NETWORKING FUNDAMENTALS

TEKsystems Global Services

WORKFORCE DEVELOPMENT

COURSE STRUCTURE

Day 1: Networking Fundamentals I

Day 2: Networking Fundamentals II

Day 3: Networking in the Cloud Era

Day 4: Configuration Management & Automation

Day 5: Troubleshooting in the Cloud & Project

AGENDA FOR DAY 1

1. **Introduction to IT Networking:** Definition and components.

2. OSI Model, TCP/IP, Subnetting, Essentials

3. CLIs & Cisco Packet Tracer

INTRODUCTION TO IT NETWORKING

WHAT IS A NETWORK?

- A system that lets devices **exchange data** and **share resources**
- Composed of **endpoints** (hosts), **interconnects** (links/media), and **intermediaries** (switches/routers)
- Scales from a **home LAN** to the **global Internet**

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WHY DO WE NEED NETWORKS?

- **Resource sharing:** printers, storage, apps, cloud
- **Communication:** email, web, APIs, voice/video**intermediaries** (switches/routers)
- **Scalability & resilience:** many paths, fault isolation
- **Security domains:** segment users/services

CORE NETWORK COMPONENTS : ENDPOINTS

- **Hosts:** laptops, servers, phones, IoT
- **NICs:** MAC address, speed/duplex, drivers
- **Virtual endpoints:** VMs, containers, pods

CORE NETWORK COMPONENTS : INTERMEDIARIES

- **Hubs** (legacy, repeaters) vs **Switches** (frame switching, MAC table)
- **Routers** (IP forwarding, subnets, gateways)
- **Wireless APs/Controllers** (RF to Ethernet bridge)
- **Firewalls** (policy enforcement)
- **Load balancers** (traffic distribution)

CABLING & PHYSICAL MEDIA

- **Copper:** UTP Cat5e/6/6A (up to 1/2.5/5/10Gb, distance limits)
- **Fiber:** MMF (OM3/OM4), SMF; transceivers (SFP/SFP+/QSFP)
- **Optics & connectors:** LC, SC; wavelength basics
- **PoE:** power over Ethernet for APs/phones/cams

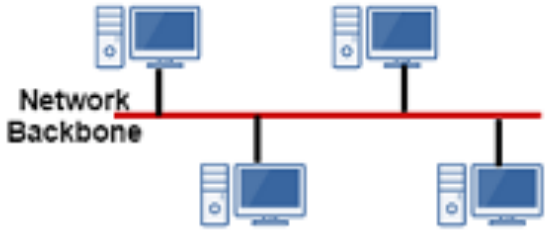
WIRELESS BASICS

- **Wi-Fi (802.11)** bands/channels; APs vs controllers
- **Cellular** (4G/5G) as WAN access
- Trade-offs: mobility vs interference/coverage/planning

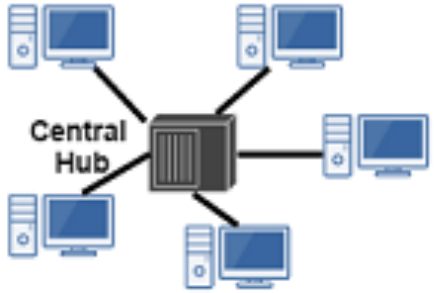
COMMON CONNECTION TYPES

- **LAN (on-prem):** Ethernet (copper/fiber), Wi-Fi
- **WAN (between sites):** MPLS, leased line, Internet + VPN/SD-WAN
- **Data center fabrics:** L2/L3, Spine-Leaf for ECMP
- **Out-of-band (OOB):** management networks/serial

TOPOLOGIES & HOW THINGS CONNECT



Bus



Star

Ring

Mesh

Tree

Point-to-Point

KEY LINK CHARACTERISTICS

- Bandwidth vs throughput (theoretical vs achieved)
- Latency, jitter, loss—impact on apps/voice/video
- Duplex and errors (CRC, drops, discards)

IDENTITY ON THE NETWORK

- MAC address (L2 identity on the local segment)
- IP address (L3 identity/routing between networks)
- Default gateway bridges local → remote networks

SECURITY & SEGMENTATION AT A GLANCE

- Broadcast domains and why we segment (VLANs)
- Routing boundaries and policy points (ACLs, firewalls)
- Principle of least privilege between segments

FROM PHYSICAL TO LOGICAL

- Physical: cables, optics, patching, racks
- Logical: VLANs, SVIs, subnets, VRFs
- Documentation links the two: diagrams, IP/VLAN tables

POP QUIZ:

What are the components of a network ?

