# Chapter 4. The Medium Access Control Sublayer

# The Medium Access Control Sublayer

- Networks can be divided into two categories: those using point to-point connections and those using broadcast channels.
- In any broadcast network, the key issue is how to determine who gets to use the channel when there is competition for it.
- When only a single channel is available, determining who should go next is much harder.
- Broadcast channels are sometimes referred to as **multiaccess channels** or **random access channels**.

- The protocols used to determine who goes next on a multiaccess channel belong to a sublayer of the data link layer called the **MAC** (**Medium Access Control**) sublayer.
- The MAC sublayer is especially important in LANs, many of which use a multiaccess channel as the basis for communication.
- WANs, in contrast, use point-to-point links, except for satellite networks.
- Technically, the MAC sublayer is the bottom part of the data link layer.

# 4.1 The Channel Allocation Problem

- **Static Channel Allocation (Fixed Channel allocation)**
- **Dynamic Channel Allocation**

**Static Channel Allocation in LANs and MANs**

- The traditional way of allocating a single channel, such as a telephone trunk, among multiple competing users is Frequency Division Multiplexing (FDM).
- If there are *N users, the bandwidth* is divided into *N equal-sized portions, each user being assigned one portion.*
- Since each user has a private frequency band, there is no interference between users.
- When there is only a small and constant number of users, FDM is a simple and efficient allocation mechanism.

- **Disadvantage:** when the number of senders is large and continuously varying, FDM presents some problems.
- If the spectrum is cut up into *N regions and fewer than N users are currently interested in communicating, a large piece of valuable spectrum will be* wasted.
- If more than *N users want to communicate, some of them will be denied permission* for lack of bandwidth, even if some of the users who have been assigned a frequency band hardly ever transmit or receive anything.
- In TDM based allocation Each user is statically allocated every *Nth time slot. If a user does not use the allocated* slot, it is just wastage of bandwidth.

# Dynamic Channel Allocation in LANs and MANs

- In dynamic channel allocation scheme, frequency bands are not permanently assigned to the users.
- Instead channels are allotted to users dynamically as needed.
- This allocation scheme optimizes bandwidth usage and results is faster transmissions.
- The allocation is done considering a number of parameters so that transmission interference is minimized.

# 4.2 Multiple Access Protocols

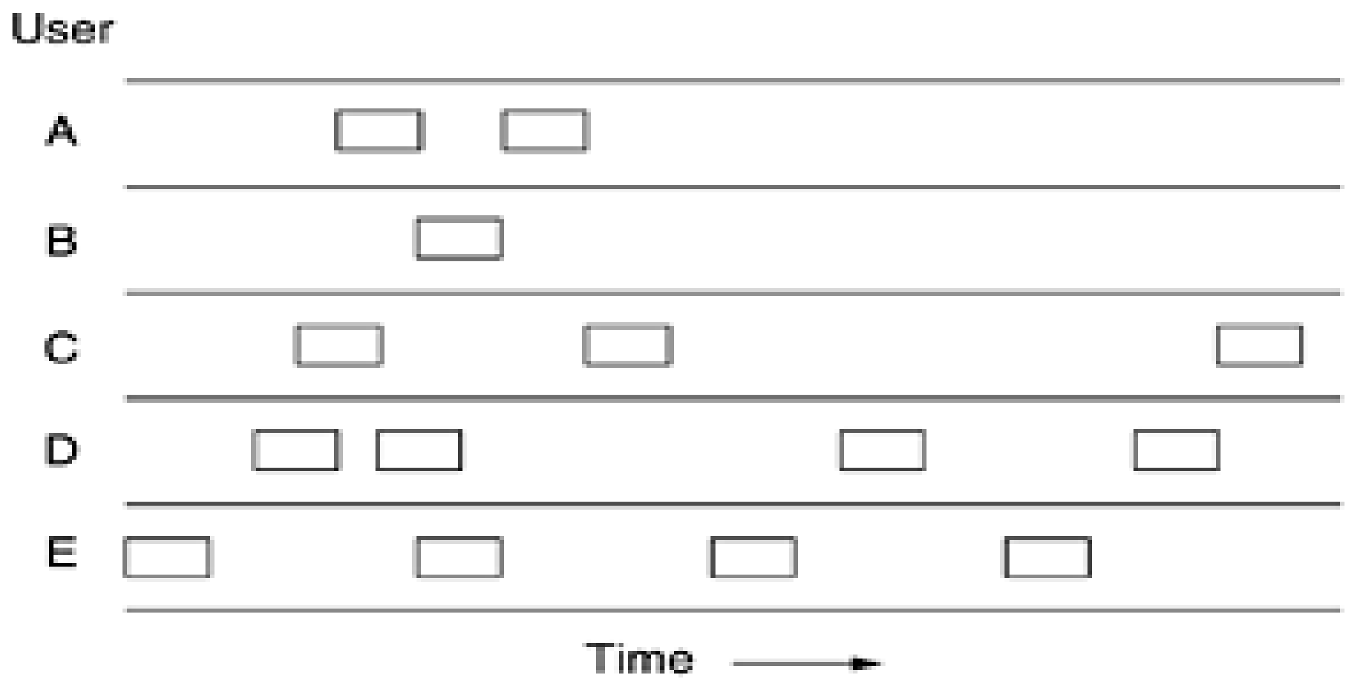
## ALOHA

- In the 1970s, Norman Abramson developed this method to solve the channel allocation problem.
- Two versions of ALOHA here: **pure and slotted**.
- They differ with respect to whether time is divided into discrete slots into which all frames must fit.
- Pure ALOHA does not require global time synchronization; slotted ALOHA does.

