CSIS 625 Week 8

LANs, Token Passing, Switching Technology

I. Overview

A. LAN technology continued

1. Less common LAN technologies
    a. Token Passing technologies
    b. Others
2. Newer fields
    a. Wireless Ethernet, Resilient Packet Rings, Others

B. Switching Technology

1. Circuit Switching
2. Circuit Switching Topologies
3. Circuit Switching Technologies (ISDN)
4. Packet Switching
5. Packet Switching Technologies

II. LAN technology

A. Ethernet - IEEE 802 Standards for LANs

1. ...... <snip> ....
2. Ethernet Auto negotiation
    a. This is a technology introduced with 100Base-T to allow a hub/switch and an Ethernet end station to automatically determine each other's capabilities.
    b. Allows two ends to negotiate
        (1) 10Mbps, 100Mbps, 1000Mbps
        (2) Half-duplex, Full-duplex,
        (3) Ability to handle Pause frames, etc.
    c. Problems commonly occur with some types of cards and some types of switches
        (1) This causes many network administrators to turn off autonegotiation and force all stations to a particular setting (usually 100Mbps, Full-duplex)
3. Ethernet Physical Layer
    a. 10BaseT Ethernet - 2 pair Cat 3
        (1) Uses Manchester encoding
            (a) This results in 10 to 20 million transitions per second on the line
            (b) Spectrum is in the 5-10Mhz range
    b. 100BaseFx Ethernet
        (1) Uses 4b5b-NRZI on fiber
            (a) This increases the bits sent to 125Mbps
    c. 100BaseT Ethernet - 2 pair Cat 5
        (1) Uses 4b5b MLT-3 on twisted pair
    d. 1000BaseX Ethernet -
        (1) Uses 8b10b NRZ @ 1.25Gbaud

            (2) 8b10b Ensures 50% ones density
   e. 1000BaseT Ethernet - 4 pair Cat 5
      (1) Uses PAM5 (Pulse Amplitude Modulation)
         (a) Provides 2 bits, plus extra symbol for FEC, special codes, transition density.
      (2) Each pair is used in both directions with echo cancellation
      (3) The use of PAM5 is a 6dB hit, but made up for with FEC.
   f. 10G Ethernet
      (1) Use of PAM5 on Fiber?
      (2) Use of SONET framing?
      (3) Wait and see
   g. All 100Base & 1000Base
      (1) Send idle codes when line is not in use.
      (2) Keeps clocks in sync.
      (3) Lets connections know when cable is broken
   h. 10BaseX
      (1) Had link pulse to keep nodes aware of connection status, but that isn't used now that everything is point to point.
4. 4b5b - Why
   a. only 16 of the 32 5b symbols needed for data.
      (1) Plus a few for control
   b. Ensures that transitions still present on line for clock recovery
      (1) No more than 3 zeros in a row
   c. More efficient than Manchester
5. MLT-3 - Multi Level Transmit
   a. Transition on a 1, no transition on a 0
   b. Goes +1, 0, -1, 0, +1, 0, -1, 0, etc.
   c. Reduces bandwidth to 31.25Mhz
6. Ethernet MLT-3 & PAM-5
   a. Eye diagrams for MLT-3 from 100BaseT and PAM-5 from 1000BaseT
   b. 100Base-T2 also uses PAM5
7. Collision Domain
   a. 10BaseX
      (1) 512 bit times => about 2km
   b. 100BaseX
      (1) 512 bit times => about 200m
   c. 1000BaseX
      (1) 512 byte times => about 200m
      (2) Have to extend short frames to 512 byte times
         (a) Didn't want to expand minimum frame size because of mixed environments.
         (b) Some methods exist to send multiple frames so the bandwidth isn't wasted
   d. With xBaseT standards, the hub sends the incoming signal to everyone but the sender.
      (1) The Sender knows a collision occurred if it receives anything while transmitting.
   e. With Switched Ethernet, the collision domain doesn't matter much.
   f. With full duplex collisions do not exist

III. Less common LAN Technologies

A. Token Bus – 802.4

1. Since CDMA/CD leads to unknown amount of delay before a packet is transmitted – Token passing architectures were developed.
2. Token bus uses coaxial cable with broadband (RF) modulation.
3. 1, 5, & 10 Mbps possible
4. Token Bus allows for 4 priorities of traffic at each node.
5. Frame format slightly different from 802.3

B. Token bus - Token Passing

1. Each node gets a Token
2. Node has the right to transmit for some time period.
3. When done, Node transmits the Token to the next node
4. Periodically, a node solicits bids from new nodes wanting to join the ring.
   a. If one responds – it is inserted into the ring and placed in order after the solicitor
   b. If two respond – a collision occurs and a
5. To leave the ring, a node tells it's predecessor who it's successor is
6. If transmission failure in token passing
   a. Retry of sending token
   b. Then, sending broadcast to find out who's next and giving them token

