Week 10 starts here.

Byte stuffing. Tanenbaum p 107 etc.

In many protocols, there are special **characters** (Bytes) that have a special meaning, such as "start of frame", ~~or~~ "end of frame". (Flag Bytes).

Similarly, in some languages there are special symbols.

Unix: \ , @, #, *, and a few more

\ functions as "escape".

If you want to have a \ in your text, just as character, without special meaning, use \\

\\ : just character \

* : just " *

\# : just " # etc.

Same in protocols.

This is called "Byte Stuffing".

(one character = one Byte).

Problem in case of ~~bitstream~~ streams that are not Byte-oriented.

Bit Stuffing Tanenbaum p 190.

Several protocols use special
delimiters (Flag Patterns).
For example "Start of Frame".
"End of Frame".
(S.o.F, E.o.F).

For example, HDLC
(High-level Data Link Control)
and related protocols use the Flag Byte

$0\underbrace{111\ 111}_{6\ \text{ones}}0$ as delimiter
(S.o.F as well as E.o.F).

What if this pattern occurs "naturally"?
(e.g. as Hexadecimal $\underbrace{0111}_{7}\ \underbrace{1110}_{E}$)?
$(= 7 \times 16 + 14 = 126)$.

Bit-Stuffing.

Bit stuffing:

Whenever there are 5 or more consecutive ones, add zero after every fifth one.

0 11111 111111 0 10100 11111 01

becomes

0 11111 0 11111 0 10101 00 11111 001

and "destuff" later on.

A question on bit-stuffing (or de-stuffing) is likely on next quiz.

De-stuffing:

0 1 0 11111 0 1110 11111 0 11111 0 11 01

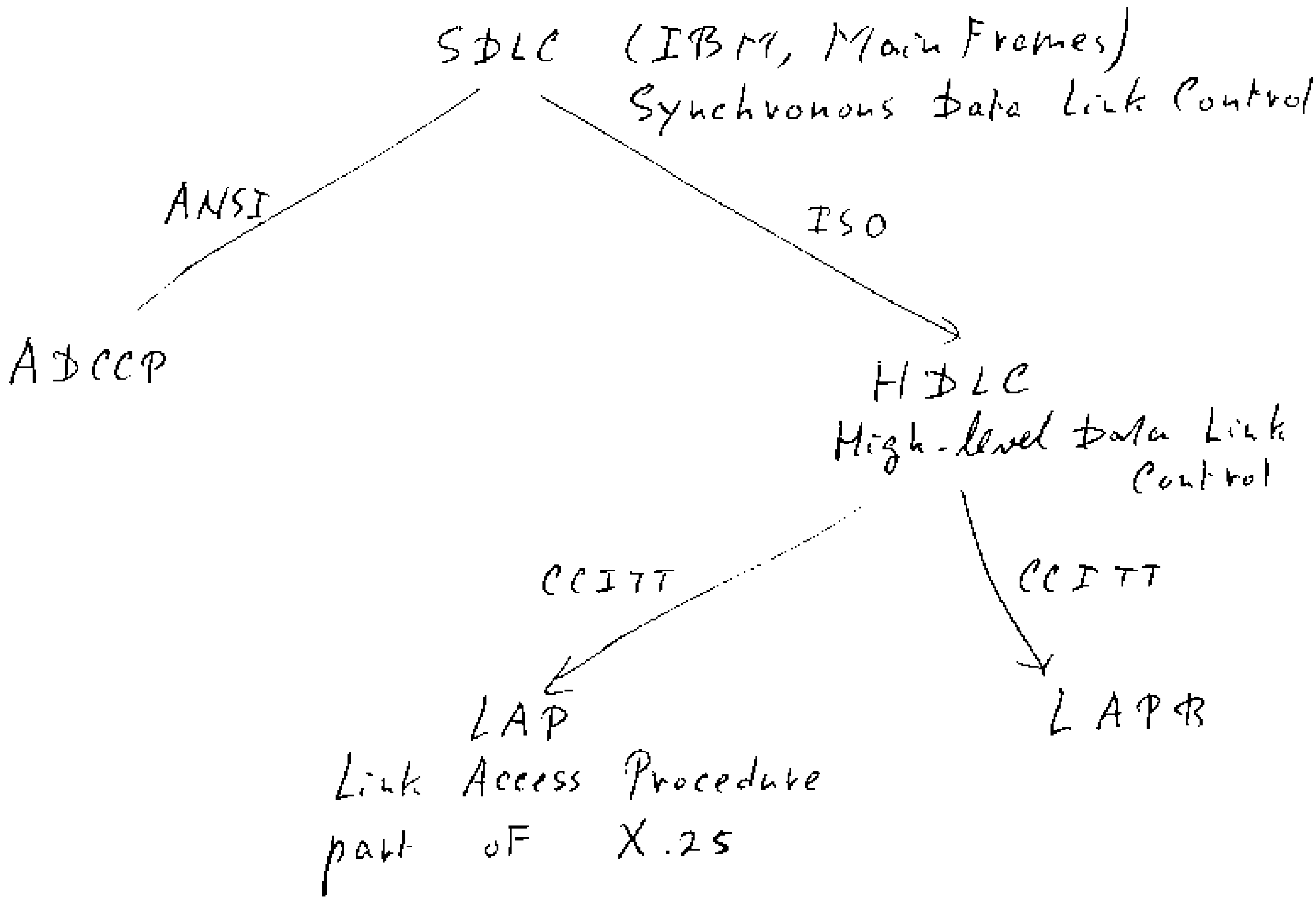
Becomes

010 11111 111 0 111111111111 01

$10\ 11\ \underbrace{0\,111111\,0}_{\text{Flag!}}\ 101011$

10 110 11111111 001   Error! (or ...).

Data Link Layer Protocols.



See Tanenbaum, p 234-238.

These protocols are <u>bit</u> oriented

Something like:

(HDLC Family).

8	8	8	≥ 0	16	8
01111110	Addr	Control	Data	CRC	01111110
Flag (Delim)					Flag (Delim).

Uses <u>Bit-stuffing</u>.

Bit-oriented:
The data <u>could</u> hold 15 or 16 or 17 <u>bits etc.</u>
("Real" bits, before stuffing).

§ HDLC can be used in "Point to Point" mode (1 link, 2 stations) and in "multipoint" mode (1 "link", one "primary station", ~~one~~ multiple "secondary stations"). (1 master, several slaves).
In "multipoint" mode, the address field contains the address of the <u>secondary</u> station that is sending or targetted.
<u>All</u> traffic is to-from primary station.

HDLC family:

(1) Remember what I said.

(2) Read Tanenbaum pp 234-237.
Remember where to find it.
I will not ask about it.

