The Medium Access Control Sublayer

CS158a

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Outline

- Static Channel Allocation
- Dynamic Channel Allocation
- Multiple Access Protocols

Static Channel Allocation

- The traditional way to allocate a single channel is to do Frequency Division Multiplexing.
- So if we have N users, the bandwidth is divided by N. Since each user has a private frequency there is no interference. If there is a small, constant number of users each with a heavy load of traffic, this is reasonably efficient.
- It is not so efficient if the number of users is highly variably and if the traffic is bursty.
- If at some point only a small number of the N users want to talk then most of the channel is wasted.

An example

- Let T be the mean time delay before get a channel of capacity C bps.
- Assume L frames arrive per second, each frame having a length draw from an exponential probability function with mean 1/M bits/Frame.
- It can be shown using queuing theory that if the frames arrive according to a Poisson process that:

  $T = 1/(MC - L)$
- So if C = 100 Mbps, the mean frame length, 1/M= 10,000 bits, and the arrival rate L is 5000 frames/sec, then T= 200 microseconds.
- Suppose now that the channel is divided into N independent channels, each with capacity C/N. The mean input rate of a channel is now L/N. In this setting the mean delay is: $T_{FDM} = 1/(M(C/N)-(L/N)) = N/(MC-L) = NT$, or N times worse.
- So if the original channel of 100Mbps was split into 10 channels of 10Mbps each, the delay would be 2 msec.
- This same argument applies to TDM channels too.

Dynamic Channel Allocation

- We will now explore dynamic techniques to try to split the channel among multiple users while trying to achieve a smaller mean time delay.
- Dynamic Channel Allocation is often done in LANs and MANs.

Underlying Assumptions

In doing our allocations, we will assume:

1. A **station model**. We will assume we have N independent stations, each with a program or user that generates frames for transmission. The probability of a frame being generated in an interval Δt is $\lambda \Delta t$ where λ is a constant. Once a frame is generated a station becomes blocked and does nothing until the frame has been successfully transmitted.
2. **Single Channel Assumption.** We assume a single channel is available for all communication.
3. **Collision Assumption**. If two frames are transmitted simultaneously, the resulting signal is garbled and is called a **collision**. All stations detect collisions. A collided frame must be retransmitted. There are no error except collisions.
4. (a) **Continuous Time.** Frame transmission can begin at any time and there is no master clock.

   (b) **Slotted Time.** Time is divided into discrete intervals called slots. Frame transmissions always begin at the start of a slot. A slot contains 0, 1, or more frames; ≥ 2 corresponding to a collision.
5. (a) **Carrier Sense.** Stations can tell if the channel is in use before trying to use it.

   (b) **No Carrier Sense.** Stations cannot sense the channel before trying to use it.

Multiple Access Protocols

- The first multiple access protocol we will consider is called ALOHA.
- It was developed at the University of Hawaii in the 1970s.
- There are two variants: **Pure Aloha** which uses continuous time, and **Slotted Aloha** which uses slotted time.

