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CS 303
Local Area Networks

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LANs in general

Major Attributes of a LAN

- Connection between the n.w. stations are usually few meters to several 100 meters.
- LAN transport data between user stations and computers
- LAN transmission capacity is usually higher than that of a WAN
  - typical bit rate is 1Mbps to 100 Mbps
- LAN channel is privately owned. Public carriers are not usually involved.
- error rate on a LAN is much better than a WAN.
  - Typical in a LAN - $1:10^8$
  - Typical in a WAN - $1: 10^3$ to $1:10^5$

Broad Band and Base Band LANs

- Broad Band
  - uses analogue technology (uses modems)
  - Uses FDM - multiple carriers and sub channels on one path
- Base Band
  - uses digital technology - a driver introduces voltage levels.
  - Possible to provide TDM to have multiple access to the medium (but often protocols are used to handle multiple access)

IEEE LAN Standards

- 802.1 - Higher layers and management
- 802.2 - Logical Link Control(LLC)
- 802.3 - CSMA/CD
- 802.4 - Token Bus
- 802.5 - Token Ring

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Relationship of 802 Standards to ISO/OSI Model

- In 802, Data Link layer is split to two layers called LLC and MAC
- LLC is a subset of HDLC
- MAC encompasses 802.3, 802.4, 802.5

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Classes of Services in 802

- Type 1
  - also called connectionless service
  - no ACKs, flow control or error control
- Type 2
  - also called connection-oriented - optional
  - provides ACKs, flow control and error control
    - In Type 1 networks these are done at a higher level protocol(i.e. transport layer)

LLC Protocol Data Unit

DSAP Address	SSAP Address	Control	Information

- If in a ring n.w., DSAP and SSAP can identify a specific ring and a specific node
- LLC is a subset of HDLC
- depending on the type (i.e. type 1 or 2), HDLC commands and responses established in the control field will be different.

MAC Protocol Data Unit

Preamble	Starting Delimiter	Frame Control	Dest. Address	Source Address	LLC PDU or MAC control unit	PAD	FCS	Ending Delimiter

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CSMA/CD (IEEE 802.3)

- Best known scheme for controlling a LAN on a bus structure
- Falls into Non-Priority category
- Most widely used implementation of CSMA/CD is Ethernet

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CSMA/CD (IEEE 802.3) cntd...

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History of CSMA-CD

- Xerox Corporation did research on CSMA/CD and developed first commercial products.
- In 1980, Xerox, Intel and DEC jointly published specifications for Ethernet local n.w.
- This was later introduced to IEEE 802 committees and with some modifications, it was standardized as 802.3 standard

CSMA/CD (IEEE 802.3) cntd...

- CSMA/CD defines 2 layers - MAC and Physical layers
  - frame format is same as MAC frame (without frame control and ending delimiter)
- Data Link layer is media independent, Physical layer is media dependent.

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CSMA-CD: Functions of DLL

- encapsulation, decapsulation
  - source/dest. addresses, error detection field etc. are encapsulated
- media access management
  - transmits/receives frames into/from physical layer
  - buffers frames
  - provides for collision avoidance or collision handling when transmitting

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CSMA-CD: Functions of Physical Layer

- Data encoding/decoding
  - provides signals to synchronise stations on the channel (using a pre-amble)
  - binary to Manchester code (transmitting) and vice-versa (receiving)
- Channel Access
  - introduces physical signals on to the channel
  - senses a carrier on the channel (both transmit and receive sides) to see whether the channel is occupied or not
  - detects a collision on the channel (at the transmit side)

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Token Ring (Priority) - IEEE 802.5

- uses a token to provide priority access to the n.w.
- the token is passed around the ring and it has an indicator to show whether the ring is free or busy
- if a station wishes to transmit data and the token is empty, it modifies the token to have:
  - start-of-user-frame identifier
  - data and control fields

    and then sends to the next station

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Token Ring cntd…

- each station generates the token again (while copying data if data is for that station)
- when the token comes to the station that appended data an control once again, it frees the token (or ring made available)

Token Ring cntd…
Ring Formats

- Token
- Abort Token
- Token and Data

Token Bus (IEEE 802.4)

4 major functions in MAC:

- IFM Interface m/c
- ACM Access Control m/c
- RxM Receive m/c
- TxM Transmit m/c

- RRM Regenerative Repeater m/c (optional)

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Token Bus (IEEE 802.4) cntd…

- 802.4 frame is same as 802.5 frame, except that it does not have access control and frame status fields.
- IEEE 802.4 determines the logical ring of the physical bus by the numeric value of the address.
- When a token is passed to a successor, the sender waits for evidence that it has been transmitted properly (i.e. the successor transmits the next frame). Otherwise it may establish a new successor (the next address to the problematic station).

