Media Access (MAC) Protocols

Lecture 10
6.02 Fall 2010
October 13, 2010

- Shared-medium networks
- Time-Division Multiple Access (TDMA)
- Contention protocols (Aloha)
- Analysis of utilization

The Problem: Share Medium Efficiently

- Want high channel utilization
  - Throughput = Useful bit rate (in bits/s or pkts/s)
  - \( U = \frac{\text{Throughput}}{\text{Channel Rate}} \)
  - Suppose node \( k \) gets \( n_k \) bits through in time \( T \), over medium of maximum rate \( R \) bits/s
  - Then utilization = \( \frac{\sum n_k}{T} / R \)
- 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 (simple view of fairness)

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)

- 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
- Extend to handle packets that are larger than one slot (in lab)

Our Aloha Protocol

- Model: time increases in multiples of a “slot time”
- All packets are an integral number of slots long; sender sends at start of a time slot
- Sender: Send packet with probability \( p \)
- Receiver: if received successfully, send ACK feedback
- 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
Aloha in Pictures: Collisions

- A collision occurs when multiple transmissions overlap in time (even partially)
- Throughput = Uncollided packets per second
- Utilization = Throughput / Channel Rate

Slotted Aloha

- Each Packet is Exactly One Time Slot Long
- Throughput = Uncollided packets per second
- Utilization = Throughput / Channel Rate

Utilization of Slotted Aloha

- Each packet = 1 slot
- Note: Node sends packets only at slot boundaries
- N backlogged nodes (nodes with data)

Then, $U = Np(1-p)^{(N-1)}$

Stabilization: Selecting the right $p$

- Use absence of ACK from receiver as hint that collision has occurred
- If pkt lost, decrease $p$
  - Multiplicative decrease: $p \leftarrow p/2$
  - Binary Exponential Backoff
- If pkt received, increase $p$
  - $p \leftarrow 2^{p}$
- Such increase/decrease thinking used widely distributed network protocols
- How well does it work?

Performance: Severely Unfair!

- Y-axis is per-node transmission probability
- Bottom panel: per-node throughput

Performance with Fixes: Much Better

- Y-axis is per-node transmission probability
- Bottom panel: per-node throughput