Today’s lecture

- Ethernet bridging
  - The learning bridge
  - Spanning tree algorithm for bridges
  - VLANs (Virtual LANs)
- Auxiliary protocols between layers 2 and 3
  - ARP
  - DHCP

Why use Ethernet bridges?

- Larger networks
- More concurrent communication
- Extend Ethernet without changing computers
Learning bridge

Bridge
I known A is to the left
I known B is to the left

From B to A

From B to A

A
B
C
D

Learning bridges

- Initially forward frames onto all ports
- Learn where hosts are based on source address
- For known addresses only forward to right port
- Multicast/broadcast go to all ports
- Terminology
  - For twisted pair based Ethernet
    - Repeaters are called hubs
    - Bridges are called switches
  - A segment or collision domain has wires and hubs
    - LAN vs. extended LAN

What happens with cycles

Bridge 1

From A to X

From A to X

A
B
C
D

Bridge 2
Solution: eliminate cycles

- On power up Ethernet bridges run a distributed spanning tree algorithm
  - Node with lowest ID is root
  - Spanning tree is the tree of shortest paths to root
  - Break ties based on bridge IDs
- Ports that are not part of the spanning tree are turned off to data traffic
  - All cycles eliminated

Spanning tree algorithm details

- Message format: (root, distance, bridgeID)
- Each bridge stores best message for each port
- Each bridge picks port closest to root
- Best message is flooded with distance incremented
- Each segment “elects” a designated bridge
- The root repeats message
- Messages are timed out

Ethernet today

- Limits to growth of bridged LANs
  - Traffic due to broadcast/multicast frames still goes to all segments
  - Throughput at root switch becomes bottleneck
    - Can have faster switches towards the middle
- Bonus for switched Ethernet: better security
  - Hosts cannot snoop on others’ traffic
  - Today switches have advanced features (VLANs)
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Why restrict reachability?

- Security – multiple defenses
  - Sometimes you don’t want some computers to communicate with the outside world
- Performance
  - Protect the performance of virtual networks from the effects of the rest of the traffic
  - VLANs cut down on broadcast traffic
- And sharing infrastructure reduces costs!!!

VLANs

- Bridges never forward frames from one VLAN to the other
- Each port is assigned to one VLAN
- Some ports assigned to many VLANs
  - Must add VLAN ID to frames
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Address Translation

• To build Ethernet frame carrying IP packet, sender needs to find out Ethernet address of destination
• Cannot encode it in 32 bit IP address
• ARP (Address Resolution Protocol)
  – Table of IP to MAC address bindings
  – Broadcast request if IP address not in table
  – Target machine responds with its MAC address
  – Table entries are discarded if not refreshed

ARP Details

• Request Format
  – HardwareType: type of physical network (e.g., Ethernet)
  – ProtocolType: type of higher layer protocol (e.g., IP)
  – HLEN & PLEN: length of physical and protocol addresses
  – Operation: request or response
  – Source/Target-Physical/Protocol addresses
• Other details
  – Table entries timeout in about 10 minutes
  – Add entry to table with source of packets you receive
    • If entry exists, update/reset timer
  – Do not refresh table entries upon reference
ARP Packet Format

<table>
<thead>
<tr>
<th>0</th>
<th>4</th>
<th>8</th>
<th>16</th>
<th>31</th>
</tr>
</thead>
<tbody>
<tr>
<td>HLen = 48</td>
<td>PLen = 32</td>
<td>ProtocolType = 0x0800</td>
<td>Operation</td>
<td>HLen = 48</td>
</tr>
<tr>
<td>SourceHardwareAddr (bytes 0 – 3)</td>
<td>SourceProtocolAddr (bytes 0 – 1)</td>
<td>TargetHardwareAddr (bytes 0 – 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SourceHardwareAddr (bytes 4 – 5)</td>
<td>TargetProtocolAddr (bytes 0 – 3)</td>
<td>TargetProtocolAddr (bytes 0 – 3)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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Dynamic Configuration

- Computers running IP needs some network configuration information (own address, router’s addr.)
- Can store information in per host configuration file
  - Hard to manage
  - Does not help with laptops moving between WLANs
- Dynamic configuration is the primary method for IP address allocation used today
  - IP address management centralized in DHCP server
  - No persistent configuration information stored on computers
Dynamic Host Configuration Protocol

- Server keeps pool of available IPs for use on demand
  - Computers request address when booting
  - IP addresses leased (may renew to keep same IP address)
- Administrator may assign permanent IP addresses to given hosts (as identified by Ethernet address)
- DHCP also manages other IP-related configuration
- The protocol relies on broadcast to find DHCP server