Aloha

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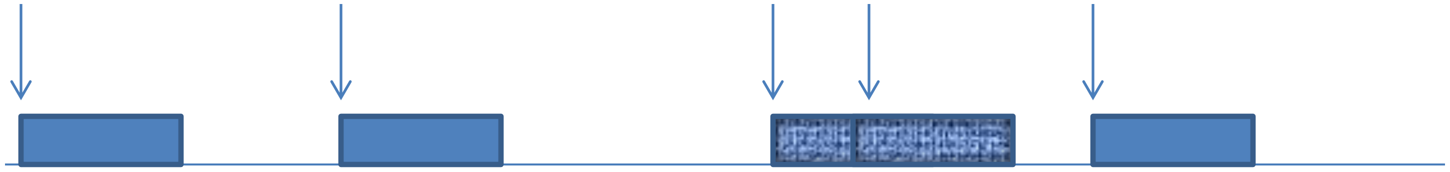
Background

- 1970’s : Wireless computer network developed at University of Hawaii to interconnect Hawaiian islands
  - First operational packet radio network
- Inspiration to many standards: Ethernet, WiFi, Cellular (random access channels)
- Simple and relatively easy to analyze

Pure Aloha

- Senders transmit whenever they have a packet to send
- Sender can determine status of packet (intact or collision) at end of transmission
- If collision, sender waits a random amount of time and tries again



Efficiency

- What is the efficiency of ALOHA?
  - What is the probability that a transmitted frame does not suffer collision?

Assumptions

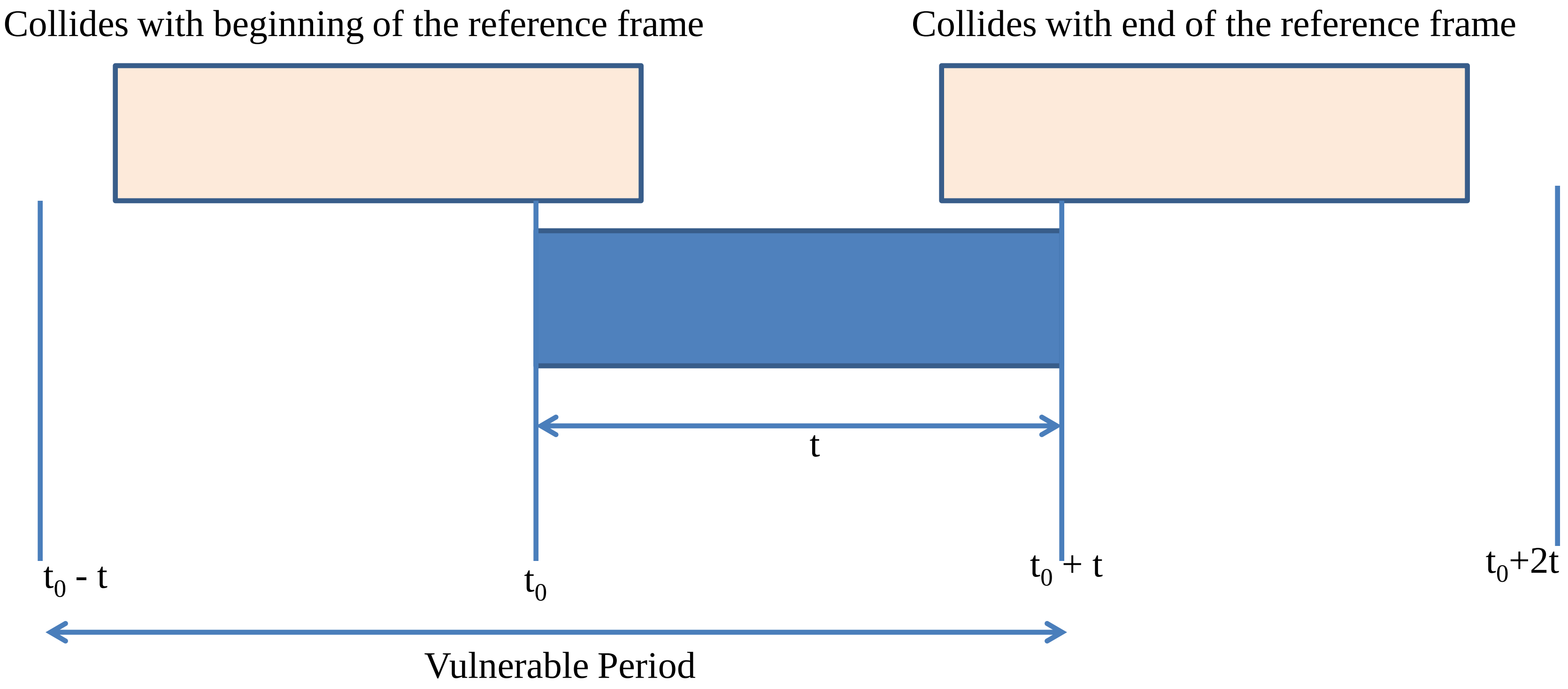
- Frames are of equal length
- Probability of k transmission attempts per frame time (old retransmissions and new) is Poisson with mean G per frame time.
  - $\Pr[k] = G^k e^{-G} / k!$

