Methods to share physical media: multiple access
  - Fixed partitioning
  - Random access

Channelizing mechanisms

Contention-based mechanisms
  - Aloha
Fixed Partitioning

- Need to share media with multiple nodes \((n)\)
  - Multiple *simultaneous* conversations

- A simple solution
  - Divide the channel into multiple, separate *channels*

- Channels are physically separate
  - Bitrate of the link is split across channels
  - Nodes can only send/receive on their assigned channel

- Several different ways to do it
  - _____ *Multiple Access* madlibs…

CSE 123 – Lecture 24: Media Access Control
Frequency Division (FDMA)

- Divide bandwidth of $f$ Hz into $n$ channels each with bandwidth $f/n$ Hz
  - Easy to implement, but unused subchannels go idle
  - Used by traditional analog cell phone service, radio, TV
Time Division (TDMA)

- Divide channel into rounds of $n$ time slots each
  - Assign different hosts to different time slots within a round
  - Unused time slots are idle
  - Used in GSM cell phones & digital cordless phones

- Example with 1-second rounds
  - $n=4$ timeslots (250ms each) per round

If a sender has a signal to send, how long can they expect to wait until they can transmit?

A. No waiting
B. 250 ms
C. 500 ms
D. 1 s
Code Division (CDMA)

- Do nothing to physically separate the channels
  - All stations transmit at same time in same frequency bands
  - One of so-called spread-spectrum techniques

- Sender modulates their signal on top of unique code
  - Sort of like the way Manchester modulates on top of clock
  - The bit rate of resulting signal much lower than entire channel

- Receiver applies code filter to extract desired sender
  - All other senders seem like noise with respect to signal

- Used in newer digital cellular technologies
Partitioning Visualization

Broadband modulation is a form of which media access scheme?
A. Frequency
B. Time
C. Code
D. None of the above

CSE 123 – Lecture 24: Media Access Control
Problem w/Channel partitioning

- Not terribly well suited for random access usage
  - Why?

- Instead, design schemes for more common situations
  - Not all nodes want to send all the time
  - Don’t have a fixed number of nodes

- Potentially higher throughput for transmissions
  - Active nodes get full channel bandwidth
Aloha

- Designed in 1970 to support wireless data connectivity
  - Between Hawaiian Islands—rough!

- Goal: distributed access control (no central arbitrator)
  - Over a shared broadcast channel

- Aloha protocol in a nutshell:
  - When you have data send it
  - If data doesn’t get through (receiver sends acknowledgement) then retransmit after a random delay
  - Why not a fixed delay?
Collisions

- Frame sent at $t_0$ collides with frames sent in $[t_0-1, t_0+1]$
  - Assuming unit-length frames
  - Ignores propagation delay
Slotted Aloha

- Time is divided into equal size slots (frame size)
- Host wanting to transmit starts at start of next slot
  - Retransmit like w/Aloha, but quantize to nearest next slot
- Requires **time synchronization** between hosts

Success (S), Collision (C), Empty (E) slots
Q: What is max fraction slots successful?
A: Suppose $n$ stations have packets to send
- Each transmits in slot with probability $p$
- Prob[successful transmission], $S$, is:

$$S = p (1-p)^{(n-1)}$$

- any of $n$ nodes:

$$S = \text{Prob}[\text{one transmits}] = np(1-p)^{(n-1)}$$

(optimal $p$ as $n \to \infty = 1/n$)

$$= 1/e = .37$$

At best: channel used for useful transmissions 37% of time!
Carrier Sense (CSMA)

- Aloha transmits even if another host is transmitting
  - Thus guaranteeing a collision

- Instead, listen first to make sure channel is idle
  - Useful only if channel is frequently idle
  - Why?

- How long to be confident channel is idle?
  - Depends on maximum propagation delay
  - Small ($<<1$ frame length) for LANs
  - Large ($>>1$ frame length) for satellites
Re-transmission Options

- **non-persistent CSMA**
  - Give up, or send after some random delay
  - Problem: may incur larger delay when channel is idle

- **1-persistent CSMA**
  - Send as soon as channel is idle
  - Problem: blocked senders all try to send at once

- **$P$-persistent CSMA**
  - If idle, send packet with probability $p$; repeat
  - Make sure $(p * n) < 1$
For Next Time

- HW 4 due on Wednesday
- Project 2b due a week from Today