CPS 422
Computer Networks

DATA LINK LAYER

DATA LINK CONTROL

- Elementary Data Link Control protocols are:
  - Stop-and-Wait ARQ.
  - Go-Back-N ARQ.
  - Selective-Repeat ARQ.

For efficient utilization of transmission medium, more than one frames should be allowed to remain outstanding at a time.

GO-BACK-N ARQ

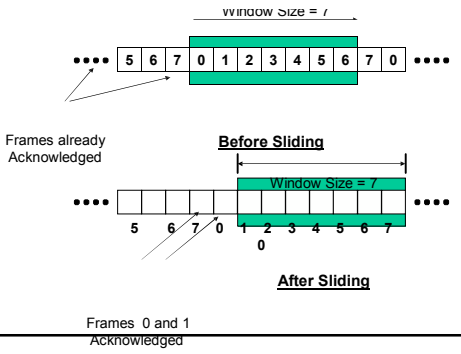
- Upto W frames can be sent before the sender must wait for an acknowledgement.
- Copy of these sent frames is maintained until Ack received.
- All frames are sequentially numbered.
- If m bits are allowed for sequence numbers in frame header, the sequence numbers can be from 0 to $2^m - 1$. (Repeated)
- E.g. if m=3, sequence numbers will be 0,1,2,3,4,5,6,7,0 1,2,3,.....

GO-BACK-N ARQ

Sender's Sliding Window

- To account for outstanding frames the concept of sliding "window" is used.
- Imagine that all frames are stored in a buffer
- The outstanding frames are enclosed in an imaginary window.
- Frames to the left of the window have already been ack and can be purged.
- Frames to the right of the window cannot be sent unless the window slides over them.
- Whenever an ack received, the window slides.
- Window size : At most $2^m - 1$

Sender's Sliding Window

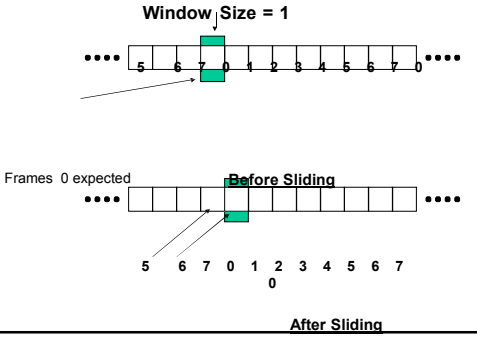


GO-BACK-N ARQ

Receiver's Sliding Window

- Window size : always 1
- Receiver always expecting one frame of a specific seq number
- Out of order frames discarded.
- Sender has timer for each frame sent, receiver does not have any timer.

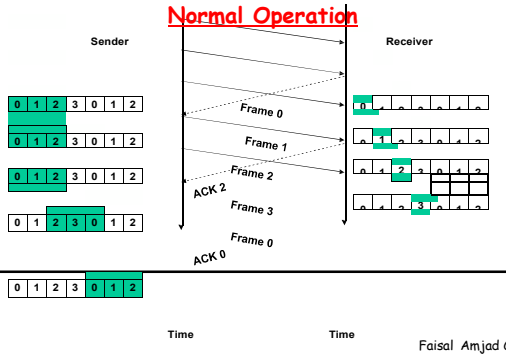
Receiver's Sliding Window



Frames 0
is received
Frames 1 expected

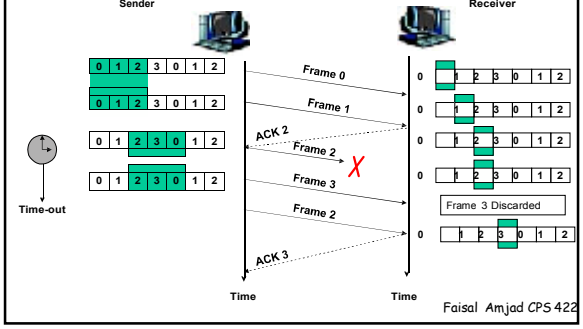
GO-BACK-N ARQ (Contd…)

Normal Operation



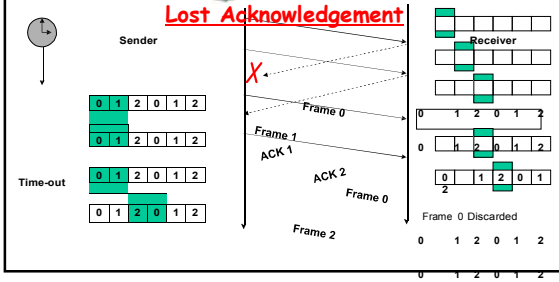
GO-BACK-N ARQ (Contd…)