C. Token ring – 802.5

1. Cabling of each node having two connections – one to each of it's neighbors.
2. Shielded twisted pair
3. 1, 4 or 16Mbps using differential Manchester
4. Typically wired in a star shaped ring
   a. All spokes plug into MAU that has relays that allow isolation of failed spokes.
   b. MAU – Multi-Station Access Unit
5. Each bit arriving at an interface is copied into a 1-bit buffer and then copied out onto the ring again.
   a. Each interface creates a 1-bit delay
6. Each node can prioritize traffic

D. Token Ring – Token passing

1. A token circulates the ring when it is idle.
2. Station wanting to transmit grabs the token and transmits data frame.
3. When done with the frame, and the frame has come back around – node transmits a token again.
4. As frames go by – there is a priority field that a node may modify if it has higher priority traffic
   a. Other nodes that have lower priority traffic will then pass on the token until the requesting node gets it.

E. FDDI - Fiber Distributed Data Interface

1. 100Mbps over Fiber optic lines – 2000m max
2. Uses a token passing architecture similar to Token ring
3. Typically is not set up with a star-shaped ring, but physically as a ring

F. Token vs. CSMA/CD

1. Token passing architectures allow for prioritization of traffic and guarantees that this traffic will get through in a fixed amount of time.

        a. Even if heavily loaded – high priority traffic gets through
    2. CSMA/CD architecture allows for lower latencies when the LAN is lightly loaded
        a. A node doesn't have to wait for a token.
    3. CSMA/CD implementations tend to be simpler (and therefore cheaper)

G. ATM LANs

1. They're dead
2. ATM allows for prioritization of traffic, mixing very time critical traffic with non-time critical traffic
3. Protocol elegance has been overpowered by cheap silicon.
4. Has nice idea of being able to use same protocols from WANs, MANs, and LANs – voice, video and data.
5. In MANs/WANs ATM is over SONET links
    a. OC-3, OC-12, OC-48 (155Mbps, 622Mbps, 2.4Gbps)
6. In LANs, ATM is over twisted pair
    a. 25Mbps, or 51Mbps

H. Fibre Channel

1. A high speed protocol over fiber optics that is tailored to use for computer interfaces.
2. Looks similar to SCSI from a software perspective.
3. Very common in Storage Area Networks (SANs)
4. 1.06 Gbps
5. Up to 10km over single mode fiber

I. HIPPI – HIgh Performance Parallel Interface

1. 800 or 1600Mbps using 50 or 100 twisted pairs.
2. Developed in late 80's when LAN was 10Mbps ethernet
3. Used for supercomputer interfaces
4. Was relatively cheap to create as it used parts from other technologies

IV. Other and Upcoming LAN technologies

A. VLANs

1. VLAN - Virtual LAN
    a. This is not the same as VPN – Virtual Private Network
2. VLANs are a configuration on some switches that group multiple ports together as one LAN or broadcast domain.
3. Different VLANs must be bridged using a router
    a. Often this router functionality is in the same box.
4. VLANs can span switches, by adding a field to the Ethernet frame that has a VLAN number in it.
    a. All switches must be configured with the same set of numbers

B. Ethernet In First Mile

1. A newer IEEE group
2. Looking at ways to use Ethernet to connect to your home.
3. Currently three areas being developed.
    a. Point to point over copper
    b. Point to point over fiber
    c. PON technology – Passive Optical Network.
        (1) Use of optical splitter/combiners that don't require any electronics.
    d. PON technology requires 2 "tricky" things
        (1) Ranging of nodes

(2) Contention for the upstream bandwidth.

C. 802.11 - Wireless Ethernet

1. Started out as 1 or 2Mbps using RF or infra-red links.
2. RF uses frequencies around 2.4GHz
   a. This is the same range used by microwave ovens
   b. Water absorbs this energy very well making hard to use for long distances.
3. 802.11b
   a. Up to 11Mbps, using 2.4Ghz spectrum
4. 802.11a
   a. Up to 54Mbps, using 5Ghz spectrum
5. 802.11g
   a. 22 – 54 Mbps in the 2.4Ghz spectrum
   b. Just being standardized
   c. May run into regulatory problems due to excessive bandwidth usage.
6. 802.11i
   a. Improved Security for wireless LANs
   b. WEP – Wired Equivalency Protocol
      (1) Current security protocol that was found to be very weak and easily broken.
7. 802.11 – For last mile
   a. Since this is unlicensed spectrum, people have started to use this with directional antennas for Internet Access.
   b. Unlicensed spectrum – RF bandwidth that you don't need to buy a license from the government to use
   c. To overcome the problems with water absorption, the link has to be carefully set up
      (1) Line of site links
      (2) No trees in the way
   d. Typically will run at less than peak rates
8. Additional wireless links
   a. http://www.80211-planet.com/
   b. http://www.wlana.com/
   c. http://www.midcoast.net/wirelessfaq.html

