CSIS 4222

Ethernet
Hardware Addressing and IP
Dynamic Host Configuration
Protocol

So far we've seen how to provide connectivity between computers with various media

- Now we need a technique for delivering a message through LAN media to a single, specific destination computer
- The most common LAN protocol is Ethernet
- Any computer on the LAN
  - Can access the network
  - Listens for data traffic
  - Can send data if there is no traffic

Ethernet data is exchanged in frames

Frame Header	Frame Data Area or Payload

Header
  - Contains address and type information
Payload
  - Contains data being sent

Ethernet Frame

Preamble	Dest. Address	Source Address	Frame Type	Data In Frame	CRC
8	6	6	2	46 - 1500	4

Header — *Payload*

- *Preamble* is for receiver synchronization
- *Source* is sender's address
- *Destination* is recipient's address
- *Frame type* is the type of data

Ethernet Addressing

- Standardized by IEEE
- Each host assigned a unique 48-bit address
- Address assigned when the network interface card *(NIC)* is manufactured
  - 24-bits for manufacturer ID
  - 24-bits for NIC serial number
- Also known as the *Media Access Control* (MAC) address

Specifying a Destination

In all LAN topologies, data sent across a shared network reaches all attached hosts
The sender must specify destination
  - Each host is assigned a unique hardware *address*
  - Each frame contains the address of intended recipient

Ethernet Address Recognition

- Each frame contains the destination address
- All stations receive a transmission
  - If destination address on incoming frame matches the local station's address, a copy of the frame is passed to the attached computer
  - Frames that are **not** addressed to the local computer are ignored
- Interface hardware checks addresses

LAN Hardware for Packet Filtering
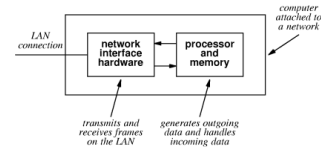
LAN interface handles all details of frame transmission and reception

Possible Destinations

A frame can be sent to
- A single destination (*unicast*)
  - Efficient for interaction between two computers
- All stations on network (*broadcast*)
  - Shared media makes this efficient
- Subset of stations (*multicast*)

Address is used to distinguish type of delivery

Broadcast on Ethernet

Address contains all *1s*
- Sender
  - Places broadcast address in frame
  - Transmits one copy on shared network
  - All stations receive copy
- Receiver always accepts a frame that contains
  - Its own unicast address
  - The broadcast address

Multicast on Ethernet

- Half of addresses reserved for multicast
- Network interface card
  - Always accepts unicast and broadcast
  - Can accept zero or more multicast addresses
- Software
  - Determines which multicast addresses to accept
  - Informs network interface card

MAC address provides the physical address for the NIC

- No information about its location in the LAN, which LAN its on, where the LAN resides
- Need a global addressing scheme to uniquely identify a computer's home network and its location within that network

Summary

- LAN technologies use *hardware addresses* to identify destination of frames
- Each LAN technology defines its own hardware format
- Addresses may be *statically* assigned, *configurable* or *automatically* assigned
- Each station must have a unique address on the LAN segment

IP (Internet Protocol) Addresses Motivation

- A key aspect of universal service is a single, uniform address format
  - Different hardware technologies have different address formats
  - Must be independent of any particular hardware address format
- Sending host puts destination *internet* address in packet
- Routers examine address and forward packet on to the destination

IP Addressing

- Addressing in TCP/IP is specified by the *Internet Protocol* (IP)
  - IP is a protocol for how packets are routed from one computer to another on the Internet
  - Each host is assigned a 32-bit number (*IP address* or *Internet address*)
  - IP addresses are unique across entire Internet
- Used by higher level protocols and applications
- A "virtual" address – only understood by software

Resolving Addresses

- Hardware only recognizes *Media Access Control (*MAC) addresses
- IP (the Internet) only uses IP addresses
- Consequence: software needed to perform translation
  - Part of network interface
  - Known as *address resolution*

Network	Physical	IP
Token ring	0001 C859 3ABC	150.230.22.5
Ethernet	08:00:09:41:5D:9C	150.251.1.5
FDDI	0002 C625 AB83	150.252.10.6

