

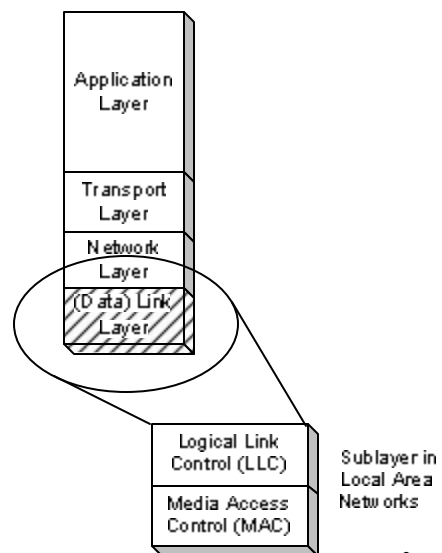
Data Link Protocols

Relates to Lab 2.

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).

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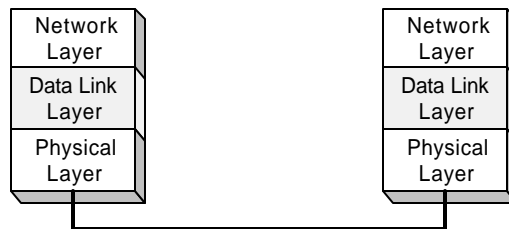
TCP/IP Suite and OSI Reference Model



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Data Link Layer

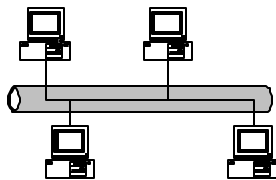
- The main tasks of the data link layer are:
 - Transfer data from the network layer of one machine to the network layer of another machine
 - Convert the raw bit stream of the physical layer into groups of bits (“frames”)



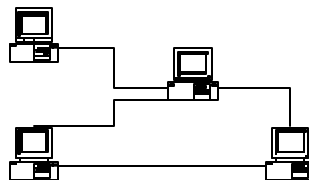
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Two types of networks at the data link layer

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



Broadcast Network



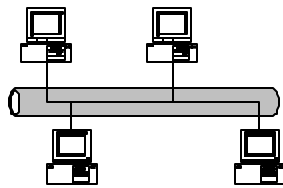
Point-to-Point Network

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

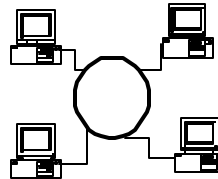
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Local Area Networks

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

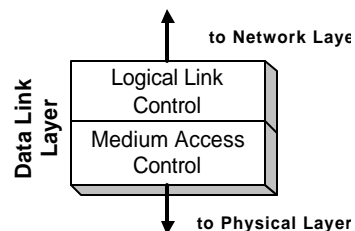


Ring LAN

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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 protocols 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)

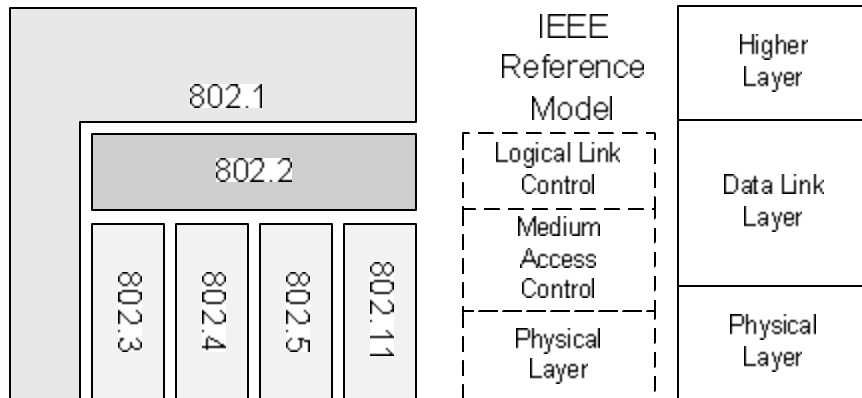


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IEEE 802 Standards

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

IEEE 802 standard



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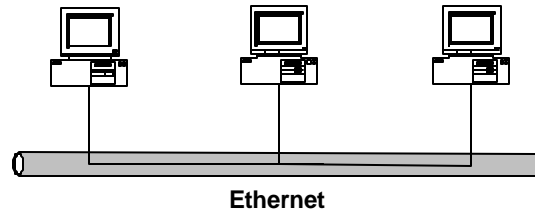
Ethernet

- 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)

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Bus Topology

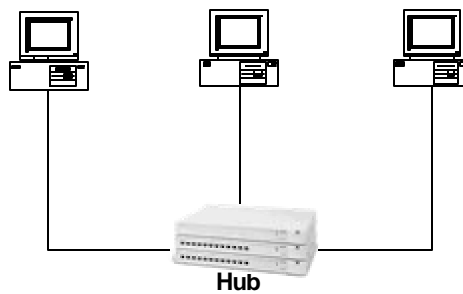
- 10Base5 and 10Base2 Ethernets has a bus topology



