# CS 43: Computer Networks
# Media Access

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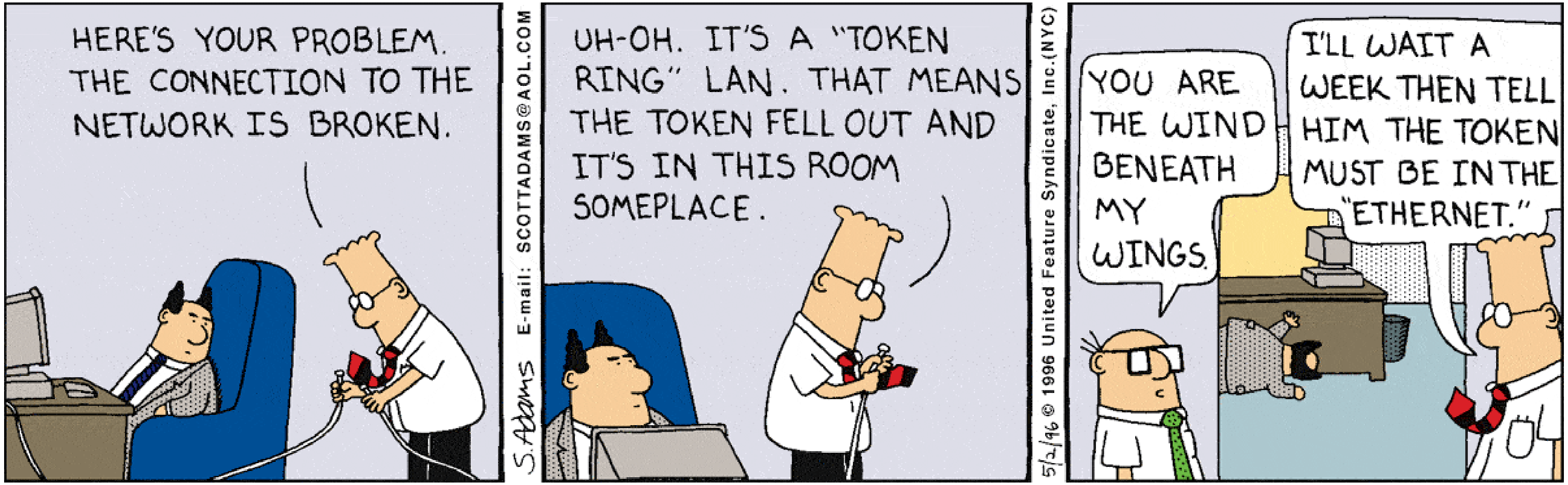


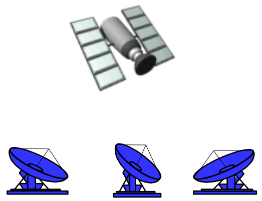
# Multiple Access Links & Protocols

Two classes of "links":

- point-to-point
  - dial-up access
  - link between Ethernet switch, host
- *broadcast (shared wire or medium)*
  - old-fashioned Ethernet
  - 802.11 wireless LAN

shared wire (e.g., wired Ethernet)

shared RF (e.g., 802.11 WiFi)



shared RF (satellite)

# Multiple Access Protocols

- Broadcast channel - every host hears every transmission
- If two or more nodes simultaneously transmit:
  - *collision* if node receives two or more signals at the same time

*multiple access protocol*

- algorithm that determines how nodes share channel, i.e., determine when node can transmit
- communication about channel sharing must use channel itself!
  - no out-of-band channel for coordination

# An ideal multiple access protocol...

*Given:* broadcast channel of rate R bps

1. if only one node wants to transmit, it can send at rate R.
2. when M nodes want to transmit, each can send at average rate R/M (fairness)
3. fully decentralized:
   - no synchronization of clocks, slots
   - no special node to coordinate transmissions
4. simple

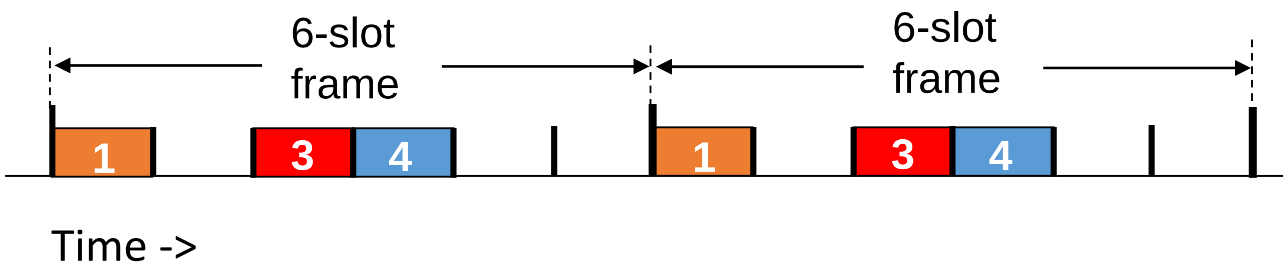
# Media Access Control (MAC) Strategies

- *channel partitioning*
  - divide channel into smaller “pieces” (time slots, frequency, code)
  - allocate piece to node for exclusive use
- *random access*
  - channel not divided, allow collisions
  - “recover” from collisions
- *taking turns*
  - nodes coordinate with one another to take turns, share channel

# Channel partitioning MAC protocols: TDMA

## TDMA: time division multiple access

- Access to channel in “rounds”, like round robin
- Each node gets fixed length time slot (length = pkt trans time) in each round
- Example: 6-station LAN, 1,3,4 have packets to send, slots 2,5,6 idle