  (Infinite user population generating new frames with a poisson distribution with mean rate less than 1 per frame)

Throughput

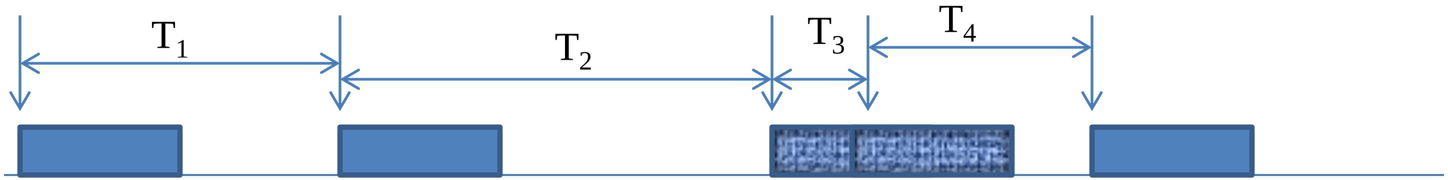
- Throughput $S = G * P_s$
  - P_s: probability that a frame is successful i.e. did not suffer collision
- Determine P_s
  - Under what conditions will a frame not suffer collision?

Vulnerable Period



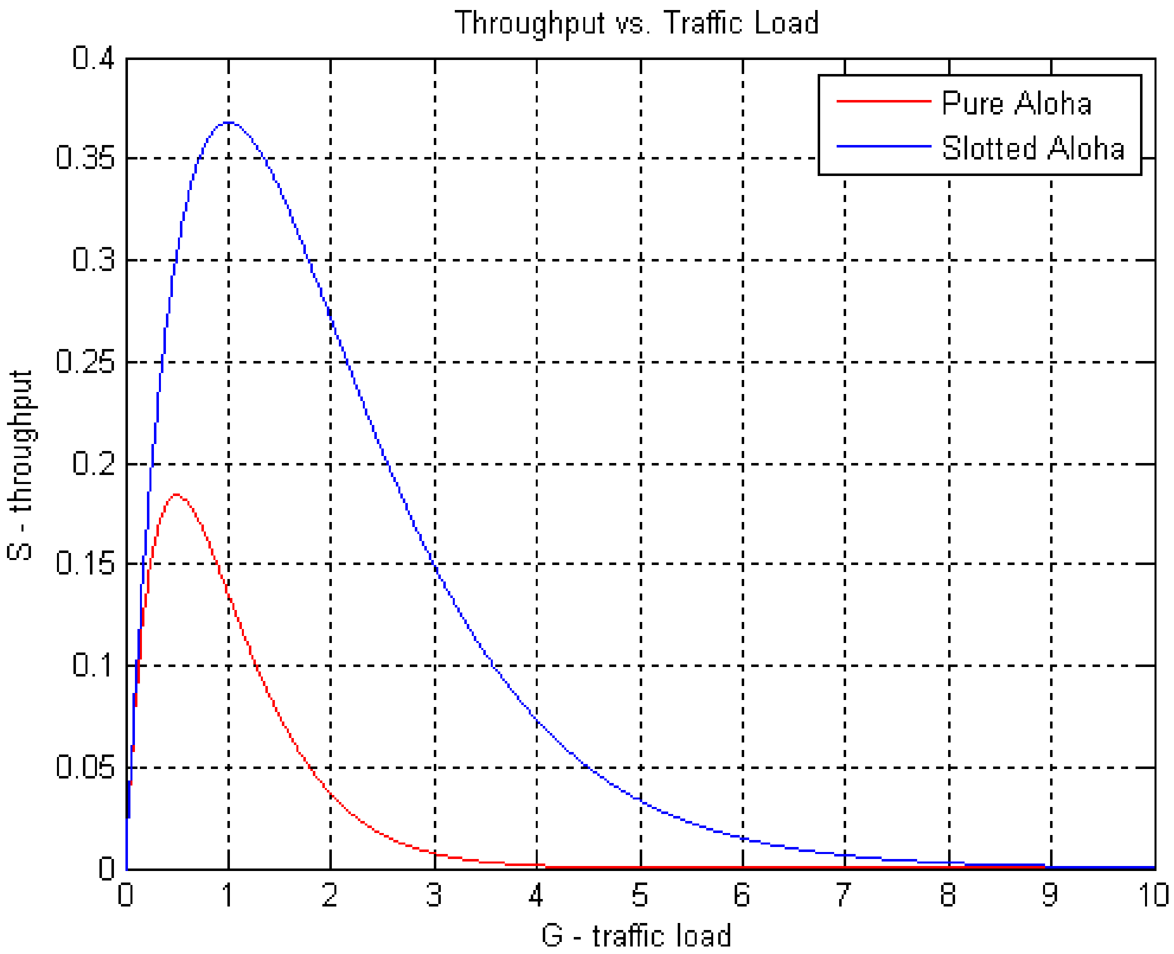
Analysis

- Consider the sequence of successive transmission attempts on the channel.
