#1

21-04-21
Wednesday

Random Access Protocols

Aloha → • Deaf and dumb stations which randomly transmits data
• If acknowledgement isn't received then frame is resend.
Cons: – throughput is low (18%) due to high collision

Slotted Aloha → better throughput than Aloha due to sending in particular timeslots but lower than other protocols.

CSMA → • senses medium before sending
cons: unable to detect collision

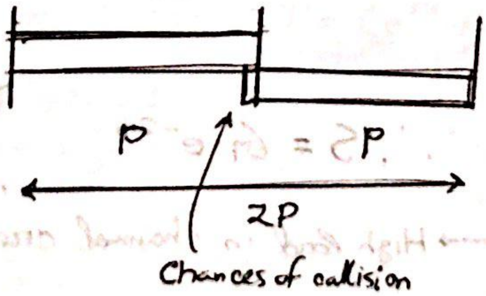
CSMA/CD → [Applied in wired LAN]
• detects collision but can not be used in wireless LAN

CSMA/CA → [Applied in wireless]

~~Valid~~ Throughput of Aloha

Vulnerable time → Time when collision is likely to happen

For pure aloha the vulnerable time is 2P.



$\alpha \rightarrow$ total units $\quad \lambda \rightarrow$ rate

$\alpha = \lambda t$

Apply if events have a constant rate independent to time

Poisson distribution $P_{(x)} = \frac{\alpha^{x} e^{-\alpha}}{x!}$

$$P_k(t) = \frac{(\lambda t)^k e^{-\lambda t}}{k!} \quad \ldots\ldots \quad k = 0, 1 \ldots \infty$$

Derivation: $\boxed{S = Ge^{-2G}}$

$G \rightarrow$ Load of the system (average no. of packet attempts)
~~(packets transmitting in a unit time)~~ avg.

$\lambda \Rightarrow$ Arrival ~~rate~~ rate

$P \rightarrow$ [~~Transmission time~~] Probability of packet suceeding in P time

vulerable time

(*) Throughput, $S = G \cdot P_s = G \cdot e^{-2G}$

Packet Success $\rightarrow P_s = P\{\text{Packet 0 is successful}\} = P\{\text{0 packet in 2P time}\}$

$$P_s = P\{\text{0 packet in p time}\} * P\{\text{0 packet in next p time}\}$$

$$= \frac{e^{-\lambda p}(\lambda p)^0}{0!} * \frac{e^{-\lambda p}(\lambda p)^0}{0!}$$

$$= e^{-\lambda p} \times e^{-\lambda p}$$

$$= e^{-2\lambda p} \quad [\lambda p \rightarrow G]$$

$$\therefore S = G \cdot e^{-2G}$$

(*) Channel Saturation $\longrightarrow$ High load in channel creates more collision, reducing ~~high saturation~~ throughput,

S_{max} can be found by differentiating S.

$$\frac{dS}{dt} = \frac{d}{dt}(G \times e^{-2G}) \quad [G = \lambda t]$$

$$\Rightarrow 0 = G \cdot e^{-2G} \cdot (-2\lambda) + \lambda e^{-2G}$$

$$= \lambda(e^{-2G})(-2G+1)$$

$$-2G + 1 = 0$$

(*) $\boxed{\therefore G = 1/2}$

$$\boxed{S_{max} = 1/2 \cdot e^{-1} = \frac{1}{2e} = 0.184} \rightarrow 18.4\%$$

$\dfrac{\text{Success Transmission \%}}{\text{Total \quad '' \quad \%}}$ (throughput) (load)

$$S = G e^{-2G}$$

$\Rightarrow \dfrac{G}{S} = e^{2G}$ [G/S means avg. no. of transmission per successful transmission]

$\Rightarrow \dfrac{G}{S} - 1 = e^{2G} - 1$ [Average number of unsuccessful transmission per successful transmission]

$\dfrac{G-S}{S}$ fail/success

$$\boxed{N_r = \frac{G}{S} - 1 = e^{2G-1}}$$

Transmission Delay

$$N_r (P + B) + P$$

[Delay due to unsuccessful transmission]

[Unsuccess attempts per success attempt]

Transmission time

Backoff time for that packet

[Delay due to successful transmission]

