Chapter 3 Internetworking

Bridges

- A *bridge* (also referred to as a *LAN switch*) is a switch that forwards packets between LANs such as Ethernets.
- One way to interconnect two Ethernets is to put a repeater between them.
  - It might exceed the physical limitation of the Ethernet (e.g., maximum 1024 hosts, maximum 2500km in length).
  - Performance will degrade due to more collisions.
- An alternative way to interconnect two Ethernets is to put a bridge between them.
  - The bridge accepts all frames transmitted on each Ethernet and forwards the frames from one Ethernet to the other.
  - The bridge implements the Ethernet’s MAC protocol (i.e., CSMA/CA) on each interface.
- A collection of LANs connected by one or more bridges is said to form an *Extended LAN*.
- Benefits of bridging:
  - Interconnects multiple LANs transparently: the presence and operation of the bridges are transparent to network hosts.
  - Isolates collision domains: each Ethernet in an extended LAN is one collision domain.
    - In contrast, in a Ethernet composed of multiple segments connected with repeaters, all hosts belong to the same collision domain.
A bridge increases the total bandwidth of a network
- If a bridge interconnects N 100 Mbps Ethernets, then the bridge can carry 100N Mbps of traffic
- Early bridges forward all received frames to all ports other than the incoming port, this inefficiency is addressed by *learning bridges*

**Learning Bridges**
- Observation: There is no need to forward a frame to all ports other than the incoming port; only need to forward a frame to the LAN that contains the destination host
- How does a bridge know on which port the various hosts reside?
  - One solution is to manually configure a forwarding table
- A better solution is to have the bridge learn the information in the table by itself
  - Forwarding table is initially empty; table entries are added over time
  - If a frame carrying source address A is received on port n, then add entry [A, n] in the table.
  - Each entry has an expiration timer
    - An entry is removed when its timer expires
    - Timer for A is reset every time the bridge sees a frame from A
    - This is to protect against the situation in which a host is moved from one network to another
- Forwarding algorithm of learning bridges
  - When a frame is received on a port, look up the destination address in forwarding table
- If destination is not found, forward the frame to all the other ports.
- If destination is found:
  - If destination and source are on the same port, discard the frame.
  - If destination and source are on different ports, forward the frame to the port indicated in the table entry.

The Spanning Tree Algorithm
- When the extended LAN has a loop, frames may loop forever.
- How does an extended LAN come to have a loop in it?
  - Network is managed by more than one administrator and no single person knows the entire configuration of the network → A bridge that closes a loop might be added without anyone knowing.
  - Loops are built into the network to provide redundancy in case of failures.
- To correctly handle loops, the bridges run a distributed spanning tree algorithm to agree upon a spanning tree (i.e., a subset of the network topology that reaches all the LANs and contains no loops).
  - Main idea: every bridge selects the ports over which it will forward frames.
  - The algorithm is dynamic: the bridges are prepared to reconfigure themselves into a new spanning tree if some bridge fails.
• The spanning tree algorithm
  o Each bridge has a unique ID
  o The bridge with the smallest ID is the root of the spanning tree
  o The root bridge always forwards frames over all of its ports
  o Each bridge computes the shortest path to the root and note which port is on this path; this port is selected as the bridge’s preferred path to the root
  o All the bridges connected to a LAN elect a single designated bridge that will be responsible for forwarding frames toward the root bridge
    ▪ The designated bridge is the one that is closest to the root
    ▪ In case of a tie, the bridge with the smallest ID is the designated bridge
  o Each bridge is connected to more than one LAN, so it participates in the election of a designated bridge for each LAN it is connected to
    ▪ Each bridge decides if it is the designated bridge relative to each of its ports
    ▪ The bridge only forwards frames over those ports for which it is the designated bridge

Broadcast and multicast
• Broadcast: each bridge forwards a frame with a broadcast destination address to each active (selected) port other than the incoming port
• Multicast is the same as broadcast, with each host deciding for itself whether or not to accept the frame