ITM 1010
Computer and Communication Technologies

Lecture #15

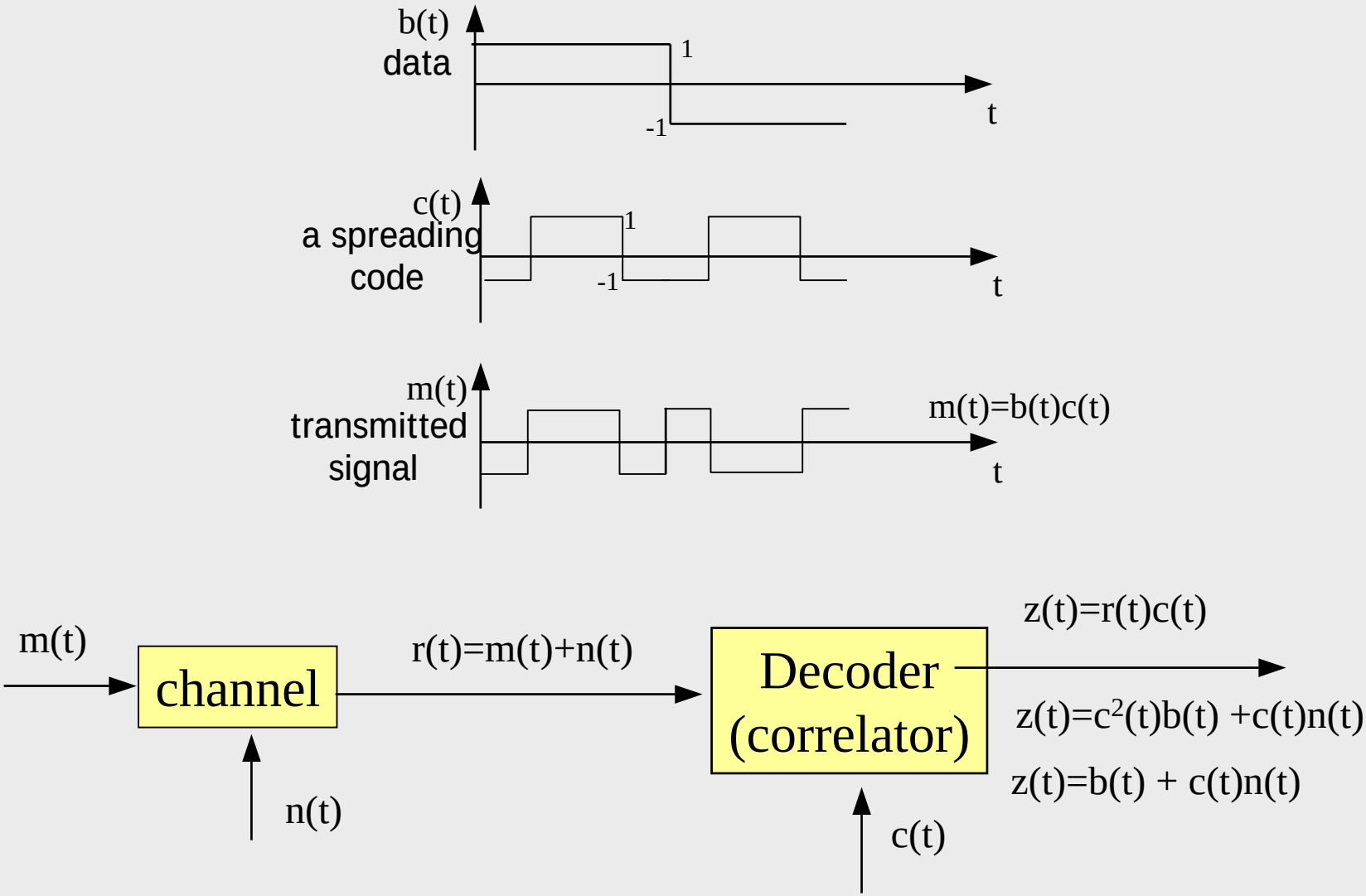
Part II Introduction to Communication Technologies:

Channel Sharing II: Multiple Access

Multiple Access

- Important distinction from multiplexing: must set-up a channel before it can be used
- Multiple access techniques include:
  - Time division multiple access (TDMA is used in mobile phone networks)
  - Frequency or wavelength division multiple access (WDMA)
  - Code division multiple access (CDMA, also used in mobile phone networks)
- Multiple access techniques may be combined (eg FD/TDMA)
- Multiple access is used in computer local area networks

How does a spreading code work?



