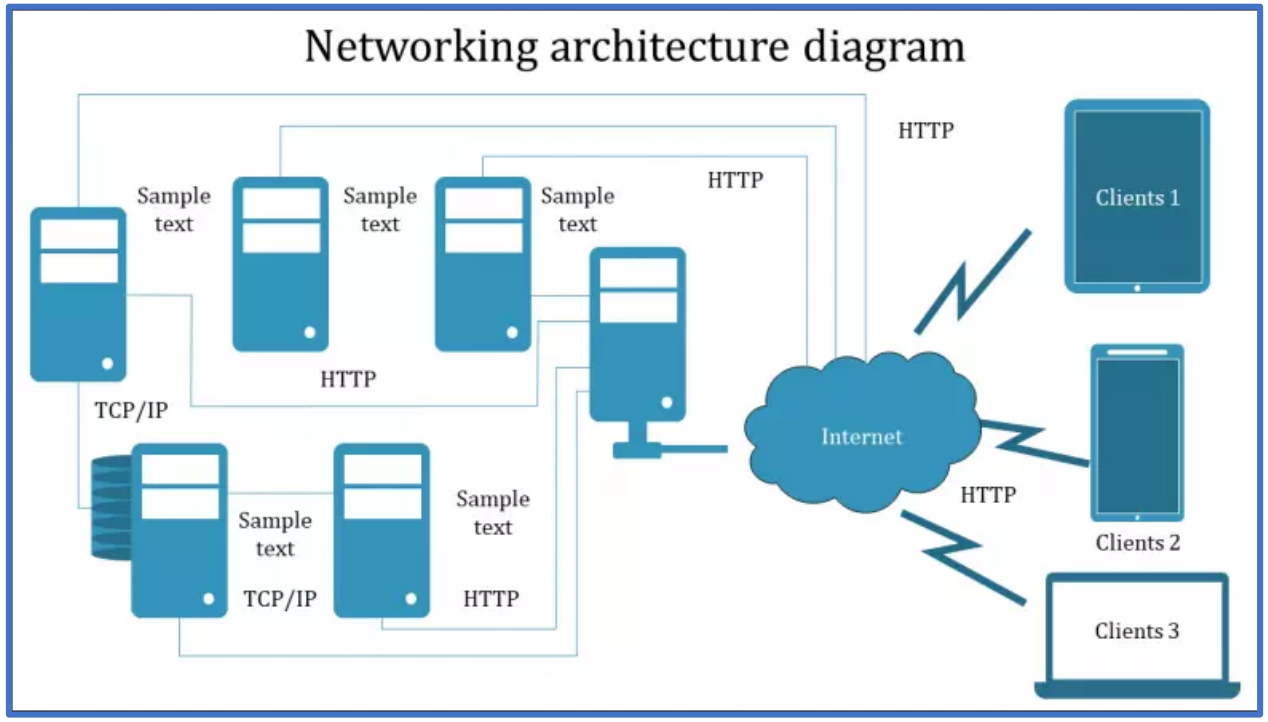
Source: Beginners-Book, Computer network tutorial, https://beginnersbook.com/2019/03/introduction-to-computer-network/

Computer Network Features

Software and hardware compatibility: A computer network **must not limit** all the computers in a computer network **to use same software and hardware**, instead it should allow the better compatibility between the different software and hardware configuration.

Security: A computer network should **be secure so that the data transmitting over a networ**k should be safe from unauthorized access. Also, the sent data should be received, which means there should not be any loss of data during transmission.

Scalability: A computer network should be scalable which means it should always allow to add new computers (or nodes) to the already existing computer network.



Source: Beginners-Book, Computer network tutorial, https://beginnersbook.com/2019/03/introduction-to-computer-network/

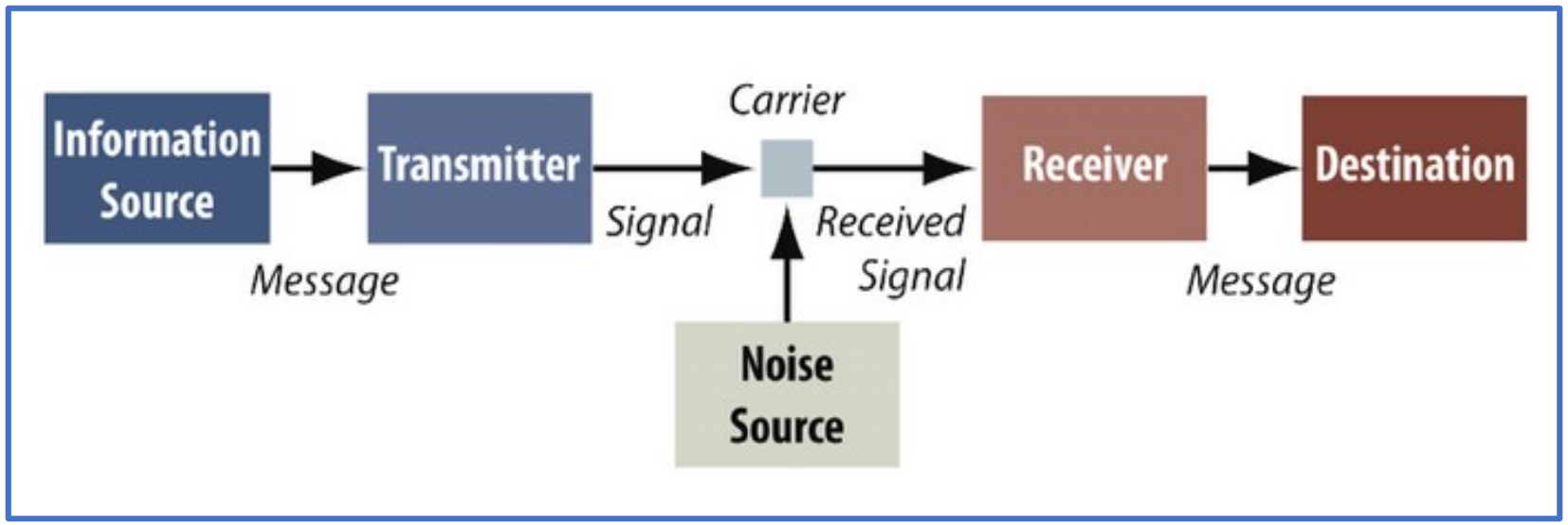
Benefits of computer networks

- Setting up a **computer network** is a fast and reliable way of sharing information and resources within a business.
- **File sharing** - It can easily share data between different users, or access it remotely if you keep it on other connected devices.
- **Resource sharing** - using network-connected peripheral devices like printers, scanners and copiers, or sharing software between multiple users, saves money.
- **Sharing a single Internet connection** - it is cost-efficient and can help protect your systems if you properly secure the network.

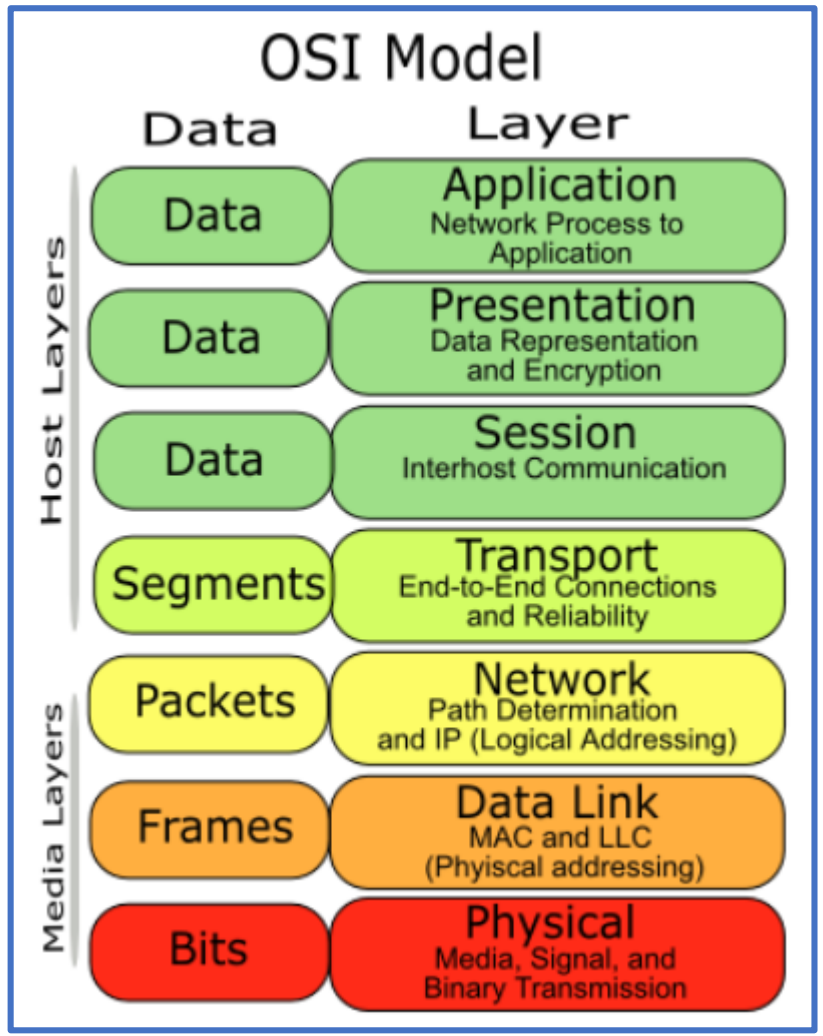
- **Increasing storage capacity** - you can access files and multimedia, such as images and music, which you store remotely on other machines or network-attached storage devices.
- I**mprove communication,** staff, suppliers and customers can share information and get in touch more easily.
- Storing information in one centralized database can also help you **reduce costs** and **drive efficiency**
- **Reduce errors** and **improve consistency** by having all staff work from a single source of information

Source: NIBUSINESS INFO.CO.OK, Benefits of computer networkshttps://www.nibusinessinfo.co.uk/content/benefits-computer-networks

General model of a communication system



Shannon's schematic diagram of a general communication system with its eight elements



MODELO ISO/OSI

Interconexión

Client
TX/RX

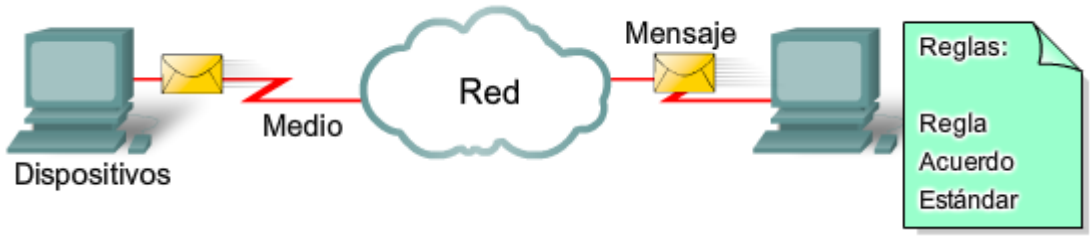
GUI/browser/CLI

Internet
PSTN, ISP
Middleware

Server
RX/TX

SISTEMA DE COMUNICACIÓN BASICO

Profesor: Walter Fuertes, PhD



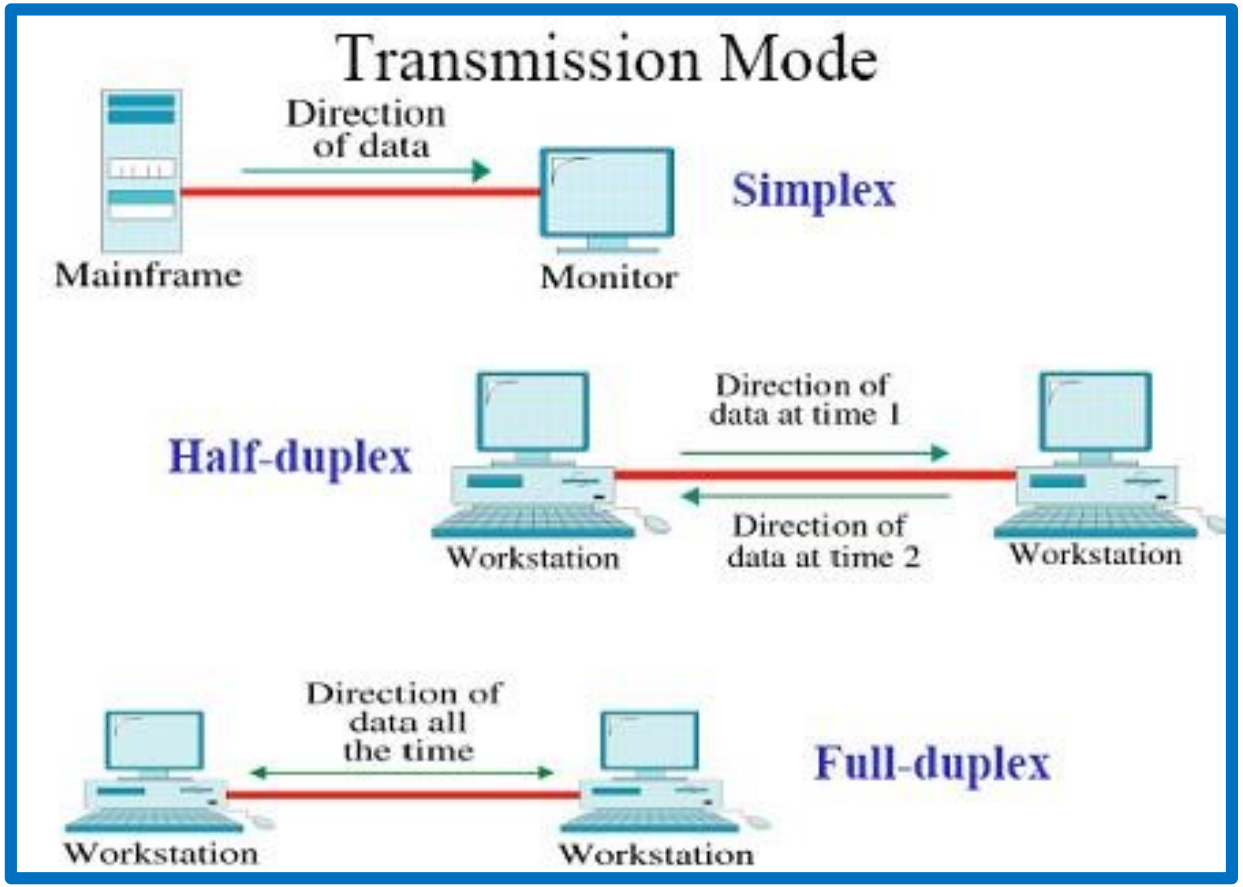
7	APLICACIÓN	E-mail, MatLab, office, webserver	APPLICATION	7	Gateway, proxy, UTM, SIEM, NG-Firewall	HTTP, SMTP, SSH, FTP, TELNET	Network services or applications.
6	PRESENTACIÓN	Data	PRESENTATION	6		ASCII, RSA EBCDIC, PNG	Data-format
5	SESIÓN		SESSION	5		NTP	Synchronization
4	TRANSPORTE	Msg/segments	TRANSPORT	4		UDP|TCP	End to end connection
3	RED	Packets	NETWORK	3	Router, switch-router, wireless-router, firewall	IP, IPSEC, ICMP	Logical addressing, routing, packet filtering
2	ENLACE DE DAT	Tramas/frames	DATA-LINK (LLC / MAC)	2	Switch, Bridge	ETHERNET, FRAME RELAY, WIFI	Physical addressing, network technology
1	FÍSICA	Bits, 0, 1	PHYSICAL LAYER	1	Repeater, Hub, modem, codec, transceiver, AP	EIA-RS-232, ?	Transmission media, physical, electricals, and mech. features
		Types of signals			Network Devices	Protocols	Functionality

Transmission Modes in Computer Networks

Transmission mode refers to the mechanism of transferring of data between two devices connected over a network. It is also called Communication Mode. These modes direct the direction of flow of information.

There are three types of transmission modes. They are:

- ❖Simplex Mode
- ❖Half duplex Mode
- ❖Full duplex Mode



Laboratory practice N ° 1

- **Topic:** Basic Windows Network Commands
- **Goals**:
  - Understand how Windows OS connectivity commands work.
  - Learn the meaning of jitter, the number of packets Tx, Rx, and lost.
  - Recognize the type of physical and logical, gateway by default, broadcasts, and netmask addresses.
- **Test topology:**
  - Laptop or desktop computers.
  - Internet access connection.
  - Windows OS.
- **Theoretical framework:**
  - Windows OS architecture
  - CMD, CLI,
  - Windows Networks
- **Develop**
- **Conclusions**
- **Bibliographic references**

Types of Networks: LAN/PAN/WLAN/WAN/MAN

➢ *Por su extensión / cobertura*

LAN y WAN

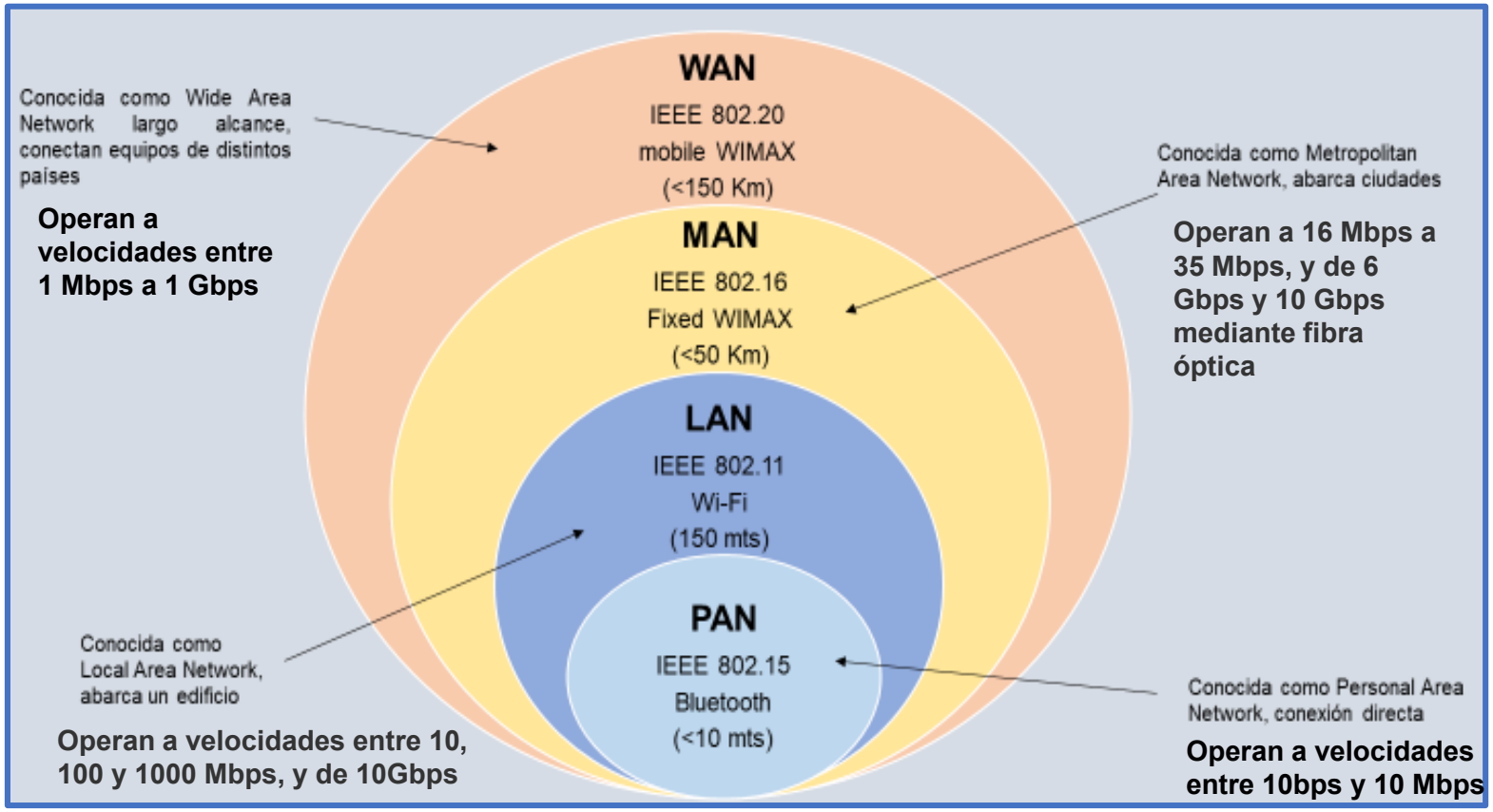
Tipos de redes

Los dos tipos más comunes de infraestructuras de red son los siguientes:

- Red de área local (LAN)
- Red de área extensa (WAN)
- Red de área Personal (PAN)

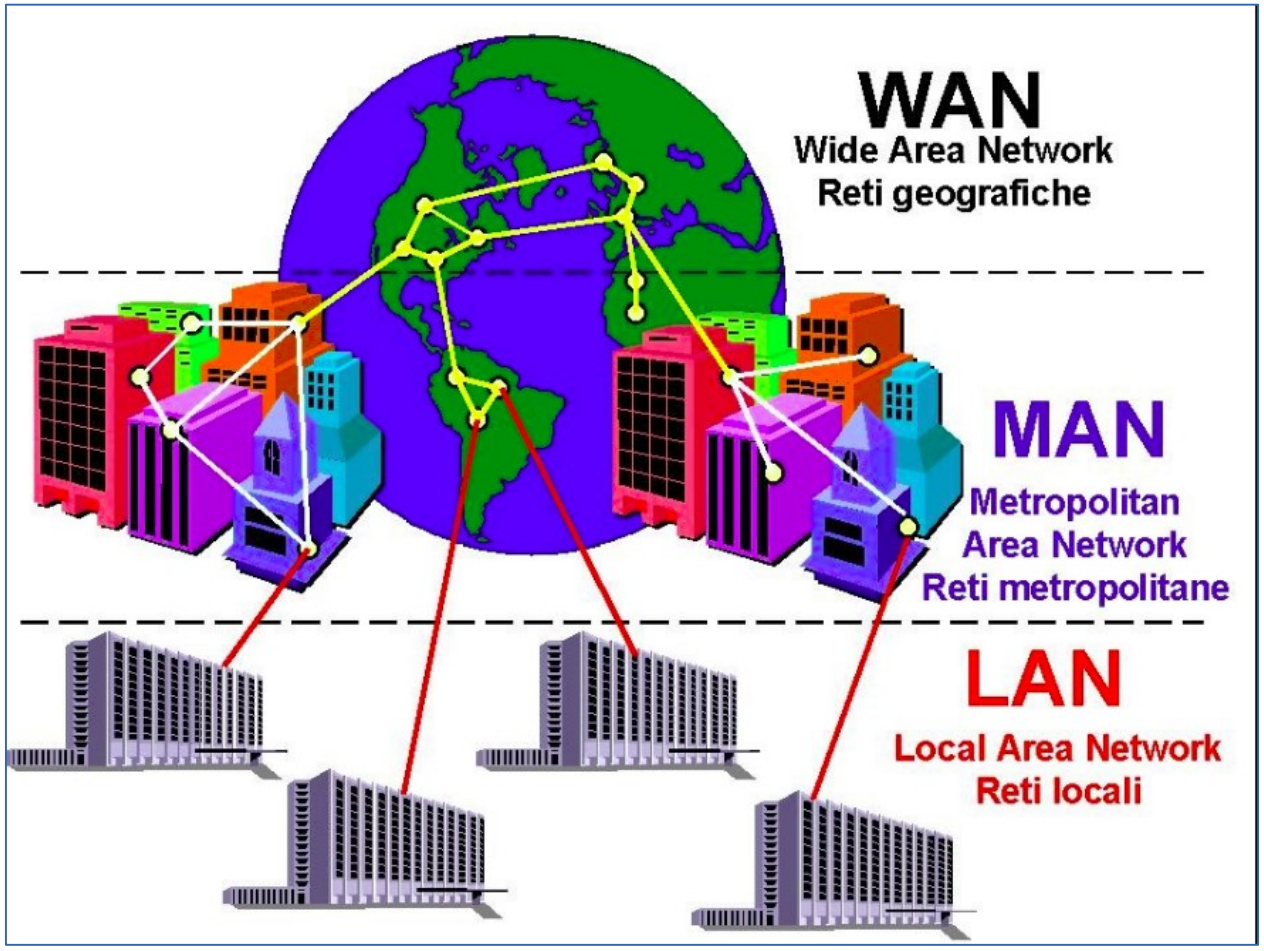
Otros tipos de redes incluyen los siguientes:

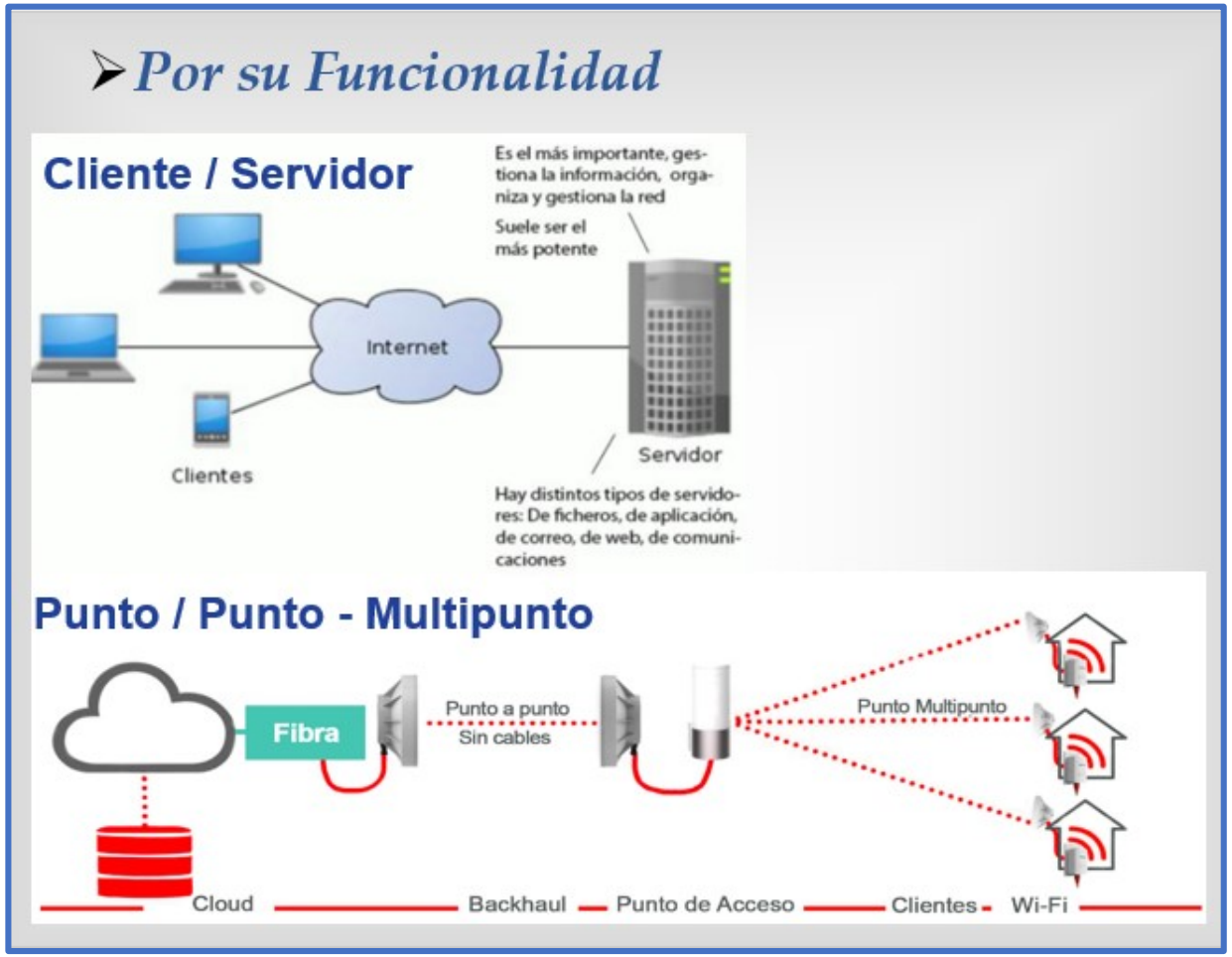
- Red de área metropolitana (MAN)
- LAN inalámbrica (WLAN)
- Storage Area Network (SAN)



Fuente: Extracto, Redes de Comunicaciones, Ingeniería en TI, Ing. Stalin Maldonado, 12-2020.

Type of Networks: LAN/PAN/WLAN/WAN

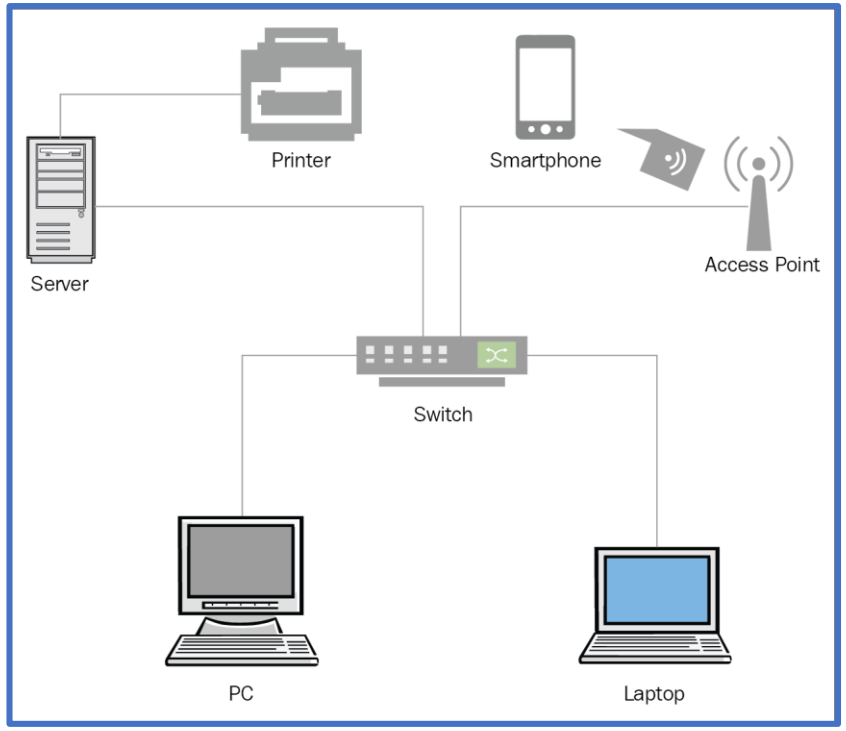




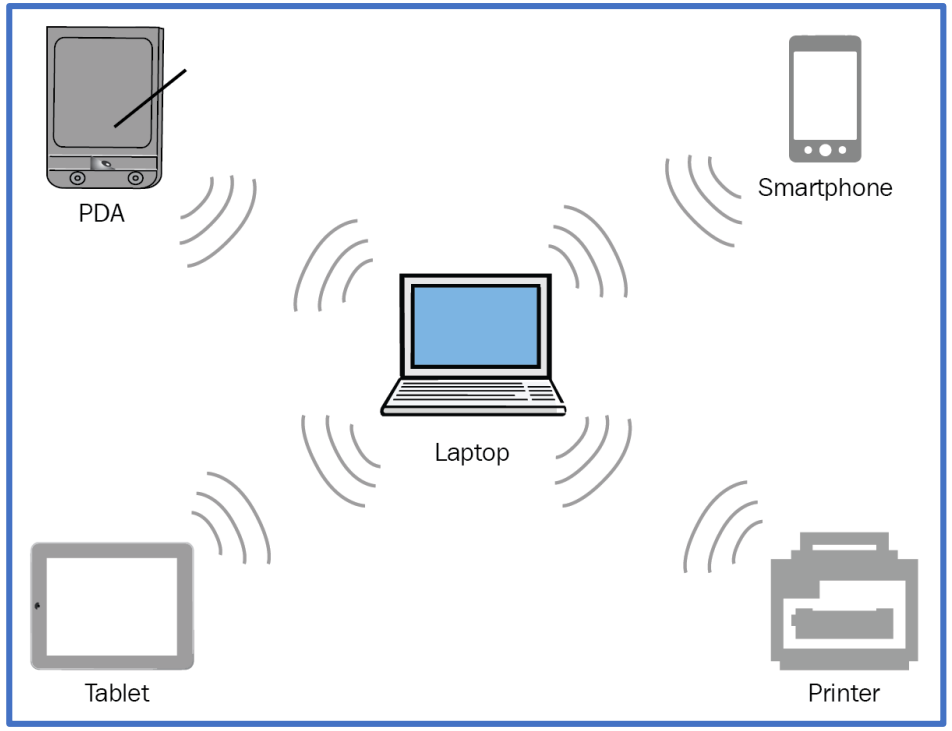
Fuente: Extracto, Redes de Comunicaciones, Ingeniería en TI, Ing. Stalin Maldonado, 12-2020.

Tipos de Redes: LAN/PAN/WLAN/WAN

LAN (Local Area Network) as a computer network that connects two or more computers in a local area for the purpose of sharing resources.



A PAN (Personal Area Network) is defined as a computer network that is used to connect and transmit data among devices located in a personal area, usually over Bluetooth or Wi-Fi to interconnect devices.

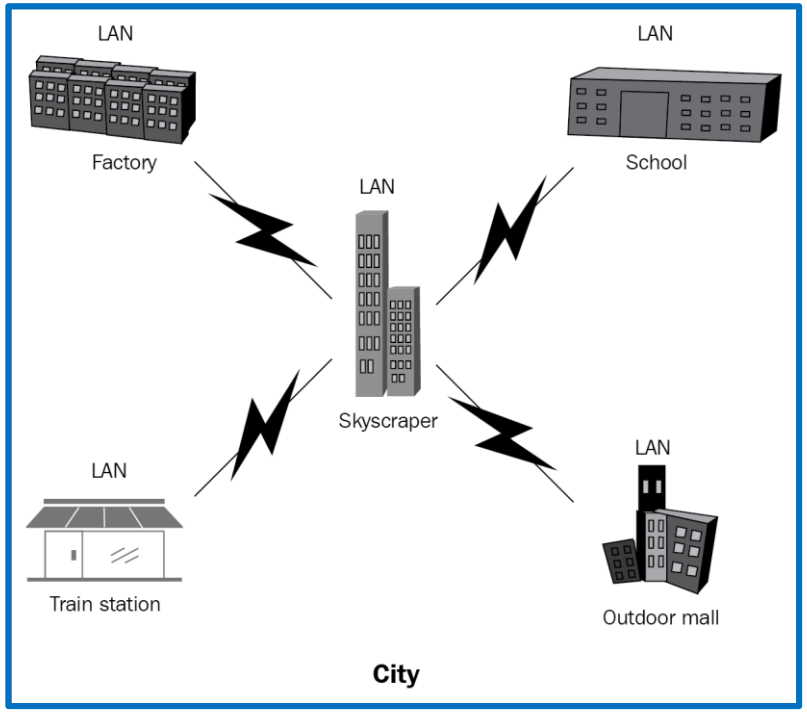


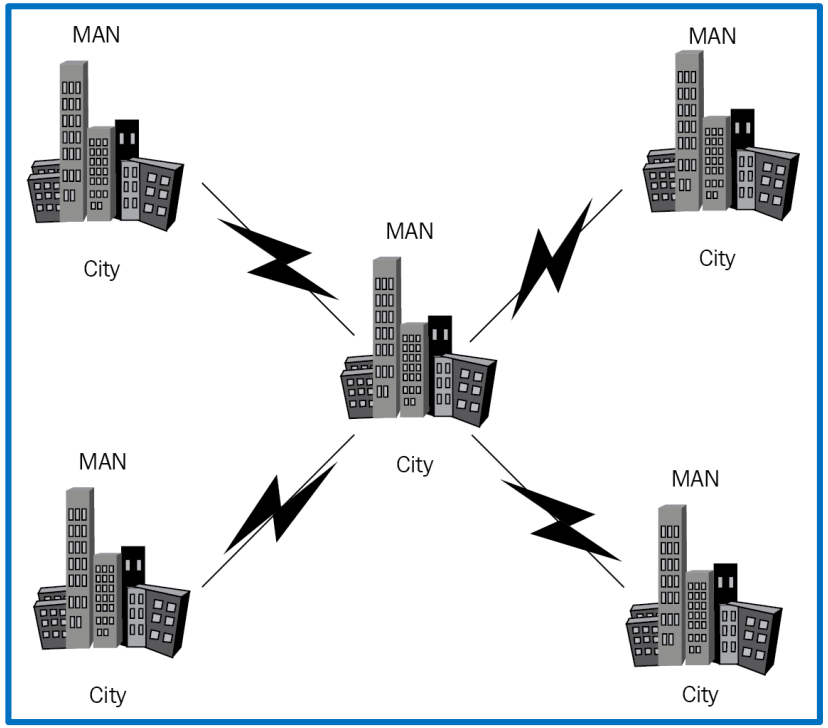
Fuente: Types of computer networks, URL: https://subscription.packtpub.com/book/networking_and_servers/9781788621434/1/ch01lvl1sec13/computer-network-topologies

Tipos de Redes: LAN/PAN/WLAN/WAN

MAN (Metropolitan Area Network) is bigger than the LAN and smaller than the WAN. The data transmission speeds of MAN is faster than both the LAN and WAN. A MAN represents a group of LANs interconnected within the geographical boundary of a town or city.

A WAN (Wide Area Network) is a computer network that covers a wide geographic area using dedicated telecommunication lines such as telephone lines, leased lines, or satellites.





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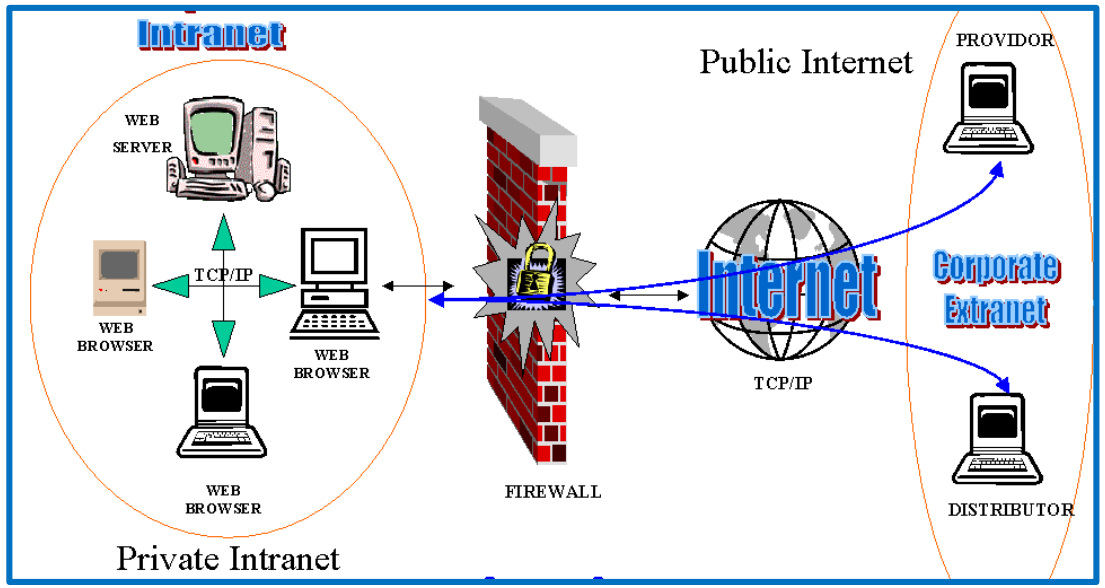
Tipos de Redes: Intranet vs Extranet

The intranet is a networking platform primarily designed for employees. That said, it is considered to be the private network of an organization where employees can access network services. The intranet is not just a portal; instead, it is a network that consists of hardware and software too. To better understand it, consider the intranet as an organization's extended LAN, or MAN, or even WAN network



The extranet is a networking platform too; however, besides employees, the extranet enables controlled access to an organization's intranet for authorized partners, suppliers, customers, or others business-related individuals and organizations outside the company. Specifically, the extranet represents a controlled access method of the organization's intranet using Internet infrastructure.

