

# Data Link Protocols

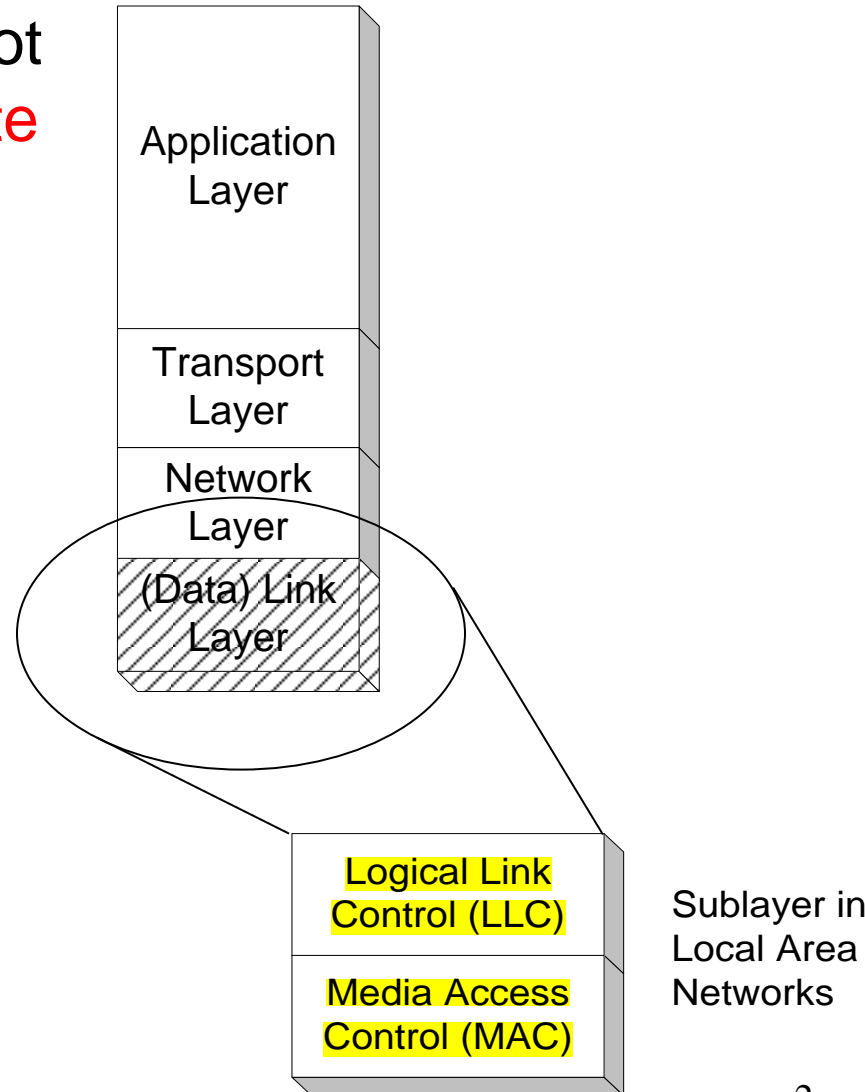
This module covers data link layer issues, such as local area networks (LANs) and point-to-point links, Ethernet, and the Point-to-Point Protocol (PPP).