D. RPR - Resilient Packet Rings – 802.17

1. Another new technology
2. Idea is to provide good protection that Sonet rings enjoy, using packet technology (most likely gig-Ethernet)
3. Sonet Rings are circuit switch oriented, and reserve 50% of the bandwidth on the ring for protection purposes.
   a. A Sonet protection switch occurs within 60ms
4. Packet rings or meshs today rely on the routing protocols to converge when a failure occurs
   a. This will often take minutes
5. RPR goal is to protection switch as fast as Sonet
   a. 60ms from start of an outage until service is restored.

V. Switching

A. Generic Switching technology

1. A switched network has both end stations or nodes and switching nodes.

2. Switching nodes may connect to
    a. only other switching nodes -or-
    b. other switching nodes and end stations
3. Connections between switching nodes can handle multiple circuits or sessions using TDM or FDM
4. Often not enough resources in the network for all nodes to be communicating simultaneously.
5. Switching nodes don't have direct connections to all other switching nodes
6. Usually there is more than one way to get between any two switching nodes
    a. This improves reliability
7. Circuit switching is common in the public telephony networks
8. Packet switching is common in data networks.
9. Latency - the amount of time it takes a signal to propagate from one node to another.
10. Jitter - the amount of variance in the latency

B. Circuit Switching

1. Circuit Switching - A dedicated path is established between two stations for communication
2. Once a connection is established it appears to the attached devices as if they are directly connected.
3. Switching and transmission resources are reserved for the exclusive use of the circuit for the duration of the connection.
4. Circuit Lifespan
    a. Circuit Establishment
        (1) Node has to signal to switching nodes who it wants to talk to.
        (2) Switching node finds and establishes path through network
        (3) Success or failure of circuit setup is communicated back to originating node
    b. Data transfer
        (1) typically full duplex communication of data
    c. Circuit disconnect
        (1) Both ends informed of disconnect and resources in network released for another user.
5. Circuit Switching - pros & cons
    a. Pathway in place even if data isn't being sent
        (1) Not the best efficiency
    b. There may be some delay in getting a circuit set up, but once done:
        (1) latency is typically minimal
        (2) jitter is very small

C. Circuit Switching Topologies

1. Space Division Switches
    a. Space division switching uses space to separate the paths of different circuits
    b. Cross bar switches have n inputs and m outputs and a switch at every intersection
        (1) Simplest cross bar has n inputs and m outputs
        (2) needs n * m switches
        (3) See Week 8 - Figure 1
    c. Folded Cross bar switch

(1) A folded cross bar switch has inputs and outputs wrapped around to allow full duplex any to any connections
(2) Requires less switches than a crossbar switch
(3) See Week 8 - Figure 2

d. Multistage switches
(1) Combine multiple smaller crossbar switches
(2) May be blocking or non-blocking based on number of input lines and stages and size of different stages
(3) Also called Clos switches after Charles Clos of Bell Laboratories who published analysis of these type of switches
(4) Usually has multiple paths increasing reliability of equipment
(5) Three stage switch Example in Week 8 – Figure 3
(6) Multi-stage switches pros and cons
(a) Allows for a far greater number of lines to be serviced with a far smaller number of cross connect switches
(b) If blocking is allowable, even smaller number of switches
(c) See Example in Week 8 Figure 4

2. Time Division circuit switches
a. By using TDM techniques, switching can be achieved
b. Time-slot Interchange (TSI) technique
(1) Mux and demux on ends with the TSI in the middle
(2) The TSI buffers all inputs and then re-sends it in a different output
c. TDM bus technique
(1) Mux and demux are "smart" and can take any timeslot to any I/O port
d. Time Division pros and cons
(1) With higher clocking speeds possible with modern silicon, it is possible to build TDM switches much larger and cheaper than crossbar switches
(2) The clock rates after the TDM operation may get very high when high speed inputs or high number of inputs are used.

