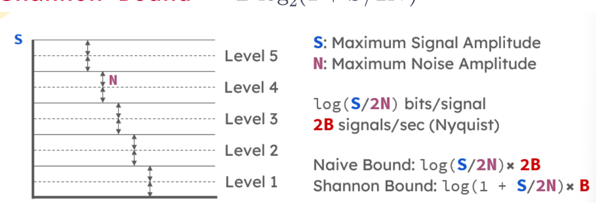
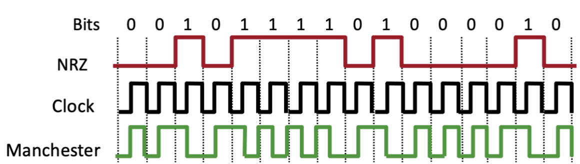
CS 118 Midterm Cheat Sheet

Physical Layer

Layer Violation - layers may only access/view their own headers/layer content
easy way to identify: if a header of a lower layer is changed, it should not impact current layer service - if it does there is a violation
ECN - Explicit Congestion Notification - added to IP & TCP to inform source abt congestion and to decrease sent packet rate
Bandwidth/Frequency (B) = $F = 1/T$ hz
where T is period an F is frequency
Intersymbol Interference (ISI) - interference between the lag of the previous symbol and the next symbol
Nyquist Limit = $2B$ bits/s
you can bypass Nyquist limit by sending on different phases or frequency
Baud Rate = $\log_2 L \times 2B$ bits/s
where L is the number of signal amplitudes
Shannon Bound = $B \log_2(1 + S/2N)$



Nyquist-Shannon Sampling Thm - Anti-aliasing iff $f_s > 2f_{\max}$
where f_s is sampling freq and $f_{\max}$ is og max freq
Synch. Clock Recovery - signals require preamble w/ transitions to reduce receiver clock overhead when sampling synchronously
Manchester Encoding - encodes bits to transitions at mid bit width: 1:hi→lo, 0:lo→hi
con: 50% efficient - encodes only half bit per transition



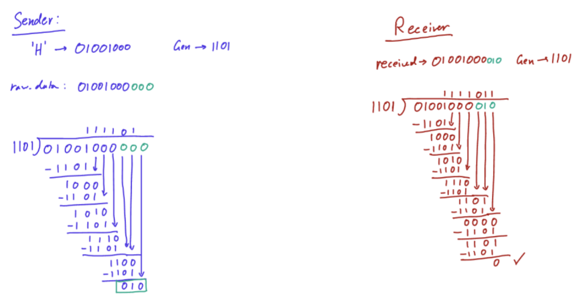
Alternate Mark Inversion (AMI) Encoding - encodes bits to alternating voltage levels: 0:0V, 1:$\pm$V. Each bit alternates positive and negative voltage.
e.g. `11100111` → `+-+00+-+`
con: issues with long seq of 0s
4-5 Encoding - encodes 4 bit seq to 5 bit seq w/ transisition
e.g., `1111` → `00001`, mitigates long preamble
con: introduces new overhead for every 4 bit pattern
Broadband Encoding - Frequency Shift Keying (FSK), Amplitude Shift Keying (ASK), Phase Shift Keying (PSK)
not limited to energy levels like baseband encoding above
Signal Demux - Time/Freq/Phase Division Mux (T/F/PDM)
e.g., tv channels - signals muxed by frequency of signal
Twisted Pair Cable - low bandwidth, cheap → Cat 5 twisted pair higher quality
Coax Cable - high bandwidth, og ether, too clunky replaced by Cat5
Fiber Optic Cable - huge bandwidth, unidirectional, but chromatic and modal (bounce) dispersion, expensive, multichannel via multicolor but expensive with prism to demux color

channels
Wireless 802.11b - broadband, requires spectrum allocation, possibly satellite, radio large passes through objects

Medium	Speed	Distance Span	Pros	Cons
Twisted Pair	1 Mps -1 G (Cat 1 – Cat 5)	1 – 2 Km	Cheap, easy to install	Low distance
Digital Coax	10-100 Mbps	1- 2 km	broadcast	Hard to install in building
Analog Coax	100-500 Mbps	100 Km	Cable companies Use it now	Expensive amplifiers
Fiber	Terabits	100 km	Security, low noise, BW	No broadcast, Needs digging
Microwave	10-100 Mbps	100 km	Bypass, no right Of way need	Fog outages
Satellite	100-500 Mbps	worldwide	Cost independent of distance	250 msec delay Antenna size
RF/Infrared	1 – 100 Mbps, < 4 Mbps	1 km 3 m	wireless	Obstacles for infrared

Data Link Layer

Flags - wrap datagrams to fragment into frames, signify start and end
HDLC - bit stuffing for false flags, no escapes
PPP (Ethernet) - byte stuffing, with escapes
Stuffing Overhead - #stuffed bits / #og bits
Stuffing Efficiency - Probability of stuff = #flags / #bit combs/patterns
CRC32 Mod2 Div - shift left by `len(gen)-1` then long divide generator, xor only for leading 1s, if leading 0 → move right until leading 1



CRC-16: $X^{16} + X^{15} + X^{2} + 1 = 11000000000000101$

We skip proofs of these properties this quarter but they are in your notes, Not required for HWs and tests.

Odd bit errors: can handle but not a big deal as parity can handle with using just 1 bit. 1

Two bit errors specially designed CRCs can do this. Beats parity!