# 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**



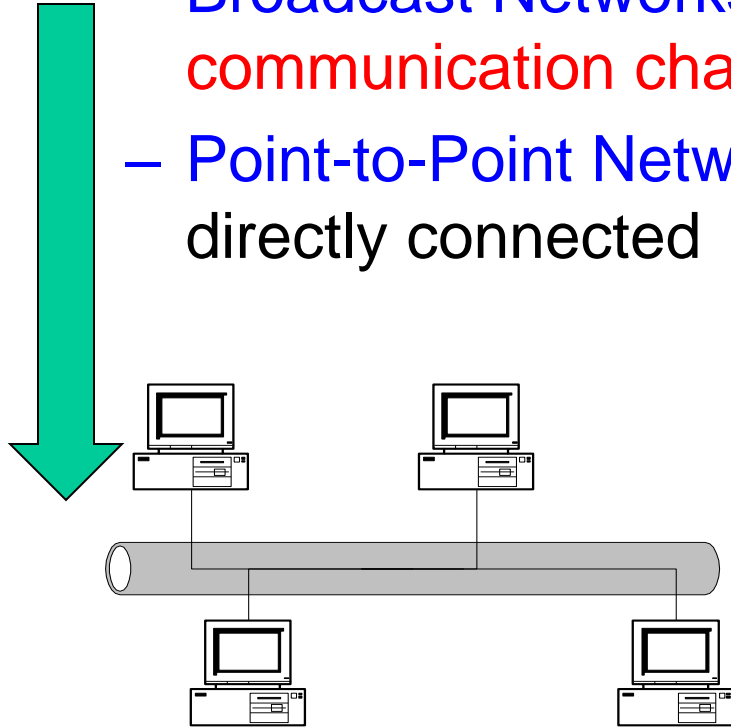
# Data Link Layer

- 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”)**

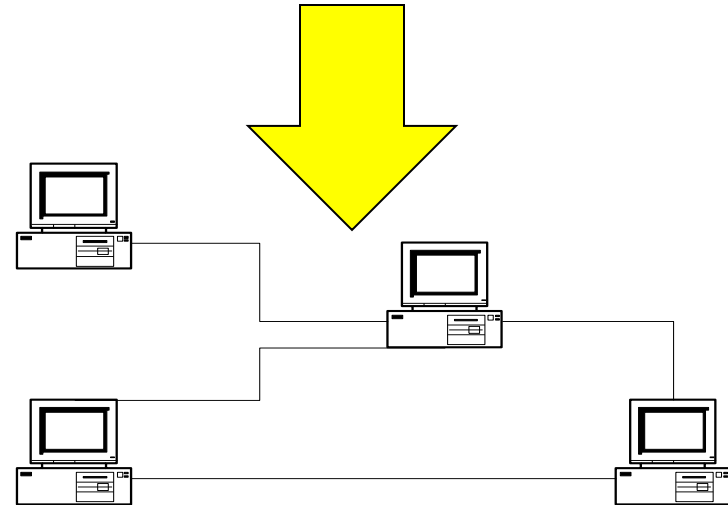


# Two types of networks at the data link layer

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



Broadcast Network

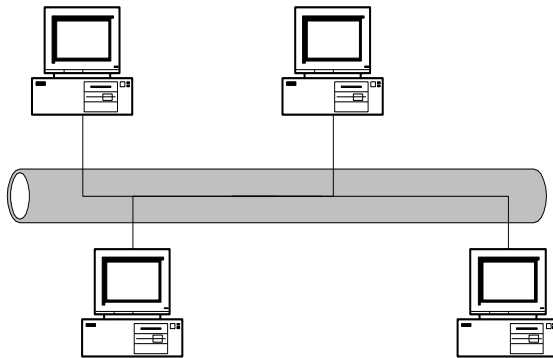


Point-to-Point Network

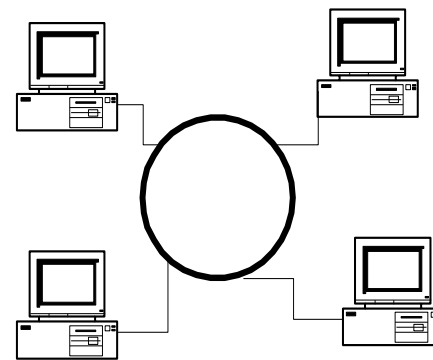
- Typically, local area networks (LANs) are broadcast and wide area networks (WANs) are point-to-point

