LAN interconnection

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LAN Interconnection

• Needed to
  – Extend LAN physical size
  – Increase the number of access nodes
  – No need to modify protocol architecture

• May increase LAN throughput performance
  – More space diversity
  – Exploits traffic locality
Interconnecting devices

- Repeater or Hub (layer 1)
  - Not an interconnecting device
  - Permit to extend cable lengths
- Bridge or Switch (layer 2)
  - Simple routing algorithms
  - Work only on loop free topologies
- Router (layer 3)
  - Complex routing algorithms
  - Any topology
- Gateway (layer 4-7)
  - Useful to interconnect networks with different layering structure

Repeater or Hub

- Multi-port device
- Operates at the bit level (layer one)
- Extend cable length
  - No increase in network capacity
- Regenerates strings of bit and forwards them on all the ports
- Shared bandwidth on all ports
- 3R: re-generation, re-shaping, re-timing
  - May introduce delays
- Repeaters
  - On coaxial cable
  - Tree-like topology (interconnected buses)
- Hubs
  - Structured cabling (ease cabling and maintenance)
  - On twisted-pair or fiber
  - Star based topology
Bridge or Switch

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical

Bridge

- Application
- Presentation
- Session
- Transport
- Network
- Data Link
- Physical

These are Layer 2 devices:
-Operate on layer 2 addresses
-From one segment LAN to extended LANs
-Interconnect segments of LANs
-Enable to increase the network size
-Store and forward devices
-Dedicated bandwidth per port
-Transparent to users (same behaviour with or without bridge/switch)
-Do not modify packet content
-Limited routing capability
-Backward learning algorithm (see later)

Bridge/Switches

- Bridge
  - Operates on coaxial cable
  - Interconnect LANs, possibly with different MAC
  - Run the spanning tree protocol (see later)

- Switches
  - Operates on twisted pair
  - Interconnect LANs (or single users) with the same MAC
  - Support VLANs
  - Sometimes do not run the spanning tree protocol (see later)
Bridge/Switch

- Packets received on LAN 1 are transmitted on LAN 2 only when needed

![Diagram of Bridge/Switch]

Bridge/switch operations

- Focus on transparent bridging
- Each bridge/switch has a unique ID
- Each bridge/switch port has a unique id
- Forwarding tables are initially empty
- Three fundamentals functions:
  - address learning: to dynamically create a routing (forwarding) table at the MAC layer (MAC Address, port id)
  - frame forwarding: forward packets depending on the outcome of the routing table look-up
  - spanning tree algorithm execution to operate on a loop-free (tree) topology

Address learning

- Exploits the backward learning algorithm
- For each received packet
  - Read the source MAC address MAC_S to associate the address with the port PORT_X from which the packet has been received
  - Update timer associated to the entry (MAC_S, PORT_X)
  - Will later use PORT_X to forward packets to MAC_S
- Timer needed to automatically adapt to topology variations and to keep the table size small
**Frame forwarding**

- When a correct packet (wrong packets are dropped) with a unicast MAC_D destination address is received on PORT_X
  - Look for MAC-D in the table
  - If found and associated to PORT_X, drop the packet
  - If found and associated to port_Y, forward to PORT_Y
  - If not found, forward to any other output port except PORT_X
- If the packet has a multicast/broadcast address
  - Forward to any port except PORT_X

**Spanning tree**

- Needed to avoid loops
  - Build a logical tree topology among bridges/switches by activating/de-activating ports
- Some switches may not support the spanning tree
  - Need to interconnect in a loop-free physical topology

**Backward learning over a loop**
Backward learning over a loop

- Q transmits to X $\Rightarrow$
  - B1 and B2 receive the packet and assume that Q can be reached using port B
- If B1 and B2 have the MAC address of X in the forwarding table
  - B1 sends the packet on port A $\Rightarrow$
    - B2 assumes that Q can be reached using port A (true, but via a loop)
  - B2 sends the packet on port A $\Rightarrow$
    - B1 assumes that Q can be reached using port A
- Thus
  - X receives two copies of the packet
  - B1 and B2 are unable to reach Q

Backward learning over a loop

- Q sends to X $\Rightarrow$
  - B1 and B2 receive the packet and assume that Q can be reached using port B
- If the MAC address of X is NOT found in the forwarding tables
  - B1 sends the packet on port A $\Rightarrow$
    - B2 assumes that Q can be reached using port A (true, but via a loop)
  - B2 sends the packet on port A $\Rightarrow$
    - B2 assumes that Q can be reached using port A (true, but via a loop)
- B1 and B2 keep sending packets forever

Bridge/Switch properties

- From a multiple-access network to a multiplexed network
  - Reduce collision probability by partitioning the network in independent segments
- For a full duplex fully switched network
  - Ethernet becomes a framing and transmission technique alternative to LAP-B, LAP-F, ATM
  - The MAC layer becomes useless
  - Physical distance limitations induced only by the media transmission properties, not by the MAC
- Ease security and management
  - Traffic separation
Bridge/Switch properties

- Throughput performance may increase
  - More space diversity (higher capacity)
  - Need to exploit traffic locality
- Introduce store and forward (and queueing) delays
  - Worse delays than hubs
  - Store and forward delay significant with respect to propagation delay
    - Transmission time of a minimum packet size at least twice of the propagation delay
- Potential packet losses when queues are filled-up
- Unfairness in resource access

VLAN (Virtual LAN)

- Host are physically connected to the same network segment, but logically separated
- Broadcast/multicast packets forwarded only on ports belonging to the VLAN
- Need to extend the PCI MAC to identify packets as belonging to a specific VLAN
- Hosts belonging to separate VLANs cannot directly exchange packets

Virtual LANs

- (a) 4 LAN segments organized as 2 VLANs (white and grey) through two bridges
- (b) similar scenario with two switches
The IEEE 802.1Q Standard

- From legacy Ethernet to Ethernet with VLANs

IEEE 802.1Q

- 802.3 Packet format (legacy) € 802.1Q.

Hierarchical LAN organization

- Dedicated network
- Shared network

- To internet
- 10BaseT
- 10BaseT
- 10BaseT

- Electrical Engineering
- Computer Science
- Systems Engineering
**Router**

- Layer 3 (network) device
  - Routes on the basis of layer 2 addresses
- Often multiprotocol

**Gateway**

- Interconnection among networks with different layered architectures
- In the worst case operate above layer 7 in the OSI model
- Example: gateway for mailing systems with different architectures