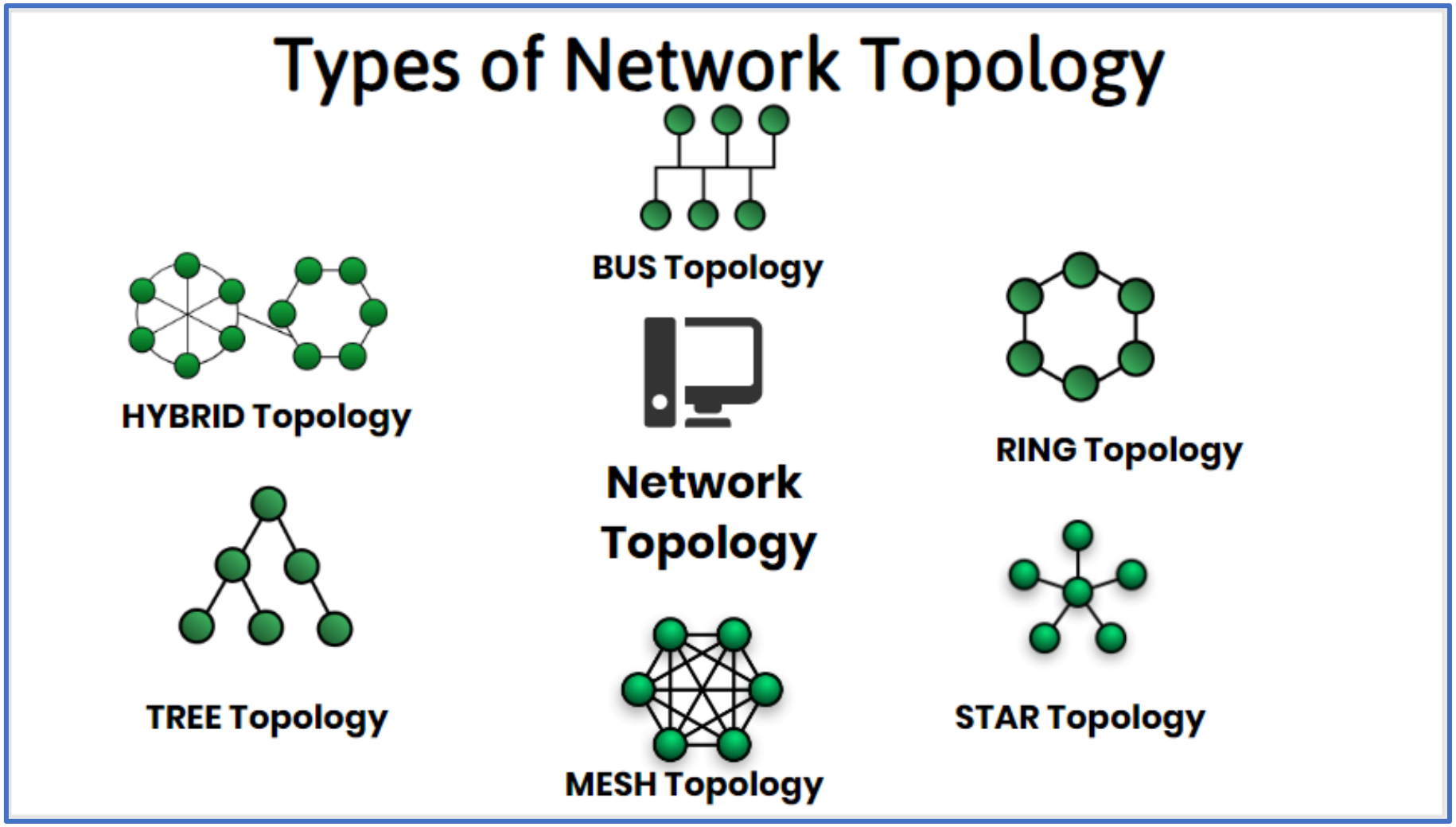
Parameter	Intranet	Extranet
Usage	Private	Private
User Types	Organization employees and Internal company departments	Suppliers, customer and Business partners.
Usage	Internal employee communication , telephone directories etc.	Check status of orders, Access data , send email
Security	High security. Configured under 100 security level in firewall	Generally uses VPN technology for secured communication over Internet. Medium security Level.
Regulated by	It is regulated by an organization.	It is regulated by multiple organization.
Ownership	Owned by Single organization	It is owned by single/multiple organization.

SOURCE:https://ipwithease.com

Computer network topologies

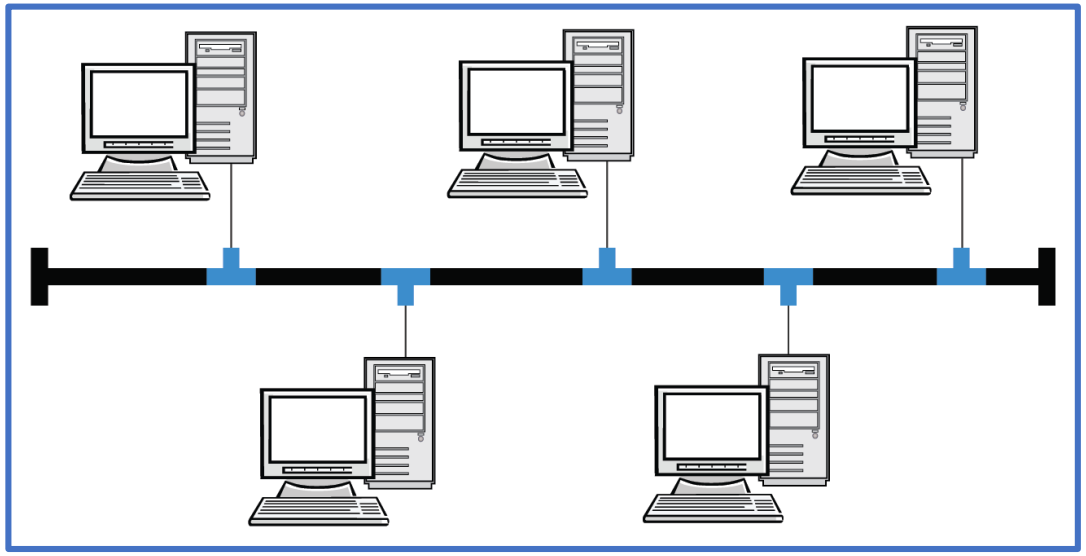
Network Topologies: Another way to categorize computer networks is by their topology, how hosts and nodes are organized and connected, and how they communicate. There are two types of topologies: **physical and logical**.

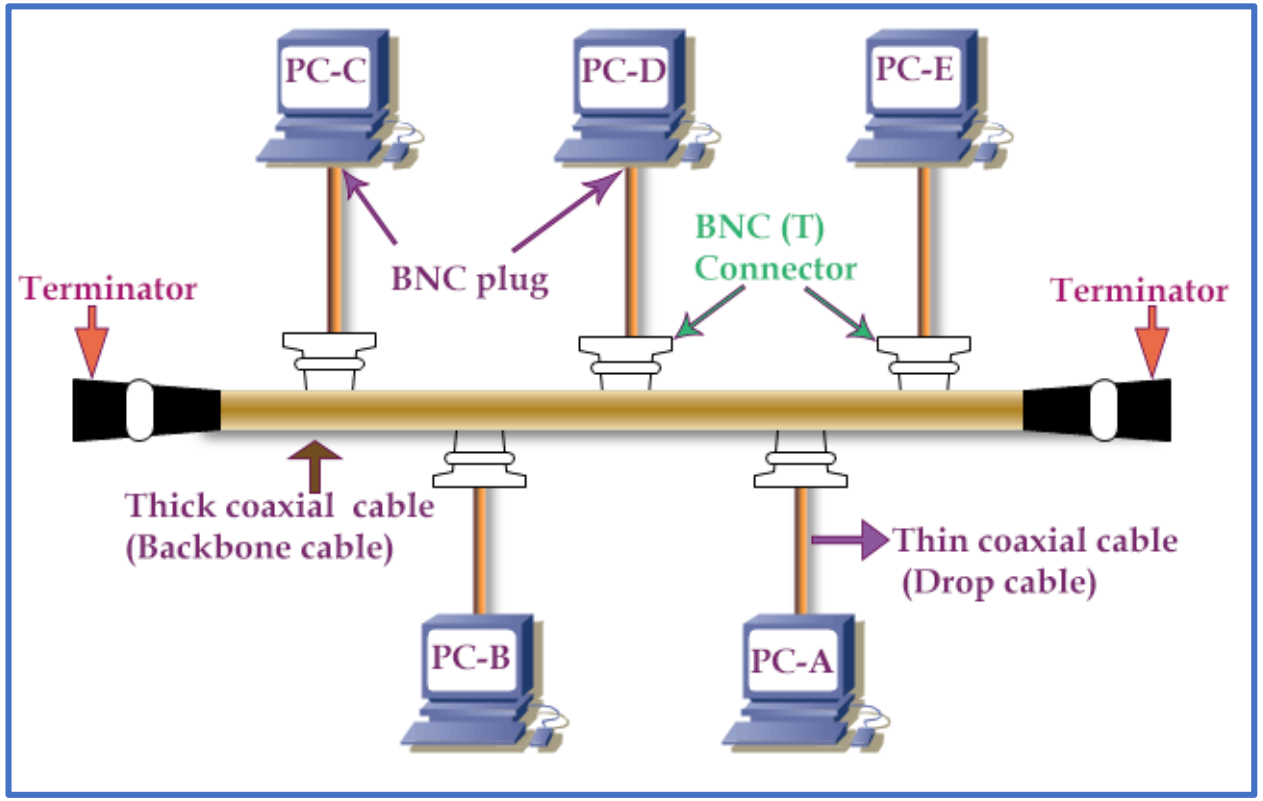
Physical topology presents ordering, arrangement, and placement of the physical parts of a computer network, such as computers, peripheral devices, cables for data transmission, and network equipment: **bus, ring, star, extended star, hierarchical, and mesh.**



Computer network topologies

Bus is the physical topology in which computers, peripheral and network devices are connected through the bus that mainly consists of a coaxial cable.

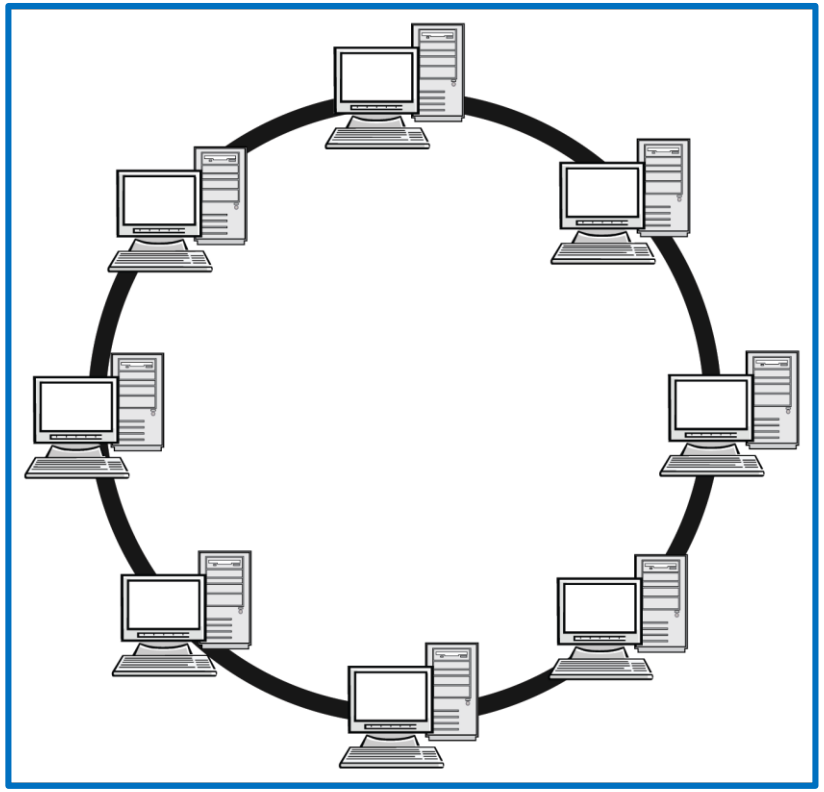




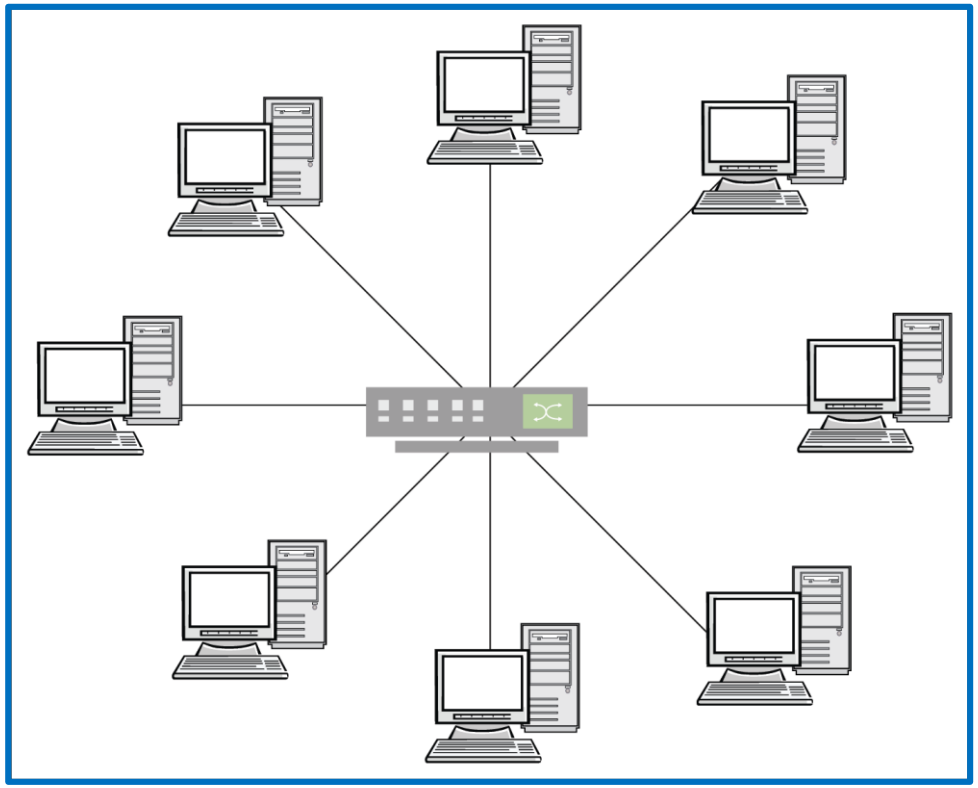
Source: Computer network topologies, URL: https://subscription.packtpub.com/book/networking_and_servers/9781788621434/1/ch01lvl1sec13/computer-network-topologies

Computer network topologies

Ring is the physical topology in which computers, peripheral and network devices form a closed cycle that takes the shape of a ring network where each device is connected to each other. In the past, the coaxial cable was used, but nowadays in dual ring networks, optical fiber is used



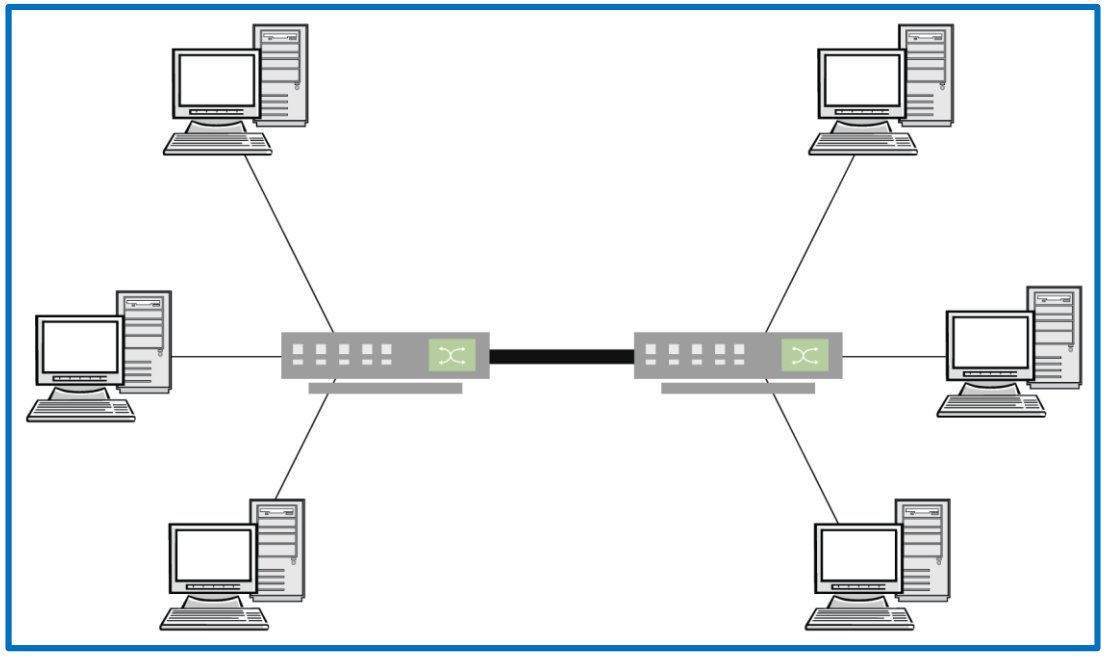
Star is the physical topology in which computers, peripheral and network devices are connected independently with a central device. For this type of topology, mainly a twisted pair cable is used:



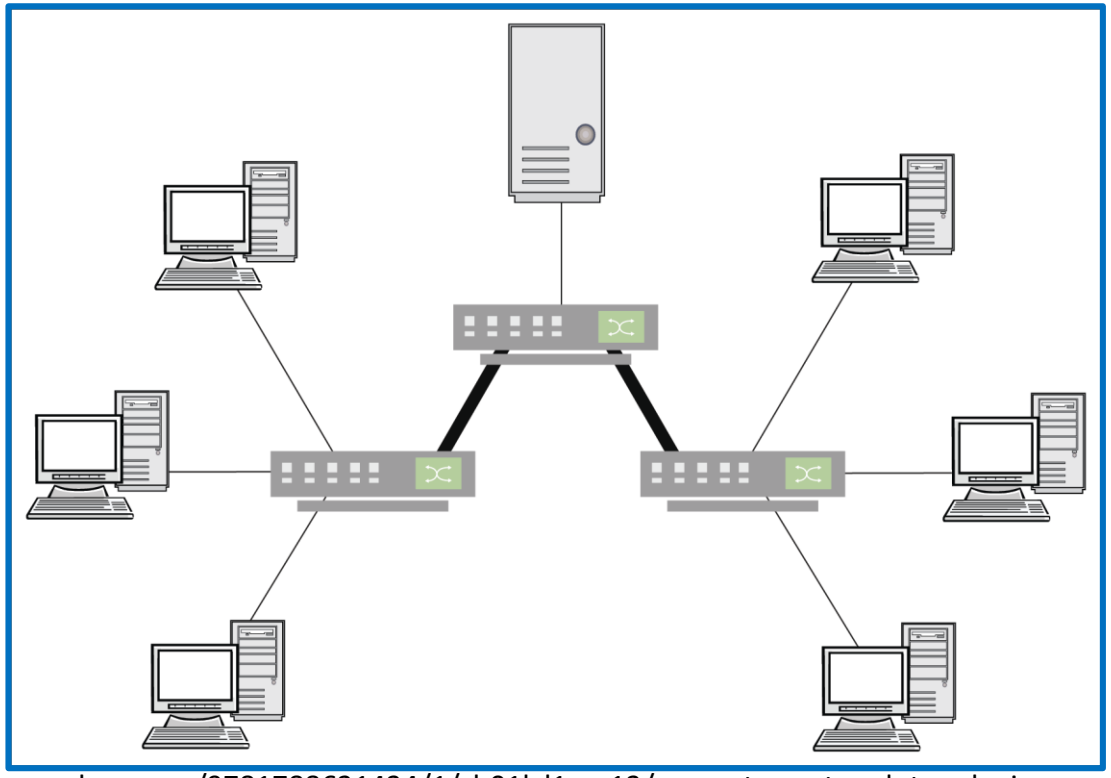
Source: Computer network topologies, URL**:** https://subscription.packtpub.com/book/networking_and_servers/9781788621434/1/ch01lvl1sec13/computer-network-topologies

Computer network topologies

Extended star is the physical topology in which computers and peripheral and network devices are connected into two or more star topology networks and then the central components (i.e., switches) are interconnected over a bus. In appearance, this type of topology combines star and bus topologies. Mainly, a twisted cable pair is used for the star topology, while an optical fiber is used for the bus topology.



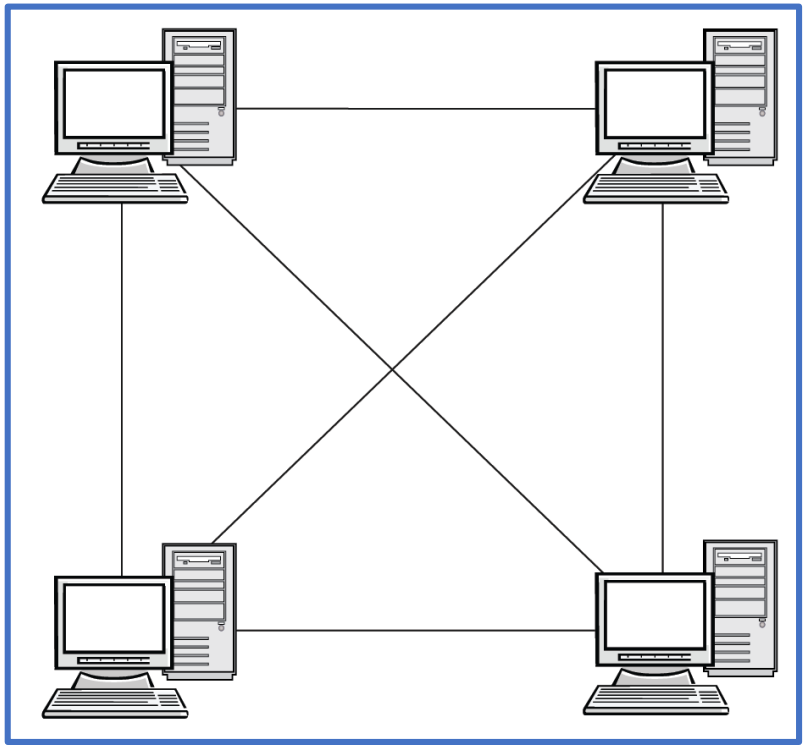
Hierarchical is the physical topology that represents a combination of star and bus topologies. This topology must have at least three levels of hierarchy in which star topologies connect one or more nodes to a single main node, so that all these together are related to the main trunk of the tree. As in the case of an extended star topology, this topology uses twisted pair cables and optical fiber.



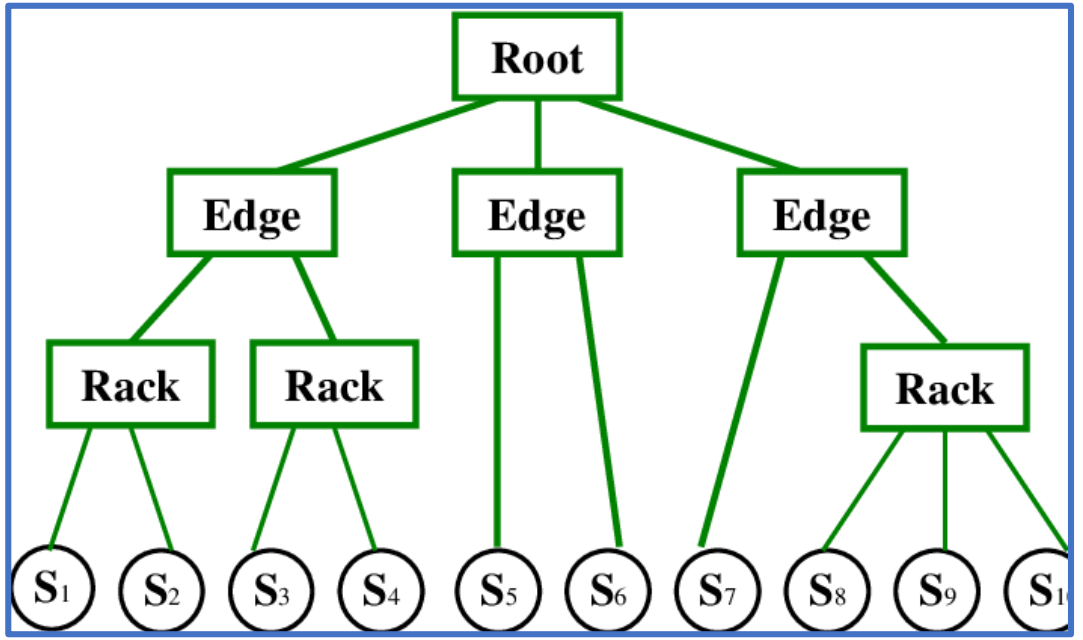
Source: Computer network topologies, URL: https://subscription.packtpub.com/book/networking_and_servers/9781788621434/1/ch01lvl1sec13/computer-network-topologies

Computer network topologies

Mesh is the physical topology in which each computer is connected with every computer to form the network. Usually, this type of topology is utilized by a WAN to interconnect LANs:



Tree is a special type of structure where many connected elements are arranged like the branches of a tree, e.g. used to organize the computers in a corporate network, or the information in a database. There can be only one connection between any two connected nodes. Because any two nodes can have only one mutual connection, tree topologies create a natural parent and child hierarchy.



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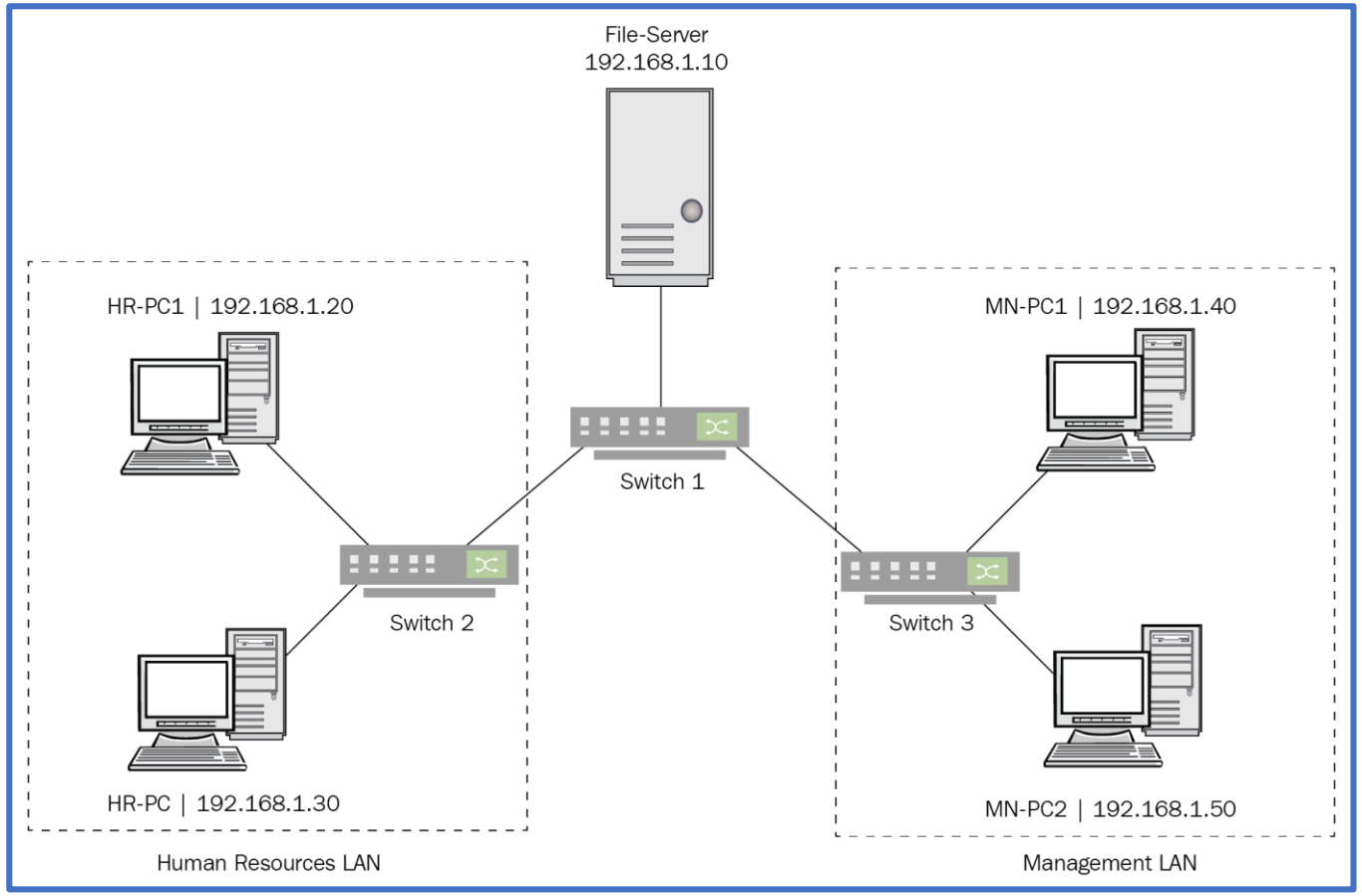
Computer network topologies

Logical Topology

Unlike physical topology, **logical topology** represents the logical aspect of the computer network.

- In logical topology, it is the logical paths that are used to carry electric or light signals from one computer to another, or from one network node to another node.
- Thus, this topology represents the way in which the data accesses the transmission medium and transmits packets through it.
- *This figure* presents the logical topology with its logical components such as computer names, network equipment, network communication technology, and IP addresses:



Source: Computer network topologies, URL: https://subscription.packtpub.com/book/networking_and_servers/9781788621434/1/ch01lvl1sec13/computer-network-topologies

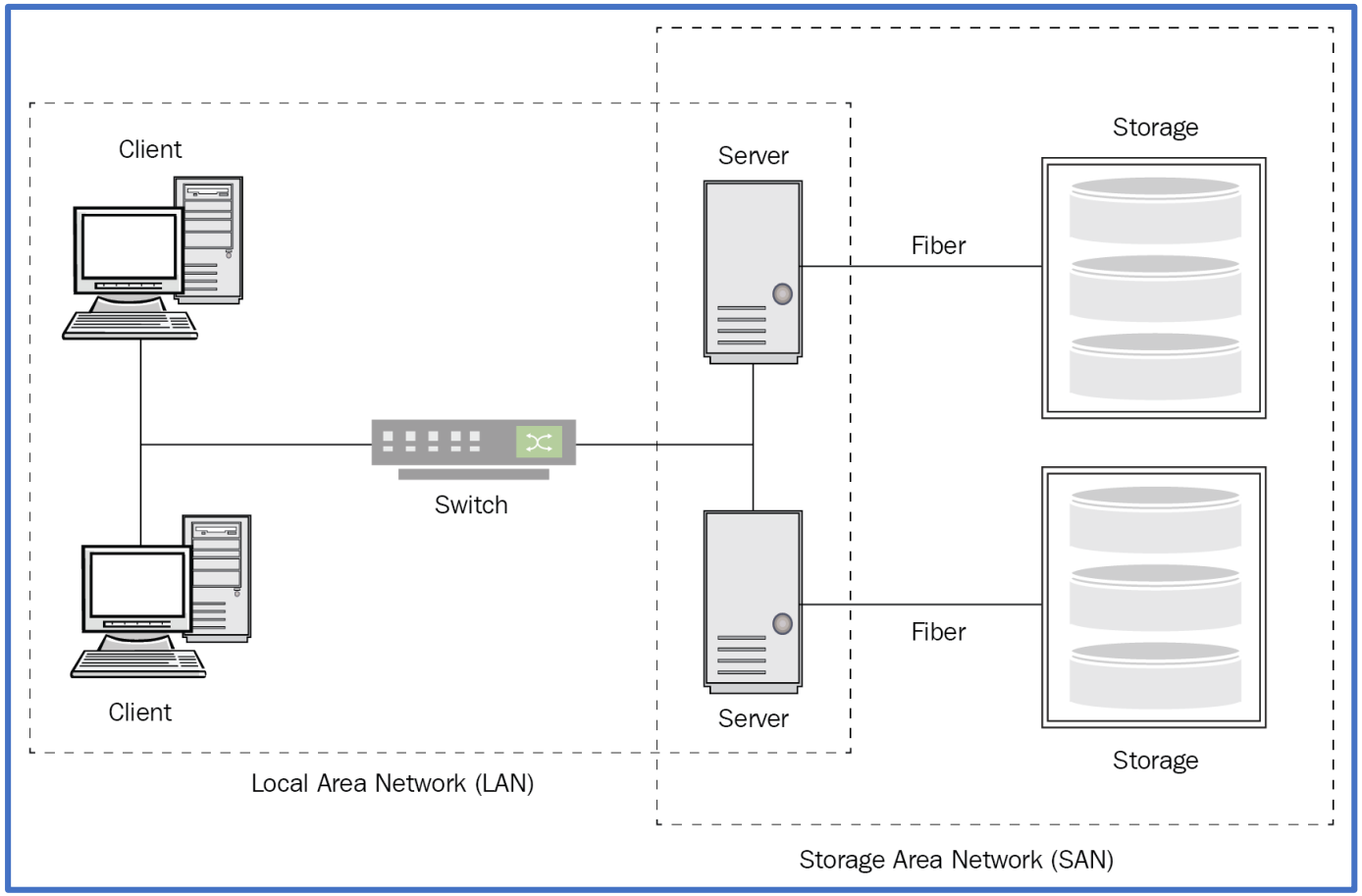
Computer network components

Network devices
- Clients
- Servers
- Host and nodes
- Network Interface cards
- Peripheral Devices
- Hub
- Switches
- Routers

Infrastructure components
- Firewalls
- Wireless Access Point
- Wireless Access controller

Transmission media

Network services and applications



Source: Computer network components, URL: https://subscription.packtpub.com/book/networking_and_servers/9781788621434/1/ch01lvl1sec13/computer-network-topologies

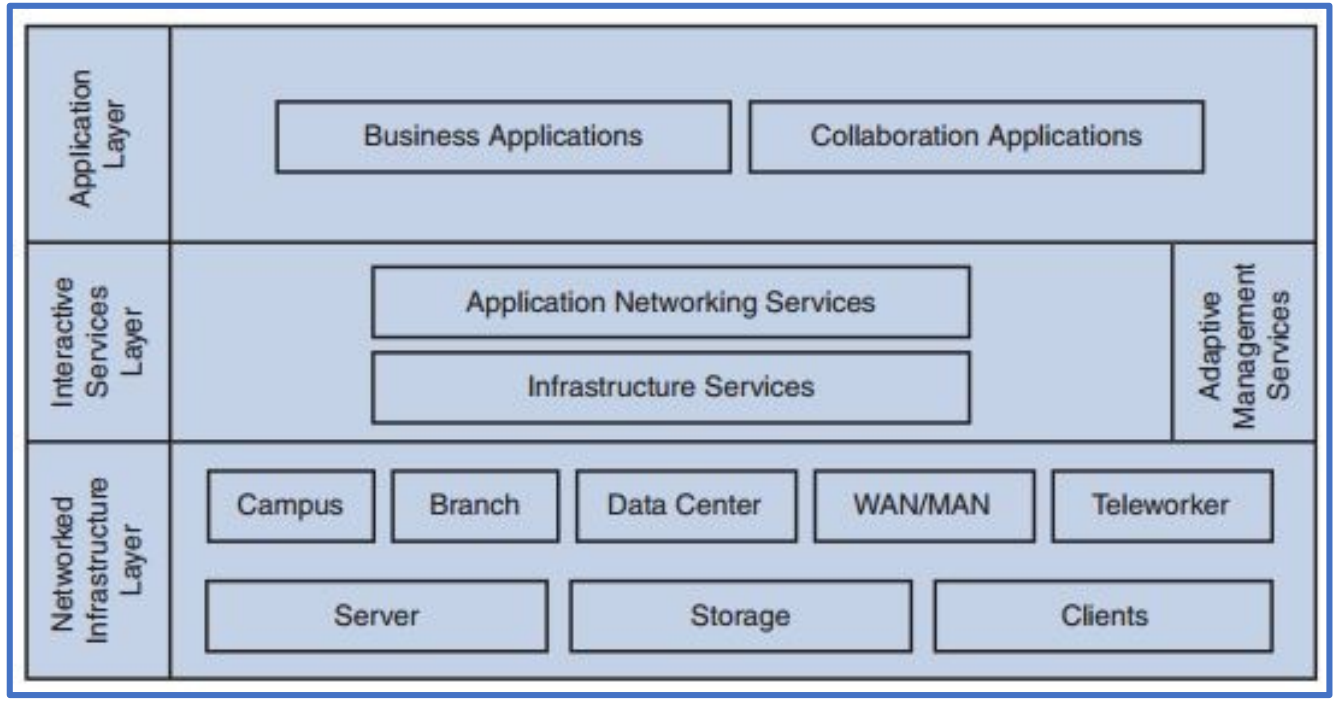
Computer network components

Transmission media

- **Metallic mediums**: copper wires in twisted pairs and coaxial cables transmit electrical impulses.
- **Glass mediums:** fiber optic cable transmit pulses of light
- **Air mediums:** waves and rays from the electromagnetic spectrum transmit signals in different frequencies

Network services and applications

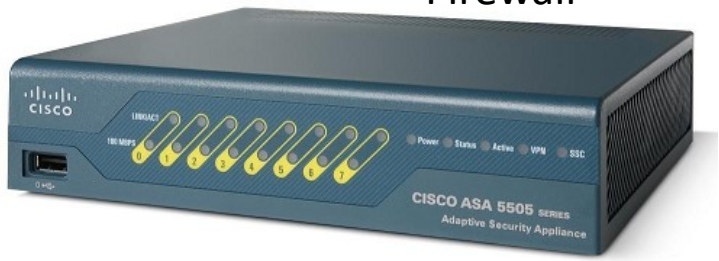
- **Integrated transport:** Voice, data, video and control are all converged onto a single transport.
- **Integrated services:** Such as VoIP or storage networking, rely on the underlying network transport mechanisms. Also, Web, Email, DNS, DBMS, FTP, SSH
- **Integrated applications:** ERP, CRM, MIS, DSS, EIS



Source: Cofig-router, CCDA Notes Strategic Network Design, URL: https://www.configrouter.com/ccda-notes-strategic-network-design-11646/

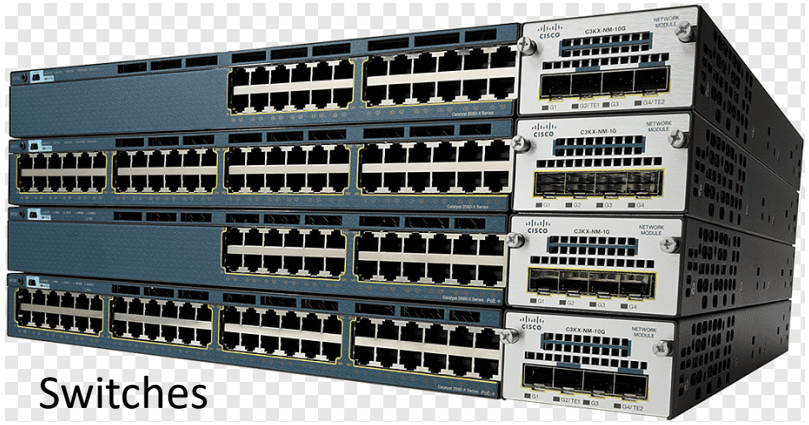
Network Devices

Firewall



Routers

NIC-PCI



Switches

NIC-PCMCIA

wiseGEEK

Different Types of Firewalls
in I.T and Computer Networks

Network Devices

- ❖Is the hardware that operates in a network.
- ❖A "network" device is a component that makes up the network infrastructure such as modems, routers and switches.
- ❖A "networked" device on the other hand refers to equipment that connects to a network, which includes computers, printers and most A/V gear (receivers, media hubs and servers, Blu-ray players, etc.), which operate in an Ethernet or Wi-Fi network or both.
- ❖Smartphones and tablets all have Wi-Fi but are considered "mobile devices.

Types of network devices

- ✓ Hub.
- ✓ Switch.
- ✓ Router.
- ✓ Bridge.
- ✓ Gateway.
- ✓ Modem.
- ✓ Repeater.
- ✓ Access Point.

Source: PC Magazine digital, URL: https://www.pcmag.com/encyclopedia/term/network-device

Network Devices

LANS are designed to:

- Operate within a limited geographic area
- Allow multi-access to high-bandwidth media
- Control the network privately under local administration
- Provide full-time connectivity to local services
- Connect physically adjacent devices

Using:


Router


Bridge


Hub


Ethernet Switch


Repeater

WANS are designed to:

- Operate over a large geographical area
- Allow access over serial interfaces operating at lower speeds
- Provide full-time and part-time connectivity
- Connect devices separated over wide, even global areas

Using:


Router


Communication Server


Modem CSU/DSU TA/NT1

Laboratory practice N ° 2

- **Topic:** Study of basic software applications for computer network management.
- **Goals**:
  - To motivate students' learning and critical thinking in the use of Web software for management of Communication Networks.
  - To differentiate the download and upload speed of its Internet connection.
  - To identify different types of tools that substitute the execution of commands via CMD.exe.
- **Test topology:**
  - Laptop or desktop computers.
  - Internet access connection.
  - Windows OS.
- **Theoretical framework:**
  - Transmission Speed, upload and download speed.
  - Computer networks management
  - Types of IP address.
- **Develop**
- **Conclusions**
- **Bibliographic references**

Speed test

Download speed refers to the **speed** at which your **internet** connection is able to retrieve data from the **internet**.

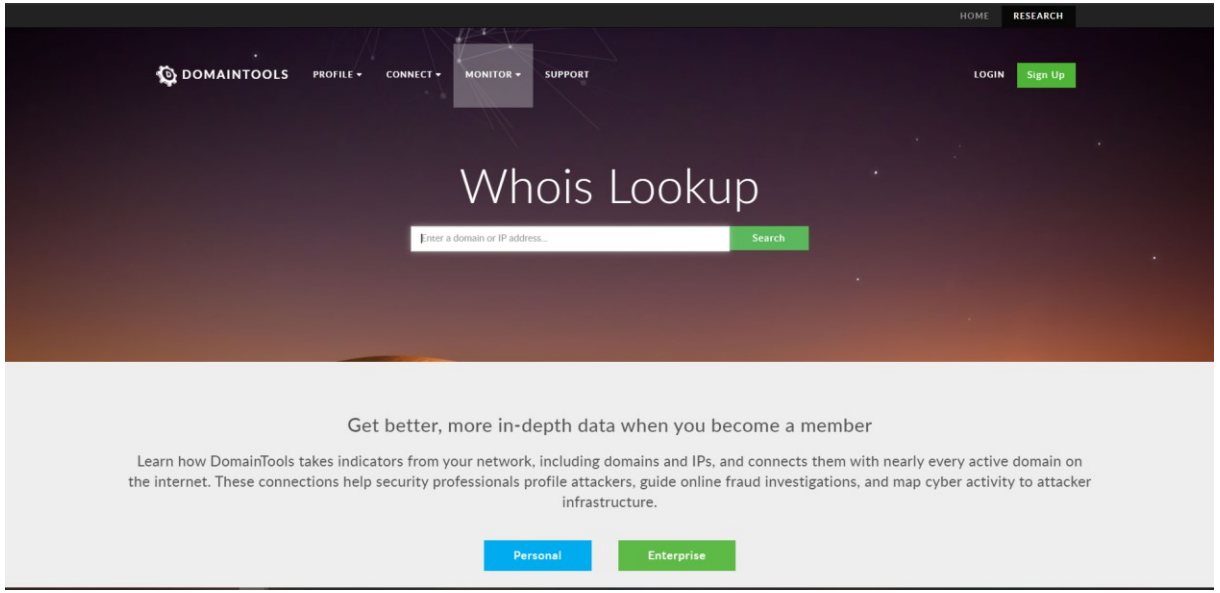
Upload **speed** refers to the **speed** that your **internet** connection can allow data to be sent from your devices to the **internet**.

