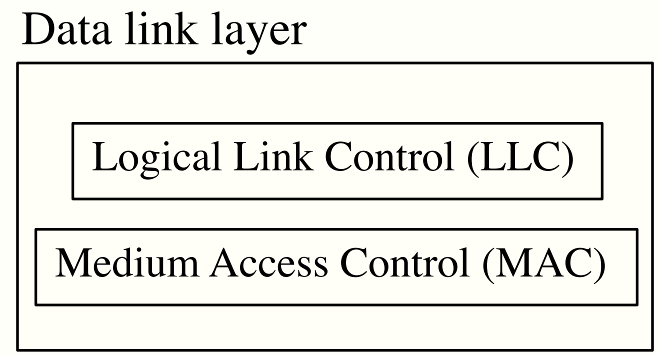
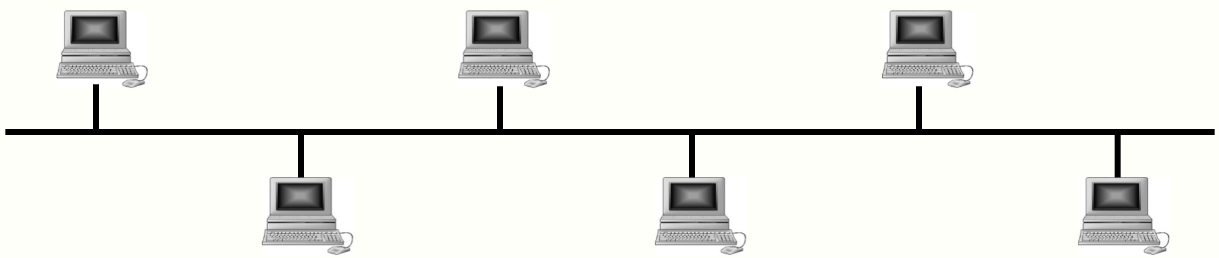
Overview

- Last Lecture
  – Introduction to networks
- This Lecture
  – Medium access control
  – Source: Sections 12
- Next Lecture
  – Flow control & Error control
  – Source: Sections 11.1-11.2, 23.2



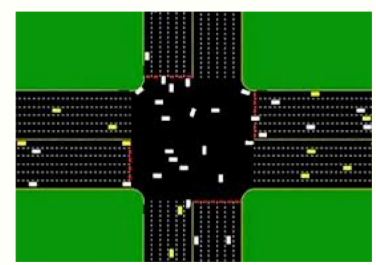
Medium Access Control

- Why have medium access control?
  - Shared communication medium
  - Multiple stations access the medium



Medium Access Control Methods

- Multiple-access protocols
  - Random-access protocols
    - ALOHA
    - CSMA
    - CSMA/CD
    - CSMA/CA
  - Controlled-access protocols
    - Reservation
    - Polling
    - Token passing
  - Channelization protocols
    - FDMA
    - TDMA
    - CDMA



Random Access

- Random Access/Contention
  - There is no scheduled time for a station to transmit
  - Stations compete with one another to access the medium
- Collision
  - Access conflict: two or more stations access the transmission medium with some overlap.
  - Frames will be either destroyed or modified
- Why do we have contention and collision?
  - Medium sharing
  - Examples in human communication

Contention and Collision (cont.)

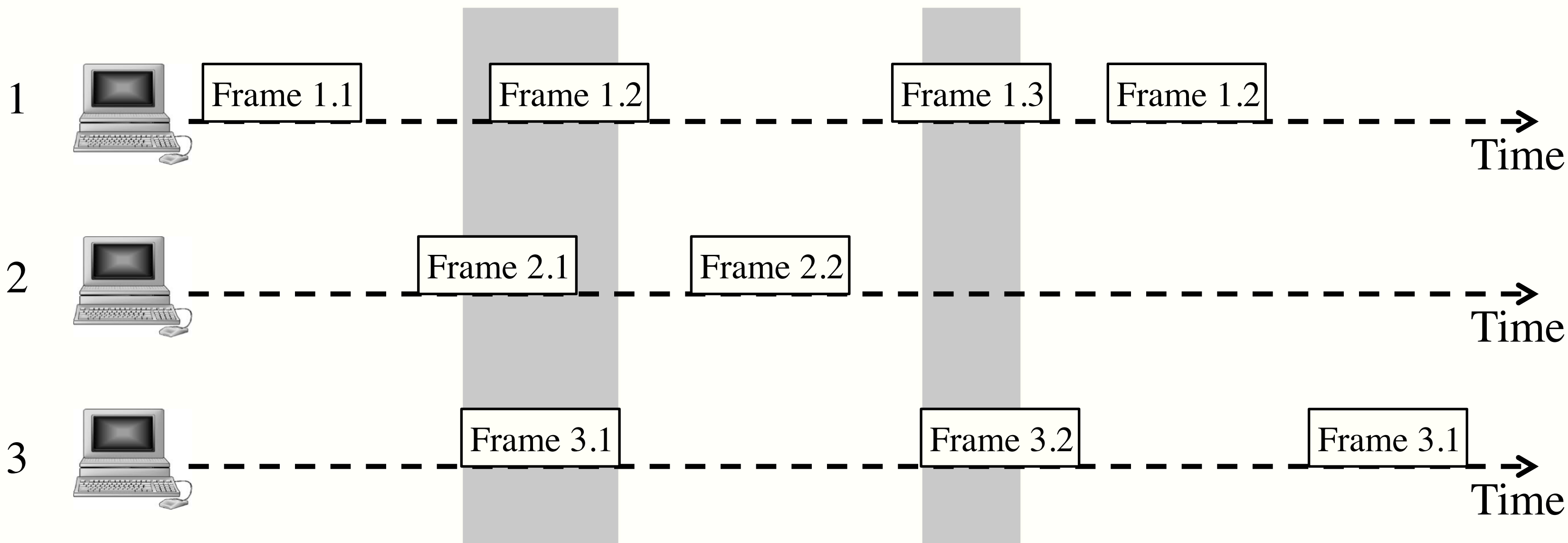
- How to avoid access conflict and resolve it when it happens?
  - When can the station access the medium?
  - What can the station do if the medium is busy?
  - How can the station determine the success or failure of the transmission?
  - What can the station do if there is an access conflict?

