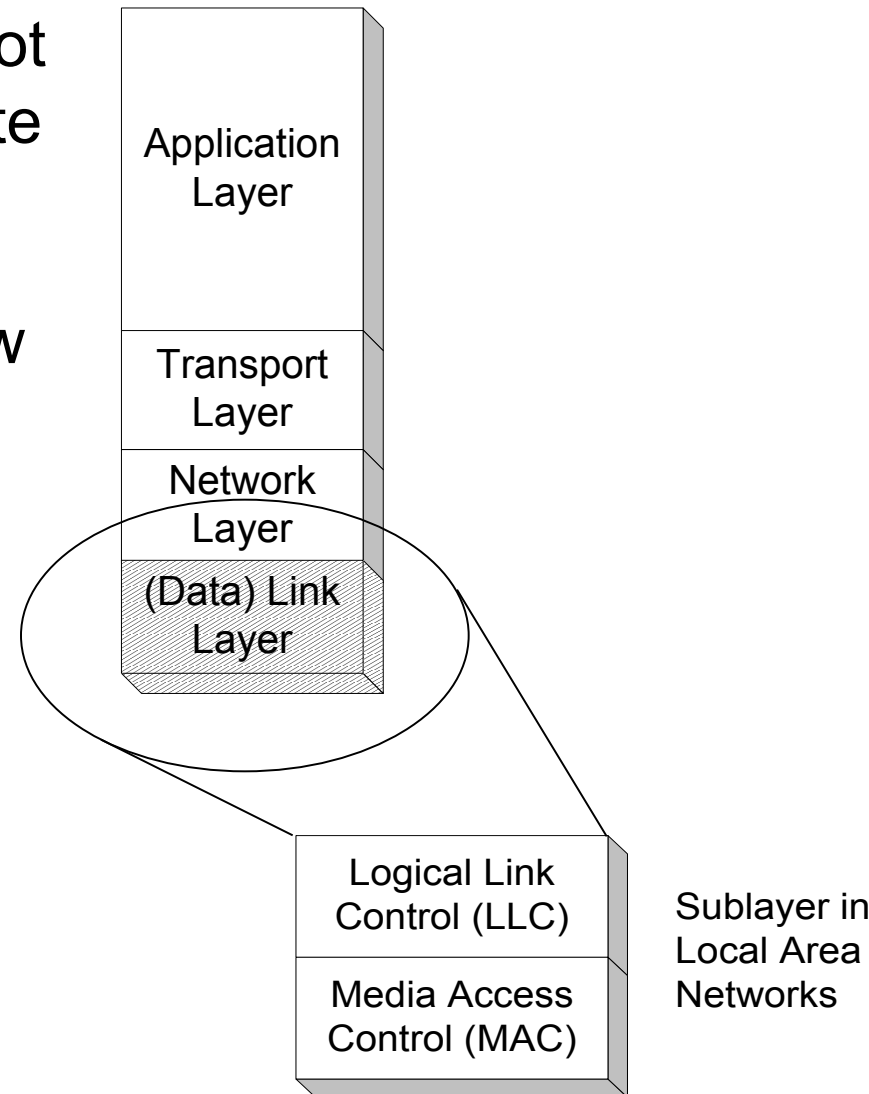# Data Link Protocols

This module covers data link layer issues, such as local area networks (LANs) and point-to-point links, Ethernet, and the Point-to-Point Protocol (PPP).

