Application
Transport
Network
Link
Physical

you are here

Network
host-to-host

Link
node-to-node
frame-by-frame

Physical
node-to-node
bit-by-bit

101101001000100101010

Network host-to-host

Link node-to-node
frame-by-frame

Physical node-to-node
bit-by-bit

101101001000100101010
MAC Address
90:AF:F4:CA:BA:03

Broadcast Address
FF:FF:FF:FF:FF:FF

Link Layer Addressing
Why Two Addresses?

178.16.23.51
90:AF:F4:CA:BA:03

Why two addresses?

- We want to keep the link layer and network layer independent so that the link layer can work with other network layer besides IP.
- We also want efficiency -- we want the adapter to be able to decide if a frame received is addressed to the adapter. To do this we need an address in the hardware. But if we use network address here, then the hardware need to be reconfigured everytime the network address changes.
ARP
Address Resolution Protocol

"What is the MAC address of 137.132.141.199?"

HEY! WHAT IS THE MAC ADDRESS OF 137.132.141.199?
That's me!

The MAC address of 137.132.141.199 is FB:CA:73:8A:9C:DD

ARP Table
**Address Resolution Protocol**

- ARP maps from the IP address of a node on the same subnet to its MAC address.
- A node, wanting to find out the MAC address of a host with IP address of X, first broadcasts an ARP query message onto its subnet. The host with matching IP address X replies (using unicast) with an ARP response, containing its MAC address.
- Information from ARP is temporarily cached in an ARP table. Entries in ARP table has a timer (just like DNS tables and RIP tables and NAT table) and the entry is removed when its timer expires.

**Inter-subnet Communications**

- A router has multiple interfaces/adapters/IP addresses/MAC addresses.
- Suppose a node A sends a packet P to another node B outside its subnet. Packet P must go through the router R first.
- P’s destination MAC address is the MAC address of R (not B) on the same subnet. R changes the destination MAC address to the MAC address of the destination node B, and forwards the packet to the destination subnet.
DHCP
Dynamic Host Configuration Protocol

DHCP discovery
“I NEED AN IP ADDRESS!”

DHCP server offers
“You can have 17.14.8.19 for 20 mins”
“You can have 17.14.9.89 for 1 hr”
DHCP request
“OK, let me have 17.14.8.19 for 20 mins”

DHCP ACK
“Your IP is now 17.14.8.19 for 20 mins”

DHCP
- DHCP is used by a host to obtain an IP address. Each administrative domain has some DHCP servers.
- A client broadcasts a DHCP discover message (over UDP). A DHCP server replies with a DHCP offer, offering an IP address and lease time to the client. A client may receive multiple offers. It picks an offer and broadcast a DHCP request back, echoing the DHCP offer it has chosen. The chosen DHCP server then response with DHCP ACK. If the DHCP server is located on a different subnet, the router (configured to be a relay agent) will forward the DHCP messages across two different subnets.
DHCP and ARP

- DHCP runs at the application layer (on top of UDP).
- ARP runs at the network/link layer (on top of link layer).
A hub is a physical layer device. When it receives a bit from one of its interfaces, it simply repeats it on all its outgoing interfaces. It does not provide multiple access control (e.g. no collision detection).

Connecting LAN segments using hubs has its limitations: (1) it merges the LAN segments into one collision domain, (2) it only connects LAN using the same Ethernet technology, and (3) there is a limit to number of nodes and maximum distance between nodes.
Switches

- A switch is a link-layer device. It operates on Ethernet frames. When a frame is received, it checks the destination address and either forwards it to the correct interface or drops (filters) it. Switches understand CSMA/CD and therefore separate the LAN segment into different collision domains.

- A switching table on a switch contains mapping from MAC addresses and their corresponding interfaces. An entry \((X, Y)\) is created automatically when the switch receives a frame from MAC address \(X\) on interface \(Y\). Entries are deleted after they expire (have not heard from \(X\) for some time).
Switch? Router?

Switches vs Routers

- Switches does not modify MAC address of frames, but routers do. Adapters on switches do not have MAC addresses.
- Switches support plug-and-play, while routers need their interfaces' IP address to be configured.
- Topology using switch is restricted to a tree, while routers (due to shortest path routing and TTL) allows loops.
- Switch is suitable for smaller networks, while router should be used for larger networks.