National University of Computer & Emerging Sciences

CS 3001 - COMPUTER NETWORKS

Lecture 26

Chapter 6

28th November, 2023

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Office Hours: 02:30 pm till 06:00 pm (Every Tuesday & Thursday)

"Random Access" MAC protocols (Cont'd)

channel partitioning MAC protocols:

- share channel *efficiently* and *fairly* at high load
- inefficient at low load: delay in channel access, 1/N bandwidth allocated even if only 1 active node!

"random access" MAC protocols

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

taking turns protocols

- look for best of both worlds!

CSMA (carrier sense multiple access)

simple CSMA: listen before transmit:

- if channel sensed idle: transmit entire frame
- if channel sensed busy: defer transmission

- human analogy: don't interrupt others!

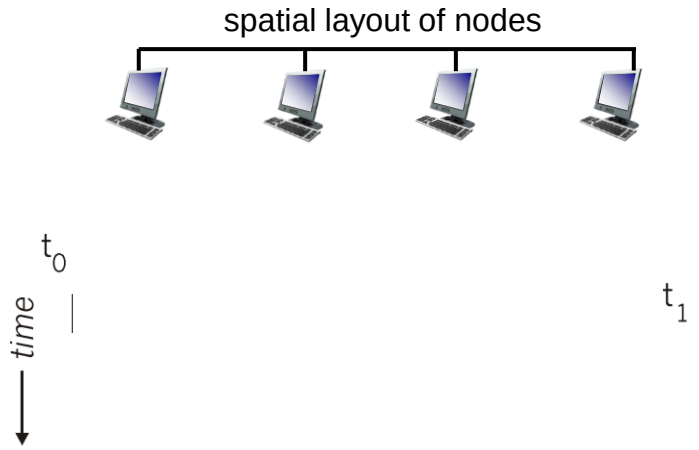
CSMA/CD: CSMA with *collision detection*

- collisions *detected* within short time
- colliding transmissions aborted, reducing channel wastage
- collision detection easy in wired, difficult with wireless

- human analogy: the polite conversationalist

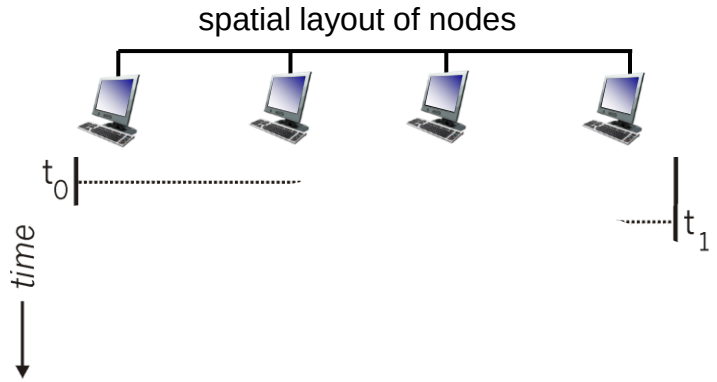
CSMA: collisions

- collisions can *still* occur with carrier sensing:
  - propagation delay means two nodes may not hear each other's just-started transmission
- collision: entire packet transmission time wasted
  - distance & propagation delay play role in in determining collision probability



CSMA/CD:

- CSMA/CD reduces the amount of time wasted in collisions
  - transmission aborted on collision detection



Ethernet CSMA/CD algorithm

1. Ethernet receives datagram from network layer, creates frame
2. If Ethernet senses channel:
   if idle: start frame transmission.
   if busy: wait until channel idle, then transmit
3. If entire frame transmitted without collision - done!
4. If another transmission detected while sending: abort, send jam signal
5. After aborting, enter *binary (exponential) backoff:* *(see example in textbook)*
   - after *m*th collision, NIC chooses *K* at random from $\{0,1,2, \ldots, 2^m-1\}$. Ethernet waits $K \cdot 512$ bit times, returns to Step 2
   - more collisions: longer backoff interval

CSMA/CD efficiency

- T_{prop} = max prop delay between 2 nodes in LAN
- t_{trans} = time to transmit max-size frame

$$efficiency = \frac{1}{1 + 5t_{prop}/t_{trans}}$$

- efficiency goes to 1
  - as t_{prop} goes to 0 (since colliding nodes will abort immediately without wasting the channel)
  - as t_{trans} goes to infinity (because when a frame grabs the channel, it will hold on to the channel for a very long time; thus, the channel will be doing productive work most of the time)
- better performance than ALOHA: and simple, cheap, decentralized!

