Media Access Protocols
Lecture 16
6.02 Spring 2010
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- 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)
- 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
- Extend to handle packets that are larger than one slot (in lab)

Our Aloha Protocol
- Model: time is slotted; all packets are integral number of slots
  - For now, assume each packet is 1 slot long
- 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.
- A node sends packets only at slot boundaries.

\[ U = Np(1-p)^{(N-1)} \]

### Stabilization: Selecting the right p

- Use feedback as hint.
- 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

### Remaining Issues

- What happens when packet > 1 slot?
  - Do we need to xmit on slot boundaries?
- 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