W 5
(1)

Computer Networks I

Data Link Control Protocols
(Medium Access Control Protocols)
(Channel Partitioning, Taking Turns)

Amitangshu Pal

Computer Science and Engineering

IIT Kanpur

Multiple access links, protocols

Two types of "links":

- Point-to-point
  - Point-to-point link between Ethernet switch, host

- Broadcast (shared wire or medium)
  - Old-school Ethernet
  - 802.11 wireless LAN, 4G/5G, satellite

humans at a cocktail party
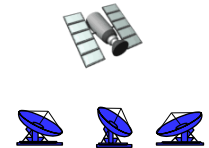(shared air, acoustical)

shared wire (e.g.,
cabled Ethernet)

shared radio: 4G/5G

shared radio: WiFi

shared radio: satellite

Multiple access protocols

- Single shared broadcast channel

- Two or more simultaneous transmissions by nodes:
  - Collision if node receives two or more signals at the same time

Multiple access protocol

- Distributed 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: multiple access channel (MAC) of rate R bps

Desired rate:

1. When 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
3. Fully decentralized:
   - No special node to coordinate transmissions
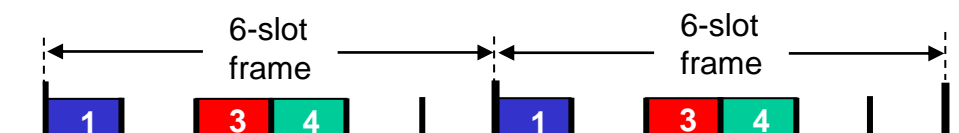   - No synchronization of clocks, slots
4. Simple

MAC protocols: taxonomy

Three broad classes:

- Channel partitioning
  - Divide channel into smaller "pieces" (time slots, frequency, code)
  - Allocate piece to node for exclusive use

- Taking turns"
  - Nodes take turns, but nodes with more to send can take longer turns

- Random access
  - Use randomization for handling collisions
  - "Recover" from collisions

Channel partitioning protocols: TDMA

**TDMA: Time division multiple access**

- Access to channel in "rounds"
- Each station gets fixed length slot (length = packet transmission time) in each round
- Unused slots go idle
- Example: 6-station scenario, 1,3,4 have packets to send, slots 2,5,6 idle

Channel partitioning protocols: FDMA

FDMA: Frequency division multiple access

- Channel spectrum divided into frequency bands
- Each station assigned fixed frequency band
- Unused transmission time in frequency bands go idle
- Example: 6-station scenario, 1,3,4 have packet to send, frequency bands 2,5,6 idle
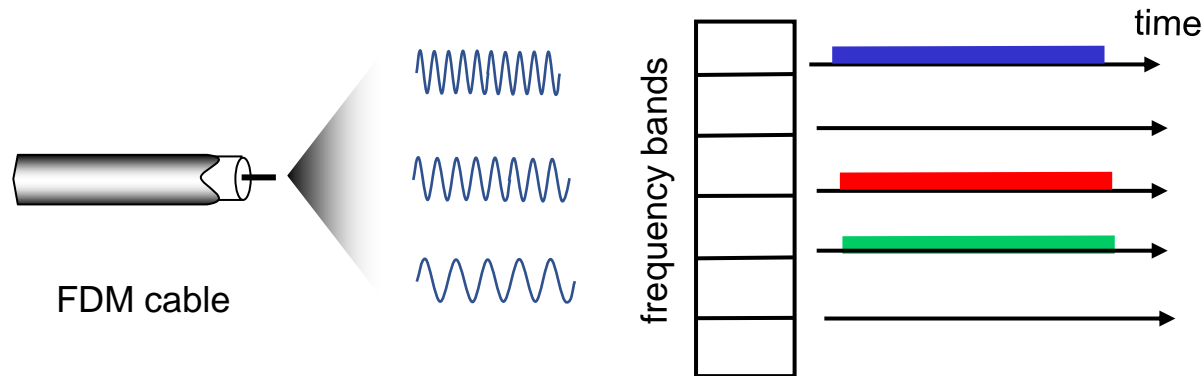
FDM cable

frequency bands

time

MAC protocols: taxonomy

Three broad classes:

