Ethernet

- Multiple access technology.
  - uses CSMA/CD: Carrier Sense Multiple Access with collision detection
- Originated from the Aloha wireless network
- Main Problem:
  - How do you mediate access to a shared medium fairly and efficiently.
- Ethernet was developed at Xerox PARC. Later the standard was proposed by the DIX conglomerate.

Ethernet (contd.)

- Standardized by IEEE as IEEE 802.3
- Operational speeds:
  - 10Mbps: Original Ethernet
  - 100Mbps: Fast Ethernet
  - 1Gbps: Gigabit Ethernet

Physical Properties

- Cabling:
  - Thin-net (10Base2): coax cable, 50Ω characteristic impedance. Both ends of the cable are terminated. Max length 200m
  - Thick-net (10Base5): coax cable. Max length 500m
  - UTP, 10BaseT, CAT-5: Unshielded twisted pair. 10/100 Mbps Ethernet. Max length 100m
  - STP: Shielded twisted pair
- Multiple Ethernet segments may be connected by repeaters.
- All data transmitted on an Ethernet segment is heard by all hosts connected to the segment

Access Protocol

- Frame Format: 14 byte header, 1500 byte body, 4 byte CRC error check code

- Dest addr 64 48 32
  - CRCPreamble Src addr 0x0 Type Body 16 48 16
- CRC

Ethernet Addresses

- Uses globally unique 6 byte addresses. They are stored in Ethernet card hardware
- 14 byte header contains 6 byte dest address, 6 byte source address and 2 byte Type or Length field
- Each adapter can receive packets with several different types of Ethernet addresses:
  - Unicast: Accept all packets destined to the adapter’s address
  - Promiscuous: Accept all packets
  - Broadcast: Accept all packets with destination address FF:FF:FF:FF:FF:FF
  - Multicast: Accept some set of user-defined addresses

CSMA/CD

1. Wait until line is idle (Carrier Sense)
2. Transmit immediately
   - 1 persistent algorithm. In a p-persistent algorithm, the transmitter transmits with a probability p, when it finds the line idle
3. Max packet length is 1500 bytes.
4. Transmitter has to wait 9.6us between back-to-back frames
CSMA/CD (contd.)

- If two transmitters find the line idle simultaneously, they will transmit simultaneously.
  - Causes a collision.
- The collision detection (CD) hardware on the Ethernet card detects the collision.
  - Transmits a 32 bit jamming sequence.
  - Min. data length on collision = 64 bit preamble + 32 bit jamming sequence
  - When does this occur?

CSMA/CD (contd.)

- Worst case scenario occurs when the 2 competing transmitters are at the opposite ends of the cable
  - Transmitter may need to send as many as 512 bits.
  - Why 512 bits? Hint: Max. cable length is 2500 m.
- Trade-off
  - Max cable length vs. susceptibility to collisions

CSMA/CD: Backoff

- If a collision is detected, wait a random interval and retry.
- Strategy: Exponential backoff
  - Choose a k randomly between 0 and 2^n –1, where n is the current retry. Initially n is 1
  - Wait for an interval given by k*51.2us. Note it takes 51.2 us to transmit 512 bits on a 10Mbps Ethernet
  - Retry the send operation
- If there are too many retries, the adaptor eventually gives up
- All this sounds very complicated. So why is Ethernet’s so popular??

Wireless Networks

- Designed for LAN conditions
- Issues
  - Mediate access to common communication channel (air space)
  - Power consumption, security, temporal guarantees

Physical Properties

- Three kinds of physical Media
  - Two based on spread spectrum technology
  - One based on infrared
- Spread Spectrum
  - Transmit signal over a wider band to minimize interference
  - Techniques:
    - Frequency hopping: Randomly switch between multiple transmission frequencies
    - Direct sequence: Transmit the XOR of the desired bit with multiple random bits. The number of random bits is the chipping sequence
- Infrared standard uses diffused transmission.
  - Range 10m
Collision Avoidance

- Use a technique similar to Ethernet?
  - Two major problems
  1. Hidden Node: A can see B, but not C.
  2. Exposed Node: C can see both A and B. If A and B are communicating, C can talk to D.