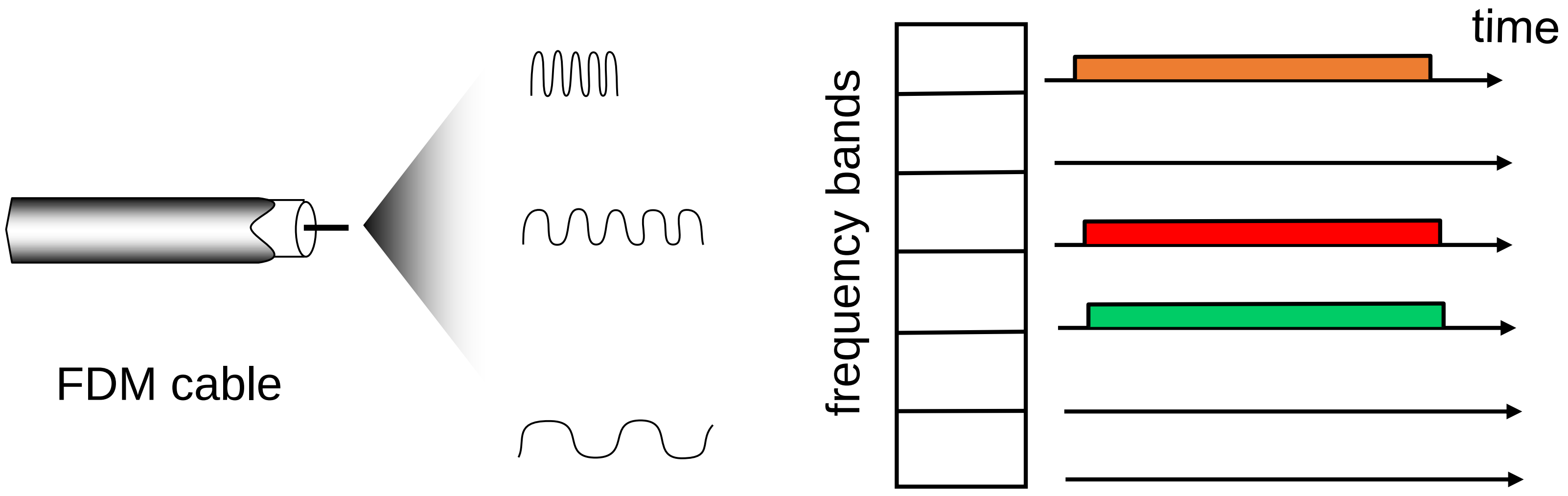


# Channel partitioning MAC protocols: FDMA

## FDMA: frequency division multiple access

- Channel spectrum divided into frequency bands
- Each node assigned a fixed frequency band

- Example: 6-station LAN, 1,3,4 have packets to send, bands 2,5,6 idle



# How many of our ideal properties does channel partitioning give us?

1. If only one node wants to transmit, it can send at rate R.
2. When M nodes want to transmit, each can send at average rate R/M (fairness)
3. Fully decentralized:
    - no synchronization of clocks, slots
    - no special node to coordinate transmissions
4. Simple

A. 0
B. 1
C. 2
D. 3
E. 4
(Which ones?)

# Do we use channel partitioning?

- In what applications might this be a good idea?

- Terrestrial radio/TV (frequency division)
- Satellite (frequency division)
- Fiber optic links (wavelength division)
- Cell phones
  - Old generations (time division)
  - Current generation (code division)

# Random Access Protocols

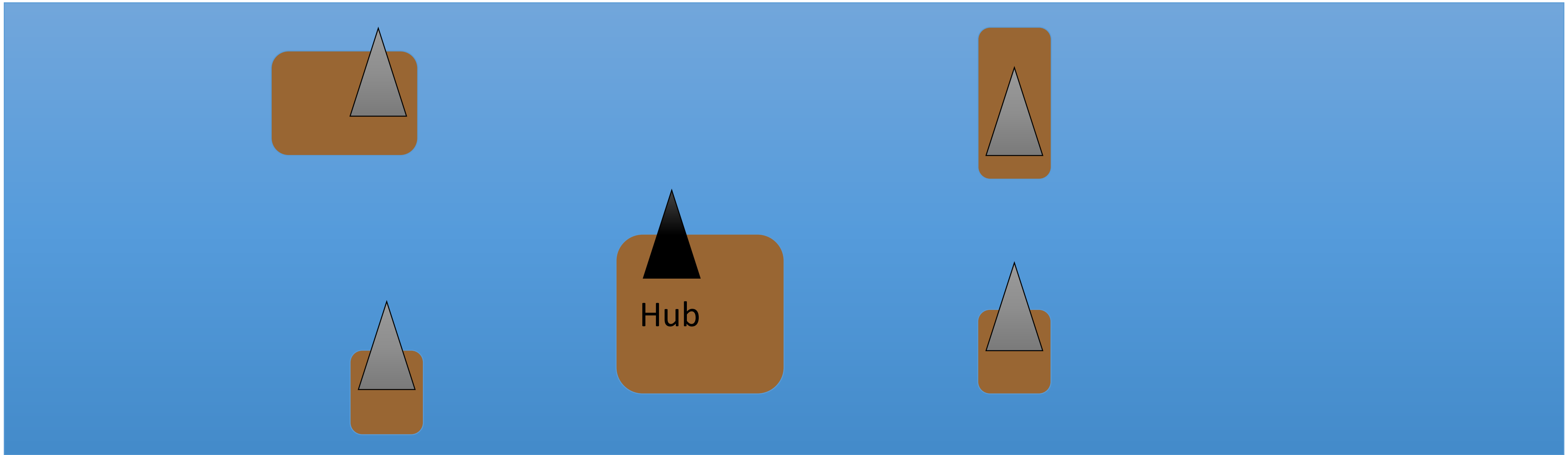
- When node has a packet to send, try to send it
  - no *a priori* coordination among nodes

- Two or more transmitting nodes → "collision"

- random access MAC protocol specifies:
  - how to minimize collisions
  - how to detect collisions
  - how to recover from collisions (e.g., via delayed retransmissions)

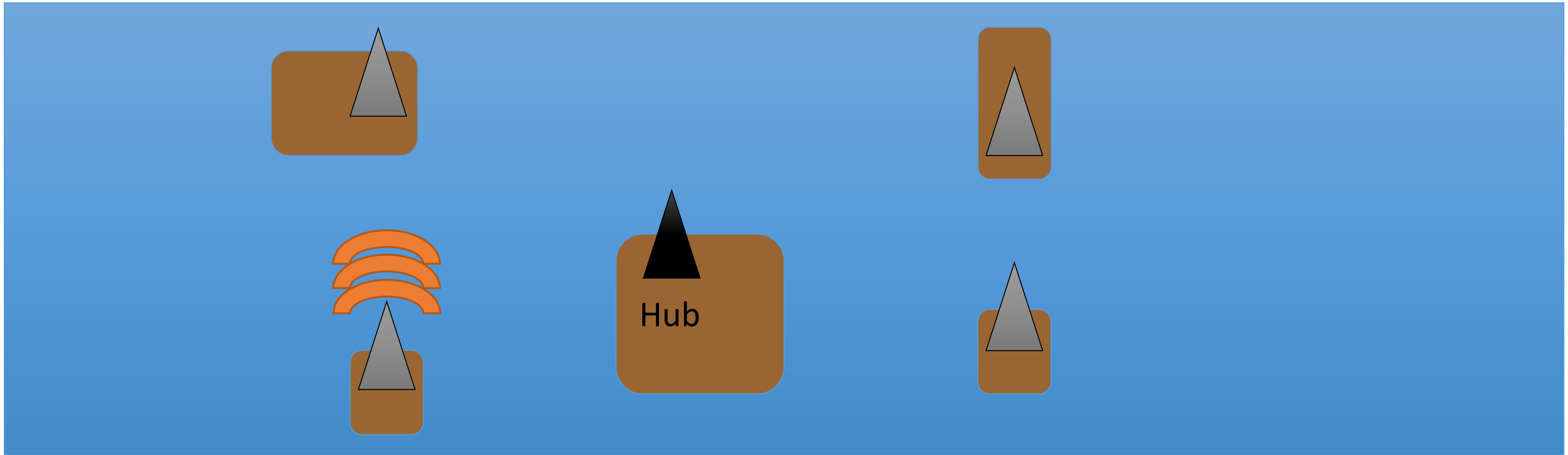
# ALOHAnet (Unslotted / Pure)