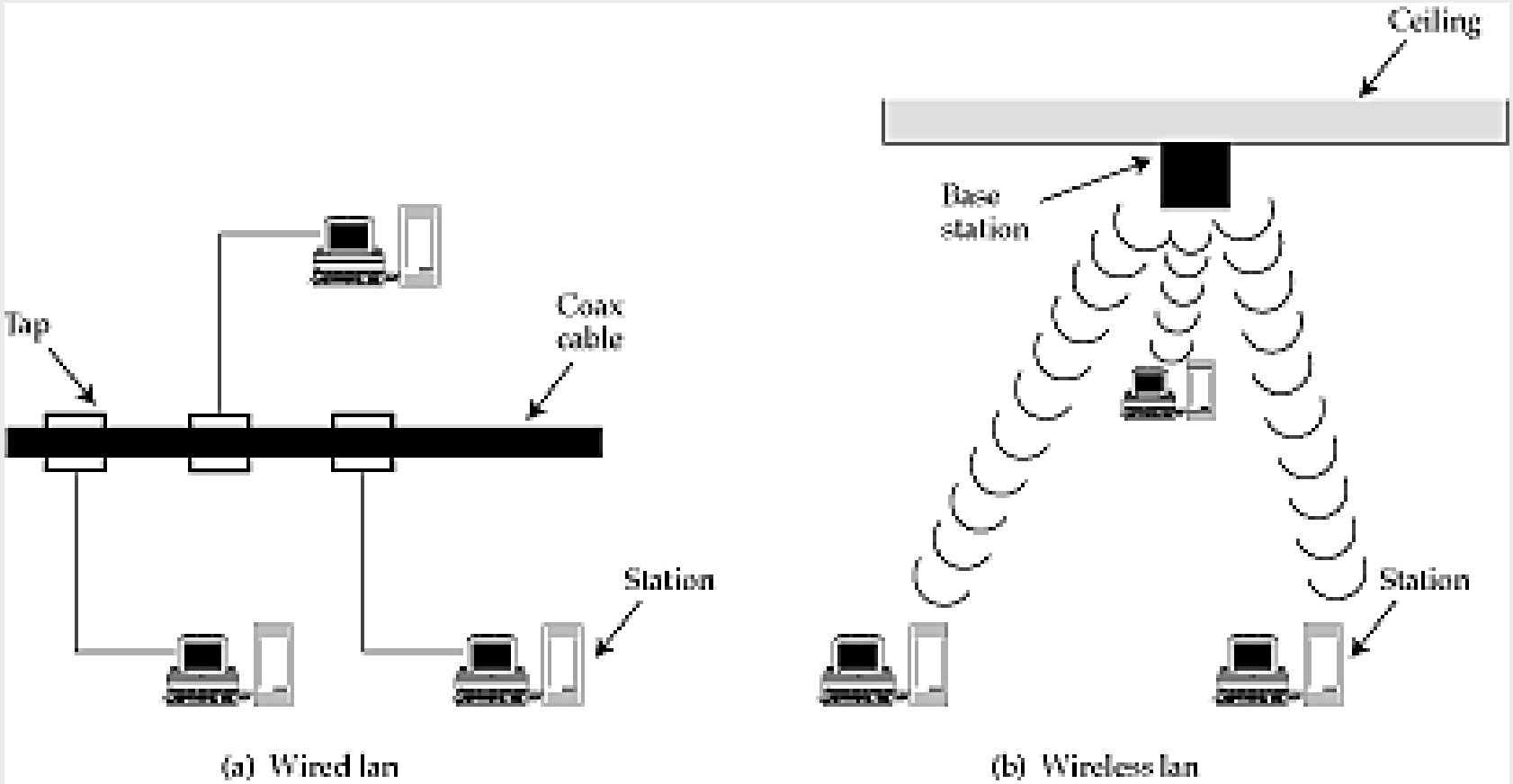
Code Division Multiple Access (CDMA)

