Media Access Protocols
Lecture 17
6.02 Fall 2009
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- Shared channel (media) 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
- 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

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

Stabilization: Selecting the right p

- Use feedback as hint
- If pkt lost, decrease $p$
  - Multiplicative decrease: $p \leftarrow p/2$
  - Called Binary Exponential Backoff (why?)
- If pkt received, increase $p$
  - $p \leftarrow p_{\text{max}}$

Such increase/decrease thinking used widely distributed network protocols

Performance: Severely Unfair!

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