Pure Aloha Protocol

- Each station transmits when it has a frame to transmit.
- When the receiver receives a frame, it sends an acknowledgment to the sender.
- If the sender receives an acknowledgment, it knows its data has been received. Otherwise the sender assumes a collision and retransmits.
- If a collision occurs, each collided sender waits a random time before retransmission.

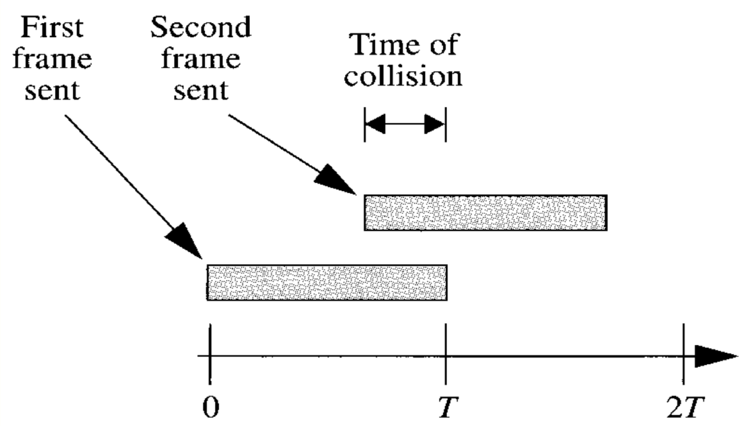
Analysis of Pure Aloha

- A simple but elegant protocol
- The randomness helps avoid more collisions.
- Works fine if there is not much traffic.



Analysis of Pure Aloha (cont.)

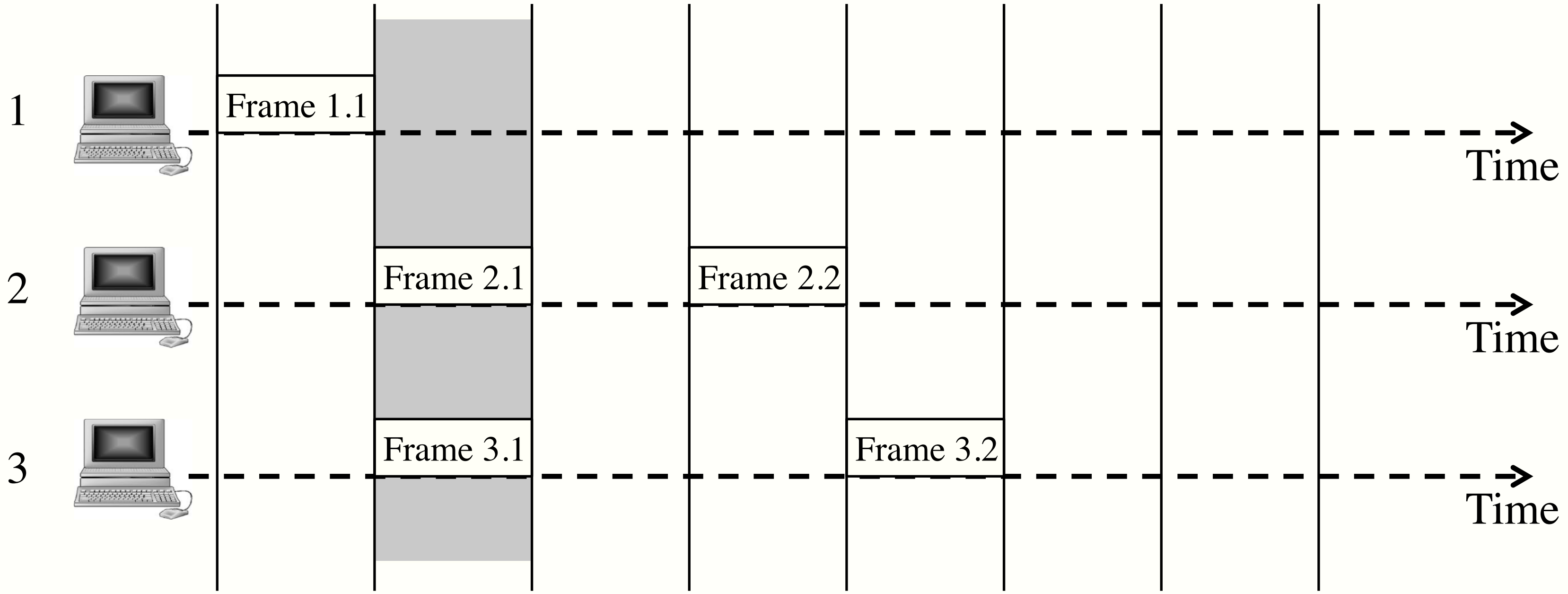
- Poor channel utilisation
  - T is time to transmit a packet.
  - Consider an interval 2T
  - One sender's packet begins at the start of the interval; another sender begins at the end of the interval.
  - The collision wastes up to 2T time