TCP/IP Suite and OSI Reference Model

• The TCP/IP protocol stack does not define the lower layers of a complete protocol stack

• In this lecture, we will address how the TCP/IP protocol stacks interfaces with the data link layer

Application Layer

Transport Layer

Network Layer

(Data) Link Layer

Logical Link Control (LLC)

Media Access Control (MAC)

Sublayer in Local Area Networks

Data Link Layer

- The main tasks of the data link layer are:
  - Transfer data from the network layer of one machine to the network layer of another machine
  - Convert the raw bit stream of the physical layer into groups of bits ("frames")
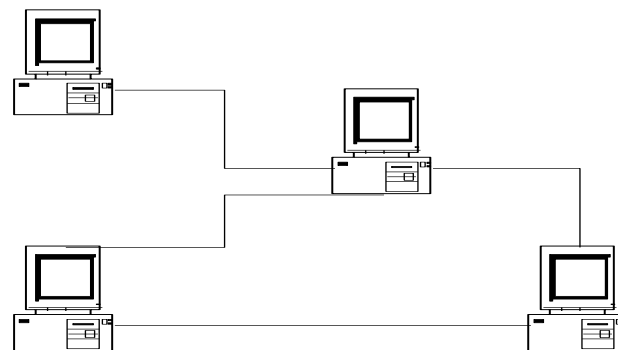
Two types of networks at the data link layer

- – Broadcast Networks: All stations share a single communication channel
- – Point-to-Point Networks: Pairs of hosts (or routers) are directly connected
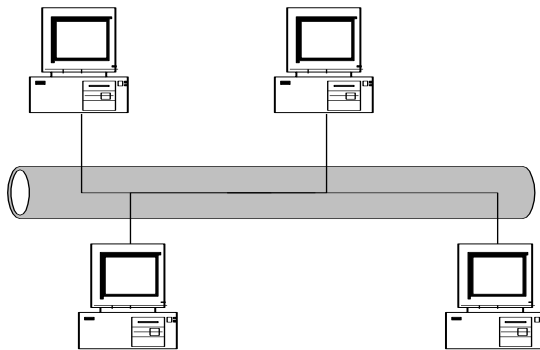

Broadcast Network   Point-to-Point Network

- • Typically, local area networks (LANs) are broadcast and wide area networks (WANs) are point-to-point

Local Area Networks

- Local area networks (LANs) connect computers within a building or a enterprise network

- Almost all LANs are broadcast networks

- Typical topologies of LANs are **bus** or **ring** or **star**

- We will work with Ethernet LANs. Ethernet has a bus or star topology.
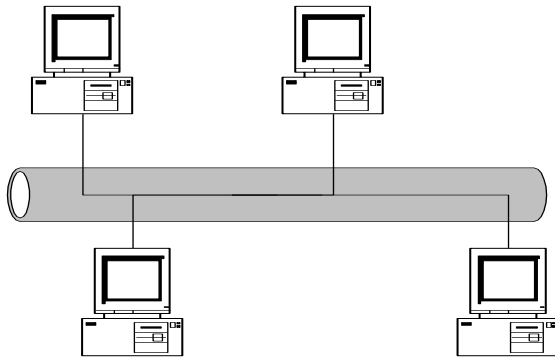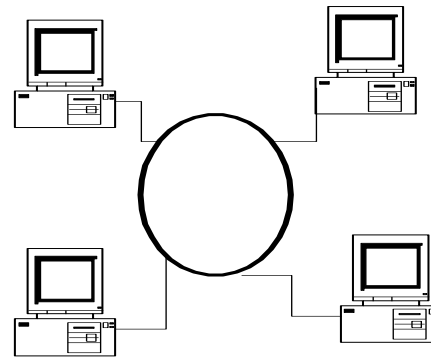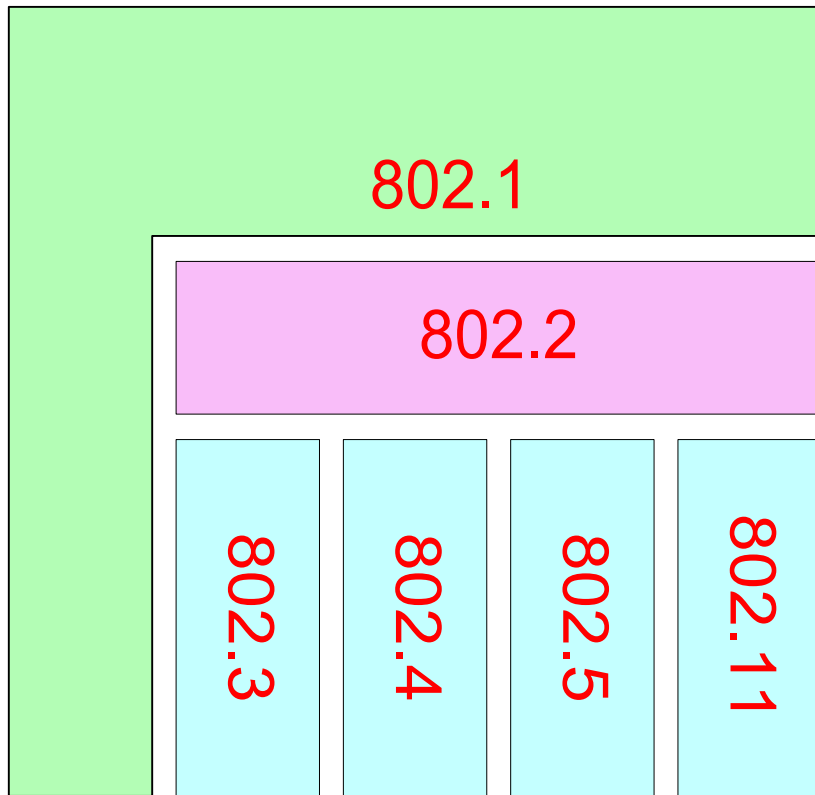
Bus LAN   Ring LAN