- CDMA does not require the frequency band allocation as in FDMA nor the time synchronization as in TDMA
- All users share the same channel and may transmit at the same time and in the same frequency band. CDMA is typically used in wireless networks (eg digital mobile phone networks)
- Messages from each user are distinguishable because each user has his own “spreading code”. The cross-correlation between two different spreading-codes is zero.
- The receiver must use a correlator that is matched to a particular code to distinguish an individual message: other messages will appear as noise which averages out to zero.

Multiple Access Control - What is it?

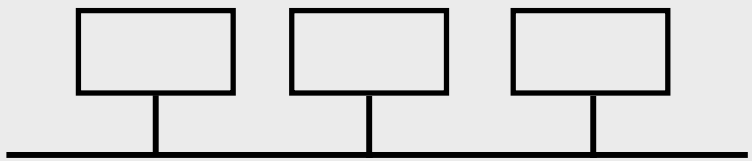
- Consider a meeting where
  - if one person speaks, all can hear
  - if more than one person speaks at the same time, messages are lost
- How should participants coordinate actions so that
  - the number of messages exchanged per second is maximized
  - time spent waiting for a chance to speak is minimized
- This is the *multiple access problem*

Multiple Access

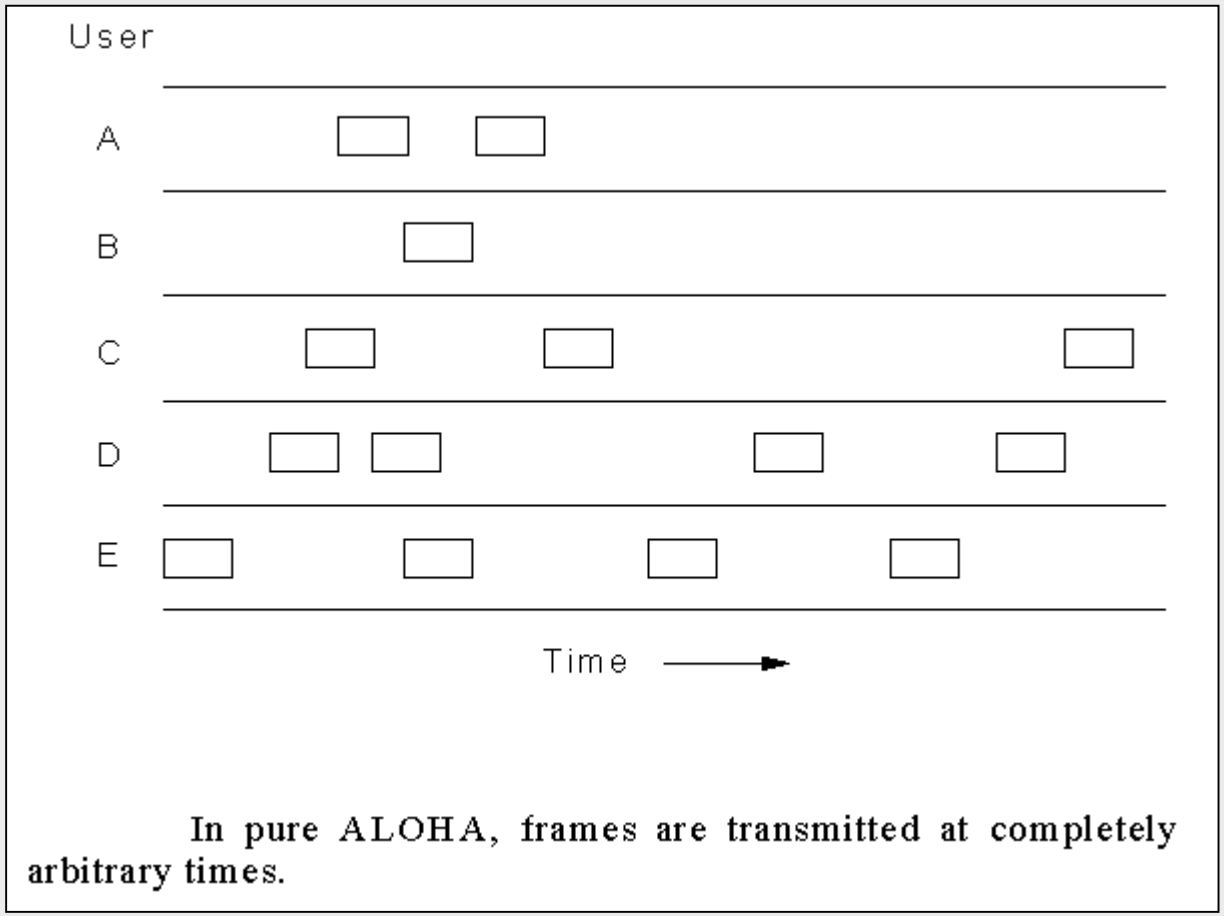


Aloha network (Abramson, 1970)

- Originally designed for ground radio
- Simplest type of multiple access channel network
- Many stations share the same channel
- if only one station is transmitting, OK
- if more than one station transmit -> collision
  - message is destroyed
  - sender can always detect whether the message is destroyed or not by listening to the channel
  - retransmit after a RANDOM period of time
    - each station must each wait a random period of time, otherwise they will retransmit data at about the same time