“Taking turns” MAC protocols

channel partitioning MAC protocols:

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random access MAC protocols

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

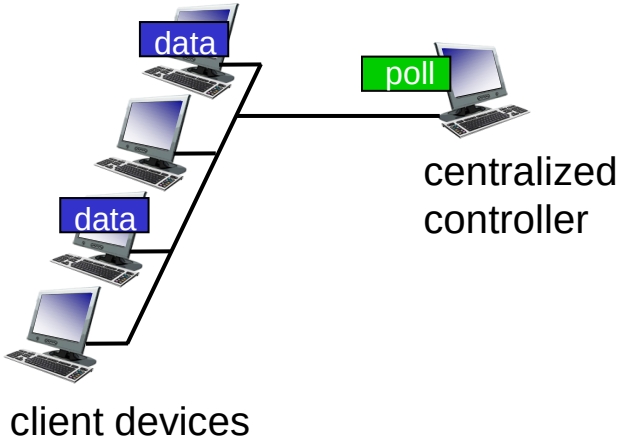
“taking turns” protocols

- look for best of both worlds!

“Taking turns” MAC protocols

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



Advantages:

- eliminates collisions
- eliminates empty slots

“Taking turns” MAC protocols

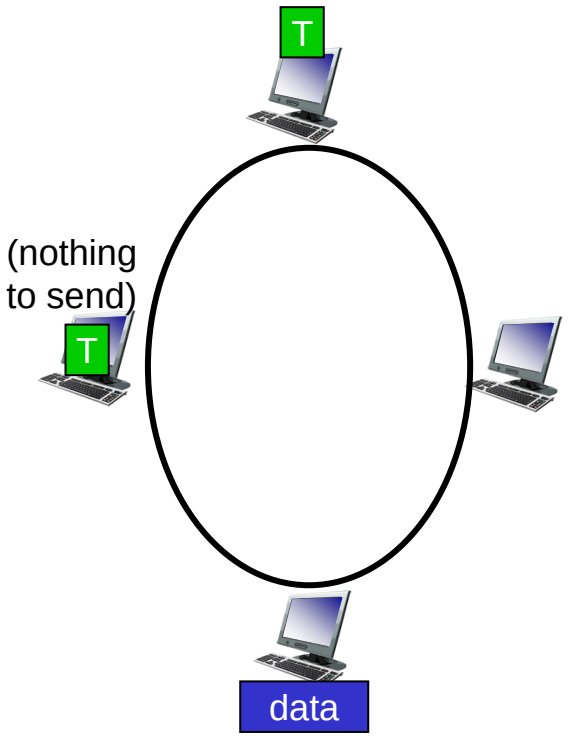
token passing:

- control *token* (a small special purpose frame) message explicitly passed from one node to next, sequentially
  - transmit while holding token

