W5

L2

Computer Networks

Data Link Control Protocols
(Medium Access Control Protocols)
(Random Access Protocols: ALOHA)

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MAC protocols: taxonomy

Three broad classes:

- Channel partitioning
  - Divide channel into smaller “pieces” (time slots, frequency, code)
  - Allocate piece to node for exclusive use
- Taking turns”
  - Nodes take turns, but nodes with more to send can take longer turns
- Random access
  - Use randomization for handling collisions
  - “Recover” from collisions

Random access protocols

- When node has packet to send
  - Transmit at full channel data rate R
  - No a priori coordination among nodes
- Two or more transmitting nodes: “collision”

- Random access protocol specifies:
  - How to detect collisions
  - How to recover from collisions (e.g., via delayed retransmissions)
- Examples of random access MAC protocols:
  - ALOHA, slotted ALOHA
  - CSMA, CSMA/CD, CSMA/CA

Slotted ALOHA

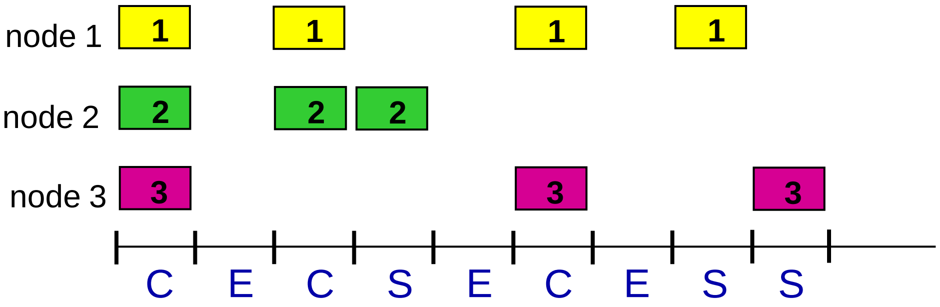
Assumptions:

- All frames same size
- Time divided into equal size slots (time to transmit 1 frame)
- Nodes start to transmit only slot beginning
- Nodes are synchronized
- If 2 or more nodes transmit in slot, all nodes detect collision

Operation:

- When node obtains fresh frame, transmits in next slot
  - If no collision: node can send new frame in next slot
  - If collision: node retransmits frame in each subsequent slot with probability **p** until success

Slotted ALOHA



C: Collision
S: Success
E: Empty

Pros:

- Single active node can continuously transmit at full rate of channel
- Highly decentralized: only slots in nodes need to be in sync
- Simple

Cons:

- Collisions, wasting slots
- Idle slots
- Clock synchronization

Slotted ALOHA: efficiency

Efficiency: Long-run fraction of successful slots (many nodes, all with many frames to send)

- Suppose: N nodes with many frames to send, each transmits in slot with probability p
  - Prob that given node has success in a slot $= p(1-p)^{N-1}$
  - Prob that any node has a success $= Np(1-p)^{N-1}$

Slotted ALOHA: efficiency

- Max efficiency: find p* that maximizes $Np(1-p)^{N-1}$

  - Max efficiency = 1/e = .37
- At best: channel used for useful transmissions 37% of time!

Pure ALOHA efficiency

P(success by given node) = P(node transmits) *

$\times$P(no other node transmits in $[t_0-1,t_0]$

$\times$P(no other node transmits in $[t_0,t_0+1]$

$= p \cdot (1-p)^{N-1} \cdot (1-p)^{N-1}$

$= p \cdot (1-p)^{2(N-1)}$

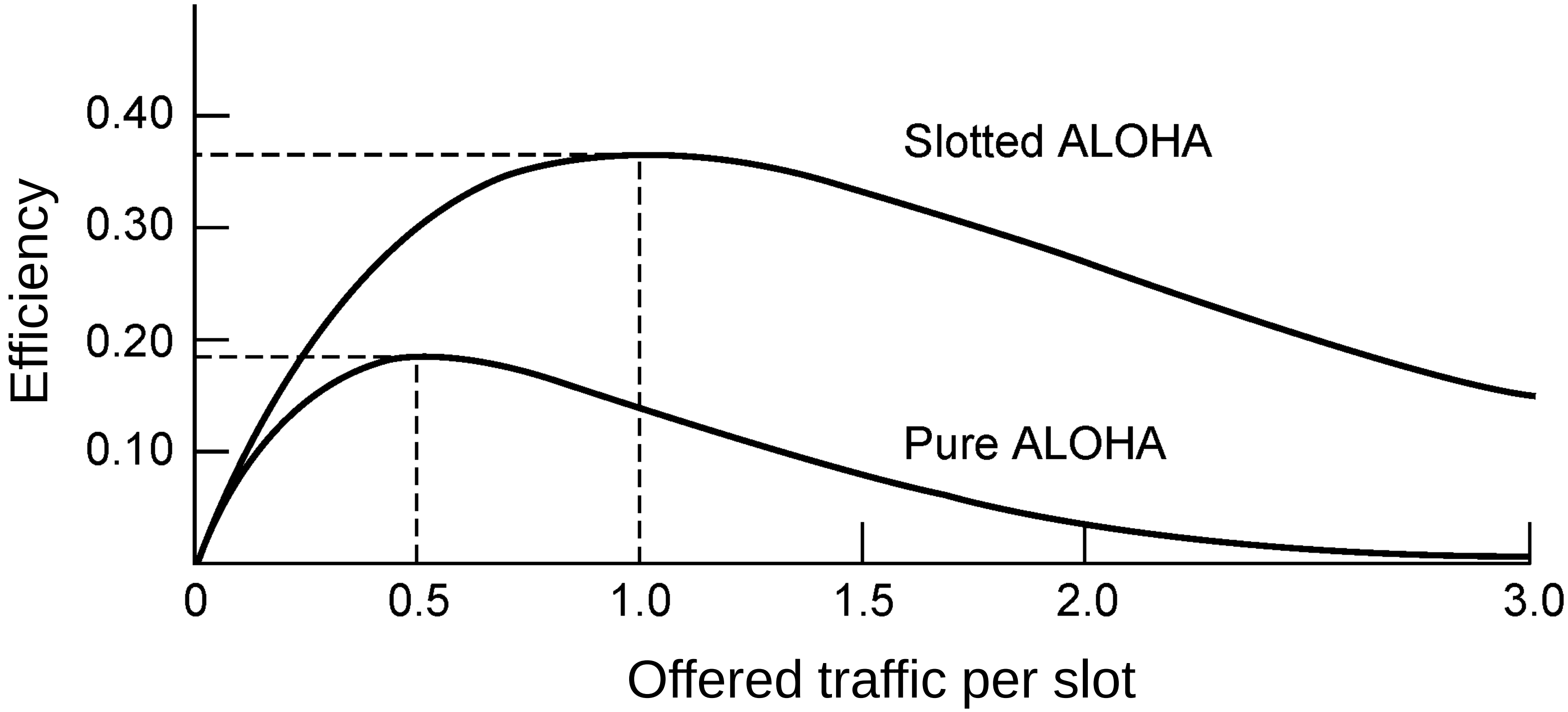
Prob that any node has a success = $Np(1-p)^{2(N-1)}$

Pure ALOHA efficiency

- Max efficiency: find p* that maximizes $Np(1-p)^{2(N-1)}$

  - Max efficiency = 1/2e = .18
- Performs even worse than slotted Aloha!

Pure ALOHA vs Slotted ALOHA



Summary

❑Multiple Access Control:

- Random access MAC protocols
  - Slotted ALOHA, Pure ALOHA