Welcome to

CS 3516:
Computer Networks

Prof. Yanhua Li

Time: 9:00am -9:50am M, T, R, and F
Location: AK219
Fall 2018 A-term

Updates

- 1. Quiz 8: Grading by Monday 10/8.
- 2. Quiz 9: Grading by Tue 10/9.
- 3. Lab 3: Grading by Wed 10/10.

Last week calendar

	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
9-9:50am	Lecture AK219	Final Review AK219	TA: Menghai 9:30AM-11:30AM	Final Exam	
10-10:30am	Prof. Li, AK130	Prof. Li, AK130		Prof. Li, AK130	
10:30am-11:30am	Prof. Li, AK130				
1-3pm	TA: Marissa	TA: Sanket	TA: Marissa	TA:Sanket	
		Project 3 & Lab 3 due			

Office hours for all questions, e.g., project/lab assignment related questions, like programming…

Office hours for lecture related questions, and general questions for labs and projects.

Link layer, LANs: outline

6.1 introduction, services

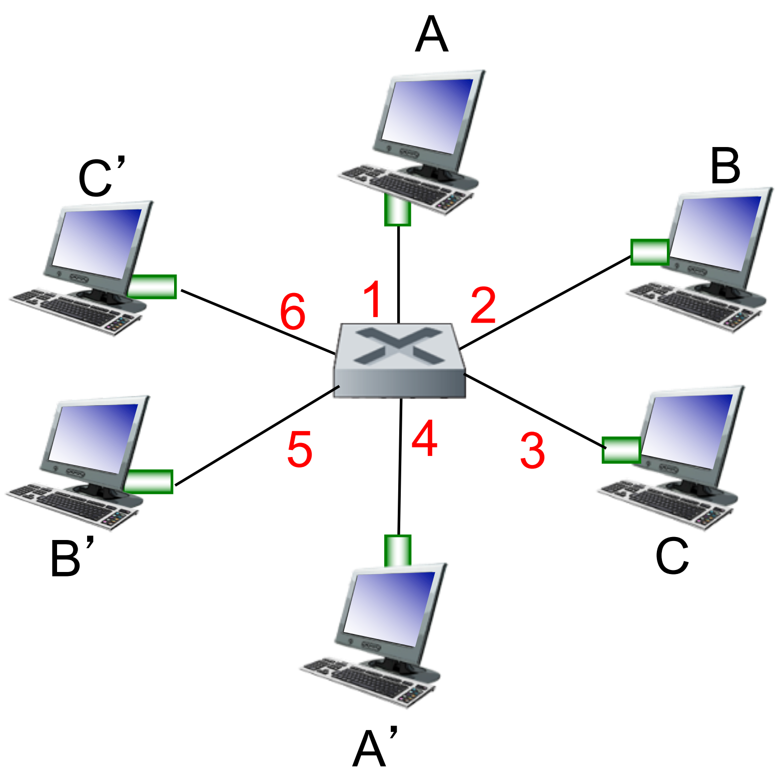
6.2 error detection, correction

6.3 multiple access protocols

6.4 LANs

- addressing, ARP
- Ethernet

Ethernet LAN



switch with six interfaces
(1,2,3,4,5,6)

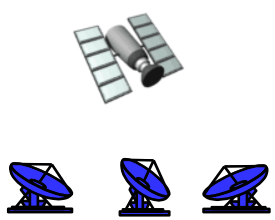
Multiple access links, protocols

two types of “links”:

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

shared wire (e.g., cabled Ethernet)

shared RF (e.g., 802.11 WiFi)



shared RF (Radio Frequency) (satellite)

PPP: Point-to-Point Protocol

Multiple access protocols (MAP)

- single shared broadcast channel
- two or more simultaneous transmissions by nodes: interference
  - *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

An ideal multiple access protocol

given: broadcast channel of rate R bps

Desired functions:

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 (***fairness***).
3. fully decentralized:
   - no special node to coordinate transmissions
   - no synchronization of clocks, slots
4. simple

shared RF
(e.g., 802.11 WiFi)

