Lecture 23: Media Access Control

CSE 123: Computer Networks

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Overview

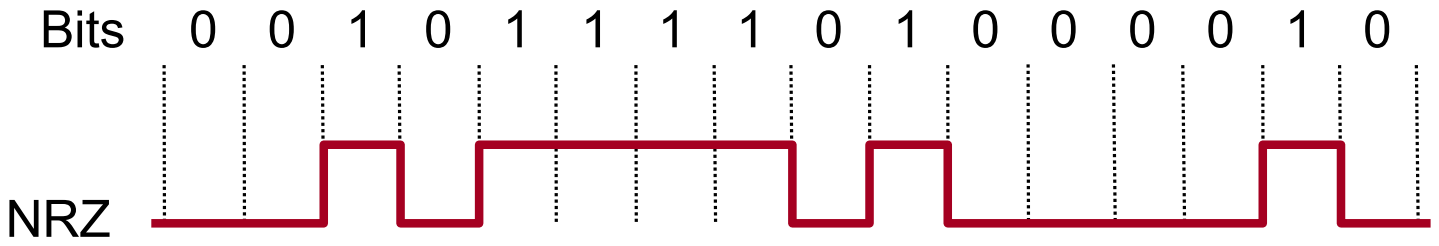
- Finish encoding schemes
  - Manchester, 4B/5B, etc.
- Methods to share physical media: multiple access
  - Fixed partitioning
  - Random access
- Channelizing mechanisms
- Contention-based mechanisms
  - Aloha

Synchronous Coding

- Asynchronous receiver phase locks each symbol
  - Takes time, limiting transmission rates
- So, start symbols need to be extra slow
  - Need to fire up the clock, which takes time
- Instead, let's do this training once, then just keep sync
  - Need to continually adjust clock as signal arrives
  - Ever hear of Phase Lock Loops (PLLs) ?
- Basic idea is to use transitions to lock in

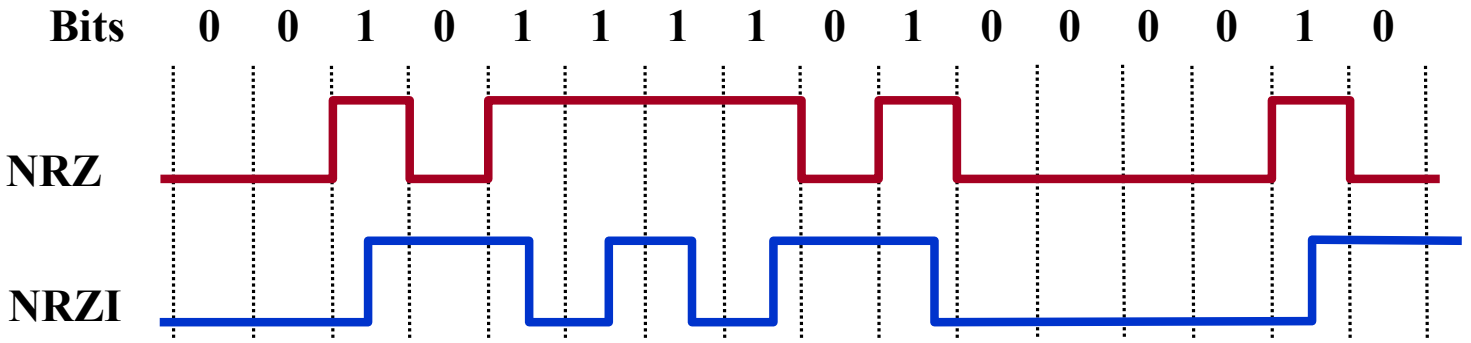
Non-Return to Zero (NRZ)

- Signal to Data
  - High ⇨ 1
  - Low ⇨ 0
- Comments
  - Transitions maintain clock synchronization
  - Long strings of 0s confused with no signal
  - Long strings of 1s causes *baseline wander*
    - » We use average signal level to infer high vs low
  - Both inhibit clock recovery