# 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.



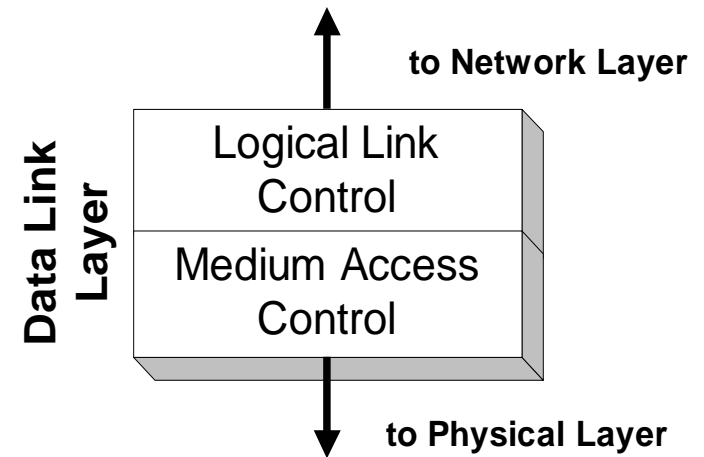
Bus LAN



Ring LAN

# MAC and LLC

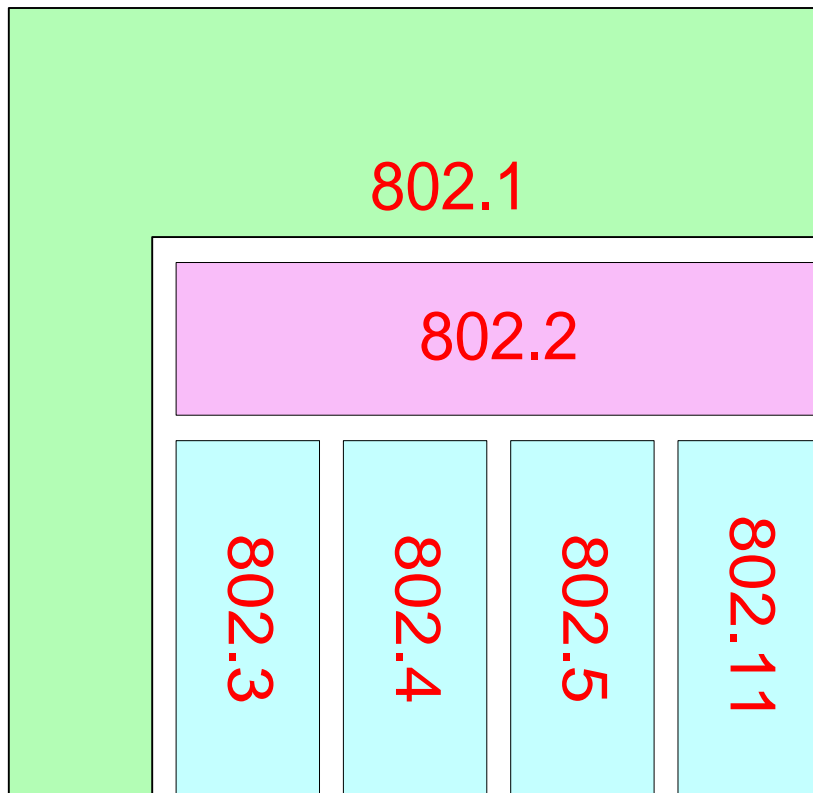
- In any broadcast network, the stations must ensure that **only one station transmits** at a time on the shared communication channel
- **The protocol** that determines who can transmit on a broadcast channel are called **Medium Access Control (MAC)** protocol
- The MAC protocol are implemented in the **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)**



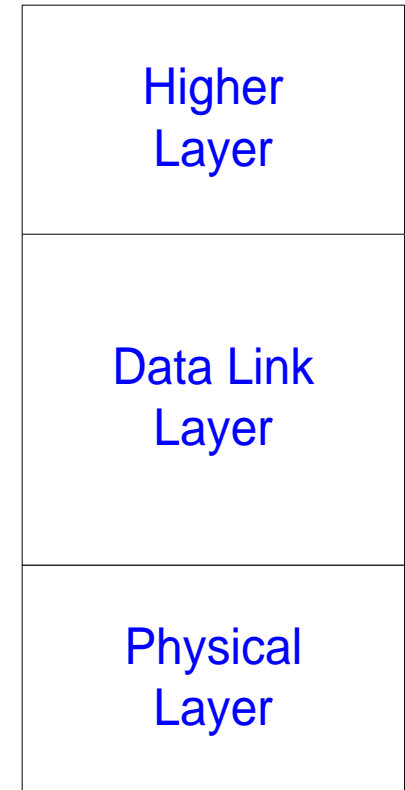
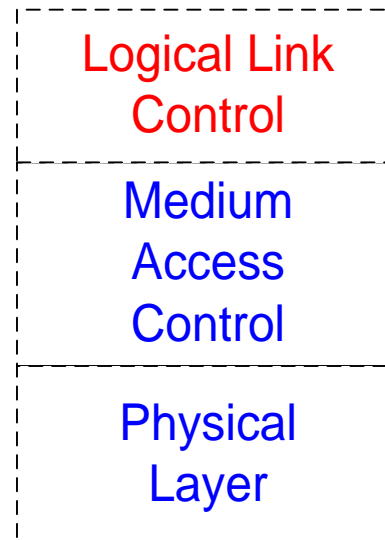
# IEEE 802 Standards