3. Circuit Switches - combinations
a. For very large circuit switches a combination of TDM and crossbar switches is often the best.
b. Multiple stage switches using different techniques in different stages

D. Circuit Switching Technology

1. ISDN - Integrated Services Digital Network
a. What is ISDN?
(1) Circuit-switched digital network
(a) In reality, extension of T hierarchy to the subscriber
(2) A misfired attempt by the circuit-switched network operators (TELCOs) to get on the "data" bandwagon
(a) Implemented based on carrier's perceptions of customer needs
(b) Total user panacea (based on TELCO view)
(3) Designed to provide fully integrated digital services to the user
(a) Broadband, nonswitched
(b) Broadband, switched
(c) Packet switched

(d) Signaling
(1) Per-call, per-customer feature selection

b. Brief history of ISDN
(1) Initially, phone networks were analog
(2) Local loops were analog as well
(3) Modems were developed to allow digital communication over analog networks
(4) Analog and digital services to subscribers
(a) Transition to digital services is gradual
(b) Analog services remain in place
(c) Customer classification emerged
(1) Traditional POT users
(2) Modem users
(3) Digital service users
(5) Integrated Digital Networks - IDN
(a) Created to meet customer demands
(b) Combination of networks available for different needs
(c) Access to IDN
(1) Analog local loop
(2) Digital local loop (Switched/56)
(3) High-speed dedicated pipes (leased lines)
(6) ISDN
(a) Integrates IDN with customer services
(b) Replaces Analog Local Loop with digital subscriber loop
(1) Voice transmission is digitized at the source
(2) Voice, data and digital video can thus be send over any digital network (provided it is capable of handling it)
(3) All services are digital, available on customer demand
(4) ISDN also introduced unified, standardized interface for all the services

c. Subscriber access to ISDN
(1) To support flexibility (and sell-ability), ISDN defines 3 channel types of different sizes
(a) Bearer – 64 Kbps (clear-channel DS0)
(1) Basic user channel
(2) Carries any type of digital information in full-duplex mode
(3) Supports multiplexing (non-addressable)
(4) Carries data end-to-end
(b) Data – 16 or 64 Kbps (DS0 or fractional DS0)
(1) Carries control information for B channels
(2) Implements common-channel signaling
(3) Carries control signals for all channels in the given path
(4) Used to connect to the network and allocate a B channel
(c) Hybrid channels

(1) High data rate channels – 384 Kbps, 1536 (H11) Kbps, 1920 Kbps (H12)

d. User Interfaces
    (1) Basic Rate Interface (BRI)
        (a) 2B+D
            (1) 2 B channels (initially 1)
            (2) 1 16Kbps D channel
        (b) Designed to meet residential and small (tiny) business offices
        (c) Existing twisted pair is used
    (2) Primary Rate Interface (PRI)
        (a) 23 B channels
        (b) 1 64Kbps D channel
        (c) 8 Kbps overhead
        (d) Total: 1.544 Mbps -- Low and behold, a T1 Line!
        (e) All travel in a single path to an ISDN office
        (f) PRI can be divided into many different combinations
        (g) D channel is used to allocate network capacity accordingly

e. ISDN Access Devices
    (1) ISDN Reference Points
        (a) Used to identify interfaces between individual ISDN devices
        (b) R – connection between a TE2 and TA
        (c) S – connection between a TA or TE1 and NT1 or NT2
        (d) T – connection between NT2 and NT1
        (e) U – connection between NT1 and ISDN office
    (2) See Week 8 - Figure 5

E. Packet Switching

1. Packet Switching - a packet of data is transferred from one node to another
2. Packet switching is designed to be more efficient for data than circuit switching.
3. Datagram Packet Switching - Each packet of data is treated independently from all others
4. Virtual Circuit Packet Switching - all packets of data that are part of a session are sent via a single route
5. Packets allow for greater usage of trunks between nodes
    a. Packets may be queued and transmitted as quickly as possible
    b. May create more latency and much more jitter than circuit switched systems
    c. Unused Bandwidth in circuit switched networks can be used.
6. On circuit switched networks, calls may be blocked, but on packet switching the packets are just delayed
7. Packet switching - prioritization
    a. In packet switched networks, some packets can be given higher priority than others.
    b. This allows for those packets to be sent before lower priority ones reducing their latency and jitter.
    c. May allow for some packets to be sent different (faster) paths than others.
8. Datagram packet switching
    a. Every packet is treated independently.
    b. Every switching node must examine every packets destination and decide on where to send it next.

c. If any node disappears it takes with it a few packets, but data keeps flowing.

9. Virtual circuit packet switching
    a. A path is set up that each packet between two nodes always follows the same path
    b. Makes switching node's job easier because it always knows where to send a packet to next.
    c. If any node disappears, that session must be torn down and a new one created
10. Virtual circuit types
    a. Switched virtual circuit - a virtual circuit is set up for each session independently
        (1) Requires a circuit setup before data flows
        (2) Adds to time required to transfer a message
    b. Permanent virtual circuit
        (1) Requires provisioning of path when creating network.
        (2) May mean that any node failure requires human intervention.