Star Topology: Each station connects to common central node, usually via p-p links. Central node operates in broadcast mode, resubmit to all stations each frame it gets. Central node acts as a frame switching device, buffer incoming, & resubmit to their dest. One station can transmit at a time (hub). Physical star, logical bus.

IEEE 802 LAN: IEEE 802.3 is a committee

SNAP/DSAP defines the protocol in LAN layers. MAC layer: receive frames from LLC, add address to frame, pass frame to physical layer; ar on rx: receive from physical, check frame error, verify dest MAC, pass to LLC. LLC layer: provides interface to higher layer, flow control & error control

PHY: encode/decode signals, preamble generation/removal, bit transmission/reception

LLC PDU in MAC Frame

MAC Frame: MAC control | Dest Addr | Sourc Addr | LLC PDU | CRC

MAC header | MAC trailer

LLC PDU: DSAP (1) | SSAP (1) | LLC Control (1 or 2) | Info (variable)

1bit: I/G | DSAP | C/R | SSAP

I/G: Individual/Group C/R: Command/Respond.

What are 3 LLC services?

Unack Connless: Requires min logic, avoid dup of mechanism, prefers option in most cases.

Conn-Mode: Used in simple devices, has flow & reliability control.

Ack-conless: large communication channel needed, time critical or emergency control signals

2 Techniques used in MAC protocol

Synchronous: allocates a specific capacity to each conn.

Asynch: dynamically allocate capacity to meet changing demands: Round Robin, Reservation, Contention

3 approaches used in Asyn MAC Allocation?

Round Robin.
- The needy stations alternately get their turn in some ordered for some duration of time.
- control of seq: centralized or distributed.

If only a few stations have data to transmit, there will be a considerable overhead of passing the turn.
- No waste of b/w
- Need a master to divide time
- Commonly used.

Reservation.
- Time in the medium is divided into slots
- Stations w/o reservation must wait for time slot to be released.

→ same.
- Good for stream traffic.
- No master, you reserve ur slots.
- Wast of time if a user has nothing to share → under utilization of B/W.

Contention:
- Different stations compete among themselves for a share.
- Control of seq: no control.
- Good for burst.
- No control of whose turn → no master, no SPOF
- Simple to implement.
- Performance tends to collapse under heavy load.
- Commonly used
- No waste of B/W

Which layer take care of flow & error control in IEEE 802?
Flow control: LLC
Error control: MAC, LLC

Describes 3 mechanisms a bridge use to update its routing table base on spanning algorithm.

Frame Fwd.
- Maintain fwding db for each port attached to LAN

Address Learning
update fwd db to include src addr of arriving frame from port X.
- Set timer on each entry, if expired → remove.
- Timer refreshe for existing record.

Loop Resolution
The algo works if there is no alternate routes (closed loop) in the network.

Spanning tree algorithm:
- each bridge is assigned unique identifier
- Cost assigned to each bridge port
- Exchang info between bridges to find spanning tree.
- Auto update when topology changes.

What are 2 types of layer 2 switch?

Store & fwd: delays, check CRC, boost integrity.

Cut thru: no delay, no error check.

Why we need VLAN? Types of VLAN.
VLAN is a logical subgroup within LAN that is created by sw rather than by physically moving & seperating devices.
It combines user stations and network devices into a single broadcast domain regardless of physical LAN segment they are attached to & allow traffic to flow more efficiently within population of mutual interest. The VLAN logic is implemented in LAN switches & functions at the MAC layer. Because the objective is to isolate traffic within the VLAN, in order to link from one VLAN to another, a router is required.

Membership by:- Port group, easy to config, network admin must record membership time to time. MAC addr: physically movable, must be assigned initially, and if user change dock (within different MAC), need to reconfig. Protocol: base on IP, flexible.

How many types of MUX? TDM & FDM

2 processes of FDM?
- use modulator to move each signal to required freq band.
- use mux device to combine the modulated signal, each called subcarrier.

Problems that FDM must cope with?
- Cross talk, since comps a close.
- Intermodulation noise.

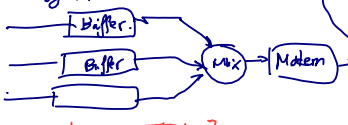
Which MUX is high capacity, long distance use?

Def: FDM, ex. AT&T.

What is derivative of FDM?
WDM, used in fiber optical cable. Multiple beams of light are transmitted with different freqs on same cable.