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

## IEEE 802 standard



## IEEE Reference Model



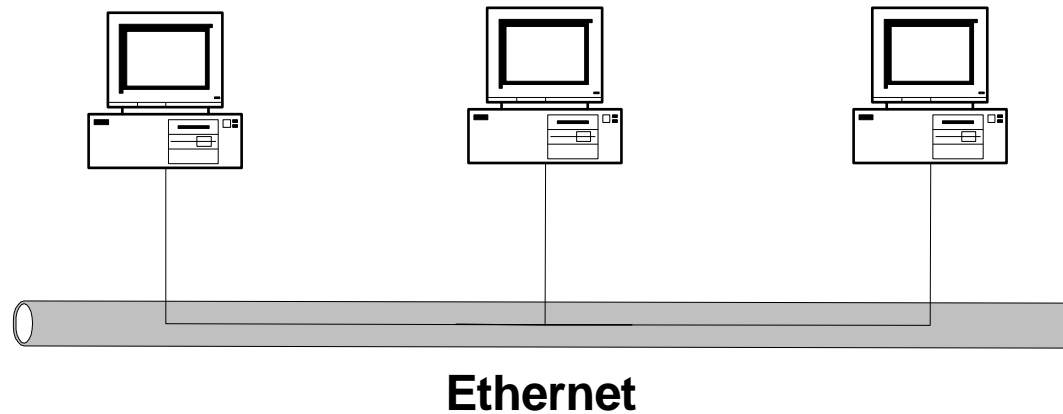
# Ethernet

- Speed: 10Mbps -10 Gbps
- Standard: 802.3, Ethernet II (DIX)
- Most popular physical layers for Ethernet:
  - 10Base5 **Thick Ethernet:** 10 Mbps coax cable 500 mtr
  - 10Base2 **Thin Ethernet:** 10 Mbps coax cable 186
  - 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 **10Gbps** over Fiber Optics (for wide area links)