- Norm Abramson at U of Hawaii in late 1960’s
- Goal: network between islands
- Shared medium: radio



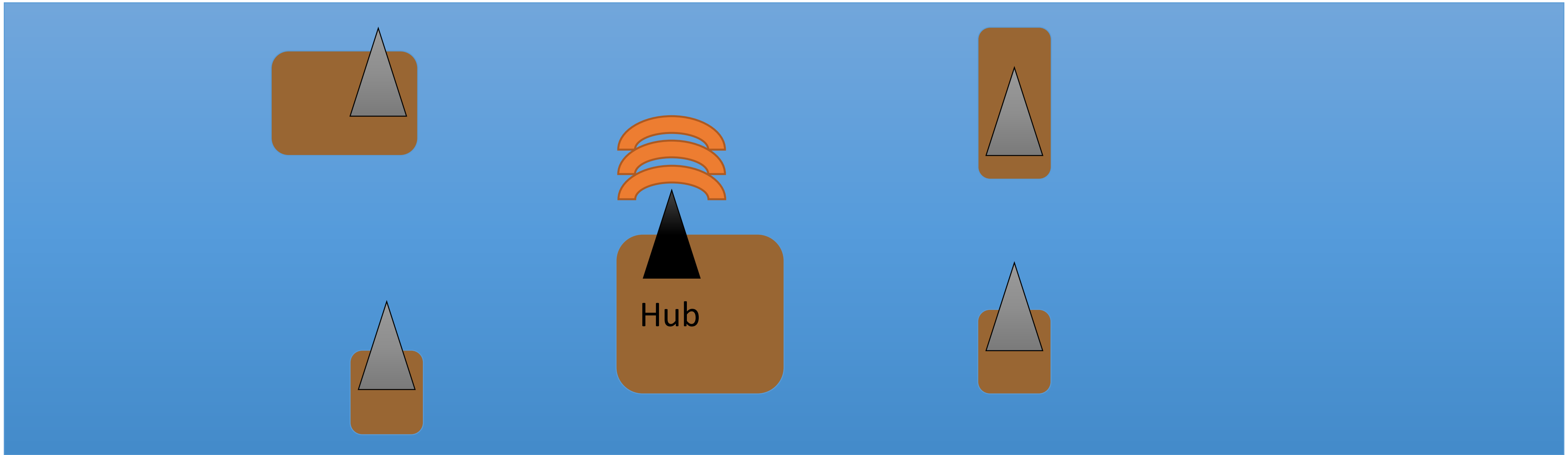
# ALOHAnet

- If user gives you data, send it all, immediately.



# ALOHAnet

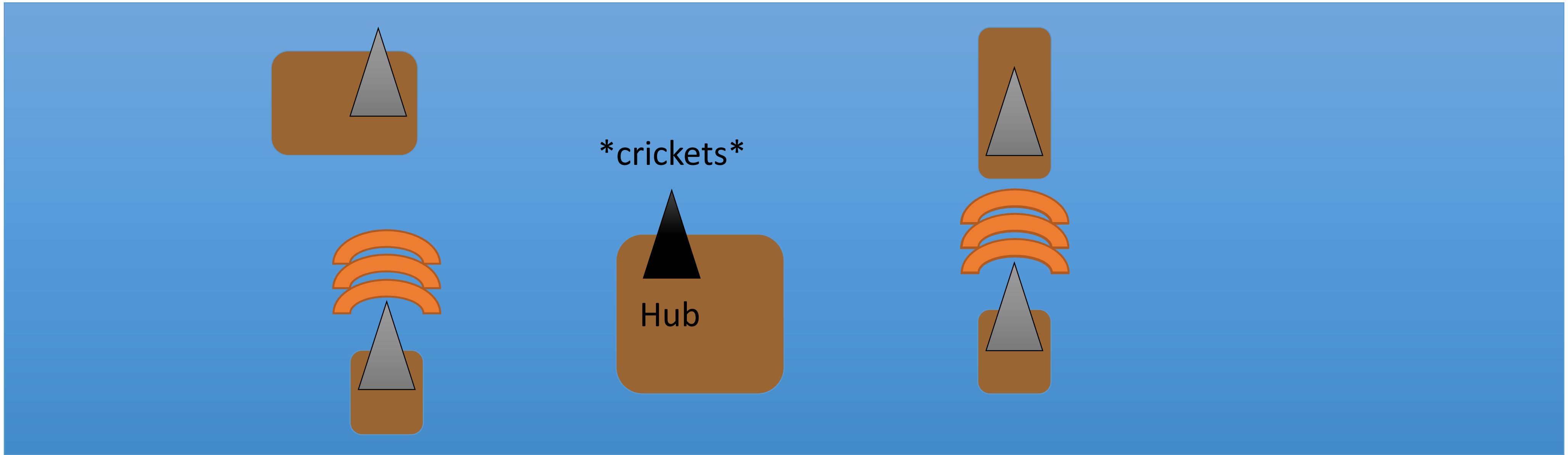
- If the hub received everything, it sends ACK.