MAC and LLC

- In any broadcast network, the stations must ensure that only one station transmits at a time on the shared communication channel

- The protocol that determines who can transmit on a broadcast channel are called Medium Access Control (MAC) protocol

- The MAC protocol are implemented in the MAC sublayer which is the lower sublayer of the data link layer

- The higher portion of the data link layer is often called Logical Link Control (LLC)

to Network Layer

Logical Link Control

Medium Access Control

Data Link Layer

to Physical Layer

6
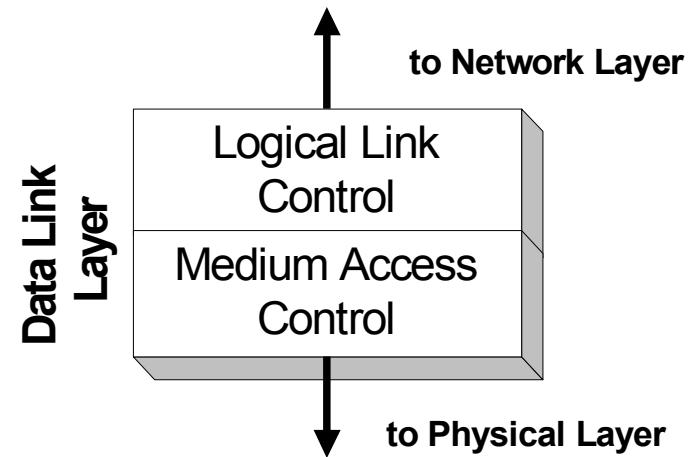
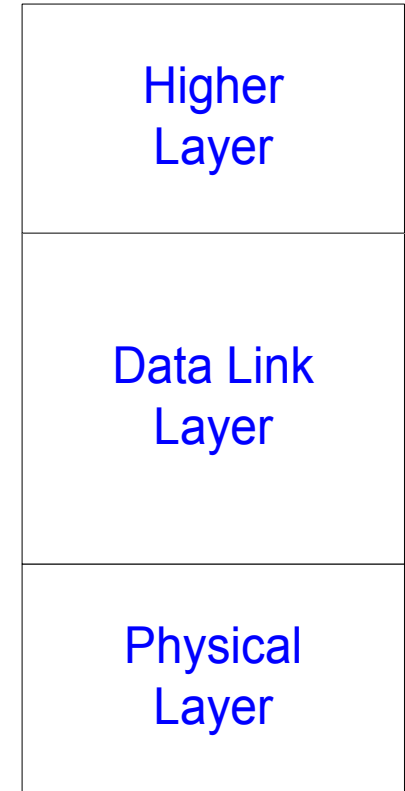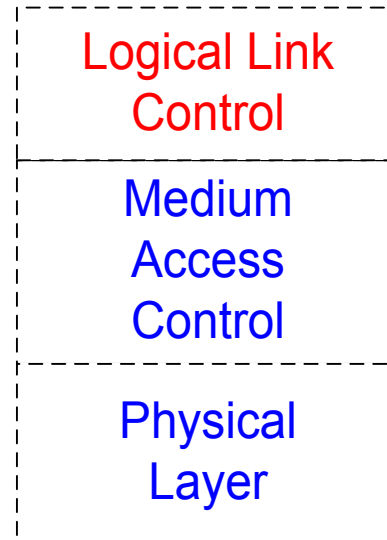# IEEE 802 Standards

