CSE 3461: Introduction to Computer Networking and Internet Technologies

Local Area Networks

Presentation E

Study: 15.1, 15.2, 15.3, 15.4, 15.5, 16.1, 16.2

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Introduction

- LAN characteristics:
  - Use packet broadcasting
  - Costs are relatively low
  - Speeds are high
  - Encompass limited geographical areas
  - Almost always belong to one organization
- LAN architectures characterized by:
  - Topologies
  - Transmission medium
  - Medium access control
- LAN applications: personal computer LANs, high speed office networks, backbone LANs (interconnect low speed local LANs), back end networks (interconnecting large systems), storage area networks (network handling storage needs)

LAN Protocol Architecture

- IEEE 802 standards define LAN layers
- Thus, studying LANs means studying of data link (mostly) and physical layers.

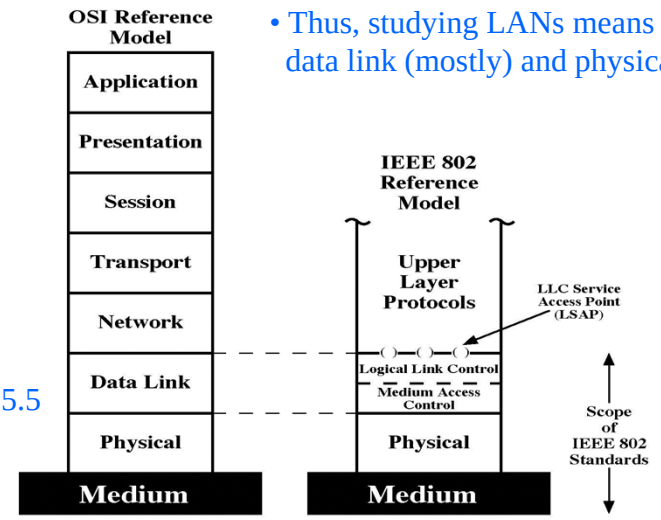
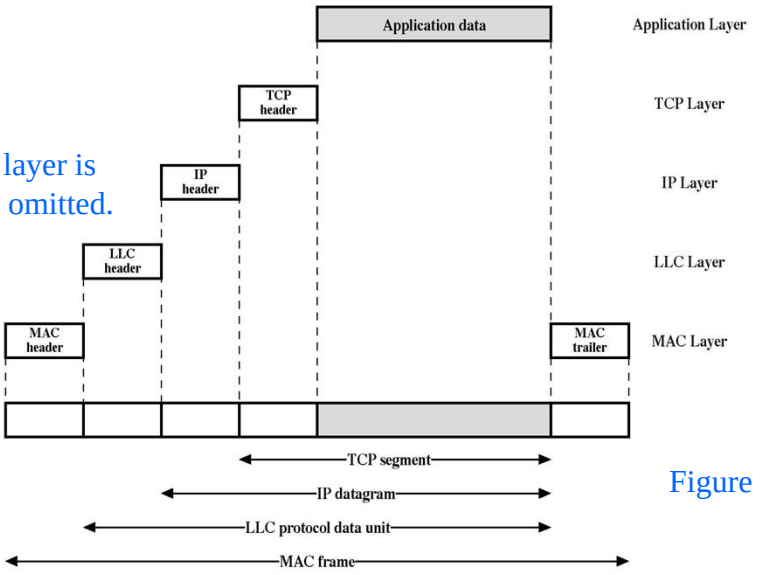


Figure 15.5

IEEE 802 Reference Model

- Physical
  - Encoding/decoding
  - Preamble generation/removal
  - Bit transmission/reception
  - Transmission medium and topology
- Media access control (MAC)
  - Govern access to transmission medium
  - Not found in traditional layer 2 data link control
- Logical link control (LLC)
  - Interface to higher levels
  - Flow and error control
  - For the same LLC, several MAC options may be available