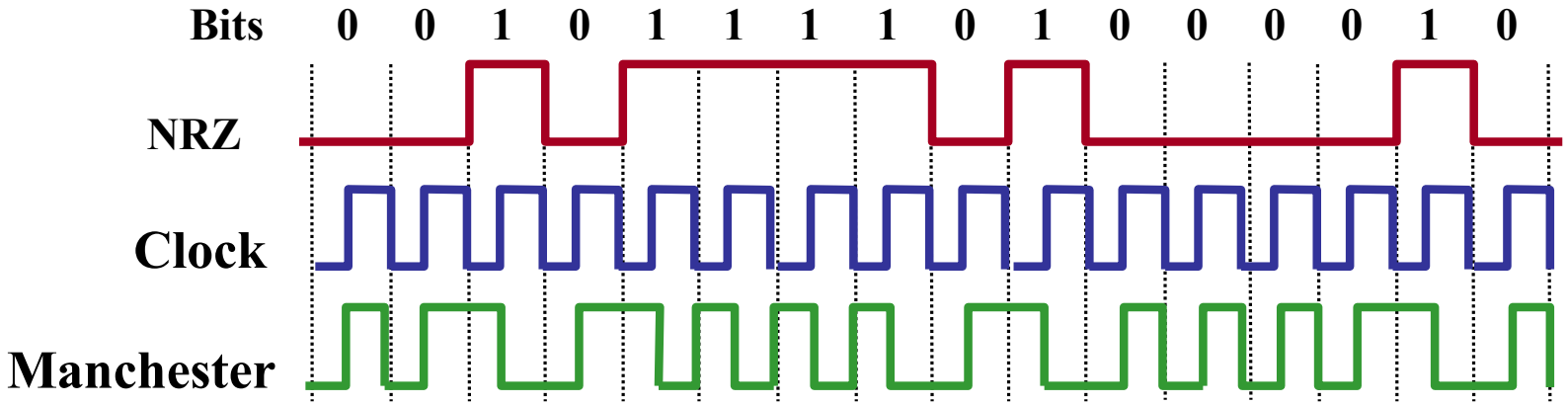
Non-Return to Zero Inverted (NRZI)

- Signal to Data
  - Transition ⇨ 1
  - Maintain ⇨ 0
- Comments
  - Solves series of 1s, but not 0s



Manchester Encoding (10Mbps Ethernet)

- Signal to Data
  - XOR NRZ data with senders clock signal
  - High to low transition ⇨ 1
  - Low to high transition ⇨ 0
- Comments
  - Solves clock recovery problem
  - Only 50% efficient (½ bit per transition)
  - Still need preamble (typically 0101010101… trailing 11 in Ethernet)



4B/5B (100Mbps Ethernet)

- Goal: address inefficiency of Manchester encoding, while avoiding long periods of low signals
- Solution:
  - Use five bits to encode every sequence of four bits
  - No 5 bit code has more than one leading 0 and two trailing 0's
  - Use NRZI to encode the 5 bit codes
  - Efficiency is 80%

4-bit	5-bit
0000	11110
0001	01001
0010	10100
0011	10101
0100	01010
0101	01011
0110	01110
0111	01111

4-bit	5-bit
1000	10010
1001	10011
1010	10110
1011	10111
1100	11010
1101	11011
1110	11100
1111	11101