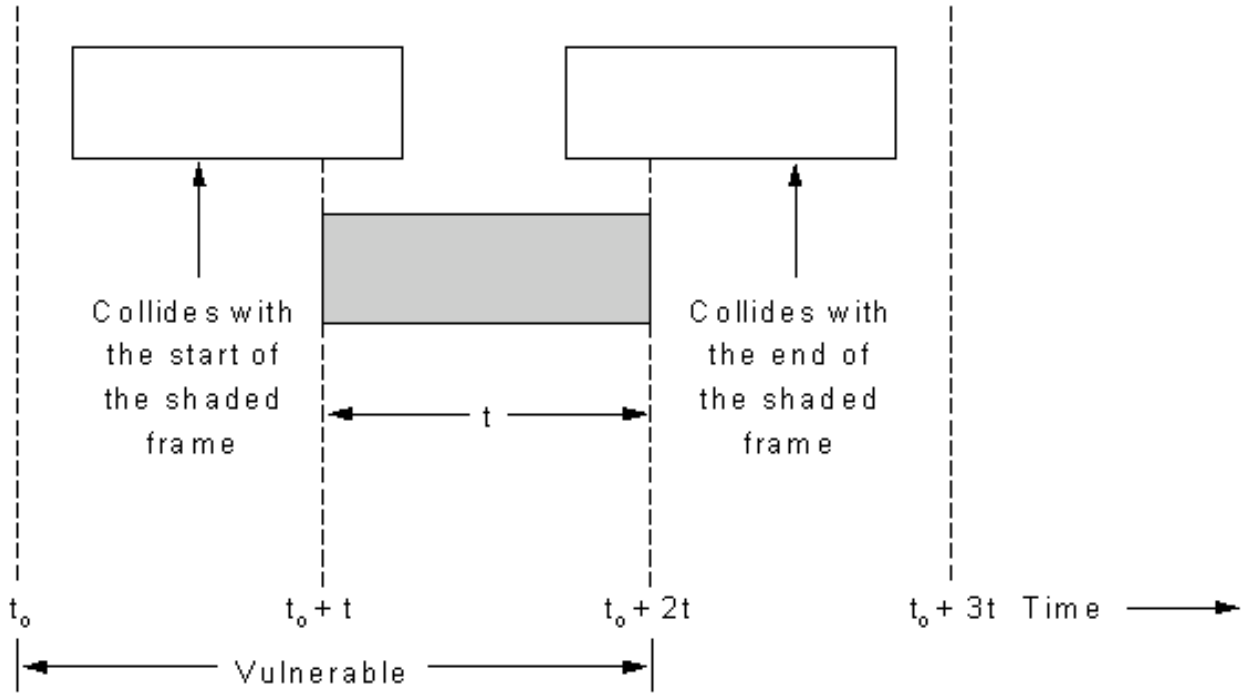
Aloha network



In pure ALOHA, frames are transmitted at completely arbitrary times.

Aloha network

- Assume the time to transmit a frame is fixed at t
- Successful transmission if no other transmission in 2t interval

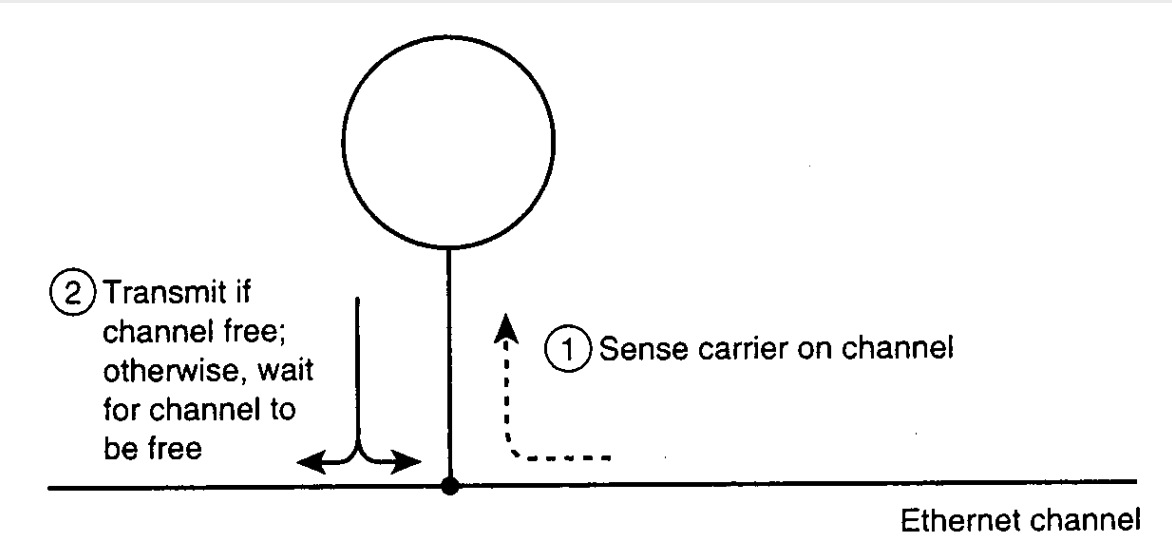


Vulnerable period for the shaded frame.

Slotted Aloha network

- Improve performance of Aloha by dividing the transmission time into slots
  - stations can transmit frames only at the beginning of a slot
  - if a station has a packet to send at a certain time in slot N, it has to delay sending the frame till the beginning of slot N+1
- What is the advantage?
  - Suppose the slot time is t, frames will collide only if both stations attempt to send data frames during slot N (both wait, transmit and collide at the beginning of slot N+1)
  - compare with Aloha network, the vulnerable period is reduced from 2t to t