- For some given i, let T_i be the time interval between the i^{th} and the $i+1^{th}$ transmission attempt
- i^{th} attempt will be successful if both T_i and T_{i-1} exceed frame time
  - Intervals are independent



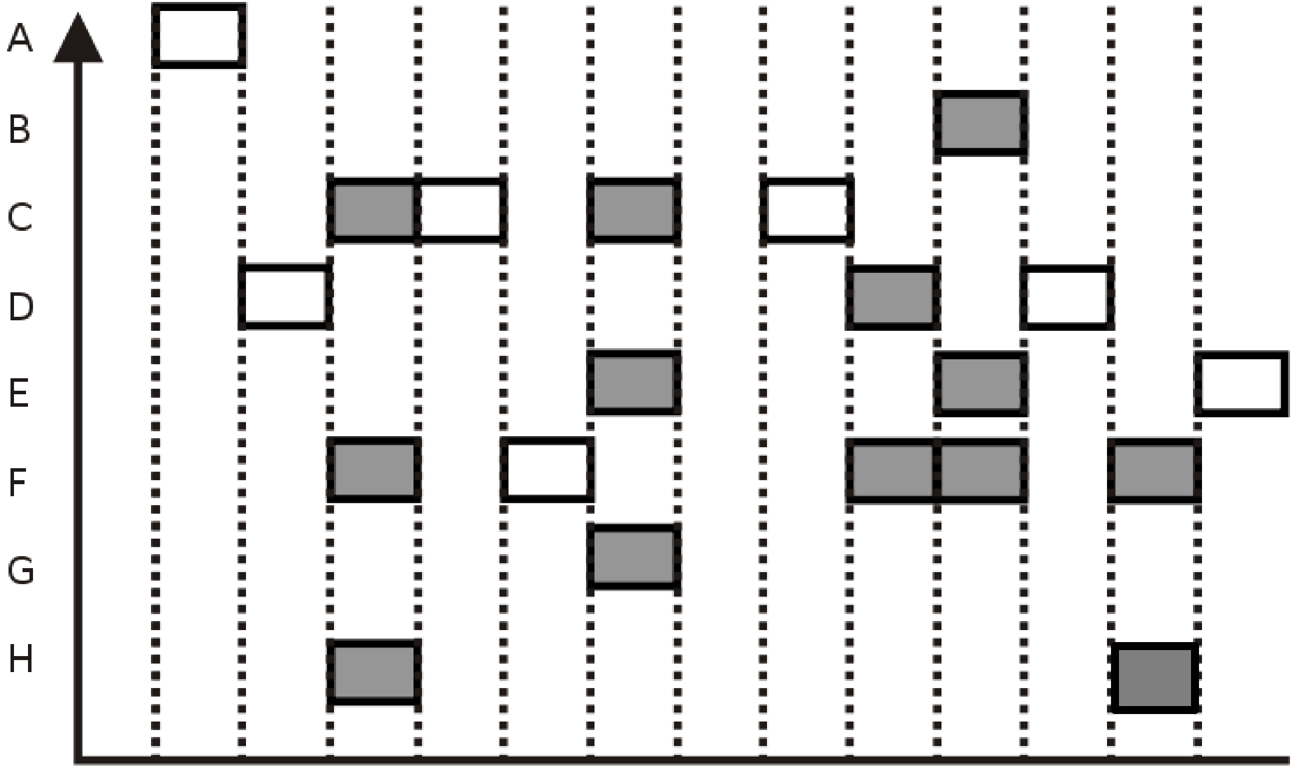
Analysis

- From Poisson distribution, the inter arrival time between attempts is exponential
  - Pr (T > frame time) = e^{-G}
  - Prob of success = $P_s = e^{-G} * e^{-G} = e^{-2G}$
  - $S = GP_s = G\, e^{-2G}$
- Maximum Throughput: G = 0.5, S = 0.184 (18%)


