CS3200: Computer Networks

Lecture 13

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Slotted ALOHA

Soon after ALOHA came onto the scene, Roberts (1972) published a method for doubling the capacity of an ALOHA system. His proposal was to divide time into discrete intervals called slots, whose length was equal to the frams time T.

A station is not permitted to send whenever it wants to. Instead, it is required to wait for the beginning of the next slot

The throughput is

$$S = Ge^{-GT} \leq 0.367/T \quad \text{double of pure ALOHA!!!}$$

Slot boundaries need to be synchronized; done by making one special station emit a pip at the start of each interval, like a clock.

Slotted ALOHA

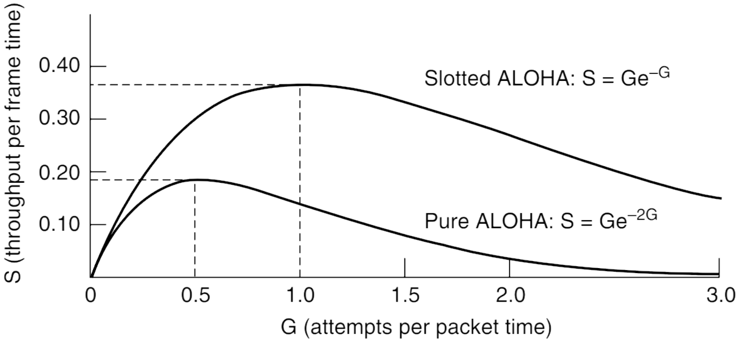


Figure: Throughput as a function of G

Slotted ALOHA

What is the expect number transmission attempt per frame?

Probability of collision in a slot is $1 - e^{-G}$. Thus, probability of a transmission requiring exactly k attempts

$$P_k = e^{-G}(1 - e^{-G})^{k-1}$$

and the expected number of transmissions is e^{G}.

1-persistent CSMA

- When a station has data to send, it first listens to the channel to see if anyone else is transmitting at that moment.
- If the channel is idle, the stations sends its data. Otherwise, if the channel is busy, the station just waits until it becomes idle. Then, the station transmits a frame.
- If a collision occurs, the station waits a random amount of time and starts all over again. The protocol is called **1-persistent** because the station transmits with a probability of 1 when it finds the channel idle.

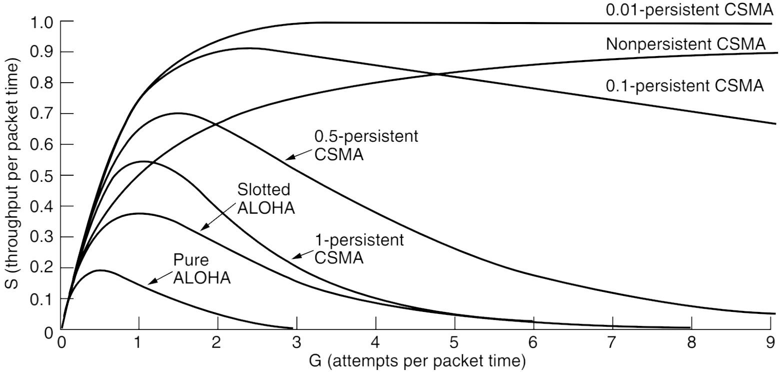
Nonpersistent CSMA

- Station senses the channel when it wants to send a frame, and if no one else is sending, the station begins doing so itself.
- If the channel is already in use, the station does not continually sense it for the purpose of seizing it immediately upon detecting the end of the previous transmission.
- It waits a random period of time and then repeats the algorithm.
- Better channel utilization but longer delays than 1-persistent CSMA.

p-persistent CSMA

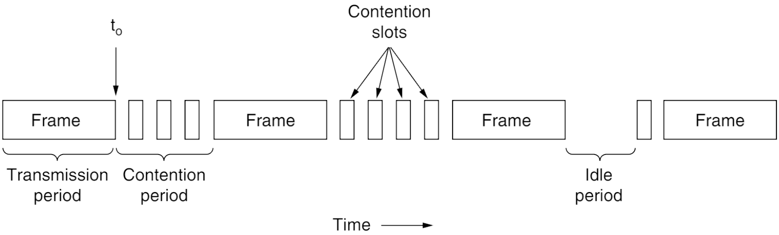
- Used in slotted systems. When a station becomes ready to send, it senses the channel.
- If channel is idle, it transmits with a probability p. With a probability $q = 1 - p$, it defers until the next slot.
- This process is repeated until either the frame has been transmitted or another station has begun transmitting.
- Better channel utilization but longer delays than 1-persistent CSMA.

Performance Comparison



CSMA with Collision Detection

Collision detection is an analog process. The station's hardware must listen to the channel while it is transmitting. If the signal it reads back is different from the signal it is putting out, it knows that a collision is occurring.

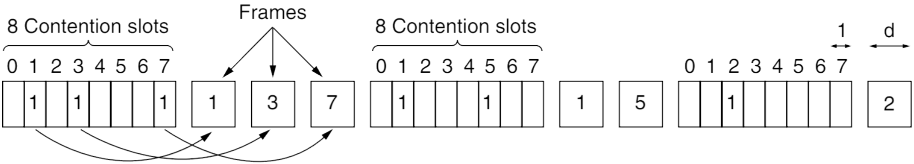


How long can the contention period be?

Collision-Free Protocols

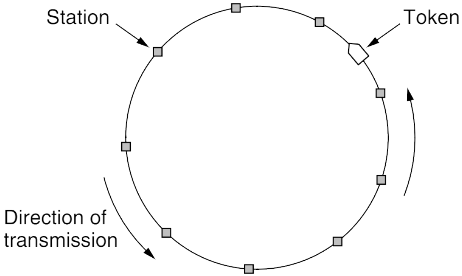
- Collisions do not occur with CSMA/CD once a station has unambiguously captured the channel.
- However, can still occur during the contention period.
- Collisions adversely affect the system performance, especially when the bandwidth-delay product is large, such as when the cable is long and the frames are short.
- How do we resolve the contention for the channel without any collisions at all, not even during the contention period?
- In the protocols to be described, we assume that there are exactly N stations, each programmed with a unique address from 0 to $N-1$, and that the propagation delay is negligible.

A Bit-Map Protocol



At low load overhead is $d/(d+N)$. Whereas at high load, overhead is $d/(d+1)$.

Token Passing



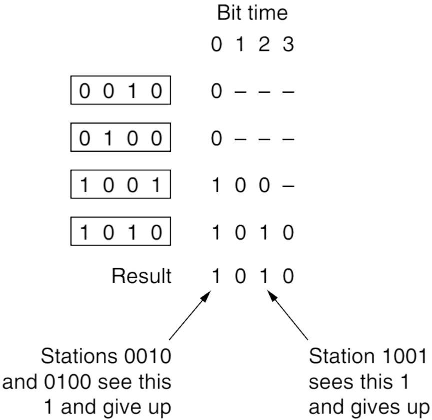
Note that we do not need a physical ring to implement token passing. The channel connecting the stations might instead be a single long bus.

Binary Countdown

The previous two protocols do not scale well with the network size. Why?

- A station wanting to use the channel now broadcasts its address as a binary bit string, starting with the highorder bit.
- The bits in each address position from different stations are BOOLEAN ORed together by the channel when they are sent at the same time.
- As soon as a station sees that a high-order bit position that is 0 in its address has been overwritten with a 1, it gives up.

Binary Countdown



The channel efficiency of this method is $d/(d + \log_2 N)$.