What is TDM?
Method for transmitting & receiving independent signals on common path by letting each signals appears on the line in a fraction of time.

Pros: Cons:

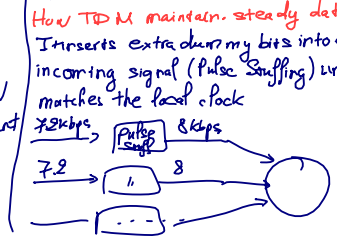


Synchronous TDM?
Time slots are pre-arranged & fixed, not bec of syn transmission.

Does TDM have header & trailer?
No, does not need data link control than. NO header no trailer. Error control shd be per channel.

How to maintain sync between src & dest in TDM
One control bit added into each TDM frame.

How TDM maintain steady data rate?
It inserts extra dummy bits into each incoming signal (Pulse Stuffing) until it matches the local clock



TDM time have on sampling?
Sampling 8kHz ⇒ $T = \frac{1}{8kHz}$ sec.
$\frac{1}{8000} = 125\mu s$.
⇒ each slot for TDM 125μs.

SONET Data rate:

SONET	ITU-T	Data Rate	Payload Rate
STS-1/OC1		51.8 Mbps	50.112 Mbps
STS3/OC3	STM-1	155.52	150.336
STS12/OC12	STM-4	622.08	601.344
STS48/OC48	STM-16	2.48832 Gbps	2.40
STS192/OC192	STM-64	9.95328	9.621
STS 768	STM-256	39.81312	38.486
STS 3072		159.25248	153.9441

STS-1 Bandwidth. calculate.
(octet) 90 columns
Rows
9 x 90 bytes = 6480 bits
125μs → 6480 bits.
1 sec → $\frac{6480}{125\mu s}$ = 51.48 Mbps.

Prove why DS-1 = 1.544 Mbps (1-bit stuffing)

TDM: channel bank

Sampling Rate = 2 x voice freq. = 8000 Hz.
Bit rate = 8 bit.
⇒ each circuit/channel b/w is.
8 x 8000 = 64 kbps → DS-0

DS-1: there are 24 channels in bit rate = 24 x 8 + 1 (framming bit) = 193 bit.
⇒ TDM = 193 x 8000 = 1.544 Mbps

Explain what TDM does to compress 24 subscriber into 1 signal $\frac{1}{8000} = 125\mu s$.
⇒ each channel now has $\frac{125}{24} = 5.2\mu s$

How many bits are stuffed for DS-2?
DS-2 has 96 channels = 4 DS-1.
125μs : 193 x 4 + x
1s : 6.312 Mbps
(193 x 4 + x) x 8000 = 6312000
⇒ x = 17 bits.

North America & Intl. TDM Standard

North America.	Channels	Rate Mbps.	ITU.		
DS-1	24	1.544	1	30	2.048
DS-1C	48	3.152	2	120	8.448
DS-2	96	6.312	3	480	34.368
DS-3	672	44.736	4	1920	139.264
DS-4	4032	274.176	5	7680	565.148

In switch, what is link type for Node-Node, Node-Node?
Node-Station: p-2-p
Node-Node: FDM or TDM.

Techs used in WAN? Circuit Switching & Packet Switching.

Which Switching derived from telephone?
Circuit switching.

Compare Circuit Switching, Datagram Packet Switching & Virtual Circuit Packet switching.

	Circuit Switching	Datagram Packet Switching	Virtual Circuit Packet switching
	- Dedicate transmission path.	- No	No.
	- Const trans of data	- Trans of packet	//
	- Fast enough for interactive.	//	//
	- Message are not stored.	- Packet may be stored	- Stored until delivered
	- Path establish for entire conversation	- Route est for each packet.	- Route established for entire converse
	- Call set up delay negligible trx delay	- Packet trx delay	- Call setup delay, packet trx delay.
	- Busy signal if callee busy	- overload increases packet delay	- Overload may block call setup, increase packet delay
	- user responsible for loss protection	- Network may be	// for packet sequence.
	- No speed (data rate) nor code conversion	- Got	- Got
	- Fixed b/w	Dynamic	Dynamic.
	- No overhead bits after call setup	Got overhead in each packet	Overhead in each packet.