Lost or damaged data frame



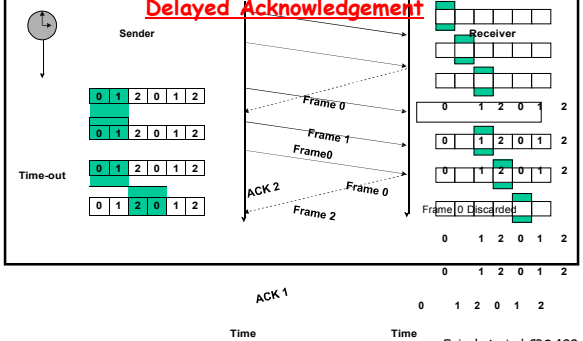
GO-BACK-N ARQ (Contd…)

Lost Acknowledgement



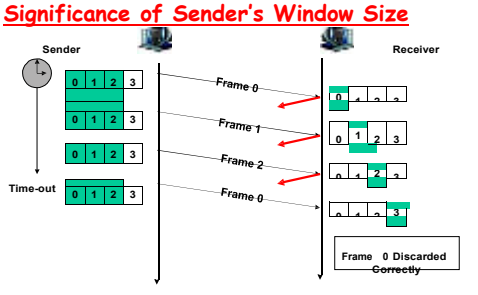
GO-BACK-N ARQ (Contd…)

Delayed Acknowledgement



GO-BACK-N ARQ (Contd…)

Significance of Sender's Window Size

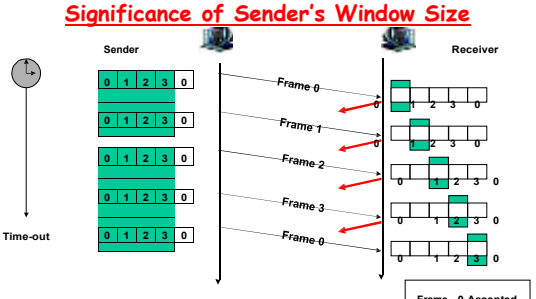


m=2 bits allowed for seq no

~~Sender's Window Size < 2^m~~

GO-BACK-N ARQ (Contd…)

Significance of Sender's Window Size



m=2 bits allowed for seq no

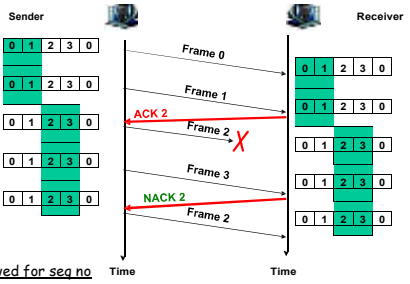
~~Sender's Window Size = 2^m~~

SELECTIVE REPEAT ARQ

- Also called Selective Reject ARQ (Stallings).
- GO-Back-N is inefficient in a noisy link.
- In Selective Repeat Only damaged or lost frames are retransmitted
- Which means Complex processing at the receiver.
- Sender window is similar as in Go-Back-N ARQ.
- However size of window is <= 2^{m-1}
- Receiver has a window of the same size as Sender. why??
- Because the receiver is looking for any frame within the same range of transmitted frames

SELECTIVE REPEAT ARQ (Contd…)

Normal Operation

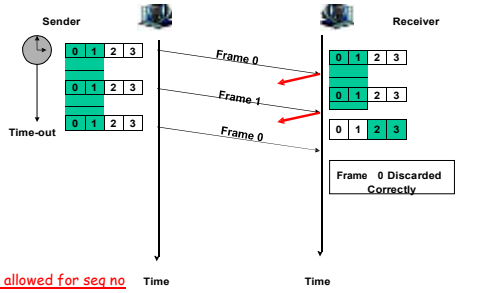


m=2 bits allowed for seq no

Window Size = 2^{m-1}

SELECTIVE REPEAT ARQ (Contd…)

Significance of Window Size

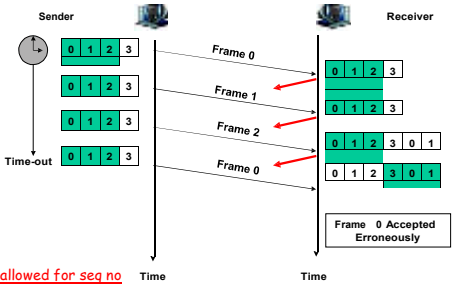


m=2 bits allowed for seq no

~~Window Size = 2^{m-1}~~

SELECTIVE REPEAT ARQ (Contd…)