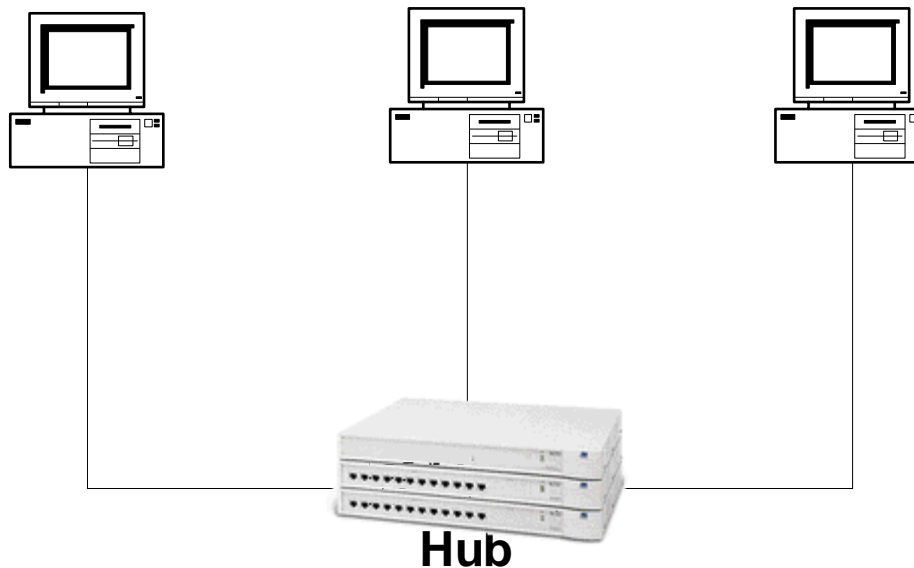
# Bus Topology

- 10Base5 and 10Base2 Ethernets has a bus topology



# Star Topology

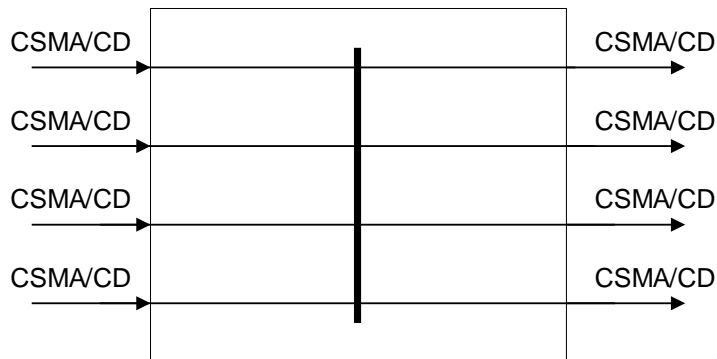
- Starting with **10Base-T**, stations are connected to a hub in a star configuration



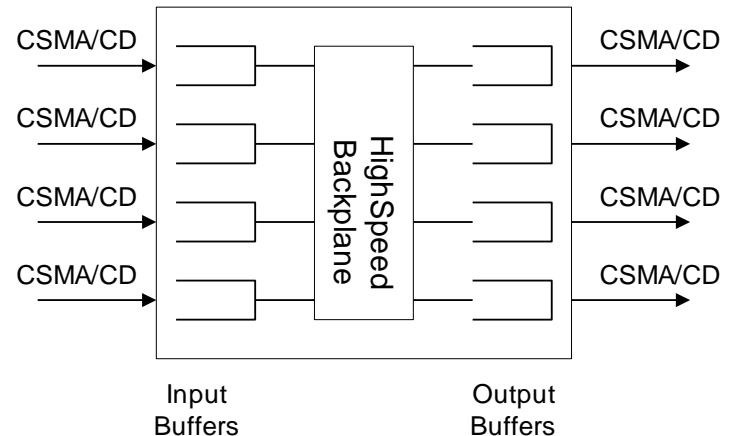
# Ethernet Hubs vs. Ethernet Switches

- 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**



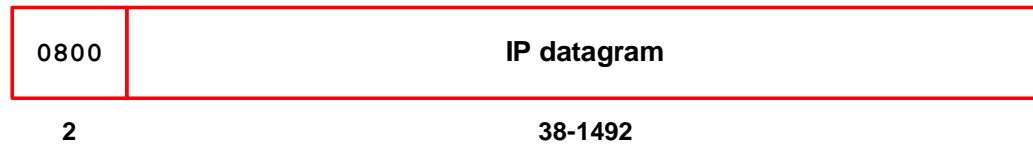
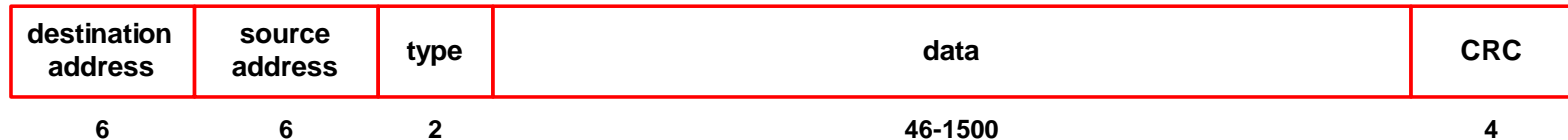
**Switch**