MAC protocols: taxonomy

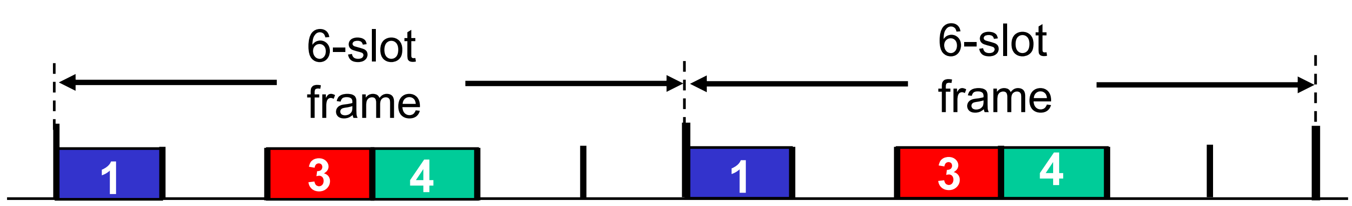
three broad classes:

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

Channel partitioning MAC protocols: TDMA

TDMA: time division multiple access

- access to channel in "rounds"
- each station gets fixed length slot (length = pkt trans time) in each round
- unused slots go idle
- example: 6-station LAN, 1,3,4 have pkt, slots 2,5,6 idle



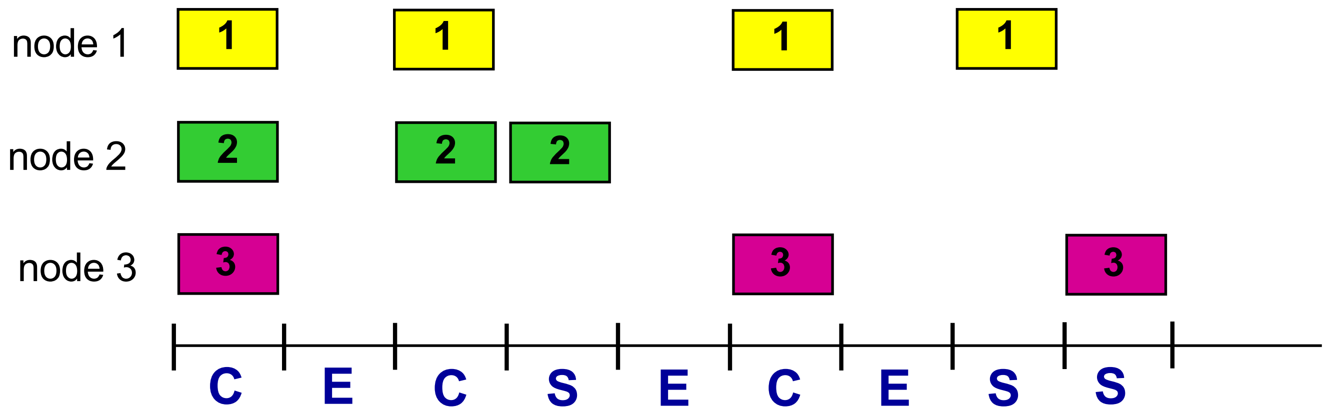
Pros: no collision

Cons: idle slots, if only one node, it cannot transmit with R bps

Random access protocols

- when node has packet to send
  - transmit at full channel data rate R.
  - no *a priori* coordination among nodes
- two or more transmitting nodes ➜ "collision",
- random access MAC protocol specifies:
  - how to detect collisions
  - how to recover from collisions (e.g., via delayed retransmissions)
- examples of random access MAC protocols:
  - slotted ALOHA
  - CSMA
  - CSMA/CD,

Slotted ALOHA



Pros:

- single active node can continuously transmit at full rate of channel
- highly decentralized: only slots in nodes need to be in sync
- simple

Cons:

- collisions, wasting slots
- idle slots
- clock synchronization

CSMA (carrier sense multiple access)

CSMA: listen before transmit:

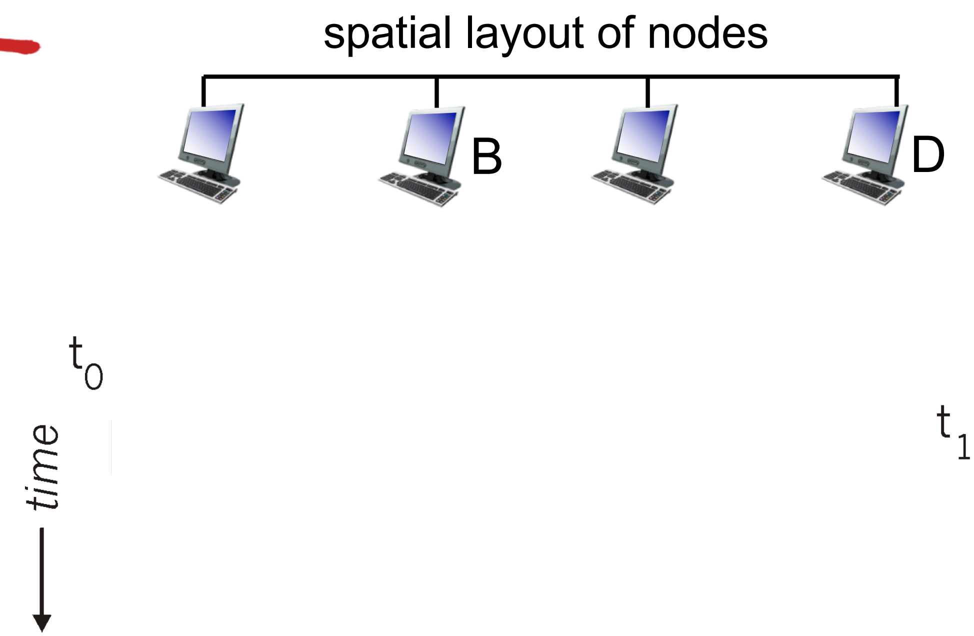
if channel sensed idle: transmit entire frame

- if channel sensed busy, defer transmission

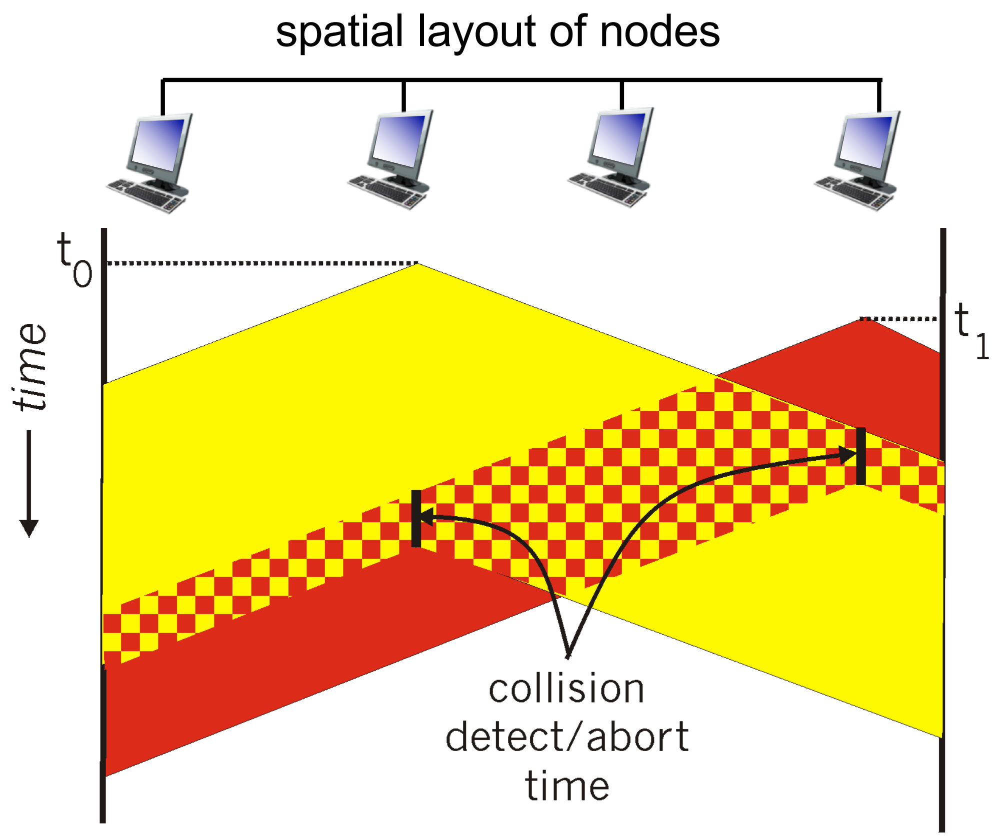
- human analogy: don't interrupt others!

