ECE 435 – Network Engineering
Lecture 23

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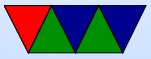
11 April 2024

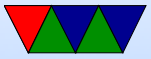
Announcements

- HW#10 will be posted
- Project Status is due Friday
  - One e-mail per group
  - One-line summary of project topic
  - Brief update on how it is going
  - Whether you're willing to present on early Thursday vs Tuesday vs Thursday



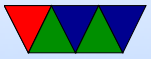
Homework #8 Review – Bandwitdh

- NOTE: be sure you use the proper log (base 10 or base 2) and not the natural log (ln)
- S/N is 25. db=10 log S/N, roughly 14dB
- 100MHz, 20dB bps = Hlog 2 (1 + S/N)
  S/N = 100, bps = 100M*log2(1+100) = 666Mbps

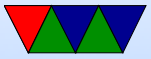


Homework #8 Review – Tradeoffs

- Fiber vs copper
  - Speed? This varies,
  - Electrons in copper 50-90% of speed of light, Light in fiber 70-90%
  - This is why microwaves used for high-speed trading
- Satellite vs fiber:
  - no need to run cables everywhere
  - Can broadcast over greater area
- Fiber vs satellite:

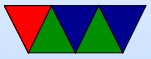


- security (harder to tap?)
- latency
- Cost? Which is more expensive?
- faster?



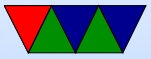
Homework #8 Review – Frequency use

- FCC won't let me be
- Though they only regulate consumer, federal govt (like military, FAA, etc, NTIA National Telecommunications and Information Administration) 4.3GHz airport/radio navigation
- FCC database lists numerous companies, but they don't own freq, just have license to make radio altimeters
- 100W sounds like a lot, but as long as you're not holding it in your hands not really that large for a transmitter.



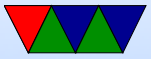
HAM radios, 100W light bulbs.

- This is in the C-band, but C-band as a whole is not reserved, it's just a descriptive name for it.



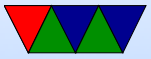
Bridging

- How do you connect together multiple groups of machines into one big LAN?
- An interconnection at the link layer is called a MAC bridge, or bridge. Also a Layer-2 switch
- IEEE 802.1D
- Transparent bridge, as users are not aware of them
- Bridge acts in promiscuous mode (receives every frame on the LAN) so it can find ones that need to forward on across the bridge



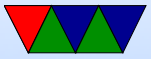
Terminology Review

- repeater – purely electronic, resends voltages (original Ethernet allowed four)
- hubs – frames coming in one port sent to all others
  creates a collision domain
- bridge – connects two or more LAs. Each line own collision domain
  can maybe bridge different types of networks (Ethernet/token, wired/wireless)
- switch – point-to-point frame routing, sort of like one



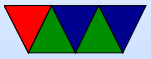
bridge per port

- router – higher layer, actually strips off headers and looks at packets



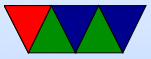
Bridging Diagram

- Some switches are just a bunch of ethernet cards, bridged together, possibly just running an embedded OS like Linux
- TODO: diagram
- Can also bridge in software, can bridge emulator/VM to external network port



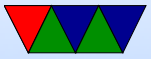
Backward/Self Learning

- How does bridge learn the MAC addresses?
- It watches for frames coming in and their source address. Puts in table.
- How does it learn where destination is? It broadcasts to all. Once the destination also sends a frame (so its source is known) then the switch updates its table and no longer broadcasts.
- How do you handle machines that are moved? Aging mechanism. If not heard from for a while, expire the



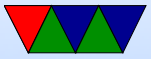
table

- Multicast or Broadcast, can follow GMRP or GARP to limit how far it is broadcast



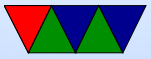
Bridge vs Switch

- Before 1991 a switch was a bridge (in the standard)
- In 1991 Kalpana made a "switch" and differentiated it by cut-through instead of store and forward
- Store and forward – whole frame received before resent larger latency, no problem with broadcast, can check FCS
- cut-through – can start transmitting before receiving completely (destination MAC at beginning). Slightly better latency, broadcast not possible, too late to check



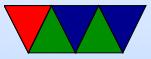
FCS

- These day most are store and forward



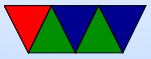
What about VPNs?