# ALOHAnet

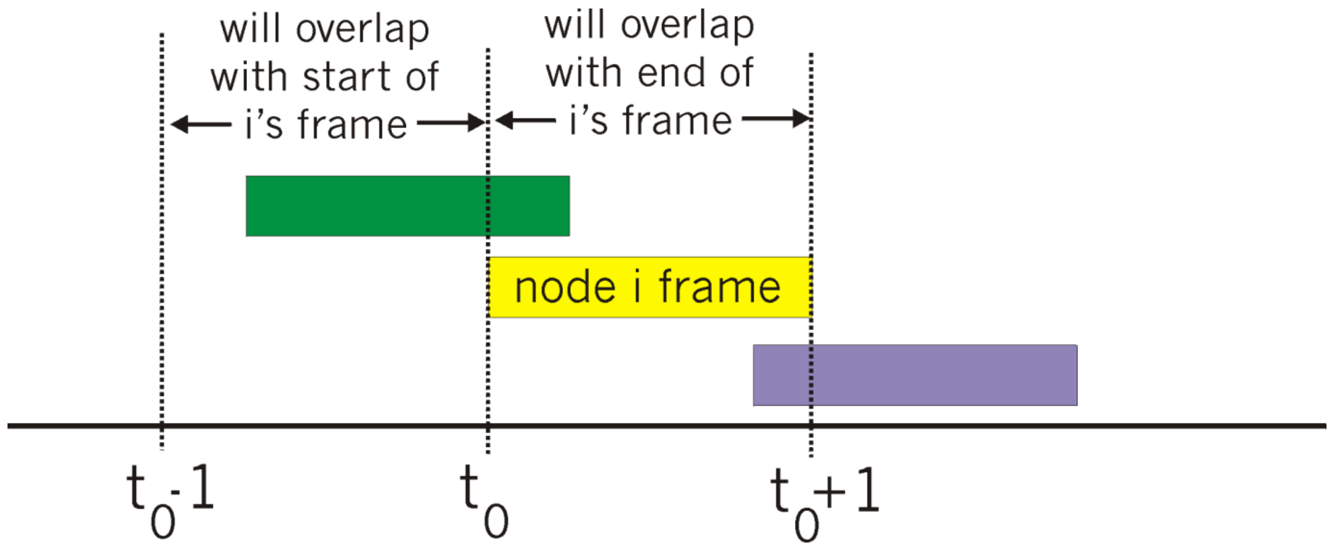
- If two senders collide…
- …hub sends back no ACKs.

- Senders wait a random time, send again.



# (Unslotted / Pure) ALOHA

- Problems:
  - Sends immediately upon receiving data
  - Sends entire packets all at once



# Carrier Sensing Multiple Access (CSMA)

*CSMA*: listen before transmit:

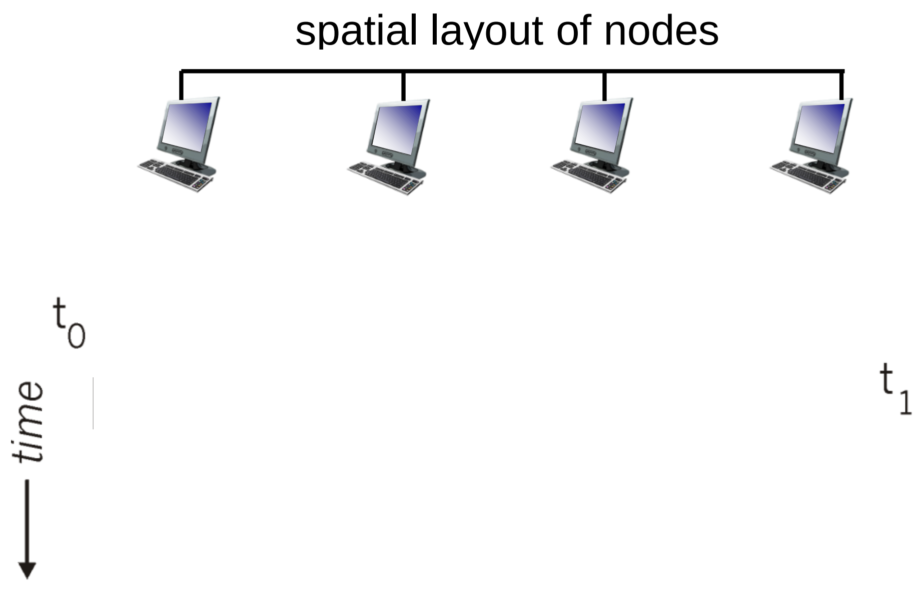
if channel sensed idle: transmit

- if channel sensed busy, defer transmission

- human analogy: don't interrupt others!

# CSMA collisions

- Collisions *can* still occur: propagation delay means two nodes may not hear each other' s transmission
- Collision: entire packet transmission time wasted
  - distance & propagation delay play role in in determining collision probability



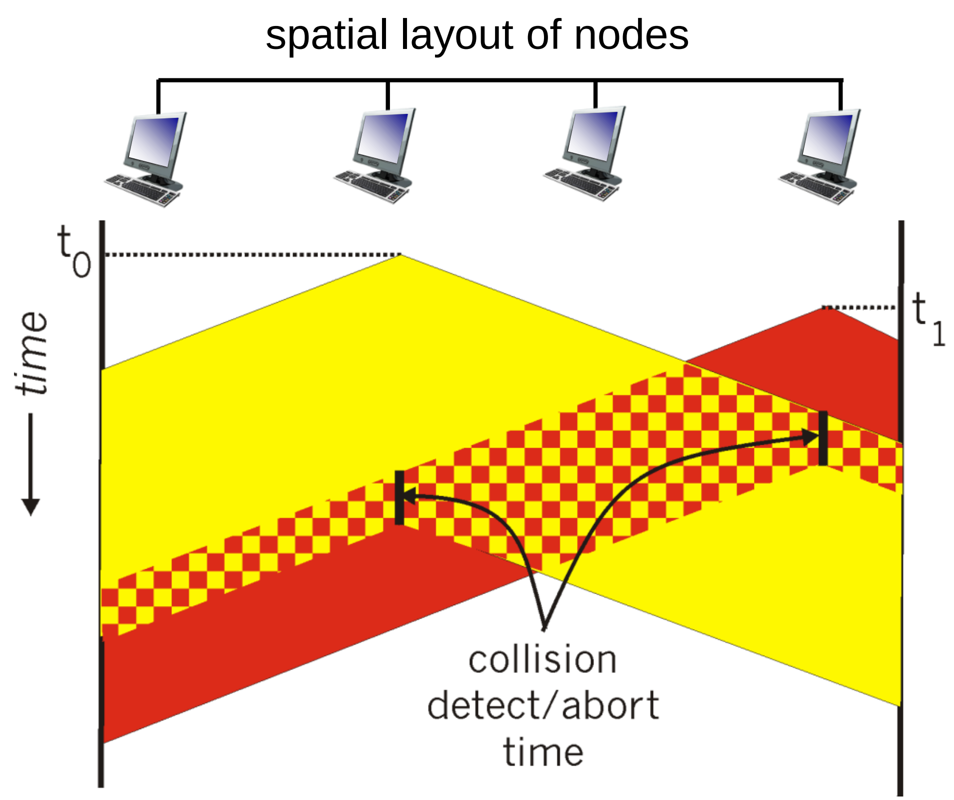
# CSMA/CD (Collision Detection)