(a) Transmission Using Pure Aloha

Slotted Aloha Protocol

- Divide time into intervals (slots) of T units each.
- Each station sends only at the beginning of a slot.



Comparison of Pure & Slotted Aloha

- Wasted time due to collision is reduced to T

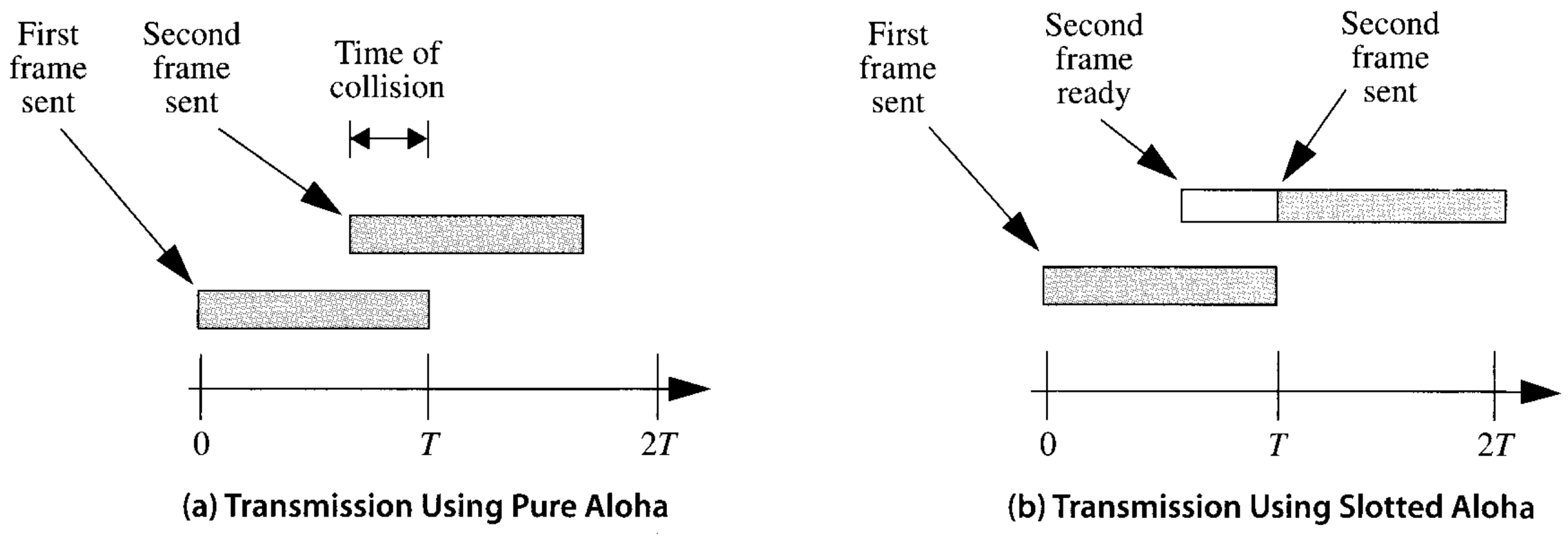


Figure 3.24 Transmission Using Pure Aloha and Slotted Aloha

Comparison of Pure & Slotted Aloha (cont.)