Significance of Window Size



m=2 bits allowed for seq no

Window Size > 2^{m-1}

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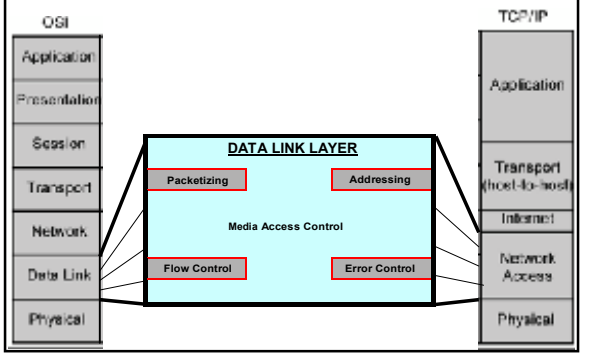
DATA LINK LAYER

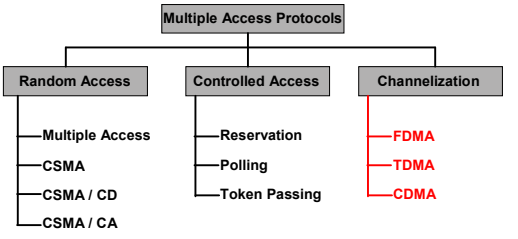
MEDIUM ACCESS CONTROL

THE PERSPECTIVE



~~The protocols used to determine who goes next~~ on a multi-access channel, belong to a sublayer of ~~the data link layer called the MAC (Medium Access Control)~~ sublayer

Categories of Multiple Access Protocols



Random Access – the Evolution

- Four Random-Access methods answered four questions regarding random access
- Multiple Access – When can a station access the medium?
- CSMA – What can a station do when medium is busy?
- CSMA/CD – how can a station determine if the transmission was a success or failure?
- CSMA/CA – if there is an access conflict, what can a station do?

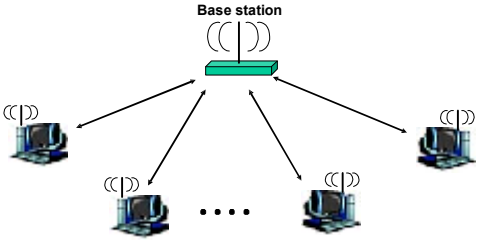
Multiple Access of a Shared Medium

Multiple Access

- ALOHA was the earliest random-access method
- Developed at the university of Hawaii (early 1970s)
- Designed for radio (wireless) LAN @ 9600bps
- Base station is the central controller
- A frame to be sent to any other station is to be sent to the base station
- Base station relays all frames to their destinations
- Uplink used 407 MHz
- Downlink used 413 MHz

Multiple Access (Contd)

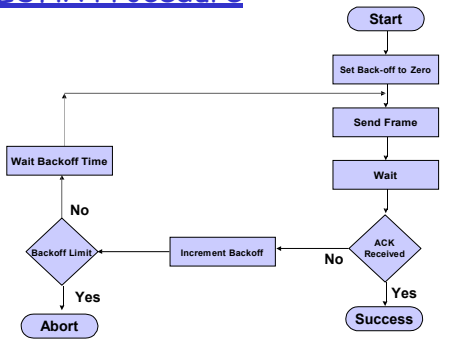
ALOHA Network Layout



Multiple Access (Contd)

- Stations transmitting simultaneously will experience collisions.
- ALOHA based on fol rules:-
  - Stations send frames whenever they have frames to send
  - After sending, waits for an Acknowledgement within the allotted time (2 times max propagation delay)
  - If ACK received, transmission was successful
  - Otherwise, it will use a back-off strategy (in this case random time) and sends the frame again
  - After several un-successful tries, the station aborts transmission

ALOHA Procedure



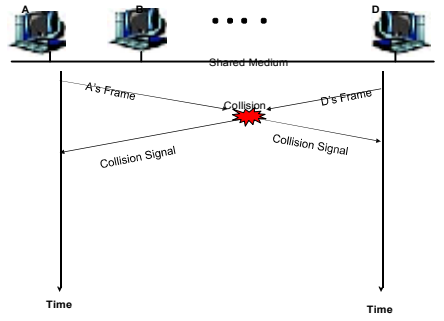
Variants of ALOHA

- Pure ALOHA
- Slotted ALOHA

Carrier Sense Multiple Access (CSMA)

