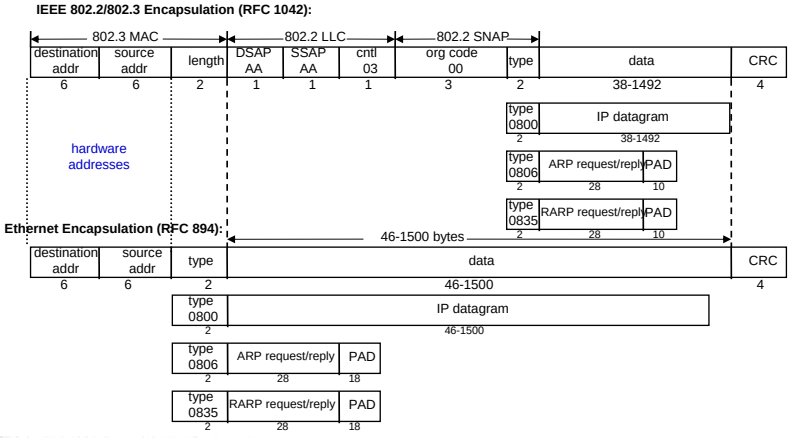
Chapter 2:
Link Layer

Ethernet and IEEE 802 Encapsulation

- **IEEE 802.2/802.3 encapsulation (RFC 1042) and Ethernet encapsulation (RFC 894)**



Ethernet and IEEE 802 Encapsulation

- **802.2 defines the LLC common to many of the 802 networks.**
- **RFC requires that every Internet host:**
  - 1. Must be able to send and receive packets using RFC 894 (Ethernet) encapsulation
  - 2. Should be able to receive RFC 1042 (IEEE 802) packets intermixed with RFC 894 packets
  - 3. May be able to send packets using RFC 1042 encapsulation. If the host can send both types of packets, default to send RFC 894
- **Same *type* field**
  - The IEEE 802 frame had same 2-byte *type* field with the Ethernet frame format
- **Trailer Encapsulation**
  - RFC 893 describes another form of encapsulation used on Ethernets called *trailer encapsulation*. It is deprecated nowadays.

SLIP: Serial Line IP

- **What's SLIP?**
  - It is a simple form of encapsulation for IP datagram on serial lines, and is specified in RFC 1055
    - SLIP has become popular for connecting home systems to Internet through RS-232 serial port and high-speed modems.
- **The rules specify the framing used by SLIP:**

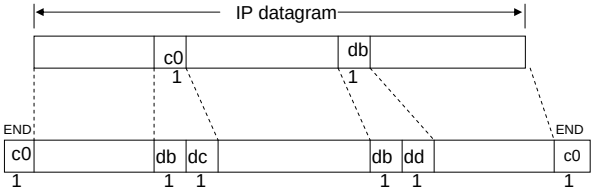


Figure 2.2 SLIP encapsulation

SLIP: Serial Line IP (Cont.)

- **Deficiencies of SLIP**
  - Each end must know the other's IP address
  - There is no *type* field: it can't be used for some other protocol at the same time
  - There is no checksum added by SLIP. This makes it essential that the upper layers provide some form of CRC.
- **Compressed SLIP**
  - SLIP performance drawback
    - Slow, to carry 1 byte of data requires 40 bytes header (IP and TCP header), an overhead of 40 bytes
  - CSLIP is specified in RFC 1144
    - CSLIP normally reduces the 40-byte header to 3 or 5 bytes
    - These smaller headers greatly improve the interactive response time

PPP: Point-to-Point Protocol

- **Three components of PPP**
  - A way to encapsulate IP datagrams on a serial link. PPP supports either an asynchronous link with 8 bits of data and no parity, or bit-oriented synchronous links
  - A *link control protocol* (LCP) to establish, configure, and test the data-link connection
  - A family of *network control protocols* specific to different network layer protocols

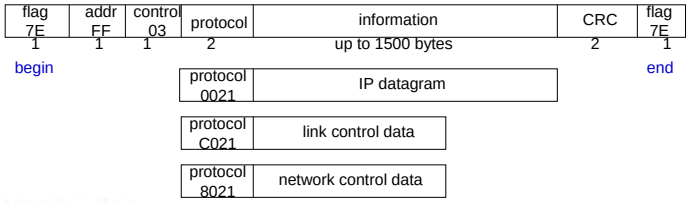


Figure 2.3 Format of PPP frames.

