ECE 435 – Network Engineering Lecture 22

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Announcements

- HW#10 will be posted
- Project Status is due Thursday
  - 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 Tuesday vs Thursday

Homework #8 Review

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

    S/N = 100, bps = 100M*log2(1+100) = 666Mbps
  3. Tradeoffs
  - (a) Fiber vs copper

Speed? This varies, Electrons in copper 50-90% of speed of light, Light in fiber 70-90%

(b) Satellite vs fiber:

no need to run cables everywhere

Can broadcast over greater area

(c) Fiber vs satellite:

security (harder to tap?)

latency

Cost? Which is more expensive?

faster?

4. 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.

Capturing 802.11 packets

- Is it possible to gather raw 802.11 packets, like you can with ethernet/tcpdump?
- Tricky. Often wireless networks restrict raw access to the transmitter/receiver for regulatory issues (don't want random code on computer able to blast out radio signals that could interfere with shared network)
- There is a special "monitor" mode you can put some wifi cards into
- None of my machines support it by default

- For pi3/pi4 there are custom firmware replacements (nexmon) that in theory enable it plus other hacking

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

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

Terminology

- 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

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.

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