A user is more likely to utilize **download speeds** than upload **speeds**

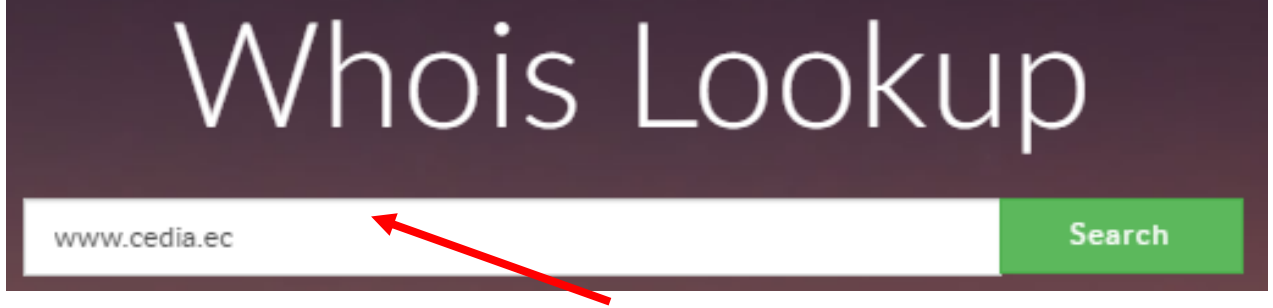
Who is Domain Tool:

https://whois.domaintools.com/

This tool is straightforward to use. It is necessary to know the domain or IP address. It allows you to indicate domains and connect them quickly and the cyber mapping that makes the connection.



It can see all the information about the servers' names, the IP addresses, location, and the current status.



Put the name of the domain in the search textbox.

DOMAINTOOLS PROFILE CONNECT MONITOR SUPPORT Whois Lookup

Whois Record for Cedia.ec

— Domain Profile

Registrar Status	taken
Name Servers	DNS.CEDIA.ORG.EC (has 57 domains) NS1.CEDIA.ORG.EC (has 57 domains)
Tech Contact	—
IP Address	190.15.132.105 - 2 other sites hosted on this server
IP Location	- Azuay - Cuenca - Universidad De Cuenca
ASN	AS61468 CEDIA, EC (registered Jul 25, 2014)

— Website

Website Title	500 Can t connect to 190.15.132.105:80 (connect: timeout)
Response Code	500

Whois Record (last updated on 2020-12-12)

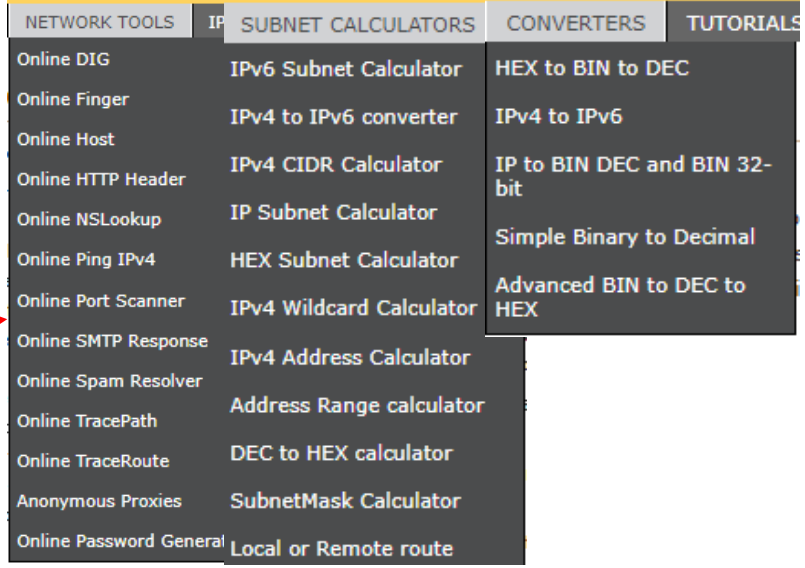
```
% NOTE: The registry for this domain name does not publish ownership
%       records (whois records) in the standard format.  This data
%       represents the most likely status of the domain based on
%       information provided by the Internet's domain name servers (DNS).

domain: cedia.ec
status: taken
nameserver: dns.cedia.org.ec
nameserver: ns1.cedia.org.ec

% For more information, please visit http://www.nic.ec
```

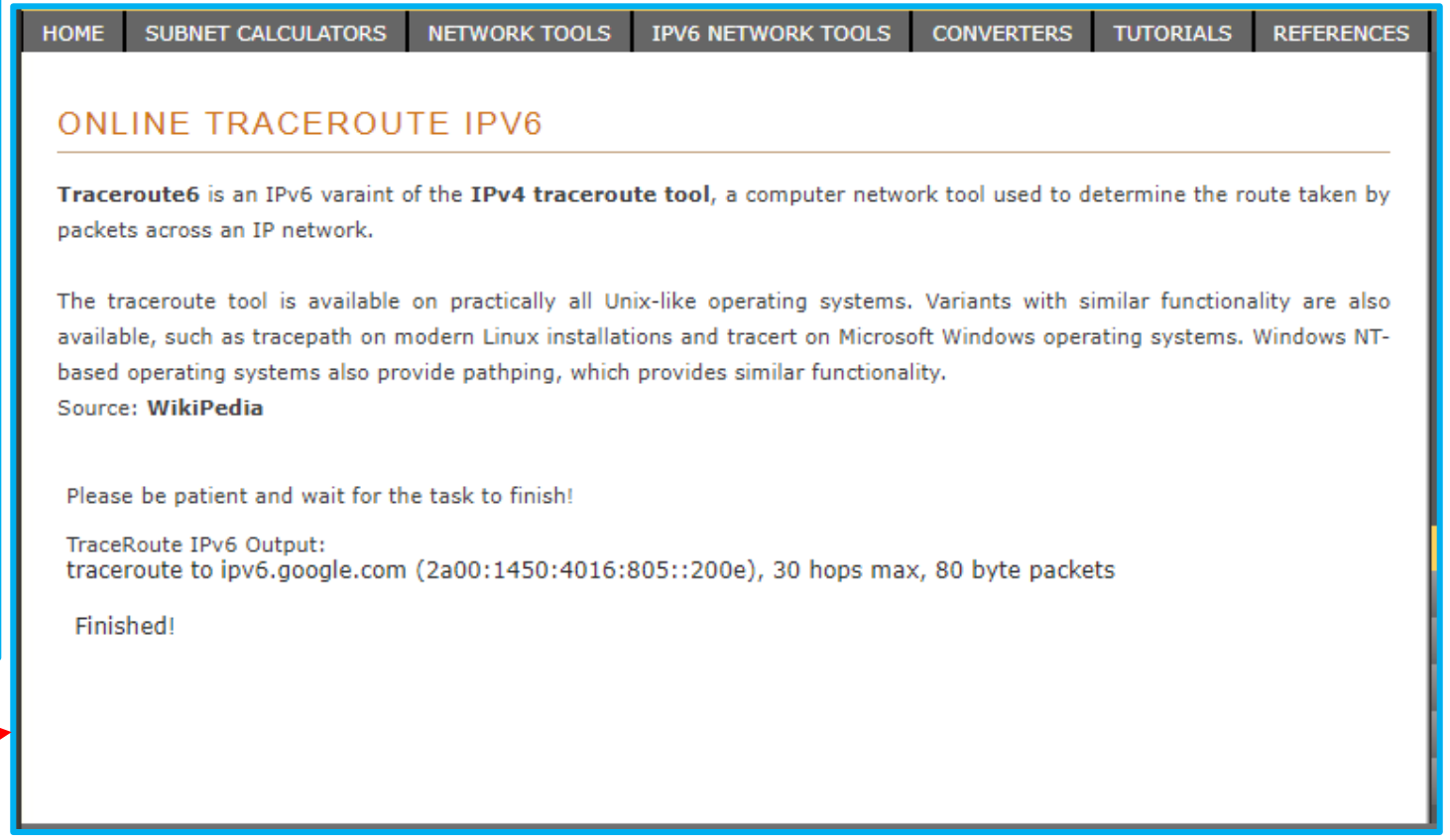
Subnetonline.com

It's an online IP subnet calculator and network tools collection. This site offers clean and straightforward online network tools, supporting IPv4 and IPv6.

Example:

Choose the tool that you want to use



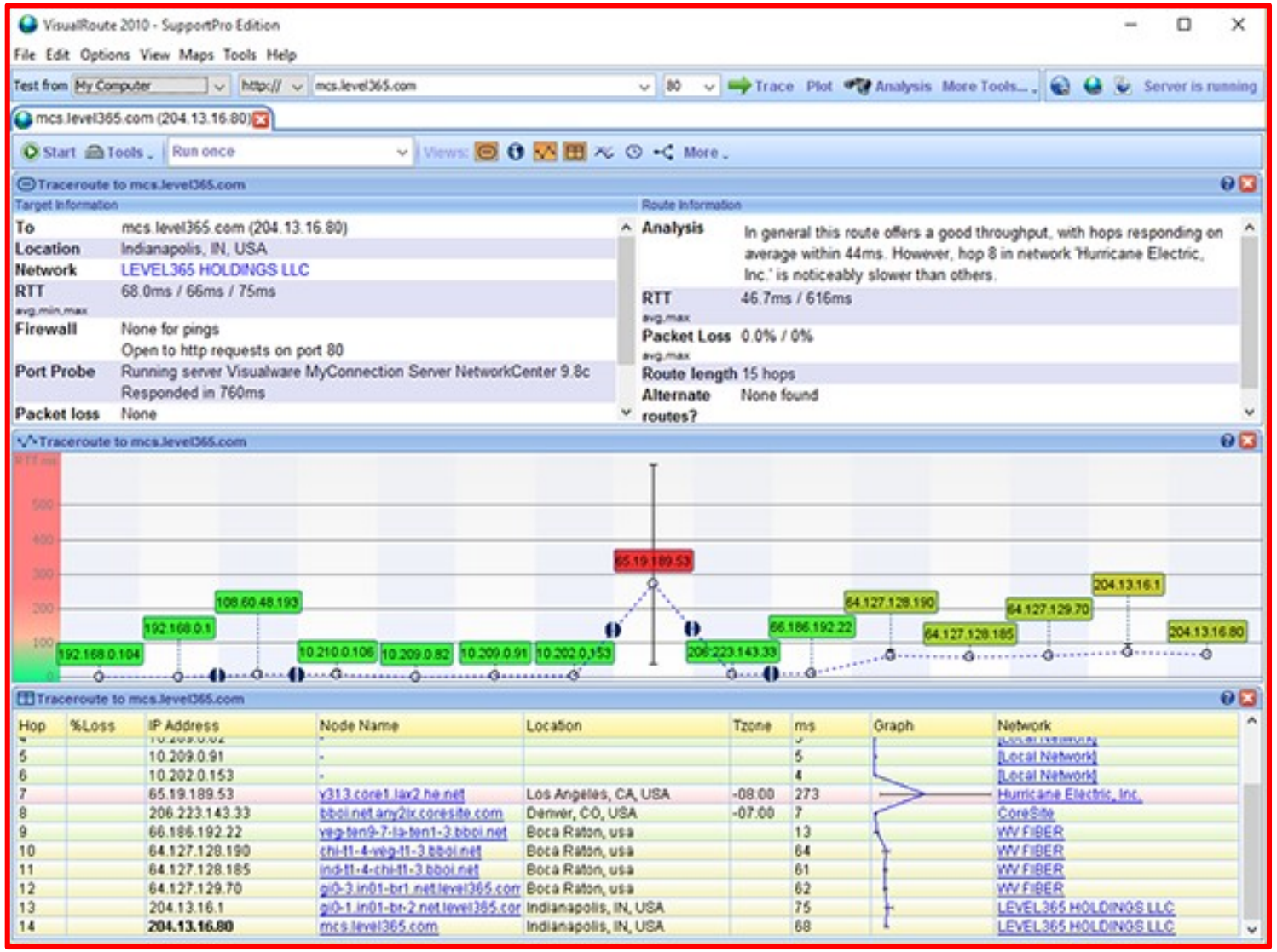


Visual Route.

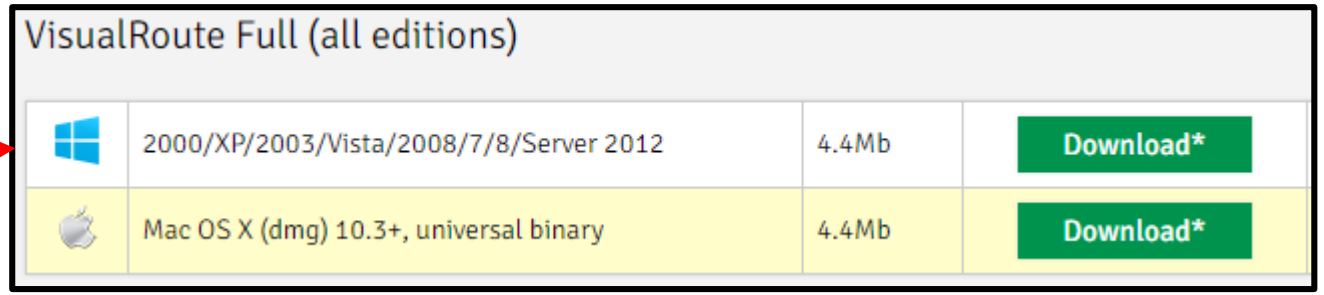
It offers a wide variety of network tools that help users keep one step ahead of network issues such as bottlenecks and packet loss/latency issues.

The tools include:

- *Continuous trace routing*
- *Reverse tracing*
- *Response time graphing*
- *Port Probing*
- *Network scanning*
- *Trace route history*
- *Side by side trace route comparison*
- *Route analysis (NetVu)*
- *Custom maps*
- *Remote access server*
- *Save traceroutes as text, image, or HTML*



It is necessary to download the version for your OS on the Web Page. Also, you have to install JAVA JM



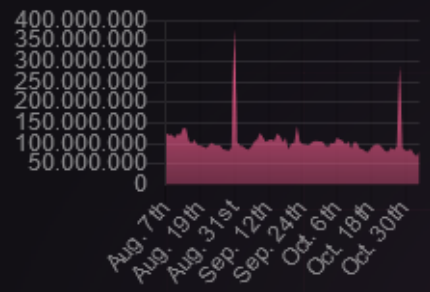
https://threatmap.checkpoint.com

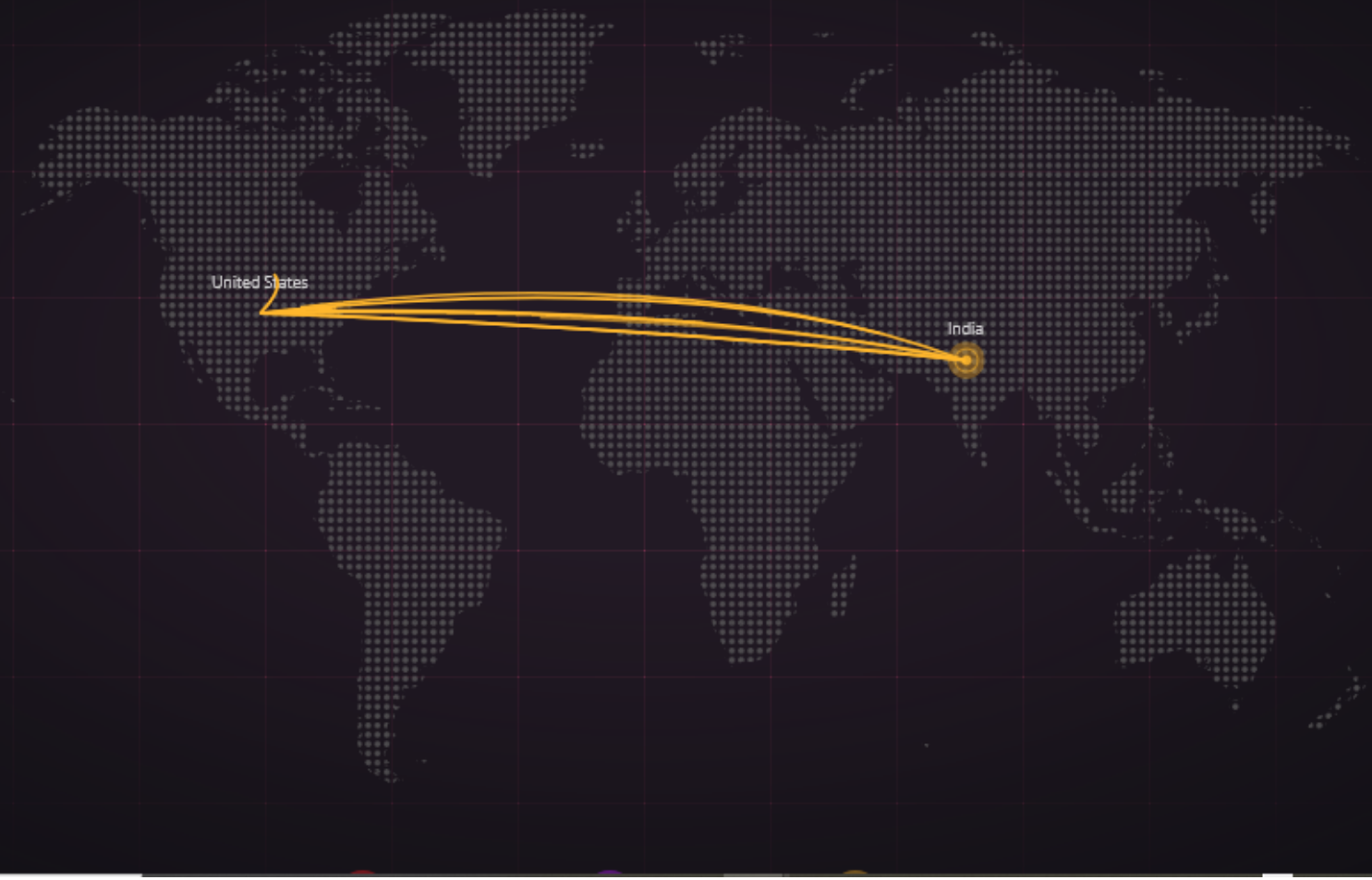
Check Point
SOFTWARE TECHNOLOGIES LTD.
THREATCLOUD

LIVE CYBER THREAT MAP

23.191.082 ATTACKS ON THIS DAY

RECENT DAILY ATTACKS





ATTACKS Current rate − 4 +

- Chrome Extension Download From T...
  08:46:34 United States → India
- Content Protection Violation
  08:46:33 United States → United States
- Chrome Extension Download From T...
  08:46:33 United States → India
- Chrome Extension Download From T...
  08:46:33 United States → India
- Chrome Extension Download From T...
  08:46:33 United States → India
- Chrome Extension Download From T...
  08:46:32 United States → India

TOP TARGETED COUNTRIES

Highest rate of attacks per organization in the last day.

- Nepal
- Mongolia
- Indonesia
- Georgia
- Nigeria

TOP TARGETED INDUSTRIES

Highest rate of attacks per organization in the last day.

- Education
- Government
- Communications

TOP MALWARE TYPES

Malware types with the highest global impact in the last day.

- Botnet

https://threatmap.fortiguard.com

FORTINET

SECURED BY FORTIGUARD.

Ecuador

Click for Details

ATTACK	SEVERITY	LOCATION
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	Netherlands
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	United States
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	Netherlands
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	United States
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	United States
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	United States
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	United States
Thunder.XPPlayer.FlvPlayerUrl.Handle.Buffer.Overflow	Medium	United States

https://cybermap.kaspersky.com

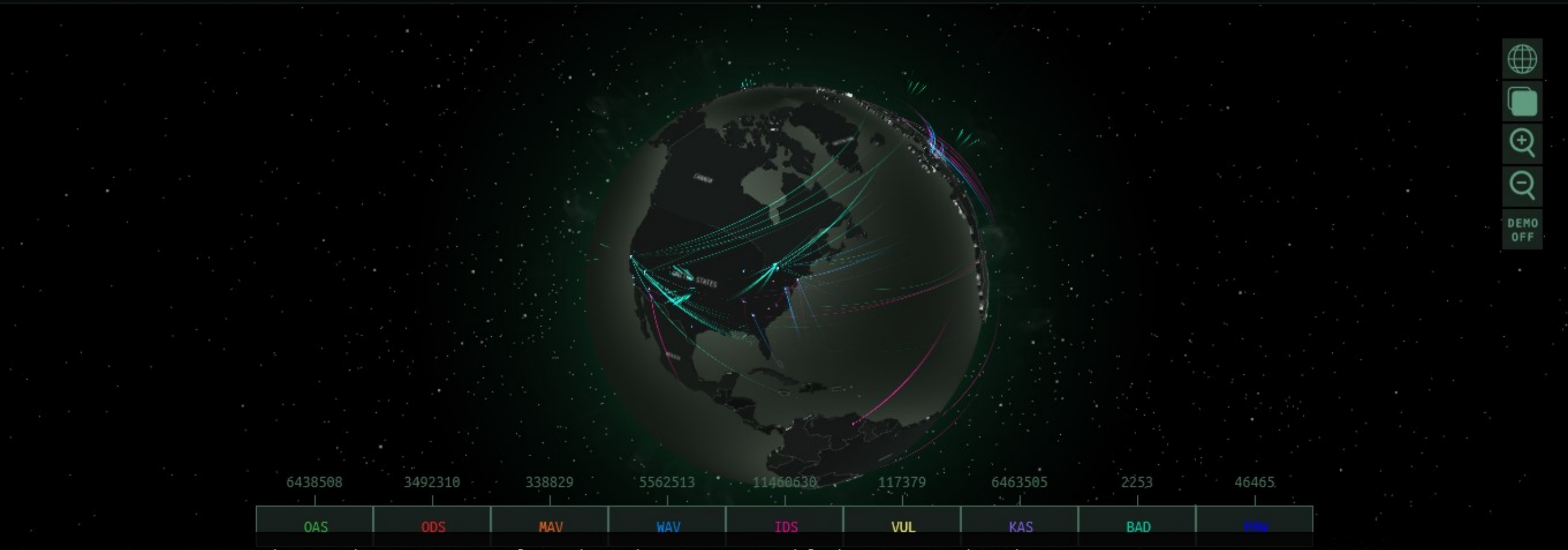
CYBERTHREAT REAL-TIME MAP

EN

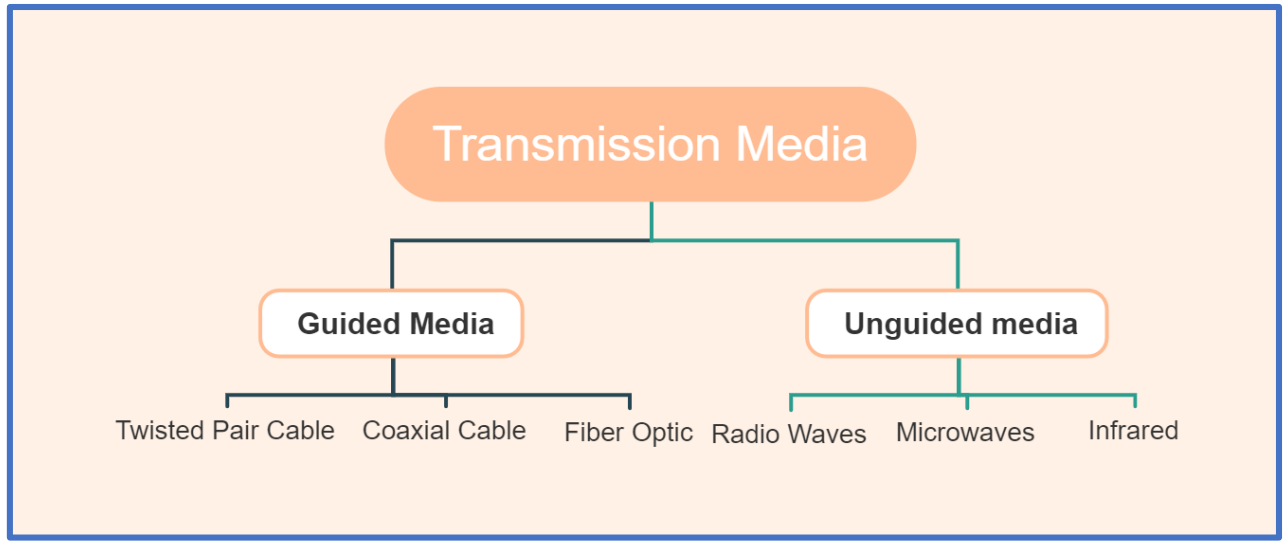
Protect Yourself

MAP STATISTICS DATA SOURCES BUZZ WIDGET

Share



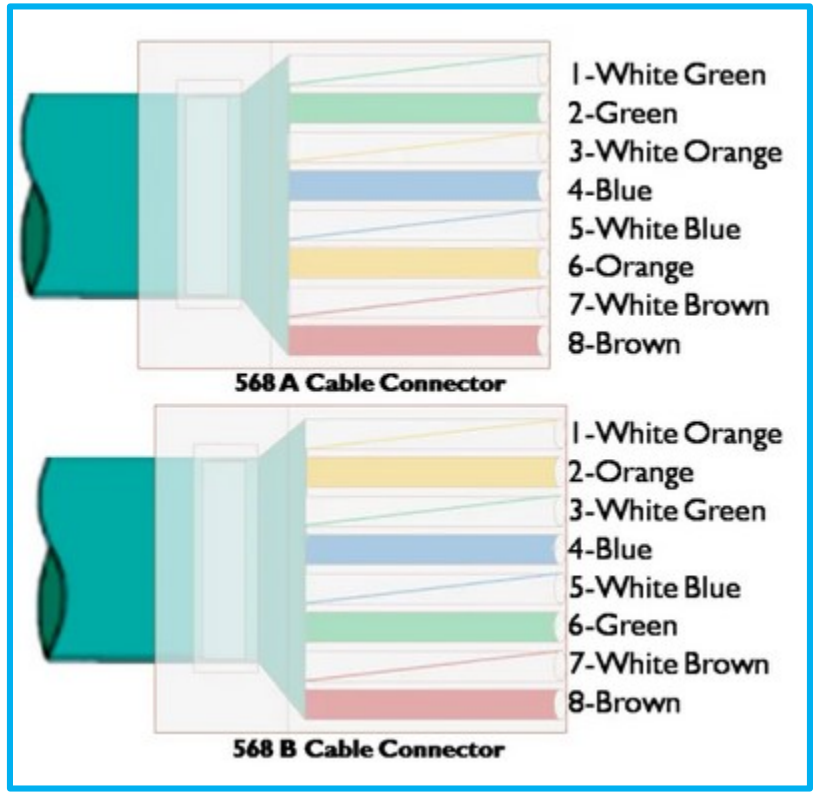
Classification of Transmission Media



- **Guided Media:** It is defined as the physical medium through which the signals are transmitted. It is also known as Bounded media. Types ff Guided media:
  - Twisted pair:
  - Coaxial Cable
  - Fiber Optic
- **Unguided Media:** An unguided transmission transmits the electromagnetic waves without using any physical medium. Therefore it is also known as **wireless transmission**. Unguided transmission is broadly classified into three categories:
  - Radio waves
  - Microwaves
  - Infrared

Source: JavaTPoint, What is Transmission media?. URL: https://www.javatpoint.com/transmission-media

Transmission Media - Guided



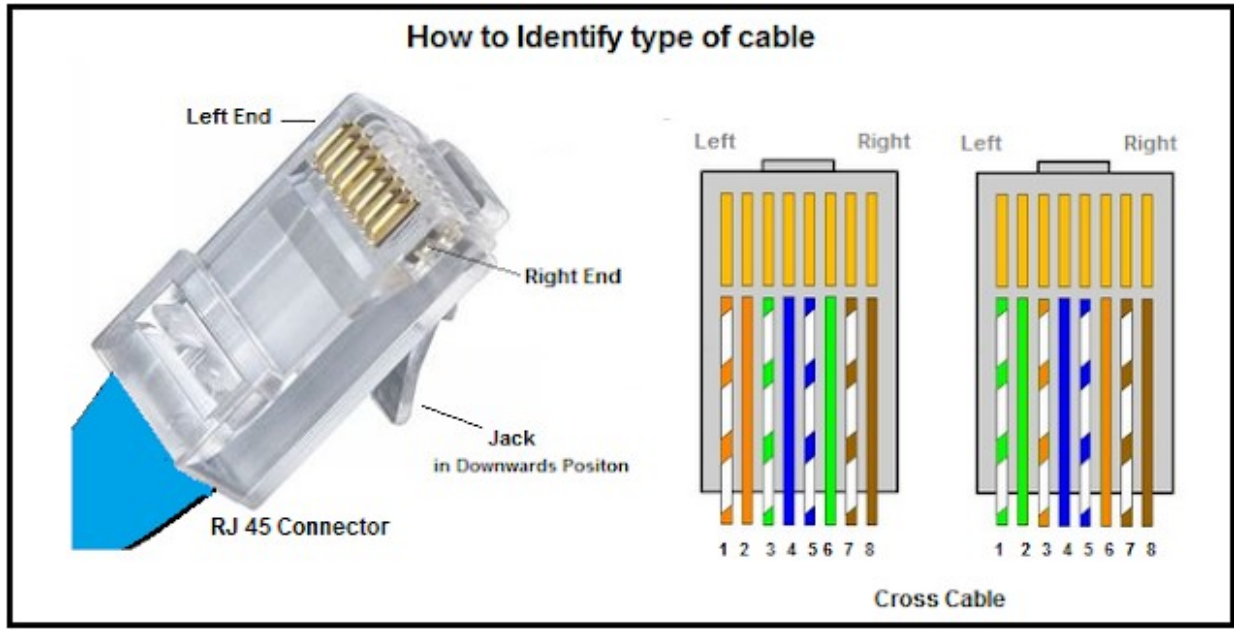
Source: Unshielded Twisted Pair (UTP) Cabling, URL: https://networkustad.com/2019/05/28/unshielded-twisted-pairutp-cabling/

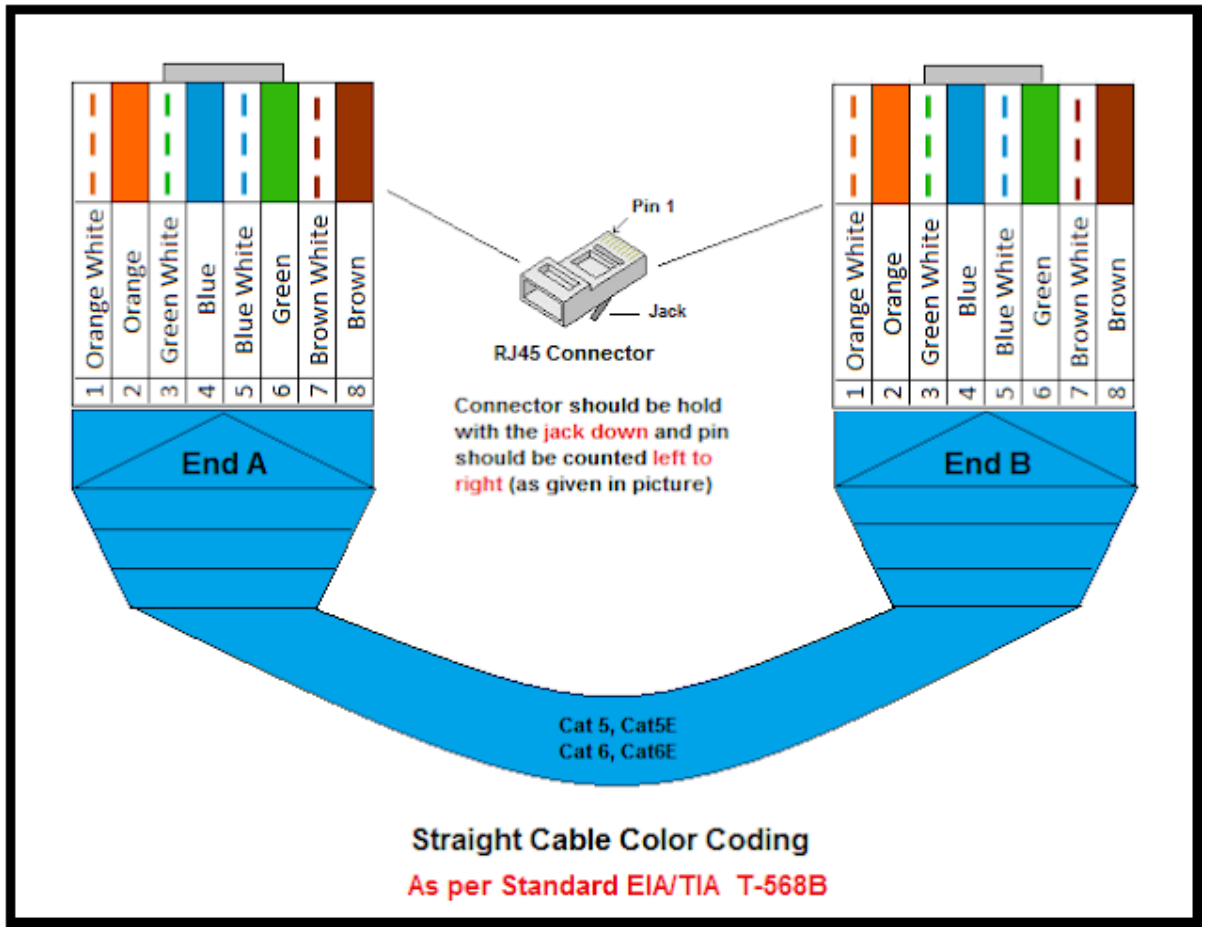
UTP Categories - Copper Cable

UTP Category	Data Rate	Max. Length	Cable Type	Application
CAT1	Up to 1Mbps	-	Twisted Pair	Old Telephone Cable
CAT2	Up to 4Mbps	-	Twisted Pair	Token Ring Networks
CAT3	Up to 10Mbps	100m	Twisted Pair	Token Rink & 10BASE-T Ethernet
CAT4	Up to 16Mbps	100m	Twisted Pair	Token Ring Networks
CAT5	Up to 100Mbps	100m	Twisted Pair	Ethernet, FastEthernet, Token Ring
CAT5e	Up to 1 Gbps	100m	Twisted Pair	Ethernet, FastEthernet, Gigabit Ethernet
CAT6	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT6a	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (55 meters)
CAT7	Up to 10Gbps	100m	Twisted Pair	GigabitEthernet, 10G Ethernet (100 meters)

Source: Transmision Media, URL: http://www.firewall.cx/networking-topics/cabling-utp-fibre/112-network-cabling-utp.html

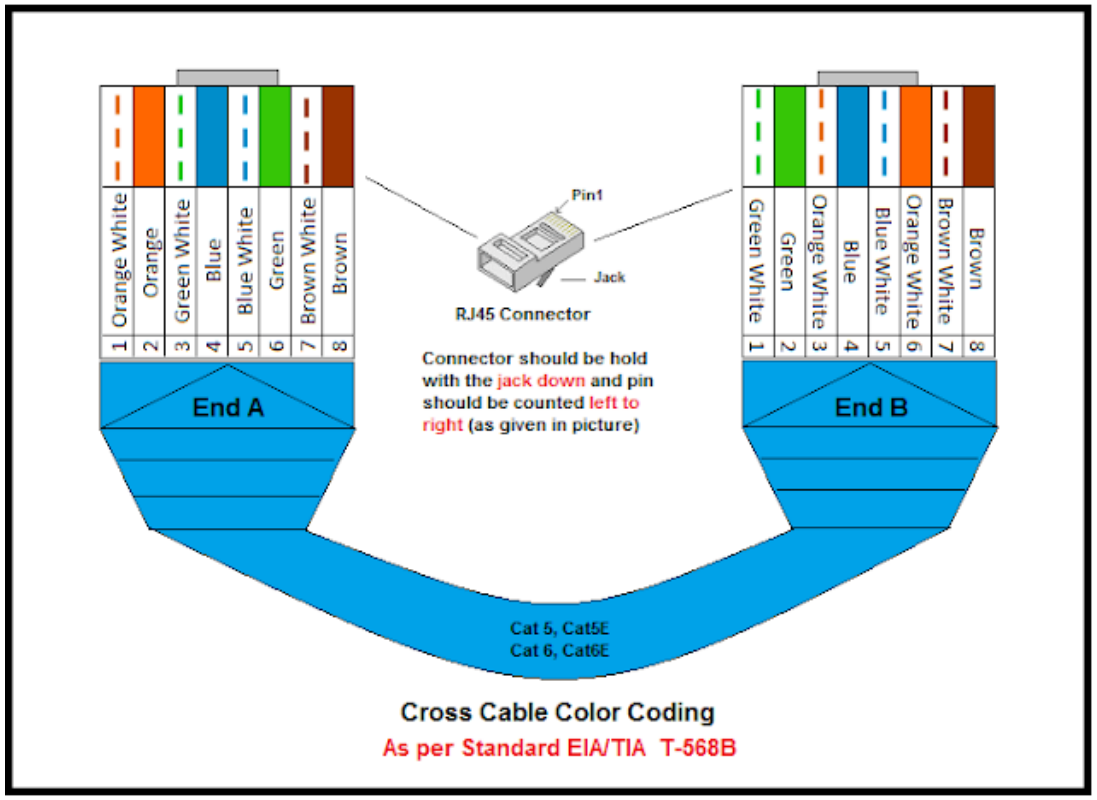
Transmission Media- - Guided

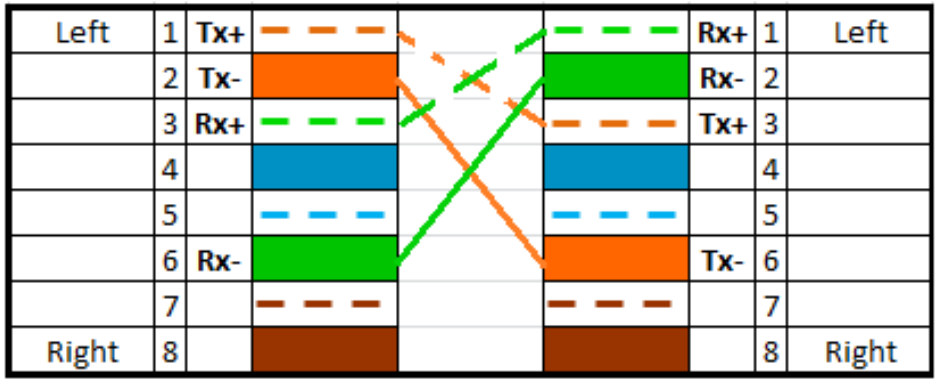




Source: Network urge: UTP Cable Color Coding, https://www.networkurge.com/2017/10/utp-cable-color-coding.html