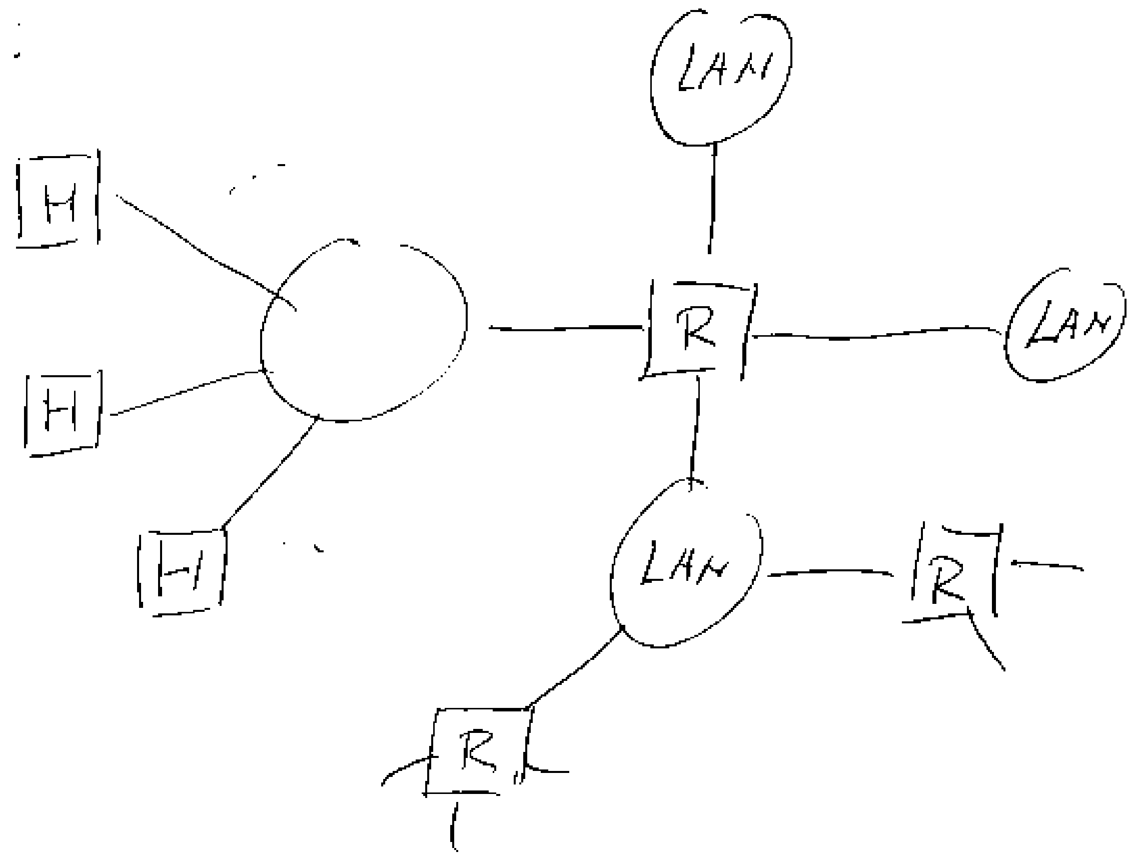
LAN (MAN, WAN) vs PtP.

LAN : Local Area Network.

PtP : Point to Point. } Not quite same.

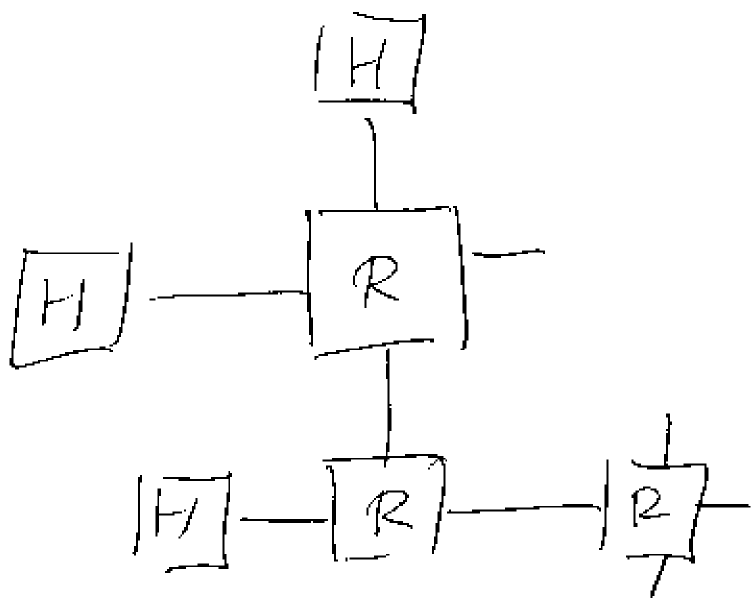
PPP : Point to Point Protocol

LAN:



LAN: multiple ~~com~~ "Hosts" (incl. Routers).

PtP:



Point-to-Point

You can think of a PtP link as a LAN (MAN, WAN) with only two participating stations.

From a "higher layer" point of view, this always correct. (From IP point of view).

Sometimes this is the only right way to think about it:

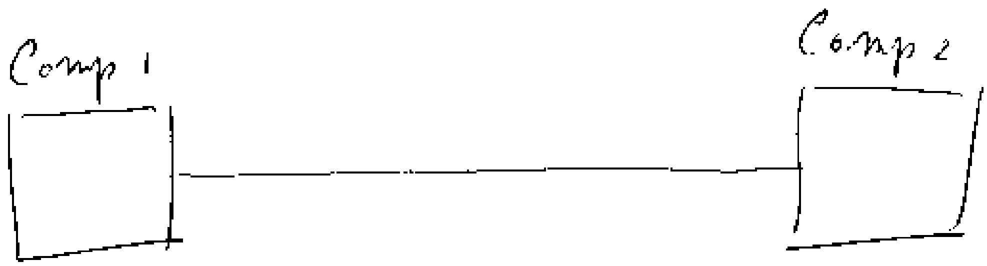
VLAN with only 2 stations.

or,

2 Computers connected by Cat 5 Cable (10/100 Base T), Crossover Mode.

Sometimes there is another way: "Fundamentally Point to Point" (tjo terminology)

E.g. two computers connected "by telephone".