Throughput vs. Traffic Load
Pure Aloha
Slotted Aloha
S - throughput
G - traffic load
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0
1
2
3
4
5
6
7
8
9
10

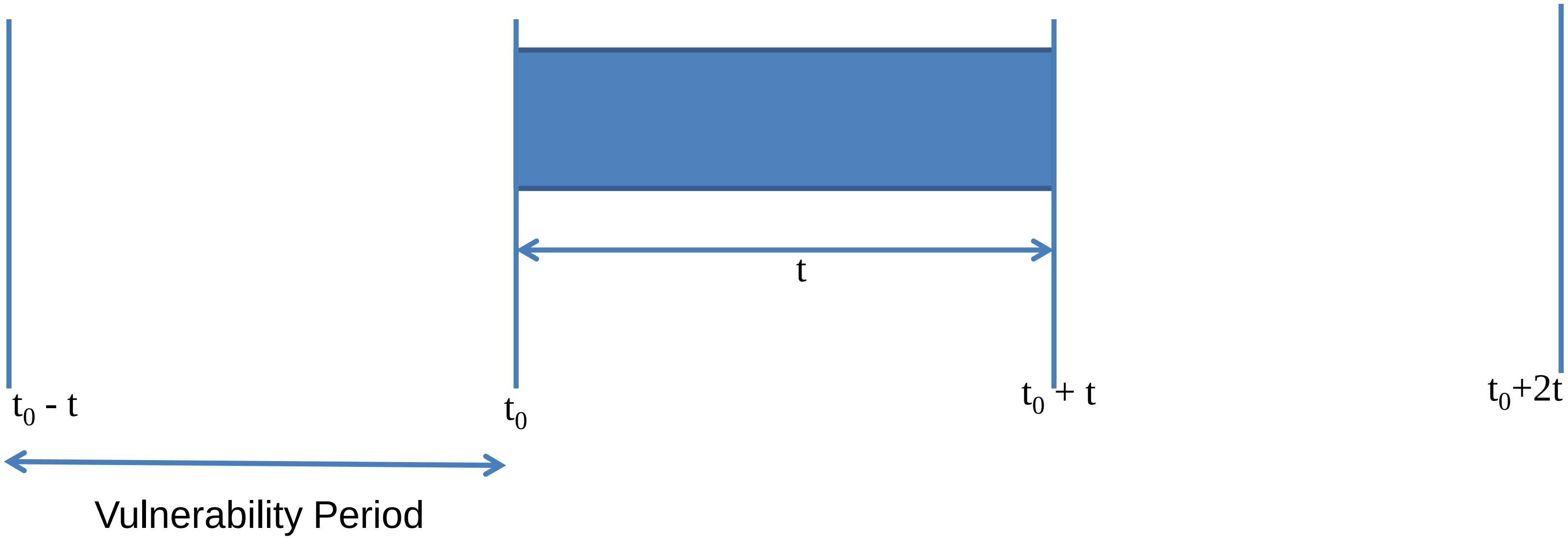
Slotted Aloha

- Time divided into discrete intervals (slots)
  - Slot interval corresponds to frame time
- Nodes can transmit frames only at beginning of slots
  - Nodes are time synchronized
- Vulnerable period reduced by half



