

Introduction to Routing and Switching

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Fundamentals, key concepts, and typical device roles in modern IP networks.

1. Overview

Layer (OSI)	Primary Function	Typical Devices	Core Purpose
Layer 2 – Data Link	Forward frames based on MAC addresses within a single broadcast domain.	Switches, bridges, NICs	Local area connectivity, VLAN segmentation.
Layer 3 – Network	Forward packets based on IP addresses across multiple broadcast domains.	Routers, Layer 3 switches, firewalls	Inter-network communication, path selection, traffic control.

Routing and switching together create a scalable, resilient network that can move data efficiently from a source host to a destination host, whether they are on the same LAN or across the globe.

2. Switching Fundamentals

2.1 Basic Operation

- Frame Reception** – Switch receives an Ethernet frame on a port.
- MAC Learning** – Source MAC → port mapping is stored in the **CAM (Content-Addressable Memory)** table.
- Forwarding Decision**
 - Known Destination MAC** → forward out the specific port.
 - Unknown Destination MAC** → **flood** to all ports in the same VLAN (except the incoming port).
- Loop Prevention** – Spanning Tree Protocol (STP) disables redundant links to avoid broadcast storms.

2.2 Key Features

Feature	Description	Benefit
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VLANs (Virtual LANs)	Logical segmentation of a switch into separate broadcast domains.	Improves security, reduces broadcast traffic.
Trunking (802.1Q)	Carries multiple VLANs over a single link using tags.	Efficient use of uplink bandwidth.
Port Security	Limits MAC addresses per port, can shut down ports on violation.	Mitigates MAC spoofing attacks.
Link Aggregation (LACP)	Bundles multiple physical links into one logical link.	Increases bandwidth, provides redundancy.
Quality of Service (QoS)	Prioritizes traffic (e.g., voice, video).	Guarantees performance for latency-sensitive apps.

2.3 Switch Types

Type	Typical Use	Notable Traits
Unmanaged Switch	Small offices, home labs.	Plug-and-play, no configuration.
Managed Switch	Enterprise LANs.	CLI/GUI/REST API, VLANs, STP, QoS.
Layer 3 Switch	Campus core/aggregation.	Hardware-based routing, high-speed inter-VLAN routing.
PoE Switch	Powering IP phones, APs, cameras.	Supplies up to 30W per port (IEEE 802.3bt).

3. Routing Fundamentals

3.1 Basic Operation

1. **Packet Reception** – Router receives an IP packet on an interface.
2. **Lookup** – Destination IP is matched against the **routing table**.
3. **Forwarding Decision** – Selects the **best route** (longest-prefix match, lowest metric).
4. **Encapsulation** – Packet is placed in a new frame appropriate for the outgoing interface.
5. **Transmission** – Frame is sent out the selected interface.

3.2 Routing Table Components

Entry Type	Description
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Directly Connected Networks attached to router interfaces (e.g., 192.168.1.