# Pure ALOHA

- The basic idea of an ALOHA system: Users transmit whenever they have data to be sent. There will be collisions, of course, and the colliding frames will be damaged.
- However, due to the feedback property of broadcasting, a sender can always find out whether its frame was destroyed by listening to the channel.
- With a LAN, the feedback is immediate; with a satellite, there is a delay of 270 msec before the sender knows if the transmission was successful.
- If listening while transmitting is not possible for some reason, acknowledgements are needed.
- If the frame was destroyed, the sender just waits a random amount of time and sends it again.
- Systems in which multiple users share a common channel in a way that can lead to conflicts are widely known as **contention** systems.

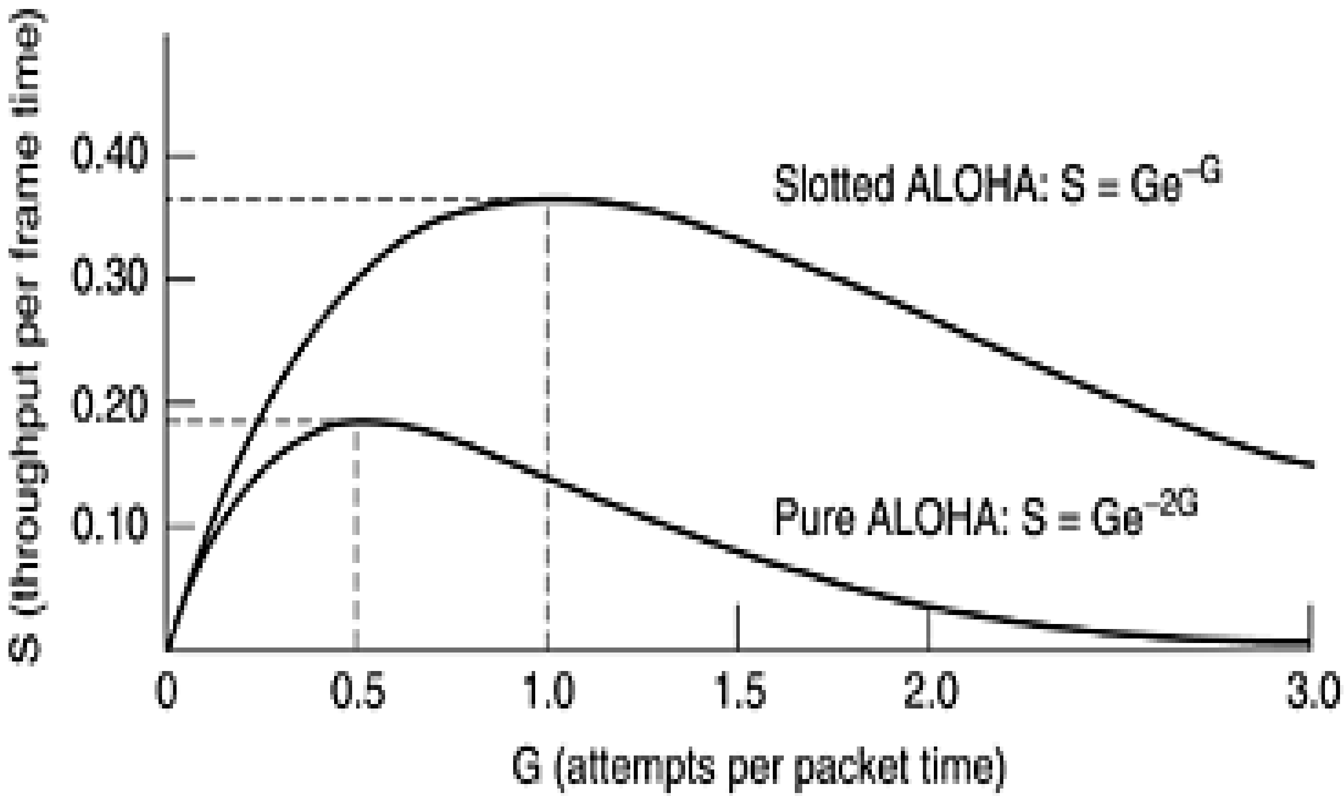
# Figure 4-1. In pure ALOHA, frames are transmitted at completely arbitrary times.



