# Chapter 5- Link Layer

Topics:

- Introduction and services
- Error detection(review)
- Multiple/Medium access control
- Link-layer addressing
- Ethernet
- switch and VLAN
- HDLC and PPP
- MPLS
- A day in the life of a web request

## Introduction and services

link layer implemented in the "adaptor"(network interface card NIC) in each host and routers.

**links** : communication channels that connect adjacent nodes with wired or wireless medium.

- point-to-point link: HDLC, PPP
- broadcast link: Ethernet, IEEE802.3

services:

- framing
  - byte stuffing: use flags of start and end. Flags of data is by adding stuffed bytes.
  - bit stuffing: add one 0 after 5 consecutive 1s. The flag is six or more 0s.
- reliable data transfer
  - error detection and correction

    - flow control
- link access for shared medium

## Reliable data transfer

Before in transport layer, there is:

- rdt1.0, rdt2.0., rdt2.1, rdt2.2, rdt3.0, GBN, SR
- reliable data transfer mechanisms:
    - checksum: the bit error checksum of transport and IP layer is limited
        - **wrap around**
    - timer
    - ACK
    - NCK
    - sequence number
    - pipelining
- CRC-> detect all burst errors less than r+1 bits.

## HDLC and PPP

Point-to-point data link protocols

- HDLC(high-level data link control) -> bit-oriented ->with flow control and error control
- PPP(point-to-point protocol) -> byte oriented -> without flow control and error control, support multiple upper layer protocols

## Multiple/Medium access protocols

used to cope with collision problem in broadcast links.

contains:

- channel partitioning(static)
- random access(dynamic)
- taking turns(dynamic)

requirements:

Suppose the broadcast cannel is of rate R bps.

- efficient: when one node wants to transmit, it can send at rate R.
- fair: when M nodes want to transmit, they can transmit at rate R/M.
- fully decentralized: no special node, no synchronization of clocks
- simple

### 1- channel partitioning

TDM, FDM, CDM

### 2- random access

how to detect and recover collisions. Transmit at full rate R, no priori coordination among nodes.

The utility is relatively low.

**ALOHA, slotted ALOHA, CSMA, CSMA/CD**

**1) ALOHA**

Transmit immediately whenever data is ready.

When collision happens, retry after a random amount of time. That is, at $p$ resend the frame immediately, else for $1-p$, wait after some time, then resend the frame at $p$.

$$\frac{1}{2e}$$

**2) slotted ALOHA**

Transmit at the beginning of **next slot** whenever data is ready.

$$\frac{1}{e}$$

**3) CSMA(carried sense multiple access)**

The node's transmission is not independent with other nodes.

Listen until the channel is idle.

$\delta$ : The collisions still happen for the propagation delay.

**4) CSMA/CD**

$$efficiency = \frac{1}{1+5d_{prop}/d_{trans}}$$

$$F_{min} \geq 2B\frac{l}{v}$$

### 3- taking turns

- polling
- taking-turns

## Link-layer addressing

Each adaptor has 48bit, permanent, globally unique MAC address.

portable.

The reasons for IP and MAC address:

To keep the layer independency.

- Link-layer not always serve IP protocol.
- If use IP, the adaptor need to be reconfigured every movement.

- If use IP, all received frames should be forwarded to network layer, causing great overhead.
- ARP(Address Resolution Protocol) -> translate IP address into MAC address

# Ethernet

## 1- structure

| Preamble | Destination address | Source address | Type | Data | Pad | Checksum |
|---|---|---|---|---|---|---|

unreliable and connectionless

## Switch and VLAN

LAN has Broadcasting Region and Collision Region. Using switch, the collision region could be reduced. Using router, the broadcasting region could be reduced.

## 1- VLAN

Use switch to reduce broadcasting region.

- traffic isolation: different groups could only reach to self group.
- dynamic membership: ports could be dynamically assigned among VLANs.

Different groups want to connect to each other:

- connect with a out router.

How can different groups being a whole:

- VLAN trunking

# MPLS