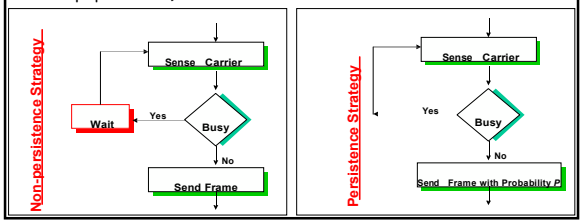
- The chance of collision can be reduced if a station senses the medium before trying to use it
- CSMA is based on the principle "sense before transmit" or "listen before you talk"
- Chance of collision is reduced but not eliminated. why??
- Propagation delay causes collisions

Collision in CSMA

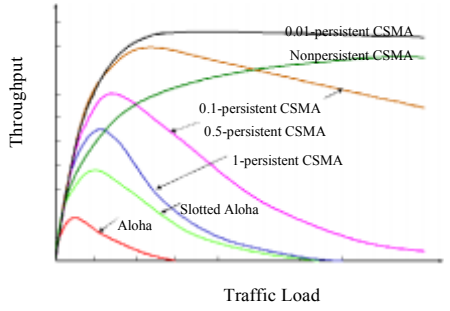


CSMA Persistence Strategies

- Persistence strategy defines the procedures for a station that senses a busy medium
- Two strategies
  - Non-persistence
  - Persistence (Two types of persistence, 1-persistent and p- persistent)



Throughput Comparison



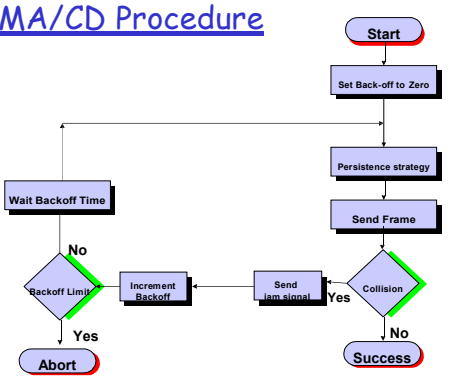
Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

- Improvement over CSMA -> after a transmission, collision is detected (if any), how??
- Reason for not representing a 0 bit with zero volts ???
- To reduce the probability of collision the next time, the station resorts to back off.
- How much should the station back off for transmitting for the next time
- Most popular strategy is called "Binary Exponential Back off" used in IEEE 802.3 standard.

Binary Exponential Backoff

- A slot is equal to 2 x max propagation delay
- After every collision, the station will choose random number between 0 and 2^{N-1} slots to wait and then retransmit (where N is the number of retransmission attempts)
- First attempt-> station chooses between 0 and 1 time slots to wait
- Second attempt-> between 0,1 and 2 time slots
- Third attempt-> between 0,1,2,3 and 4 time slots
- Fourth attempt-> between 0,1,2,3,4,5,6,7 and 8 time slots

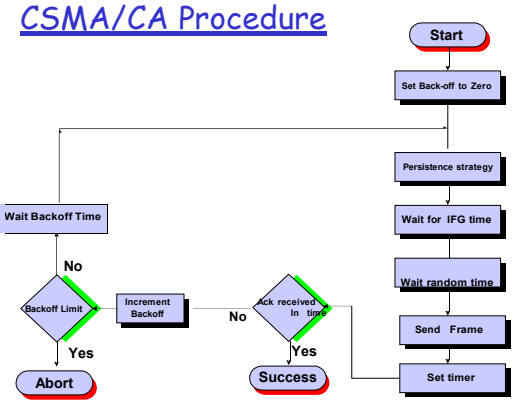
CSMA/CD Procedure



Carrier Sense Multiple Access with ~~Collision Avoidance (CSMA/CA)~~

- This tries its level best to avoid a collision of frames
- Improvement over CSMA/CD->After the persistence strategy has given clearance for sending the frame, wait for another Inter-Frame-Gap (IFG) which may be one propagation delay
- After IFG wait for another random amount of time before transmitting
- Set a timer for receiving ACK
- This will further reduce the chance of a collision

CSMA/CA Procedure



Comparison

- Multiple Access – Transmit whenever ready, if collision occurs wait a random time and transmit again
- CSMA – Before transmitting sense the carrier, if unsuccessful, use backoff strategy before retransmitting
- CSMA/CD – Abort transmission as soon as collision detected, use backoff strategy before retransmitting
- CSMA/CA – waits for two additional time intervals than CSMA/CD