PPP: Point-to-Point Protocol (Cont.)

- **How to escape flag byte (0x7e)?**
  - On a synchronous link
    - done by the hardware using a technique called *bit stuffing*
  - On asynchronous link
    - use 0x7d as an escape character, the next character of 0x7d had its sixth bit complemented as follows:
      - ✓ *0x7e is transmitted => 0x7d 0x5e*
      - ✓ *0x7d is transmitted => 0x7d 0x5d*
      - ✓ *ASCII control character (less than 0x20) For example, the byte 0x01 is transmitted => 0x7d 0x21*
- **PPP using the link control protocol**
  - omit the constant flag and address fields and to reduce the size of the protocol field from 2 bytes to 1 byte

PPP: Point-to-Point Protocol (Cont.)

- **Advantages of PPP over SLIP**
  - support for multiple protocols on a single serial line
  - a CRC on every frame
  - dynamic negotiation of IP address for each end
  - TCP and IP header compression similar to CSLIP
  - a link control protocol for negotiating many data-link options. The price we pay for all these features is 3 bytes of additional overhead
- **What's Loopback Interface**
  - A loopback interface allow a client and server on the same host to communicate with each other using TCP/IP
  - Most system assign the IP address of 127.0.0.1, named *localhost*
  - In brief, it is just doing a test job.

Loopback Interface

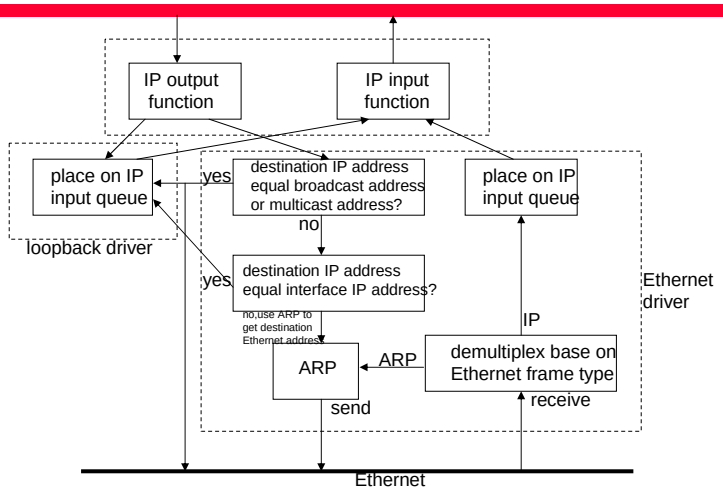


Figure 2.4 Processing of IP datagrams by loopback interface.

MTU

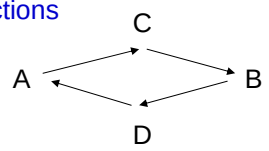
- **What's MTU (maximum transmission unit)**
  - The limits the number of bytes of data is called the MTU
- **If datagram is larger than the link layer's MTU**
  - Breaking the datagram up into smaller pieces (fragments), so that each fragment is smaller than the MTU

Network	MTU (bytes)
Hyperchannel	65535
16 Mbits/sec token ring (IBM)	17914
4Mbits/sec token ring (IEEE 802.5)	4464
FDDI	4352
Ethernet	1500
IEEE 802.3/802.2	1492
X.25	576
Point-to-point (low delay)	296

Figure 2.5 Typical maximum transmission units (MTUs).

Path MTU

- **What's path MTU**
  - Path MTU is the smallest MTU of any data link that packets traverse between the two hosts
- **Why the path MTU between any two hosts need not be constant?**
  - Routing need not be symmetric, hence the path MTU need not be the same in the two directions



- **Serial Line Throughput Calculations**

960 bytes/sec 480 bytes/sec

Summary

- Since both SLIP and PPP are often used on slow links, both provide a way to compress the common fields that don't often change.
  - Better interactive response.
- Loopback data has been completely processed by the transport layer and by IP when it loops around to go up the protocol stack