Transmission Media - Guided



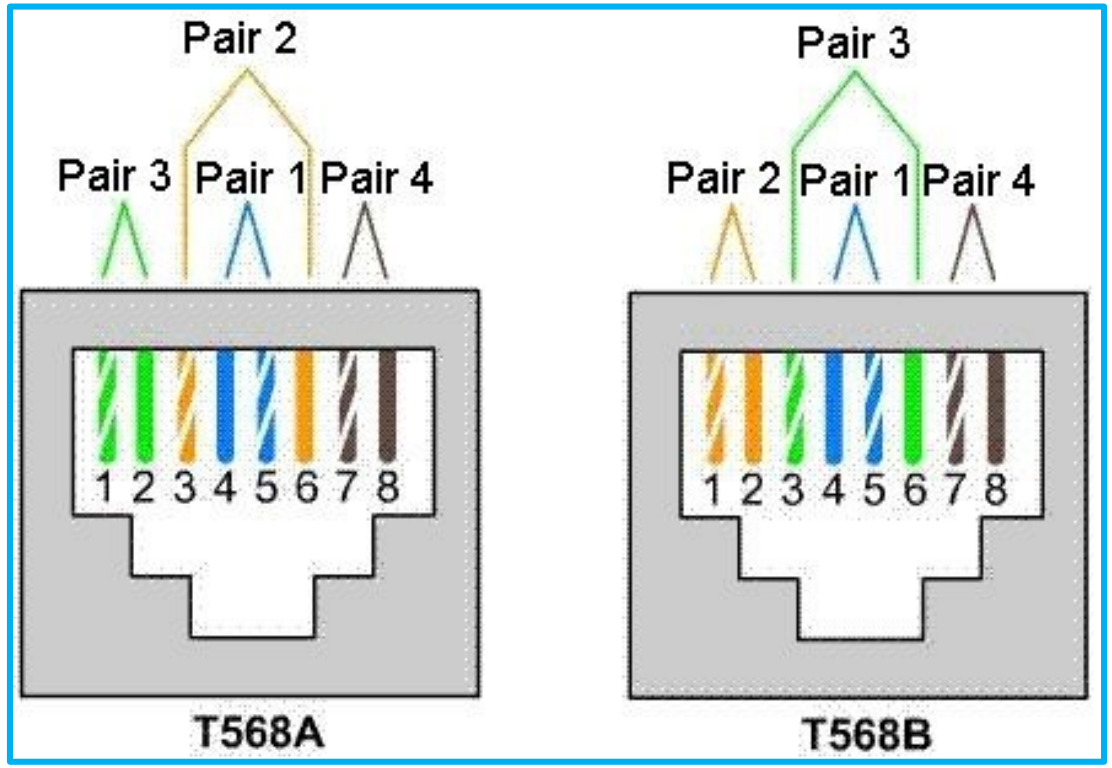


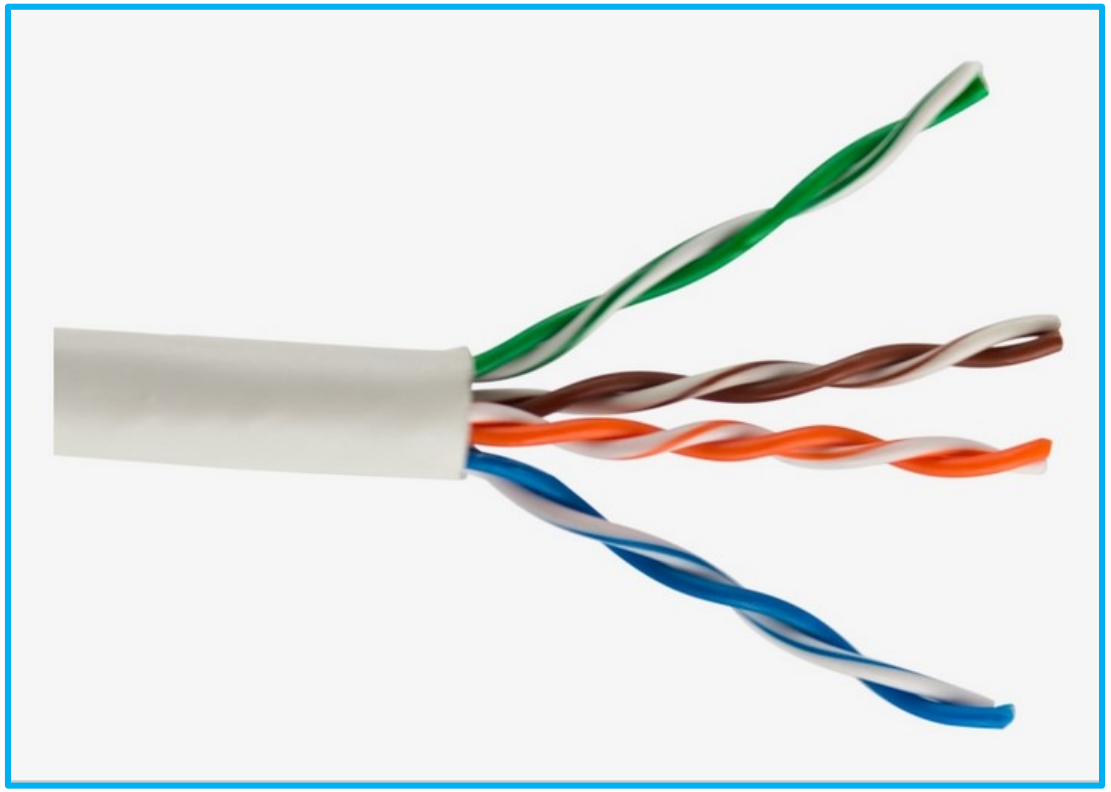
Cross Cable

Patch cord

Source: Network urge: UTP Cable Color Coding, https://www.networkurge.com/2017/10/utp-cable-color-coding.html

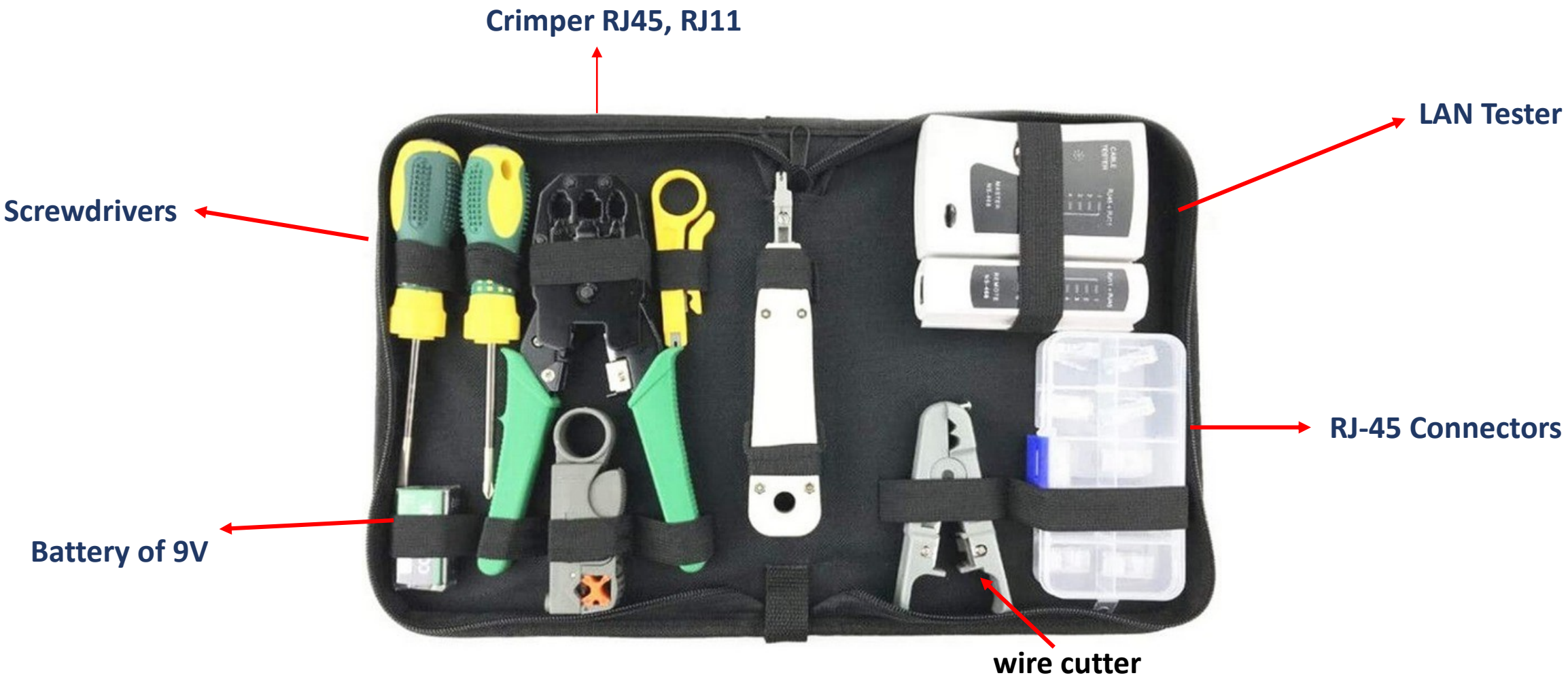
Transmission Media - Guided





Source: Network urge: UTP Cable Color Coding, https://www.networkurge.com/2017/10/utp-cable-color-coding.html

Cabling systems toolkit

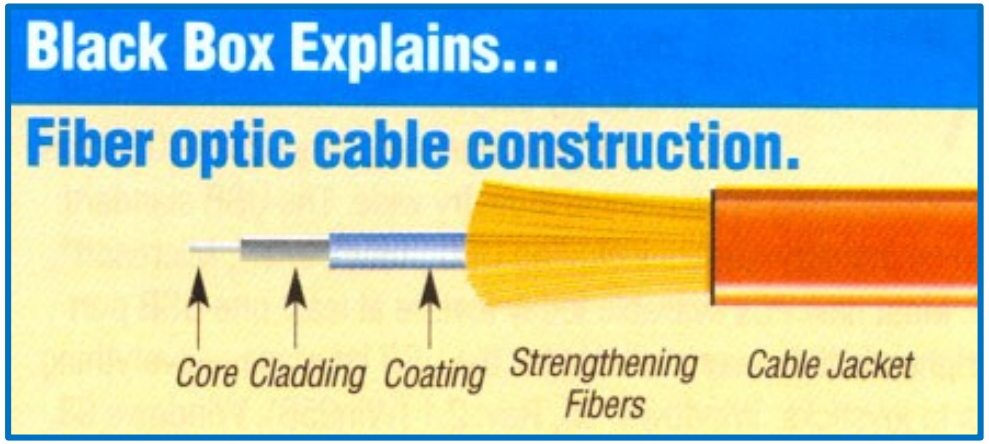


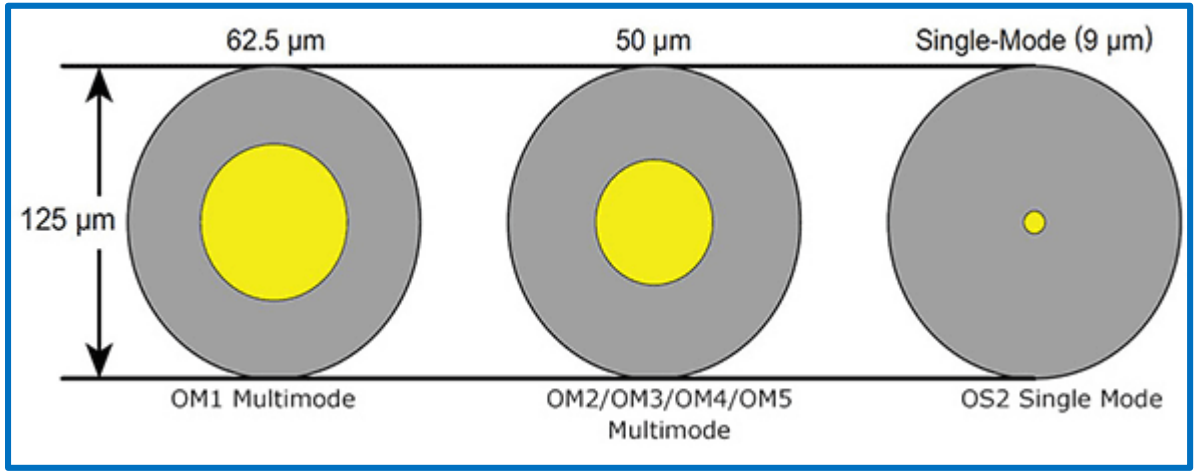
Laboratory practice N ° 3

- **Topic:** Manufacture of a pair-to-pair patch cord.
- **Goals**:
  - Identify the manufacturing process for an Ethernet patch cord
  - Identify the elements necessary for its manufacture.
  - Identify the twisted pair cable tool kit for construction.
- **Test topology:**
  - Laptop or desktop computers.
  - Internet access connection.
  - Windows OS/Linux.
  - Virtual Network Environment.
- **Theoretical framework:**
  - Structured Cabling Systems
  - UPT cabling
  - EIA/TIA 568
- **Develop**
- **Conclusions**
- **Bibliographic references**

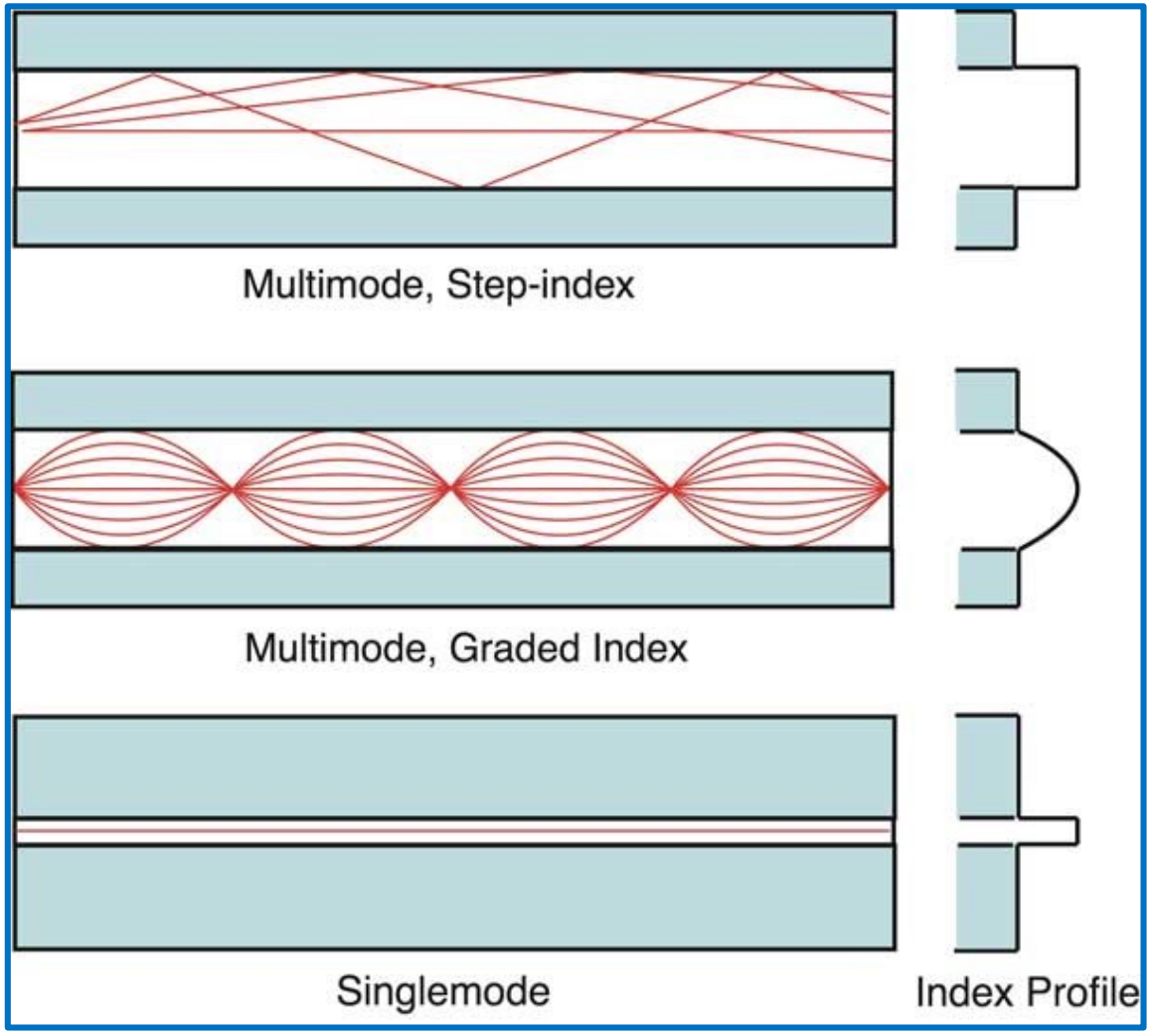
Single and Multimode Fiber Optic

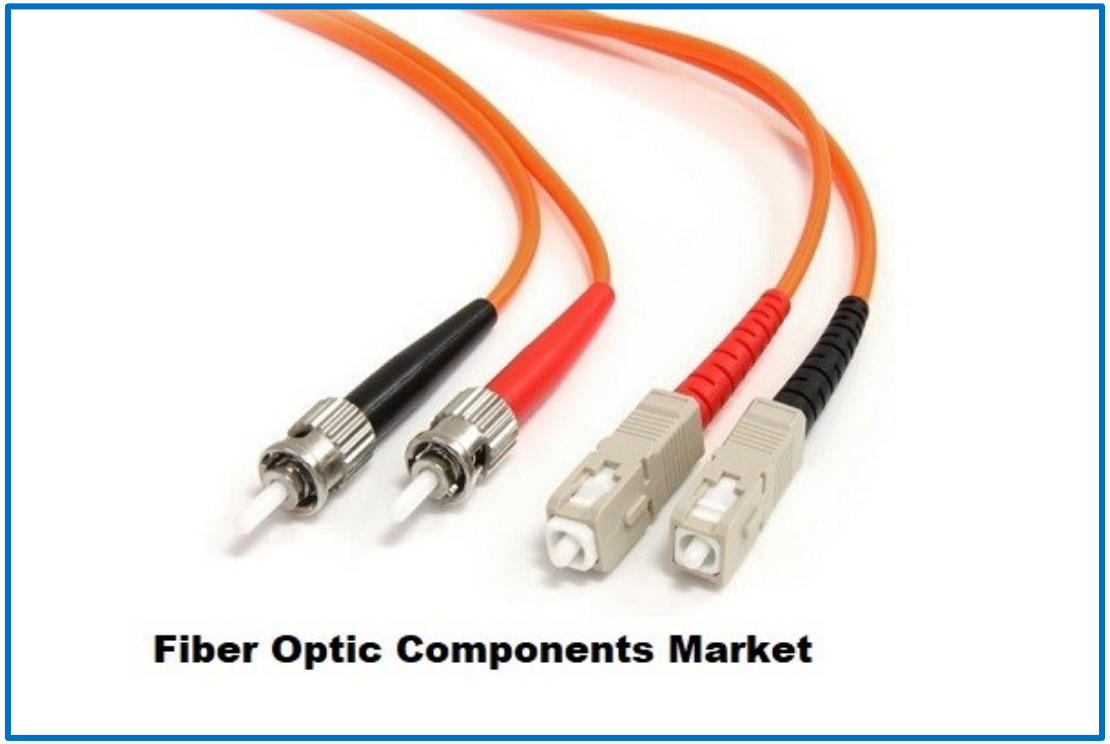
- **Fiber optics**, or optical fibers, are long, thin strands of carefully drawn glass about the diameter of a human hair using to transmit light signals over long distances. It is a transmission medium that is distinguished by the following parameters:
  - **speed:** Fiber optic networks operate at high speeds - up into the gigabits
  - **Bandwidth:** large carrying capacity;
  - **Distance:** Signals can be transmitted further without needing to be "refreshed" or strengthened;
  - **Resistance:** Greater resistance to electromagnetic noise such as radios, motors or other nearby cables;
  - **Maintenance:** Fiber optic cables costs much plus to maintain.





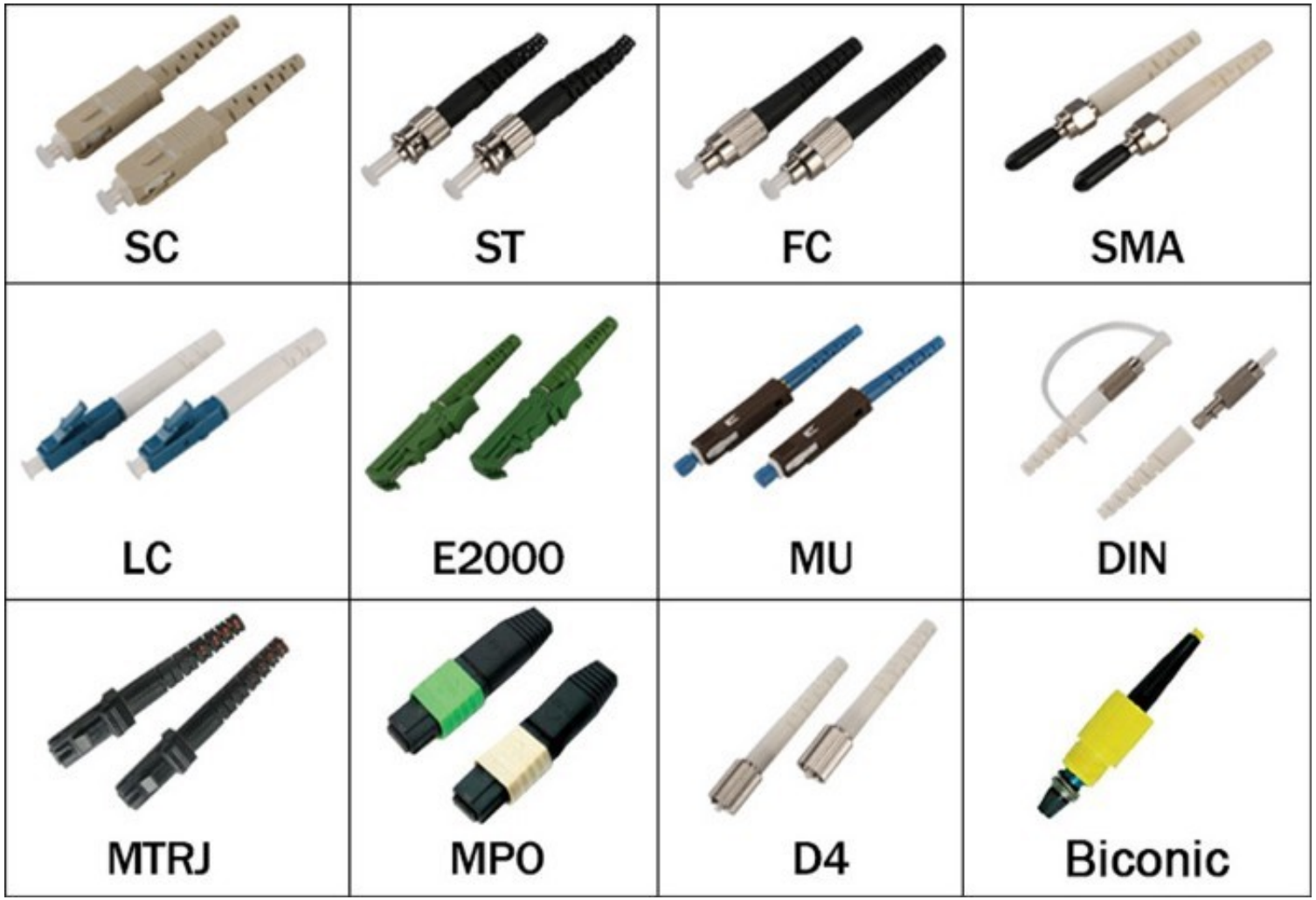
Single and Multimode Fiber





Source: FOA Reference Guide, Optical Fiber. URL: https://www.thefoa.org/tech/ref/basic/fiber.html

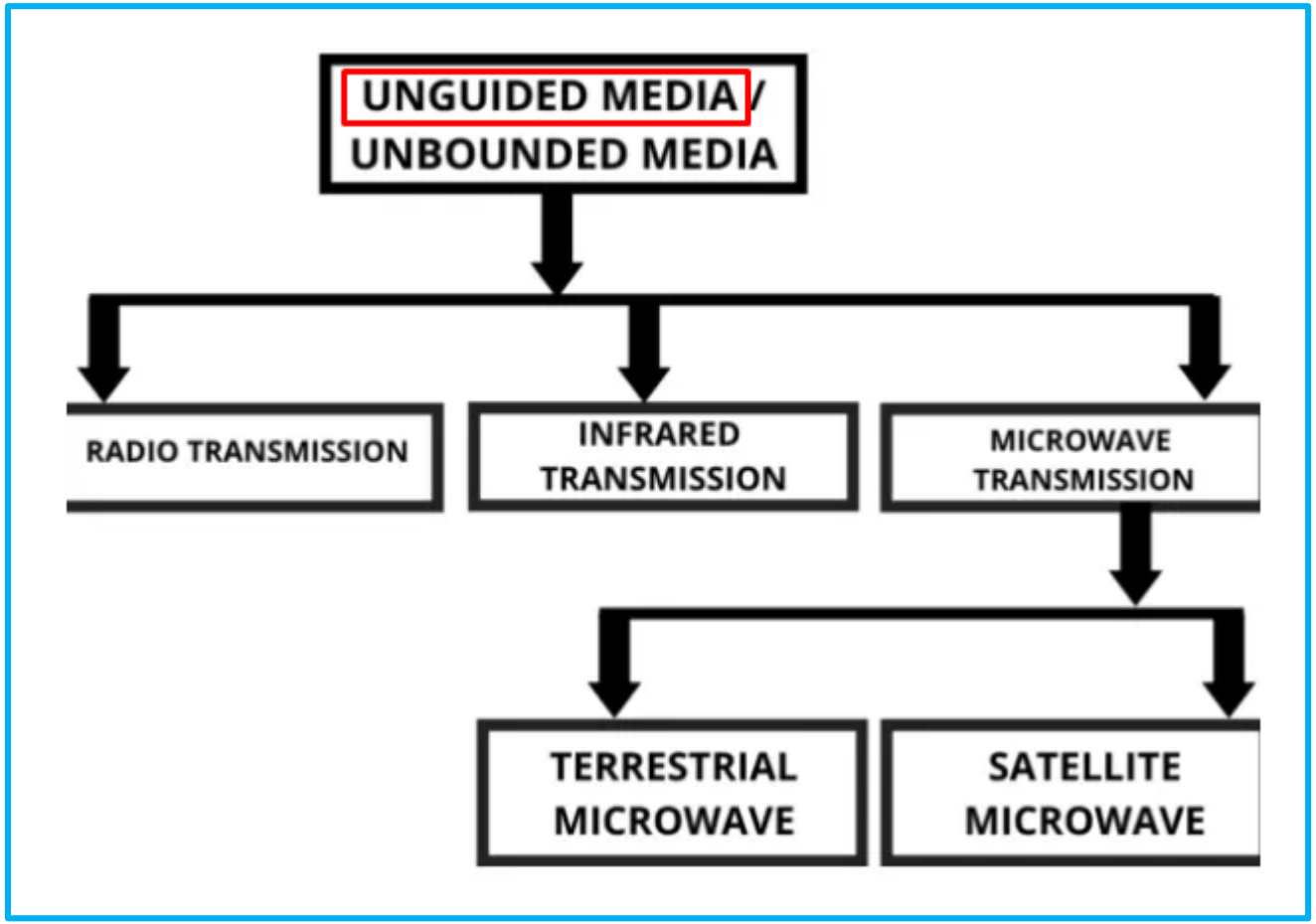
The optical fibre connector



- **SC**: Subscriber connector
- **ST:** Straight Tip connector
- **FC**: fibber-optic connector
- **SMA**: Sub Miniature A connector
- **LC:** Lucent Connector
- **MU:** Miniature unit
- **MTRJ:** Mechanical Transfer Registered Jack
- **MPO:** Multiple-Fiber Push-On/Pull-off

Source: Kounnra-Kounnra, The optical fiber connector, URL: https://medium.com/@konnra2000/the-optical-fiber-connector-cd376ba97a7c

Transmission Media - Unguided

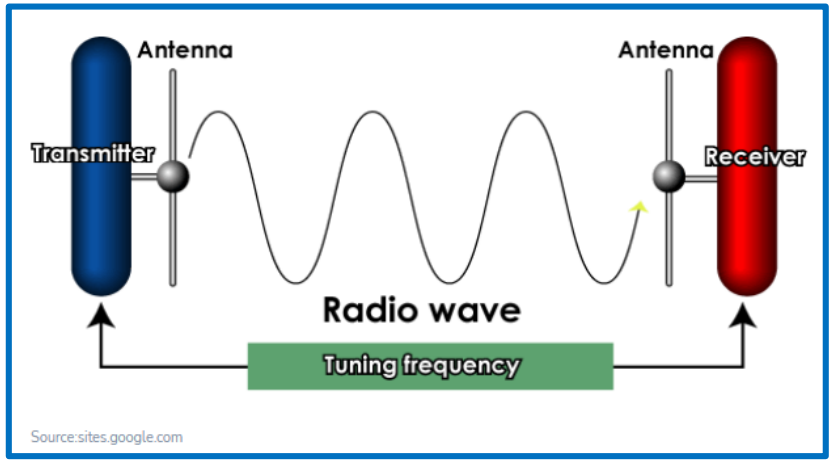


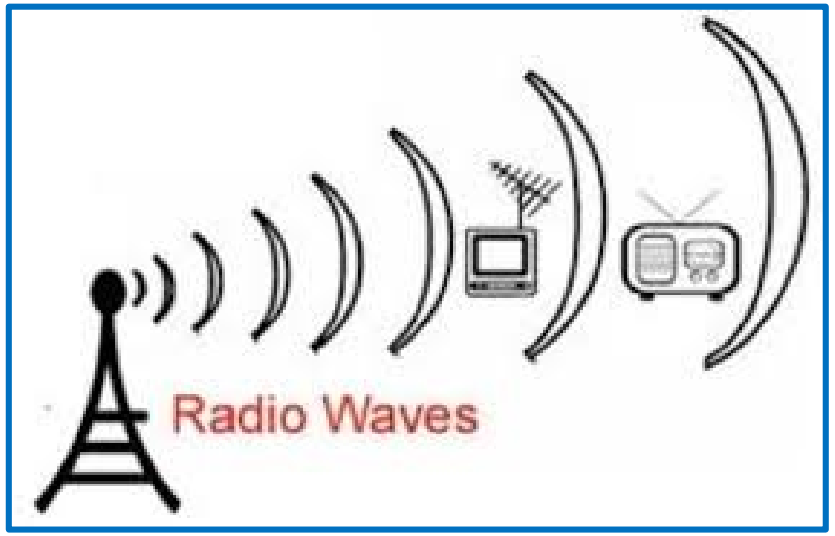
Source: Edifyclue https://edifyclue.in/unguided-media-in-computer-network/

Unguided media:

- It is also known as wireless communication.
- It does not require any physical medium to transmit any electromagnetic signals.
- Medium media transmits electromagnetic signals through the air to all.
- These signals are available to anyone who has a device capable of receiving those signals.
- It is also known as unbounded media and does not have any specific limits.
- All this allows the user to stay connected at all times.
- Because the communication done by it is wireless, due to which the user can connect himself anywhere on the network.
- It is also classified into three **radio waves, microwave, and infrared waves.**

Transmission Media – Unguided - 5G.





Source: EMF-Explained 2.0, 5G and Health - L2, URL: http://www.emfexplained.info/?ID=25914

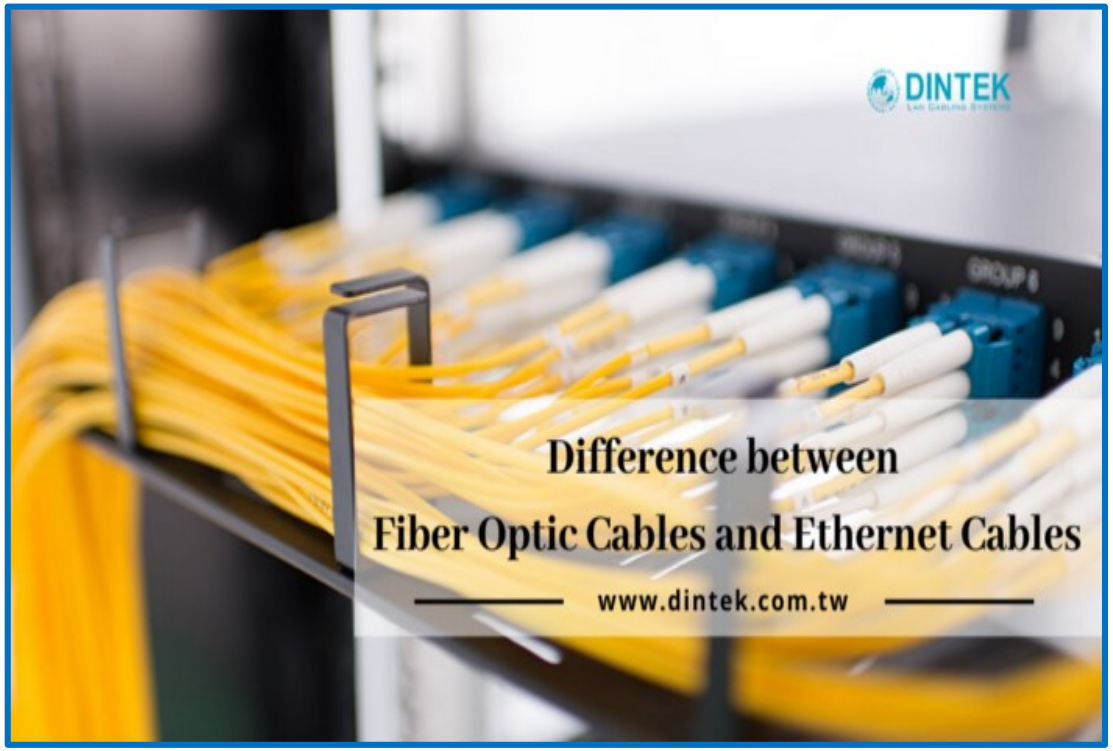
The Basics of Structured Cabling Systems

- A **structured cabling system** is a complete **system** of **cabling** and associated hardware, which provides a comprehensive telecommunications infrastructure. This infrastructure serves a wide range of uses, such as to provide telephone service or transmit data through a computer **network**.
- It is a cabling system that allows the transmission and reception of telecommunications signals, by the same transmission medium such as:
  - Voice,
  - Data,
  - Video, and
  - Control.
- There are three main cabling standards:
  - EIA/TIA 568A - This is the American standard and was the first to be published (1991).
  - ISO/IEC 11801 - The International standard for structured cabling systems.
  - CENELEC EN 50173 - The European cabling standard.

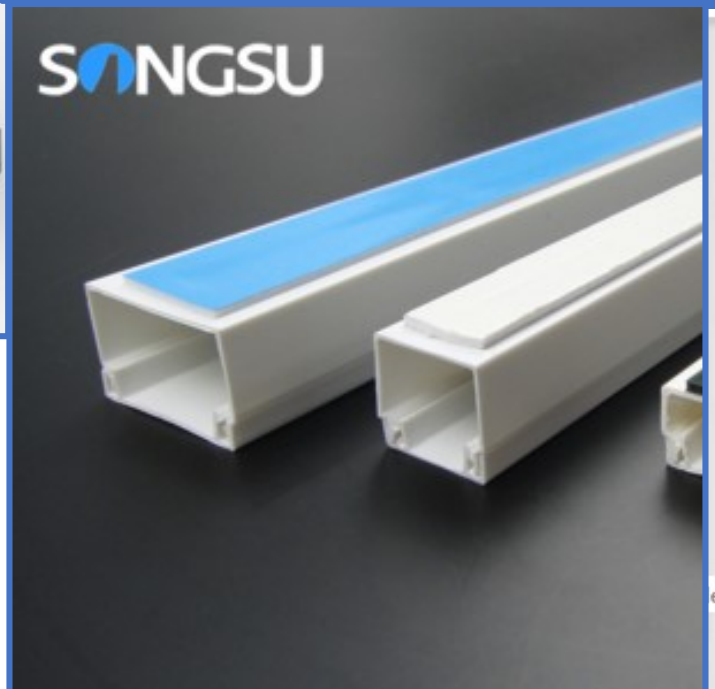
EIA/TIA-568

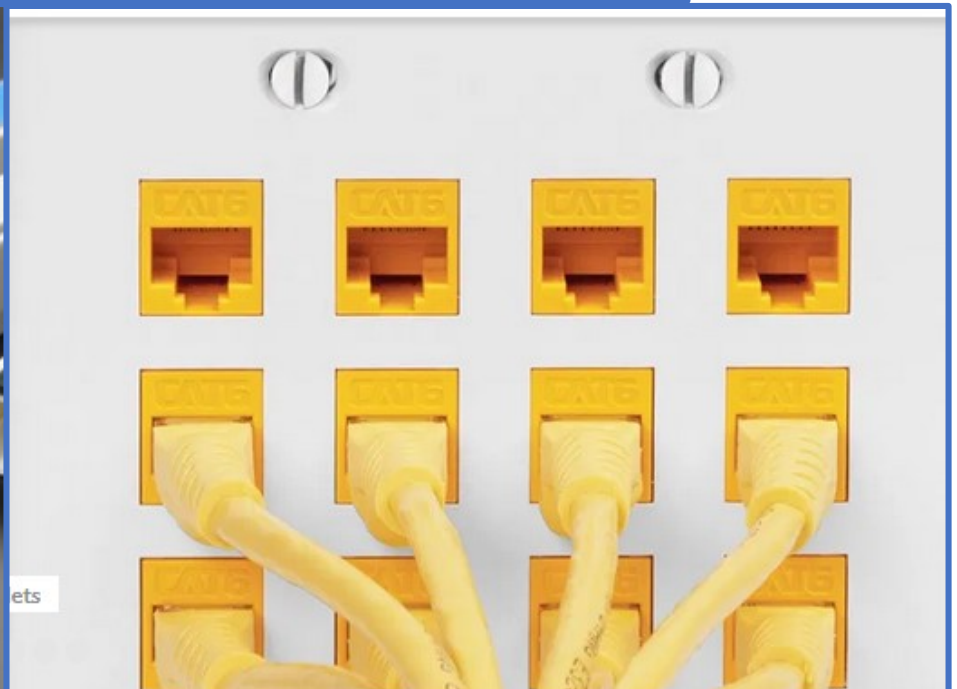
Specifically, structured cabling systems typically fall into six subsystems.

- **Entrance facilities.** This is where the telephone wiring or internet access provider connects to the business's network.
- **Equipment rooms.** Large networks have this environmentally controlled room that houses wiring equipment and consolidation points.
- **Backbone cabling.** These systems facilitate communications between the equipment rooms and entrance facilities.
- **Horizontal cabling.** This cabling connects telecommunications rooms to individual outlets and work areas on each floor.
- **Telecommunications rooms**. These connect between the backbone cabling and horizontal cabling.
- **Work-area components.** This hardware and cabling connects end-user equipment to outlets, dialing them into the network.



Source: DEITEK Electronics, Top Features of A Structured Cabling System, URL: https://medium.com/@dintekdci/top-features-of-a-structured-cabling-system-20ce0a54506c





Source: https://icc.com/

The Basics of Structured Cabling Systems

Las principales normas y estándares relacionados con el cableado estructurado y la instalación de redes de datos y telecomunicaciones en la actualidad son los siguientes:

- **ANSI/EIA/TIA-568**: estándar de cableado para telecomunicaciones en edificios comerciales. Establece los requisitos de los elementos de la red y los medios empleados para la transmisión. Es una norma definida para los EE. UU. pero, en la práctica, se ha asumido a nivel mundial.
- **ANSI/TIA/EIA-569**: estándar para espacios y canalizaciones de telecomunicaciones en edificios comerciales. Define la metodología de diseño y construcción en los edificios, y entre estos, para poder integrar en ellos una red de datos y telecomunicaciones.
- **ANSI/TIA/EIA-570:** estándar de cableado para telecomunicaciones en edificios residenciales y de pequeños comercios.
- **ANSI/TIA/EIA-606**: estándar de administración de la infraestructura de telecomunicaciones en edificios comerciales. Establece el estándar de rotulación del cableado, así como el registro y mantenimiento de la documentación de la red.
- **J-STD-607:** estándar de requisitos de conexión a tierra y conexión de telecomunicaciones en edificios comerciales. Especifica las características de la red de conexión a tierra, así como los sistemas empleados.
- **ANSI/TIA/EIA-942:** estándar de infraestructura de telecomunicaciones para centros de datos. Define las características de un centro de datos como un edificio o una parte de edificio dedicados a alojar salas de telecomunicaciones y de equipos de gran envergadura.

About

Networking Academy

Cisco Packet Tracer

An innovative and powerful networking simulation tool used for practice, discovery and troubleshooting

Integral to the Skills-to-Jobs Learning Experience

Version: 7.3.1.0362

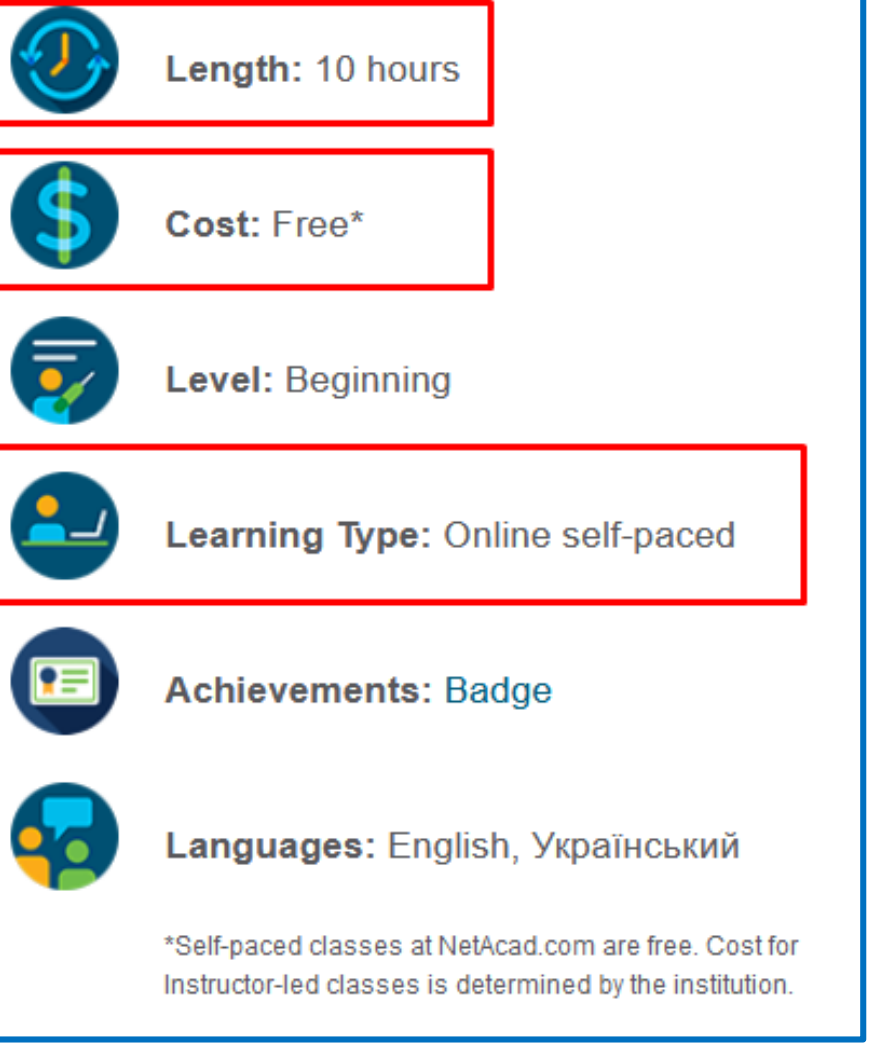
Using Packet Tracer

Networking Academy

Cisco Packet Tracer

An innovative and powerful networking simulation tool used for practice, discovery and troubleshooting

- Introduction to Packet Tracer
- Introduction to IoT
- IoT Fundamentals: Connecting Things
- IoT Fundamentals: IoT Security
- IT Essentials
- Networking Essentials
- CCNA: Introduction to Networks
- CCNA: Switching, Routing, and Wireless Essentials
- CCNA: Enterprise Networking, Security, and Automation
- CCNP Enterprise: Core Networking
- CCNP Enterprise: Advanced Routing
- Cybersecurity Essentials
- CyberOps Associate
- CCNA Security
- DevNet Associate



Introduction to Packet Tracer v1.1

Networking Academy

Cisco Packet Tracer

An innovative and powerful networking simulation tool used for practice, discovery and troubleshooting

Chapter 1: Introduction to Packet Tracer

Packet Tracer is an exciting network design, simulation and modelling tool that allows you to develop your skill set in networking, cybersecurity, and the Internet of Things (IoT). It allows you to model complex systems without the need for dedicated equipment. It is used across numerous Cisco Academy courses to help develop and assess the skill set necessary for successful completion of the course.