A. Endpoints
B. Interstations
C. Intermediaries
D. Hosts

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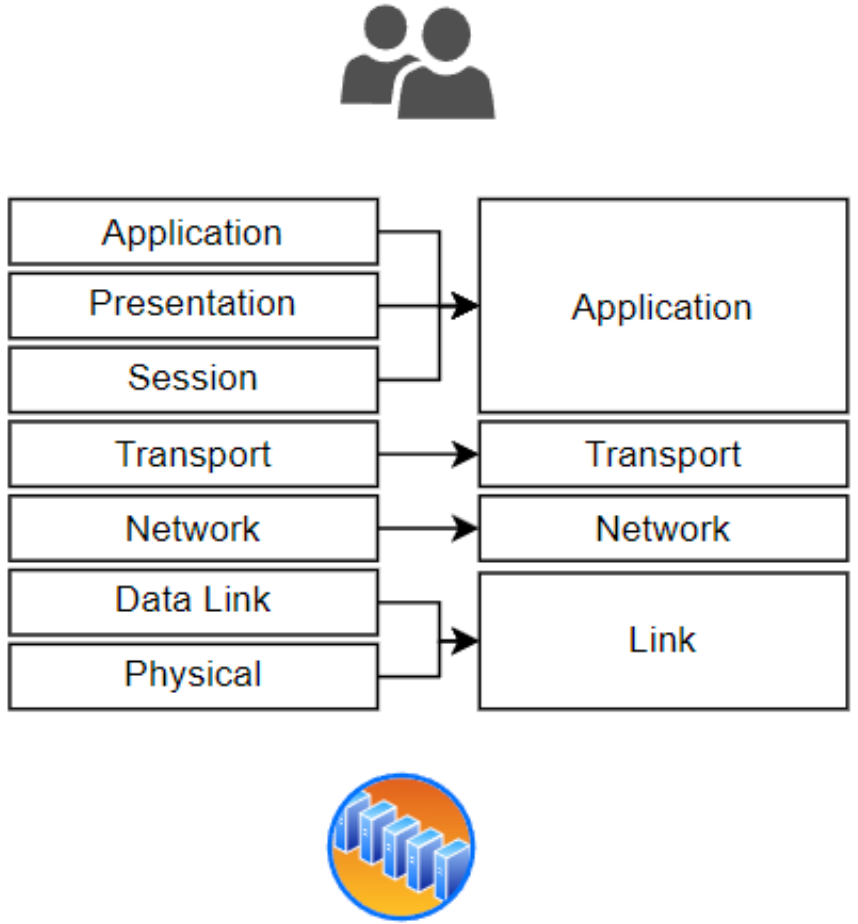
OSI MODEL , TCP-IP, SUBNETTING, ESSENTIAL NETWORKING CLI TOOLS

LEARNING OBJECTIVES

- Explain OSI vs TCP/IP and map real protocols to layers
- Trace a packet end-to-end (ARP → DNS → TCP/HTTP)
- Read key fields in Wireshark (Ethernet, IP, TCP/UDP, DNS)
- Navigate IOS/EOS CLIs, use show, configure interfaces, and save