Pure Aloha

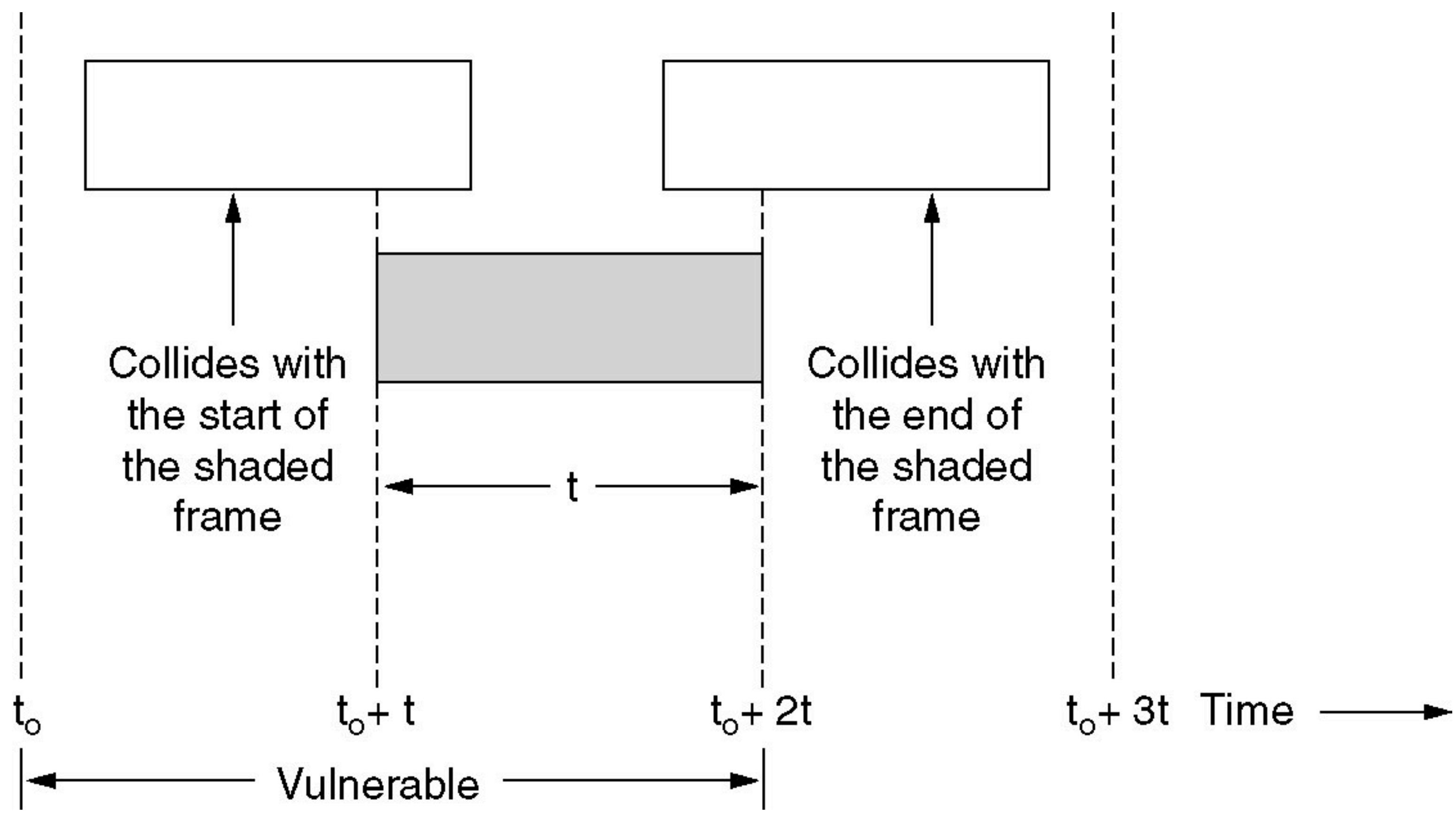
- The basic idea of an ALOHA system is to let users transmit whenever they have data to send.
- There might be collisions; however, we assume by the feedback property of the broadcast channels, a sender can always determine if its frame was destroyed by listening to the channels. In the case of satellites there might be some delay in finding out (270 msec).
- If a collision occurs, the sender waits a random amount of time and resends the frame.
- Since this system allows multiple users to share the same channel in a way that might cause conflicts, it is called a **contention** system.

Analyzing Pure Aloha

- We would like to know what fraction of transmitted frames escape collisions?
- Notice after a collision a retransmitted frame might be involved in a second collision.
- Let N be the mean number of frames that arrive in any time interval of length the frame time (time to transmit 1 frame). So $0<N<1$.
- Let k be the number of transmission attempts in any give frame time. Let G be the E[k]. So $G \geq N$.
- The throughput is then $S=GP_0$ where P_0 is the probability that a frame does not suffer a collision

More analysis of Aloha.