Listen before talking

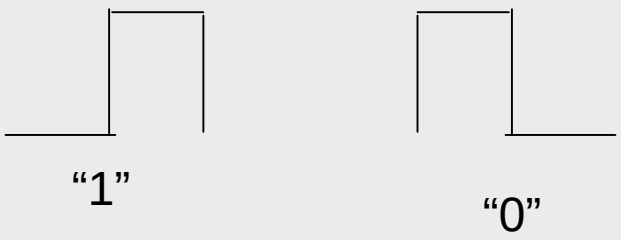


- If a station detects a busy channel, the station refrains from transmission.
- After channel appears to be free, wait a minimum of 9.6μs to provide proper inter-frame spacing. If the channel is still free, transmission is initiated
- If collision detected, cease transmission immediately

Carrier Sense Multiple Access (CSMA)

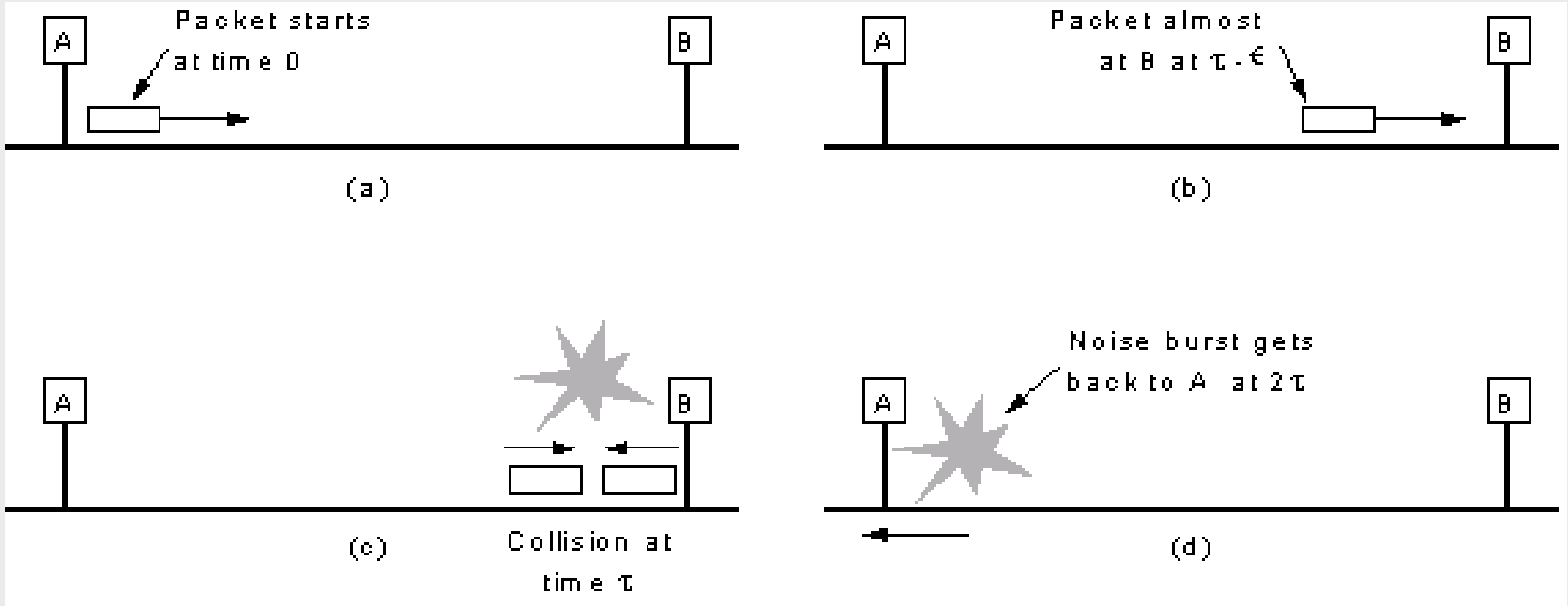
- Carrier sense multiple access
  - if channel is busy, DON`T SEND to avoid collision

- but how to tell whether channel is busy?
  - if binary code is used, cannot distinguish between idle channel with string of zero bits
  - Solution: Use Manchester code
    - 0 and 1 are represented by voltage transition (edge)
    - no edge indicates channel is idle



