Data Link Issues

- LANs and Point-to-point links
- LAN Protocols: Ethernet, FDDI
- Point-to-Point Protocols: 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 and the MAC sublayer
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")

Types of Networks

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

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

- Local area networks (LANs) typically connect computers within a building or a campus
- Almost all LANs are broadcast networks
- Typical topologies of LANs are **bus** or **ring**
- We will work with two types of LANs: Ethernet (bus) and FDDI (ring)

![Bus LAN and Ring LAN](image)

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

Ethernet

- Speed: 10-1000 Mbps
- Standard: 802.3

- Most popular physical layers for Ethernet:
  - 10Base-T  10 Mbps Twisted Pair
  - 10Base2  Thin Ethernet: 10 Mbps thin coax cable
  - 100Base-TX  100 Mbps over Category 5 twisted pair
  - 100Base-FX  100 Mbps over Fiber Optic
Bus Topology

- 10Base5 and 10Base2 Ethernets have a bus topology

Star Topology

- 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 (or anything, really):
  • Collisions occur if two frames arrive at the same time.

Ethernet and IEEE 802.3: Any Difference?

• On a conceptual level, they are identical. But there are subtle differences that are relevant if we deal with TCP/IP.
  • “Ethernet”:
    • 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.
IEEE 802.2/802.3 Encapsulation (RFC 1042)

<table>
<thead>
<tr>
<th>destination address</th>
<th>source address</th>
<th>length</th>
<th>DSAP AA</th>
<th>SSAP AA</th>
<th>ctrl</th>
<th>org code</th>
<th>type</th>
<th>data</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>3-1492</td>
<td>4</td>
</tr>
</tbody>
</table>

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

0800

IP datagram

0806

ARP request/reply
PAD

0835

RARP request/reply
PAD

Ethernet Encapsulation (RFC 894)

<table>
<thead>
<tr>
<th>destination address</th>
<th>source address</th>
<th>type</th>
<th>data</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>6</td>
<td>2</td>
<td>46-1500</td>
<td>4</td>
</tr>
</tbody>
</table>

0800

IP datagram

0806

ARP request/reply
PAD

0835

RARP request/reply
PAD
FDDI

- Some Facts:
  - **FDDI** = Fiber Distributed Data Interface
  - FDDI is a high-speed token ring
  - Fiber-optic (dual redundant counter rotating) ring LAN
  - Multimode fiber
  - Standardized by ANSI and ISO X3T9.5 committee
  - 100 Mbps data rate
  - Maximum frame size is 4500 bytes
  - Allows up to 1000 connected stations
  - Maximum ring circumference 200 km

FDDI - Protocol Architecture

- **SMT**: Station Management
- **MAC**: Medium Access Control
- **PHY**: Physical Layer Protocol
- **PMD**: Physical Layer Medium Dependent
Dual Redundant Counter Rotating Ring

- Second ring adds a certain level of fault tolerance

Station Types - Dual Attached Station

- Two PHY (and one or two MAC) entities
- Connects to another Class A station or to a concentrator
Station Types - Single Attached Station

- One PHY (and one MAC) entity
- Connects to a concentrator

Station Types - Concentrator

- Connects Class A and Class B stations into one of the counter rotating rings.
- Concentrator can bypass failing stations.
Topology Example

Single-Attached Stations

Concentrator

Dual-Attached Stations

Frame and Token Format

<table>
<thead>
<tr>
<th>Preamble</th>
<th>SD</th>
<th>FC</th>
<th>DA</th>
<th>SA</th>
<th>Info</th>
<th>FCS</th>
<th>ED</th>
<th>FS</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Frame Format</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Preamble</th>
<th>SD</th>
<th>FC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Token Frame Format</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- SD  Starting Delimiter
- FC  Frame Control (type of frame)
- DA  Destination Address
- SA  Source Address
- FCS Frame Check Sequence (CRC)
- ED  End Delimiter
- FS  Frame Status
- Total Frame length ≤ 4500 bytes
PPP - Point-to-Point Protocol

- **PPP protocol** is a data link protocol for transmission on a serial link.
- Use of PPP today:
  - Dial-in or DSL access to Internet
  - Routers connected by point-to-point links
- Main purpose of PPP is encapsulation of IP datagrams
- PPP was proposed in 1992; a predecessor of PPP was the Serial Link IP (SLIP) protocol

PPP - IP encapsulation

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

<table>
<thead>
<tr>
<th>flag</th>
<th>addr</th>
<th>ctrl</th>
<th>protocol</th>
<th>data</th>
<th>CRC</th>
<th>flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>7E</td>
<td>FF</td>
<td>03</td>
<td>&lt;= 1500</td>
<td></td>
<td>2</td>
<td>7E</td>
</tr>
</tbody>
</table>

- 0021 IP datagram
- C021 link control data
- 8021 network control data
Other than a framing method PPP provides:

- The **link control protocol (LCP)** which is responsible for establishing, configuring, and negotiating a data-link connection
  - LCP is specified in RFC 1331.

- For each network layer protocol supported by PPP, there is one **network control protocol (NCP)**
  - The NCP for IP is specified in RFC 1332