Applied Networks & Security

Wired Local Area Networks (LANs)

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Local Area Network (LAN)

- LAN can be a difficult term to define
- Generally speaking...
  - Most computers have a LAN link interface
  - Ethernet, by far, most popular link technology
  - Good capacity, measured in Mb/s minimally
  - Most LAN links cover short distances
  - Historically shared medium access
    - Increasingly less true today
Cabling demonstration

• Let's look at and talk about some basic cabling, connectors and installation practices

• If you're just looking at these slides outside of class with no video, well, you should have been here
The data link interface

I don't remember where I swiped this diagram from :-(
Physical (and logical) topologies

diagrams courtesy of http://www.netbook.cs.purdue.edu
Ethernet

- Most popular link technology by far
- IEEE standardized as IEEE 802.3
- Several generations and updates
  - Mostly same frame format
  - Updates mainly to increase transmission rate
  - Physical layer requirement changes as needed
Ethernet transmission

diagram courtesy of http://www.netbook.cs.purdue.edu

• One station successfully transmits at a time
• Signal propagates the entire cable length (bus)
• All stations receive all transmissions
• CSMA/CD medium access control
CSMA/CD

- Carrier sense (CS)
  - Wait until channel is idle, then transmit
- Multiple access (MA)
  - All stations on channel use same MAC protocol
- Collision detection (CD)
  - Listen to medium while transmitting
  - Detect if another station transmits simultaneously
  - If collision, enter back-off algorithm
Exponential back-off algorithm

- Sending station backs-off after collision is detected
- Let 1 slot time = 512 bit times (64 byte min. frame)
- Upon 1\textsuperscript{st} collision, randomly choose \{0,1\} slot delay
- Upon 2\textsuperscript{nd} collision, randomly choose \{0,1,2,3\}
- Choose from [0 to 2\textsuperscript{n}–1], N=transmission attempt
- Up to a maximum of 16 retransmission attempts
- And up to a maximum of 1023 * slot delay time
- Give up after 16 retransmission attempts
- Capture effect: brief, unfair advantage for busy sender, in practice a non-problem
Collision domain

- Min length frame must be \( \geq \) than the maximum round trip time (RTT) of the entire ethernet segment
- Must hear collision before transmission completes
- Historically minimum frame was 512 bits (64 bytes)
  - Requires 46 payload bytes, pad if unavailable
- Cabling distance decreases as speed increases
- Use of full-duplex removes collision domain restriction
Are collisions bad?

- Collision stats are usually meaningless
  - Unless the collisions are late
  - Or you see them on full-duplex links
- Collisions are an efficient arbitration scheme
- Collisions resolved and detected within the round trip time (RTT) of the channel (that is, quickly), stations do not finish their frame transmissions
- Short answer, no, collisions usually aren't bad
Ethernet frame format

- Sender fills in:
  - Its own src address
  - Target dst address
  - Type (next protocol)
  - Payload
  - Calculated FCS
Promiscuous mode

• Interface accepts all frames regardless of destination address
• Useful for debugging
• Available on most wired adapters, some wireless chipsets do not support it
Ethernet addressing

• IEEE standard address is 48 bits long
• Written as 12 hexadecimal digits (e.g. ff:ff:ff:ff:ff:ff:ff:ff)
• Also known as:
  • Layer 2 address
  • Hardware address
  • MAC address
  • Data link address
Visualizing ethernet addresses

First bit transmitted
0 = unicast destination
1 = multicast destination

Second bit transmitted
0 = globally administered
1 = locally administered

Destination Address

<table>
<thead>
<tr>
<th>first byte</th>
<th>second byte</th>
<th>third byte</th>
<th>fourth byte</th>
<th>fifth byte</th>
<th>sixth byte</th>
</tr>
</thead>
</table>

Organizationally Unique Identifier (OUI)

<table>
<thead>
<tr>
<th>first byte</th>
<th>second byte</th>
<th>third byte</th>
<th>fourth byte</th>
<th>fifth byte</th>
<th>sixth byte</th>
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</thead>
</table>

Organization Assigned Portion

<table>
<thead>
<tr>
<th>first byte</th>
<th>second byte</th>
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</tr>
</thead>
</table>

Source Address

Second bit transmitted
0 = globally administered
1 = locally administered

First bit transmitted
Routing information indicator (RII) - token ring and FDDI only - must be zero if not token ring or FDDI
0 = Routing information not present (not source routed)
1 = multicast destination
Why bridge?

- LANs may have physical distance limitations
- Limitation on the number of hosts per LAN
- Allocate more capacity per station
- Contain traffic to local LAN segment
- Accommodate hosts with no layer 3 protocol
- Support any layer 3 protocol
- Connect dispersed LANs together
Visualizing bridges
diagrams courtesy of http://www.netbook.cs.purdue.edu
Transparent bridging

diagram courtesy of http://www.netbook.cs.purdue.edu

- Bridge listens to each interface promiscuously
- Bridge inspects layer 2 information
- Forward frames to other interfaces if necessary
Bridge forwarding and filtering

• Receive a frame on an ingress interface
• Inspect destination address
• If multicast/broadcast, forward to all except incoming (ingress) interface
• Query address table (cache) for destination address
  • If found, forward out (egress) associated port
  • Except when ingress = egress, just drop it
• If not found, flood to all interfaces except the incoming (ingress) interface
Source address learning

- Bridge listens promiscuously on all interfaces
- Store source address and associated ingress interface port in address table (cache)
Bridge table (cache) entry aging

- Low-priority or non-time critical operation
- Allows station mobility and small table size
- Aging process periodically clears the H bit
- If H bit is clear, clear the V bit
- If H and V bits are clear, remove the table entry
LAN switches

- LAN switches = LAN bridges
- Switches imply newer, better, faster, bigger, etc.
- Switching is a successful marketing term
- Often used to further segment shared LANs
- Switch port per device/customer becoming the norm
- Most LAN switches are relatively simple and cheap
Why switch?

• Reduce/remove shared medium contention
• Maximize aggregate capacity
• Extend distance limitations
• Data rate flexibility
Visualizing LAN switches
Store and forward switching

- Completely receive frame on ingress port
- Check frame check sequence (FCS) for validity
- Perform address learning
- Make forwarding/filtering decision
Cut-through switching

• Begin making forwarding decision as soon as you get the destination address (do not wait for the entire frame)

• Goal is to improve switch latency

• More successful marketing
Cut-through switching fallacies

- Latency only improves if outgoing (egress) port is free, this is not when you need the improvement
- Switch latency is the least of your problems
- Multicast/broadcast cut-through too?
- Input (ingress) and output (egress) port rate must match
- Propagates errors (but generally not a problem)
- Store-and-forward is usually the default (good choice)
LAN switch configurations

- Bounded/stand-alone
- Stack-able
- Chassis