In this chapter, Packet Tracer is introduced and instructions are provided to allow you to download and install it.

For additional help and practice using Packet Tracer, please visit the **Tutorials** located under **Help** in the Packet Tracer program. To view some examples of how Packet Tracer can be used, select **File**, then **Open Samples** from the main menu.

Overview of Packet Tracer

Cisco Packet Tracer is an innovative network simulation and visualization tool. This free software helps you to practice your network configuration and troubleshooting skills via your desktop computer or an Android or iOS based mobile device. Packet Tracer is available for both the Linux and Windows desktop environments.

With Packet Tracer you can choose to build a network from scratch, use a pre-built sample network, or complete classroom lab assignments. Packet Tracer allows you to easily explore how data traverses your network. Packet Tracer provides an easy way to design and build networks of varying sizes without expensive lab equipment. While this software is not a replacement for practicing on physical routers, switches, firewalls, and servers, it provides too many benefits to ignore!

Download and Install Packet Tracer

Students commonly use Packet Tracer to:

- Prepare for a certification exam.
- Practice what they learn in networking courses.
- Sharpen their skills for a job interview.
- Examine the impact of adding new technologies into existing network designs.
- Build their skills for jobs in the Internet of Things.
- Compete in Global Design Challenges (take a look at the 2017 PT 7 Design Challenge on Facebook).

Packet Tracer is an essential learning tool used in many Cisco Networking Academy courses.

Chapter 2
The User Interface

Packet Tracer User Interface

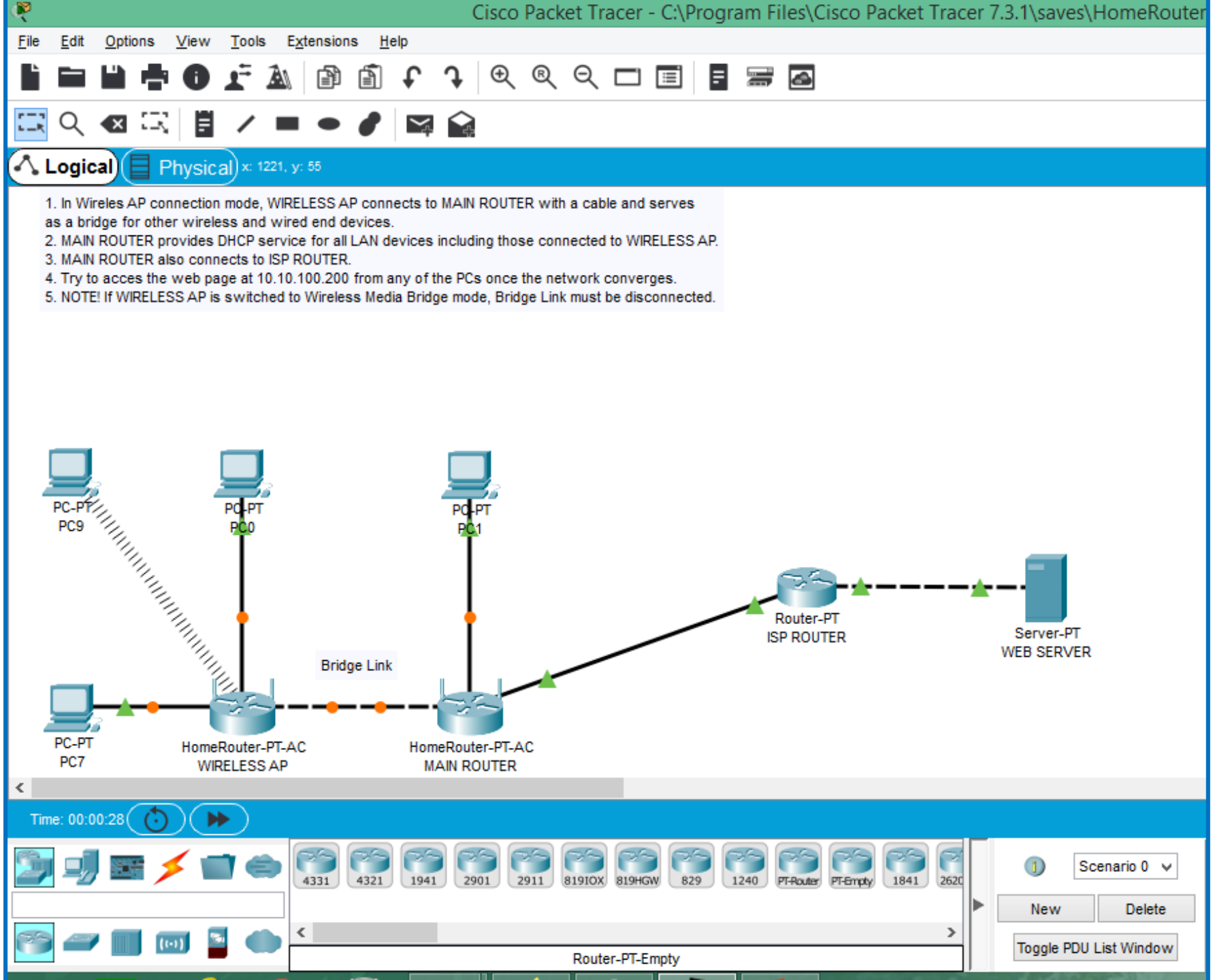
Packet Tracer is a tool that allows you to simulate real networks. It provides three main menus that allow you to:

- add devices and connect them via cables or wireless
- select, delete, inspect, label, and group components within your network
- manage your network

The network management menu allows you to:

- open an existing/sample network
- save your current network
- modify your user profile or your preferences

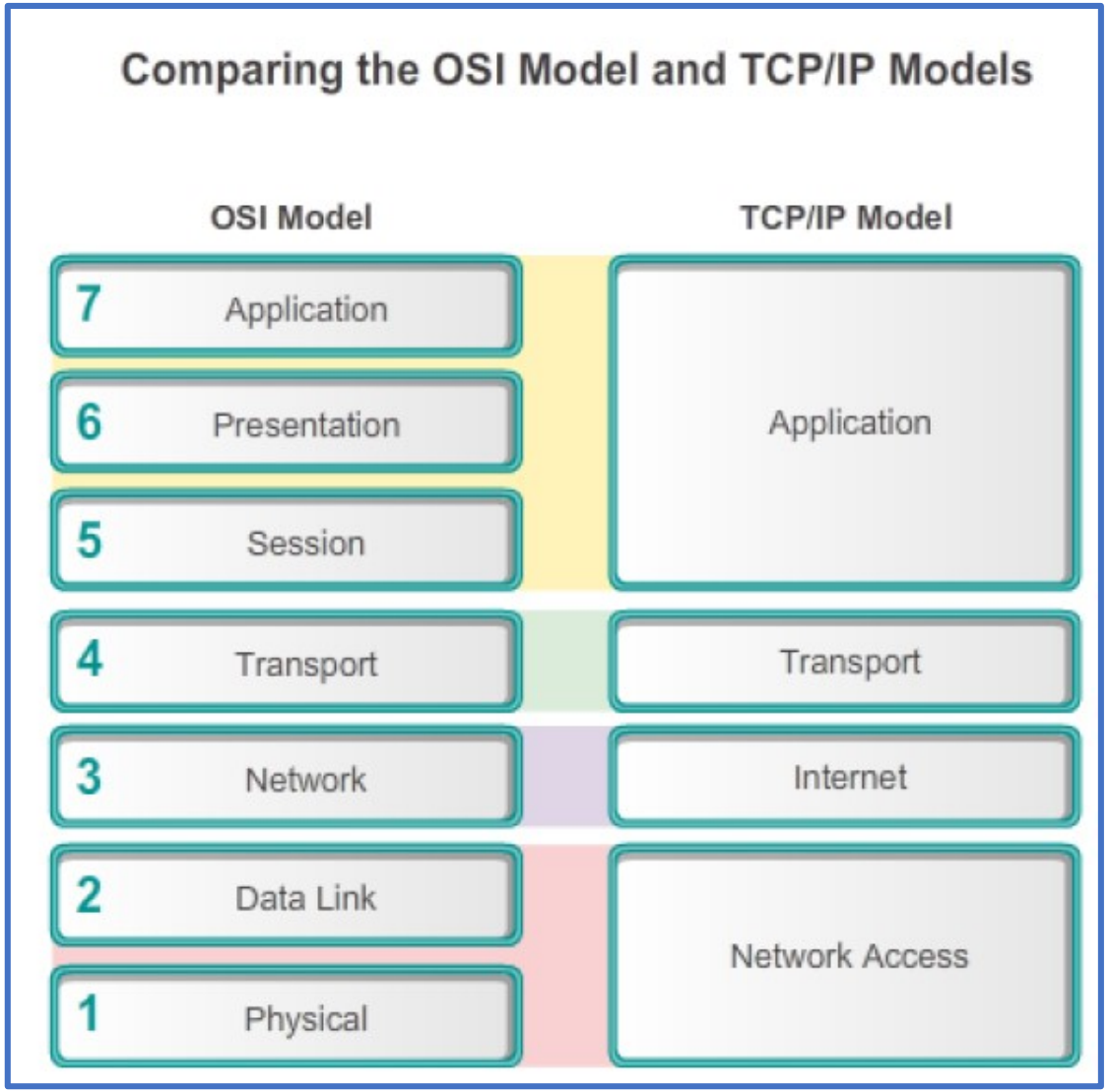
Click Play in the video to learn how to use the menus and how to create your first Packet Tracer network.



Laboratory practice N ° 4

- **Topic:** CISCO Networking Academy packet tracer installation.
- **Goals**:
  - Learn about the Packet tracer installation process.
  - Install Packet Tracert on the client
  - Make the free Introduction to Packet Tracert course, available at the Cisco Regional Academy..
- **Test topology:**
  - Laptop or desktop computers.
  - Internet access connection.
  - Windows OS/Linux.
  - Virtual Network Environment.
- **Theoretical framework:**
  - Network simulators
  - Computer networks
- **Develop**
- **Conclusions**
- **Bibliographic references**

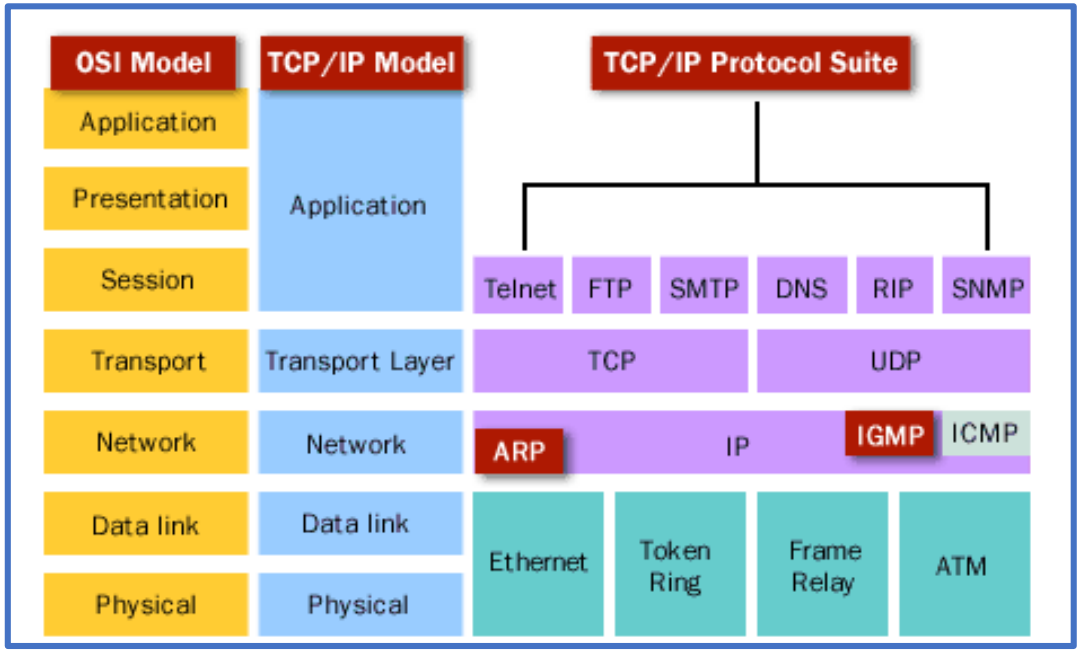
Network Interconnection



The OSI Model (Open Systems Interconnection Model) is a conceptual framework used to describe the functions of a networking system. The OSI model characterizes computing functions into a universal set of rules and requirements in order to support interoperability between different products and software. In the OSI reference model, the communications between a computing system are split into seven different abstraction layers: Physical, Data Link, Network, Transport, Session, Presentation, and Application

TCP/IP, or the Transmission Control Protocol/Internet Protocol, is a suite of communication protocols used to interconnect network devices on the Internet. TCP/IP can also be used as a communications protocol in a private computer network (an intranet or an extranet). TCP/IP specifies how data is exchanged over the Internet by providing end-to-end communications that identify how it should be broken into packets, addressed, transmitted, routed and received at the destination.

TCP/IP Model

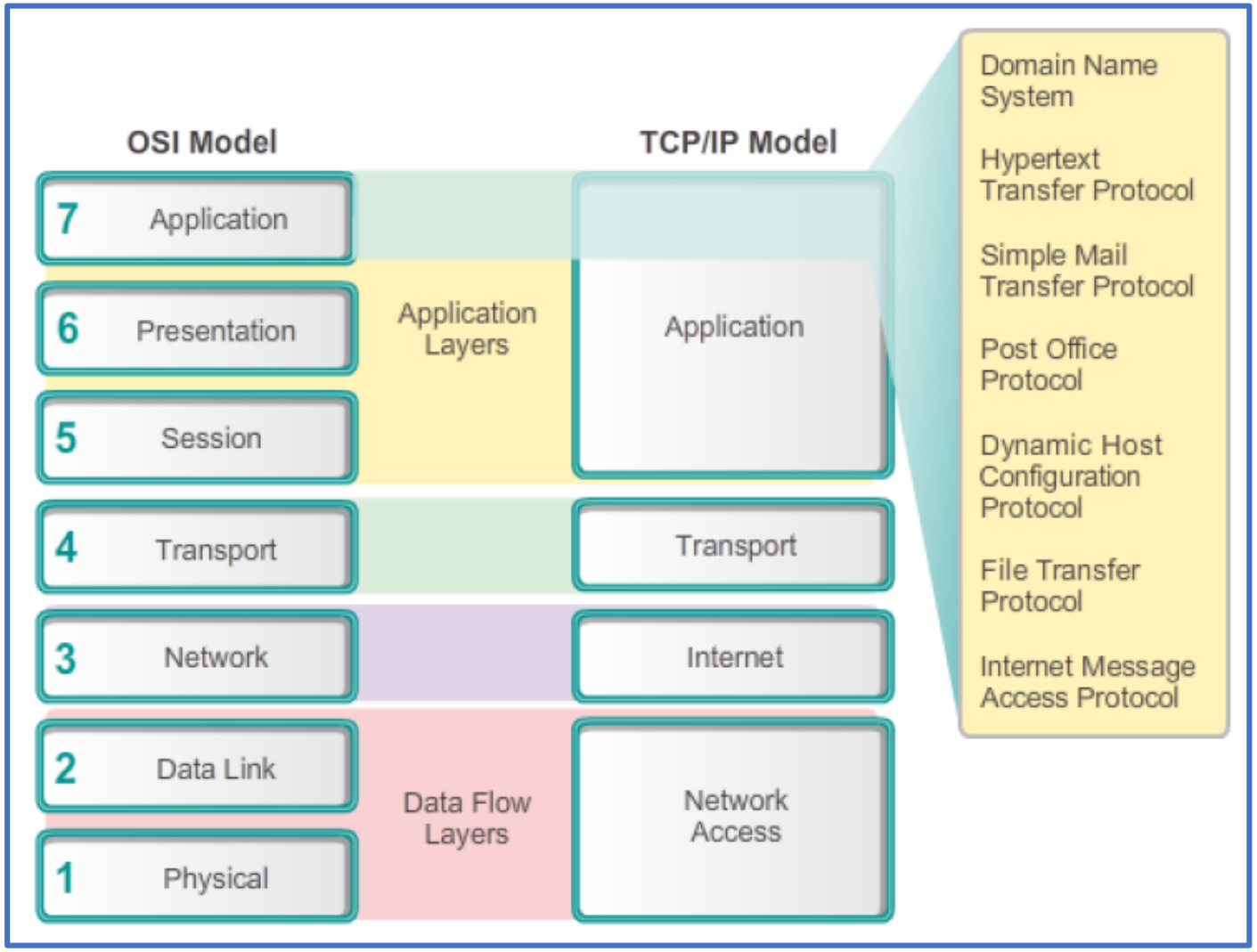


Source: TCP/IP an overview, URL: https://www.oreilly.com/library/view/tcpip-network-administration/0596002971/ch01.html

Features

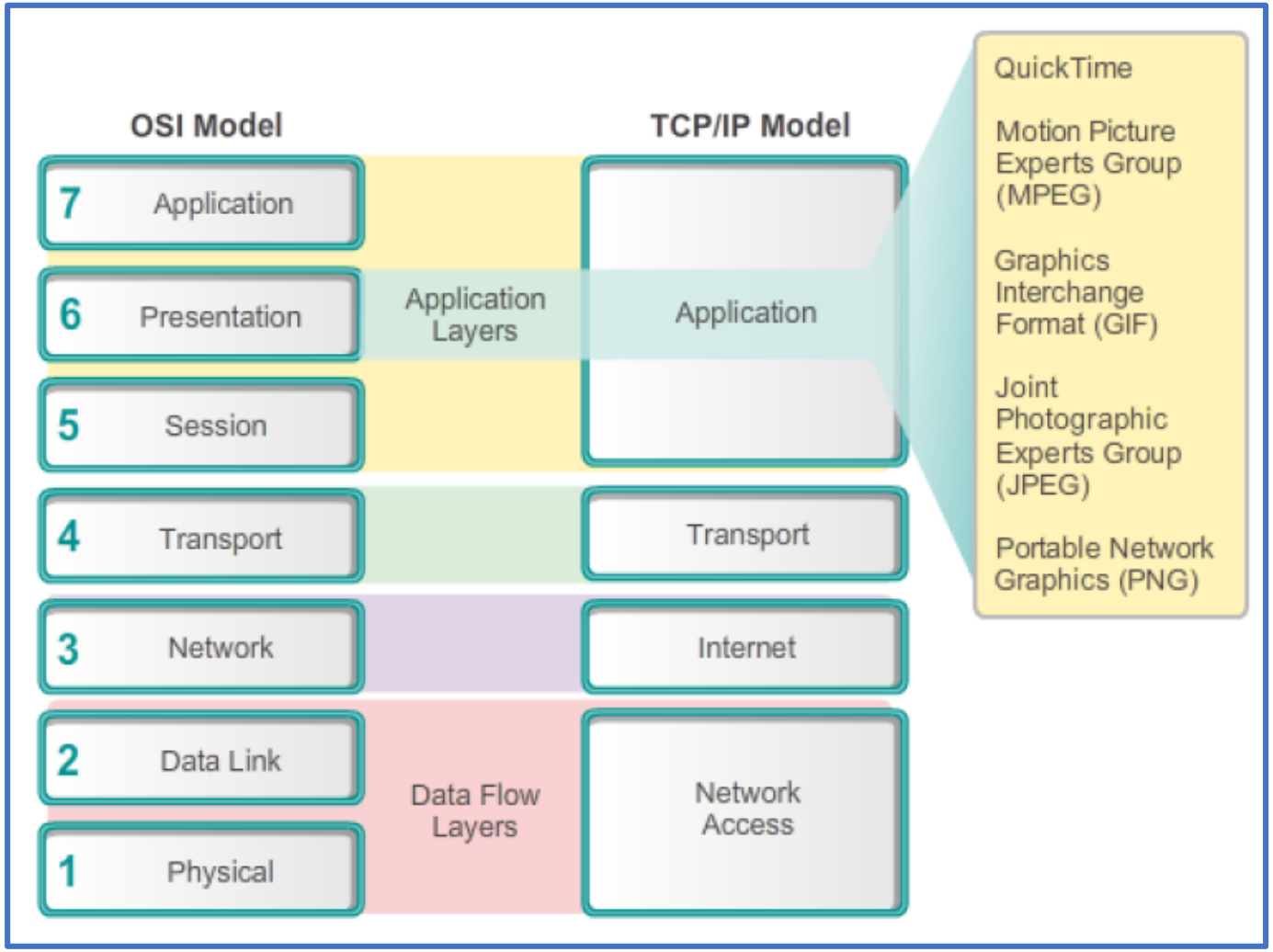
- Open protocol standards, freely available and developed independently from any specific computer hardware or operating system. Because it is so widely supported, TCP/IP is ideal for uniting different hardware and software components, even if you don't communicate over the Internet.
- Independence from specific physical network hardware. This allows TCP/IP to integrate many different kinds of networks. TCP/IP can be run over an Ethernet, a DSL connection, a dial-up line, an optical network, and virtually any other kind of physical transmission medium.
- A common addressing scheme that allows any TCP/IP device to uniquely address any other device in the entire network, even if the network is as large as the worldwide Internet.
- Standardized high-level protocols for consistent, widely available user services.

TCP/IP model: Application Layer



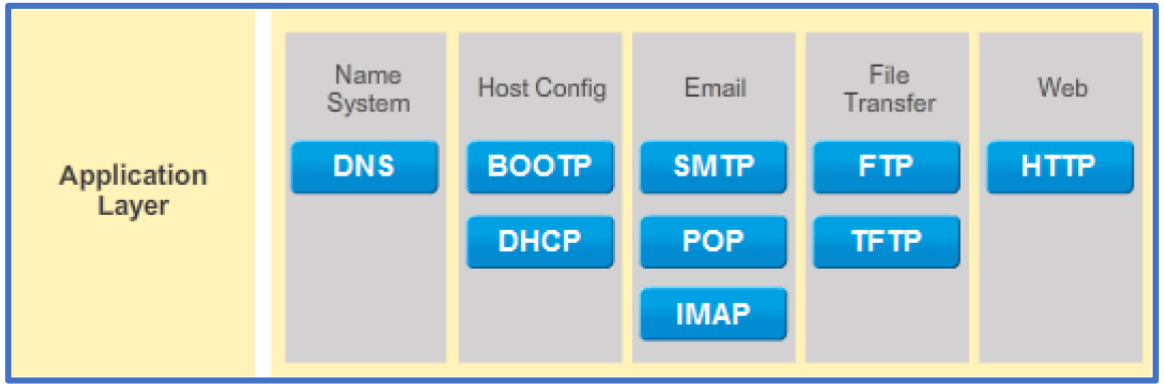
- Interacts with an application program, which is the highest level of OSI model.
- The application layer is the OSI layer, which is closest to the end-user. It means this layer allows users to interact with other software application to implement a communicating component.
- **The function of the Application Layers are:**
  - Application-layer helps you to identify communication partners, determining resource availability, and synchronizing communication.
  - It allows users to log on to a remote host
  - This layer provides various e-mail services
  - This application offers distributed database sources and access for global information about various objects and services.

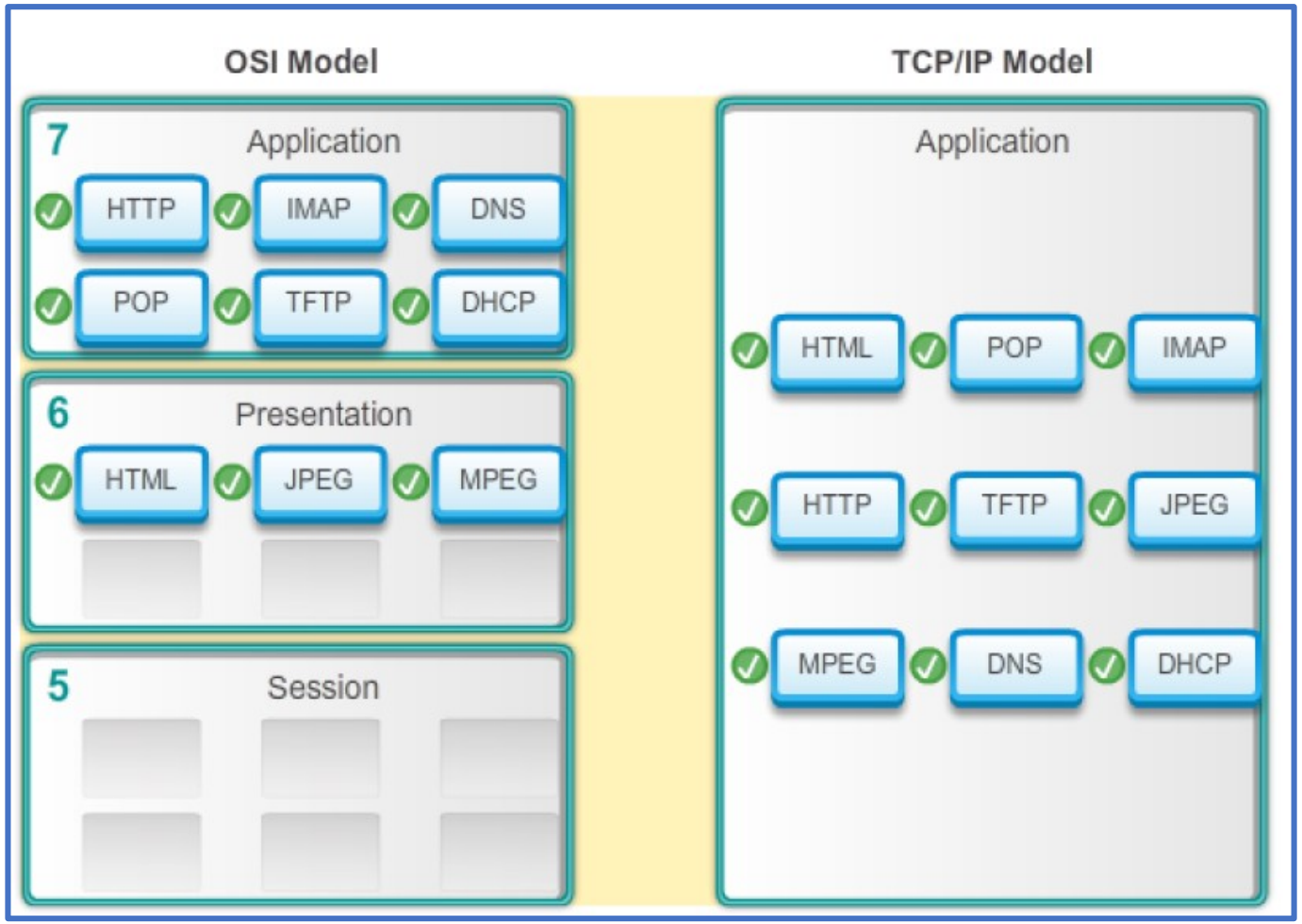
TCP/IP model: Application Layer



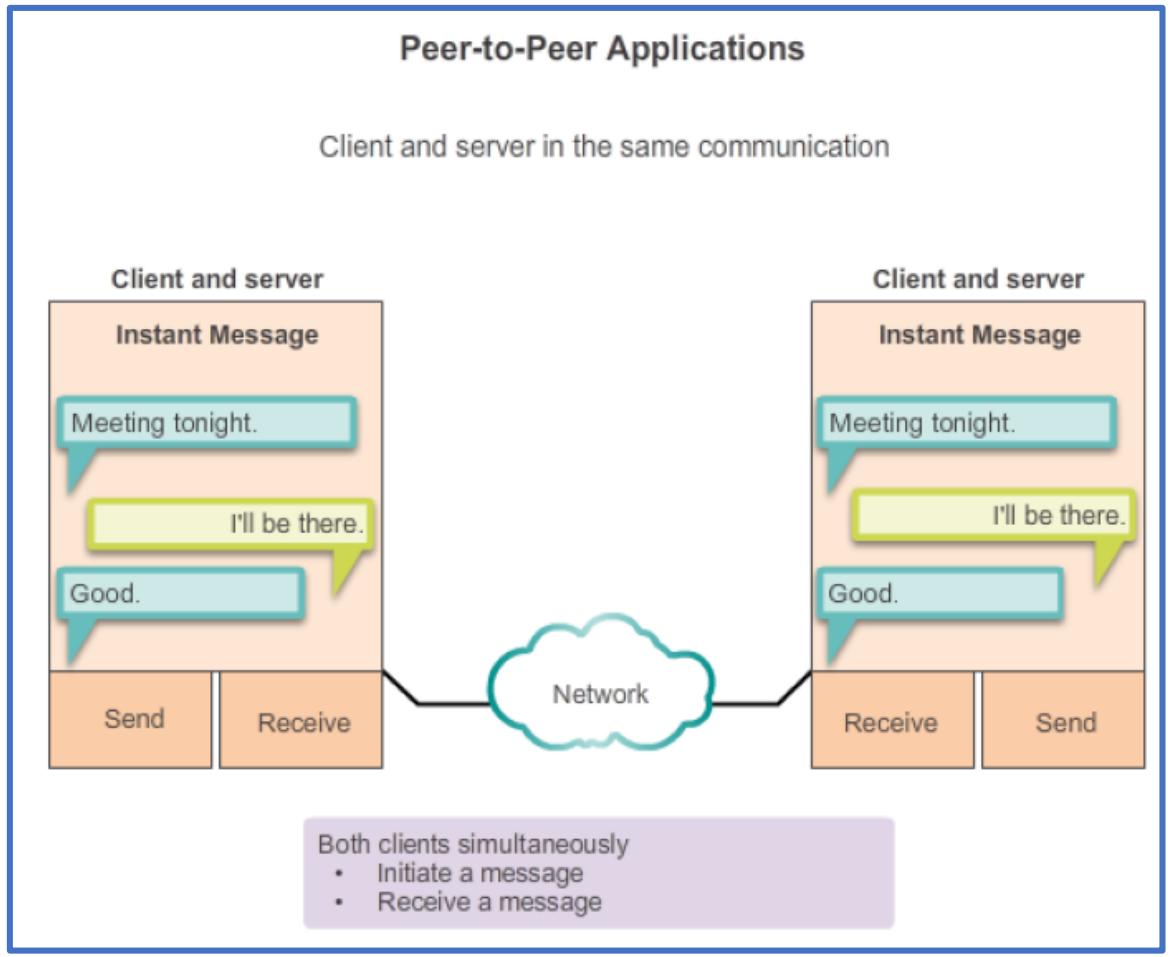
- The presentation layer has three primary functions:
  - **Formats**, or presents, data from the source device into a compatible form for receipt by the destination device.
  - **Compression of the data** in a way that can be decompressed by the destination device.
  - **Encryption of the data** for transmission and the decryption of data upon receipt by the destination.