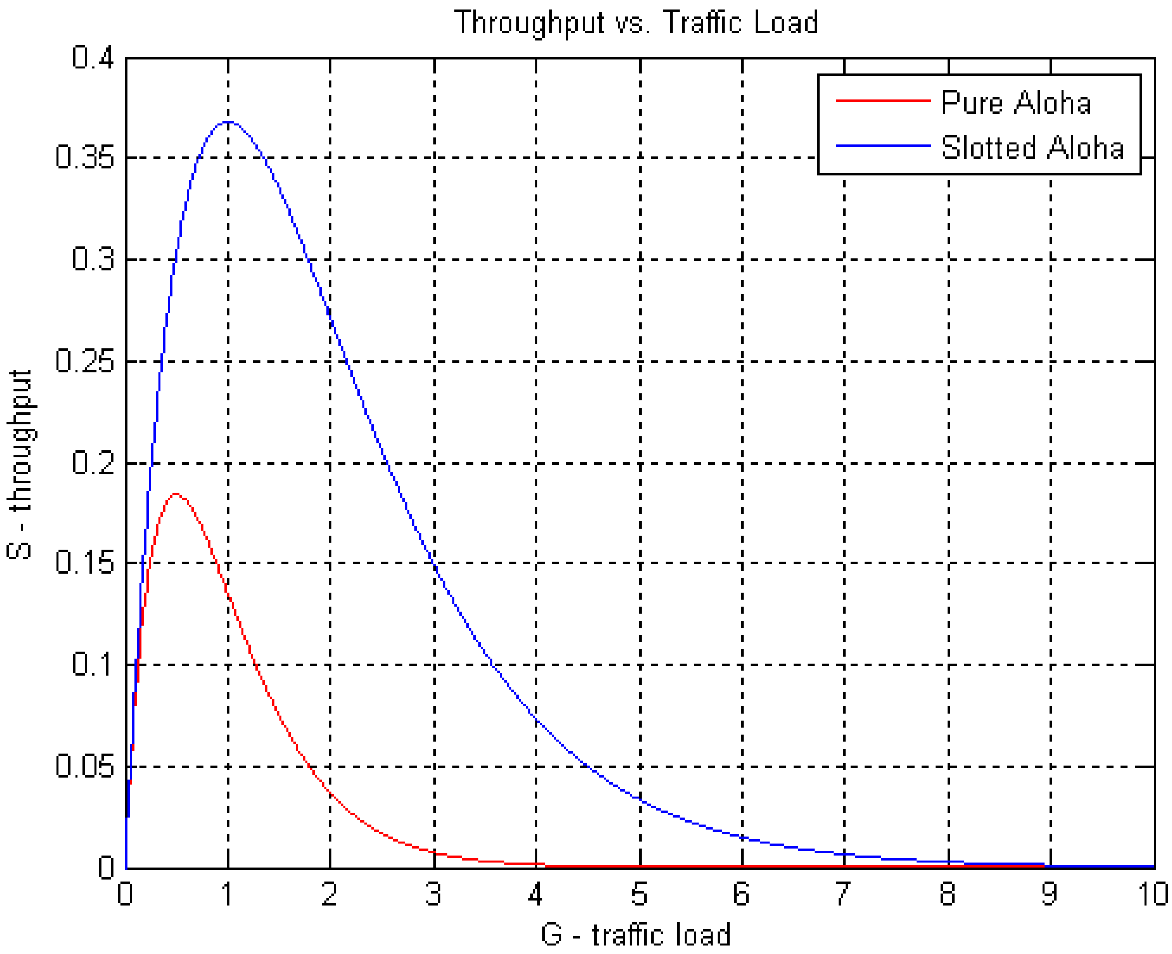
Slotted ALOHA protocol (shaded slots indicate collision)

Vulnerable Period



Analysis

- $S = G\,e^{-G}$
- Maximum Throughput: $G=1$, $S = 1/e = 0.368$ (36.8%)
  - At $G=1$, empty slots is 37%, successes is 37% and collisions is 26%
  - Higher values of G decrease empty slots, but increase collisions exponentially


Throughput vs. Traffic Load
Pure Aloha
Slotted Aloha
S - throughput
G - traffic load
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
1
2
3
4
5
6
7
8
9
10

Another Method

- N nodes with many frames to send
- A node transmits with probability p in a slot
- Prob that a given node succeeds = $p\,(1-p)^{N-1}$
- Prob that a slot is a success = $E(N,p)$ = prob any node succeeds = $Np(1-p)^{N-1}$

Another Method

- For maximum efficiency, find p such that maximizes $Np(1-p)^{N-1}$
- p* turns out to be 1/N
- Efficiency = 1/e, In the limit N→ infinity

Theory vs Practice

- Assumptions very important
- Reality can be very different from theory
- Example:
  - Poisson arrivals not true
  - Fixed packet size not true
  - Infinite population not true
  - Other parameters, buffering, slotting

Summary

- Looked at two simple random access protocols – Pure Aloha and Slotted Aloha
- Looked at how such protocols can be theoretically evaluated
- Maximum efficiency of both is rather poor
- Ahead: Study some popular link layer technologies along with their MACs