Computer Network

B.Tech, Computer Engineering

Delhi Technological University

Module 2_4: Medium Access Control Sublayers

Instructor: Divyashikha Sethia

Assistant Professor, Department of Software Engineering

- Network can be divided into two categories-
- i) Using pt to pt connections
- ii) Using broadcast channels

- LANs use broadcast channel.
- WANs are Pt to Pt except for satellite network.

Medium Access Control

- The protocols used to determine who goes next on a multiaccess channel belong to a sublayer of the data link layer called the **MAC (Medium Access Control) sublayer.**

broadcast channels

- Key Issues:

- who gets to use the channels when there are multiple nodes competing for it
- MAC sublayer of the data link layers determines which node gets to access the broadcast channel.
- A network of computers broad or multi-access medium requires protocol for effective sharing of media, as only one node can send or transmit signal at a time using broadcast node.
- **where** and **how** control to medium is given to a node.

Broadcast Channels

- Where control: is the control centralised or decentralised distributed.

Centralised control

Centralised Master node grants access for medium to other nodes.
Advantages:
•Greater control for priority, guarantied bandwidth
•Simpler logic at each node.
•Easy coordination.

Disadvantages:
- Vulnerable to failure of the master node.

Distributed approach in which nodes collectively perform a medium access control function and dynamically decide which node gets the medium access.

How refers what manner the control is exercised.
MAC technique can be broadly be divided into four categories:-

```
                                   MAC
                                    |
        ________________________________________________________________________
        |                |                       |                                 |
      Random        Round Robin             Reservation                     Channelization
       |                 |                       |                               |
___________Pure Aloha    _______          ________________          _________________
|_________ Slotted Aloha  |        |        |                 |         |          |       |
|_________CSMA        Polling  Token Passing  Centralised  Distributed    FDMA  TDMA CDMA
|_________CSMA/CD
|_________CSMA/CA
```

•Focus of random MAC.

•CSMA/CA is a wireless LAN protocol.

•Channelisation based MACs are used in cellular telephone network.

•Reservation based MACs are used in satellite.

Contention Based Approach

•This is suitable where there are few nodes which have data for brief periods of time suitable for bursty nature of traffic.

•Node which wants to transmit data contends for gaining control of the medium.

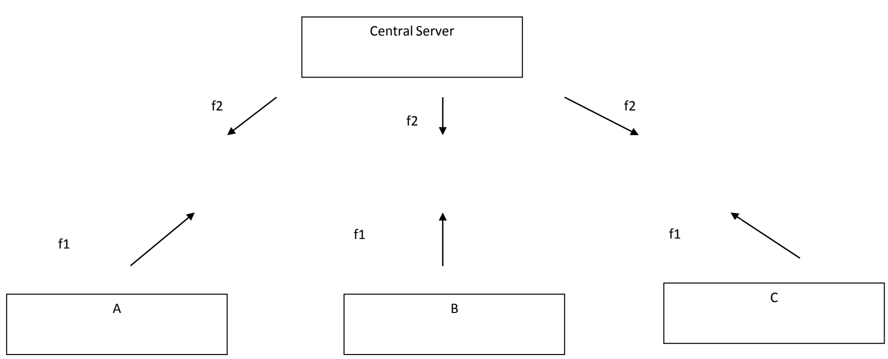
ALOHA

•Invented in 1970 for packet radio network connecting remote stations to a central computer and various data terminals at campus at Howard University.

• Users are allowed random access of central campus through common radio frequency band f1 & the central campus broadcasts all received signal at a different frequency band f2.

•Enables users to monitor pkt collisions.