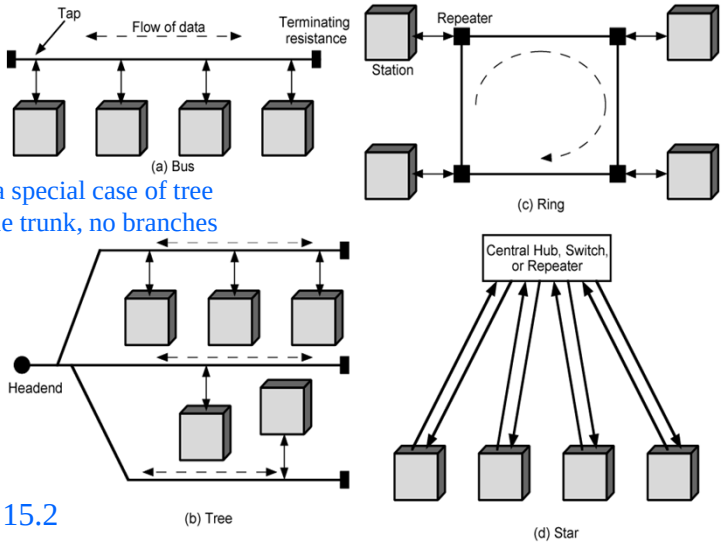
LAN Protocols in Context of TCP/IP



LLC layer is often omitted.

Figure 15.6

LAN Topologies



Bus is a special case of tree with one trunk, no branches

Figure 15.2

Frame Transmission on Bus LAN

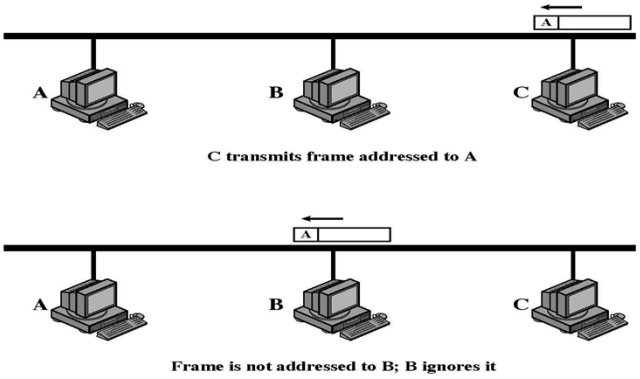
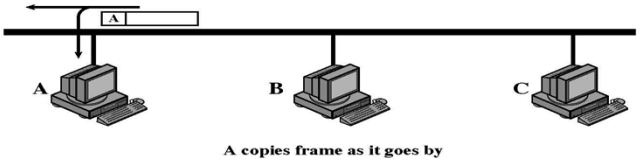


Figure 15.3

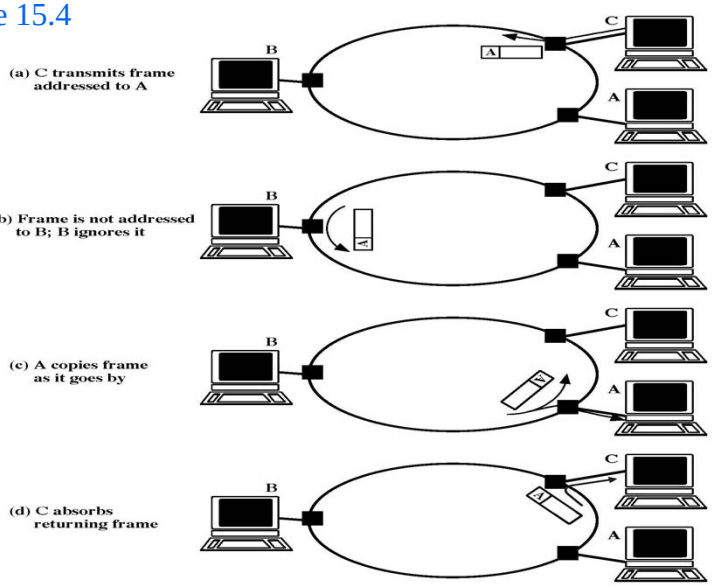


Bus and Tree Topologies

- Multipoint medium
- Transmission propagates throughout medium
- Heard by all stations
  - Need to identify target station and each station has unique address
- Full duplex connection between station and tap
  - Allows for transmission and reception
- Need to regulate transmission (medium access control)
  - To avoid collisions
- Terminator absorbs (and remove) frames at end of medium

Frame Transmission on Ring LAN

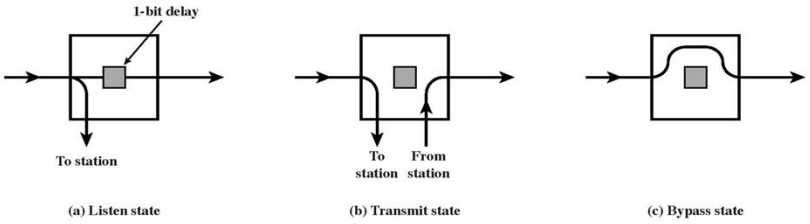
Figure 15.4



Ring Topologies

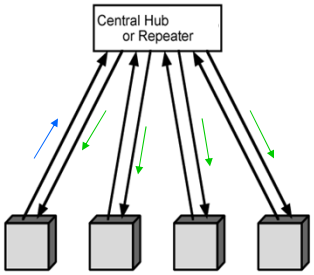
- Repeaters joined by point to point links in closed loop
  - Receive data on one link and retransmit on another
  - Links unidirectional
  - Stations attach to repeaters
- Data in frames
  - Circulate past all stations
  - Destination recognizes address and copies frame
  - Frame circulates back to source where it is removed
- Media access control determines when station can insert frame