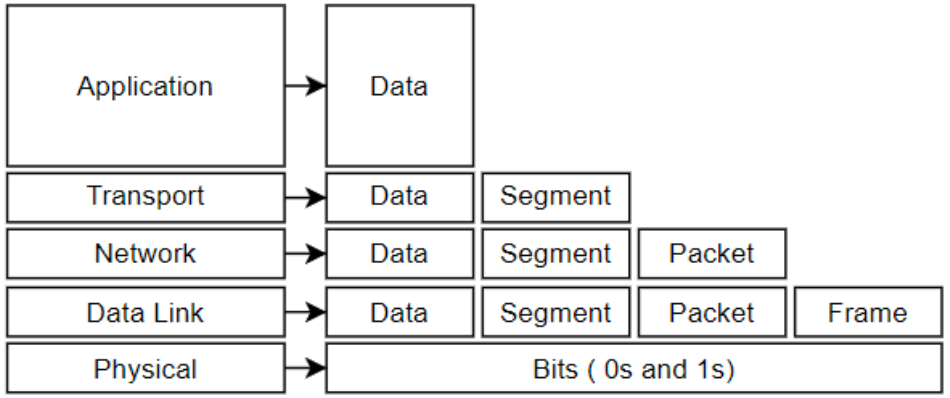
OSI VS TCP/IP MODELS

- OSI Model (7 Layers): Application, Presentation, Session, Transport, Network, Data Link, Physical
- TCP/IP Model (4 Layers): Application, Transport, Internet, Network Access
- Relationship: OSI is a conceptual reference; TCP/IP is practical implementation.



ENCAPSULATION

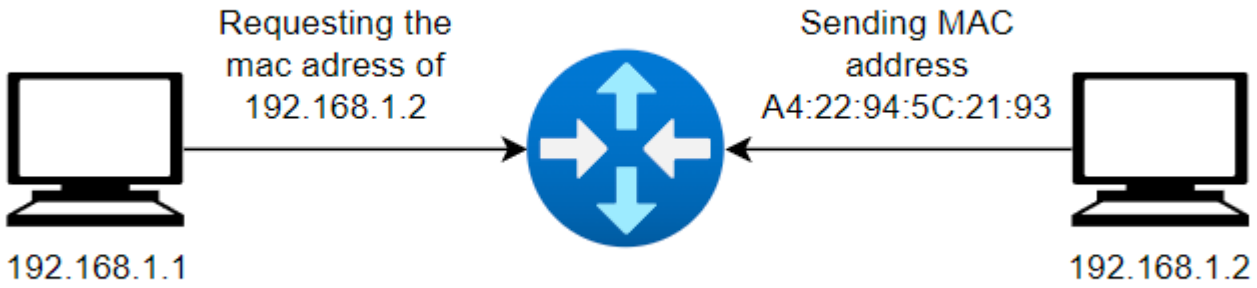
- Encapsulation: Each layer adds headers/trailers around data.
- Process: Application Data → TCP/UDP Segment → IP Packet → Ethernet Frame.
- Transmission: bits on wire; Reception: decapsulation removes headers.
- Purpose: interoperability and abstraction between layers.