# Ethernet and IEEE 802.3: Any Difference?

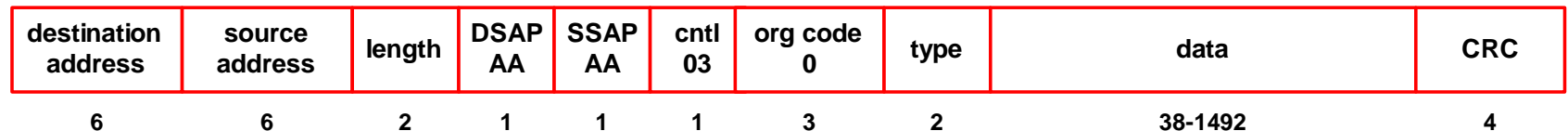
- There are two types of Ethernet frames in use, with subtle differences:
- **“Ethernet” (Ethernet II, DIX)**
  - An industry standards from 1982 that is based on the first implementation of CSMA/CD by **Xerox**.
  - Predominant version of CSMA/CD in **the US**.
- **802.3:**
  - IEEE’s version of **CSMA/CD** 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)



# IEEE 802.2/802.3 Encapsulation (RFC 1042)

← 802.3 MAC → ← 802.2 LLC → ← 802.2 SNAP →



- **destination address, source address:**

MAC addresses are 48 bit

- **length:** frame length in number of bytes

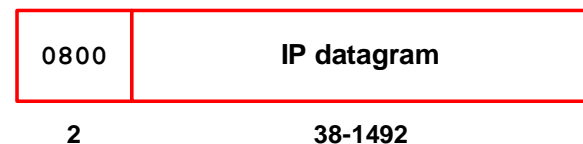
- **DSAP, SSAP:** always set to 0xaa

- **Ctrl:** set to 3

- **org code:** set to 0

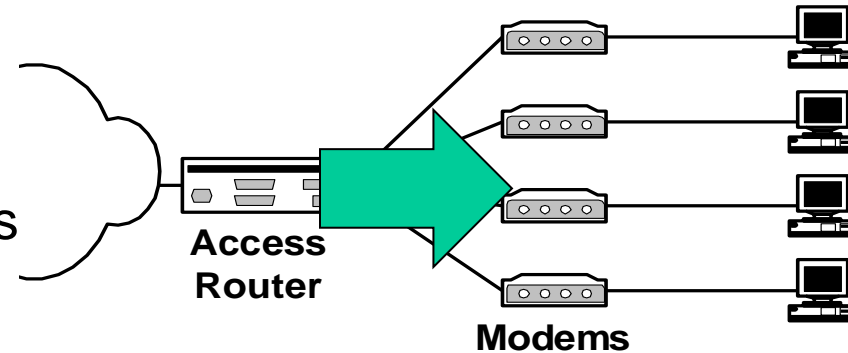
- **type field** identifies the content of the data field

- **CRC:** cyclic redundancy check



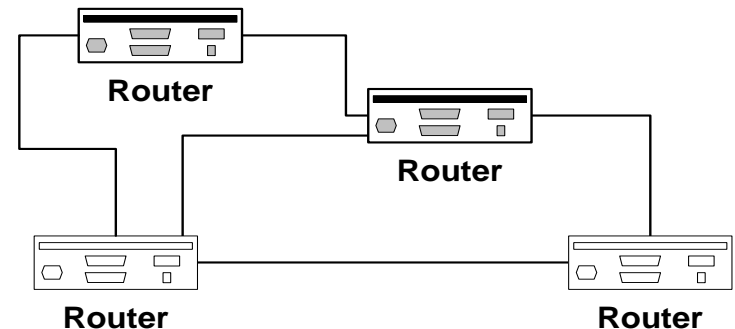
# Point-to-Point (serial) links

- 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



Dial-Up Access

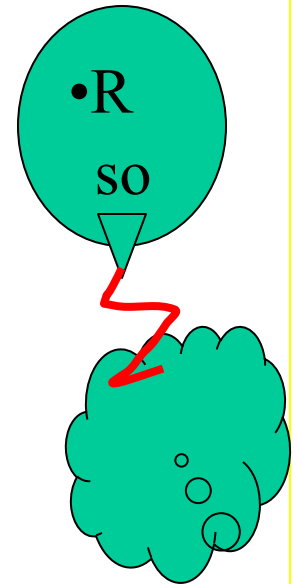
- Here, IP hosts and routers are connected by a serial cable
- Data link layer protocols for point-to-point links are simple:
  - Main role is encapsulation of IP datagrams
  - No media access control needed