Ring Repeater States

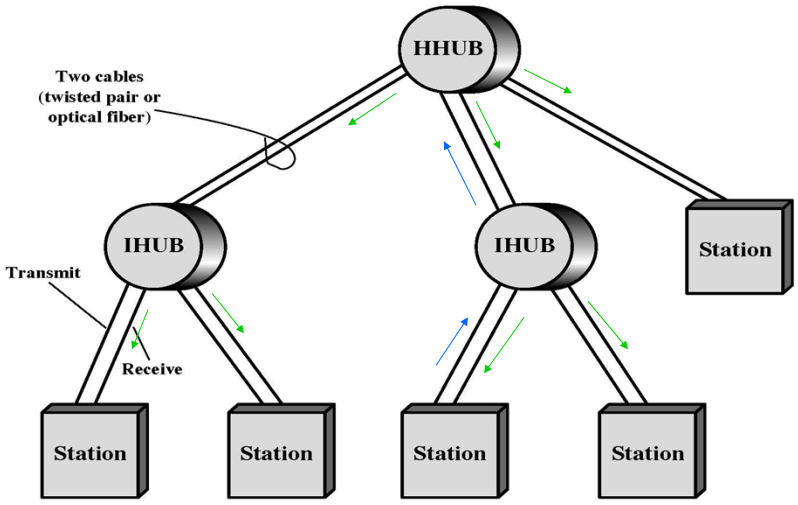


Star Topology

- Each station connected directly to central node
  - Usually via two point to point links
- Central node (hub or repeater) broadcasts
  - Physical star, logical bus
  - Only one station can transmit at a time
- Central node can be and act as a frame switch, instead of a hub
- Multi-level star topologies



Transmission on Two–Level Star Topology



LAN Media

- Voice grade unshielded twisted pair (UTP Cat 3)
  - — Cheap, well understood, but low data rates
  - — Use existing telephone wiring in office buildings
- Shielded twisted pair
  - — More expensive than UTP Cat 3, but higher data rates
- Baseband coaxial
  - — More expensive than UTP, but higher data rates
  - — Used in original Ethernet
  - — Still used but not often in new installations
- High performance UTP (Cat 5 and above)
  - — High data rate for small number of devices
  - — Switched star topology for large installations

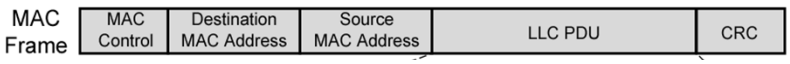
LAN Media (continued)

- Optical fiber
  - — Electromagnetic isolation
  - — High capacity
  - — Small size
  - — High cost of components

  Expensive taps
  - — High skill needed to install and maintain
  - — Not used in bus LANs
  - — Prices are coming down as demand and product range increases
- In conclusion, hard to work with compared with star topology twisted pair

Media Access Control

- MAC layer receives data from LLC layer (or Network layer)
- Assembly of data into frame with address and error detection fields
- Destination MAC address
- Source MAC address
- CRC field
- Govern access to transmission medium for transmission and receiving frames
- Disassembly of received frame
  - — Address recognition and error detection
- MAC layer discards frames detected in errors
- LLC or some upper layer retransmits unsuccessful frames



LAN Addresses

32-bit IP address:

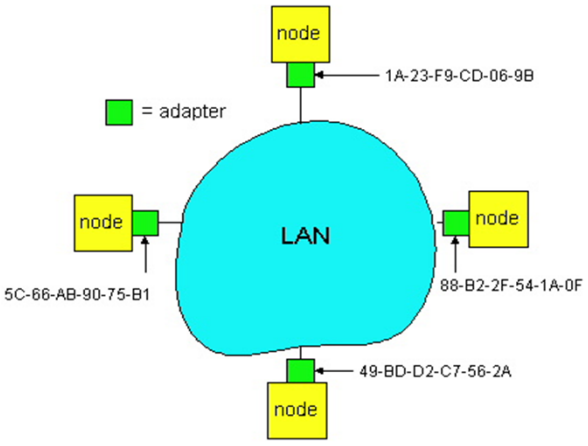
- *network-layer* address
- used to get datagram to destination network (recall IP network definition)