"True Point to Point Link".

How do we <u>describe</u> the link?

(1) Bandwidth.
56 kb/sec., 64 kb/sec., T1, T3, OC-1.

(2) Physical. Twisted Pair.
Co-ax (Cable)
Optical Fiber (OC-1, OC-3, ..)

(3) Way signals are represented.
Baseband (e.g. Manchester, ...)
Carrier Wave (e.g. QAM 16, QAM 64, ...)

(4) <u>Protocol</u> ←

Protocol on P-P connections:

Very often : PPP

Point-to-Point Protocol.

Used for:

PC-at-home – modem – phoneline – modem – Router – (Internet)

Router – Router

// And others.

PPP is an <u>IETF</u> protocol.

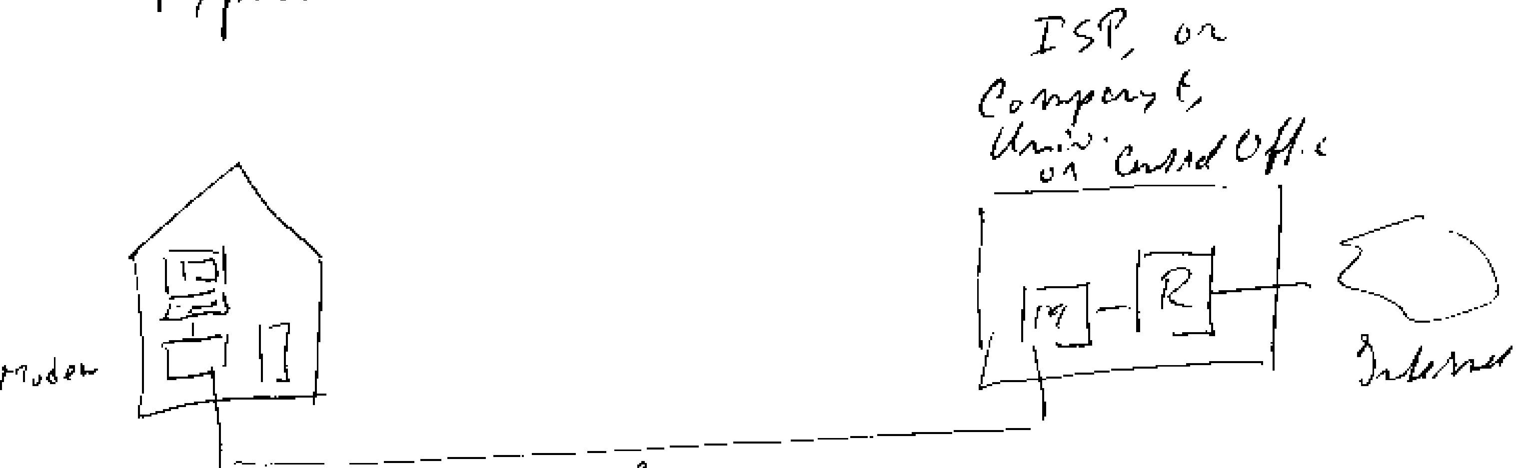
IETF RFCs 1661, 1662, 1663.
and later ones.

"Request for Comments".
Really Standards.

PPP: <u>IP oriented</u>.

Tanenbaum section 3.6.2,
p 237 etc.

Typical use:



PPP link.
(Telephone line).

If the phoneline is an ordinary phoneline (~ 50-3100 Hz only), analog)

we need a modem

Modulator - Demodulator

to ~~put~~ transform the digital signal from the computer to something that can be transmitted on an analog line.

Modulation Techniques:

16-QAM (9600 bits/sec at 2400 Baud).