- **Channel partitioning**
  - Divide channel into smaller "pieces" (time slots, frequency, code)
  - Allocate piece to node for exclusive use

- **Taking turns"**
  - Nodes take turns, but nodes with more to send can take longer turns

- **Random access**
  - Use randomization for handling collisions
  - "Recover" from collisions

"Taking turns" MAC protocols
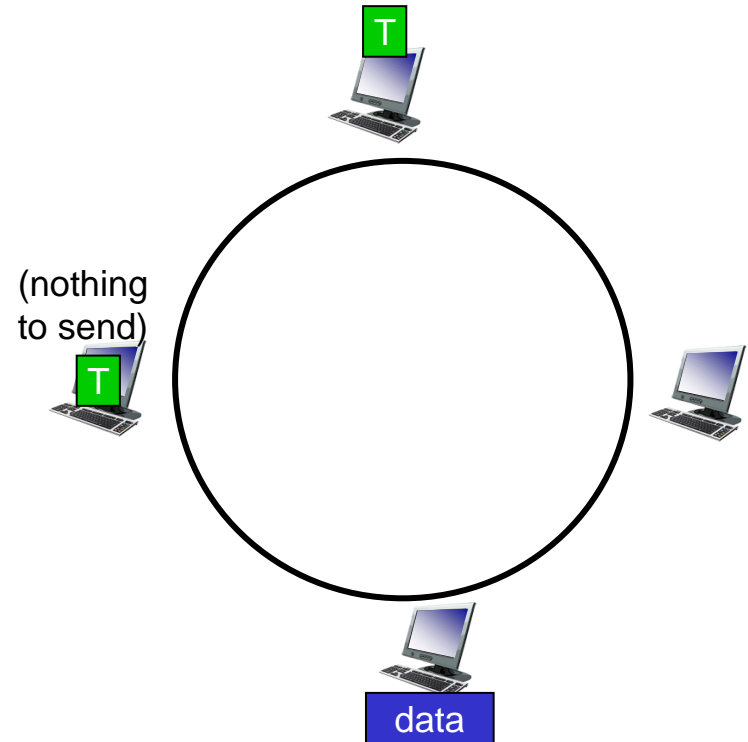
Polling:

- Centralized controller "invites" other nodes to transmit in turn
- Typically used with "dumb" devices
- Concerns:
  - Polling overhead
  - Latency
  - Single point of failure (master)
- Bluetooth uses polling

data

poll

centralized controller

data

client devices
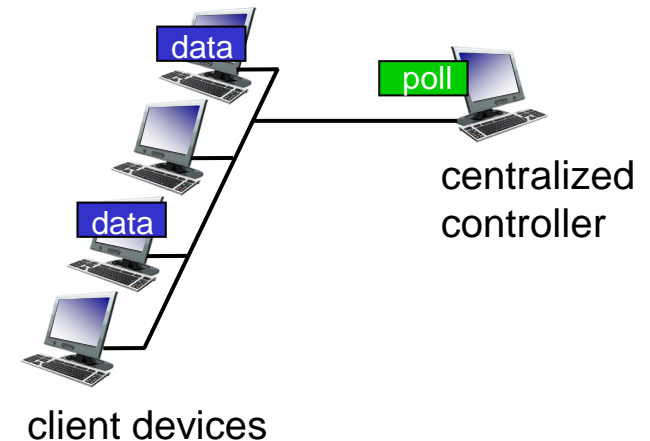
"Taking turns" MAC protocols

Token passing:

- Control token message explicitly passed from one node to next, sequentially
  - Transmit while holding token
- Concerns:
  - Token overhead
  - Latency
  - Single point of failure (token)

T

(nothing to send)

T

data

Summary

❑ Multiple Access Control:

- Channel partitioning, by time, frequency or code
  - TDMA, FDMA

- Taking turns
  - Polling from central site, token passing