LAN (or MAC or physical) address:

- used to get datagram from one interface to another physically-connected interface (same network)
- 48 bit MAC address (for most LANs) burned in the adapter ROM

LAN Addresses

Each adapter on LAN has unique LAN address



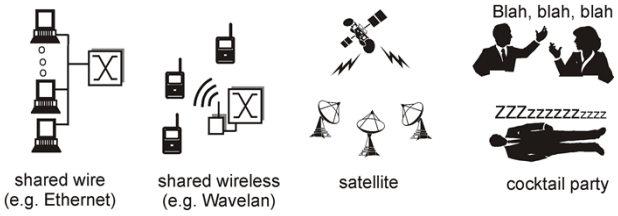
LAN Address (more)

- MAC address allocation administered by IEEE
- manufacturer buys portion of MAC address space (to assure uniqueness)
- Analogy:
  - (a) MAC address: like Social Security Number
  - (b) IP address: like postal address
- MAC flat address => portability
  - can move LAN card from one LAN to another
- IP hierarchical address NOT portable
  - depends on network to which one attaches

Multiple Access Links and Protocols

Three types of "links":

- point-to-point (single wire, e.g. PPP, SLIP)
- broadcast (shared wire or medium; e.g, Ethernet, Wavelan, etc.)



- switched (e.g., switched Ethernet, ATM etc)

Multiple Access protocols

- single shared communication channel
- two or more simultaneous transmissions by nodes: interference
  - only one node can send successfully at a time
- *multiple access protocol:*
  - distributed algorithm that determines how stations share channel, i.e., determine when station can transmit
  - communication about channel sharing must use channel itself!
  - what to look for in multiple access protocols:
    - synchronous or asynchronous
    - information needed about other stations
    - robustness (e.g., to channel errors)
    - performance

MAC Protocols: a taxonomy

Three broad classes:

- Channel Partitioning
  - TDMA: time division multiple access
  - FDMA: frequency division multiple access
  - CDMA (Code Division Multiple Access)
- Random Access
  - allow collisions
  - "recover" from collisions
- **"Taking turns"**
  - tightly coordinate shared access to avoid collisions

Goal: efficient, fair, simple, decentralized

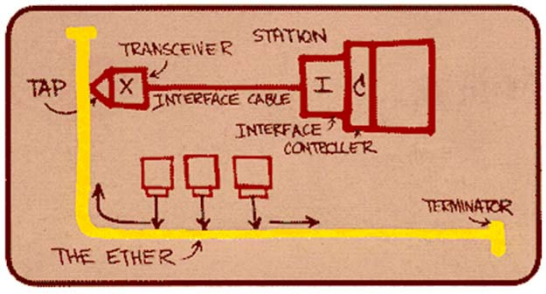
Random Access protocols

- When node has packet to send
  - transmit at full channel data rate R.
  - no *a priori* coordination among nodes
- two or more transmitting nodes -> “collision”,
- random access MAC protocol specifies:
  - how to detect collisions
  - how to recover from collisions (e.g., via delayed retransmissions)
- Examples of random access MAC protocols:
  - slotted ALOHA and ALOHA
  - CSMA and CSMA/CD

Ethernet

“dominant” LAN technology:

- cheap $20 for 100Mbs!
- first wildey used LAN technology
- Simpler, cheaper than token LANs and ATM
- Kept up with speed race: 10, 100, 1000 Mbps



Metcalfe’s Etheret sketch

CSMA/CD (Ethernet) Media Access Control

- Carriers Sense Multiple Access with Collision Detection
- Introduced in early 1970's by Xerox - Ethernet
- Standardized by IEEE 802.3
- Random Access
  - — Stations access medium randomly
- Contention
  - — Stations content for time on medium
- Evolved from Aloha and Slotted Aloha through different CSMA

CSMA: General Principles

- Carrier Sense Multiple Access
- Propagation time is much less than transmission time
- All stations know that a transmission has started almost immediately
- First listen for clear medium (carrier sense)
- If medium idle, transmit
- If two stations start at the same instant, collision
- Wait for ACK reasonable time (round trip plus small increment)
- No ACK then retransmit
- Max utilization depends on propagation time (medium length) and frame length
  - — Longer frame and shorter propagation gives better utilization