V.34 (Trellis) 28,800 bits/sec at 2400 Baud.

V.90 (Trellis) 33,600 bits/sec.

If the phoneline is modified to allow a higher frequency range we get

DSL (Digital Subscriber Line).

Trellis Code and higher Frequencies and multiple frequencies. (Trellis or QAM on each)

QAM with 4000 Baud, 15 bits/Baud per Frequency Band

Tanenbaum pp 128-134.

4000 * 15 = 60,000 bits/sec per band.

each Frequency Band: ~ 4.312 kHz wide.

~ 250 bands used for data: 250 * 60,000 = 15 M bits/sec

Theory!

DSL: each of the frequency bands is half duplex ~~(or duplex?)~~

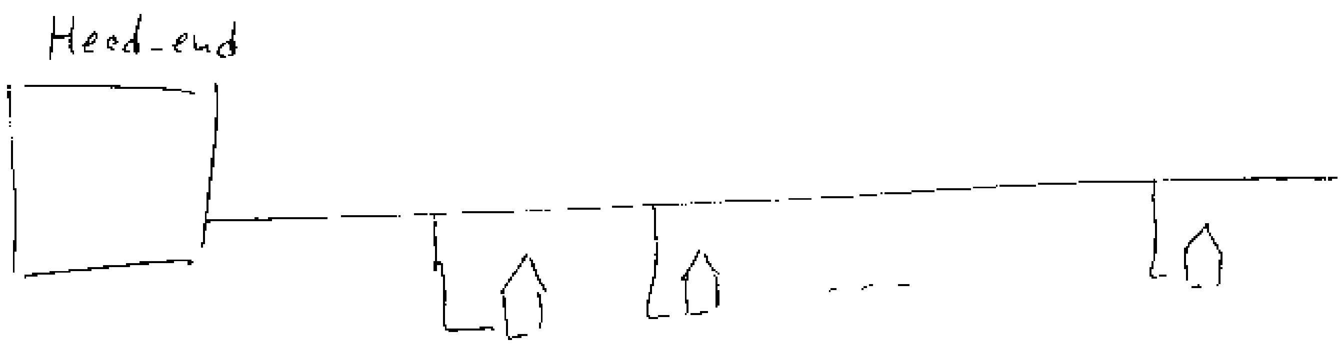
More used for up than down: ADSL

Actual achievable: depends on length, quality of local loop.

often: upstream: 64 kb/s to 1 Mb/s.

downstream: 500 kb/s to 8 Mb/s.

Cable modem (more later)



~~Part of the~~ Most of the frequency used for downstream TV.

Some for downstream data

Some for upstream data.

complicated Protocol.

Cable Modem:

Downstream data 64-QAM, (6 bits/baud)

or 256-QAM (8 bits/baud)

Upstream: is done at lower frequencies.

(5-42 MHz).

QAM is unsuitable.

used: QPSK, 2 bits/baud.

(4 phases).

Bandwidth is <u>shared</u> between users.

Complicated protocol (for sharing).

Wireless local loop. Later.

Advantage of DSL over Cable, Wireless: <u>Security</u>.

Back to PPP.

Point-to-Point Protocol.

link : could be telephone line
Cable,
Fiber,
T1, T3, OC-x
Wireless.

But always P-P.

Frame Layout:

Derived from HDSL.

Flag 8	Address 8	Control 8	Protocol		FCS	
01111110	11111111	11000000		Data & Padding	CRC	Flag 01111110

(meaningless!) But: ... (HDLC Broadcast)

2 Bytes (16 bits)

2044 Bytes

Frame Check Sequence.

often: IP packet.

Depending of the protocol inside "Data & Padding" it may (will) have its own structure.

If the "Data" is an IP packet,

$$\text{Protocol} = 0021_{16} = 0000\ 0000\ 0010\ 0001$$

PPP is IP oriented.
Unlike HDLC (High-level Data Link Control),
it is Byte oriented.
Always multiple of 8 bits.
(Before stuffing!)

It has options to exchange information
(IP addresses) at opening.
It has options to assign IP addresses.

ISP has "stack of addresses".
At opening: "Home" requests a temporary
IP address.
Like DHCP
Dynamic Host Configuration Protocol.