MAC ADDRESSING & ARP OVERVIEW

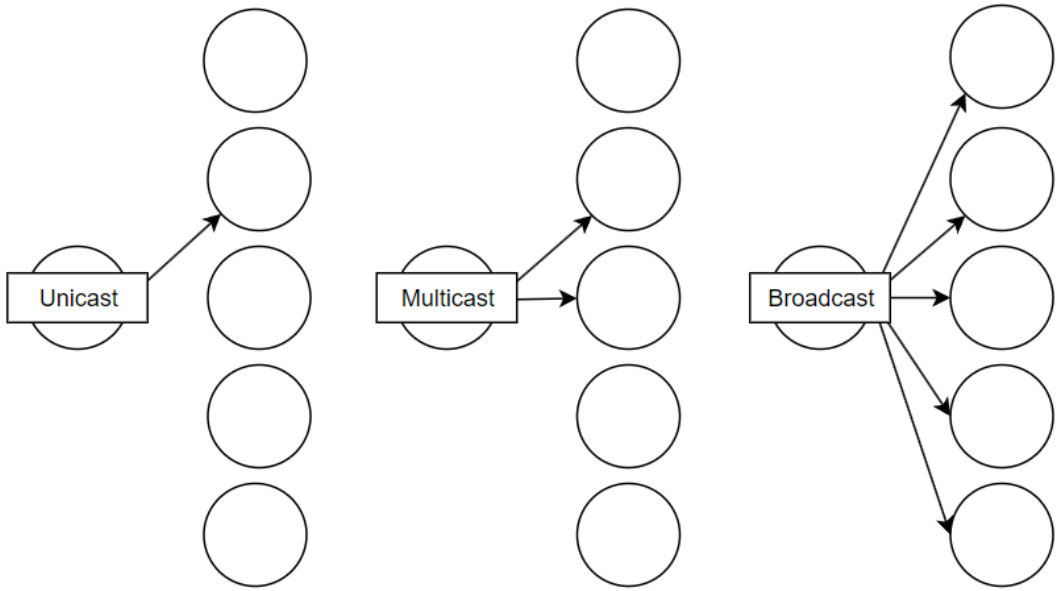
- MAC Address: 48-bit hardware ID, unique per device (e.g., 00:1C:42:2B:60:5A).
- ARP: Resolves IP → MAC within a local network (broadcast request, unicast reply).

- ARP Cache: stores mappings; cleared periodically.
- IPv6 uses Neighbor Discovery instead of ARP.



UNICAST VS BROADCAST VS MULTICAST

- Unicast: one-to-one communication (most traffic).
- Broadcast: one-to-all in a subnet; routers block broadcasts.
- Multicast: one-to-many for groups; receivers opt-in (IGMP/MLD).
- IPv4 multicast 224.0.0.0/4;
  IPv6 multicast ff00::/8.



MTU, FRAGMENTATION, TTL, ICMP

- MTU: Maximum Transmission Unit (e.g., Ethernet 1500 bytes).
- Fragmentation: IPv4 may fragment; IPv6 doesn’t (uses Path MTU Discovery).
- TTL/Hop Limit: prevents loops, decremented per hop.
- ICMP: sends control messages (ping, unreachable, time exceeded).

PHYSICAL MEDIA: COPPER/FIBER, DUPLEX, AUTO-MDIX

- Copper: twisted pair (Cat5e–Cat7); 100m max; sensitive to EMI.
- Fiber: single-mode (long distance), multi-mode (shorter).
- Duplex: full (simultaneous) vs half; mismatches cause errors.
- Auto-MDIX: automatic cross-over correction on Ethernet ports.

IP ADDRESSING 101: NETWORK VS HOST

- IP Address = Network Portion + Host Portion.
- Examples : 10.0.0.1/24

- Subnet mask defines boundary between network and host.
- 255.255.255.0 -> available ip addresses

- Routers forward between networks; switches forward within one network.

PRIVATE VS PUBLIC RANGES (RFC1918)

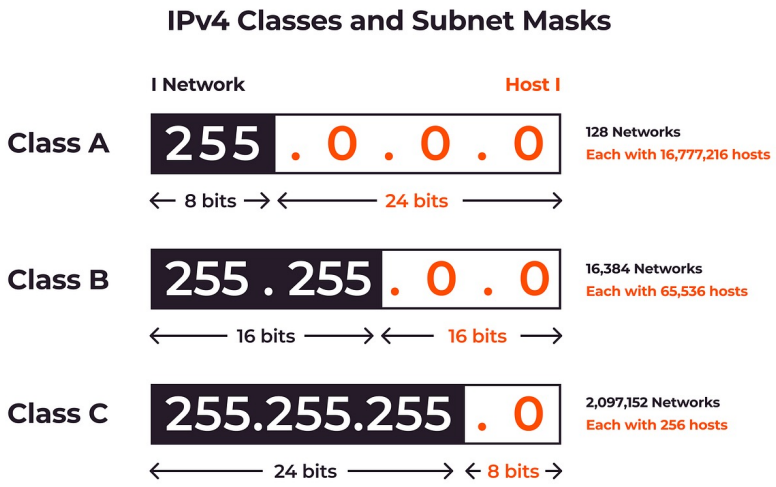
- Private IPv4 ranges: 10.0.0.0/8, 172.16.0.0–172.31.0.0/12, 192.168.0.0/16.
- Public IPs are routable on the Internet; private are not.
- NAT (Network Adress Translation) translates private ↔️ public addresses.
- RFC1918 defines private use ranges.