ALOHA Example

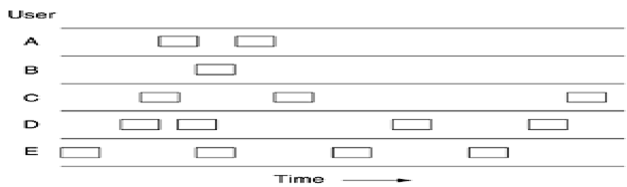


f1- random access   f2 - broadcast

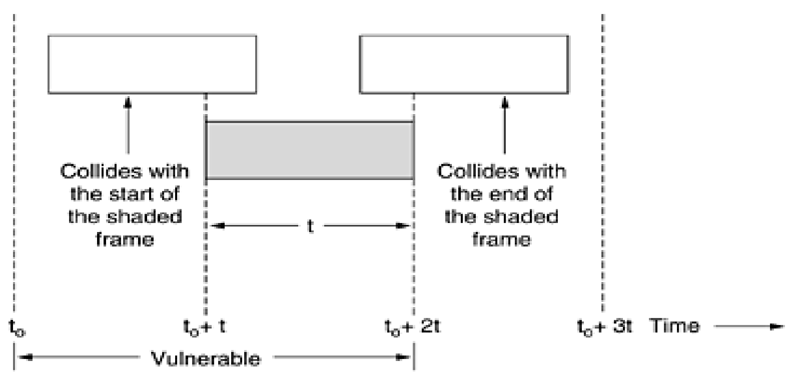
Pure ALOHA

•This is pure Aloha- whenever node has a packet to send, it simply does so.
•Frames will suffer collision and colliding frames will be destroyed.

•A user comes to know whether the packet sent has suffered collision, by monitoring signal sent by control computer.
•*After collision wait for random time and then retransmit*



In pure ALOHA, frames are transmitted at completely arbitrary times.



Assumes all packets have fixed duration t. Packet will collide if there is an overlap.
Vulnerable period is 2t.

Calculating throughput for Pure ALOHA

•In probability theory, Poisson distribution expresses no of events occurring in a fixed period of time if these events occur with a known average rate & independently of the time since the last event. If expected number of occurrence in this interval is G, then probability that there are exactly k occurrences.

$P[k] = G^k e^{-G} / k!$

Calculating throughput for Pure ALOHA

•Frame Time denotes the amount of time needed to transmit the standard fixed length frame (Frame Time = Frame length / Bit Rate)

•Assume infinite users generate *new frames* according to Poisson distribution at rate of mean N frames per frame time

•If $N > 1$, users are generating frames at a higher rate than channel can handle & frames will suffer collision. Hence $0 < N < 1$

•Along with new frames these are retransmissions of frames that previously suffered collisions.

•Probability of k transmissions attempts per frame time, old and new combined is also considered Poisson with mean G per frame time.

Calculating throughput for Pure ALOHA...

=> G >= N
- At low load N approximately 0, there are few collision hence few retransmission => G appx N
-At high load there are many collisions
Probability for packet x to be successfully delivered =
Probability that there is no other packet during the period =
P(0) = Probability of 0 other frames in the period.
Throughput for the time period has G frames transmitted.
Throughput S = Offered Load = Average number of packets that can successfully go throughout
= G Po.
Po = Probability that a frame does not suffer a collision. i.e Po is probability of successful frames.
Pr [0] = Probability of 0 frames
$= G^0 e^{-G} / 0! = e^{-G}$

Calculating throughput for Pure ALOHA...

No other frames are sent within one frame time.
Interval of 2 frames long i.e vulnerable period, mean number of frames generated = 2G.
Probability that no other traffic is being controlled during the vulnerable period to given by:
Po= e^{-2G} (2 because it is probability for 2 frame period)
But S = GPo
$S = G e^{-2G}$ = Throughput in frames of offered load

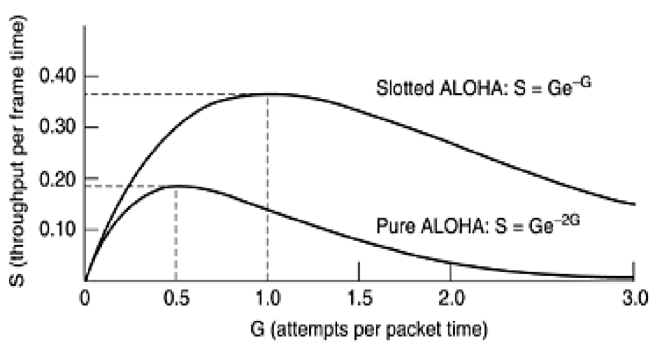
Slotted ALOHA

It is an Improvement over pure ALOHA. Channel is divided into slots equal to time t and pkt transmission can only start at the beginning of a slot.
i.e. the vulnerable period is reduced from 2t to t
Probability that no other traffic is being initiated during vulnerable period is

$Po = = G^0 e^{-G} / 0! = e^{-G}$

$\Rightarrow S = G P0 = G e^{-G}$

Slotted ALOHA peaks at G = I with throughput S = 1/e or about 0.368 twice that of pure ALOHA.



Best channel utilisation of 18% is obtained at 50% of the offered load.
Smaller offered load, channel capacity is underused.
Higher load, too many collisions reduce throughput.

CSMA

-Poor efficiency of ALOHA is due to the fact that a node starts transmitting w/o considering what other nodes are doing.