Compare Bridge, Hub, Switch:

Hub
- Central element of star layout physically (bus logically), act as repeater
- Each station connects to hub using 2 lines
- Broadcast mode
- Good for building wiring practices
- Limited length of line 100m
- Collission occur if 2 station transmit at the same time.

Bridge
- Connect similar LANs with identical physical & link layer protocols
- Review dest addr but NOT modify MAC fields, thus do not contain LLC layer
- Frame handling by SW
- Fwd 1 frame at a time
- Only has stored fwd option
- Reliability
- Performance
- Security
- Geography
- Only 2 ports

Switch
- Frame is delivered to recepient node (no broadcast)
- Frame Fwding HW
- Can handle multiple frames at a time
- Can have cut through ops. beside store & fwd
- Dedicated capacity equal to orig. LAN
- Total network thruput increases (no broadcast)
- No change to SW or HW is required to replace current bus/Hub to switch.
- Scale easily
- More ports than bridge

Compare 2 types of Space Division Switching

	Single Stage Switch. (Crossbar)	Multistage Switch
Advantage	- simple - nonblocking scheme - every one can talk to each other.	- lesser/smaller switches → effecient in cost & hw maintenance.
Disad	- list of switch grows huge, difficult to maintain. - SPOF	Maybe blocking, i.e there is limit of no. of conns at the same time

Which packet switch is more suitable for long msg? Virtual Circuit

Packet Switching is Connless.

What is the advantage of Connless?
Flexible, can be made robust, no unnecessary overhead.

Which layers are implemented at all station & routers in IP?
Physical, MAC, LLC, IP

What does IP layer provide?
Routing service, datagram lifetime, fragmentation, reassembly, error control, flow control.

What are routing techniques used in IP?
Routing table (dyn or static), source routing, route recording, seq for each packet.

How Error Control work?
to discard certain diagrams: expired lifetime, congestions, FCS error.

How Flow Control Work? Target sends ICMP to indicate business & next availability. Source will reset waiting time when receive new availability.

What is SoftSwitch?
A general purpose computer running specialised s/w and as smart phone with cost less & has more funcs than traditional switches.

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What is 4 Frame Exchange ?

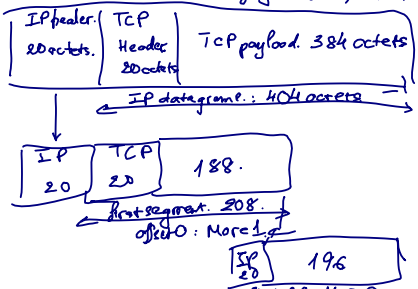
Used in 802.11 for reliable data transfer:
- Src sends Request to send (RTS)
- Dest responds Clear to Send (CTS)
- Source transmit data after CTS
- Dest ack immediately each time it receives new frame

this technique replaces Collision Detection.

Structure of IP Fragmentation

- Org datagram split into multiple fragments, in multiple of 8 bits. - Each fragment has IP header, 1 Payload.

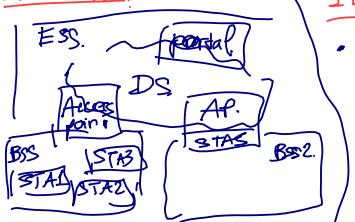
Each IP header has:
- Data ID: source addr & dest addr, the protocol layer that generate data.
- Data length: length of user data field (1 unit = 8 bits)
- offset: post of fragment (1 unit = 64 bits, 208 in octets → 26 in 64bits)
- IP flag: 0 (false) no more, 1 (true) has more



IEEE 802.11 WLAN Std

	Freq band.	bandwidth	Modulation.	Max Data rate
802.11.	2.4 Ghz	20 Mhz	DSSS, FHSS	2Mb/s
802.11b	2.4	20	DSSS.	11Mb/s
802.11a	5.	20	OFDM.	54Mb/s
802.11g	2.4.	20	DSSS, OFDM.	54Mb/s
802.11n.	2.4, 5	20, 40	OFDM.	600Mb/s
802.11ac	5	20/40, 80, 160.	OFDM.	6.93Gb/s
802.11 ad.	60	2.16 Ghz.	SC, OFDM.	6.76Gb/s

WLAN Arch:



IEEE 802.11 Services:

- Station. Service. : connect STA & similar to plug into ethernet cable.
  - Auth.
  - Deauth.
  - Enc.
  - MSDU delivery
  - Dynamic Freq Selection (DFS.
  - Transmit Power Control (TPC)
  - Higher layer timer sync (QOS)
  - Radio Measurement (QOS)
  - DSE
- Distribution System Service (DSS): is all about getting data from 1 pair to the other, it exchanges the MAC. frames. from 1 sta in 1 BSS to another STA in another BSS. It also works in same BSS.
  - Assoc : before can transmit data
  - Reassoc : move from one BSS to another
  - Disassoc : terminate
  - Distribution.
  - Integration
  - QoS traffic scheduling (QOS)
  - DSE
  - internetworking with DS

Integration Service (IS) enable delivery of MAC frame between DS & non. non 802.11 network via portal, aka frame format transmethot, translates 802.11 frame into 802.3 frame

Why we need IP addr if we already had MAC add?

- Carry info from one network to another
- Distribute info based upon MAC addr
- IP is dynamic, MAC is fixed.

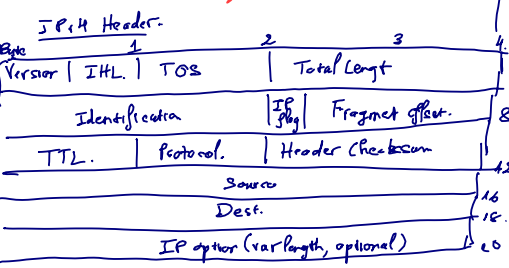
Which encapsulate way IP use? At destination.

How does IHL measure IP header? 1 unit IHL = 4 bytes

How does Total Length measure size of IPv4 data? 1 unit in Total Length = 1 byte in datagram

What are IP service parameters?
Source & dest addr, protocol, type of service, identification, fragment indicator, TTL, data length, option data, user data. IPv4 header size? 20 byte min. (5x4)

IPv4 Header.



What is SAP? How many bits are used for SAP field?

SAP is service access point, 8bit. 802.2 header has 2 SAP, SSAP DSAP.

Benefits of incorporating bridge into a phy network?

Reliability: partition the network for fail safe

Performance: smaller network improve performance.

Security: Keep traffic confidential network

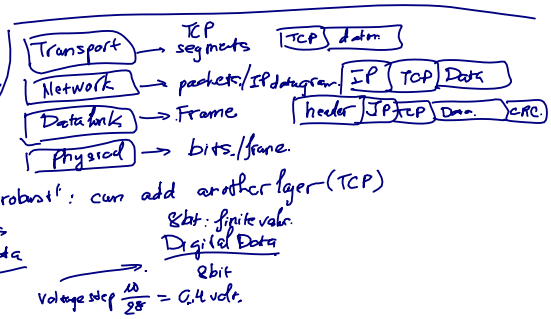
Geography: split by geographically demand.

Key design aspect?

- Makes no mod to frame content
- Contain enough buffer for peak
- contain routing & addressing
- connect more than 2 LANs
- bridge is transparent to STA.

What is HUB?

- active central element of star layout.
- station connects to HUB 2 lines
- acts as repeater.
- length of a line is limited 100m. (500 for fiber)



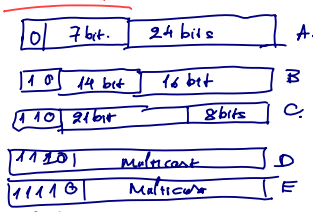
"robust": can add another layer (TCP)

Infinite values Analog Data ↑10V

8bit: finite value Digital Data 8bit

Voltage step 10/28 = 0.4 volt.

IPv4 Classes.



Calculate Network ID, host ID from IP & network.

- Network IP: AND IP & Netmask / 192.228.17.57 AND 255.255.255.224
- Host ID: AND on the IP and inverted bit of Subnet mask.

How congestion is controlled in IP?

Via ECN bit, congestion indication.

What VLAN consist of?

- Backbone wired LAN
- Control Module, interface of WLAN, incl. bridge, router.
- stations, user modules (bridged no. of station on another wired LAN)

10 requirements of WLAN?

- throughput: max capacity of medium use.
- number of nodes:
- connection to backbone LAN
- service area
- battery consumption
- trans robustness & security.
- collocated network operation
- licensee free operation
- hand off/roaming: use can move different cells.
- dynamic configuration.

What are mobility transition types of WLAN?

No transition, BSS trans, ESS trans

3 func areas of Medium Access Control?

Reliable data delivery (using 4 frame exchange), access control, security.