Ethernet Wiring and Addressing

COMP476 Networked Computer Systems

Network Interface
- The network interface connects to the network cable (or antennae) and the I/O controller.

CPU
- The Network Interface, Network Interface Card or NIC manages the network protocol.
- The NIC receives packets, checks for errors, determines if the packet is for this computer and saves the data in memory.
- To send packets it creates the header and trailer and transmits the bits on the network.
- The interface interrupts the CPU when data is received or sent.

Memory

I/O

I/O

Network Interface

CPU Involvement
- The CPU does not have to do a lot of processing to handle the network.
- The network interface operates in parallel with the CPU.
- Fast Ethernet runs at 1 Gbit/sec
- Fast CPUs run at 3.5 GHz. If it can execute an instruction per cycle, it would be difficult to process each bit.
Ethernet Wires

- Originally Ethernet used thin or thick coax cables.
  - The wires were expensive
  - Routing the wires through a building to form a bus topology could be a challenge.
- Most Ethernets used twisted pair cables.
- The connections use an RJ-45 connector.

Types of Twisted Pair

<table>
<thead>
<tr>
<th>Category</th>
<th>Bandwidth</th>
<th>Typical Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>16 MHz</td>
<td>older, low-speed networks; analog telephones</td>
</tr>
<tr>
<td>4</td>
<td>20 MHz</td>
<td>short distance 10Base-T</td>
</tr>
<tr>
<td>5</td>
<td>100 MHz</td>
<td>10Base-T Ethernet; some 100Base-T</td>
</tr>
<tr>
<td>5E</td>
<td>100 MHz</td>
<td>100Base-T (Fast Ethernet); some 1000Base-T</td>
</tr>
<tr>
<td>6</td>
<td>250 MHz</td>
<td>1000Base-T Gigabit Ethernet) or ATM</td>
</tr>
<tr>
<td>7</td>
<td>600 MHz</td>
<td>future (possibly 10 Gigabit Ethernet)</td>
</tr>
</tbody>
</table>

Most installations use “Cat 5” wiring, although “Cat 6” is becoming popular for future expansion.

Ethernet Wiring

A twisted pair wire connects each computer to a central hub or switch.

Ethernet Central Connection

- Twisted pair Ethernet connects to an Ethernet hub, switch or router.
- Switches usually connect from 4 to 48 nodes.
- If the switch breaks, the network stops working.
Hub vs. Switch

• A hub looks like it just connects all the wires.
• Network packets sent to a hub are forwarded to all nodes.
• A switch checks the address and only sends packets to a node if it is to receive it.
• A switch can avoid a collision if X sends to Y while W sends to Z. A hub would have collision.
• Switches are more expensive.

Auto-Speed Detection

• Original 10Base-T operated at 10 Mbps
• 100Base-T Ethernet operates at 100 Mbps
• 1000Base-T Ethernet operates at 1 Gbps
• All three twisted pair wiring schemes use the RJ-45 connectors
• New technology is designed to be backward compatible
• The systems negotiate a speed when a physical connection is first established

LAN Addressing

• Nodes on a LAN have an address that identifies that node to other nodes on that network.
• Packets are sent using the LAN address to identify the node on that network that should receive the packet.
• LAN addresses are meaningless outside of the LAN.

Types of LAN Addresses

The various address forms can be grouped into three broad categories:
• Static
  – Manufacturer assigns a unique address to each NIC
• Configurable
  – Customer can set the address
• Dynamic
  – Automatically assigns an address to a station when the station first boots
Ethernet Addresses

- Ethernet uses static 48 bit (6 byte) addresses
- Every Ethernet interface has a unique address set by the manufacturer.
- Both the sending and receiving computer’s Ethernet address are in the header

<table>
<thead>
<tr>
<th>Preamble</th>
<th>Dest. Address</th>
<th>Source Address</th>
<th>Frame Type</th>
<th>Data In Frame</th>
<th>CRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>6</td>
<td>6</td>
<td>2</td>
<td>46 - 1500</td>
<td>4</td>
</tr>
</tbody>
</table>

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NIC Filters Packets

- The network interface card examines the destination address of all received packets.
- If the destination address matches the node’s address, the packet is stored in RAM. The NIC interrupts the CPU to inform the software that a packet has arrived.
- If the destination address does not match, the NIC does not save the message or interrupt the CPU.

Broadcasting

- Broadcasting is when a single packet is sent to all nodes on the network.
- A special network address specifies that a packet is to be accepted by all nodes.
- The Ethernet broadcast address is all 1 bits FF:FF:FF:FF:FF:FF

Identifying Packet Contents

- The Ethernet header contains a frame type field that indicates the protocol that should handle the packet.
- There is a frame type code specifying that the “data” in the Ethernet packet is an Internet Protocol packet.
Ethernet type values

<table>
<thead>
<tr>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>0000-05DC</td>
<td>Reserved for use with IEEE LLC/SNAP</td>
</tr>
<tr>
<td>0800</td>
<td>Internet IP Version 4</td>
</tr>
<tr>
<td>0803</td>
<td>ISO X.25</td>
</tr>
<tr>
<td>0900</td>
<td>Ungermann-Bass Corporation network debugger</td>
</tr>
<tr>
<td>0BAD</td>
<td>Banyan Systems Corporation VINES</td>
</tr>
<tr>
<td>1000-100F</td>
<td>Berkeley UNIX Trailer encapsulation</td>
</tr>
<tr>
<td>6004</td>
<td>Digital Equipment Corporation LAT</td>
</tr>
<tr>
<td>8036</td>
<td>Frame Relay</td>
</tr>
<tr>
<td>8038</td>
<td>Hewlett-Packard Corporation network probe</td>
</tr>
<tr>
<td>8039</td>
<td>AT&amp;T Corporation</td>
</tr>
<tr>
<td>814C</td>
<td>Silicon Graphics Corporation network games</td>
</tr>
<tr>
<td>8335</td>
<td>Internet Reverse ARP</td>
</tr>
<tr>
<td>8638</td>
<td>Digital Equipment Corporation LANBridge</td>
</tr>
<tr>
<td>803C</td>
<td>Stanford University V Kernel</td>
</tr>
<tr>
<td>809B</td>
<td>Apple Computer Corporation AppleTalk</td>
</tr>
<tr>
<td>80C4-80C5</td>
<td>Banyan Systems Corporation</td>
</tr>
<tr>
<td>80D5</td>
<td>IBM Corporation SNA</td>
</tr>
<tr>
<td>80FF-8103</td>
<td>Wellfleet Communications</td>
</tr>
<tr>
<td>8137-8138</td>
<td>Novell Corporation IPX</td>
</tr>
<tr>
<td>818D</td>
<td>Motorola Corporation</td>
</tr>
<tr>
<td>FFFF</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

Packet Identification in the Data

- Some packets do not have a data type field in the header.
- The first few bytes of the Ethernet “data” identify what should be done with the packet
- The IEEE LLC / SNAP header is often used to identify the protocol for the packet
  -- Logical Link Control (LLC)
  -- Sub Network Attachment Point SNAP header

Network Analyzers

- Network analyzers can display all packets on the wire.
- To read packets, analyzer software places the computer's network interface hardware into promiscuous mode
- Promiscuous mode means the NIC is configured to accept all frames, not just the one’s with the computers address.

Security Implications

- Anybody can read all the packets that arrive at their computer even if they are not addressed to their computer.
- Messages sent over a LAN are not guaranteed to be private.