- IEEE 802 is a family of standards for LANs, which defines an LLC and several MAC sublayers

IEEE 802 standard

802.1			
802.2			
802.3	802.4	802.5	802.11

IEEE Reference Model

Logical Link Control
Medium Access Control
Physical Layer

Higher Layer
Data Link Layer
Physical Layer

Ethernet

- Speed: 10Mbps -10 Gbps
- Standard: 802.3, Ethernet II (DIX)

- Most popular physical layers for Ethernet:
    - 10Base5 **Thick Ethernet:** 10 Mbps coax cable
    - 10Base2 **Thin Ethernet:** 10 Mbps coax cable
    - 10Base-T 10 Mbps Twisted Pair
    - 100Base-TX 100 Mbps over Category 5 twisted pair
    - 100Base-FX 100 Mbps over Fiber Optics
    - 1000Base-FX 1Gbps over Fiber Optics
    - 10000Base-FX 1Gbps over Fiber Optics (for wide area links)

Bus Topology

- 10Base5 and 10Base2 Ethernets has a bus topology
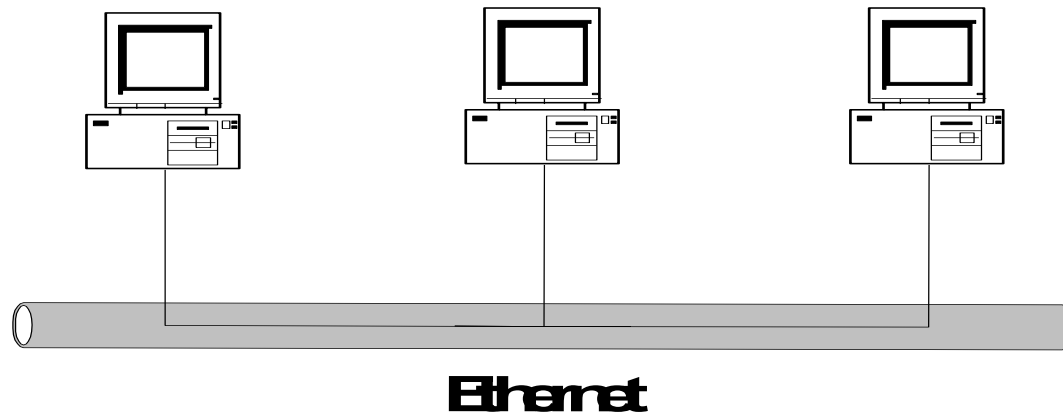
Ethernet

