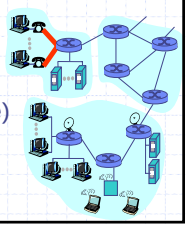
ECE453 – Introduction to Computer Networks

Lecture 7 – Multiple Access Control (I)

1

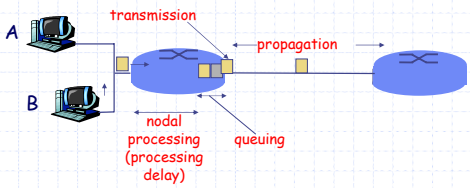
Broadcast vs. PPP

- Broadcast channel = multiaccess channel = random access channel
- Broadcast
  - LAN
  - Satellite network
- PPP
  - WAN (router-router lease line)
  - Home user ←→ ISP



Delay

- Packet experiences delay from end to end
- Nodal delay = processing delay + queuing delay + transmission delay + propagation delay



3

The Channel Allocation Problem

- Static Channel Allocation in LANs and MANs
  - FDM or TDM
  - Problems
    - Fewer than N users
      - A valuable chunk of time (TDM) or bandwidth (FDM) is wasted
    - More than N users
      - Some users are denied (even if another user is idle)
    - Exactly N users
      - Idle users waste bandwidth
      - e.g. bursty traffic
- Dynamic Channel Allocation in LANs and MANs

4

Five Assumptions for Dynamic Channel Allocation

- Station Model
  - N independent stations generating frames
  - Once a frame is generated, the station is blocked until the frame has been transmitted
- Single Channel Assumption
  - A single channel is available for all communication
  - All stations are equivalent
- Collision Assumption
  - If two frames are transmitted simultaneously, they overlap in time and the resulting signal is garbled. This event is called a *collision*.
  - All stations can detect collisions.
- Time Assumption
  - Continuous time
  - Slotted time
- Carrier assumption
  - Carrier Sense (LAN)
  - No Carrier Sense (Satellite)

5

Multiple Access Protocols

- ALOHA
- Carrier Sense Multiple Access Protocols
- Collision-Free Protocols
- Limited-Contention Protocols
- Wireless LAN Protocols

6

Some Terminologies

- Contention systems
  - Systems in which multiple users share a common channel in a way that can lead to conflicts
- Throughput
  - The maximum continuous traffic rate that a device can handle without dropping a single packet.
  - Measured in terms of the number of frames per second at a given frame size
- Frametime
  - Time used to transmit a frame (frame_size/data rate)

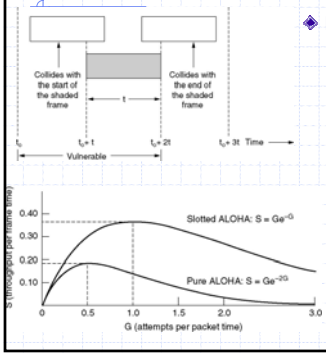
7

ALOHA

- Pure ALOHA
  - 1970, Norman Abramson, U. of Hawaii
  - Users transmit whenever they have data
  - When collision occurs, wait for a **random** amount of time and send again
- Slotted ALOHA
  - 1972, Roberts
  - Divide time into discrete intervals
  - A computer is not permitted to send until the beginning of the next slot
  - Doubles the maximum throughput

8

*ALOHA – Performance Analysis



- Poisson process (1837)
  - Simplest model for arrivals into a queue system
  - the probability of an arrival in a small interval of time depends only on the size of the interval
  - The probability that k frames are generated during a given frame time follows the Poisson distribution

$$\Pr[k] = \frac{G^k e^{-G}}{k!}$$

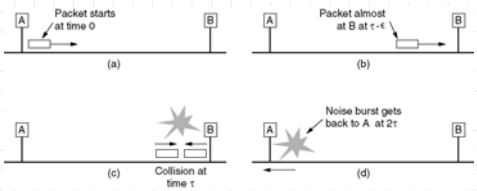
9

CSMA – Carrier Sense Multiple Access (LAN)

- 1-persistent
  - When idle, transmit a frame
  - When busy, **continuously** sensing
  - When collision, wait for a random amount of time
- Non-persistent
  - When idle, transmit a frame
  - When busy, wait for a random amount of time
  - When collision, wait for a random amount of time then re-sense
- p-persistent
  - Slotted channels
  - When idle, transmit with a probability p, defers until the next slot with probability 1-p
- CSMA with collision detection (CSMA/CD)
  - As soon as a collision is detected, abort the transmission
  - Basis of Ethernet LAN

10

A Worst Case Scenario

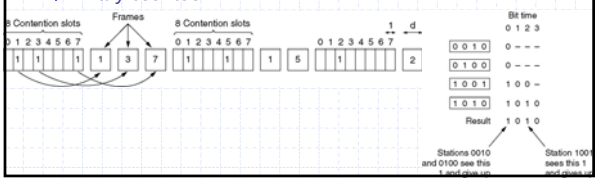


Collision detection can take as long as 2τ.

11

Collision-Free Protocols

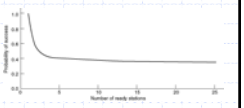
- Assumption
  - N stations with a unique address from 0 to N-1
  - Propagation delay is negligible
- The bit-map protocol
  - A reservation protocol: the desire to transmit is broadcast before the actual transmission
- Binary countdown

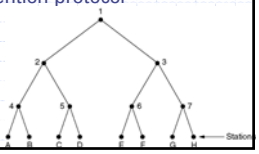


Limited-Contention Protocols

- ALOHA
  - Low load: improved efficiency
  - High load: high delay
- Collision-free protocols
  - Low load: high delay
  - High load: improved efficiency
- New protocol? – limited contention protocol
  - Uses contention at low load
  - Uses collision-free at high load
  - Adaptive tree walk protocol

$$\Pr[\text{success with optimal p}] = \left(\frac{k-1}{k}\right)^{k-1}$$





$$i = \log_2^q$$

Wireless LAN Protocols

- (a) The hidden station problem (C → B)
- (b) the exposed station problem (C → D)

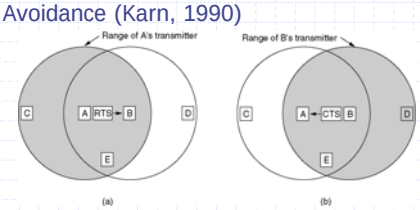
- Activity around the receiver vs. activity around the sender

Problem: limited radio range

14

Wireless LAN Protocols

- MACA – Multiple Access with Collision Avoidance (Karn, 1990)



Solution: RTS (Request To Send) – contains the length of frame
CTS (Clear To Send) – contains the data length too

15

Multiple Access Protocols

- ALOHA
  - Pure ALOHA
  - Slotted ALOHA
- Carrier Sense Multiple Access Protocols (CDMA)
  - 1-persistent
  - Non-persistent
  - *p*-persistent
  - CDMA/CD (Ethernet)
- Collision-Free Protocols
  - Bitmap protocol
  - Binary countdown
- Limited-Contention Protocols
  - Contention when load is light
  - Collision-free when load is heavy
- Wireless LAN Protocols

16