1-persistent CSMA

- Station wishing to transmit listens and obeys following:
  1. If medium idle, transmit; otherwise, go to step 2
  2. If medium busy, listen until idle; then transmit immediately
- If two or more stations waiting, collision guaranteed
  - Gets sorted out after collision

Nonpersistent CSMA

1. If medium is idle, transmit; otherwise, go to 2
2. If medium is busy, wait amount of time drawn from probability distribution (retransmission delay) and repeat 1

- Random delays reduces probability of collisions
  - Consider two stations become ready to transmit at same time while another transmission is in progress
  - If both stations delay same time before retrying, both will attempt to transmit at same time
- Capacity is wasted because medium will remain idle following end of transmission if one or more stations waiting

P-persistent CSMA

- Compromise that attempts to reduce collisions
  - — Like nonpersistent
- And reduce idle time
  - — Like 1-persistent
- Rules:
  1. If medium idle, transmit with probability P, and delay one time unit with probability (1 – P)
     - Time unit typically maximum propagation delay
  2. If medium busy, listen until idle and repeat step 1
  3. If transmission is delayed one time unit, repeat step 1
- What is an effective value of P?

Ethernet's CSMA/CD

- With CSMA, collision occupies medium for duration of transmission
- CSMA/CD (CD = collision detection) stations listen while transmitting and collision period can be shortened.
- IEEE 802.3 uses 1-persistent CSMA/CD:

1. If medium idle, transmit, otherwise, step 2
2. If busy, listen for idle, then transmit
3. If collision detected, jam and then cease transmission
4. After jam, wait random time then start from step 1

- Attempt to transmit repeatedly if repeated collisions
- To ensure stability, IEEE 802.3 and Ethernet use binary exponential backoff
- With random backoff, unlikely to collide on next tries

Ethernet's CSMA/CD (more)

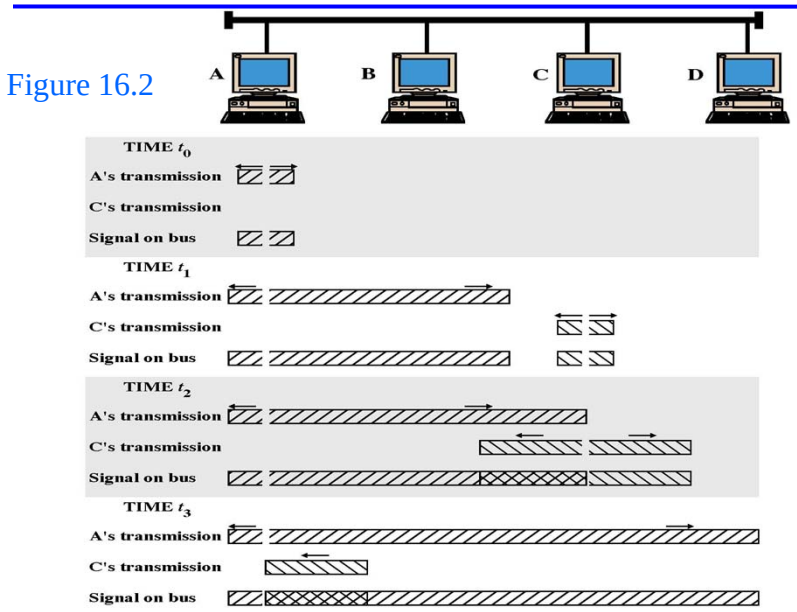
Jam Signal: make sure all other transmitters are aware of collision; 48 bits;

Exponential Backoff:

- *Goal* : adapt retransmission attempts to estimated current load
  - —heavy load: random wait will be longer
- first collision: choose K from {0,1}; delay is K x 512 bit transmission times
- after second collision: choose K from {0,1,2,3}…
- after ten or more collisions, choose K from {0,1,2,3,4,…,1023}