Star Topology

- Starting with 10Base-T, stations are connected to a hub in a star configuration
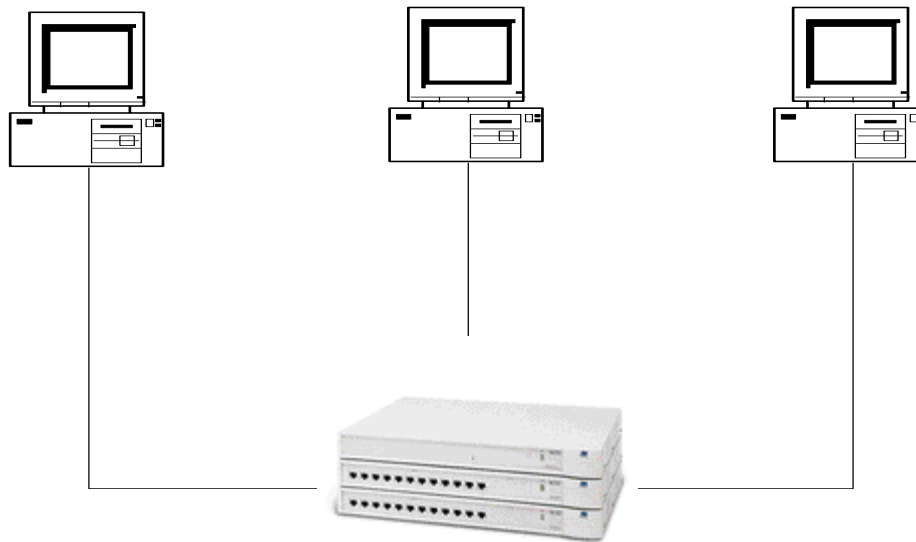
Ethernet Hubs vs. Ethernet Switches

- An **Ethernet switch** is a packet switch for Ethernet frames
  - Buffering of frames prevents collisions.
  - Each port is isolated and builds its own collision domain
- An **Ethernet Hub** does not perform buffering:
  - Collisions occur if two frames arrive at the same time.

Hub

Switch

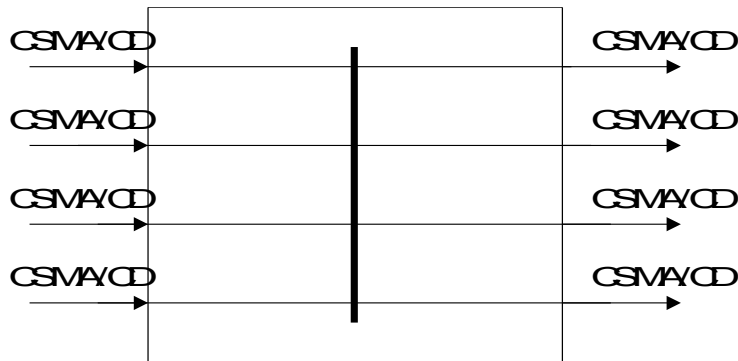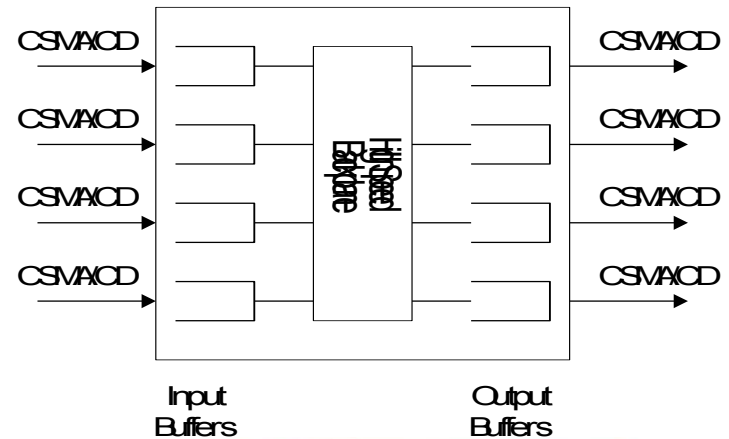# Ethernet and IEEE 802.3: Any Difference?

- There are two types of Ethernet frames in use, with subtle differences:

- *"Ethernet" (Ethernet II, DIX)*
    - An industry standards from 1982 that is based on the first implementation of CSMA/CD by Xerox.
    - Predominant version of CSMA/CD in the US.