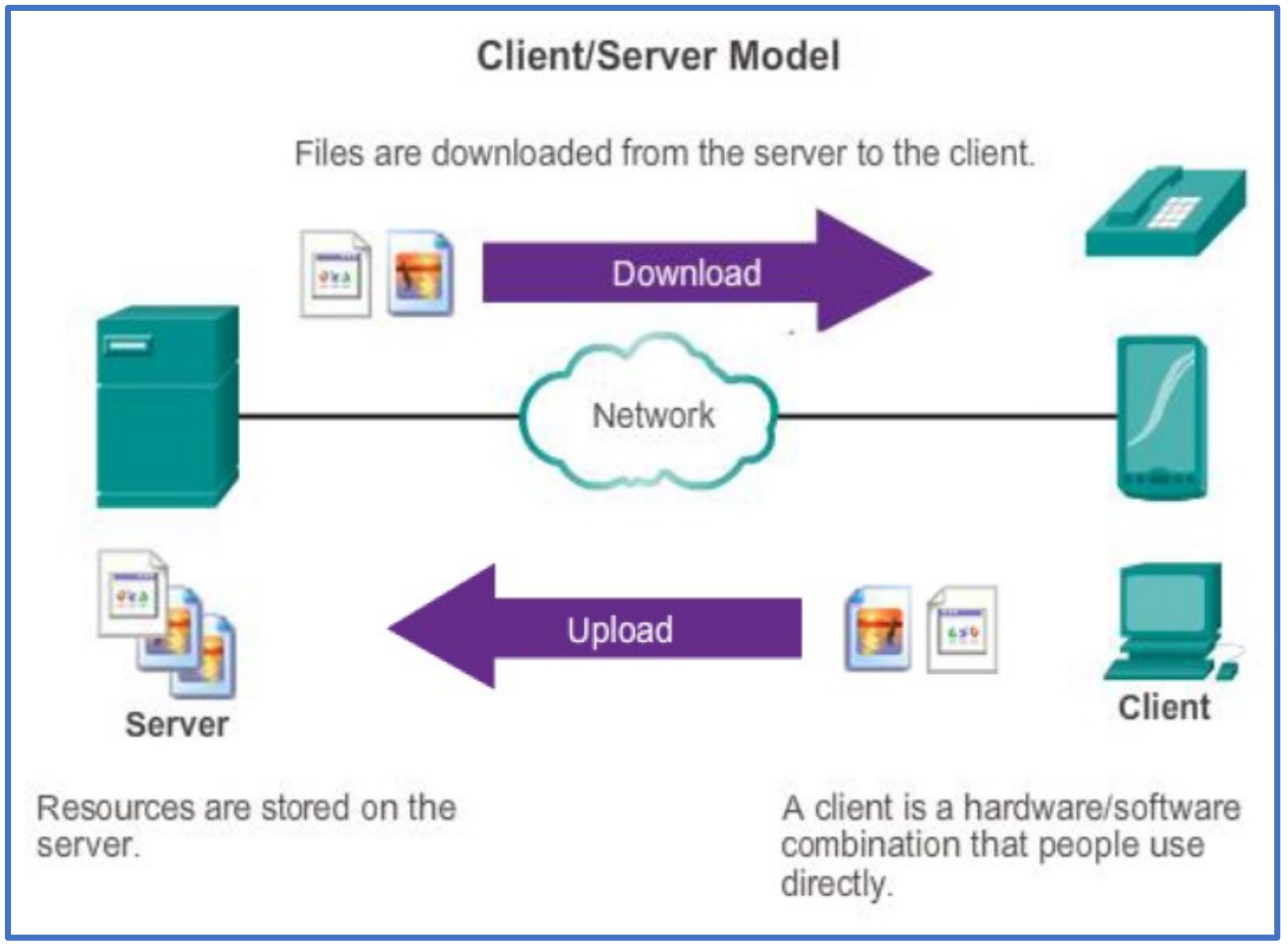
TCP/IP model: Application Layer



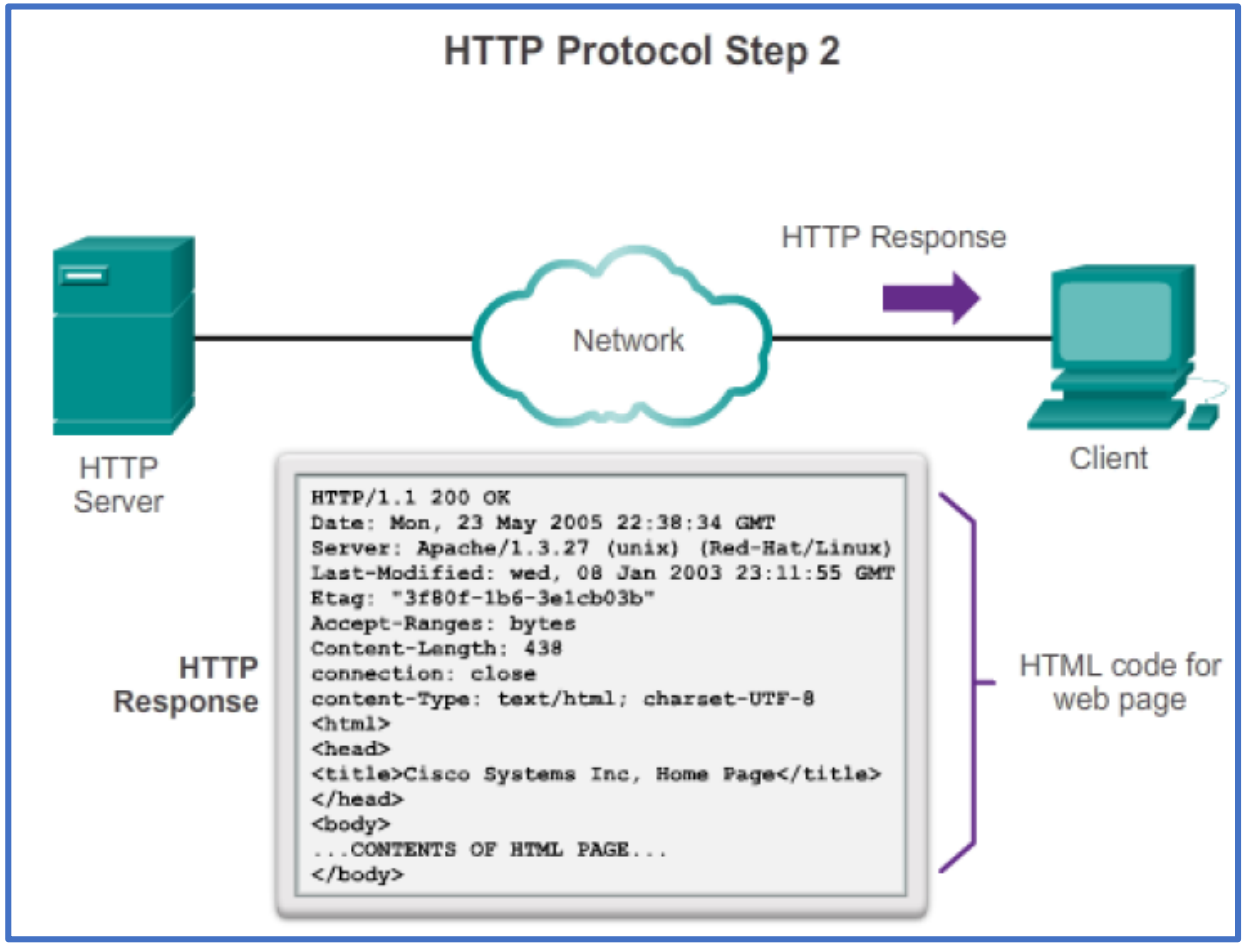


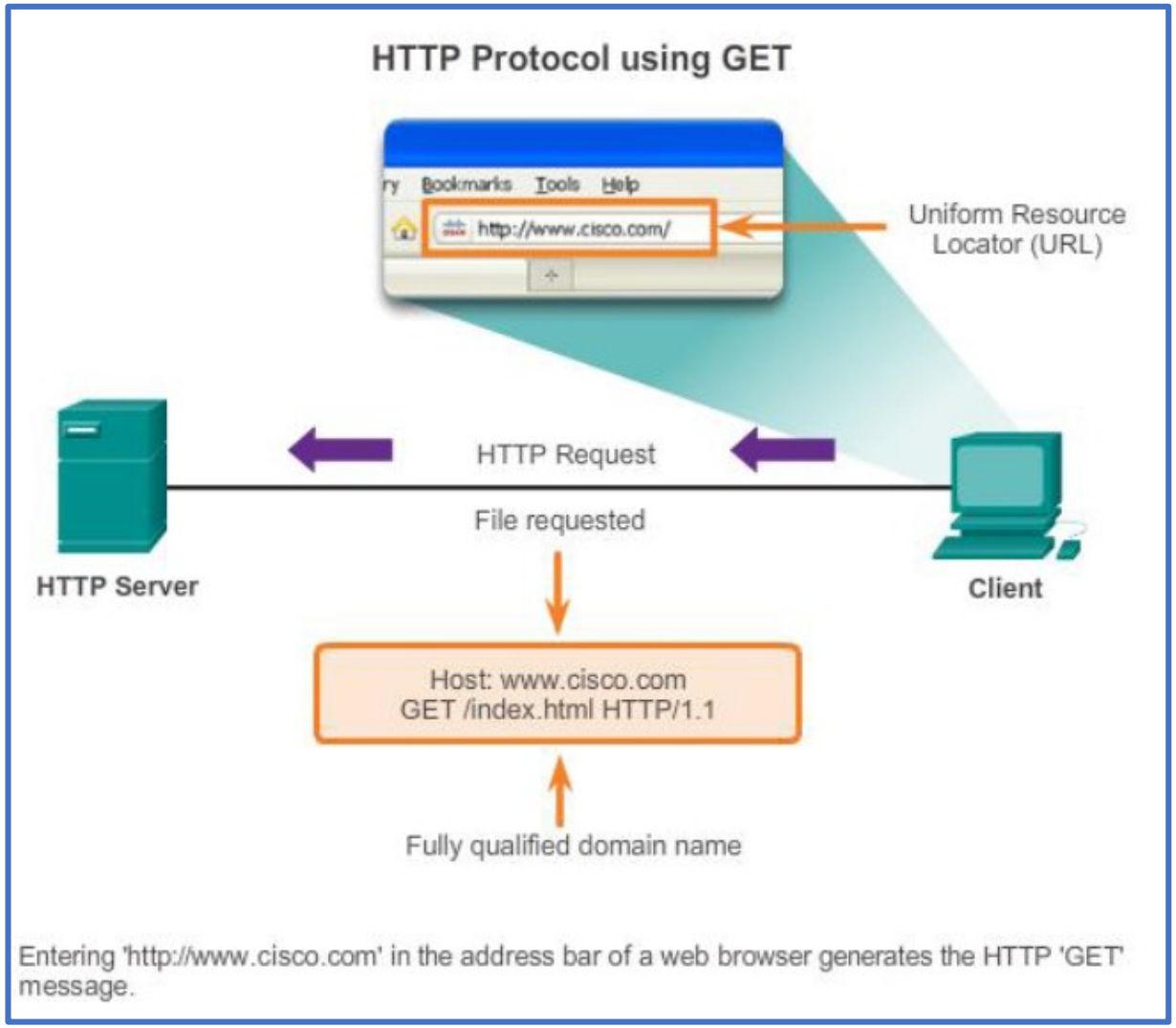
TCP/IP model: Application Layer



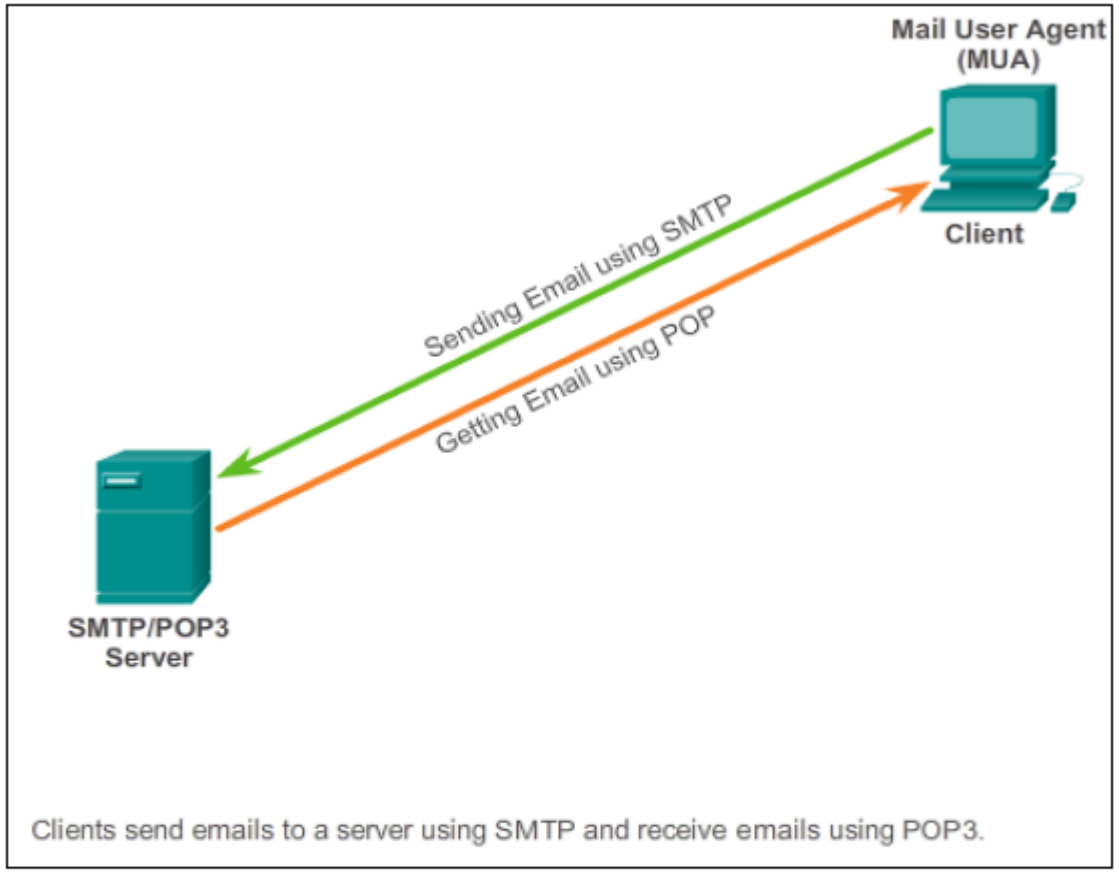


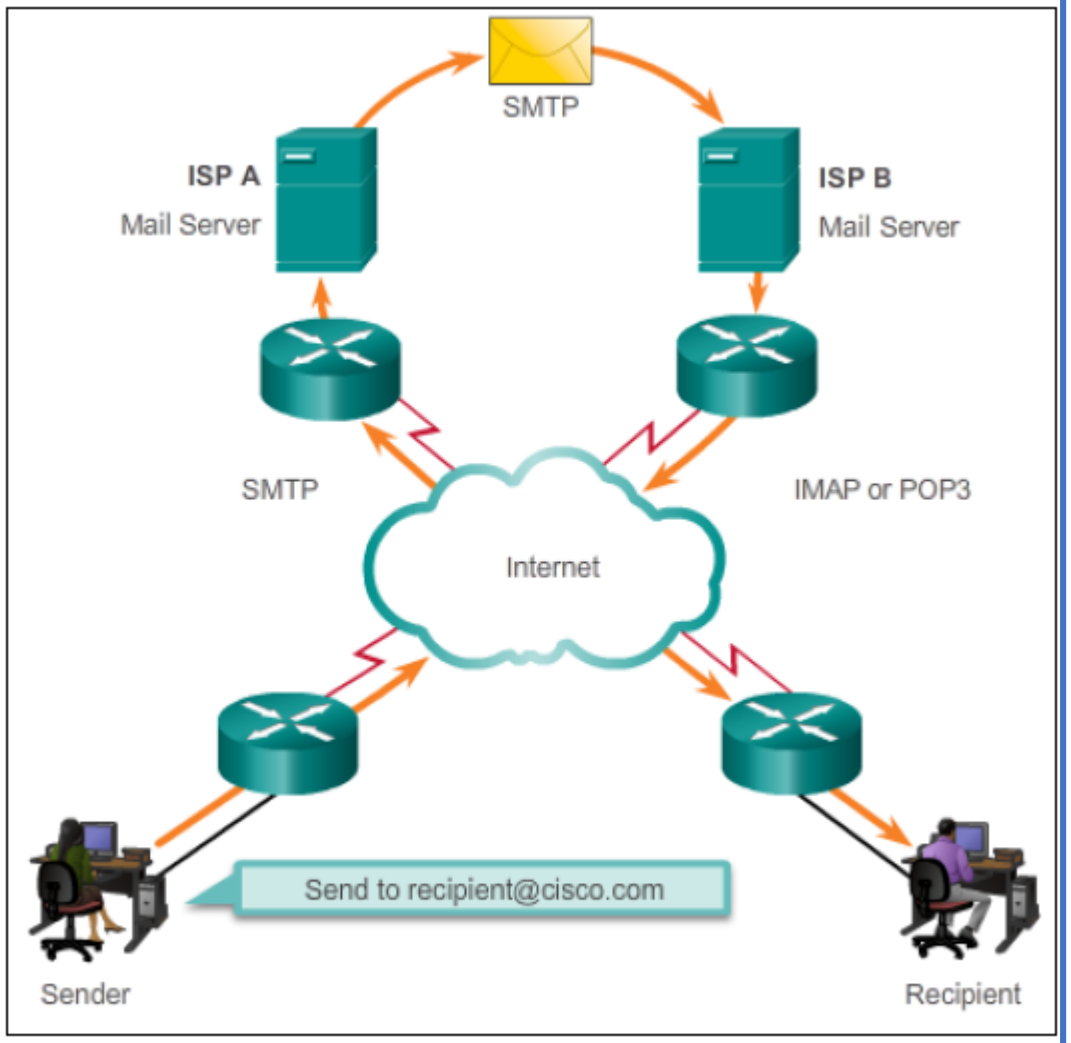
TCP/IP model: Application Layer





TCP/IP model: Application Layer





Email is a store-and-forward method of sending, storing, and retrieving electronic messages across a network. Email messages are stored in databases on mail servers. ISPs often maintain mail servers that support many different customer accounts.

OSI/ISO Model: Transport Layer

- Transport layer builds on the network layer in order to provide data transport from a process on a source system machine to a process on a destination system. It is hosted using single or multiple networks, and also maintains the quality of service functions.
- It determines how much data should be sent where and at what rate. This layer builds on the message which are received from the application layer. It helps ensure that data units are delivered error-free and in sequence.
- Transport layer helps you to control the reliability of a link through flow control, error control, and segmentation or de-segmentation.
- The transport layer also offers an acknowledgment of the successful data transmission and sends the next data in case no errors occurred. TCP is the best-known example of the transport layer.

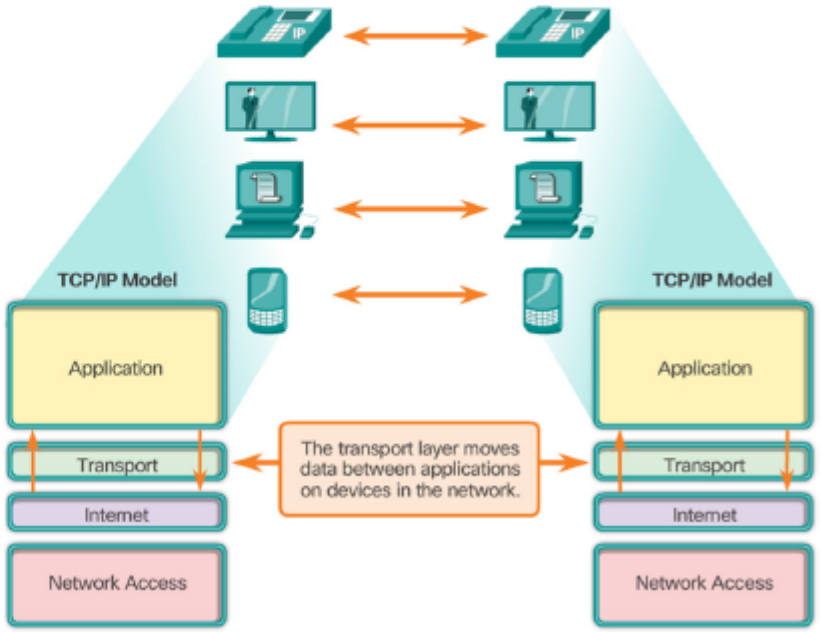
Important functions of Transport Layers:

- It divides the message received from the session layer into segments and numbers them to make a sequence.
- Transport layer makes sure that the message is delivered to the correct process on the destination machine.
- It also makes sure that the entire message arrives without any error else it should be retransmitted.

TCP/IP model: Transport Layer

Role of the Transport Layer

- The transport layer is responsible for establishing a temporary communication session between two applications and delivering data between them.
- The transport layer provides services, such as:
  - Connection-oriented data stream support
  - Reliability
  - Flow control
  - Multiplexing



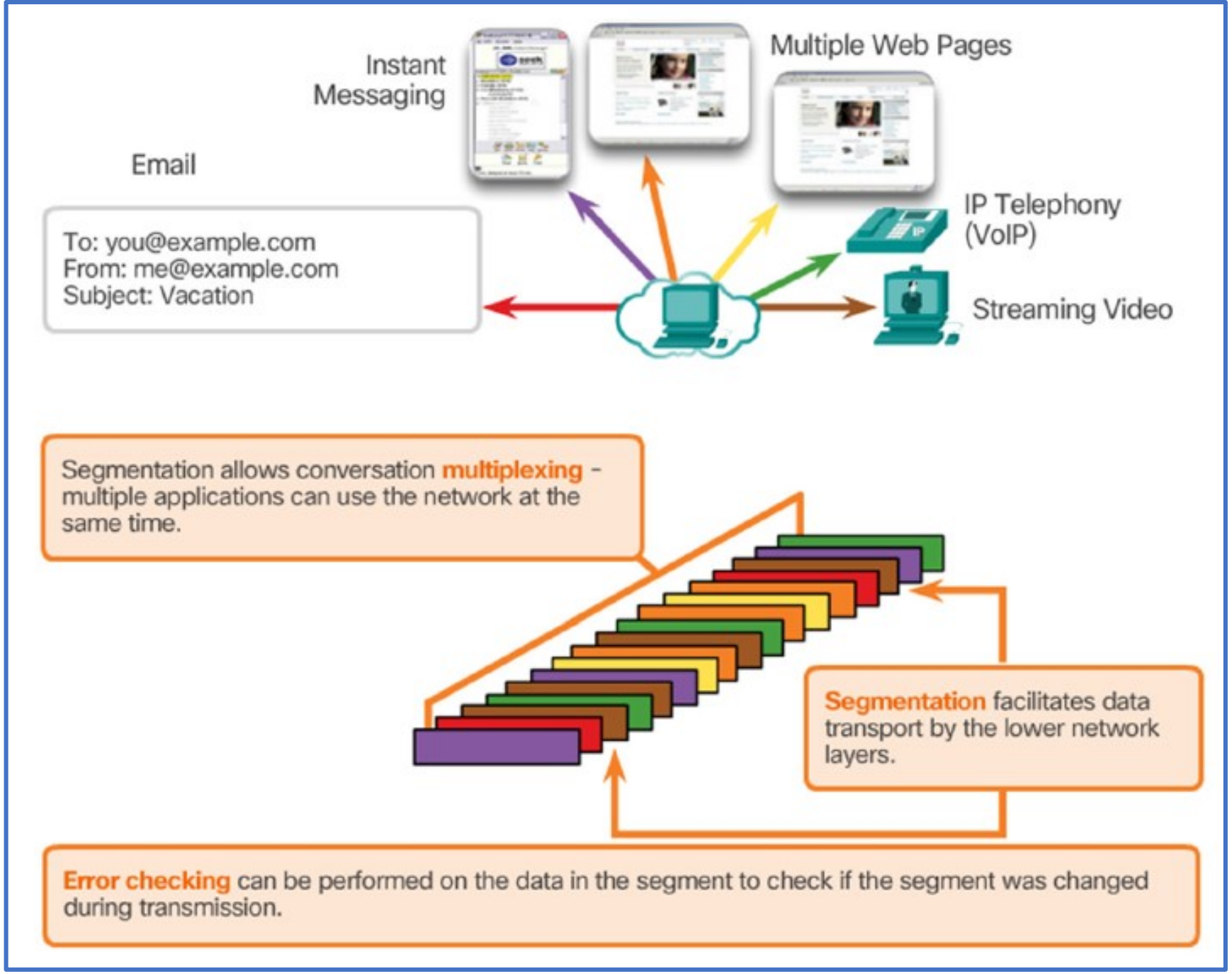
Responsibilities

- **Track Individual Conversations**
  - By tracking each individual conversation flowing between a source application and a destination application separately.
- **Segment Data and Reassemble Segments**
  - By dividing the data into segments that are easier to manage and transport.
- **Identify the Applications**
  - By ensuring even when multiple applications are running on a device, all applications receive the correct data.

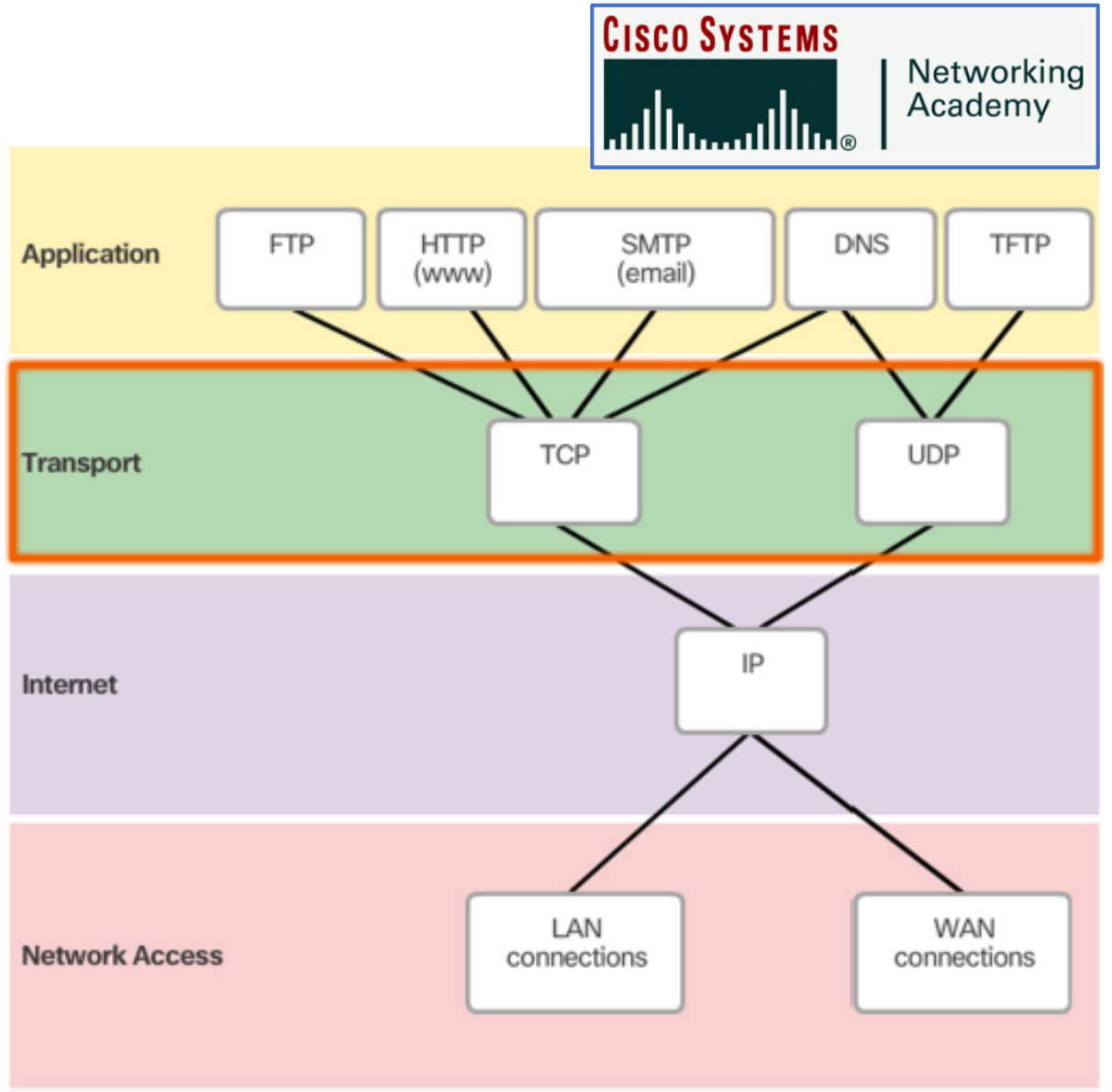
Transport Layer

Conversation Multiplexing

- Segmenting the data into smaller chunks enables many different communications, from many different users, to be interleaved (multiplexed) on the same network.
- The transport layer adds a header that contains binary data to identify each segment of data and to enable various transport layer protocols to perform different functions in the management of datacommunication.

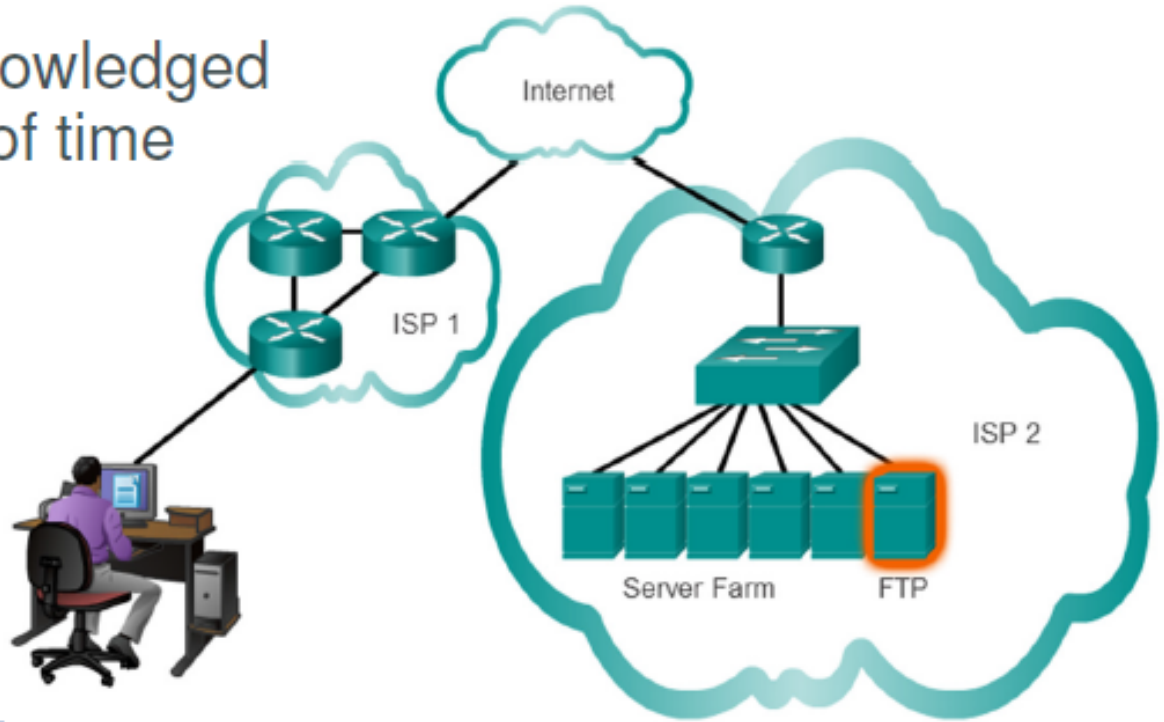


- The transport layer is also responsible for managing reliability.
- Some applications may not require reliability. Transport layer requirements vary from application to application.
- TCP/IP suite provides two transport layer protocols, Transmission Control Protocol (TCP) and User Datagram Protocol (UDP).
- IP uses these transport protocols to enable hosts to communicate and transfer data.
- TCP is considered a reliable, full-featured transport layer protocol, which allows for packet data delivery confirmation.
- In contrast, UDP is a very simple transport layer protocol that does not provide any reliability.

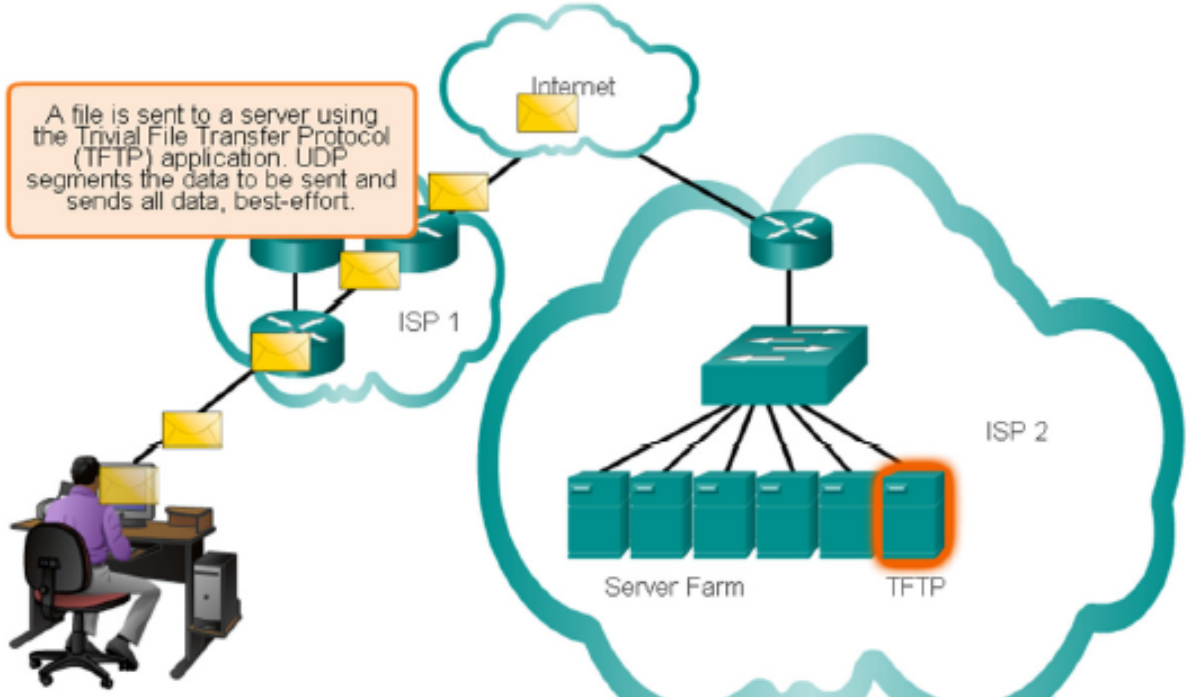


TCP

- TCP transport is reliable because it supports packet delivery confirmation.
- There are three basic operations that enable reliability with TCP:
  - Numbering and tracking data segments transmitted to a specific host from a specific application
  - Acknowledging received data
  - Retransmitting any unacknowledged data after a certain period of time

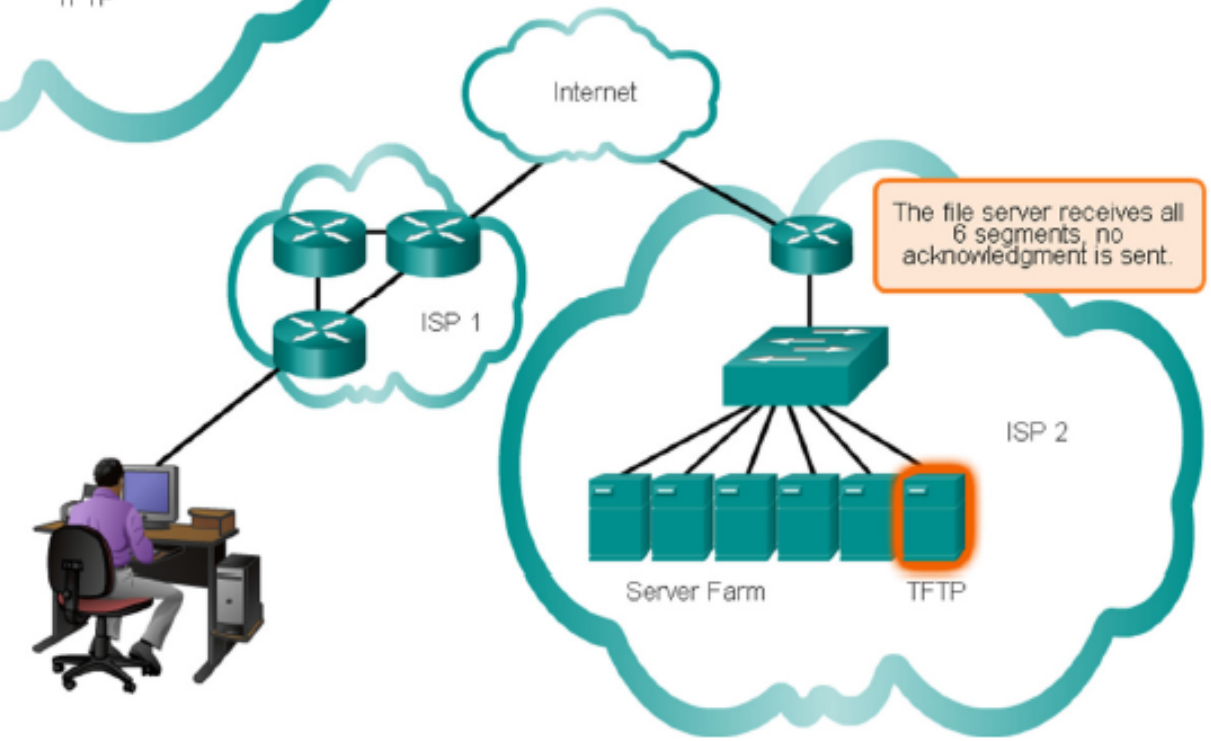


UDP



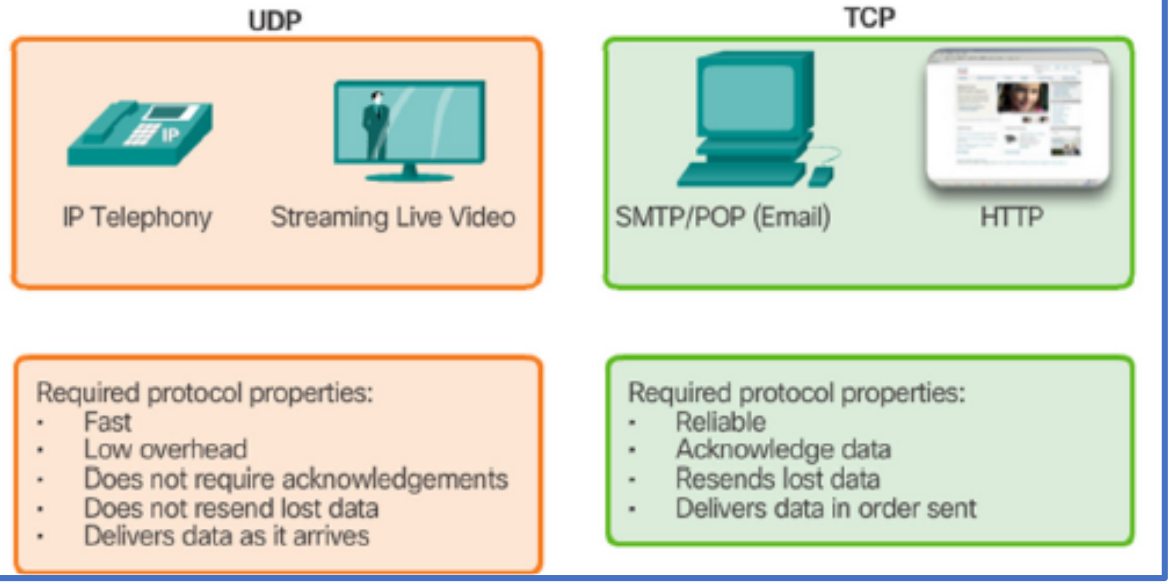
- Some applications do not require reliability. Reliability incurs additional overhead and possible delays in transmission.
- Adding overhead to ensure reliability for some applications could reduce the usefulness of the application and can even be detrimental.

- If reliability is not required, UDP is a better transport protocol.
- UDP provides the basic functions for delivering data segments between the appropriate applications, with very little overhead and data checking.



Transport Layer Protocols

- TCP is a better choice for:
  - Applications whose segments must arrive in a very specific sequence to be processed successfully.
  - Application in which all data must be fully received before any is considered useful.
- Applications requiring TCP include: Databases, Web browsers, Email clients.
- UDP is a better choice for applications that can tolerate some data loss during transmission, but delays in transmission are unacceptable.
- Applications using UDP include:
  - Live audio streaming
  - live video streaming
  - Voice over IP (VoIP)

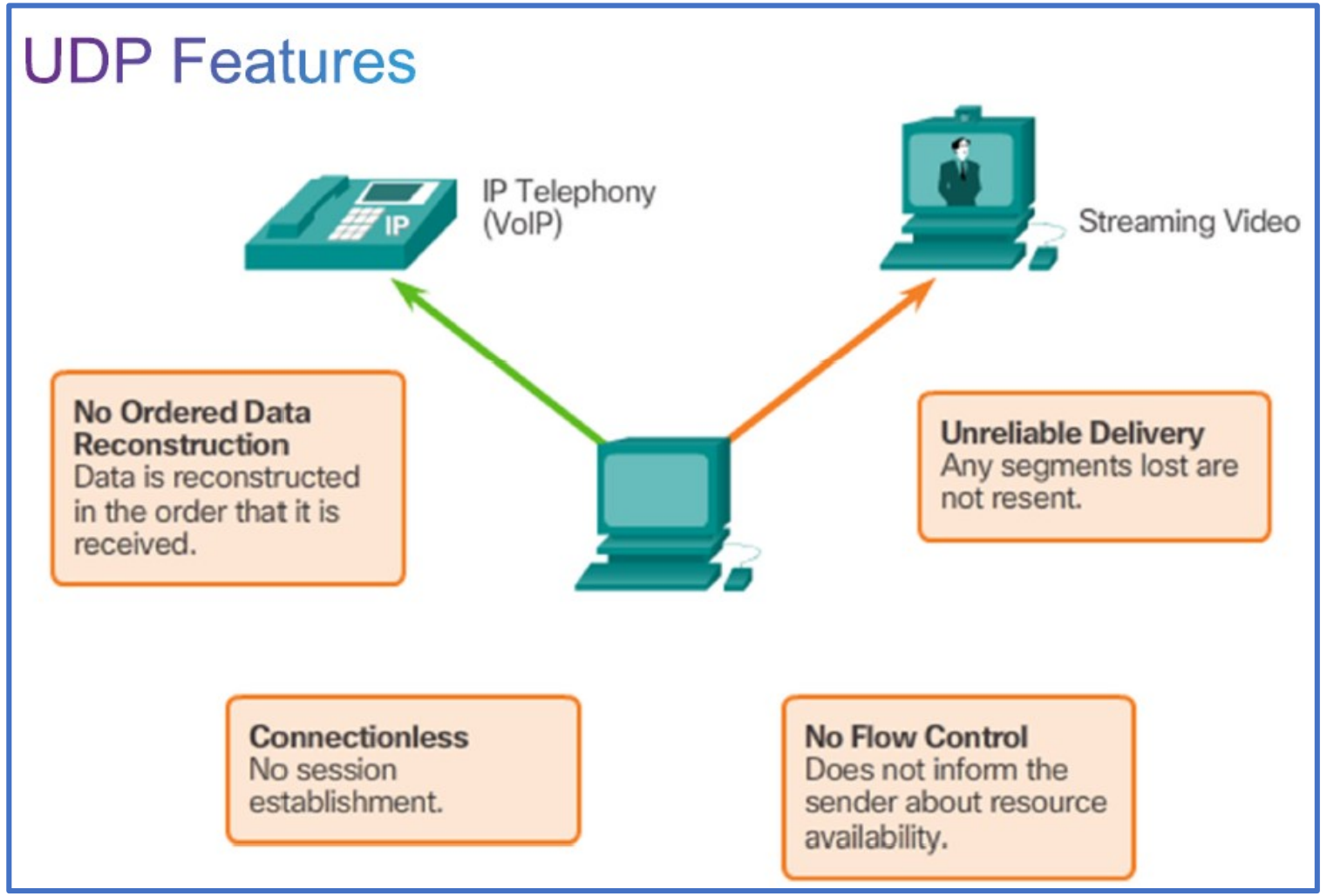


TCP/IP model: Transport Layer

TCP Features

In addition to supporting the basic functions of data segmentation and reassembly, TCP provides the following services:

- ❖Establishing a Session;
- ❖Reliable Delivery;
- ❖Same-Order Delivery;
- ❖Flow Control.



TCP/IP model: Transport Layer

- **Source Port**
  - The source port number is dynamically chosen by the sending device to identify a conversation between two devices.
  - An HTTP client usually sends multiple HTTP requests to a web server at the same time. Each separate HTTP conversation is tracked based on the source ports.
- **Destination Port**
  - Used to identify an application or service running in the server.
  - A server can offer more than one service at the same time, offering a web service on port 80 and FTP on port 21 simultaneously.
- The Internet Assigned Numbers Authority (IANA) is the standards body responsible for assigning various addressing standards, including port numbers.

Port Numbers

Port Number Range	Port Group
0 to 1023	Well-known Ports
1024 to 49151	Registered Ports
49152 to 65535	Private and/or Dynamic Ports

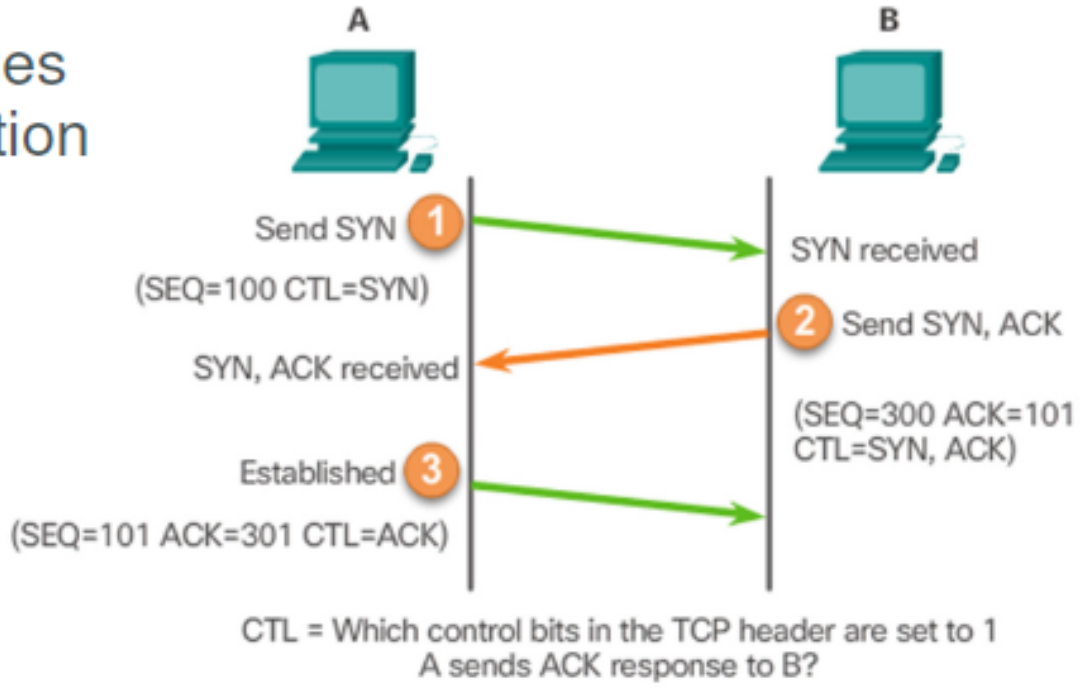
Well-Known Port Numbers

Port Number	Protocol	Application	Acronym
20	TCP	File Transfer Protocol (data)	FTP
21	TCP	File Transfer Protocol (control)	FTP
22	TCP	Secure Shell	SSH
23	TCP	Telnet	–
25	TCP	Simple Mail Transfer Protocol	SMTP
53	UDP, TCP	Domain Name Service	DNS
67, 68	UDP	Dynamic Host Configuration Protocol	DHCP
69	UDP	Trivial File Transfer Protocol	TFTP
80	TCP	Hypertext Transfer Protocol	HTTP
110	TCP	Post Office Protocol version 3	POP3
143	TCP	Internet Message Access Protocol	IMAP
161	UDP	Simple Network Management Protocol	SNMP
443	TCP	Hypertext Transfer Protocol Secure	HTTPS

TCP Connection Establishment

A TCP connection is established in three steps:

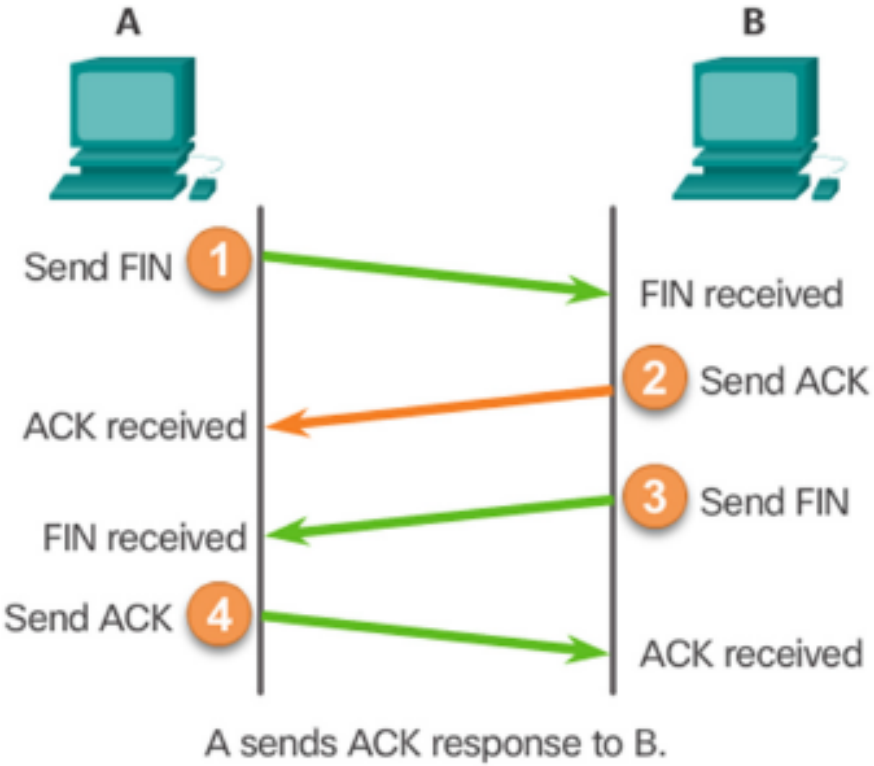
1. The initiating client requests a client-to-server communication session with the server.
2. The server acknowledges the client-to-server communication session and requests a server-to-client communication session.
3. The initiating client acknowledges the server-to-client communication session.