*CSMA/CD:* carrier sensing, deferral as in CSMA

- collisions *detected* within short time
- colliding transmissions aborted, freeing channel

- Collision detection:
  - easy in wired LANs: measure signal strengths, compare transmitted, received signals
  - difficult in wireless LANs: received signal strength overwhelmed by local transmission strength

# CSMA/CD (collision detection)



# Ethernet and CSMA/CD

1. NIC receives datagram from network layer, creates frame
2. If NIC senses channel idle, starts frame transmission. If NIC senses channel busy, waits until channel idle, then transmits.
3. If NIC transmits entire frame without detecting another transmission, NIC is done with frame !
4. If NIC detects another transmission while transmitting, aborts and sends jam signal
5. After aborting, NIC enters *binary (exponential) backoff*

# Exponential Back off

- After *m*th collision, NIC chooses *K* at random from $\{0,1,2, \ldots, 2^m-1\}$.
- NIC waits K·512 bit times, then returns to checking if the channel is idle
- Longer back off interval with more collisions

# How many of our ideal properties does CSMA/CD give us?

1. If only one node wants to transmit, it can send at rate R.
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3. Fully decentralized:
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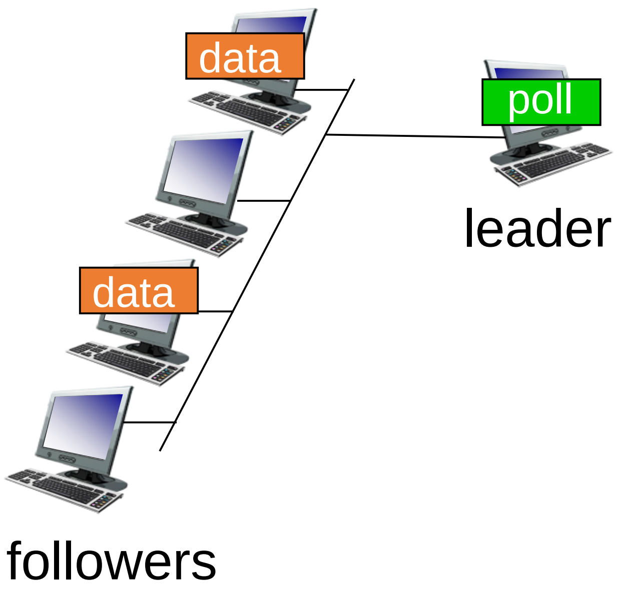
(Which ones?)

# “Taking turns” MAC protocols

*Polling:*

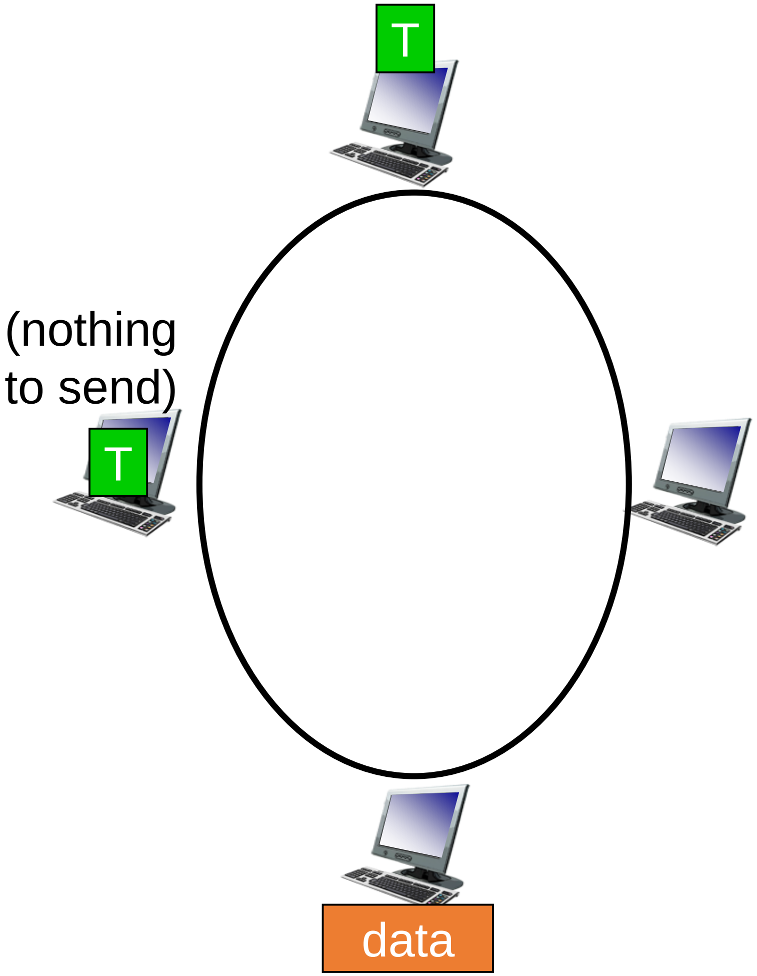
- leader node “invites” follower nodes to transmit in turn
- typically used with “dumb” follower devices
- Concerns:
  - polling overhead
  - latency
  - centralized leader



# “Taking turns” MAC protocols

## Token passing:

- Control token passed from one node to next sequentially.
- Can only transmit if holding the token.
- Limit on number of bytes sent per token.



# How many of our ideal properties does taking turns (token passing) give us?

1. If only one node wants to transmit, it can send at rate R.
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# In Practice…

- Techniques often combined. (e.g., DOCSIS cable modems)

- What about wireless Ethernet?
  - Old joke: “I don’t know what the next link layer technology will look like, but I’m sure it will be named Ethernet.”