- **802.3:**
    - IEEE's version of CSMA/CD from 1985.
    - Interoperates with 802.2 (LLC) as higher layer.

- **Difference for our purposes:** Ethernet and 802.3 use different methods to encapsulate an IP datagram.

Ethernet II, DIX Encapsulation (RFC 894)

destination address	source address	type	data	CRC
6	6	2	46-1500	4

0800	IP datagram
2	38-1492

0806	ARP request/reply	PAD
2	28	10

0835	RARP request/reply	PAD
2	28	10
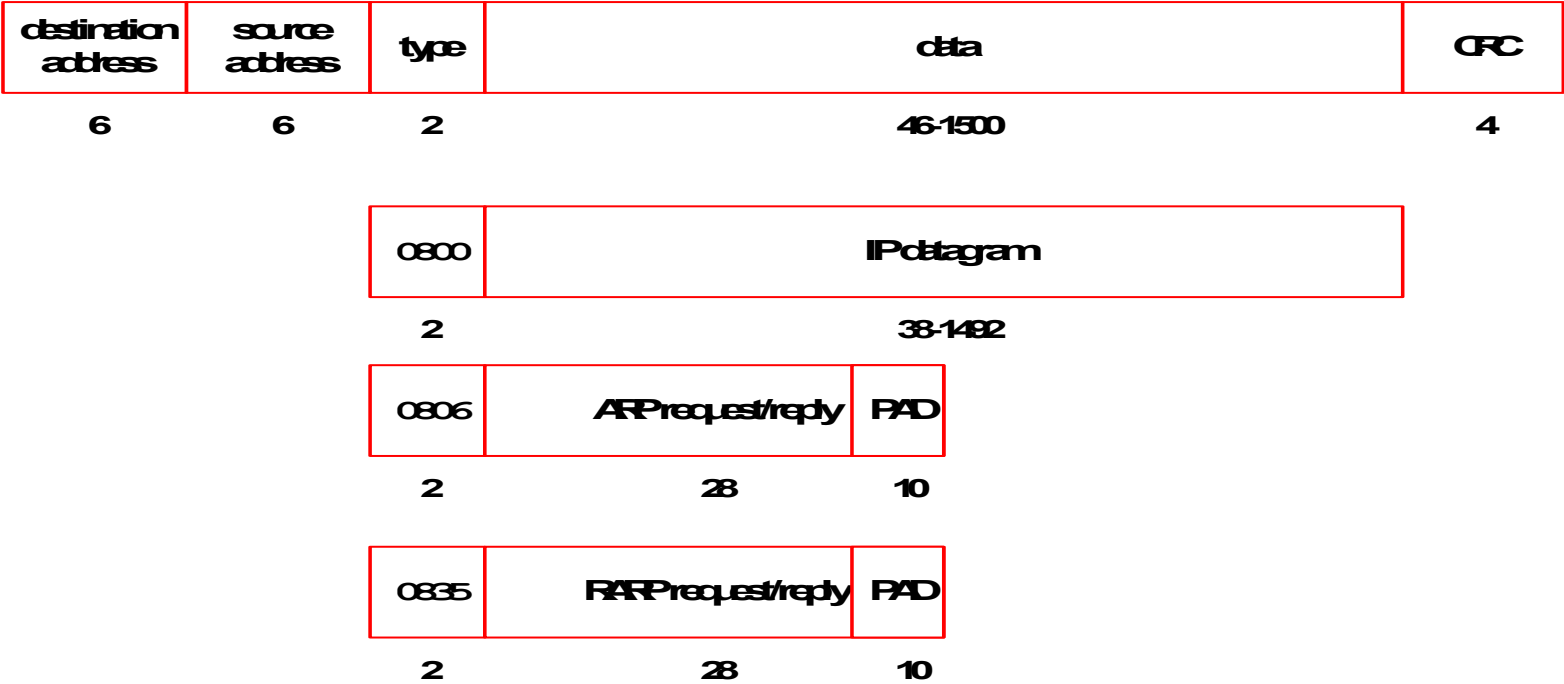
IEEE 802.2/802.3 Encapsulation (RFC 1042)

←————— 802.3 MAC —————→		←— 802.2 LLC —→			←— 802.2 SNAP —→			
destination address	source address	length	DSAP AA	SSAP AA	cntl 03	org code 0	type	data	CRC
6	6	2	1	1	1	3	2	38-1492	4