Encoding Summary

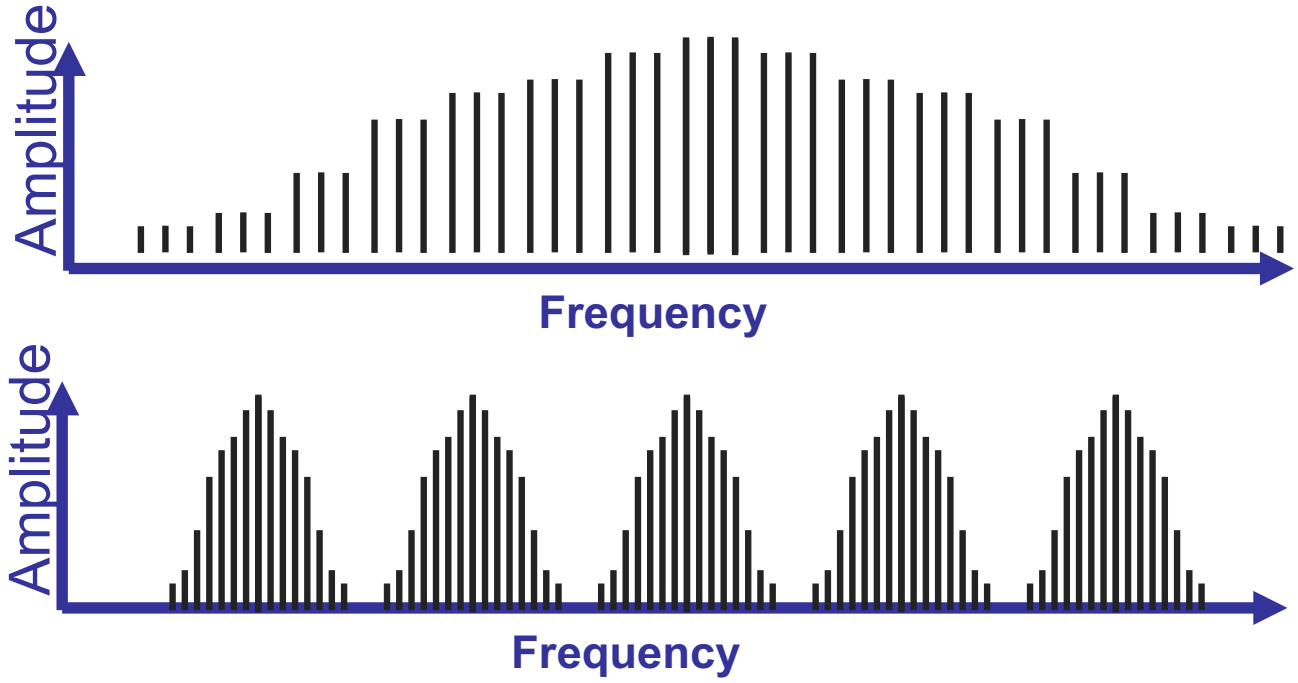
- Signaling & Modulation
  - Transforming digital signal to and from analog representation
  - Fundamental limits (Shannon)
  - Lots of ways to encode signal (modulation) onto a given medium
- Clock recovery
  - Receiver needs to adjust its sampling times to best extract signal from channel
  - Sender can code signal to make it far easier to do this

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…

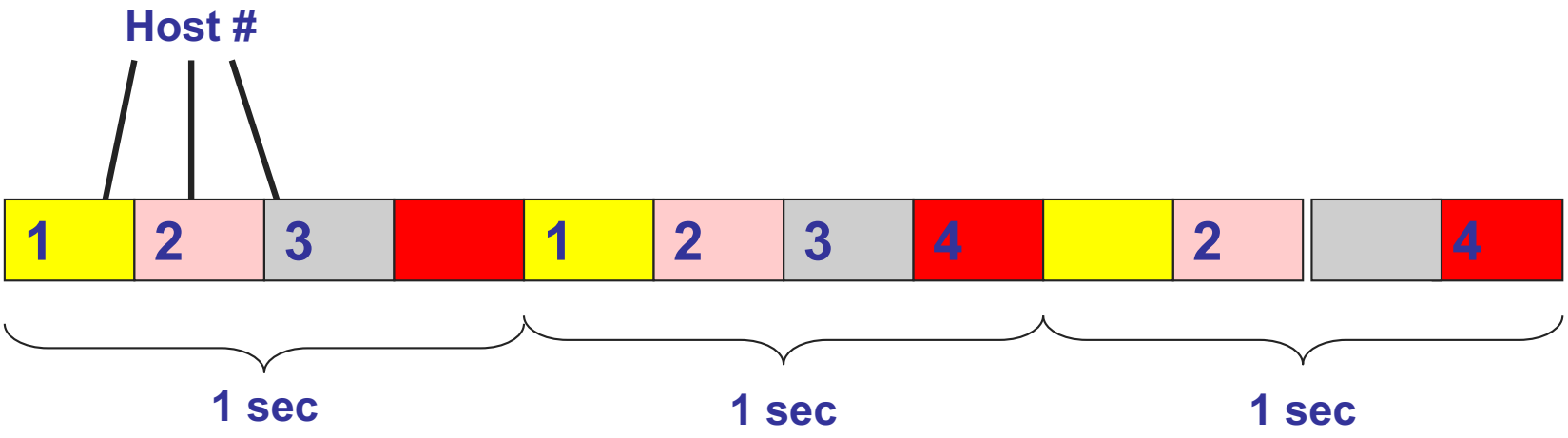
Frequency Division (FDMA)