Average transfer/transmission delay (Avg. time for 1 successful transmission)

$$\overline{T} = (e^{2G} - 1)(P + \overline{B}) + P$$

Difference

Since backoff time is random, we take [average of random time]

$$\rightarrow \overline{B} = \frac{\sum_{k=0}^{k-1} k \cdot P}{k} = \frac{P \sum_{k=0}^{k-1} k}{k} = \frac{P(k-1)(k-1+1)}{2k} = \frac{Pk(k-1)}{2k}$$

$$\therefore \overline{B} = \frac{P(k-1)}{2}$$

$$\rightarrow \overline{T} = (e^{2G} - 1)\left[P + \frac{P(k-1)}{2}\right] + P$$

$$= P\left[(e^{2G} - 1)\frac{(k+1)}{2} + 1\right]$$

Normalizing with respect to P

$$\boxed{\overline{T}/P = (e^{2G} - 1)\frac{(k+1)}{2} + 1}$$

Sometimes denoted as $\overline{T}$

#2

Slotted aloha, $P_s = P\{0' \text{ packets in } p \text{ time}\}$

$\hookrightarrow$ vulnerable time

$$= \frac{e^{-\lambda p}(\lambda p)^0}{0!} = e^{-\lambda p} = e^{-G}$$

$$\therefore S = G \cdot e^{-G}$$

$$\boxed{S = G \cdot P_s}$$

$S \rightarrow$ Throughput

$G \rightarrow$ Load

$P_s \rightarrow$ Probability of succeeding in P time

For, $\frac{dS}{dt} = 0$; $G = 1$; $S_{max} = 36.8\%$

Avg. No of unsuccessful transmission per successful transmission

$$\rightarrow \left[N_r = \frac{G-S}{S} = e^G - 1\right]$$

(*) Average transmission Delay (avg. time for 1 successful transmission)

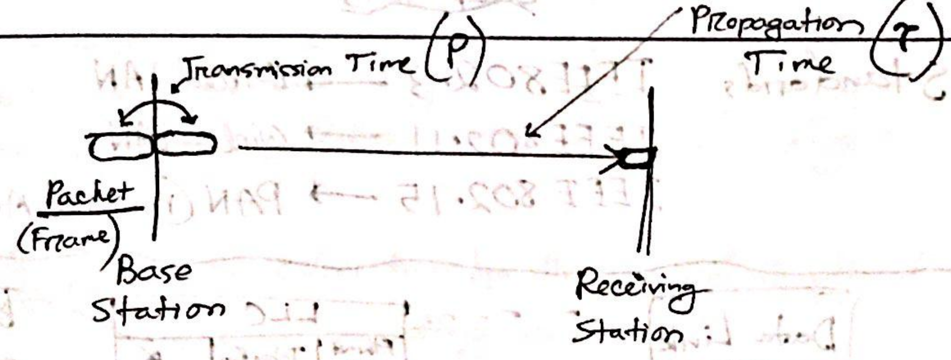
$$\text{For Aloha, } \overline{T} = \underbrace{N_r(P+\overline{B})}_{\text{Unsucesss time}} + \underbrace{P}_{\text{Success Time}}$$

(i) For slotted unsuccess time,

$$\left[\overline{T}_{unsucc} = \underbrace{\left(P + \cancel{\gamma P} + \overline{B}\right)}_{\text{Time/Unsuccessful Attempt}} \underbrace{N_r}_{\text{Attempts}} + \cancel{\ }\right]$$

$2\tau_p \rightarrow$ Time to go from one station to another [Propagation Time]

$P \rightarrow$ ~~[illegible]~~ Time for packet to emit from base station [Transmission Time]



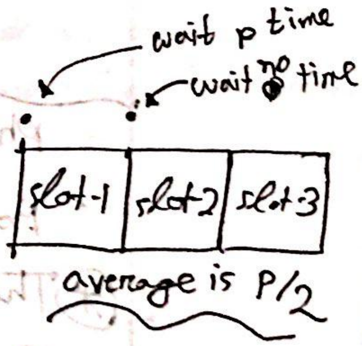
So, $\frac{2\tau}{\cancel{\ }}$ means time to receive acknowledgement

$rp \longrightarrow$ where r is smallest integer greater than $\frac{2\tau}{P}$

So, rp means time required to get acknowledgement i

(ii) Average propagation time, $\frac{\tau_p}{3}$

(iii) Time to get to next slot (avg.) $= P/2$ (think of it)



(iv) Transmission Time $= P$

Average Transmission Delay

average Wait time to get a slot

$$\overline{T} = P/2 + P + \tau_p/3 + N_r(P + rP + \overline{B})$$

and previously, $\overline{B} = (k-1)P/2$

$$N_r = e^{G} - 1$$

[Self-Study]

Evolution of standard ethernet

Bridges → (connects two LAN segments)
- increase bandwidth
- seperate collision domain

IMP.

Switch (N-port bridge) → all devices connected to single switch (star topology).

Full duplex switch → two connections; sending and receiving

Advantages — $\boxed{\text{double bandwidth}}$

— no need for $\boxed{\text{CSMA/CD}}$ → because of point to point connection with switch

→ MAC control layer — new sublayer between LLC and MAC layer to $\boxed{\text{provide flow and error control.}}$

✓ (*) TCP/IP and OSI doesn't define protocols of layer-1 and layer-2.