- Can happen at either level2 or level3
- More or less encapsulate the level2 frames, tunnel them through higher layers, and de-encapsulate at remote location so they look like they came from local LAN



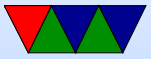
Switch Implementation

- Can implement in software with an OS like Linux
- Multiple ethernet cards
- Use operating system bridge support to bridge the interfaces together



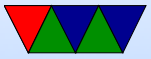
Connecting switches together

- Can chain switches together (TODO: diagram)
- Why? Because large-number of ports expensive?
  Redundancy?
  Bonding (combine connections for more bandwidth)
- What happens if loop?



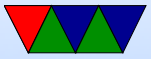
Spanning Tree Protocol

- Invented by Radia Perlman at DEC
- Can have problems if cause a loop in the topology. Frames can circulate loop forever
- Why have a loop then? Redundancy.
- `https://spectrum.ieee.org/how-dec-engineers-saved-ethernet`

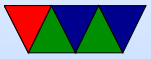


Spanning Tree Protocol – 802.1D

- Each switch and port assigned an ID with priority
- Each link assigned a cost, inversely proportional to link speed
- The lowest ID gets to act as root (there is a protocol on how to elect the root)
- Each LAN connected to upstream port in active topology, called the dedicated port. Receives from root port
- Config info comes from root as bridge protocol data unit (BPDU) on reserved multicast address 01:80:c2:00:00:00

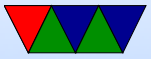


- Switch may configure itself based on BPDU.
- BDPU sent every 2 seconds
- Can take 30-50s to notice failure



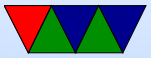
Rapid Spanning Tree Protocol – 802.1w

- Modern replacement
- Can detect failure in milliseconds



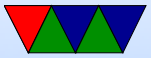
Bridging 802.11 to 802.3

- Your wifi router probably does that
- Need to strip off one header, put new one on
- Need to put fields in as needed, recalc checksum, etc
- What if bridging faster net to slower one
- What if maximum frame size different on different LANs? Can't always fragment
- What if one has encryption and one doesn't
- What of quality of service?

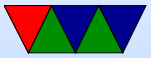


Why might you want to split up LANs

- Bandwidth concerns
- Different groups, privacy/security
- Equipment costs
- Distance
- Reliability (equipment failure)
- Security (someone in promisc mode not see everything)
- Load – two groups, one not happy if other group takes up all bandwidth
- Broadcasting – when asks for a connection, broadcasts

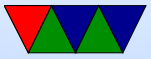


to all broadcast storms – entire LAN brought down with all machines broadcasting



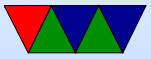
VLAN

- How to switch machines between networks? Request? Someone in wiring closet?
- Physical LAN
- What if want to partition a switch so some nodes are on one and one on another (virtual LANs)



802.1Q

- IEEE 802.1Q (dot1Q)(?)
- can have priority
- link aggregation, combine two links for higher bandwidth
- how to bridge VLANs?
  - special VLAN field in Ethernet frame
  - priority, CDI (makes connectionless interface have some manner of connection)
  - Changes Ethernet frame, but only between bridges. Endpoints don't see modified frames



- Adds 32-bit field between SRC and Ethertype.

16 bits	3	1	2
TPID	TCI		
	PCP	DEI	VID

- Tag Protocol Identifier – 0x8100, same location as ethertype so it tells that it's special VLAN frame
- PCP – priority code point
- DEI – drop eligible indicator (OK to drop frame)
- VID – VLAN Identifier