Media Access Protocols

Lecture 18
6.02 Spring 2009
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- Shared channel (media) networks
- Time-Division Multiple Access (TDMA)
- Contention protocols (Aloha, CSMA)
- Analysis of utilization (throughput)

Shared Media Networks

The Problem: Share Medium Efficiently

- Want high *channel utilization*
  - Throughput = Useful bit rate (in bits/s or pkts/s)
  - **U = Throughput / Channel Rate**
  - Suppose node k gets n_k bits through in time T, over medium of maximum rate R bits/s
  - Then utilization = (Σn_k /T) / R
- Easy to achieve: just allow one node to send all the time
- So… want *fairness* also
  - Example: All nodes with data to send should get equal share over time (overly simplified, but useful)

Many Media Access (MAC) Protocols

- Aka "multiple access" protocols
- Frequency Division Multiple Access (FDMA)
- Time Division Multiple Access (TDMA)
  - Used in some cellular networks, Bluetooth
  - Poor performance with burst traffic
- Contention-based protocols
  - **Aloha**
  - **Carrier Sense Multiple Access** (CSMA) used in Ethernet, WiFi
- Channel reservation schemes
- Topic of active research in wireless networks

Time Division (TDMA)

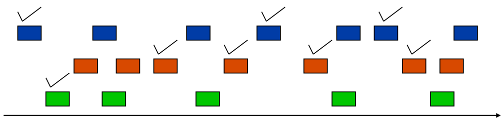
- Conceptually similar to TDM in circuit switching
- Simple version: Time is slotted, each packet ("frame") is one slot in length, nodes are numbered 0, 1, …, N-1
- Nodes take turns in round-robin order
- If current time-slot is t, then node #(t mod N) gets to send, where N is the maximum number of nodes

Our Aloha Protocol

- Sender: Send packet with probability p
- Receiver: if received successfully, send ACK
- Sender: If no ACK within small timeout, sender believes packet was lost ("collision")
- Now sender has two choices:
  - Drop this packet and move to next packet
  - Or, **retry** packet

Analysis of Collisions

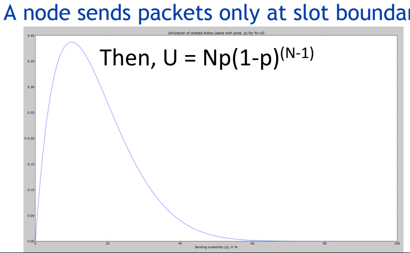
- A *collision* occurs when multiple transmissions overlap in time



- Throughput = *Uncollided* packets per second
- Utilization = Throughput / Channel Rate

Utilization

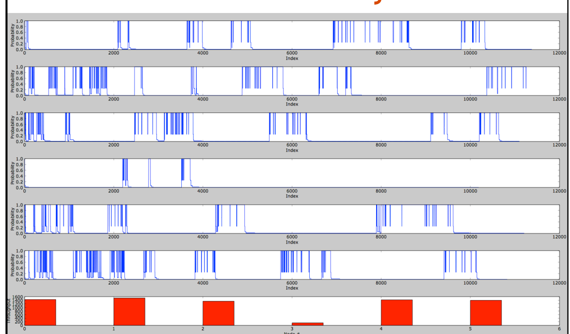
- Consider a simple, **slotted model** with N **backlogged** nodes
- Time slots of duration τ, each packet fits exactly in slot
- A node sends packets only at slot boundaries



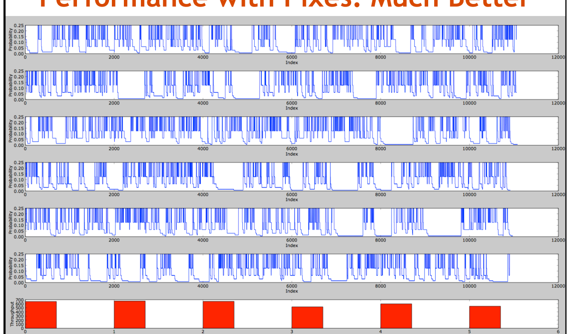
Stabilization: Selecting the right p

- Use feedback as hint
- If pkt lost, decrease p
  - Multiplicative decrease: p ← p/2
  - Called **Binary Exponential Backoff** (why?)
- If pkt received, increase p
  - p ← p_max (say, 1 for now)
- Such increase/decrease thinking used widely distributed network protocols

Performance: Severely Unfair!



Performance with Fixes: Much Better



Extensions

- Unslotted Aloha: What happens when packets are of different sizes?
  - Utilization lower than slotted Aloha
- Carrier Sense Multiple Access (CSMA)
  - On broadcast media such as wired Ethernet or wireless LANs, can listen for activity
  - If channel busy, then wait
  - If idle, more likely for xmit to succeed
  - Improves throughput over slotted Aloha
  - Doesn't require slotting