- Success rate for transmission
  - G is the average number of frames generated per slot
  - S is the average number of frames sent successfully per slot

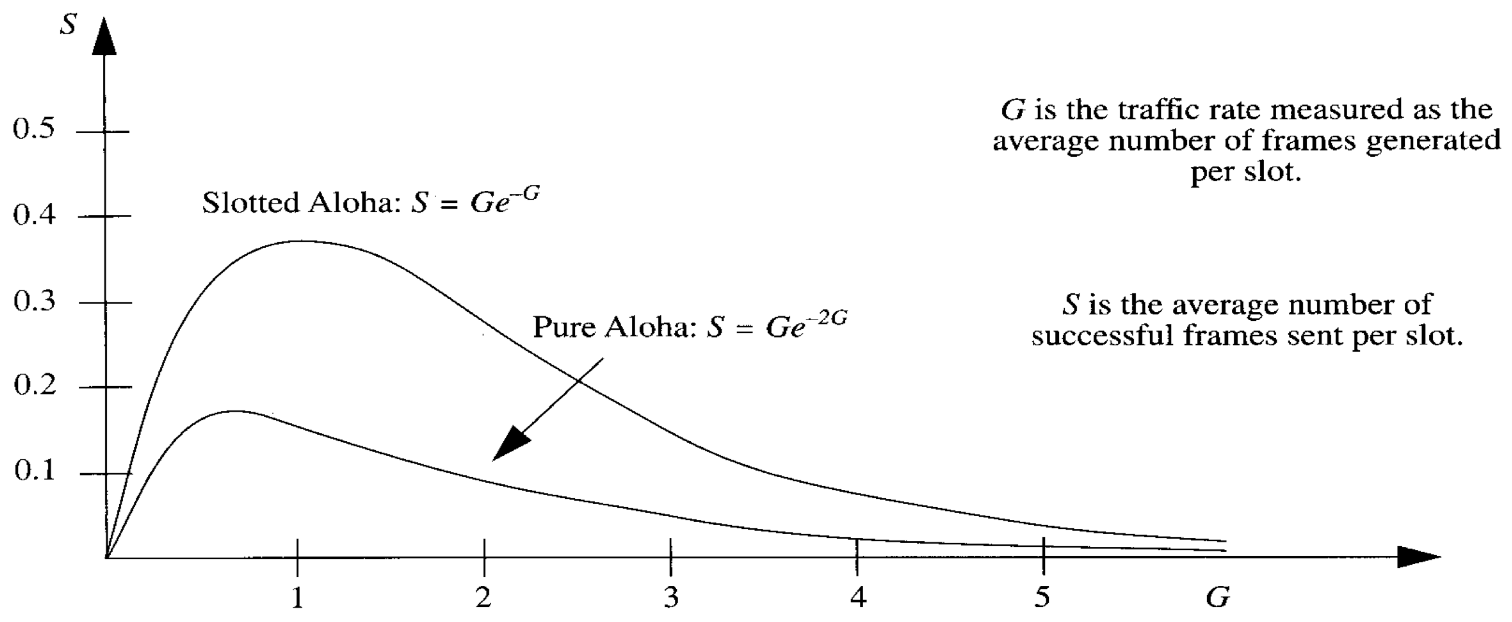
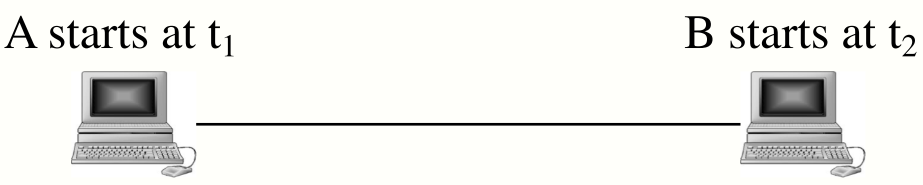


Figure 3.25 Success Rate for Slotted and Pure Aloha Protocols

CSMA

- Carrier Sense Multiple Access (CSMA)
  - “Sense before transmit” or “listen before talk”
  - If a station has a frame to send:
  - It first check the status of the medium.
  - If there is no activity, transmit; otherwise, wait.
  - Does it eliminate collisions?

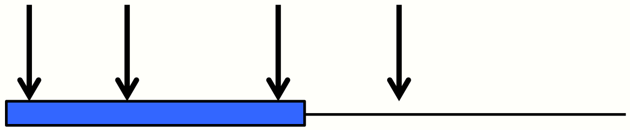


(1) $t_1 = t_2$

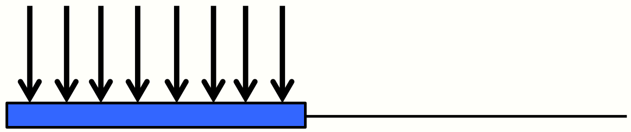
(2) $t_1 < t_2$ or $t_1 > t_2$, $|t_1 - t_2| < \text{propagation delay}$

Medium Sensing Methods

- Nonpersistent method
  - If the medium is not idle, wait a random amount time and then senses again
  - Reduce collision, reduce network efficiency