CIDR NOTATION & SUBNET MASKS

- CIDR: Classless Inter-Domain Routing, written as /N (e.g., 192.168.1.0/24).
- Subnet mask determines prefix length: /24 = 255.255.255.0.
- CIDR enables efficient IP allocation and reduces routing table size.

VLSM CONCEPT AND BENEFITS

- VLSM: Variable Length Subnet Masking – using different subnet sizes.
- Allows optimal address usage by assigning smaller/larger subnets as needed.
- Enhances flexibility and reduces waste of IP addresses.



SUBNETTING METHOD

- Step 1: Determine required subnets and hosts.
- Step 2: **Borrow** bits from host portion for subnets.
- Step 3: **Calculate** subnet **ranges**, broadcast, and host counts.
- Formula: Hosts = 2^h - 2.

SUBNETTING EXAMPLE 1 (/24 TO /26, /27)

- Start with 192.168.10.0/24 (256 addresses).
- /26 → 64 addresses per subnet (62 usable).
- /27 → 32 addresses per subnet (30 usable).
- Demonstrate creating four /26 subnets and eight /27 subnets.

Subnet	Network	First Usable	Last Usable	Broadcast
1	192.168.10.0/26	192.168.10.1	192.168.10.62	192.168.10.63
2	192.168.10.64/26	192.168.10.65	192.168.10.126	192.168.10.127
3	192.168.10.128/26	192.168.10.129	192.168.10.190	192.168.10.191
4	192.168.10.192/26	192.168.10.193	192.168.10.254	192.168.10.255

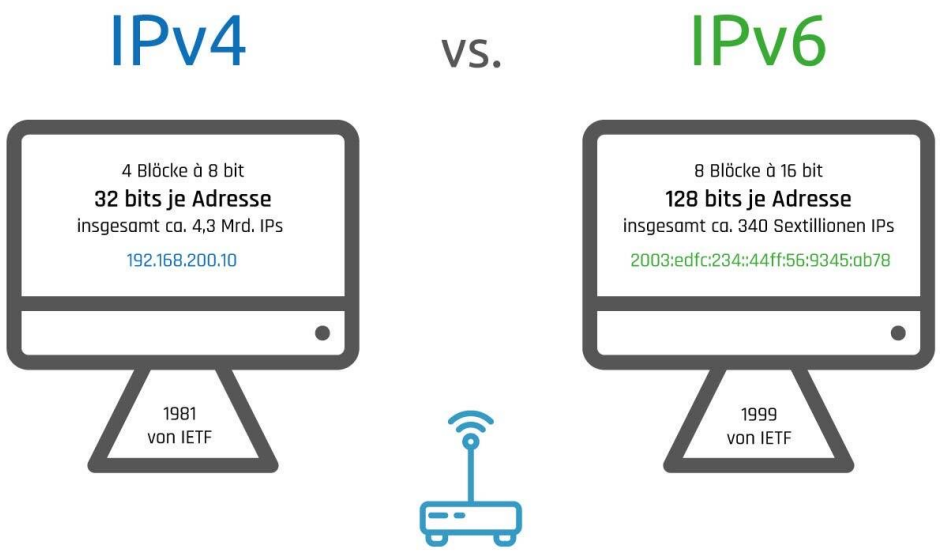
SUBNETTING EXAMPLE 2 (VLSM FOR MIXED SIZES)

- Example: Need subnets for 50 hosts, 20 hosts, 10 hosts.
- Start from largest: allocate /26 (62 hosts), then /27 (30 hosts), then /28 (14 hosts).
- VLSM prevents waste of addresses.