- **destination address, source address:**
  MAC addresses are 48 bit
- **length** frame-length in number of bytes
- **DSAP, SSAP:** always set to 0xaa
- **Cntl:** set to 3
- **org code:** set to 0
- **type field** identifies the content of the data field
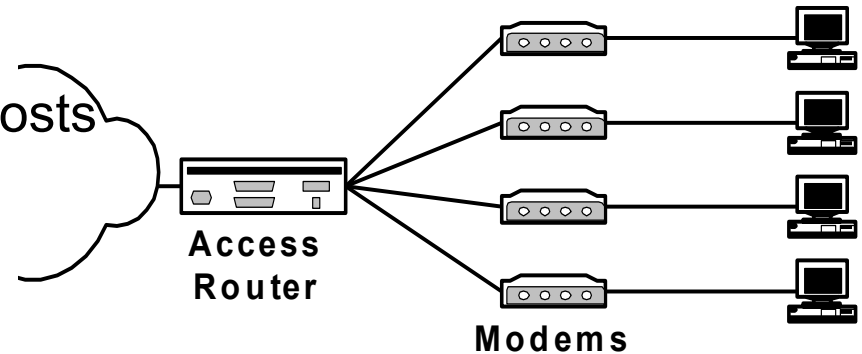- **CRC:** cylic redundancy check

0800	IP datagram
2	38-1492

0806	ARP request/reply	PAD
2	28	10

| 0835	RARP request/reply	PAD
2	28	10

Point-to-Point (serial) links

- Many data link connections are point-to-point serial links:
  - Dial-in or DSL access connects hosts to access routers
  - Routers are connected by high-speed point-to-point links

Access Router

Modems

Dial-Up Access

- Here, IP hosts and routers are connected by a serial cable

- Data link layer protocols for point-to-point links are simple:
  - Main role is encapsulation of IP datagrams
  - No media access control needed

Router

Router

Router

Router

Point-to-Point Links

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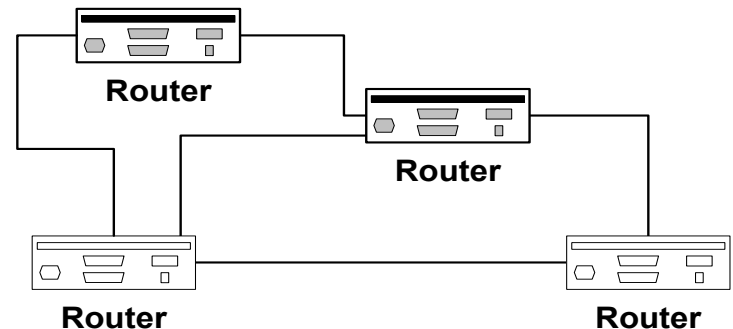
Data Link Protocols for Point-to-Point links

- **SLIP (Serial Line IP)**
  - First protocol for sending IP datagrams over dial-up links (from 1988)
  - Encapsulation, not much else

- **PPP (Point-to-Point Protocol):**
  - Successor to SLIP (1992), with added functionality
  - Used for dial-in and for high-speed routers

- **HDLC (High-Level Data Link) :**
  - Widely used and influential standard (1979)
  - Default protocol for serial links on Cisco routers
  - Actually, PPP is based on a variant of HDLC

PPP - IP encapsulation

- The frame format of PPP is similar to HDLC and the 802.2 LLC frame format:

flag	addr	ctrl	protocol	data	CRC	flag
7E	FF	03				7E
1	1	1	2	<= 1500	2	1

0021	IP datagram

C021	link control data

8021	network control data

- PPP assumes a duplex circuit
- Note: PPP does not use addresses
- Usual maximum frame size is 1500