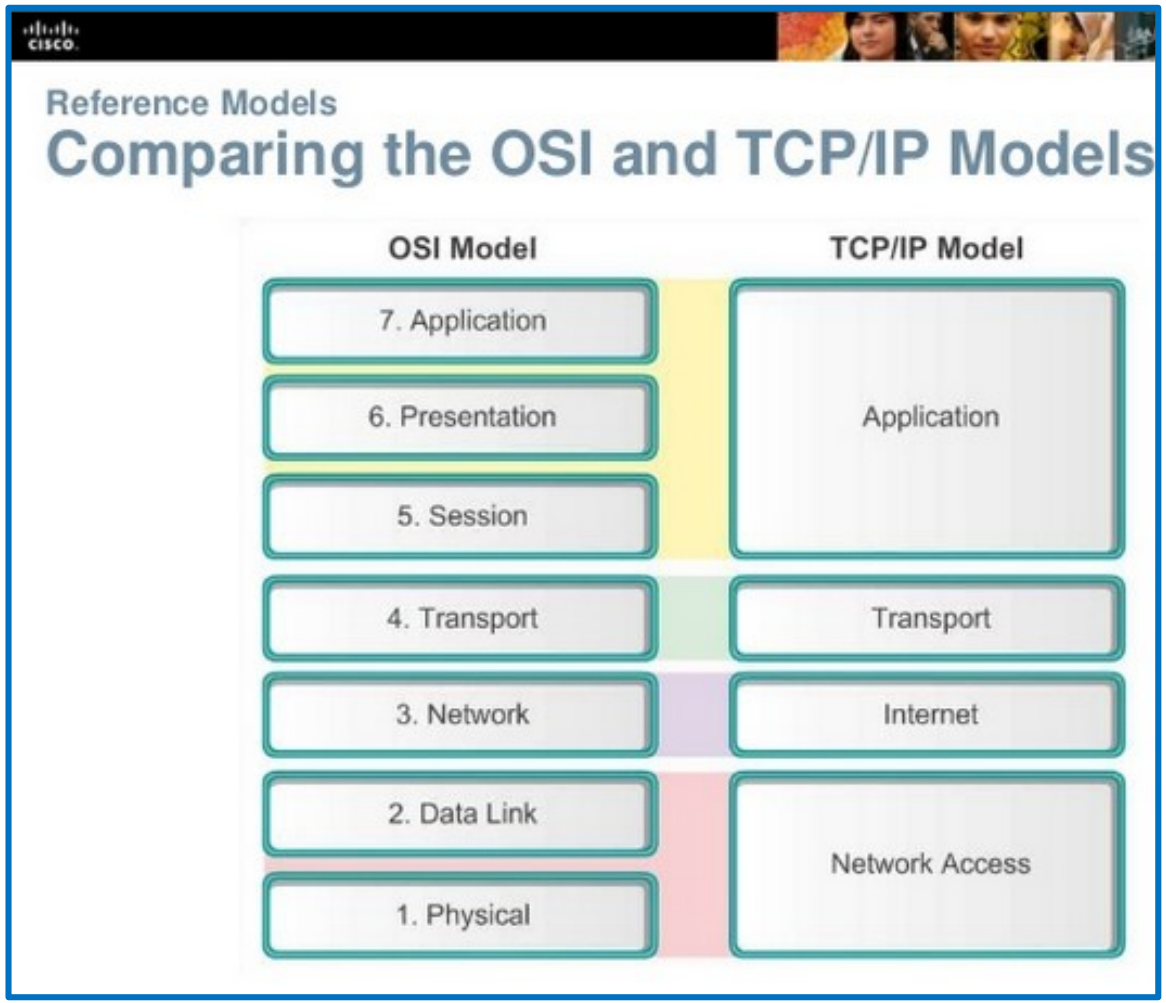
TCP Session Termination

The FIN TCP flag is used to terminate a TCP connection.

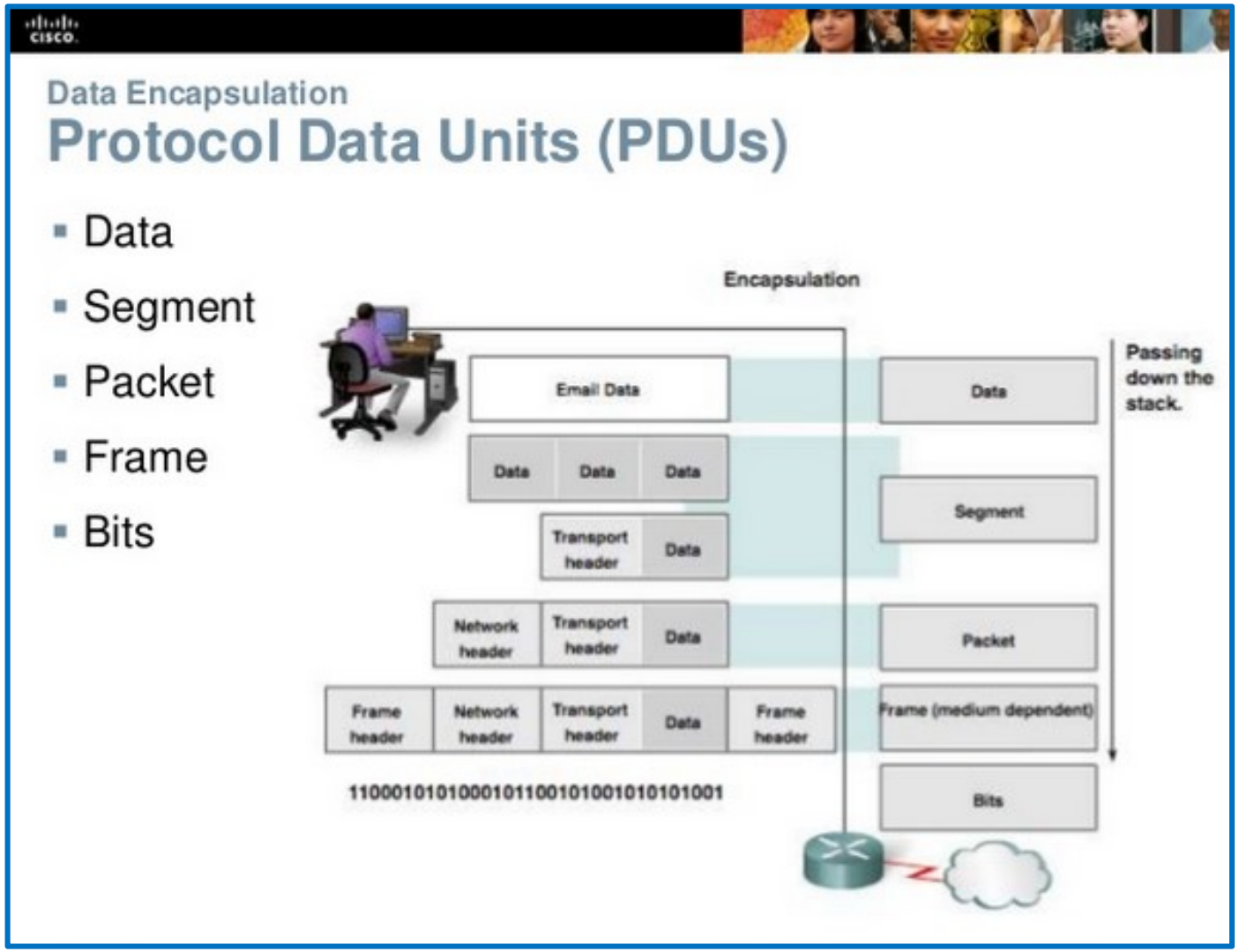
1. When the client has no more data to send in the stream, it sends a segment with the FIN flag set.
2. The server sends an ACK to acknowledge the receipt of the FIN to terminate the session from client to server.
3. The server sends a FIN to the client to terminate the server-to-client session.
4. The client responds with an ACK to acknowledge the FIN from the server.
5. When all segments have been acknowledged, the session is closed.



TCP/IP model: Internet Layer



TCP/IP model: Internet Layer

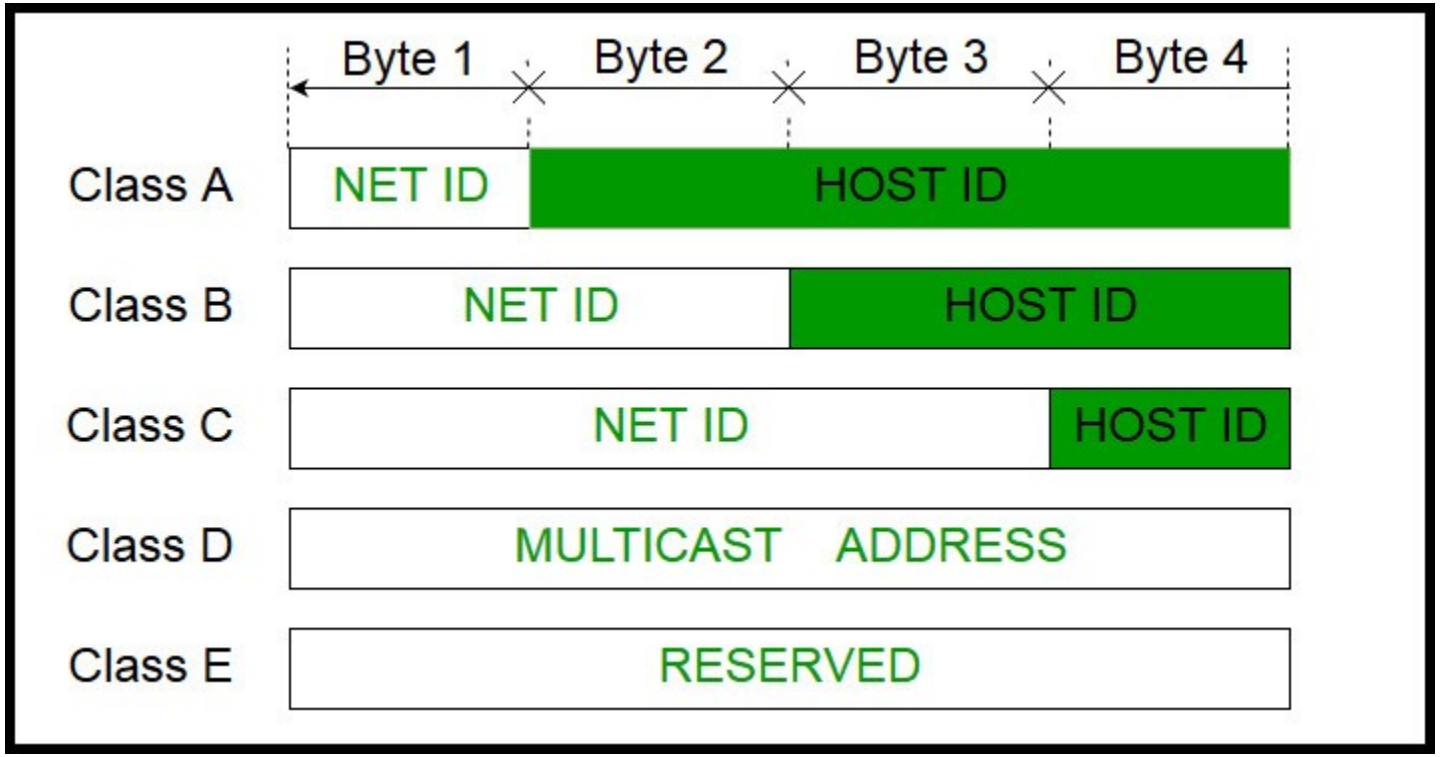


A **protocol data unit (PDU)** is a single unit of information transmitted among peer entities of a computer network. A PDU is composed of protocol-specific control information and user data.

The **Transmission Control Protocol** (TCP) implements a connection-oriented transfer mode, and the PDU of this protocol is called a segment, while the User Datagram Protocol (UDP) uses datagrams as protocol data units for connectionless communication. A layer lower in the Internet protocol suite, at the Internet layer, the PDU is called a packet, irrespective of its payload type.

Classful IP-Addressing

- It is a Universal Addressing (IETF).
- It works at the Internet layer (2-TCP / IP) and layer 3 of the OSI model.
- There are two versions:
- IP-V4, four octets (bytes), 32 bits, decimal and binary format (10.0.1.154)
- IP-v6-IP-NG 16 octets 128 bits, hexadecimal format.
- RFC-791, IP, IP addressing
- It is classified into Types or Classes of Network Addresses A, B, C, D, and E.
- IP address is an address having information about how to reach a specific host, especially outside the LAN.



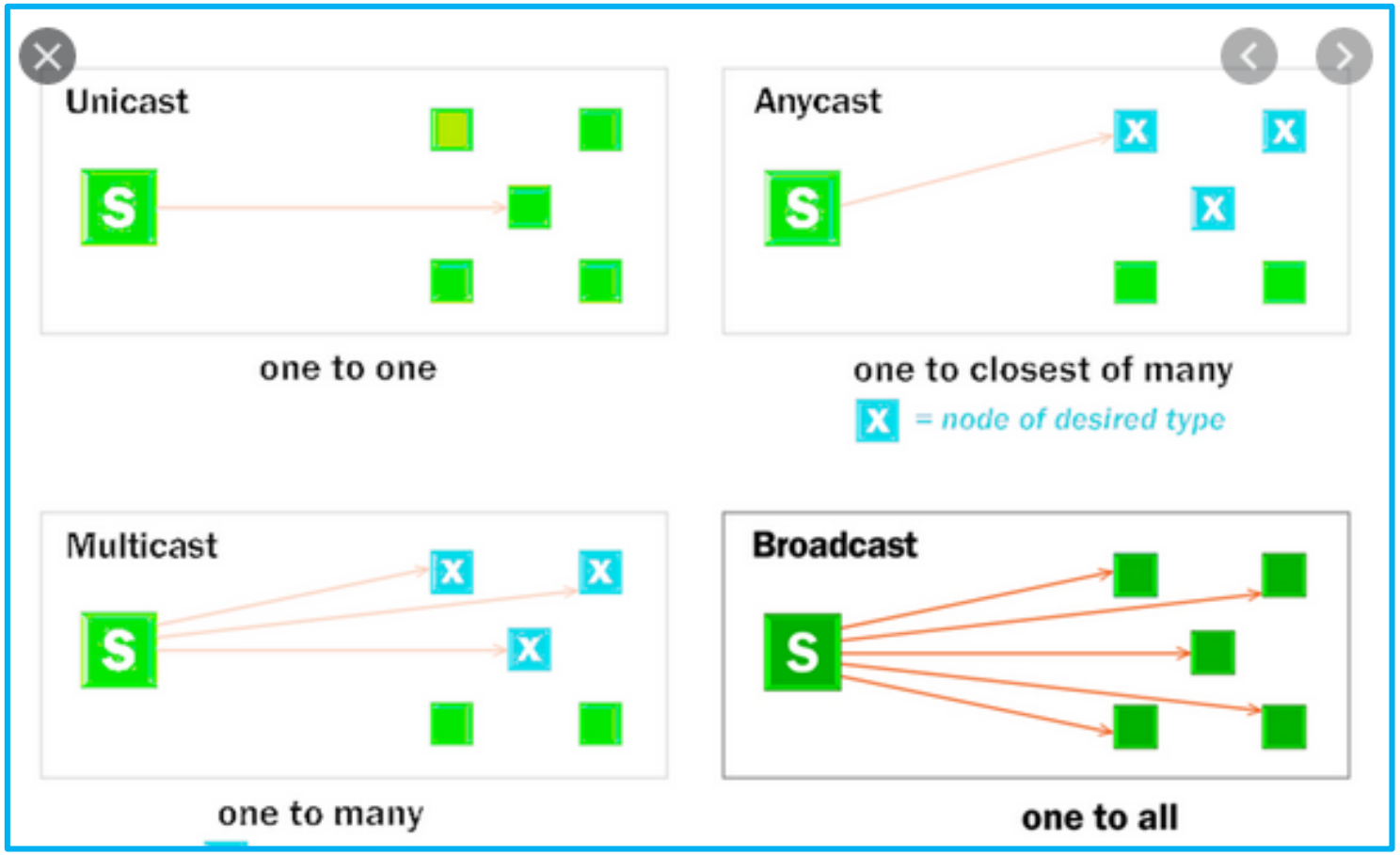
Source: GeeksforGeeks, Introduction of Classful IP Addressing, https://www.geeksforgeeks.org/introduction-of-classful-ip-addressing/

IPv4 Unicast, Broadcast, and Multicast

In an IPv4 network, the hosts can communicate one of three ways:

- **Unicast** – The process of sending a packet from one host to an individual host
- **Broadcast** – The process of sending a packet from one host to all hosts in the network
- **Multicast** – The process of sending a packet from one host to a selected group of hosts (to several hosts), possibly in different networks

These three types of communication are used for different purposes in data networks



Source: Hitechmv, IPv4 Unicast, Broadcast, and Multicasthttps://www.hitechmv.com/ipv4-unicast-broadcast-and-multicast/

Summary of Classful IP-Addressing

CLASS	LEADING BITS	NET ID BITS	HOST ID BITS	NO. OF NETWORKS	ADDRESSES PER NETWORK	START ADDRESS	END ADDRESS
CLASS A	0	8	24	2^7 (128)	2^{24} (16,777,216)	0.0.0.0	127.255.255.255
CLASS B	10	16	16	2^{14} (16,384)	2^{16} (65,536)	128.0.0.0	191.255.255.255
CLASS C	110	24	8	2^{21} (2,097,152)	2^8 (256)	192.0.0.0	223.255.255.255
CLASS D	1110	NOT DEFINED	NOT DEFINED	NOT DEFINED	NOT DEFINED	224.0.0.0	239.255.255.255
CLASS E	1111	NOT DEFINED	NOT DEFINED	NOT DEFINED	NOT DEFINED	240.0.0.0	255.255.255.255

Source: GeeksforGeeks, Introduction of Classful IP Addressing, https://www.geeksforgeeks.org/introduction-of-classful-ip-addressing/

IP Addressing, Binary Arithmetic

Convert Binary to decimal.

1 byte (8 bits)

1	1	1	1	1	1	1	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128+	64+	32+	16+	8+	4+	2+	1

$255_{(10)}$

0	0	0	0	1	0	1	0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
0	0	0	0	8+	0	2+	0

$10_{(10)}$

1	0	1	0	1	0	1	0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	0	32	0	8+	0	2+	0

$10_{(10)}$

$170_{(10)}$

IP Addressing, Binary Arithmetic

Convert Binary to decimal.

1 byte (8 bits)

1	1	0	1	1	0	1	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64		16	8		2	1

$?_{(10)}$

0	1	0	1	0	1	0	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
	64		16		4		1

$?_{(10)}$

1	1	1	0	1	1	1	0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	32	64		8	4	2	

$?_{(10)}$

IP Addressing, Binary Arithmetic

Convert decimal to binary.

1 byte (8 bits)

Transform 196 ($_{10}$) to binary

1	1	0	0	0	1	0	0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64				4		

Transform 18($_{10}$) to binary

0	0	0	1	0	0	1	0
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

Transform 191($_{10}$) a binary

1	0	1	1	1	1	1	1
2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

IP Addressing, Binary Arithmetic

Convert decimal to binary.

Transform $10.16_{(10)}$ to binary

1 byte (8 bits)

Transform $192.168_{(10)}$ to binary

Transform $173.250_{(10)}$ to binary

IP Addressing, Binary Arithmetic

Convert decimal to binary.

Transform $100.161_{(10)}$ to binary

1 byte (8 bits)

Transform $191.169_{(10)}$ to binary

Transform $223.150_{(10)}$ to binary

IP Addressing, Binary Arithmetic

Convert decimal to binary.

1 byte (8 bits)

Transform 11.116.155.192($_{10}$) to binary

Transform 128.110.46.251($_{10}$) to binary

Transform 193.169.201.249($_{10}$) to binary

IP Addressing, Binary Arithmetic

Convert decimal to binary.

1 byte (8 bits)

Transform $10.31.197.224_{(10)}$ to binary

Transform $128.50.146.231_{(10)}$ to binary

Transform $195.179.211.248_{(10)}$ to binary

AND operation.

p	q	p v q (OR)
F	V	V
V	F	V
F	F	F
V	V	V

p	q	p ^ q (AND)
F	V	F
V	F	F
F	F	F
V	V	V

AND

1	1	1	1	0	0	0	1	
1	1	0	1	0	1	0	1	
1	1	0	1	0	0	0	1	

AND

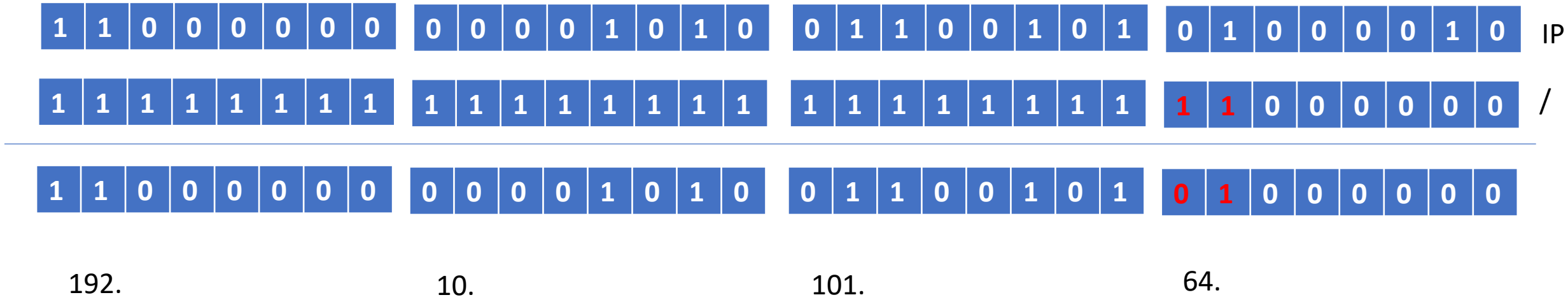
0	1	0	0	0	0	0	1	192.168.100.65
1	1	0	0	0	0	0	0	192.168.100.192
0	1	0	0	0	0	0	0	192.168.100.64

AND

1	0	0	0	0	0	0	1	192.168.100.129
1	1	0	0	0	0	0	0	192.168.100.192
1	0	0	0	0	0	0	0	192.168.100.128

Exercises

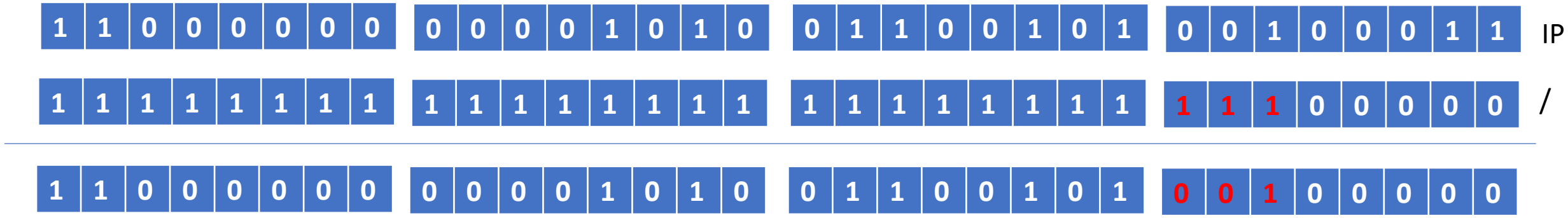
Given the Address 192.10.101.66/26 calculate the address of your Subnet.



Exercises

192.10.101.0 RED
192.10.101.32 SUBRED
192.10.101.64 SUBRED
192.10.101.96 SUBRED

Given the Address 192.10.101.35/27 calculate the address of your Subnet.

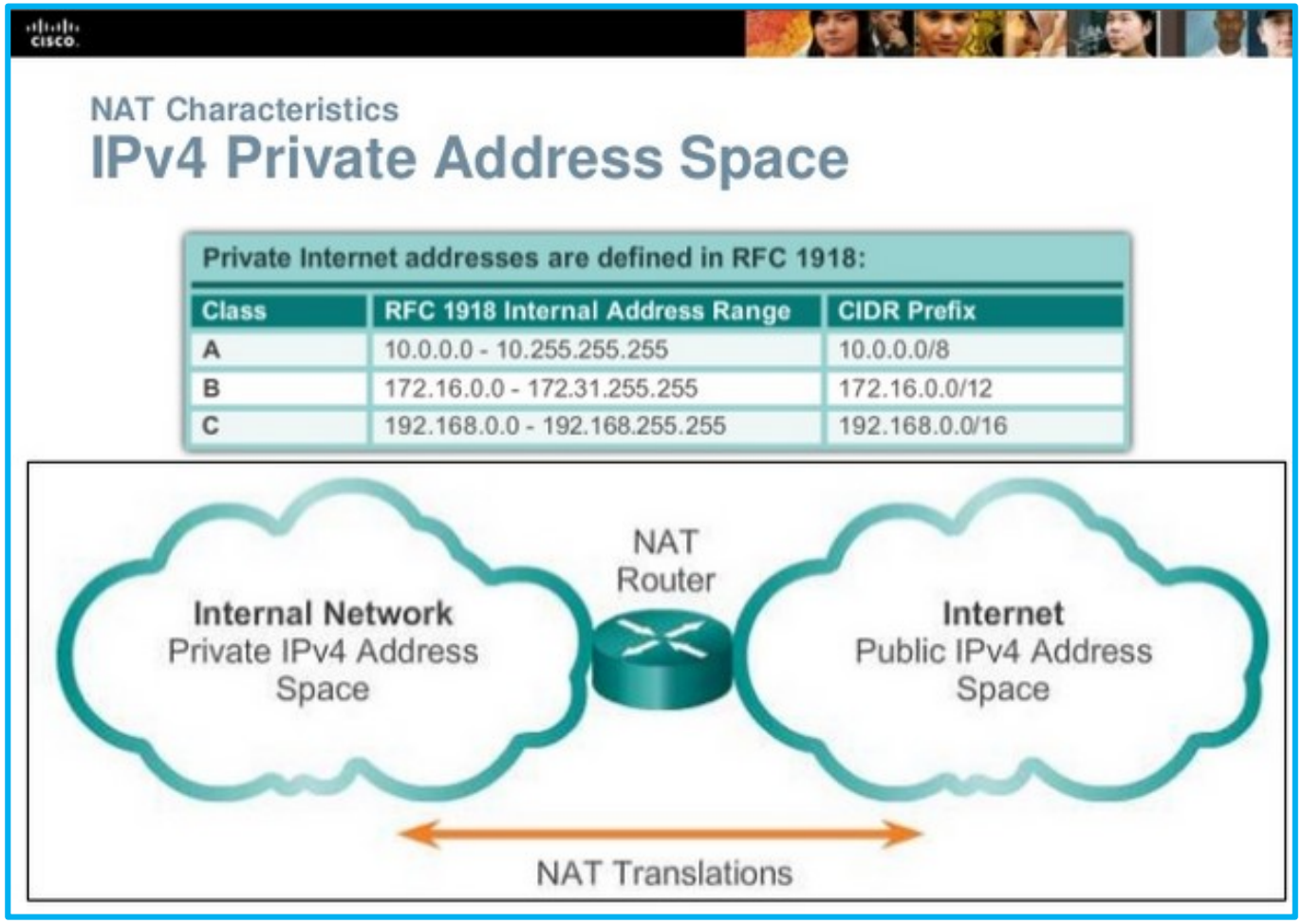


RFC-1918

The Internet Assigned Numbers Authority (IANA) has reserved the following three blocks of IP address space for private Internet:

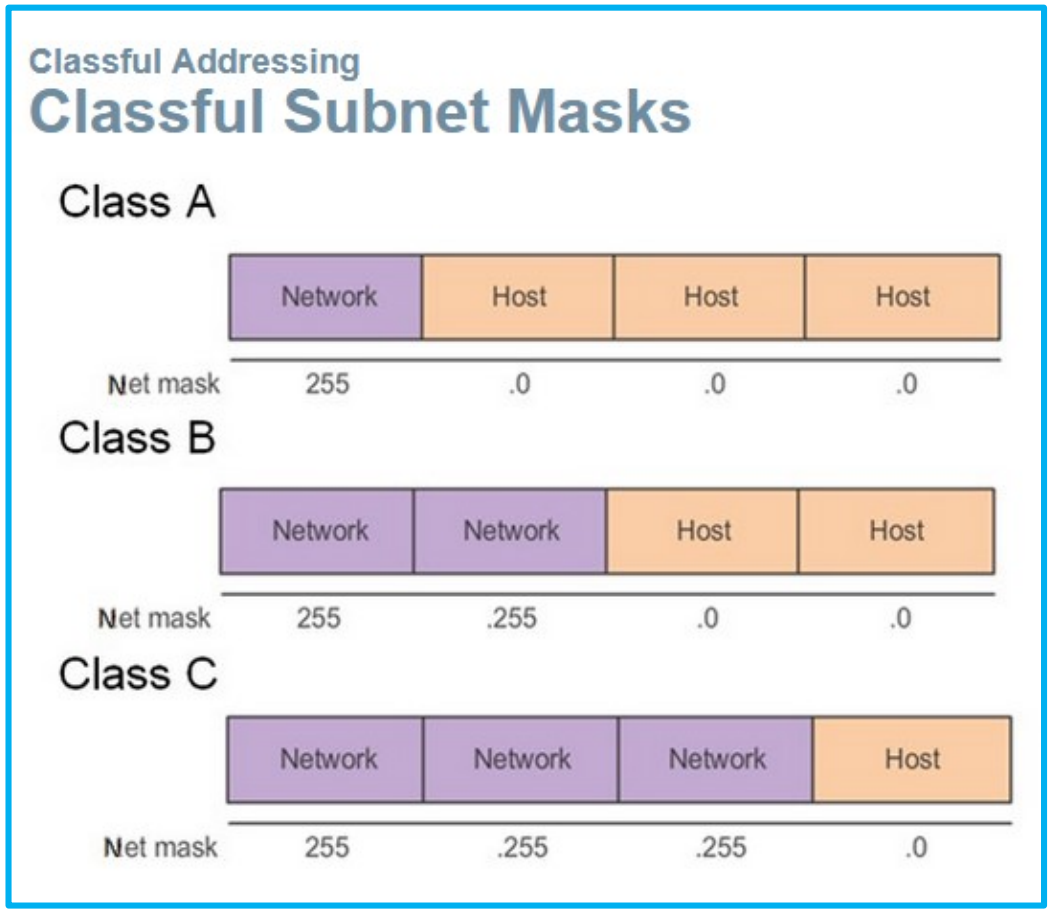
Start Range	Completion Range
10.0.0.0	10.255.255.255
172.16.0.0	172.31.255.255
192.168.0.0	192.168.255.255

The Internet Corporation for Assigned Names and Numbers (ICANN) is an American multi stakeholder group and nonprofit organization responsible for coordinating the maintenance of several databases related to the namespaces and numerical spaces of the Internet, ensuring the network's stable and secure operation



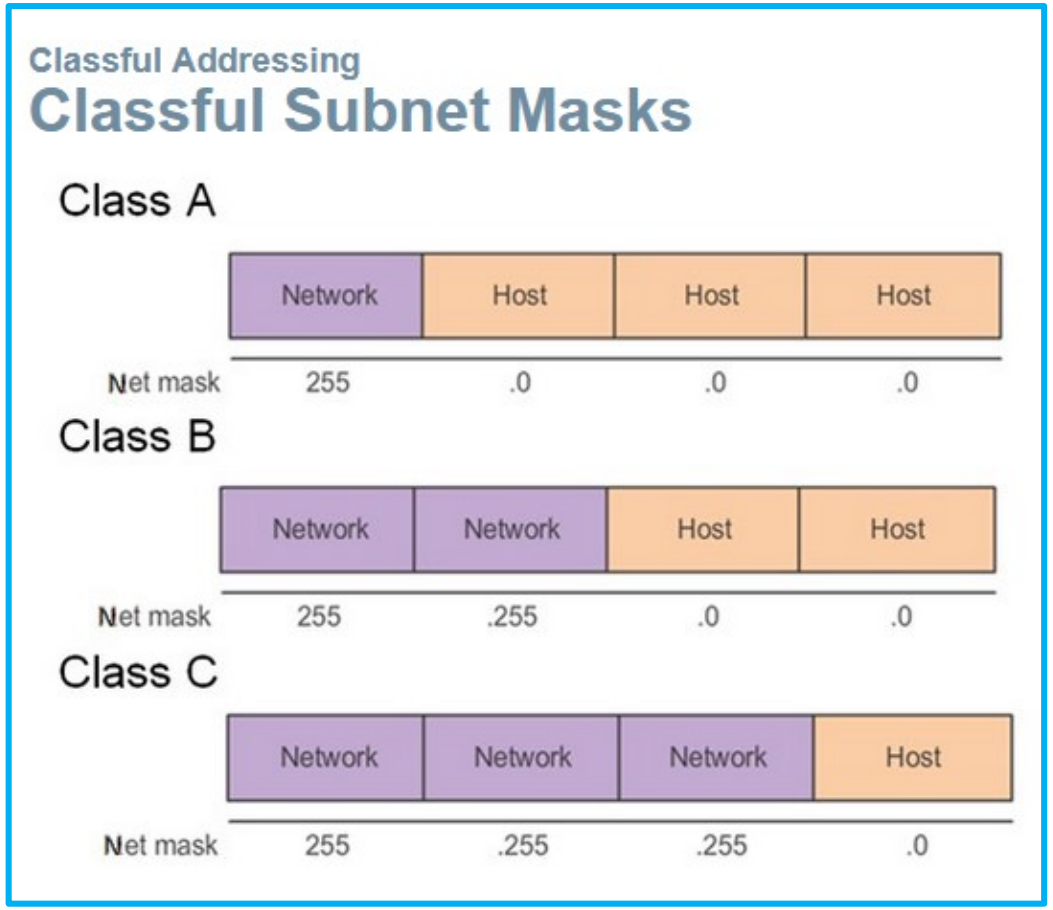
Class A Networks

Range: 0.0.0.0 -127.255.255.255 (127.x-x-x is a reserved loopback address)
1.0.0.0-126.255.255.255
N°. Of Networks= 2^n-2
= 2^7-2
= 128-2=126
N°. De hosts= 2^n-2
=2^{24}-2
=16.777.214
Default Netmask
255.0.0.0
Broadcast
10.255.255.255
E.g.: 10.16.32.128, 126.168.152.10, 1.100.120.199



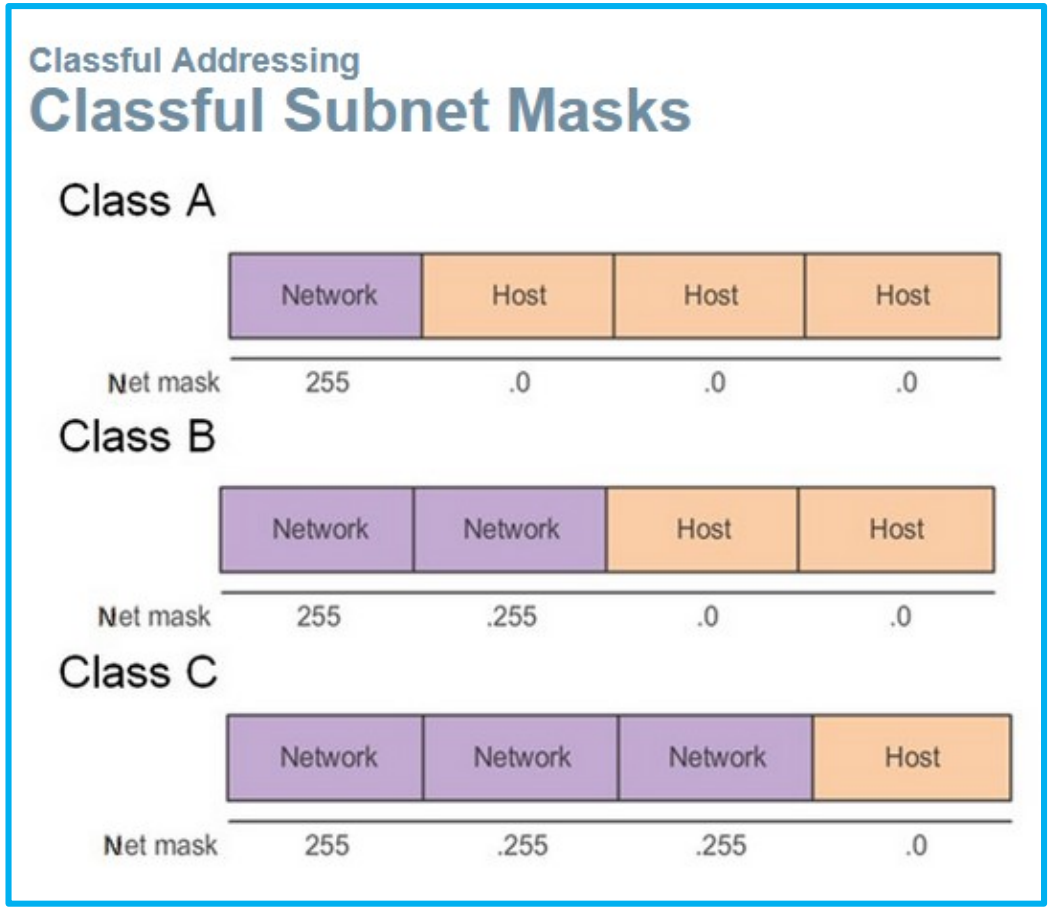
Class B Networks

Range:
128.0.0.0 – 191.255.255.255
N° of networks= 2^n-2
= 2^{14}-2
= 16384-2=16382
N°. of hosts= 2^n-2
=2^{16}-2
=65534
Default Netmask
255.255.0.0
Broadcast
10.16.255.255
E.g.: 128.15.31.177, 191.168.177.253, 191.255.255.254.



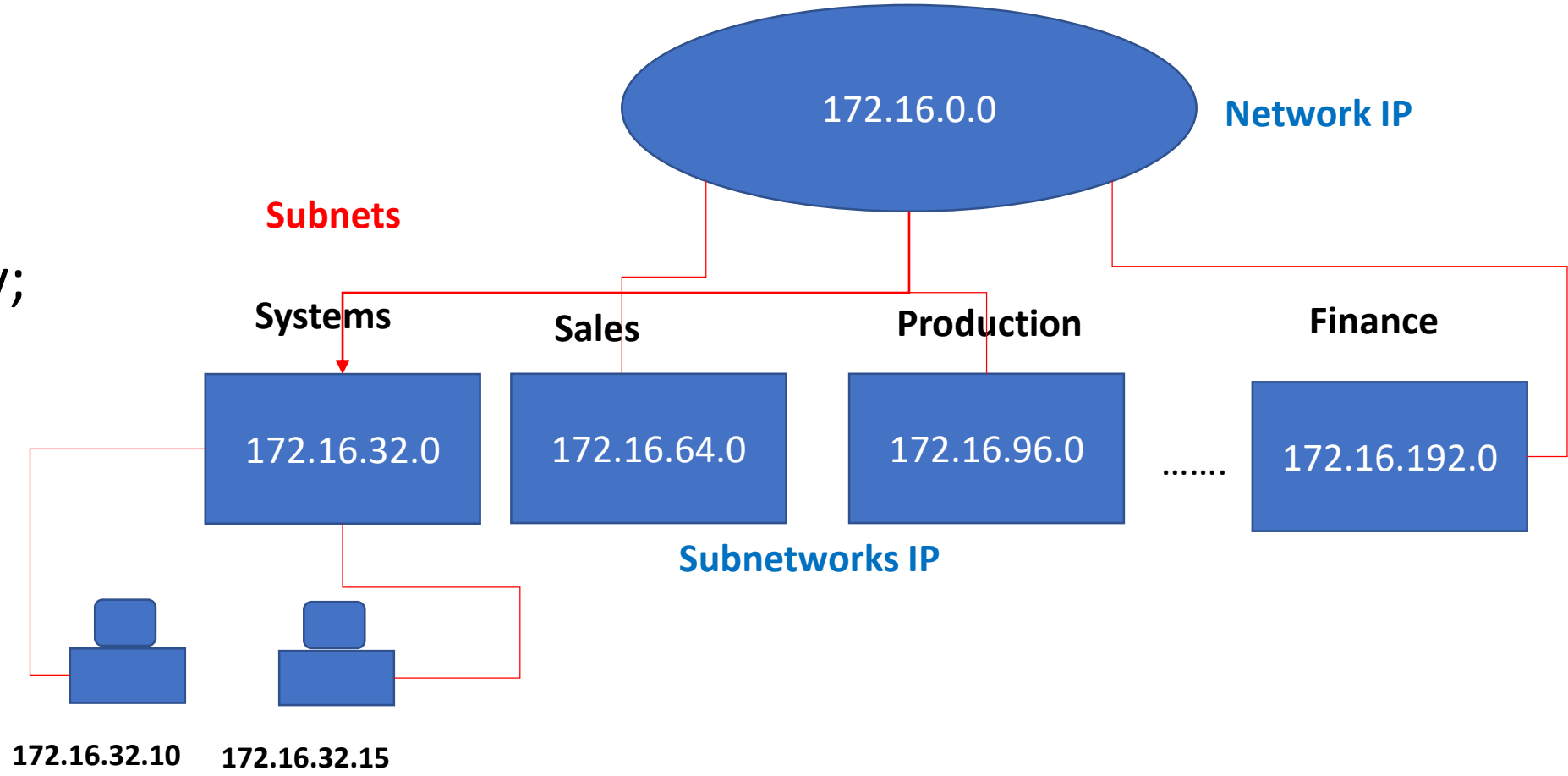
Class C Networks

Range:
192.0.0.0 – 223.255.255.255
N° of networks= 2^n-2
= 2^{21}-2
= 2.097.150
N° of hosts= 2^n-2
=2^8-2
=254
Default Netmask
255.255.255.0
Broadcast
192.168.100.255
E.g: 192.254.253.252, 222.222.222.222.