Requirement	Subnet	Network	Usable Hosts	Broadcast
50 hosts	/26	192.168.10.0	192.168.10.1–62	192.168.10.63
20 hosts	/27	192.168.10.64	192.168.10.65–94	192.168.10.95
10 hosts	/28	192.168.10.96	192.168.10.97–110	192.168.10.111

IPV6 BASICS: NOTATION, TYPES, SCOPE

- IPv6 = 128-bit address written in hexadecimal (e.g., 2001:db8::1).
- No broadcast; supports unicast, multicast, anycast.
- Abbreviations: omit leading zeros, use :: for consecutive zeros once.



LINK-LOCAL VS GLOBAL UNICAST, EUI-64

- Link-local (fe80::/10): auto-configured, used on local link only.
- Global unicast: routable on Internet (e.g., 2000::/3).
- EUI-64: generates interface ID from MAC (inserts ff:fe and flips bit).

TOOLS: PING, TRACEROUTE, IPCONFIG/IFCONFIG

- ping: tests reachability using ICMP Echo.
- traceroute/tracert: displays path and latency per hop.
- ipconfig (Windows) / ifconfig or ip (Linux): shows IP configuration.
- nslookup / dig: DNS resolution diagnostics.

POP QUIZ:

What is the subnet mask for a /26 network?

A. 255.255.255.0
B. 255.255.255.192
C. 255.255.255.224
D. 255.255.255.240

POP QUIZ:

What is the subnet mask for a /26 network?

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POP QUIZ:

Which of the following is the broadcast address of the subnet 192.168.10.0/27?

A. 192.168.10.31
B. 192.168.10.32
C. 192.168.10.30
D. 192.168.10.1

POP QUIZ:

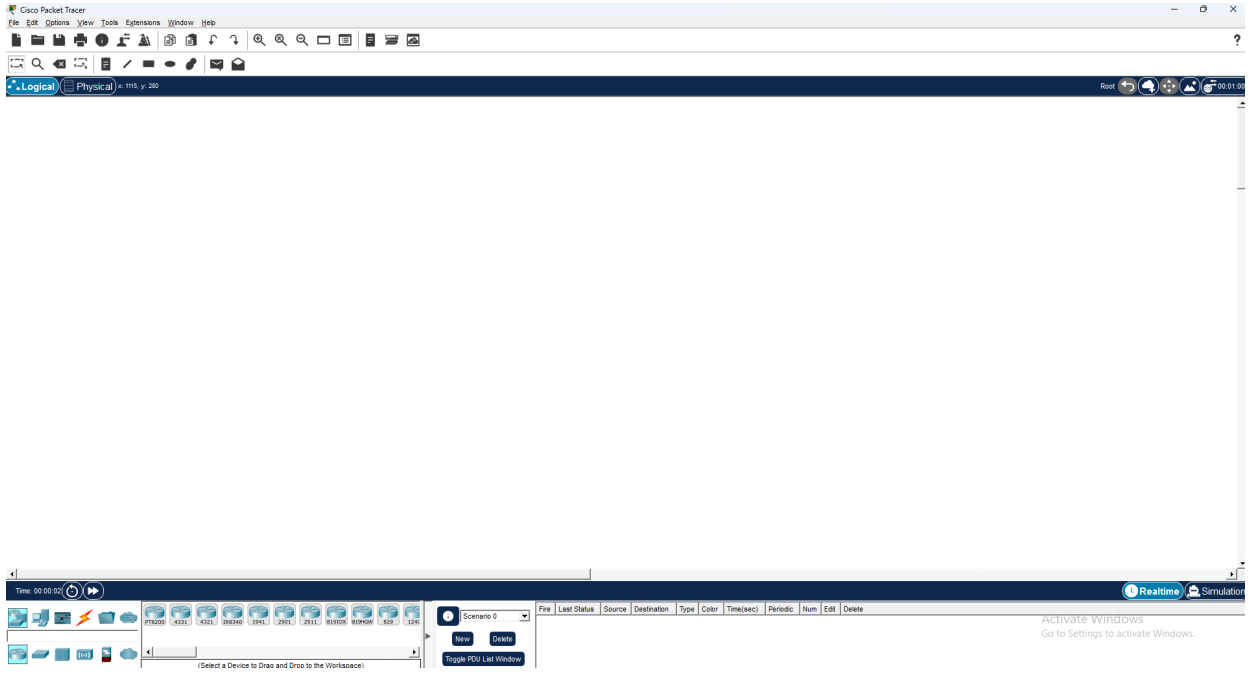
Which of the following is the broadcast address of the subnet 192.168.10.0/27?