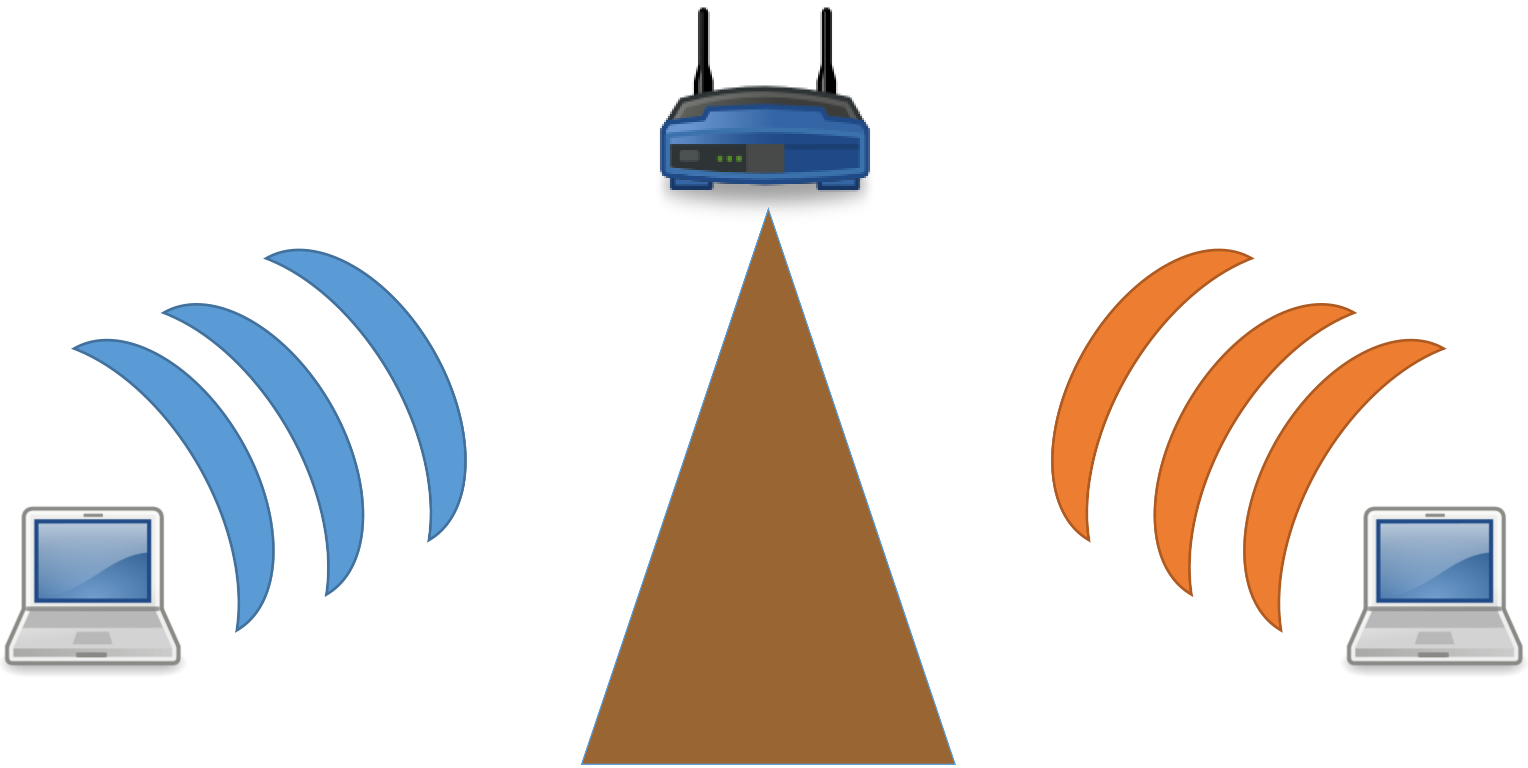
# WiFi (802.11)

- Senders do carrier sensing like Ethernet.

Assumes hosts can hear each other!

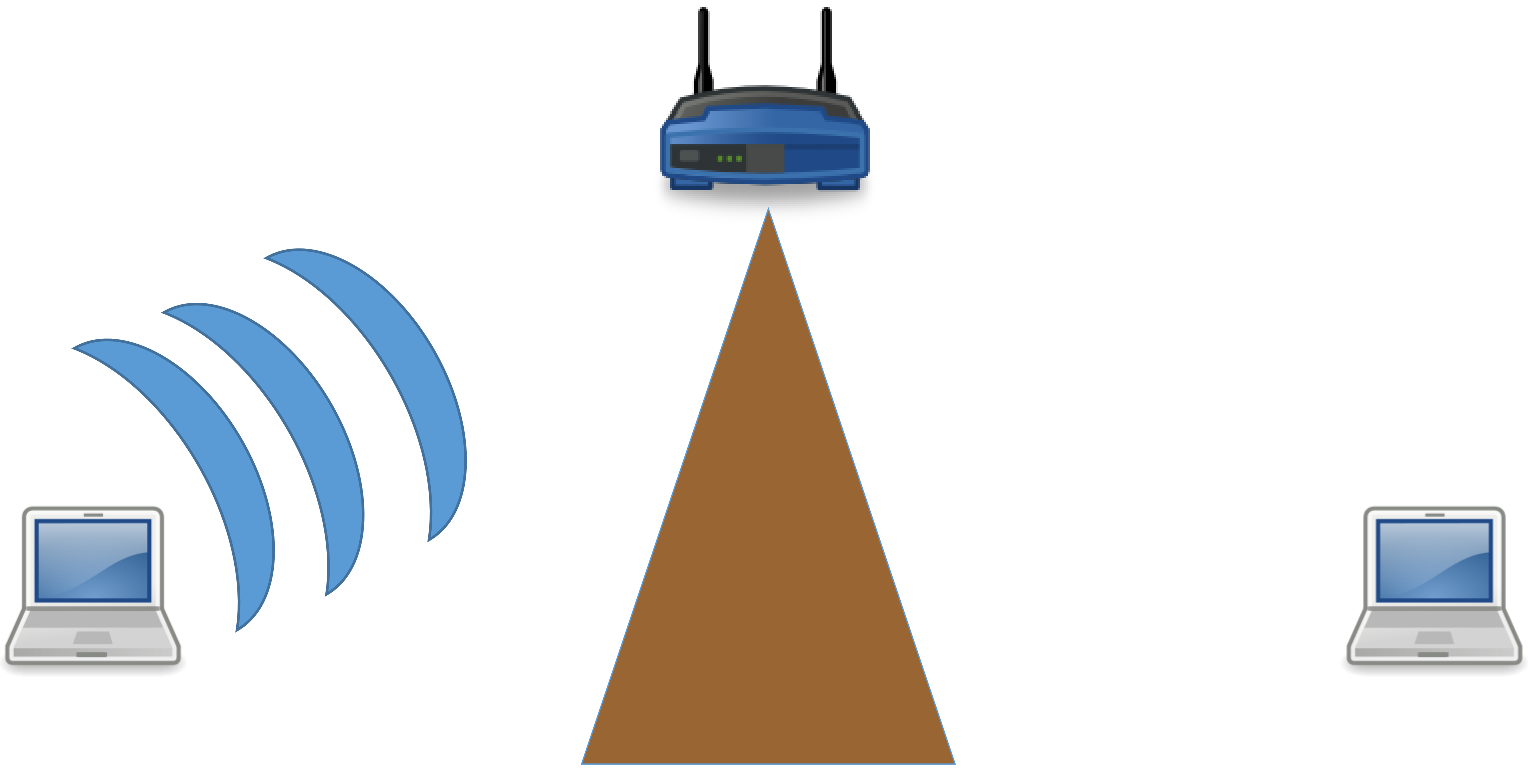
# “Hidden Terminal” Problem

- Senders collide at receiver, but they can’t hear each other!