- 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)

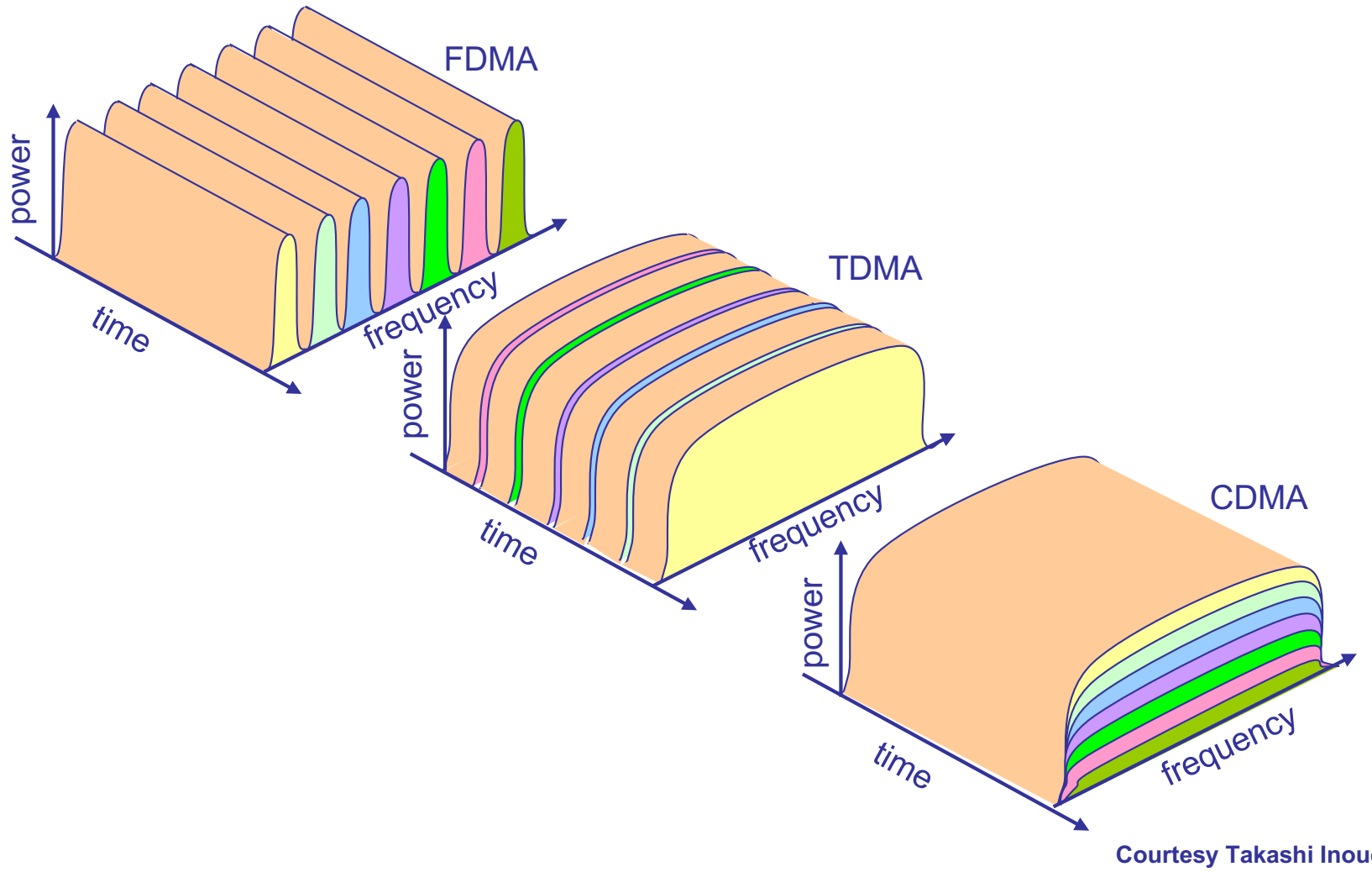
- Divide channel into rounds of *n* time slots each
  - Assign different hosts to different time slots within a round
  - Unused time slots are idle
  - Used in GSM cell phones & digital cordless phones
- Example with 1-second rounds
  - *n*=4 timeslots (250ms each) per round