A. 192.168.10.31
B. 192.168.10.32
C. 192.168.10.30
D. 192.168.10.1

CLIS & CISCO PACKET TRACER

INTRODUCTION TO CISCO PACKET TRACER

- Free Cisco simulation tool for network configuration and troubleshooting
- Visualizes packet flow between devices
- Supports routers, switches, PCs, servers, and IoT devices
- Ideal for CCNA-level labs and classroom demos



KEY FEATURES AND SIMULATION MODES

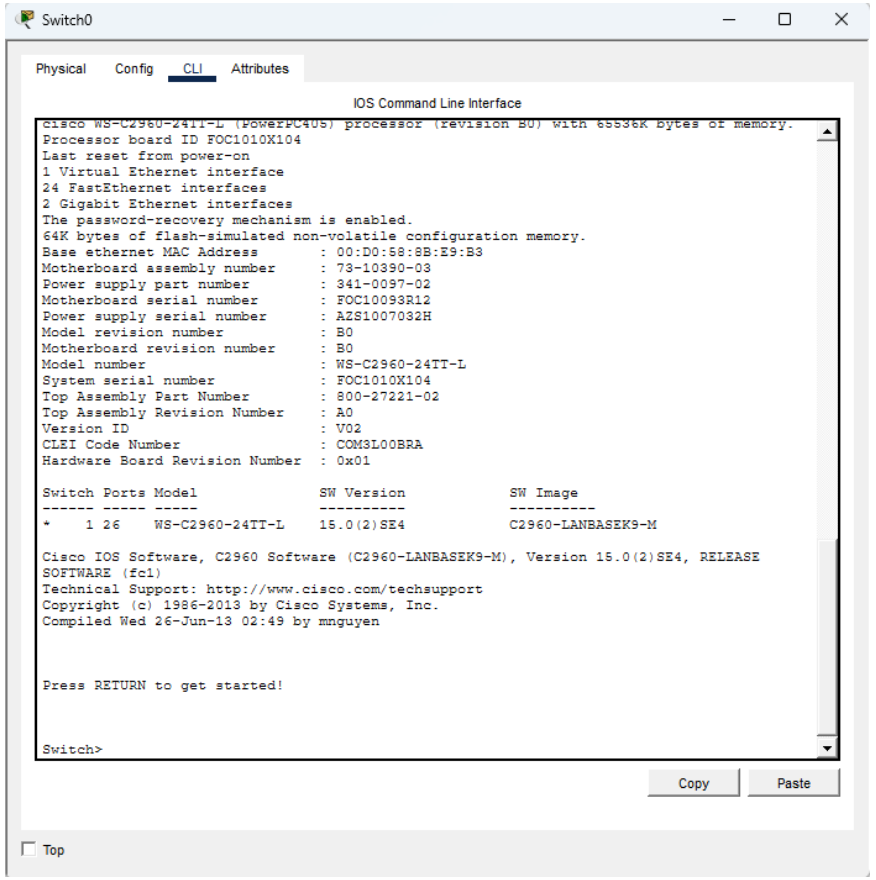
- Free Cisco simulation tool for network configuration and troubleshooting
- Visualizes packet flow between devices
- Supports routers, switches, PCs, servers, and IoT devices
- Ideal for CCNA-level labs and classroom demos

LAB DESIGN TIPS

- Start small: test connectivity between 2–3 nodes
- Add routers and subnets progressively
- Use labels for IPs and interfaces
- Save snapshots for each step
- Verify using ping, show ip int brief, and arp

CISCO IOS OVERVIEW

- Cisco IOS = Internetwork Operating System
- Runs on Cisco routers and switches
- Hierarchical CLI: User EXEC → Privileged EXEC → Global Config → Interface Config
- Uses context-sensitive help (?)