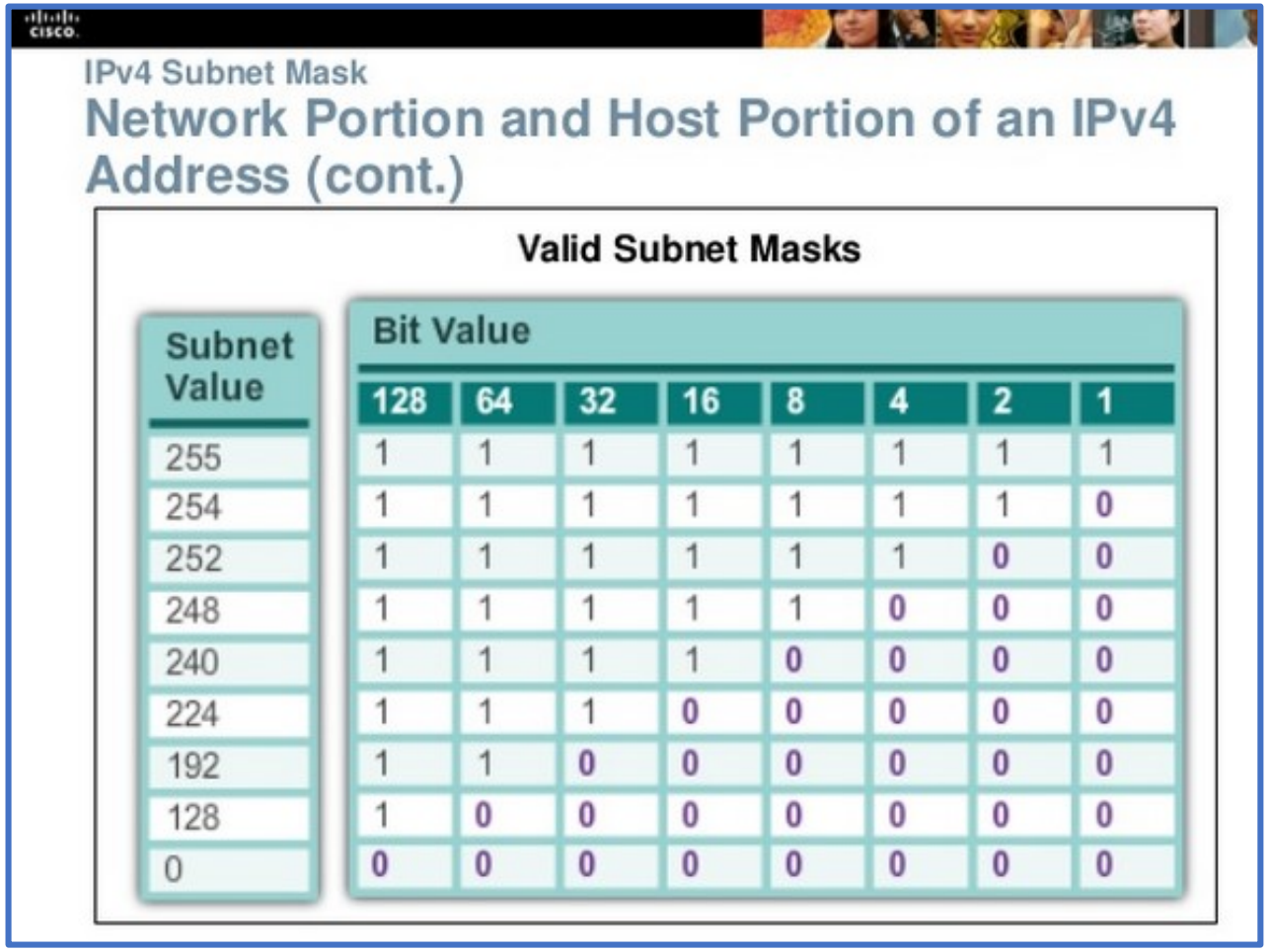
Fixed-length subnet mask (*FLSM*)

- Definition;
- Benefits;
- Calculation way;
- Exercises.



Subnetworks -Definition

- Subnets are a method of maximizing the 32-bit IPv4 address space and reducing the size of the routing tables in a larger internetwork.
- In any address class, subnets provide a means of allocating some of the host address space to network addresses, allowing for more networks.
- The part of the host address space assigned to new network addresses is known as the subnet number.



Subnet Value	Bit Value							
	128	64	32	16	8	4	2	1
255	1	1	1	1	1	1	1	1
254	1	1	1	1	1	1	1	0
252	1	1	1	1	1	1	0	0
248	1	1	1	1	1	0	0	0
240	1	1	1	1	0	0	0	0
224	1	1	1	0	0	0	0	0
192	1	1	0	0	0	0	0	0
128	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0

Subredes- Beneficios

- Subnets provide a set of benefits for network administrators and users, ultimately making management and routing more efficient:
  - Avoid unnecessary broadcasts or retransmissions;
  - Increase security options;
  - Simplify administration;
  - Control growth;

IPv4 Subnet Mask

Examining the Prefix Length

	Dotted Decimal	Significant bits shown in binary
Network Address	**10.1.1.0/24**	10.1.1.00000000
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.254	10.1.1.11111110
Broadcast Address	10.1.1.255	10.1.1.11111111
Number of hosts: 2^8 – 2 = 254 hosts		

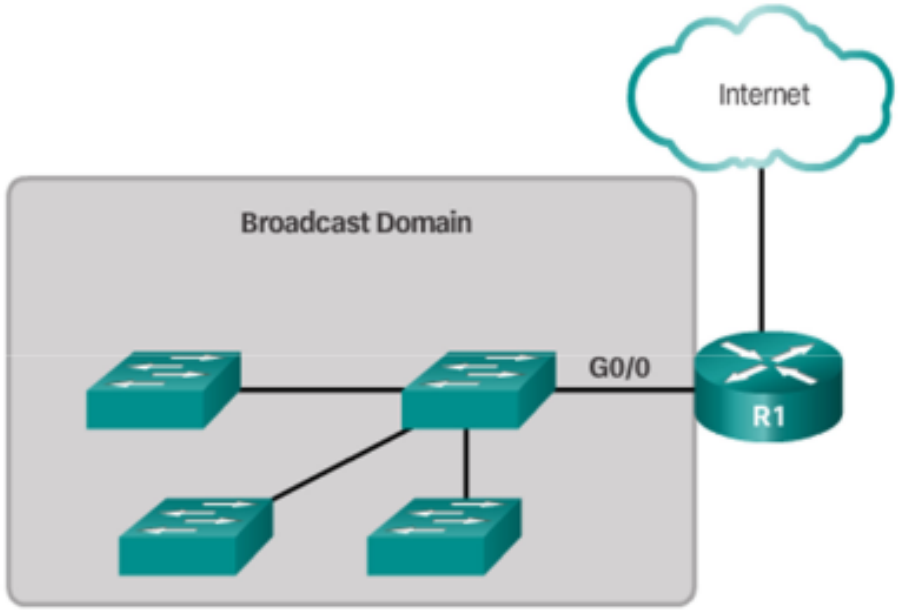
Network Address	**10.1.1.0/25**	10.1.1.00000000
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.126	10.1.1.01111110
Broadcast Address	10.1.1.127	10.1.1.01111111
Number of hosts: 2^7 – 2 = 126 hosts		

Network Address	**10.1.1.0/26**	10.1.1.00000000
First Host Address	10.1.1.1	10.1.1.00000001
Last Host Address	10.1.1.62	10.1.1.00111110
Broadcast Address	10.1.1.63	10.1.1.00111111
Number of hosts: 2^6 – 2 = 62 hosts		

IPV4 subnet calculation

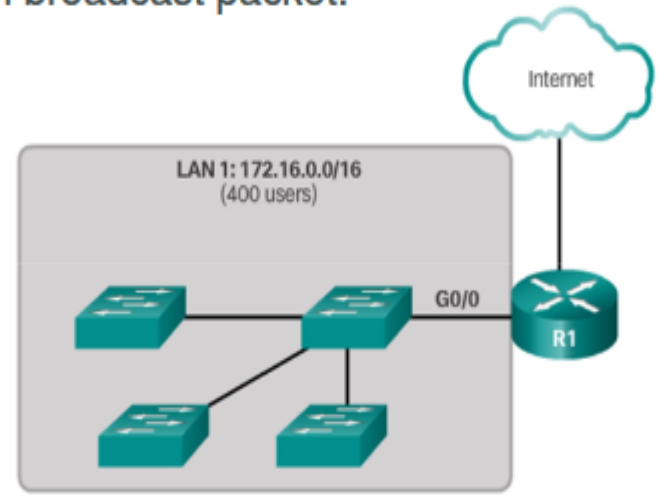
Broadcast Domains

Each router interface connects a *broadcast domain* and broadcasts are only propagated within its specific broadcast domain.



Problems with Large Broadcast Domains

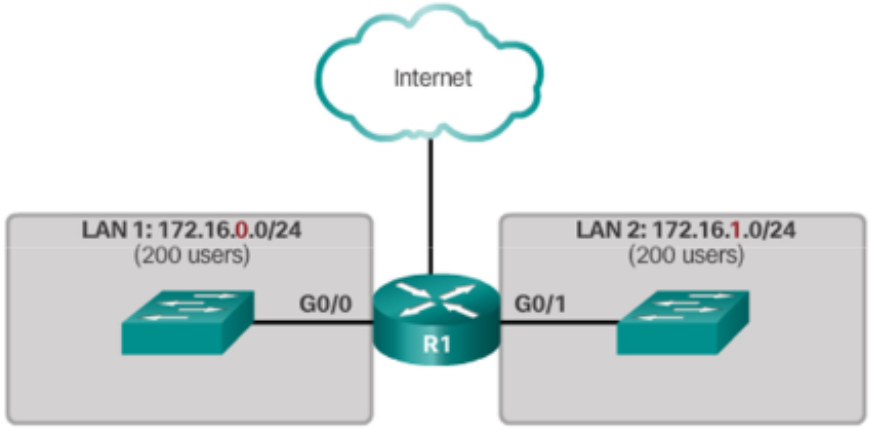
- Slow network operations due to the significant amount of broadcast traffic.
- Slow device operations because a device must accept and process each broadcast packet.



IPV4 subnet calculation

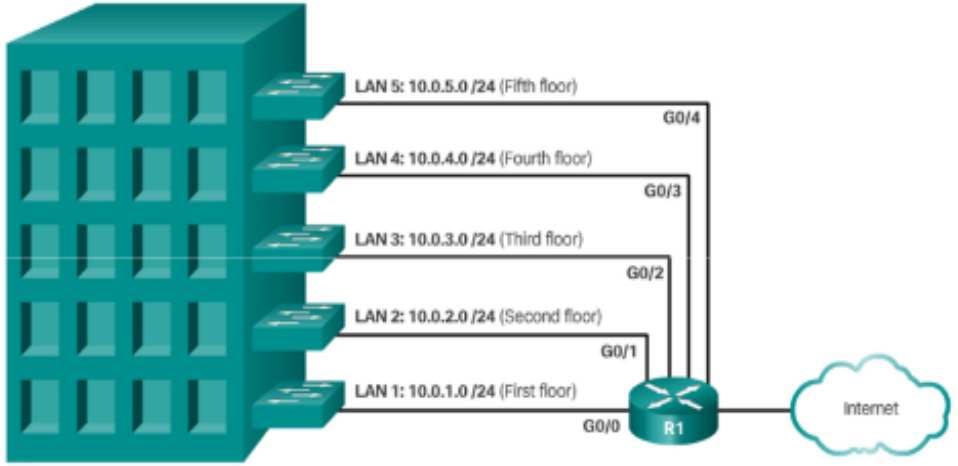
Problems with Large Broadcast Domains (cont.)

- Solution -reduce the size of the network to create smaller broadcast domains in a process called *subnetting*.
- These smaller network spaces are called *subnets*.



Reasons for Subnetting

Network administrators can group devices and services into subnets that are determined by: Location



IPV4 subnet calculation

Octet Boundaries

Subnetting Networks on the Octet Boundary

Prefix Length	Subnet Mask	Subnet Mask in Binary (n = network, h = host)	# of hosts
/8	255.0.0.0	nnnnnnnn.hhhhhhhh.hhhhhhhh.hhhhhhhh 11111111.00000000.00000000.00000000	16,777,214
/16	255.255.0.0	nnnnnnnn.nnnnnnnn.hhhhhhhh.hhhhhhhh 11111111.11111111.00000000.00000000	65,534
/24	255.255.255.0	nnnnnnnn.nnnnnnnn.nnnnnnnn.hhhhhhhh 11111111.11111111.11111111.00000000	254

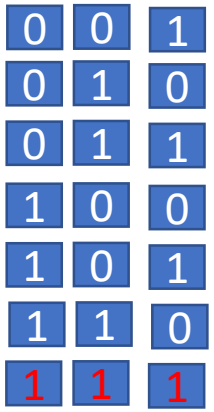
Class B, Subnet Calculation

- We have the network of the company XXY with the address 172.16.0.0. It is requested to divide it into 6 subnets because there are six departments.

1. Calculate the number of subnets (calculate n)

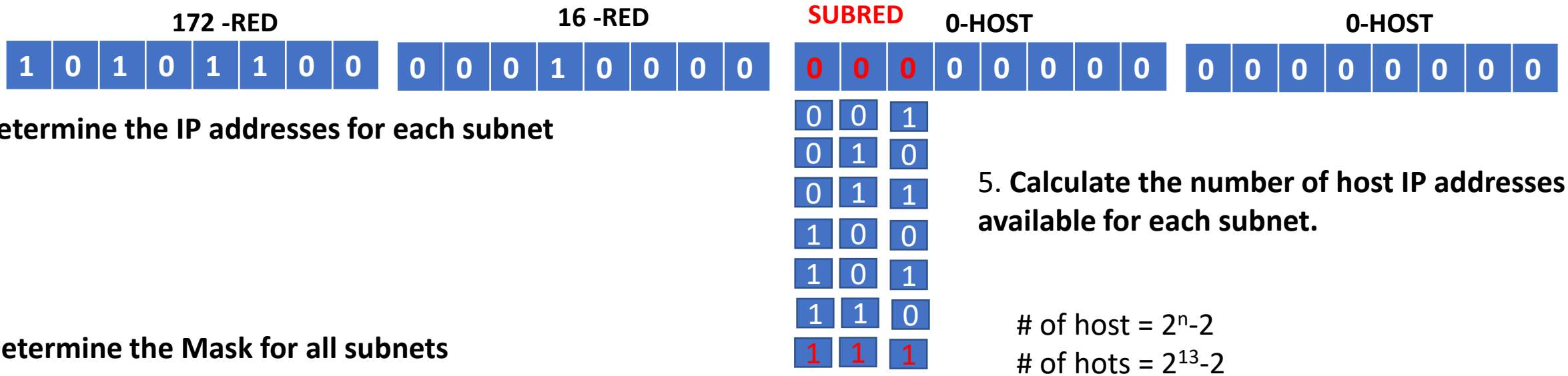
- # de Subredes = 2^n-2
- 6<= 2^3-2
- **n=3**
- Where **n** is the number of bits from the host octet that I will borrow to calculate the subnets

2. **Determine the IP addresses for each subnet**



3. Determine the Mask for all subnets

Class B, Subnet Calculation



2. **Determine the IP addresses for each subnet**

3. **Determine the Mask for all subnets**

4. **Calculate the range and broadcast address for each subnet**

	SUBNET	IP Range Start	IP Range End	BROADCAST
1	172.16.32.0	172.16.32.1	172.16.63.254	172.16.63.255
2	172.16.64.0	172.16.64.1	172.16.95.254	172.16.95.255
3	172.16.96.0	172.16.96.1	172.16.127.254	172.16.127.255
4	172.16.128.0	172.16.128.1	172.16.159.254	172.16.159.255
5	172.16.160.0	172.16.160.1	172.16.191.254	172.16.191.255
6	172.16.192.0	172.16.192.1	172.16.223.254	172.16.223.255

5. **Calculate the number of host IP addresses available for each subnet.**

# of host = 2^n-2
# of hots = 2^{13}-2
# of host = **8190.**

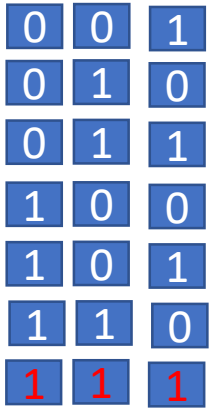
Netmask 255.255.**224**.0

Calculus validation

IP Subnet Calculator (executable, online)

Ejercicio: Cálculo de Subredes-Clase B

- Se tiene la red de la empresa XXY con la dirección 172.16.0.0. Se pide dividirla en 6 subredes por disponer seis departamentos.
  1. **Calcular el número de subredes (calcular n)**
     - # de Subredes = 2^n-2
     - 6= 2^3-2
     - **n=3**
     - Donde **n** es el número de bits del octeto del host que tomaré prestado para calcular las subredes

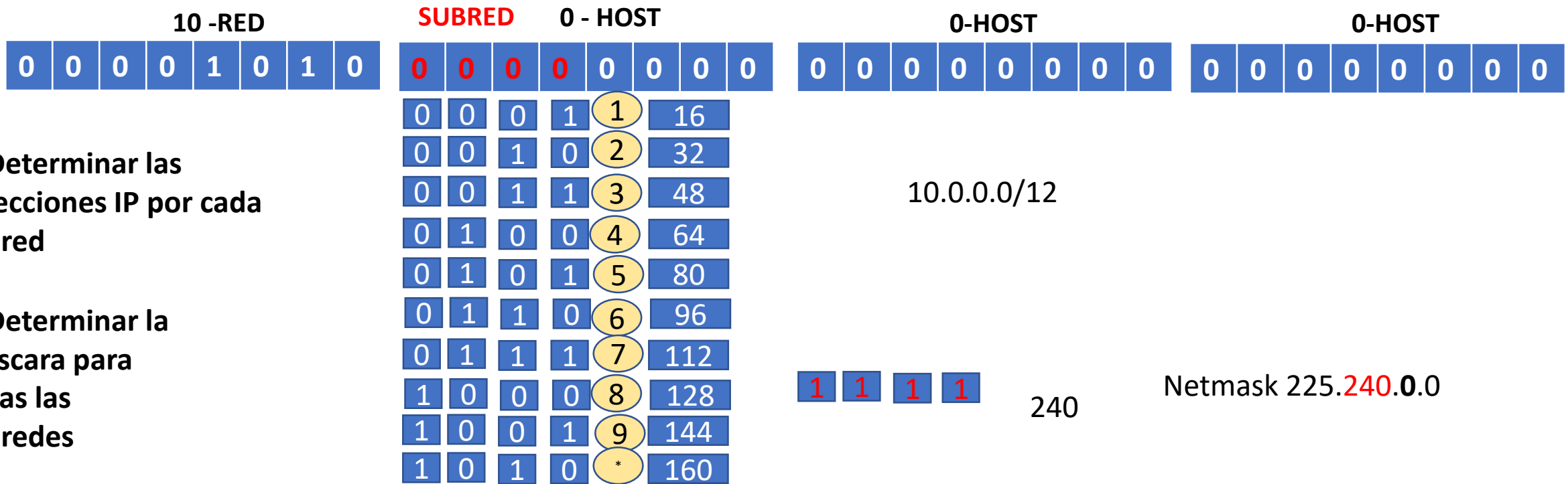


2. **Determinar las Direcciones IP por cada subred**

3. **Determinar la Máscara para todas las subredes**

Cálculo de Subredes-Clase A

- La empresa Líderes dispone de la dirección 10.0.0.0. Se pide dividirla en 10 subredes por disponer diez departamentos.
  1. **Calcular el número de subredes (calcular n)**
     - # de Subredes = 2^n-2
     - 10<= 2^4-2
     - **n=4**
     - Donde **n** es el número de bits del octeto del host que tomaré prestado para calcular las subredes



Cálculo de Subredes-Clase A

4. **Calcular el rango y la dirección de broadcast para cada subred**

N°	SUBRED	INCIO	FIN	BORADCAST
1	10.16.0.0	10.16.0.1	10.31.255.254	10.31.255.255
2	10.32.0.0	10.32.0.1	10.47.255.254	10.47.255.255
3	10.48.0.0	10.48.0.1	10.63.255.254	10.63.255.255
4	10.64.0.0	10.64.0.1	10.79.255.254	10.79.255.255
5	10.80.0.0	10.80.0.1	10.95.255.254	10.95.255.255
6	10.96.0.0	10.96.0.1	10.111.255.254	10.111.255.255
7	10.112.0.0	10.112.0.1	10.127.255.254	10.127.255.255
8	10.128.0.0	10.128.0.1	10.143.255.254	10.143.255.255
9	10.144.0.0	10.144.0.1	10.159.255.254	10.159.255.255

5. **Calcular el número de direcciones IP de host disponibles por cada subred**

de host = 2^n-2
de hots = 2^{20}-2
de host = **1’048.574**

Cálculo de Subredes-Clase C

- La empresa Líderes dispone de la dirección 192.168.100.0. Se pide dividirla en 2 subredes por disponer de dos departamentos.
  1. **Calcular el número de subredes (calcular n)**
     - # de Subredes = 2^n-2
     - 2<= 2^2-2
     - **n=2**
     - Donde **n** es el número de bits más significativos del octeto del host que tomaré prestado para calcular las subredes

2. **Determinar las Direcciones IP por cada subred**

3. **Determinar la Máscara para todas las subredes**

Netmask 225.255.**255**.192

Cálculo de Subredes-Clase C

4. **Calcular el rango y la dirección de broadcast para cada subred**

N°	SUBRED	INCIO	FIN	BROADCAST
1	192.168.100.64	192.168.100.65	192.168.100.126	192.168.100.127
2	192.168.100.128	192.168.100.129	192.168.100.190	192.168.100.191

5. **Calcular el número de direcciones IP de host disponibles por cada subred**

de host = 2^n-2
de hots = 2^6-2
de host = **62**

192.168.100.0/24 255.255.255.0
192.168.100.0/**26** 255.255.255.192
192.168.100.0/28 255.255.255.240
192.168.100.0/29 255.255.255.248

Cálculo de Subredes

Below is a table providing typical subnets for IPv4.

Prefix size	Network mask	Usable hosts per subnet
/1	128.0.0.0	2,147,483,646
/2	192.0.0.0	1,073,741,822
/3	224.0.0.0	536,870,910
/4	240.0.0.0	268,435,454
/5	248.0.0.0	134,217,726
/6	252.0.0.0	67,108,862
/7	254.0.0.0	33,554,430
Class A		
/8	255.0.0.0	16,777,214
/9	255.128.0.0	8,388,606
/10	255.192.0.0	4,194,302
/11	255.224.0.0	2,097,150
/12	255.240.0.0	1,048,574
/13	255.248.0.0	524,286
/14	255.252.0.0	262,142
/15	255.254.0.0	131,070
Class B		
/16	255.255.0.0	65,534
/17	255.255.128.0	32,766
/18	255.255.192.0	16,382
/19	255.255.224.0	8,190
/20	255.255.240.0	4,094
/21	255.255.248.0	2,046
/22	255.255.252.0	1,022
/23	255.255.254.0	510
Class C		
/24	255.255.255.0	254
/25	255.255.255.128	126
/26	255.255.255.192	62
/27	255.255.255.224	30
/28	255.255.255.240	14
/29	255.255.255.248	6
/30	255.255.255.252	2
/31	255.255.255.254	0
/32	255.255.255.255	0

Parte 1: Determinar la división en subredes de la dirección IPv4

En la parte 1, dadas una dirección IPv4 y una máscara de subred, determinará las direcciones de red y de difusión, además de la cantidad de hosts.

REVISIÓN: para determinar la dirección de red, realice la operación AND binaria en la dirección IPv4 utilizando la máscara de subred proporcionada. El resultado será la dirección de red. Sugerencia: si la máscara de subred tiene el valor decimal "255" en un octeto, el resultado SIEMPRE será el valor original de dicho octeto. Si la máscara de subred tiene el valor decimal "0" en un octeto, el resultado SIEMPRE será "0" para dicho octeto.

Por ejemplo:

Dirección IP	192.168.10.10
Máscara de subred	255.255.255.0
	==========
Resultado (red)	192.168.10.0

Si sabe esto, es posible que solamente deba realizar la operación AND binaria en un octeto cuyo valor no sea "255" ni "0" en la porción de la máscara de subred.

Por ejemplo:

Dirección IP	172.30.239.145
Máscara de subred	255.255.192.0

Al analizar este ejemplo, puede ver que solamente debe realizar la operación AND binaria en el tercer octeto. Los primeros dos octetos darán como resultado "172.30" debido a la máscara de subred. El cuarto octeto dará como resultado "0" debido a la máscara de subred.

Dirección IP	172.30.239.145
Máscara de subred	255.255.192.0
	==========
Resultado (red)	172.30.?.0

Realice la operación AND binaria en el tercer octeto.

	Decimal	Binario
	239	11101111
	192	11000000
		=======
Resultado	**192**	11000000

Al analizar este ejemplo otra vez, se obtiene el siguiente resultado:

Dirección IP	172.30.239.145
Máscara de subred	255.255.192.0
	==========
Resultado (red)	172.30.192.0

Continuando con este ejemplo, la cantidad de hosts por red se puede calcular analizando la máscara de subred. La máscara de subred se representa en formato decimal punteado, como 255.255.192.0, o en formato de prefijo de red, como /18. Una dirección IPv4 siempre tiene 32 bits. Al restar la cantidad de bits utilizados para la porción de red (como representa la máscara de subred), se obtiene la cantidad de bits utilizada para los hosts.

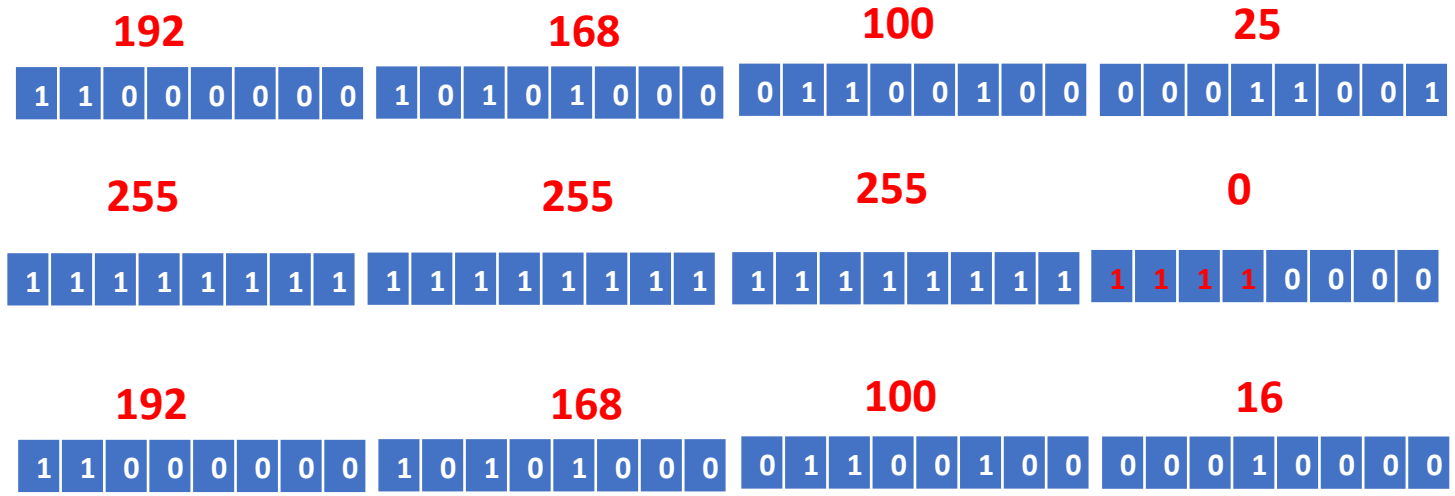
En nuestro ejemplo de arriba, la máscara de subred 255.255.192.0 equivale a /18 en notación de prefijo. Si se restan 18 bits de red de los 32 bits, quedan 14 bits para la porción de host. Desde ahí, el cálculo es sencillo:

$2^{(\text{cantidad de bits de host})} - 2 = \text{Cantidad de hosts}$

$2^{14} = 16\,384 - 2 = 16\,382 \text{ hosts}$

Determine las direcciones de red y de difusión y la cantidad de hosts y de bits de host para las direcciones IPv4 y prefijos dados en la siguiente tabla.

Dirección IPv4/prefijo	Dirección de red	Dirección de difusión	Cantidad total de bits de host	Cantidad total de hosts
192.168.100.25/28	192.168.100.16	192.168.100.31	4	16
172.30.10.130/30	172.30.10.128	172.30.1.131	2	4
10.1.113.75/19	10.1.96.0	10.1.127.255	13	8190
198.133.219.250/24	198.133.219.0	198.133.219.255	8	256
128.107.14.191/22	128.107.12.0	128.107.15.255	10	1024
172.16.104.99/27	172.16.104.96	172.16.104.127	5	32



Parte 2: Calcular la división en subredes de la dirección IPv4

Dadas una dirección IPv4, la máscara de subred original y la máscara de subred nueva, podrá determinar lo siguiente:

- Dirección de red de esta subred
- Dirección de difusión de esta subred
- Intervalo de direcciones de host de esta subred
- Cantidad de subredes creadas

172 16 77 120

10101100 00010000 01001101 01111000

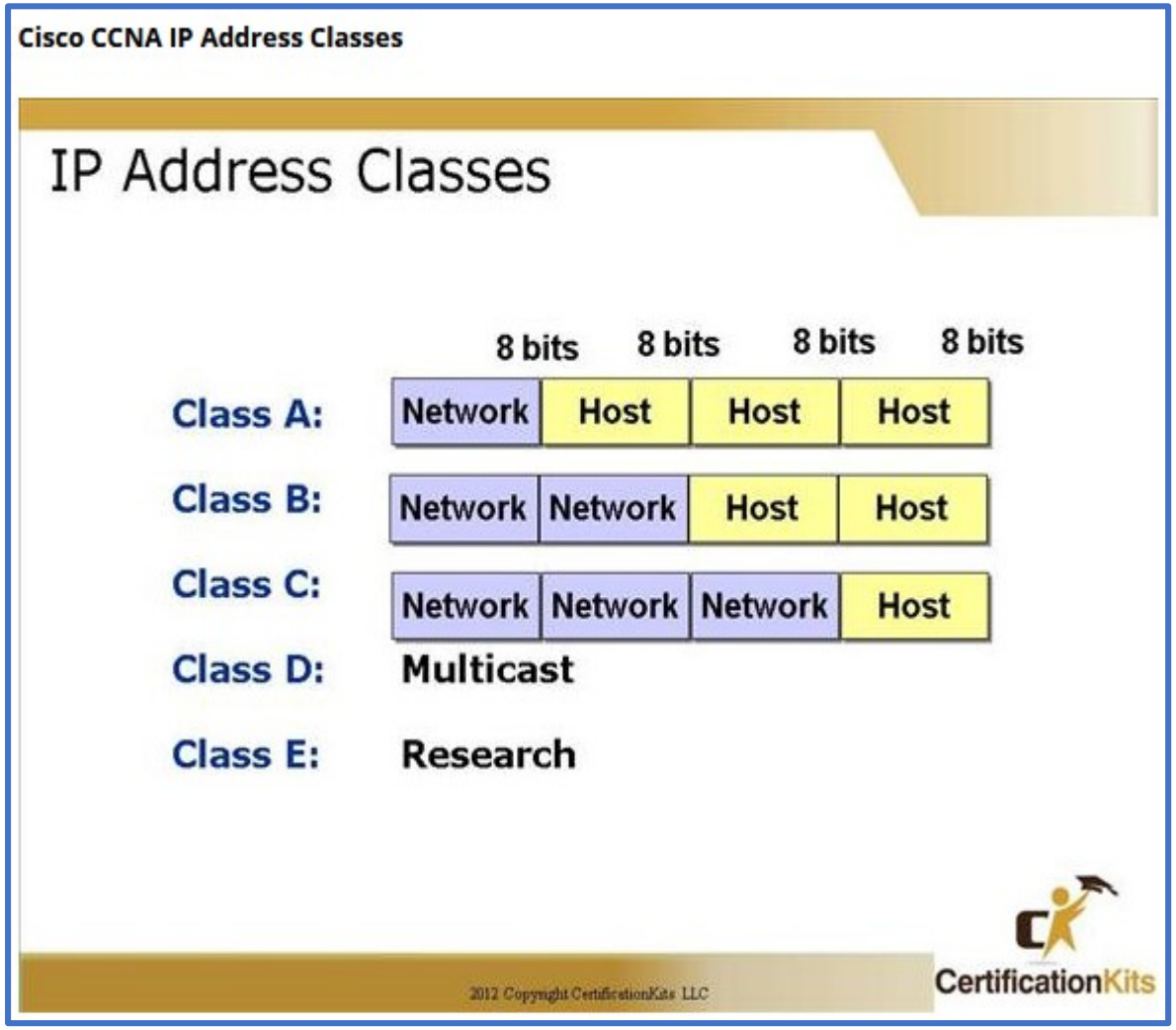
- Cantidad de hosts por subred

En el siguiente ejemplo, se muestra un problema modelo junto con su solución:

Dados:	255 255 240 0 11111111 11111111 11110000 00000000
Dirección IP de host:	172.16.77.120
Máscara de subred original:	255.255.0.0
Máscara de subred nueva:	255.255.240.0
Encontrar:	172 16 64 0 10101100 00010000 01000000 00000000
Cantidad de bits de subred:	4
Cantidad de subredes creadas:	16
Cantidad de bits de host por subred:	12
Cantidad de hosts por subred:	4094
Dirección de red de esta subred:	172.16.64.0
Dirección IPv4 del primer host de esta subred:	172.16.64.1
Dirección IPv4 del último host de esta subred:	172.16.79.254
Dirección IPv4 de difusión de esta subred:	172.16.79.255

What are Classful IPv4 Networks?

- Classful IPv4 Networks are Class A, B, and C networks with an IP range and a mask for each class.
- In this chapter we have seen how from an IP determine:
  - Class (A, B, or C)
  - Default Netmask
  - Network octets / bits Host octets / bits
  - Addressing number of the host on the network
  - Network ID
  - Network broadcast address
  - First and last usable network addresses



Redes Classful: Número de Redes y Hosts soportados para la Clase A, B y C

Clase	Redes	Hosts por Red
A	126	16,777,214
B	16,384	65,534
C	2,097,152	254

Fuente: https://ccnadesdecero.com/curso/redes-classful-ipv4/

Redes Classful: Número de Redes y Hosts soportados para la Clase A, B y C

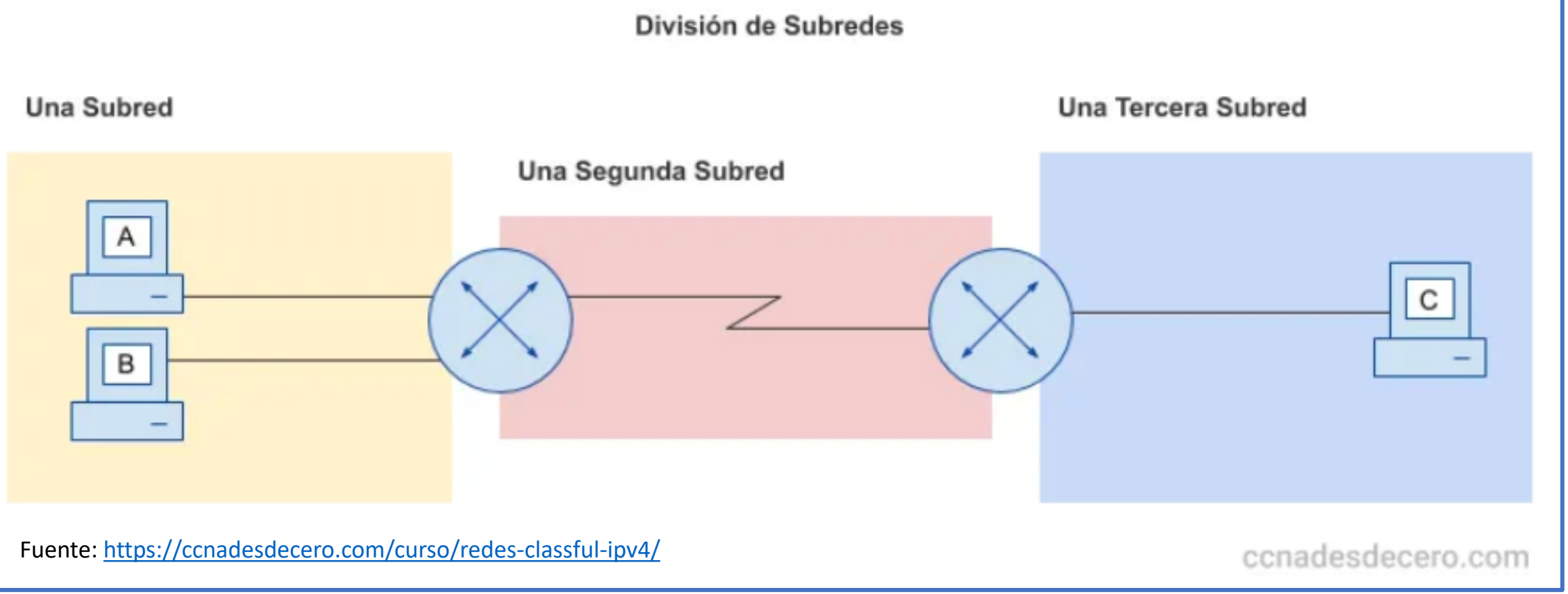
Clase	Rango del Primer Octeto	Redes válidas	Propósito	Número total de redes	Número total de host	Máscara
A	1 a 126	1.0.0.0 a 126.0.0.0	Unicast (redes grandes)	$2^7 - 2 =$ 126	$2^{24} - 2 =$ 16,777,214	255.0.0.0
B	128 a 191	128.0.0.0 a 191.255.0.0	Unicast (redes medianas)	$2^{14} - 2 =$ 16,384	$2^{16} - 2 =$ 65,534	255.255.0.0
C	192 a 223	192.0.0.0 a 223.255.255.0	Unicast (redes pequeñas)	$2^{21} - 2 =$ 2,097,152	$2^8 - 2 =$ 254	255.255.255.0
D	224 a 239	224.0.0.0 a 239.255.255.255	Multicast			Máscara no definida
E	240 a 255	240.0.0.0 a 255.255.255.255	Reservada (formalmente experimental)			Máscara no definida

Fuente: https://ccnadesdecero.com/curso/redes-classful-ipv4/

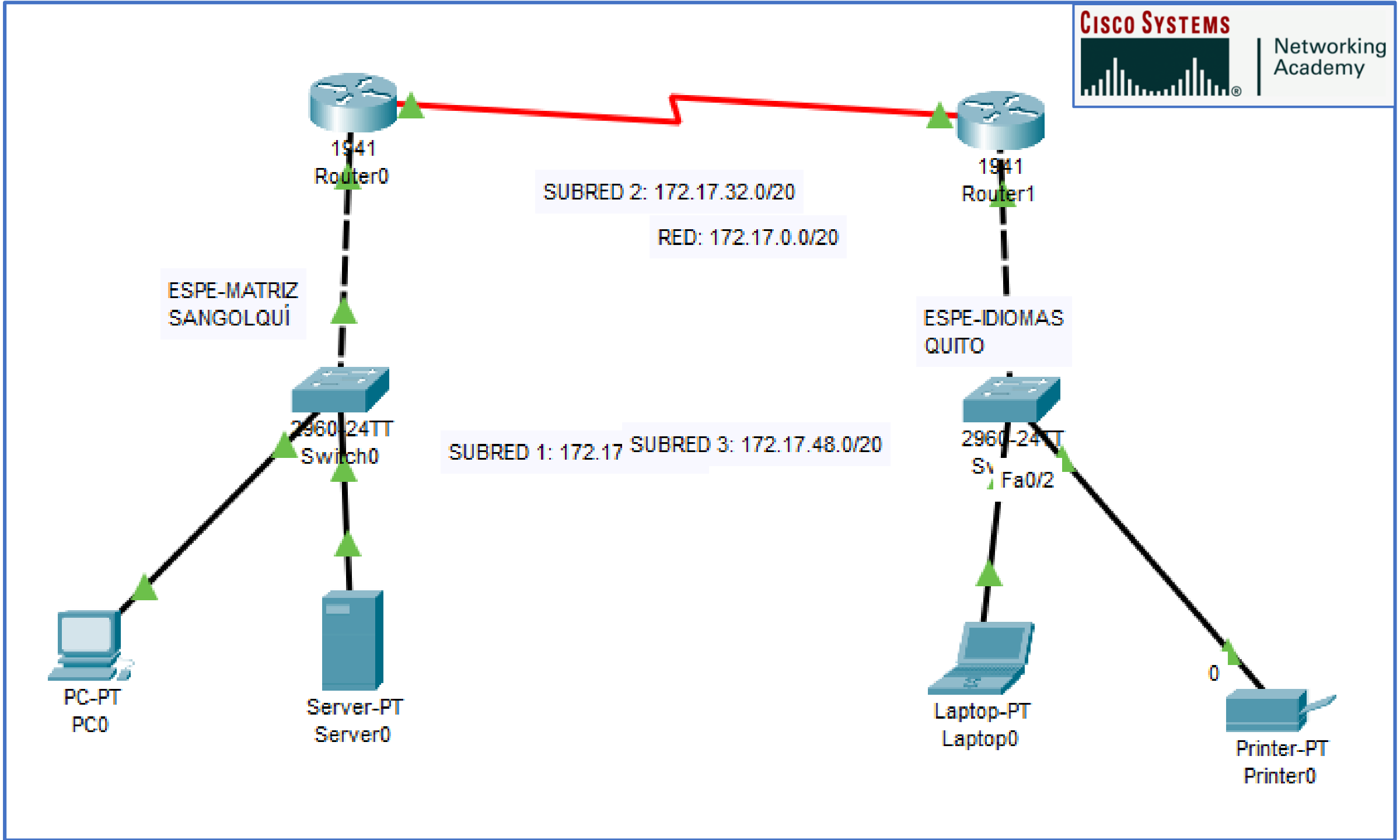
Reglas sobre Subredes y Hosts:

Para que el ruteo funcione eficientemente, **los grupos de direcciones IP se agrupan en subredes** y ésta decisión se toma en base a estas reglas:

- ❑ Direcciones **IP en la misma subred no son separadas** por el router.
- ❑ Direcciones **IP en diferentes subredes son separadas** por al menos un router.



Fuente: https://ccnadesdecero.com/curso/redes-classful-ipv4/


Cisco Systems
Networking Academy
1941
Router0
1941
Router1
SUBRED 2: 172.17.32.0/20
RED: 172.17.0.0/20
ESPE-MATRIZ
SANGOLQUÍ
ESPE-IDIOMAS
QUITO
2960-24TT
Switch0
SUBRED 1: 172.17
SUBRED 3: 172.17.48.0/20
Fa0/2
PC-PT
PC0
Server-PT
Server0
Laptop-PT
Laptop0
Printer-PT
Printer0