- Persistent method
  - If the medium is not idle, **continuously** sense the medium.
  - p-Persistent method



p-Persistent CSMA

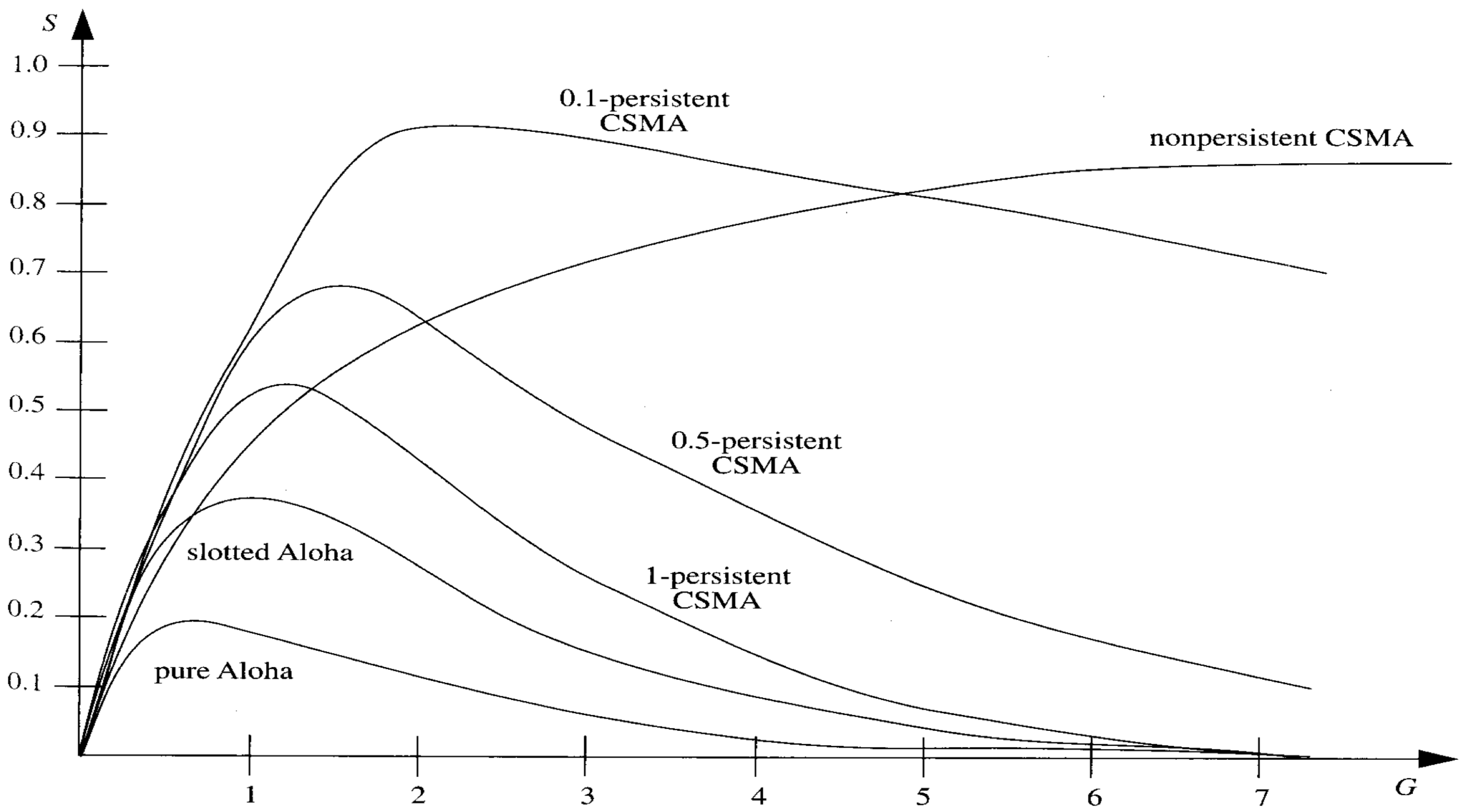
- Method:
  - Listen to the medium
  - If there is no activity, transmit; otherwise, continue to monitor the medium.
  - When the medium becomes idle, transmit with a probability *p*; otherwise wait for the next time slot (probability 1-*p*) and repeat the above steps.
    - If p = 1, we call it **1-persistent CSMA**, which means it always transmits when the medium is quiet.
    - If p = 0, we call it **0-persistent CSMA**, which means it always waits for one time slot.

Collisions with p-Persistent CSMA

- Collisions still occur.
- If p = 0.5 and there are 2 stations, 4 possibilities exist when the medium becomes idle.
  - Both transmit immediately
  - Both wait
  - Station A sends and station B waits
  - Station A waits and station B sends
- Result
  - 0.5 probability one will transmit successfully
  - 0.25 probability medium will not be used
  - 0.25 probability of collision