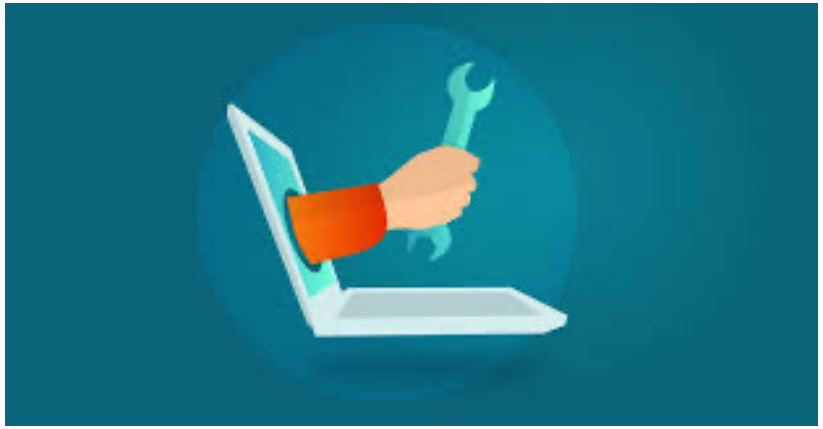


ESSENTIAL IOS COMMANDS

- show ip int brief – list interfaces
- show running-config / show startup-config
- configure terminal, interface g0/0, ip address …, no shutdown
- copy running-config startup-config

IOS TROUBLESHOOTING TOOLS

- ping and traceroute
- show arp, show mac address-table
- debug ip packet, show logging
- clear counters, reload



ARISTA EOS OVERVIEW

- EOS = Extensible Operating System
- Based on Linux (Fedora Core)
- Modular architecture with independent processes (SysDB, agents)
- CLI compatible with Cisco IOS (similar syntax)

ARISTA EOS CLI & CONFIGURATION

- Privilege levels like Cisco IOS (enable, configure terminal)
- Common commands:
  - show interfaces status
  - show ip route
  - copy running-config startup-config
- Supports eAPI, Python, and Ansible for automation

EOS IN MODERN NETWORKS

- Used in spine-leaf architectures and data centers
- Supports advanced features: VXLAN, MLAG, EVPN
- Programmable and API-driven (JSON-RPC)
- Backed by a strong open automation ecosystem

POP QUIZ:

Which of these commands runs on the ICMP protocol?

A. ssh
B. ping
C. telnet
D. curl

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A. show ip interface brief
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C. systemctl status
D. kubectl get pods

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LAB 00: PACKET TRACER DISCOVERY

- Goal: Discover CISCO Packet Tracer
- Steps:
  - Navigate through panels
  - Drag and drop network devices and endpoints
  - Connect components

LAB 01: NETWORKING FUNDAMENTALS WITH CISCO

- Goal: Master basic networking concepts and packet analysis.
- Steps:
  - Build basic LAN topology with PCs and switch.
  - Configure IP addressing and test connectivity.
  - Analyze ARP tables and MAC address learning.
  - Observe packet encapsulation in simulation mode.

LAB 02: VLSM ADDRESS DESIGN

- Goal: Design efficient IP addressing using VLSM.
- Steps:
  - Calculate subnet requirements for different departments.
  - Apply VLSM to minimize IP waste.
  - Configure subnets on router interfaces.
  - Verify routing between subnets.

LAB 03: IPV6 CONFIGURATION

- Goal: Implement IPv6 addressing and routing.
- Steps:
  - Configure IPv6 addresses on devices.
  - Enable IPv6 routing on router.
  - Test IPv6 connectivity with ping6.
  - Compare IPv4 and IPv6 address structures.