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 determining collision probability



CSMA/CD (collision detection)



Ethernet CSMA/CD algorithm

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:*
   - after *m*th collision, NIC chooses *K* at random from $\{0,1,2, \ldots, 2^m-1\}$. NIC waits $K \cdot 512$ bit times, returns to Step 2
   - longer backoff interval with more collisions

NIC: Network Interface Card

"Taking turns" MAC protocols

channel partitioning MAC protocols: high load

- share channel *efficiently* and *fairly* at high load
- inefficient at low load: delay in channel access.

random access MAC protocols: low load

- efficient at low load: single node can fully utilize channel
- high load: collision overhead

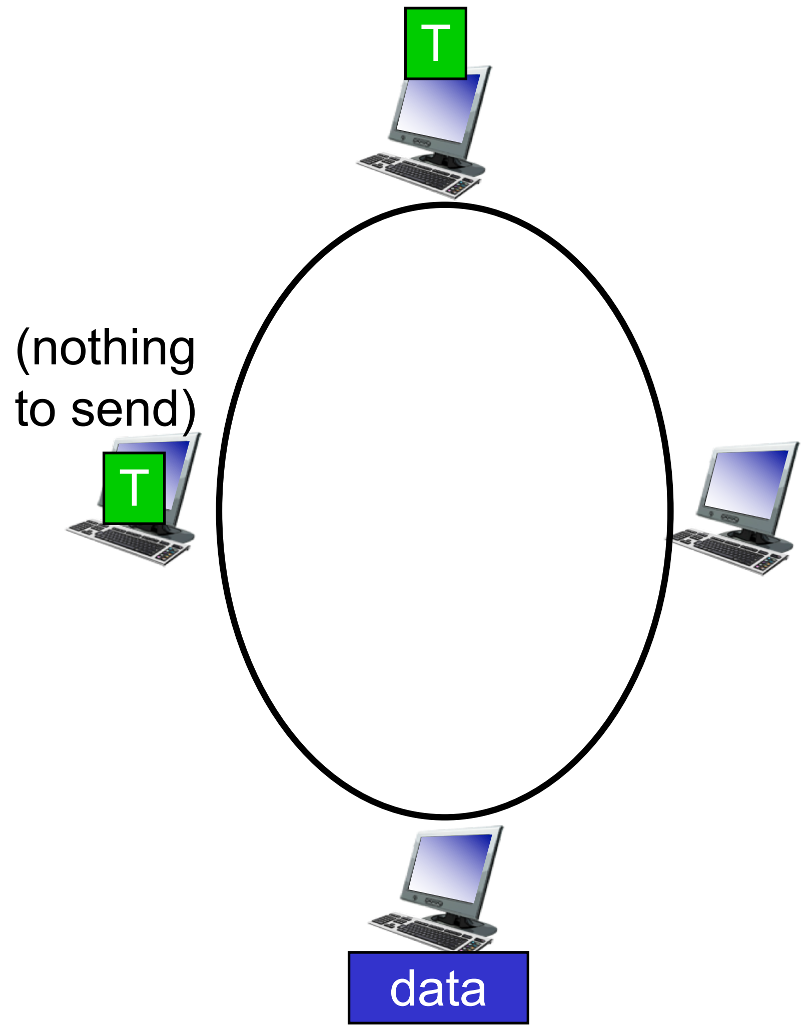
"taking turns" protocols

look for best of both worlds!

"Taking turns" MAC protocols

token passing:

- control *token* passed from one node to next sequentially.
- token message
- concerns:
  - token overhead
  - latency
  - single point of failure (token)



Summary of MAC protocols

- *channel partitioning,* by time, frequency or code
  - Time Division, Frequency Division
- *random access* (dynamic),
  - S-ALOHA, CSMA, CSMA/CD
- *taking turns*
  - polling from central site, token passing
  - Bluetooth, token ring

Chapter 6: let's take a breath

- journey down protocol stack *complete* (except PHY)
- solid understanding of networking principles, practice
- ….. could stop here …. but *lots* of interesting topics!
  - wireless
  - multimedia
  - security
  - network management

Questions?