Success Rate of CSMA and Aloha

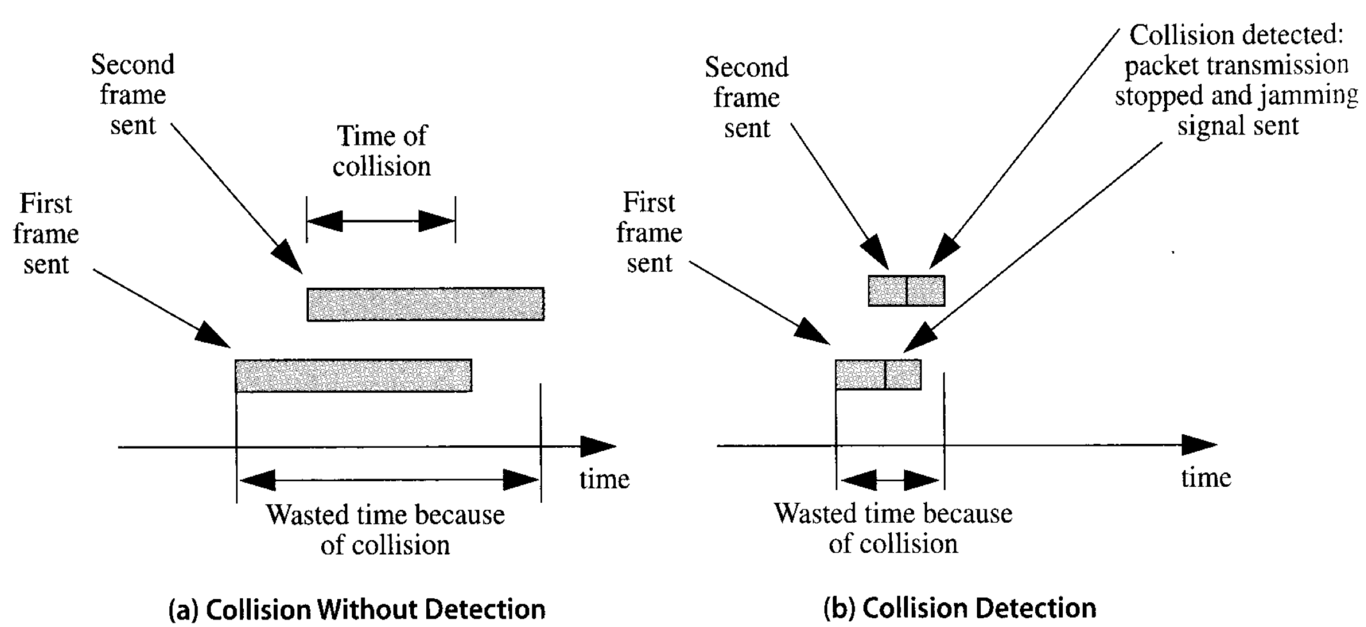
Figure 3.26 Success Rate of CSMA and Aloha Protocols



Collision Detection

- Can we do better?
- Is there some way to have a station monitor the medium to listen for collisions?

Figure 3.27 Collision with and without Detection



CSMA/CD

- Carrier Sense Multiple Access with Collision Detection
  - To send a frame, listens to the medium to see if it is busy.
  - If the medium is busy, waits per the persistent CSMA.
  - If the station is able to transmit a frame, it listens to the medium for collision while transmitting the frame.
  - If it detects a collision, it immediately stops the transmission and sends a short jamming signal.
  - If it receives a jamming signal, it stops the transmission immediately.
  - After a collision, it waits a random amount of time according to the **Binary Exponential Backoff** algorithm and then repeats the above steps.