Multiple Access with Collision Avoidance

- Solution: Sender and receiver exchange control frames before data transmission
  - Uses an RTS/CTS protocol with length, similar to modem/PC communication.
  - Any node that sees an RTS but not a CTS knows that it is free to transmit to other nodes.
  - Receiver transmits ACK after successful reception.
  - Collisions cannot be detected. If two RTS’s collide, the collision is inferred by the absence of a CTS within a timeout interval.

Distribution System

- 802.11 supports ad-hoc network configuration
  - Need support for mobility
- Mobile nodes connect to the network through non-mobile access points
  - Access points are interconnected over a regular wired network called a distribution system

Distribution System (contd.)

- To transmit a packet, a mobile node first sends it to its access point.
- The access point transmits the packet over the distribution system to the access point of the destination.
- The access point of the destination sends the packet to the destination.

Distribution Network

Selecting the Access Point

- Active Scanning
  - Node sends a Probe frame
  - All reachable APs reply with a Probe Response
  - Node selects an AP and sends an Association Request frame
  - AP replies with an Association Response frame
- Passive Scanning
  - APs periodically broadcast their capabilities with a beacon frame
  - AP selection is repeated when a node detects degradation in signal quality
Frame Format

<table>
<thead>
<tr>
<th>Field</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>16</td>
</tr>
<tr>
<td>Duration</td>
<td>16</td>
</tr>
<tr>
<td>Addr1</td>
<td>48</td>
</tr>
<tr>
<td>Addr2</td>
<td>48</td>
</tr>
<tr>
<td>Addr3</td>
<td>48</td>
</tr>
<tr>
<td>Addr4</td>
<td>48</td>
</tr>
<tr>
<td>SeqCtrl</td>
<td>48</td>
</tr>
<tr>
<td>CRC</td>
<td>32</td>
</tr>
</tbody>
</table>

- **Control Field**:
  - 6 byte Type Field: Indicates if the packet is data, RTS or CTS
  - 2 fields called ToDS and FromDS
- **Duration**: 16 bits
- **Control**: 16 bits
- **Four 48 bit address fields.**
  - Simplest: ToDS=FromDS=0, Addr1 = Dest, Addr2=Src
  - Complex: ToDS=FromDS=1, Addr1=Dest, Addr2=AP2, Addr3=AP1, Addr4 = Src

Network Adaptors

- **Components**
  - System Bus Interface: PCI, VMS, ISA (8, 16, 32 bit, 8, 25, 33, 66 Mhz)
  - Buffers: FIFO
  - Link Interface: Single chip (Intel 82557/82559)

Host Programming Interface

- Adaptor hides its functionality behind a Control Status Register (CSR)
  - Most common adaptors have a reasonably sophisticated control unit on board
- Adaptor can be programmed by setting the appropriate bits in the CSR
- Adaptors may be operated in one of two modes
  - Interrupt driven: Adaptor interrupts CPU when it has data
  - Polling: CPU continuously monitors the adaptors for arrival of data

Memory Interface

- **Direct Memory Access (DMA)**
  - CPU gives a list of free address/length pairs (buffers) to adaptor.
  - Adaptor automatically puts data as it arrives into these buffers
- **Programmed IO (PIO)**
  - Adaptor is interrupted when data arrives
  - CPU reads data from adaptor and writes it to main memory, byte by byte

Memory Interface

- Most adaptors support scatter gather operations
  - Scatter Read: OS reads packet by combining multiple buffers
  - Gather Write: Adaptor reads packet by combining multiple buffers to create one frame
- Per packet processing must be small.
  - Interrupts are disabled during packet processing. Long processing latencies might cause packet loss

Device Drivers

- **Two Main Functions**
  - Transmit
    - Semaphore wait for available buffer
    - Set Mutex
    - Disable interrupts
    - Transmit
    - Enable interrupts
    - Clear Mutex
  - Interrupt Handling
    - Identify type of interrupt
    - Error Interrupt: Flag an error
    - Transmit Interrupt: Clear buffer wait semaphore
    - Receive Interrupt: Receive Packet