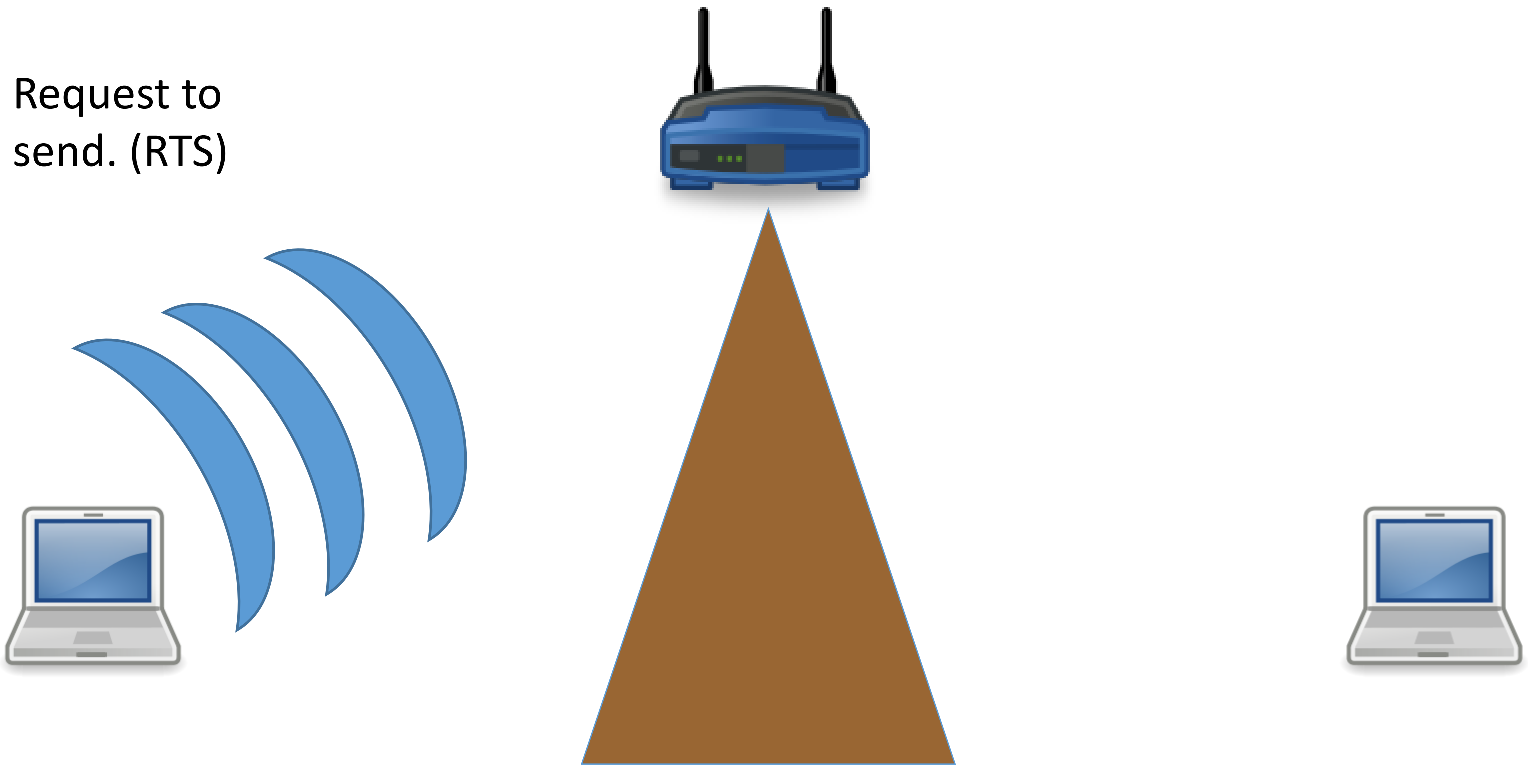
# CSMA/CA (Collision Avoidance)

- If sending small (threshold configurable) frame, just send it.