Address Resolution

- Given
  - A locally-connected network, *N*
  - The IP address of computer *C* on *N*
- Find
  - Hardware address for *C*
- Technique
  - Address Resolution Protocol

Address Resolution Protocol (ARP)

- Keeps address bindings in a table
- Table contains pairs of addresses for computers
  - IP address
  - Hardware address
- Builds table automatically as needed

ARP Table

- Only contains entries for computers on the local network
- IP network prefix in all entries identical

| IP Address	Hardware Address
197.15.3.2	0A:07:4B:12:82:36
197.15.3.3	0A:9C:28:71:32:8D
197.15.3.4	0A:11:C3:68:01:99
197.15.3.5	0A:74:59:32:CC:1F
197.15.3.6	0A:04:BC:00:03:28
197.15.3.7	0A:77:81:0E:52:FA

ARP Lookup Algorithm

- Look for target IP address, *T*, in ARP table
- If not found
  - Send ARP request message to *T*
  - Receive reply with *T's* hardware address
  - Add entry to table
- Return hardware address from table

ARP Exchange

- A machine doesn't send out an ARP packet each time it wishes to send an IP datagram
- Instead, each machine maintains a cache of recently used mappings, and an ARP request is only sent if the desired mapping is not already in the cache

ARP Exchange

197.15.3.2   197.15.3.6

PC — ARP Cache
197.15.3.6 = 0A:04:BC:00:03:28

Host

| Broadcast | 197.15.3.6 |

| 197.15.3.6 | 0A:04:BC:00:03:28 |
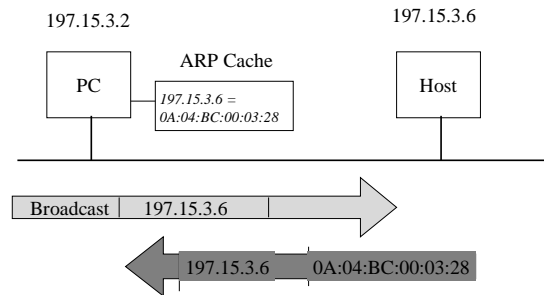
ARP Exchange

ARP request packets also contain the sender's IP and Ethernet address pair. Why?

- To eliminate the need for a second ARP request
- If *machine A* wishes to communicate with *machine B*, there is high probability that *B* will need *A*'s Ethernet address as well
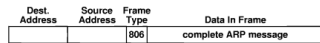
ARP Message Frame Transmission

- ARP message sent in payload area of frame

ARP MESSAGE

| FRAME HEADER | FRAME DATA AREA | CRC |
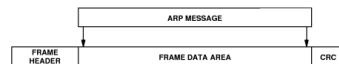
Frame Type

- Frame type identifies message as ARP
  (For Ethernet = 806)
- Receiver examines frame type

Dest. Address	Source Address	Frame Type	Data In Frame
		806	complete ARP message

Because ARP software is part of the network interface software, all higher-layer protocols and applications can use IP addresses exclusively, and remain completely unaware of hardware addresses.

Summary

- Address resolution
  - Needed to map IP address to equivalent hardware address
  - Part of network interface
  - Uses table
  - Automatically updates table entries
  - Broadcasts requests

Network Analyzers

- A *network analyzer* (*packet sniffer*) is used to examine performance or debug a network
- Can report statistics such as capacity utilization, distribution of frame size, collision rate or token circulation time
- Can record and display specific frames, to understand and debug packet transmissions and exchanges

Network Analyzers

- A computer with a network interface that receives **all** frames
  - Called *promiscuous mode*
- Many desktop computers have an interface that can be configured for promiscuous mode
  - Computer receives and displays (but does not respond to) all frames on the LAN
  - Combined with software, computer can examine *any* frame on LAN
  - Communication across a LAN is **not** guaranteed to be private!

Filtering Incoming Packets

Analyzer can be configured to filter and process frames
- Count frames of a specific type or size
- Display only frames from or to specific computers
- In general, can be configured to match the value of any field and capture only those frames meeting the filter specification

Analyzer can display real-time performance by computing running totals over specific time periods