Point-to-Point Links

# 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

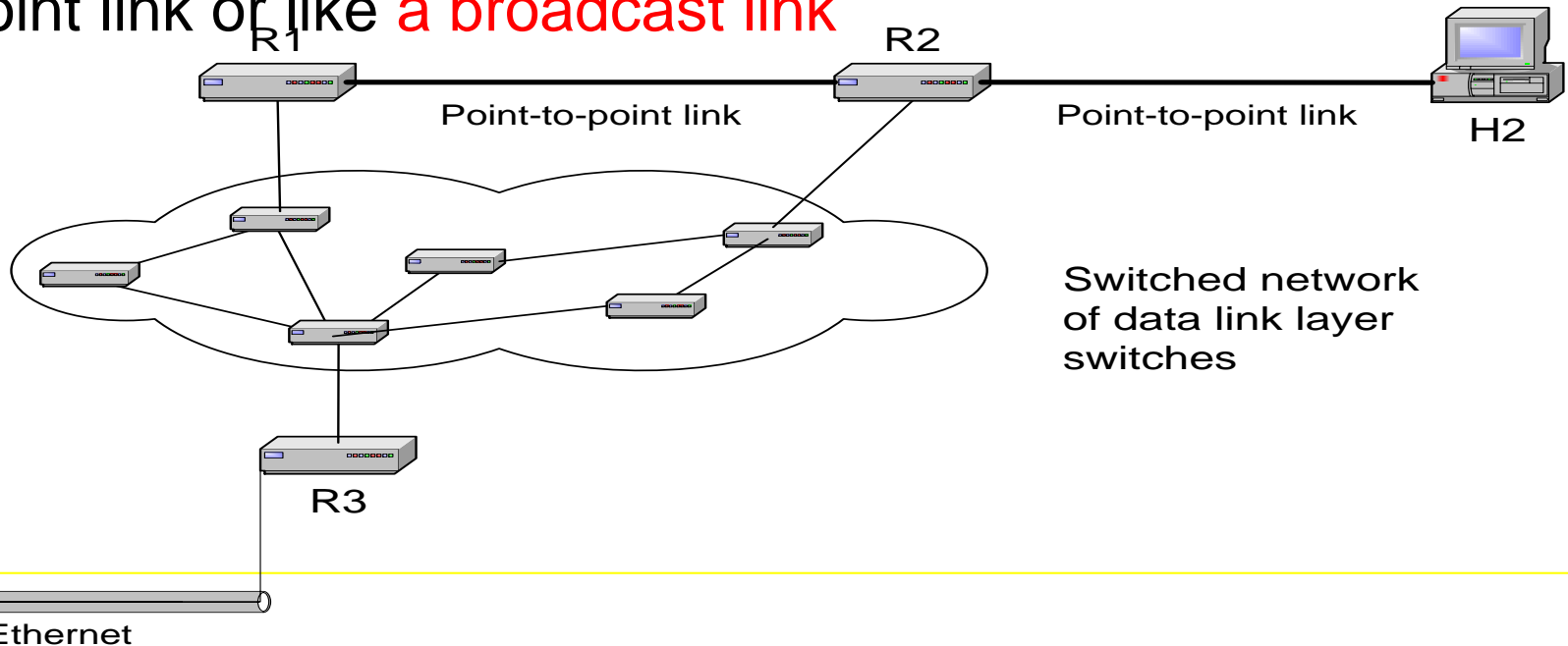
- In addition to encapsulation,
- **PPP supports:**
  - multiple network layer protocols (**protocol multiplexing**)
  - Link configuration
  - Link **quality testing**
  - Error detection
  - Option negotiation
  - Address notification
  - Authentication
- The above functions are supported by helper 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 **العديد من** 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 look 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.