-If the propagation delay of the signal b/w 2 nodes is small compared to the transmission time of a pkt, all other nodes will know quickly when a node starts transmission.

- This is the observation made is Carries Sense Multiple Access (CSMA)
  * Node that wants to transmit data first listens to the medium to check whether another transmission is in progress.
  * Node starts sending only when the channel is free.

CSMA…

Variations-

- **1 Persistent CSMA:**
  -If the channel is free when sensed by a node, it transmits data.
  -If channel is busy, *nodes continues to monitor unit channel is idle & then starts sending.*

- **Non-Persistent CSMA:**
  -If channel is free, node transmits.
  -If busy, *node waits for random amount of time & then monitors again.*

CSMA..

• 3- P-Persistent

i) When station becomes ready to send it senses the channel

ii)If idle it transmits with prob p. and with prob q = 1-p defers it until next slot. If that slot is also idle it either transmits or defers again with prob p and q. Continues until frame has been transmitted or anther station has begum transmitting.

iii)If channel is busy it waits for random time and starts again from i)

iv) If initially it senses channel busy then waits until next slot and starts again i)

CSMA/CD

Carrier sense multiple access with collision detection:

-Refinement over CSMA. In CSMA, when 2 pkts collide, channel remains unutilized for entire duration of transmission time for both the pkt.

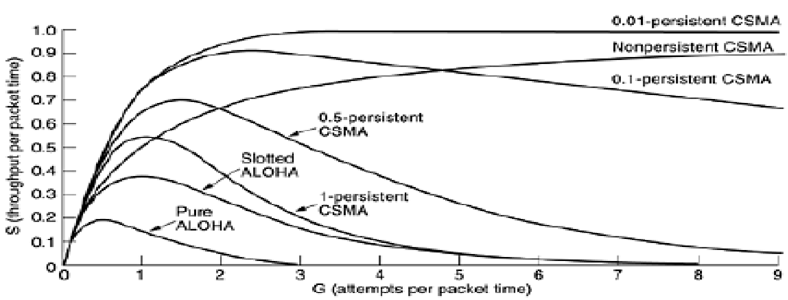
-Wasted channel capacity can he large if the propagation time is small compared to pkt transmission.

-This wastage of channel capacity can be reduced if nodes continue to monitor channel during pkt transmission & immediately cease transmission when collision is detected. It transmits jamming signal for brief duration to ensure that all station know that collision occurred.

CSMA/CD

-After this, node waits for random time & then retransmits, to ensure that nodes involved in collision are not likely to have collision on retransmission.

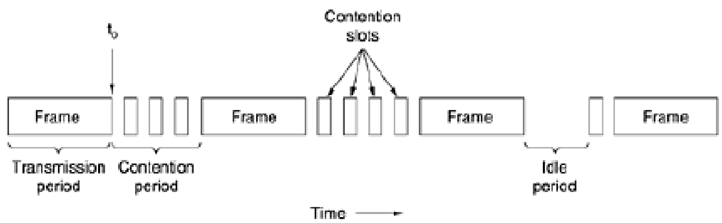
-To achieve stability binary exponential backoff is used. If there are repeated collisions node attempts to retransmit each time at each collision, value of random delay is doubled after 15 retries including original try. Unlucky pkt is discarded.



Pure ALOHA gives max throughput of 100% & is suitable only for very low offered load.
-Slotted ALOHA: S max = 0.36
-Non -persistent CSMA is better than persistent due to smaller probability of collision for retransmitted pkt in non-persistent.
-Non -persistent CSMA/CD provides high throughput and can tolerate heavy load.

CSMA/CD

Can be in one of three state contention, transmission or idle t0



Idle time implies no work.

t0 is the time frame finished transmission.

•If 2 stations starts transmit at t0, minimum time to detect collision is time it takes the signal to propagate from one at to another.

•Time signal takes to propagate between 2 farthest station = τ
Most distant station begins transmission at τ - ϵ instant before this signal comes.

•The most distant station detects collision & stops instantly but the noise burst generated from the collision gets back to the original station only until 2τ - ϵ

$\Rightarrow$Station can be sure that it has seized the channel until it has transmitted for 2τ w/o hearing a collisions

The contention interval is considered as SLOTTED ALOHA at slot 2τ wide.

Assume each slot contains 1 bit.
Once the channel is seized, station can transmit at any rate not just 1 bit per 2τ second.

THANKS

References:
Tanenbaum chapter 4 (4.1, 4.2.1, 4.2.2)