- Whenever two frames try to occupy the channel at the same time, there will be a collision and both will be garbled.
- The checksum cannot (and should not) distinguish between a total loss and a near miss.
- A user is always in one of two states: **typing or waiting.**
- Initially, all users are in the typing state. When a line is finished, the user stops typing, waiting for a response.
- The station then transmits a frame containing the line and checks the channel to see if it was successful. If so, the user sees the reply and goes back to typing.
- If not, the user continues to wait and the frame is retransmitted over and over until it has been successfully sent.
- A frame will not suffer a collision if no other frames are sent within one frame time of its start.
- In pure ALOHA a station does not listen to the channel before transmitting, it has no way of knowing that another frame was already underway.

- An interesting question is: What is the **efficiency of an ALOHA channel?** what fraction of all transmitted frames escape collisions under these chaotic circumstances?
- Throughput $S = Ge^{-2G}$
- The **maximum throughput** occurs at *G* = 0.5, with *S* = 1/2*e*, which is about **0.184**.
- In other words, the best we can hope for is a channel utilization of 18 percent.

# Figure 4-3. Throughput versus offered traffic for ALOHA systems



# *Slotted ALOHA*

- In **1972, Roberts** published a method for doubling the capacity of an ALOHA system.
- **His proposal was to divide time into discrete intervals, each interval corresponding to one frame.**
- In Roberts' method, which has come to be known as **slotted ALOHA**, in contrast to Abramson's **pure ALOHA**, **a computer is not permitted to send whenever a carriage return is typed.**
- Instead, **it wait for the beginning of the next slot.** Thus, the continuous pure ALOHA is turned into a discrete one.

- Throughput $S = Ge^{-G}$
- Slotted ALOHA peaks at $G = 1$, with a throughput of $S = 1/e$ or about 0.368, twice that of pure ALOHA.
- In other words, the best we can hope for is a channel utilization of 37 percent.

# Carrier Sense Multiple Access Protocols

- Carrier Sense Multiple Access (CSMA) is a network protocol for carrier transmission that operates in the Medium Access Control (MAC) layer.
- With slotted ALOHA the best channel utilization that can be achieved is 1/*e.*
- In local area networks, however, it is possible for stations to detect what other stations are doing, and adapt their behavior accordingly. These networks can achieve a much better utilization than 1/*e.*
- Protocols in which stations listen for a carrier (i.e., a transmission) and act accordingly are called **carrier sense protocols**.
- It senses or listens whether the shared channel for transmission is busy or not, and transmits if the channel is not busy.

**Working Principle**

- When a station has frames to transmit, it attempts to detect presence of the carrier signal from the other nodes connected to the shared channel.
- If a carrier signal is detected, it implies that a transmission is in progress.
- The station waits till the ongoing transmission executes to completion, and then initiates its own transmission.
- Generally, transmissions by the node are received by all other nodes connected to the channel.
- Since, the nodes detect for a transmission before sending their own frames, collision of frames is reduced.

<u>**Medium Access Control Sub layer Numerical**</u>

**Problem 1**

**A group of *N* stations share a 56-kbps pure ALOHA channel. Each station outputs a 1000-bit frame on an average of once every 100 sec, even if the previous one has not yet been sent (e.g., the stations can buffer outgoing frames). What is the maximum value of *N*?**

**Solution:**

There are N Stations Sharing 56kbps Pure ALOHA Channel

so with pure ALOHA Usable Bandwidth = 0.184* 56kbps=10.3kbps

1 Station Outputs 1000 bits in every 100sec

so in 1sec One station will ouput at rate 1000/100=10bits/sec

so For N stations in 1 sec Total Output Data is 10*N bits this should be equal to the Channel Capacity in pure ALOHA

N*10=10300

N=1030 it is the maximum value of Number of Station Possible.

**Problem 2**

**Ten thousand airline reservation stations are competing for the use of a single slotted ALOHA channel. The average station makes 18 requests/hour. A slot is 125 µsec. What is the approximate total channel load?**

**Solution:**

The average station makes $\frac{18}{3600} = \frac{1}{200}$ requests/sec. The total channel load is $10000 \times \frac{1}{200} = 50$ requests/sec. Using slot as the time unit, the total channel load is $50 \times (125 \times 10^{-6}) = \frac{1}{160}$ requests/slot.

**Problem 3**

**A slotted aloha system has packets (both new and retransmissions) arriving at a rate of 50 per second. Packets take 40 ms to transmit.**
**a) What is G (packets per slot)?**
**b) What is the probability of success of during a slot?**
**c) What is the average number of slots per successful transmission?**

**Solution:**

a) $G = 50 * 0.04 = 2$ packets per slot.
b) $P_s = G e^{-G} = 0.27$
c) $1/P_s = 3.69$

**Problem 4**

**Measurements of a slotted ALOHA channel with an infinite number of users show that 10 percent of the slots are idle.**
**(a) What is the channel load, *G*?**
**(b) What is the throughput?**
**(c) Is the channel underloaded or overloaded?**

**Solution:**

a) $P(0) = e^{-G} = 0.1 \Rightarrow G = 2.3$
b) $T = G e^{-G} = 0.23$
c) Since $G > 1$, the system is overloaded.

**Problem 5**

**Sketch the Manchester encoding for the bit stream: 10000101111**

**Solution:**