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



Courtesy Takashi Inoue

Problem w/Channel partitioning

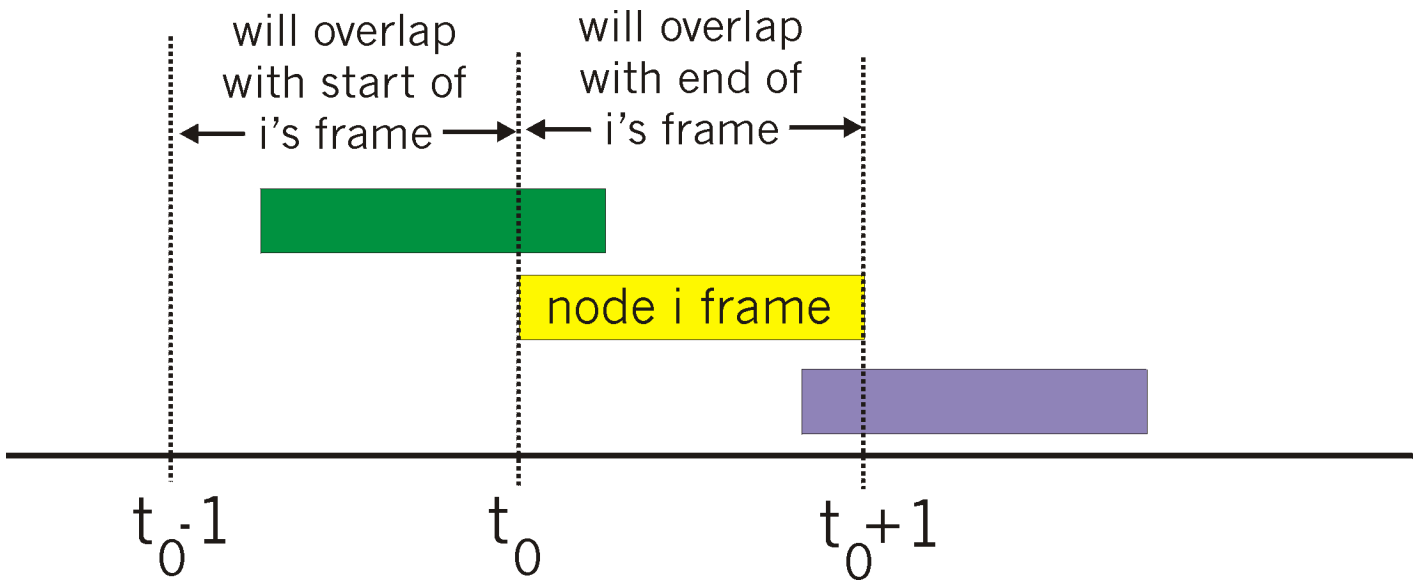
- Not terribly well suited for random access usage
  - Why?
- Instead, design schemes for more common situations
  - Not all nodes want to send all the time
  - Don't have a fixed number of nodes
- Potentially higher throughput for transmissions
  - Active nodes get full channel bandwidth

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?