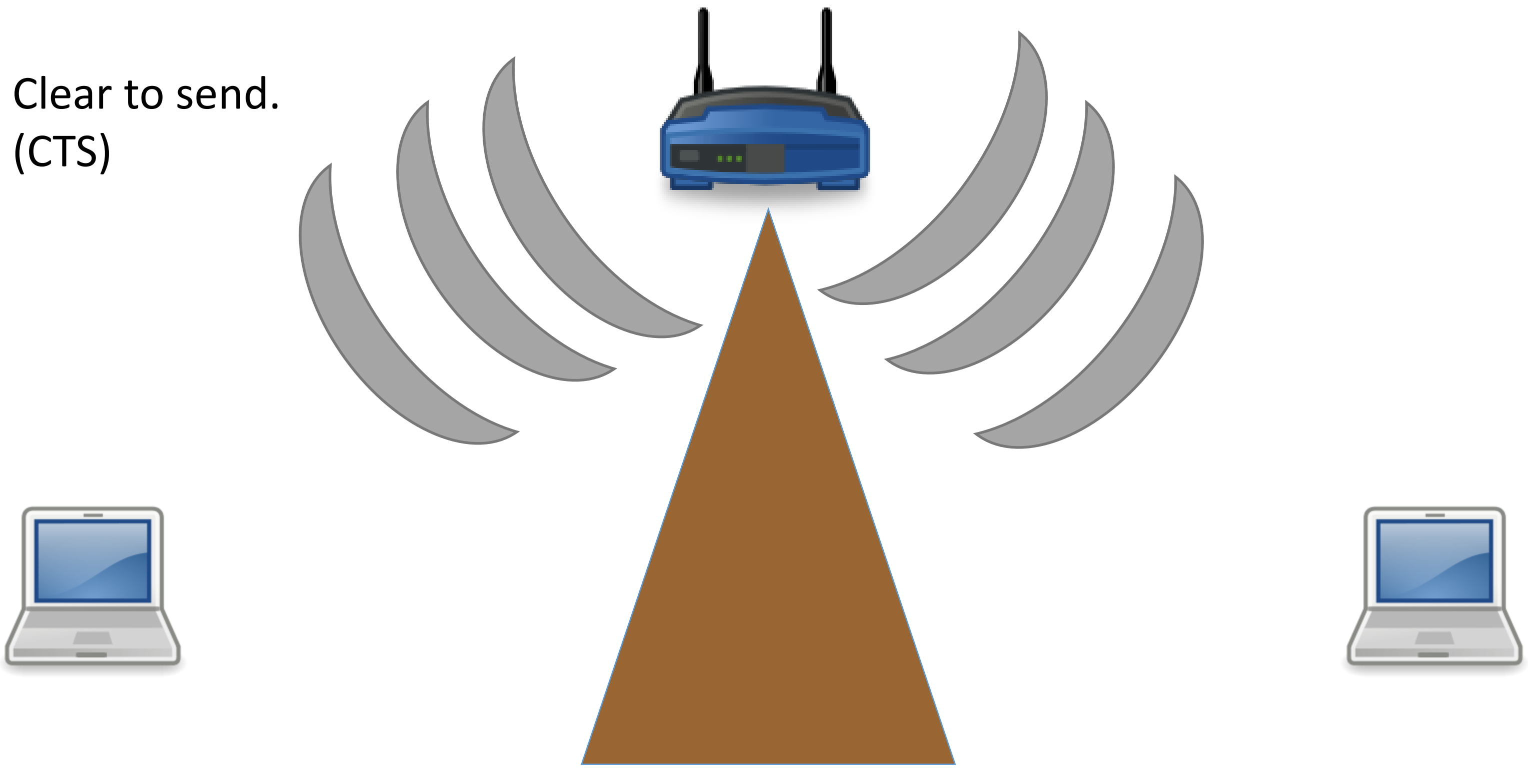
# CSMA/CA (Collision Avoidance)

- If sending large frame, ask for permission first.



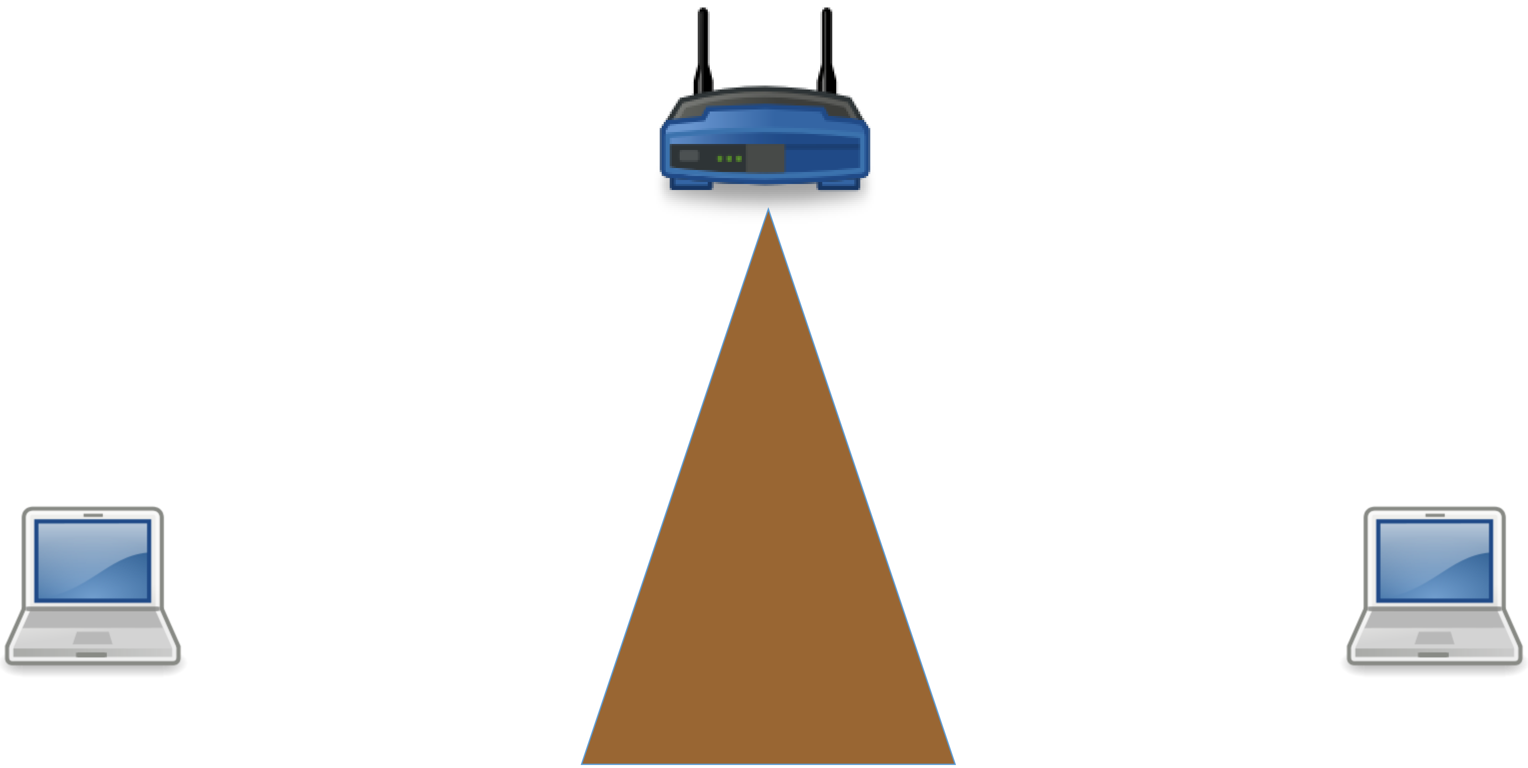
# CSMA/CA (Collision Avoidance)

- If granted, it will be heard by everyone.



# CSMA/CA (Collision Avoidance)

- RTS/CTS is like taking turns, but it's rarely used in practice.



# Summary of MAC protocols

- *channel partitioning,* by time, frequency or code
  - Time Division, Frequency Division
- *random access* (dynamic),
  - ALOHA, S-ALOHA, CSMA, CSMA/CD
  - carrier sensing:
    - easy in some technologies (wire), hard in others (wireless)
  - CSMA/CD used in Ethernet
  - CSMA/CA used in 802.11
- *taking turns*
  - Polling from central site, token passing
  - Bluetooth, FDDI, token ring