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Ethernet in detail

IEEE Supplements

- Some examples:

Supplement	*Year*	*Description*
802.3a	1985	10 BASE-2 Thin Ethernet
802.3c	1985	10 Mbps Repeater Specification
802.3d	1987	Fiber Optic Inter Repeater Link
802.3i	1990	10 BASE-T Twisted Pair
802.3j	1993	10 BASE-F Fiber Optic
802.3u	1995	100 BASE-T Fast Ethernet and Auto Negotiation
802.3x	1997	Full-duplex Standard
802.3z	1998	1000 BASE-X Gigabit Ethernet – SX, LX, CX
802.3ab	1999	1000 BASE-T Gigabit Ethernet over Twisted Pair
802.3ac	1998	Frame size extension to 1522 bytes for VLAN tag
802.3ad	2000	Link Aggregation for Parallel Links

Ethernet Frame

Preamble 64 bits	Dest addr 48 bits	Source addr 48 bits	type/length 16 bits	Data 46-1500 bytes	FCS (CRC) 32 bits

- Maximum total of 1518 bytes without preamble
- According to IEEE, preamble is 56 bits and SFD (Start of Frame Identifier) is 8 bits
  - Preamble – alternate 1s and 0s
  - SFD – 6 bits of alternate 1s and 0s and two 1s at last (10101011)
- Type/length filed – if the value is 1518 or less, it gives the length, else it gives the higher layer protocol number
    - Protocol numbers are assigned by IEEE

Media Access Control Rules

1. When a signal is being transmitted on the channel that condition is called a carrier
2. When a station attached to the Ethernet wants to transmit a frame it waits until the channel goes idle (called absence of carrier)
3. When channel becomes idle the station waits for brief period called the Inter Frame Gap (IFG) and then transmits the frame
4. If two stations transmit simultaneously, they detect the collision of signals and re-schedule their frame transmission

Back-off Algorithm

- If no carrier and period of no carrier exceeds IFG,
  - then transmit immediately
  - IFG = 96 bit times – to allow a brief recovery time between frame reception
    - For 10 Mbps, IFG = 9.6 μs,
    - For 100 Mbps, IFG = 960 ns
- If there is a carrier(i.e. the channel is busy) the station continues to listen until carrier ceases
    - Then wait for an IFG and start transmitting

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Back-off Algorithm cont…

- If collision detected during transmission, the station will continue to transmit 32 bits of Data (called collision enforcement jam signal) even if it is detected during pre-amble. (This allows other stations to detect collision)
- After sending jam signal, wait a random period of time and then go to Step 1 (called Back-Off)
- If the collision occurs after back off, the random wait will be longer
- If 512 bits are transmitted without collision (in 10 / 100 Mbps), then the station is said to have acquired the channel. After channel acquisition, there should not be collision in a proper Ethernet network.
- ***This 512 bit time is called Slot Time (for 10 / 100 Mbps)***

Slot Time Considerations

- Physical layer round trip propagation time (signal travel time from one end to the other end and back)
- Time required by collision enforcement (to detect and send the jam signal)
- Original 10 Mbps slot time
- In coaxial cable, 512 bit time was enough for the signal to travel 2800m
- In Fast Ethernet, 512 bit time was enough only for 205m – but this is still acceptable with Ethernet switches and hubs for twisted pair. (However in twisted pair the maximum length is only 100m for other reasons)
- In Gigabit Ethernet 512 bit slot time allows only 20m and hence it has been extended to 4096 bits (called carrier extension)
- 512 bits require 46 bytes of data (minimum length of data)

Back-off Operation

Delay time for a station = an integral multiplication of slot time (512 bit time)

(for 10 Mbps 1 bit time = 100 ns, for 100 Mbps 1 bit time = 10 ns)

To calculate this integer "r", the following formula is used:

$0 \leq r < 2^k$

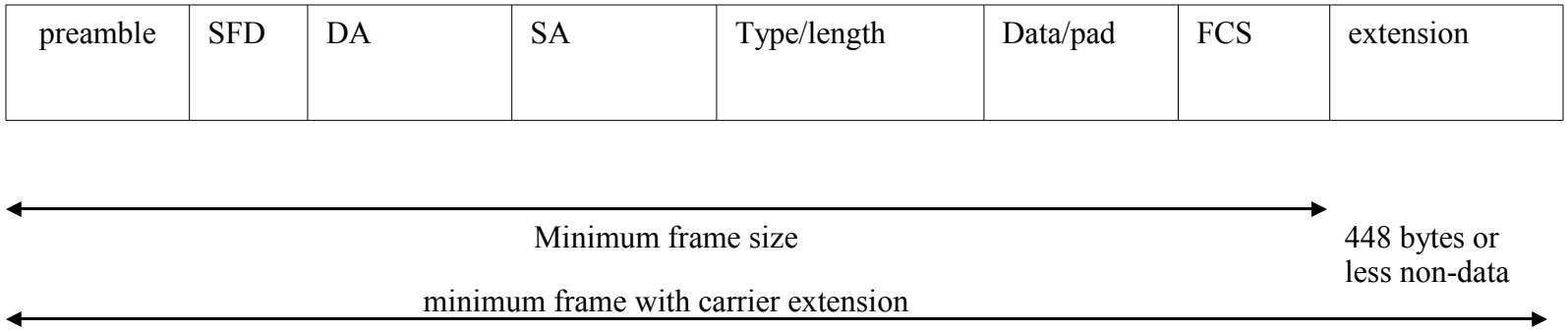
- where k = min(n,10), n = number of transmission attempts
- "r" is assigned a random integer but with an upper limit of 2^k
- when k = 10, $2^k = 1024$. Therefore $0 \leq r \leq 1023$
- number of maximum re-tries = 16.
- After 16 re-tries the interface gives up and transmission failure is notified to the higher layers.

After a successful transmission, back off counter is reset.

Gigabit Ethernet - Half Duplex

- If half duplex, same as 10 Mbps or 100 Mbps, except slot time difference
- (But most Gigabit Ethernet today follow full duplex technique)
- Signaling 10 times faster than fast Ethernet – hence network diameter is only 20m
- Delays:
  - Repeaters: not improved up to expected target yet
  - Propagation delay of media – still at fast Ethernet
- Hence instead of 512 bit slot time, 4096 bit (512 byte) slot time is defined
- For smaller frames, use a carrier extension

Carrier Extension



Frame Bursting

- Hence for shorter data field, higher overhead
- To overcome this frame bursting is used
- This enables a station to send more than one frame for smaller data
- 1st frame normal – if no collision then send the burst frame

Frame burst limit (65,536 bits)

- IFG is filled with frame extension symbols so that others will not capture the network
- For smaller data – efficiency improved over 90% by frame bursting

Full Duplex Ethernet

- Happens in both directions simultaneously
- The link should be a point-to-point media segment – hence twisted pair or fibre optic
- Independent transmit or receive paths
- Hence if 100 Mbps fast Ethernet is used 200 Mbps could be obtained
- No requirement of timing limits that exist in a shared medium
- Only limits are signal carrying capabilities of the media segment
- Specified by 802.3x
- No collision detection (or it is ignored)
- IFG is however present – to transmit a frame Ethernet interface stays for an IFG
- No multiple access since only one station at each end
- The full bandwidth is used only in back bone connections

Media types that support full duplex Ethernet

- 10 BASE T
- 10 BASE FL
- 100 BASE T
- 100 BASE FX
- 1000 BASE SX/LX/CX
- 1000 BASE T
- cable lengths for Gigabit Ethernet:
- 100 m for twisted pair – this is because of cable characteristics – same as 10/100 BASE T
- fibre optic
  - Multi-mode
    - e.g. Some fibres - 412 m (in half duplex), 2 km in full duplex
  - Single mode – 20 km or more

VLANs

- Concept: to assign groups of ports in a switch as independent hubs
  - Newer switches: based on frame traffic, a filter criteria is formed to restrict traffic between VLANs
- Using frame tags, VLANs can span across multiple switches

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VLAN Standard

- IEEE 802.1q
  - A vendor independent way of implementing VLANs
  - The frame is added with a VLAN tag filed
  - 4 bytes – increases maximum frame size to 1522 bytes

preamble	SFD	DA	SA	TPID	TCI	Type/length	Data/pad	FCS	extension

VLAN Standard cont..

- TPID – Tag Protocol Identifier (2 bytes)
- This identifies the frame a tagged frame (0x8100 hex)
- TCI – Tag Control Information (2 bytes)
  - 3 bits for priority information – based on **802.1p** standard
  - 12 bits – VLAN identifier – uniquely identifies the VLAN
- network management software is needed to keep track of network configurations and traffic rules since it becomes very complex with VLANs

Other related topics

- Wireless LANs (WLANs)
  - IEEE 802.11a & 802.11b
- Metropolitan Area Networks (MANs)
  - IEEE 802.3ah Ethernet in the First Mile (EFM)

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