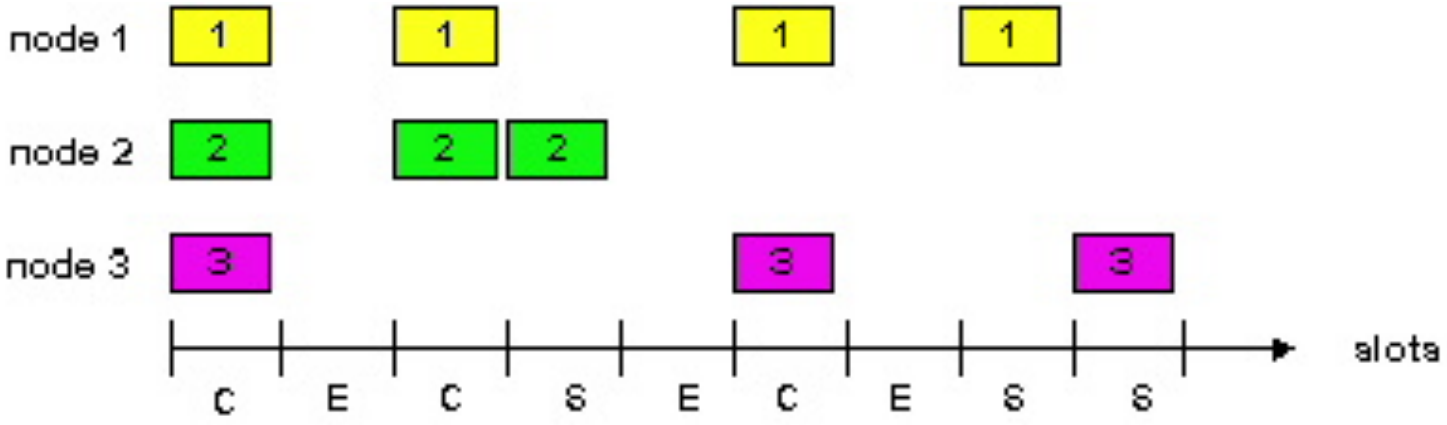
Collisions

- 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

Channel Efficiency

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:

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

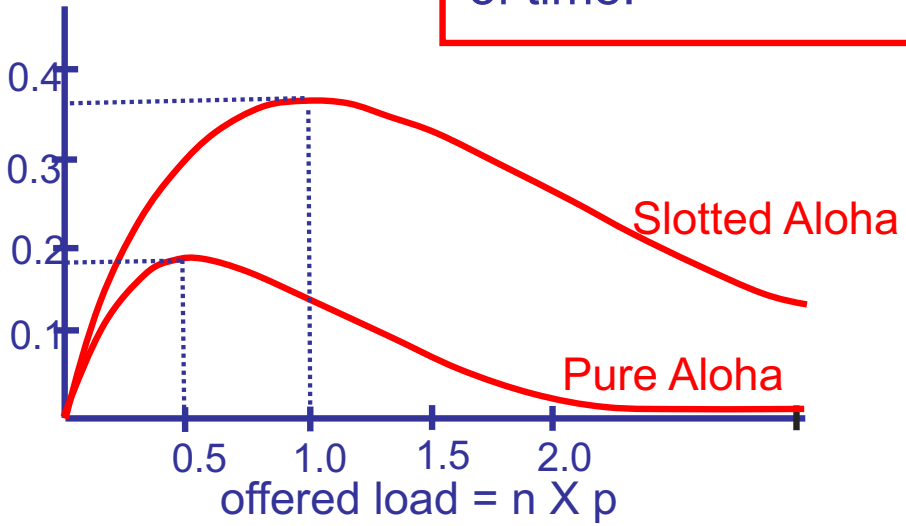
- any of *n* nodes:

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

(optimal *p* as *n*->infinity = *1/n*)

= *1/e* = *.37*

At best: channel used for useful transmissions 37% of time!



For Next Time

- NO CLASS ON MONDAY
- Keep going on the project…