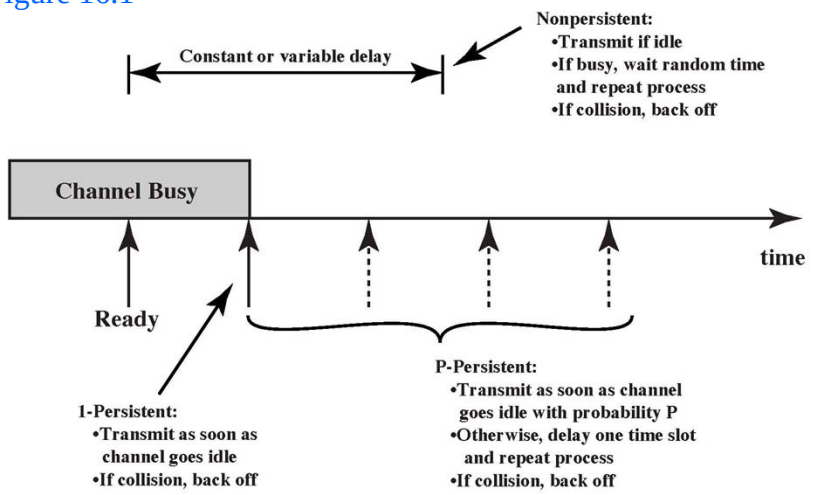
CSMA/CD (Ethernet) Operation

Figure 16.2



CSMA Persistence and Backoff

Figure 16.1

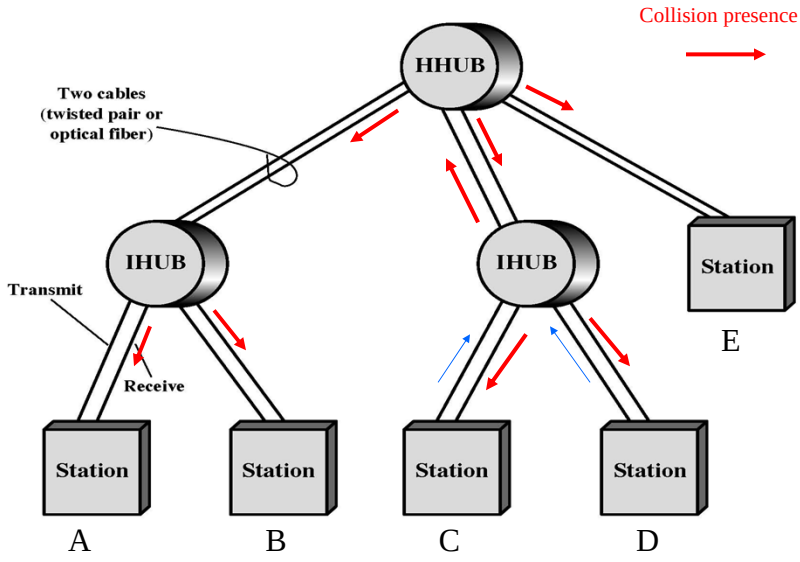


Collision Detection

- On baseband bus, collision produces much higher signal voltage than signal:
  - Collision detected if cable signal greater than single station signal
  - Signal attenuated over distance
  - Limited distances to 500m (10Base5) or 200m (10Base2)
- For twisted pair (star-topology) activity on more than one port is collision:
  - Special collision presence signal
- Different on wireless LAN's, since a receiver shut off while transmitting.

Collision in Star Topology: Case 1

C and D transmitting



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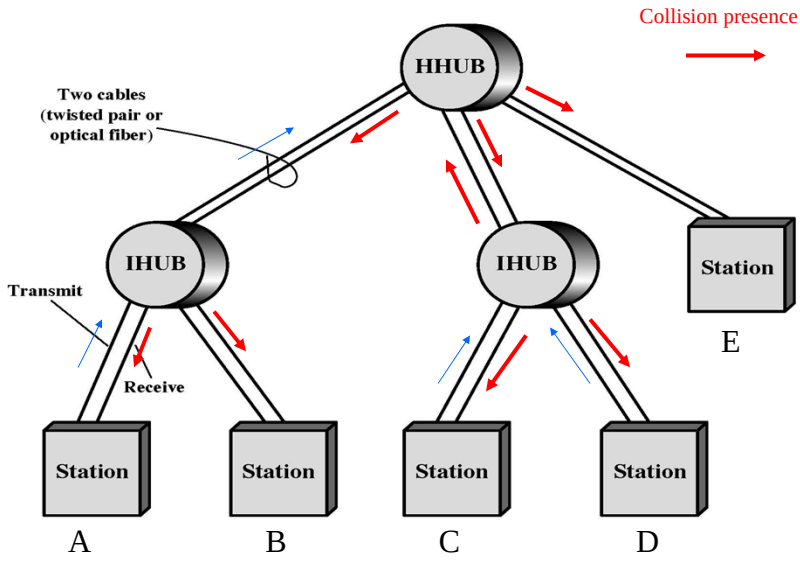
Collision in Star Topology: Case 2

A, C and D transmitting



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