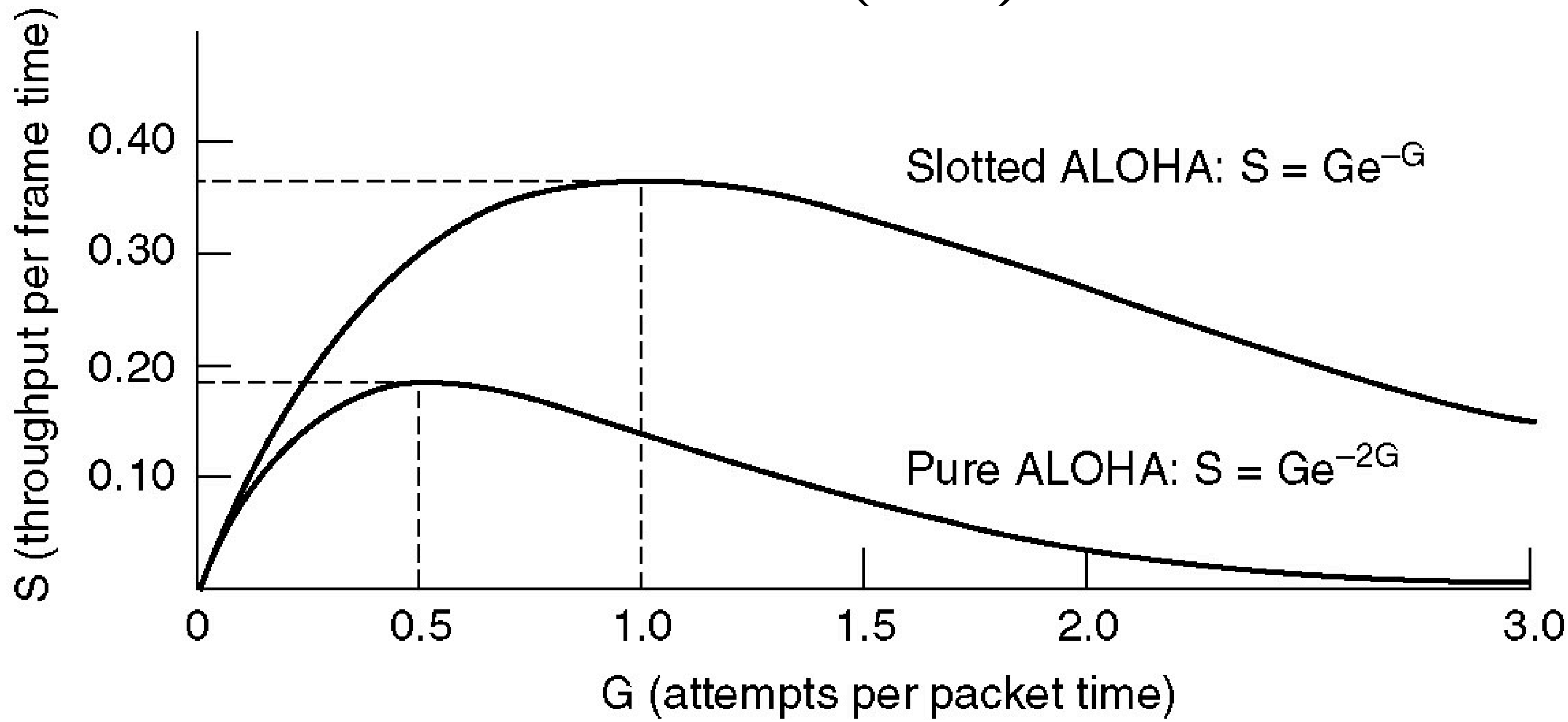
- How long is a frame vulnerable?



Aloha (III)

- The probability that k frames are generated during a frame time is $Pr[k] = G^k e^{-G}/k!$
- In any interval two frames long the mean number of frames generated is 2G.
- The probability that no other traffic (k=0) is generated over the entire vulnerable period is thus $P_0=e^{-2G}$.
- So as $S= GP_0$. $S= Ge^{-2G}$
- The maximum throughput occurs when G=1/2 and S=1/(2e).

Aloha (IV)



S (throughput per frame time)
0.40
0.30
0.20
0.10
Slotted ALOHA: S = Ge^{–G}
Pure ALOHA: S = Ge^{–2G}
0
0.5
1.0
1.5
2.0
3.0
G (attempts per packet time)