CSMA

- Collision problem - even with collision avoidance, collision can still happen for two reasons:
  1. propagation delay in cable
  2. stations that avoid sending data during the busy period will transmit immediately after the channel is free



CSMA

- 1-persistent CSMA
  - if channel is free, always send data
    - It is named 1-persistent because the stations transmit whenever it finds the channel free.
  - if channel is busy - wait and listen to the channel until it is free, then send immediately
    - In case of collision, stations will start the back off algorithm
    - **back off** - each station will retransmit after a random period of time
    - collision can be detected by reading back the sent data from channel

CSMA

- non-persistent CSMA
  - if channel is free, sends data
  - if channel is busy, the station does not continually sense it, but starts back-off algorithm
    - this eliminates the risk of collision immediately after the channel is free
    - less collision means better channel efficiency
    - the price to pay is longer delay
- p-persistent CSMA
  - if channel is free, transmit with probability p
    - else wait till next slot (will talk about the optimal slot size later in CSMA/CD)
  - if channel is busy, sense until channel is free, repeat above process
  - again the price to pay is longer delay with less collision

CSMA/CD (Collision Detection)

- Unlike CSMA, CSMA/CD aborts a transmission immediately if collision is detected
  - then start a backoff algorithm
  - the first station to detect the collision sends out a special jamming pulse to alert all stations

- binary exponential backoff algorithm
  - each station picks a random number out of N and then waits for that random number of slot time
  - if N is large, then long average waiting time (N/2 slots)
  - if N is small, in case the number of re-transmitting stations is large, then the chance that data will collide again will be very high

CSMA/CD

- Binary exponential backoff
  - start with a small N (N=2)
    - station choose between 0 (no delay), or 1 (wait 1 slot)
  - if collide again, double N
  - after 10 collision, N is fixed at the maximum value at 1024, the chance that stations will collide again is very small
  - after 16 collision, the algorithm gives up and sends alert message to sys admin
    - the chance that data collides 16 times is so small that more likely there is something wrong with the system

CSMA/CD and Ethernet

- Collision detection
  - A and B are two stations located at the two ends

    τ is the propagation time for signal to travel from A to B
  - it takes time τ for station A to seize the channel
    - because after time τ, the signal will reach all stations on the LAN, and stop other stations in sending data
  - but it may take as long as time 2τ for A to know it has seized the channel
  - if A has completed the transmission before 2τ, it will not be able to detect the collision if it happens
- 10Mb/s Ethernet (IEEE802.3)
  - maximum length of 10Mb/s LAN is specified as 2.5km

    $\Rightarrow \tau = 2.5\text{km}/(2\text{x}10^8\text{m/s}) = 12.5\mu\text{s} \Rightarrow 2\tau = 25\mu\text{s}$
  - therefore 2τ is equivalent to 250 bits time
  - minimum packet size must be greater than 250 bits, The IEEE803.2 defines minimum packet to be 512bits (64 bytes)

Ethernet

- What happen if we extend the network beyond 2.5km?
  - If we extend the maximum distance, τ will be increased too
    - problem 1: chance of collision increase with t
    - problem 2: we need to increase the min frame size
  - because of these problems (particularly the first), CSMA/CD (and CSMA as well) cannot be used for WAN

- What happen if we increase the speed of the network (100Mb/s ethernet)?
  - If we increase the speed by a factor of 10, the max propagation time τ remains unchanged, but packet transmission is completed 10 times faster i.e. may complete the transmission before 2τ period
  - Therefore either the minimum frame size must be increased by the same factor (10 times) or the transmission distance must be reduced (IEEE802.3u specifies a max link of only 100m for 100Mb/s ethernet).

Summary

- Sharing of a channel may be by multiplexing or multiple access
  - Multiplexing: users can transmit data in their own dedicated channel (frequency channel in FDM, time slot in TDM)
  - Multiple Access: Users must first request and set up the channel before transmitting data

- Ethernet standard uses CSMA/CD
  - Maximum distance of ethernet link determined by frame size and bitrate (minimum packet transmission time > 2τ)