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Star Topology

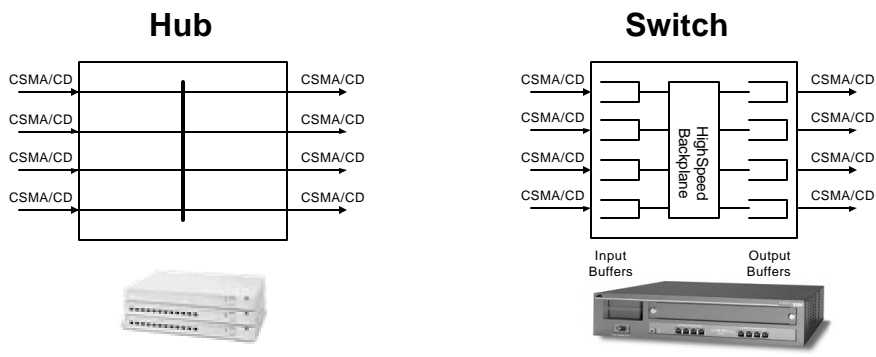
- Starting with 10Base-T, stations are connected to a hub in a star configuration



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Ethernet Hubs vs. Ethernet Switches

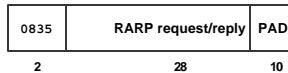
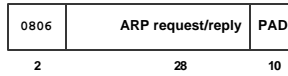
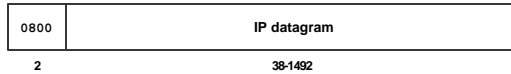
- An **Ethernet switch** is a packet switch for Ethernet frames
 - Buffering of frames prevents collisions.
 - Each port is isolated and builds its own collision domain
- An **Ethernet Hub** does not perform buffering:
 - Collisions occur if two frames arrive at the same time.



Ethernet and IEEE 802.3: Any Difference?

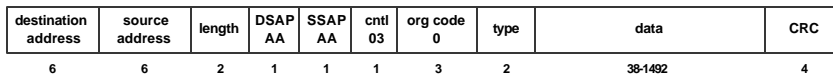
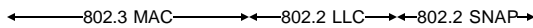
- There are two types of Ethernet frames in use, with subtle differences:
- **“Ethernet” (Ethernet II, DIX)**
 - An industry standards from 1982 that is based on the first implementation of CSMA/CD by Xerox.
 - Predominant version of CSMA/CD in the US.
- **802.3:**
 - IEEE’s version of CSMA/CD from 1985.
 - 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)



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IEEE 802.2/802.3 Encapsulation (RFC 1042)



- destination address, source address:

MAC addresses are 48 bit

- length: frame length in number of bytes

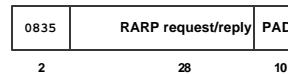
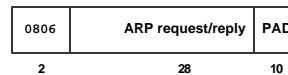
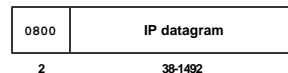
- DSAP, SSAP : always set to 0xaa

- Ctrl: set to 3

- org code: set to 0

- type field identifies the content of the data field

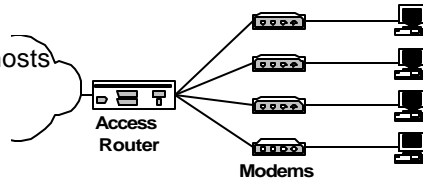
- CRC: cyclic redundancy check



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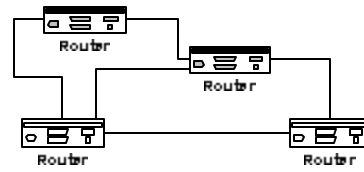
Point-to-Point (serial) links

- 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

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Data Link Protocols for Point-to-Point links

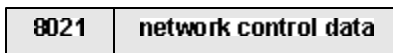
- **SLIP (Serial Line IP)**
 - First protocol for sending IP datagrams over dial-up links (from 1988)
 - Encapsulation, not much else
- **PPP (Point-to-Point Protocol):**
 - Successor to SLIP (1992), with added functionality
 - Used for dial-in and for high-speed routers
- **HDLC (High-Level Data Link) :**
 - Widely used and influential standard (1979)
 - Default protocol for serial links on Cisco routers
 - Actually, PPP is based on a variant of HDLC

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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



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

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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

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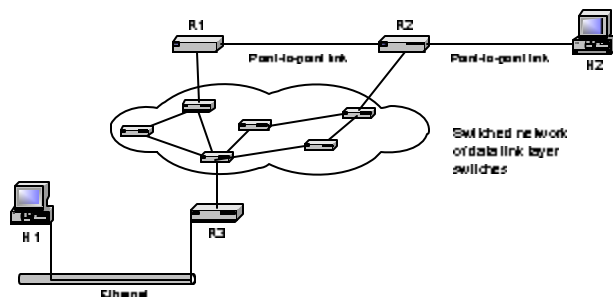
PPP Support protocols

- **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.

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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



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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.