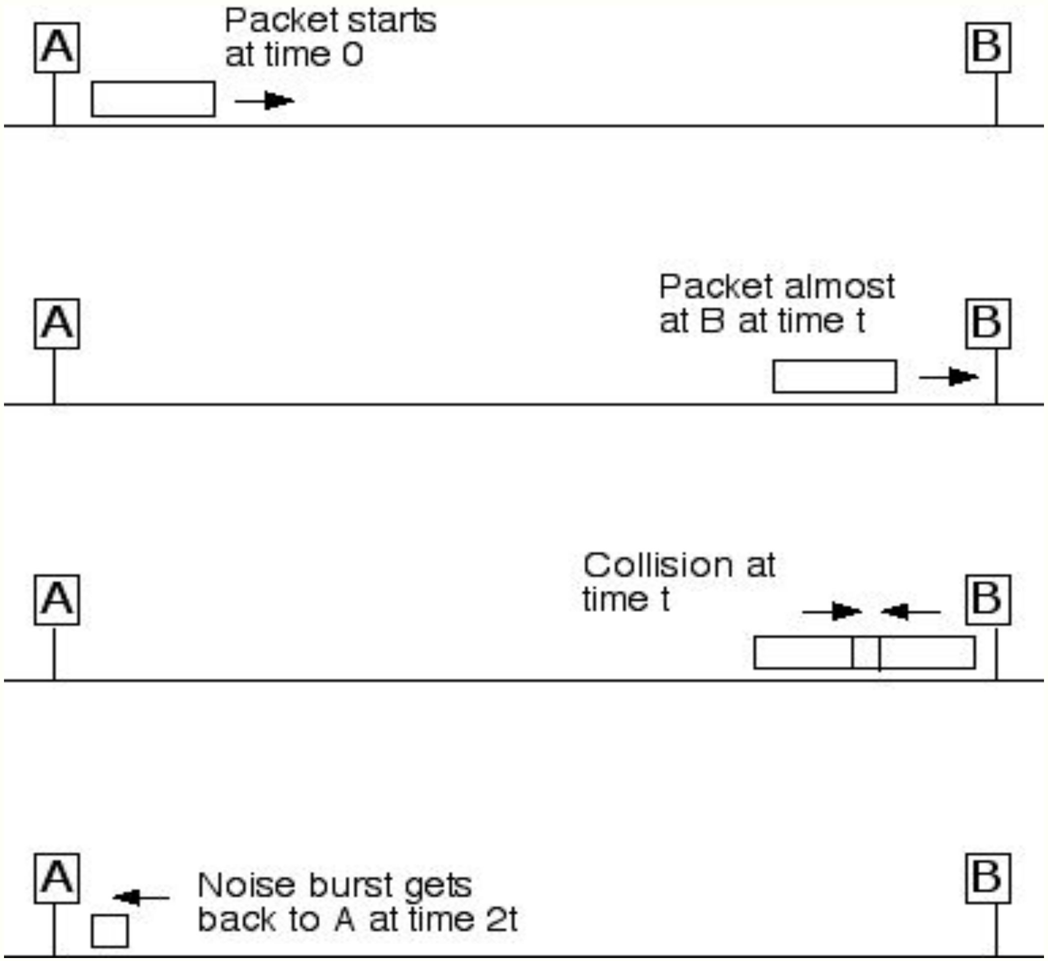
Binary Exponential Backoff Algorithm

- Algorithm:
  - If a station's frame collides for the first time, wait 0 or 1 time slot (randomly chosen)
  - If it collides a second time, wait 0, 1, 2, or 3 slots (randomly chosen)
  - After a third collision, wait from 0 to 7 slots.
  - After *n* collisions, wait from 0 to 2^n-1 slots if n <= 10. If n > 10, wait from 0 to 1024 (2^{10}) slots
  - After 16 collisions, give up and report an error.

Frame Size and Transmission Distance

- If frames are too large, one station can monopolise the medium; but if a frame is too small, a collision may not be detected.
- Collision detection requires a minimum size frame so a station can detect a collision before it finishes sending its frame. If it detects a collision after the frame is sent, it does not know if its frame was involved.
- How small can a frame be?
  - Example: Assume coax cable with a rate, B=10 Mbps; longest distance, L= 2 km; propagation rate, P=200 m/μsec. Then the minimum frame size required MF=((2*L)/P)*B=200bits=25bytes
- According to IEEE802.3 standard, Ethernet requires a minimum frame size of 512 bits

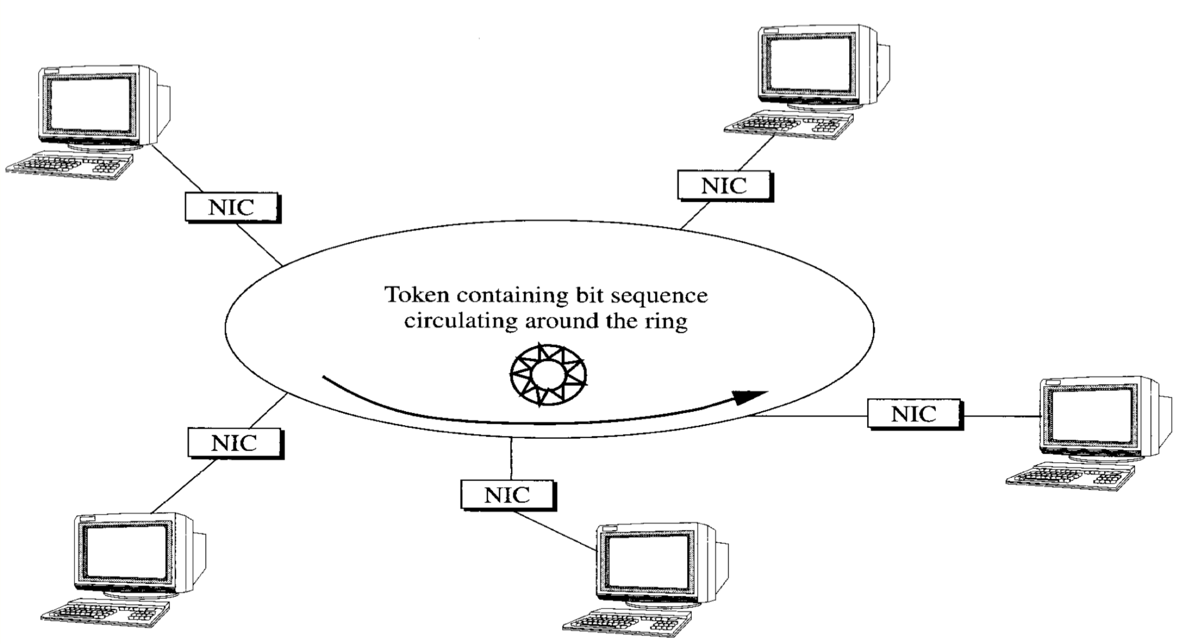
Frame Size and Transmission Distance (cont.)