Additional PPP functionality

- In addition to encapsulation, PPP supports:
    - multiple network layer protocols (protocol multiplexing)
    - Link configuration
    - Link quality testing
    - Error detection
    - Option negotiation
    - Address notification
    - Authentication

- The above functions are supported by helper protocols:
    - LCP
    - PAP, CHAP
    - NCP

PPP Support protocols

- **Link management:** The link control protocol (LCP) is responsible for establishing, configuring, and negotiating a data-link connection. LCP also monitors the link quality and is used to terminate the link.

- **Authentication:** Authentication is optional. PPP supports two authentication protocols: Password Authentication Protocol (PAP) and Challenge Handshake Authentication Protocol (CHAP).

- **Network protocol configuration:** PPP has network control protocols (NCPs) for numerous network layer protocols. The IP control protocol (IPCP) negotiates IP address assignments and other parameters when IP is used as network layer.

Switched networks

- Some data link technologies can be used to build complete networks, with their own addressing, routing, and forwarding mechanisms. These networks are often called switched networks.

- At the IP layer, a switched network may like a point-to-point link or like a broadcast link
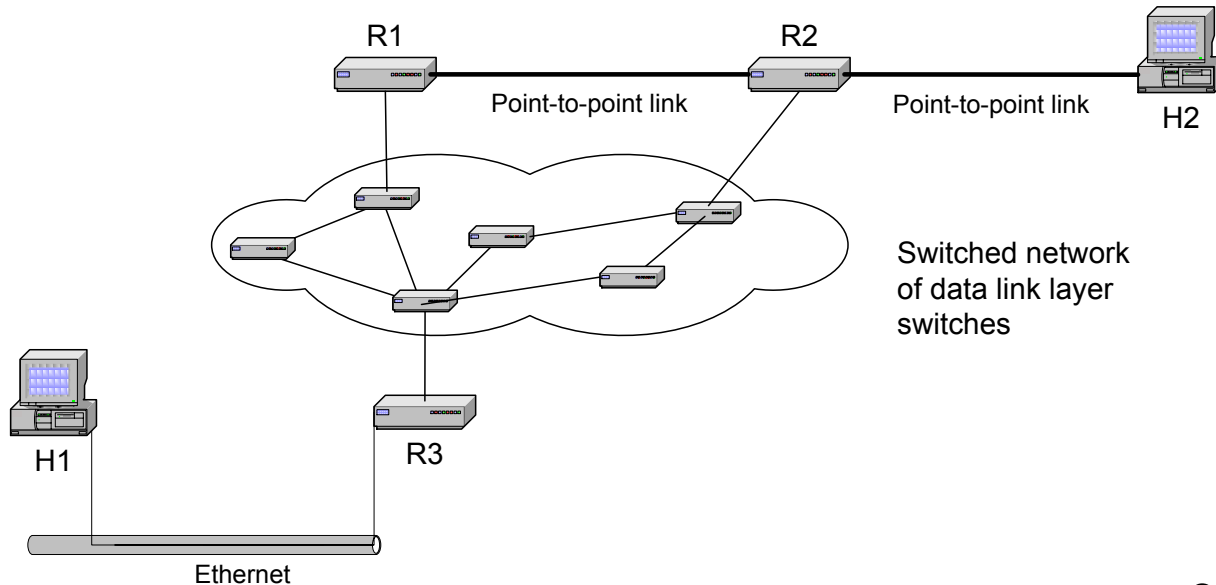
Switched networks

Data link layer technologies:

- – Switched Ethernet
- – ATM (Asynchronous Transfer Mode)
- – Frame Relay
- – Multiprotocol Label Switching (MPLS)

- Some switched networks are intended for enterprise networks (Switched Ethernet), wide area networks (MPLS, Frame Relay), or both (ATM)

- Some switched networks have a complete protocol suite.