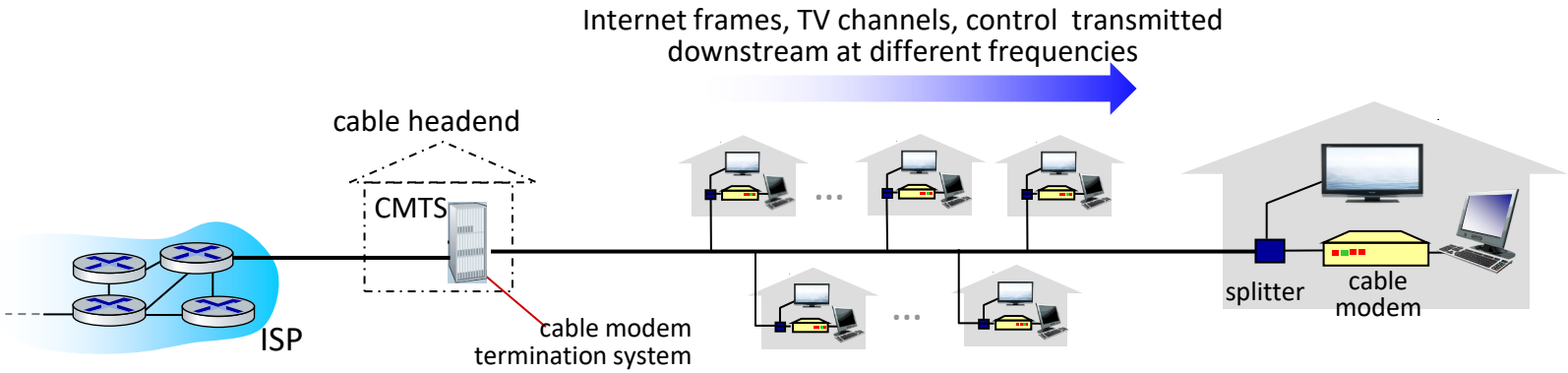
❖ Advantages:

- decentralized
- highly efficient

- concerns:
  - token overhead
  - latency
  - single point of failure (token)



Cable access network: FDM, TDM *and* random access!



- multiple downstream (broadcast) FDM channels: up to 1.6 Gbps/channel
  - single CMTS transmits into channels
- multiple upstream channels (up to 1 Gbps/channel)
  - multiple access: all users contend (random access) for certain upstream channel time slots; others assigned TDM

Summary of MAC protocols

- channel partitioning, by time, frequency or code
  - Time Division, Frequency Division, CDMA etc.
- 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

Link layer, LANs: roadmap

- introduction
- error detection, correction
- multiple access protocols
- LANs
  - addressing, ARP
  - Ethernet
  - switches
  - VLANs
- link virtualization: MPLS
- data center networking

- a day in the life of a web request

MAC addresses

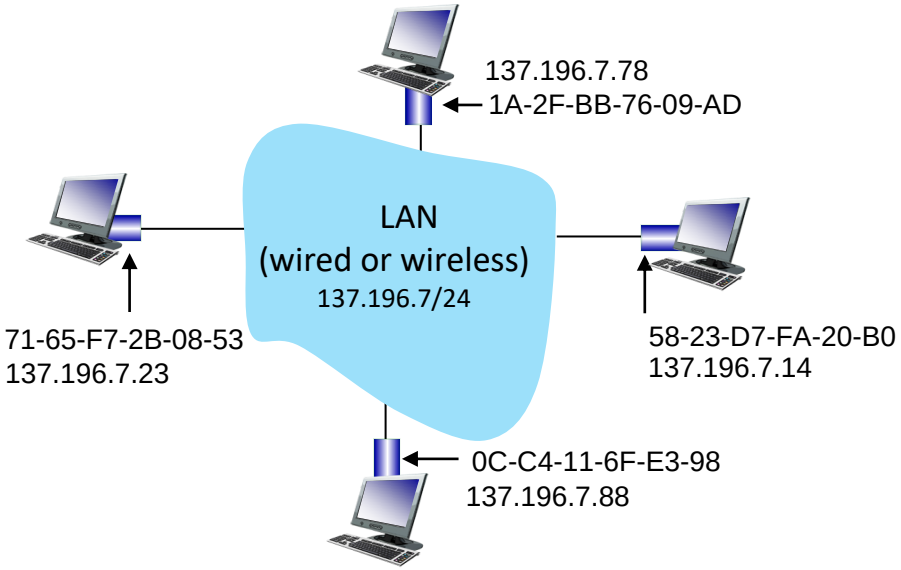
- 32-bit IP address:
  - *network-layer* address for interface
  - used for layer 3 (network layer) forwarding
  - e.g.: 128.119.40.136
- MAC (or LAN or physical or Ethernet) address:
  - function: used "locally" to get frame from one interface to another physically-connected interface (same subnet, in IP-addressing sense)
  - 48-bit (6 bytes) MAC address (for most LANs) burned in NIC ROM, also sometimes software settable (thus 2^{48} possible MAC addresses)
  - e.g.: 1A-2F-BB-76-09-AD (each byte of the address expressed as a pair of hexadecimal numbers)

hexadecimal (base 16) notation
(each "numeral" represents 4 bits)