Burst errors: CRC-32 can catch any 32 bit burst error for sure. Further it can catch larger burst errors with very high probability: (1 - 1/ 2^{32})

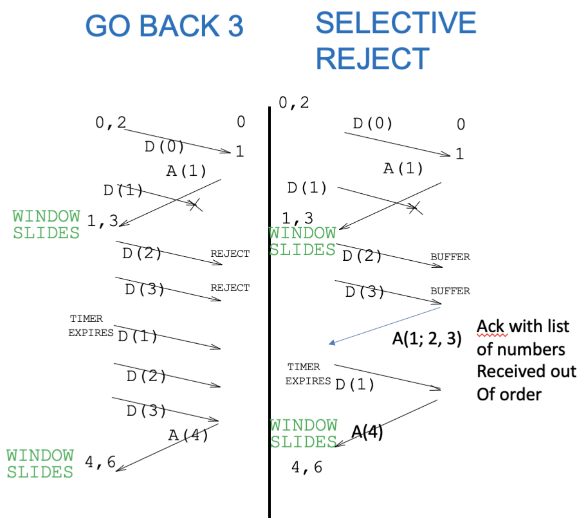
Summary: So the big deal is that it can for sure catch up to 3 bit errors, and can detect **any** error with very high probability. Like a hash function with with some deterministic guarantees

Band Invariance - sender and receiver will alway be within $x+1$ packet ids of each other. Receiver state is id of packet waiting to receive, ack is id of receiver state

```
----------          5 4 3 2 1 0           ---------
|  s = 3 | --------------------------------|  r = 3 |
|        |--------------------------------|        |
 ---------                                  --------
```

Sender state updates with ack
Throughput (bits/s) - jobs/s (usually round trip)

Latency (s) - worst case time to complete 1 job
1-way propagation delay (s) - time for transmitted bit to cross link
Transmission Rate (bps) - bit rate over link bits/s
Pipe Size aka Bandwidth Delay Product (bits) = Transmission Rate $\times$ Round-trip propagation delay
Sliding Window Ack Protocol
only fifo packets with ordering, fails on UDP
mod for packet ids depends on window size W (max number of packets sent in sequence)
alternating bit - mod 2
go back W - mod W+1
selective reject - mod 2W



Restart Signal - requires ids to mitigate multi restart
usually uses max frame time timer then restart - issue is must wait for timer so longer time to reboot

LAN

Ethernet - multi-access many-to-many, demux via MAC addr

01010111 preamble	Dest (6)	Source (6)	Length (2)	Data	Pad	CRC

Total Frame length
64<=L<=1500

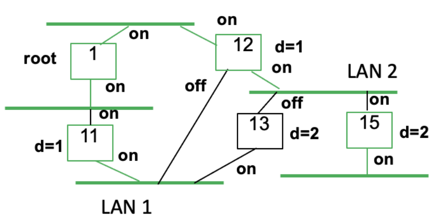
Strict Multiplexing (B/N) - allocate static bandwidth via TDM/FDM
Stat. Mux.(B/x s.t. x < N) - allocate bandwidth based on traffic
allows clients to use others' bandwidth when low traffic
CSMA/CD - Collision detection via carrier sense - stations must listen and detect collisions occurring at their station and propagate info to all stations
Ethernet uses min frame size of 64 bytes = Pipe size = Trans. Rate (10 Mbps) $\times$ RTPD (51.2μs) = 512 bits
Limits cable length if link has higher transmission rate
Collision detection via voltage, if high is 1, avg volt for 0 or 1 is 0.5V, collision would cause avg volt of 1V
Jam bits during collision to extend collision to be detected by other stations
Binary Exponential Backoff - wait longer time for more collisions
Choose wait time after k collisions from $2^k - 1$ time sots
e.g., after 1st, choose 0 or 1 wait, then 2nd choose 0 to 3 wait
Hubs - Single point of connection for all nodes on ether, requires CD

Wireless 802.11b

Multichannel - 12 allocated channels, 3 orthogonal channels at a time
Stations can be on orthogonal channels so CD wont be detected if on diff channel
RTS/CTS (MACA) - before node A transmits, send couple bytes called Request-to-Send on all channels, node B hears and calls Clear-to-Send broadcast → node C hears and defers

Bridges/Switches

MAC Addr - 6 bytes (48 bits)
Unique to device, unique to terminal (rec/send)
first 3 bytes for vendor, last 3 host
MSB leading 1 → multicast
IPv4 - 4 bytes (32 bits)
allocated per network via DHCP
Accessible IPs mapped via DNS
leading 1 (or `1110`) signifies multicast
Switches - 1-to-many, point to point, buffer frames if link is busy
Entries in DB by looking at Src addr (up)
Flood down if dest not known
No loops → tree topology
Timer for buffering, timer expires → flood all buffered frames
Switch Transparency - bridges must be transparent to nodes, must appear as simple ether/cable
Promiscuous Receive - Switches buffer from all stations regardless of src
Flood - Forward to all stations on line, picked up by correct MAC
Filtering - filter packets by ether header for forward or buffer
Bridge Spanning Tree Algo - bridge ids, drop longer links to same LANs



- Root is Min ID node (in this case Bridge 1)
- Other bridges finds Min port, port through which it has shortest path to root (parent), For 11 it is upper port.
- Each bridge also finds the ports for which this bridge is on the shortest path between root and corresponding LAN: Designated Ports. For example, 11 and 12 have d= 2 for LAN 1, so we pick shorter ID as tiebreaker, Bridge 11 is designated bridge for LAN 1, 12 for LAN 2
- Each bridge turns ON Min port and all Designated Ports. ON,OFF are software states: always receive hello and management messages on all ports. Drop data packets to/from OFF port.