Fundamentals of Computer Networks
ECE 478/578

Lecture #8: Multiple Access Protocols
Instructor: Loukas Lazos
Dept of Electrical and Computer Engineering
University of Arizona

The Channel Allocation Problem

How to share access to a common medium

Attributes of the channel allocation problem
- Dynamic or Static Allocation
- A single channel is available
- Time is continuous vs. slotted
- Carrier sensing (CS)
- Collision detection (CD)

2

Multiple Access Protocols

Aloha (Pure vs. Slotted)

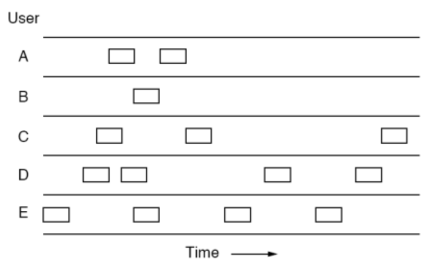
Carrier Sense Multiple Access (CSMA)

Collision Resolution Algorithms

3

Pure Aloha

Continuous time, no CD, no CS



Assumptions of Pure Aloha

New arrivals of packets at each host are transmitted immediately
Arrivals are Poisson with total rate λ

If a packet is involved in a collision it is retransmitted after a random period of time. Node becomes backlogged

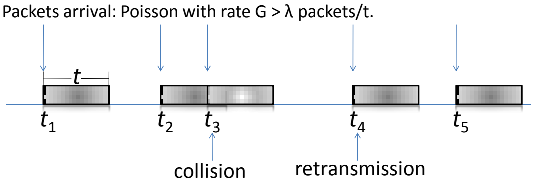
Receivers provides feedback on received packet to implement the collision detection (we know a collision happened)

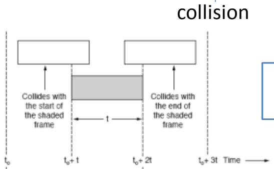
No buffering: A backlogged node does not buffer any arriving packets

Or the set of nodes accessing the medium is infinite

Collisions Occurence

Packets arrival: Poisson with rate G > λ packets/t.





Vulnerable period: 2t

Aloha Throughput

Probability that k frames are generated within the unit of time t

$$P[N(t)=k]=\frac{e^{-Gt}(Gt)^k}{k!}, \quad P[N(1)=k]=\frac{G^k e^{-G}}{k!}$$

Probability that no traffic is generated within 2t

$$P[N(2)=0]=e^{-2G}$$

Aloha throughput: Arrival rate times success probability

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

7

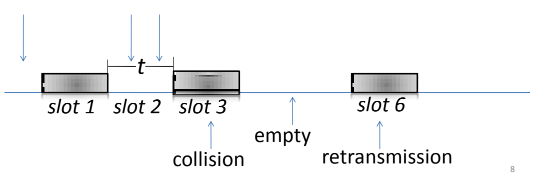
Slotted Aloha

Time is divided into slots

Transmissions start only at the beginning of a slot

A collision would occur in slot n, if more than one arrival occurs in slot n – 1

No arrival: Unused slot



8

Throughput of Slotted Aloha

Simplistic Analysis: arrival rate at each slot is G

Probability of successful transmission

$$P[N(t)=1]=Ge^{-G}$$

Probability of an idle slot

$$P[N(t)=0]=e^{-G}$$

Probability of a collision

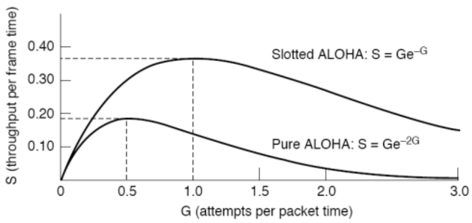
$$P[N(t)>1]=1-Ge^{-G}-e^{-G}$$

Probability of a wasted slot

$$1 - P[N(t)=1]=1-Ge^{-G}$$

9

Pure vs. Slotted Aloha



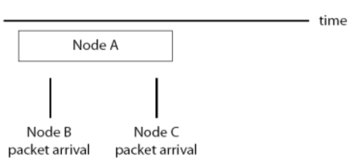
10

Carrier Sense Multiple Access (CSMA)

Stations listen before transmission

1-persistent

- Stations listen to the channel continuously
- If channel is busy wait till free
- If channel is free, transmit (i.e. with probability 1)
- If a collision occurs, wait a random amount of time



11

Alternative CSMA Strategies

Non-persistent CSMA

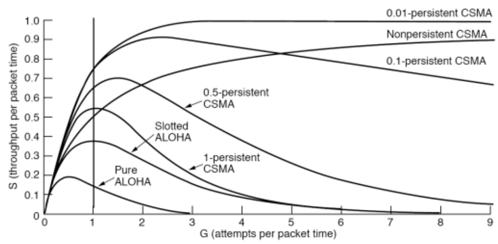
- If channel is busy, defer from sensing for a random time
- Better medium utilization than persistent CSMA

p-persistent CSMA

- If channel is sensed busy, transmit when idle with probability p, else wait for a period τ.
- Low throughput on low loads due to idle time
- Improves throughput on high loads

12

Comparison of Protocols



13

CSMA with Collision Detection (CSMA/CD)

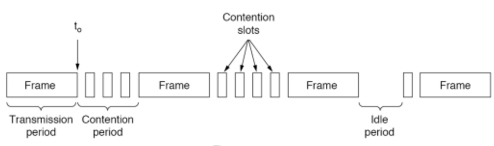
Detect a collision early and abort transmission

Two types of slots, packet slots and contention slots

Each node tries to transmit at a contention slot with probability p

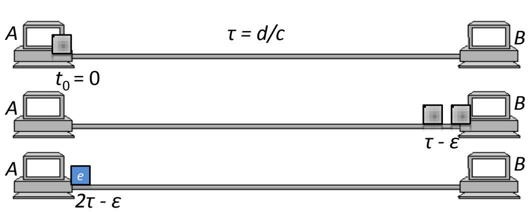
If collision, it is detected at the end of contention slot

If success, no transmission tries till end of packet slot



14

Duration of Contention Slots



A will detect collision after 2τ in the worst case.

Contention slots have to be at least 2τ long

Minimum frame size $2\tau C$ (why?)

Ex. 1Km cable, $\tau = 5\mu s$, If C = 100MBps, Frame size 100bits

C = 1 Gbps Frame size = 10,000 bits

15