MAC addresses

each interface on LAN

- has unique 48-bit MAC address
- has a locally unique 32-bit IP address (as we've seen)

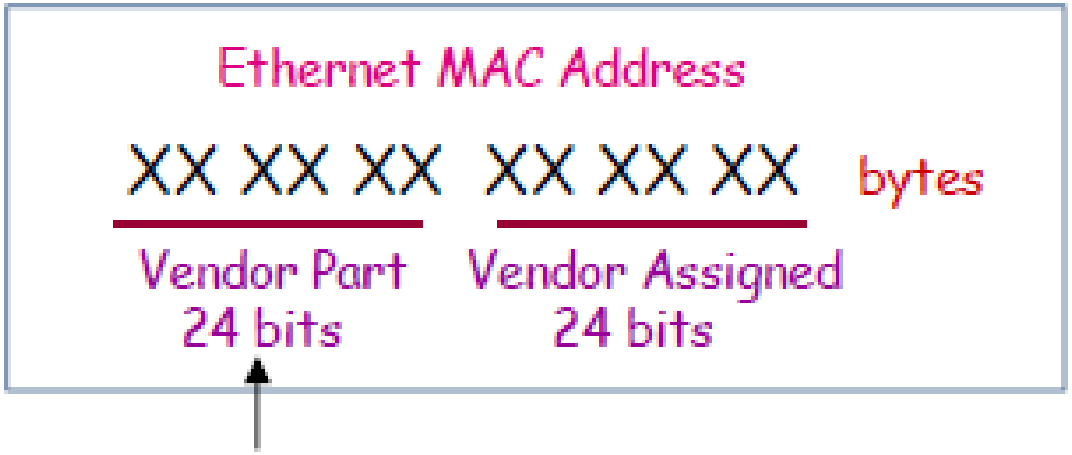


MAC addresses

- MAC address allocation administered by IEEE
- manufacturer buys portion of MAC address space (to assure uniqueness)
- analogy:
  - MAC address: like Social Security Number
  - IP address: like postal address
- MAC flat address: portability
  - can move interface from one LAN to another
  - recall IP address *not* portable: depends on IP subnet to which node is attached

MAC Addresses

- Source and destination MAC addresses. These are the hardware addresses. They are 48-bits long each



http://standards.ieee.org/regauth/oui/
http://www.cavebear.com/CaveBear/Ethernet/

Types of MAC Addresses

- **Unicast**: one interface to one interface
  - Means when an adapter receives a frame, it will check to see whether the destination MAC address in the frame matches its own MAC address. If there is a match, the adapter extracts the enclosed datagram and passes the datagram up the protocol stack. If there isn't a match, the adapter discards the frame, without passing the network-layer datagram up.
- **Broadcast**: all 1's destination address means that every attached interface to a LAN should read the frame.
  - MAC Address: FF:FF:FF:FF:FF:FF
- **Multicast**: an interface can be configured to read frames sent to one or more multicast addresses.

Key Questions

- How does a host/router get the MAC address of another host/router on the same LAN?
  - Answer: Address Resolution Protocol: ARP
- How does a host get the IP address of another host across the Internet?
  - Answer : Domain Name System: DNS
- How does a host get it's own IP address?
  - Answer: Dynamic Host Configuration Protocol (DHCP)
- How do we distinguish between two or more applications running on the same host?
  - Answer: Port Numbers/Sockets

Assignement # 6 (Chapter – 6)

- *6th Assignment will be uploaded on Google Classroom on Thursday, 30th November, 2023, in the Stream - Announcement Section*

- *Due Date: Tuesday, 5th December, 2023 (Handwritten solutions to be submitted during the lecture)*

- *Please read all the instructions carefully in the uploaded Assignment document, follow & submit accordingly*

Quiz # 6 (Chapter – 6)

- *On: Tuesday, 5th December, 2023 (During the lecture)*

- *Quiz to be taken during own section class only*