Token Passing

- The stations are organized into a logical ring.
- Token - a specially frame that circulates the ring
- A station can transmit data only when it has the token frame.

Figure 3.28 Token Ring Network



Token-Passing Protocol

- When a station receives the token frame:
  - If it wants to transmit data, it inserts data into the token frame which then becomes a data frame, and passes the frame to the next neighbour.
  - If it does not have data to transmit, it passes the token to the next neighbour.

Token-Passing Protocol (cont.)

- When a station receives a data frame:
  - If the station is the sender of the data frame, it removes the data from the frame, makes the frame a token frame, and passes the token to the next neighbour.
  - If it is the destination of the frame, it copies data from the frame to its memory and passes the frame to the next neighbour.
  - If the station is not the destination or the sender of the frame, it passes the frame to the next neighbour.

Monopoly on a Token Ring

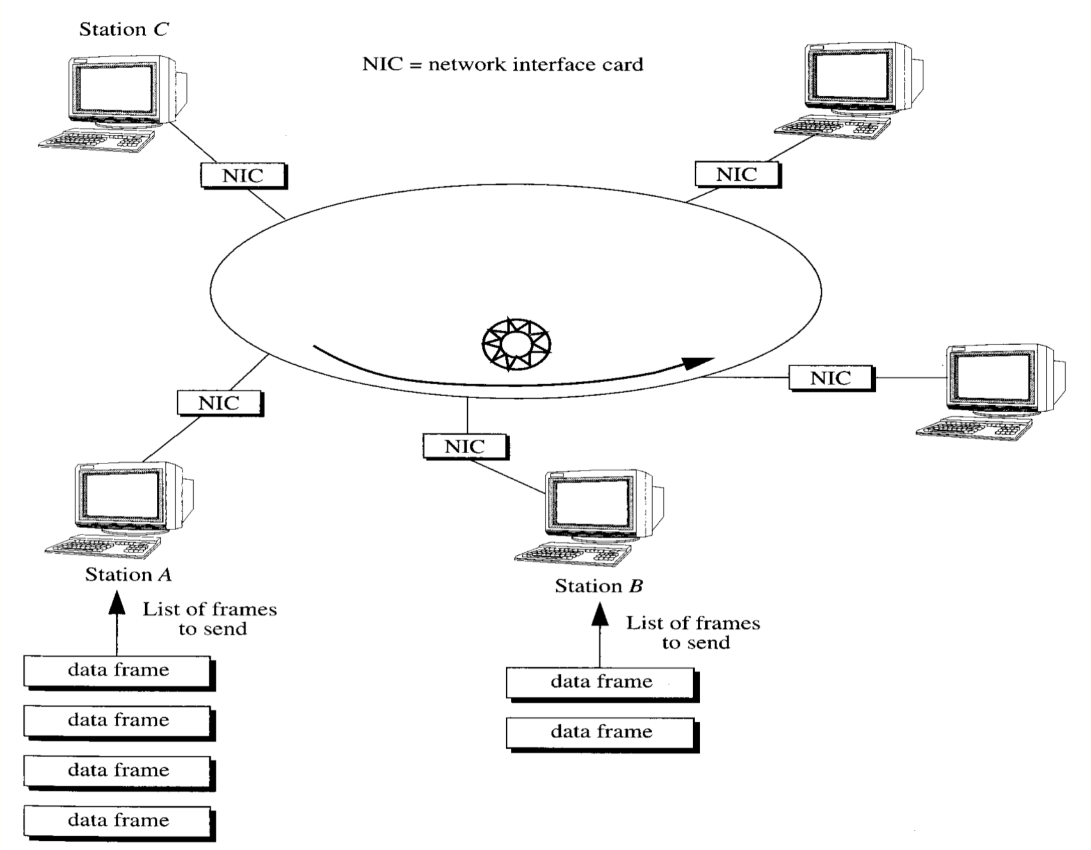


Figure 3.29 One Station Sending Many Frames

Slotted Ring

- Similar to token ring except it contains several rotating tokens or slots.
- A station must wait for a free slot.
- A station cannot send any other frames until the slot that carried its previous data frame returns.

Ring Problems

- A break in a link between any two stations can bring the network down.
- A faulty interface card can result in a "lost" token or an improperly formatted token.
- If a station sends a data frame and fails before removing its data, the frame circulates forever.

Summary

- Concepts
  - Contention
  - Collision
- Contention protocols
  - Aloha protocol
  - Slotted Aloha Protocol
  - Carrier Sense Multiple Access (CSMA)
    - p-persistent CSMA
    - Non-persistent CSMA

Summary (cont.)

- CSMA/CD protocol
    - Binary Exponential Backoff
    - Relationship between frame size and transmission distance in CSMA/CD
- Token method
    - Simple token ring
    - Slotted ring