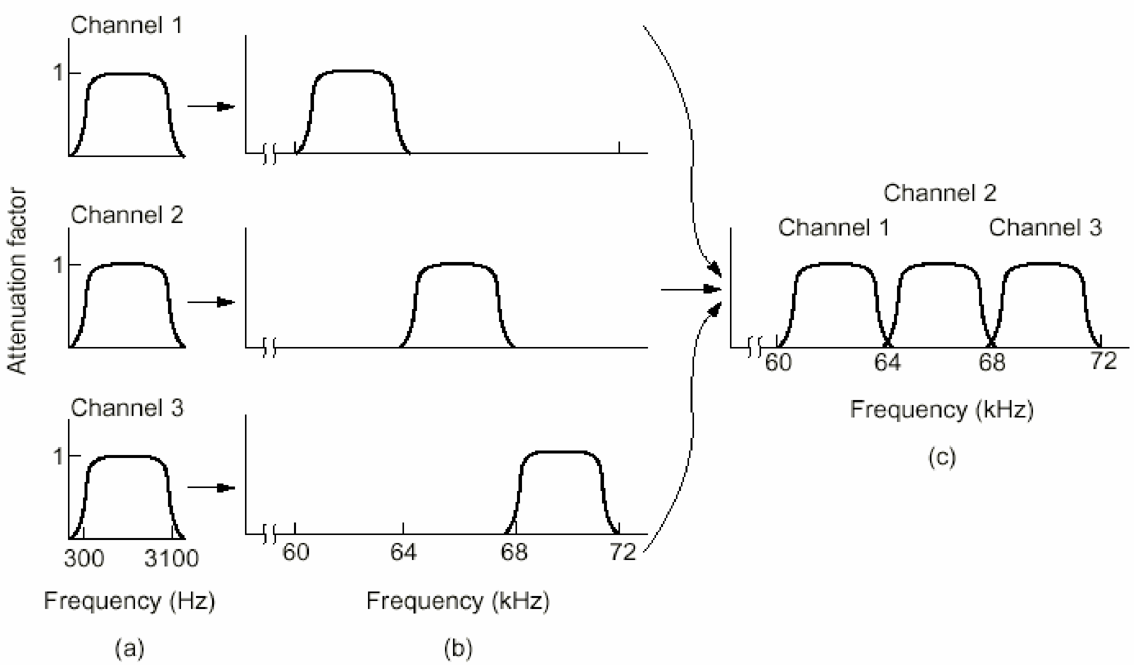
MAC Sublayer(1)

Principal service of the Medium Access Control Sublayer:

Allocating a single broadcast channel (mostly a LAN) among competing users

Static Channel Allocation:

• Frequency Division Multiplexing (FDM)



- each user (channel) has exclusive possession of some frequency band
- FDM requires analog circuitry and is not amenable to being controlled by computer

MAC Sublayer(2)

• Time Division Multiplexing (TDM)
  - the user periodically (round robin) gets the entire bandwidth for a short time slot
  - TDM can be handled entirely by digital electronics (a computer)

• Main drawbacks of static allocation
  - raises problems (waste or lack of bandwidth) when number of users varies
  - inherently inefficient (in most computer systems, data traffic is extremely bursty (1000:1 ratios)

Dynamic Channel Allocation:

Underlying most of the work done in this area are 5 key assumptions:

• Station model

• Single channel assumption

• Collision assumption

• Continuous or Slotted time

• Carrier Sense or No Carrier Sense

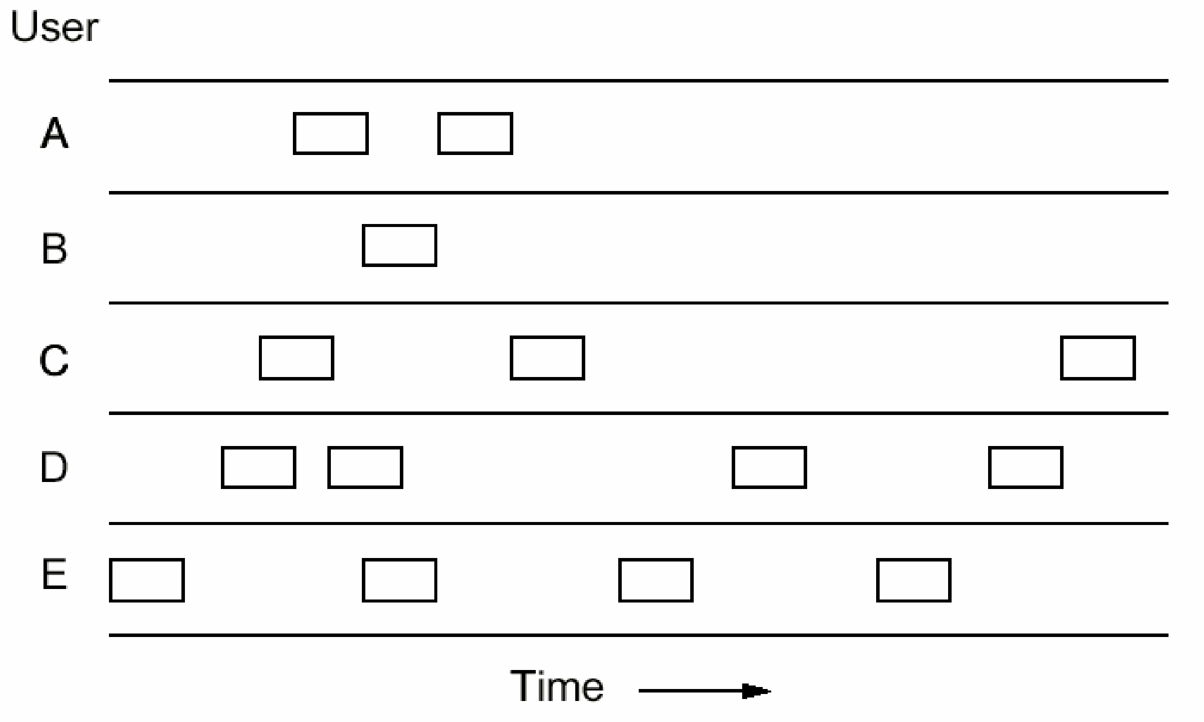
MAC Sublayer(3)

ALOHA

• most prominent representative of No Carrier Sense - protocols
• two versions: *pure* and *slotted*
• uniform frame (message units) size to maximize throughput

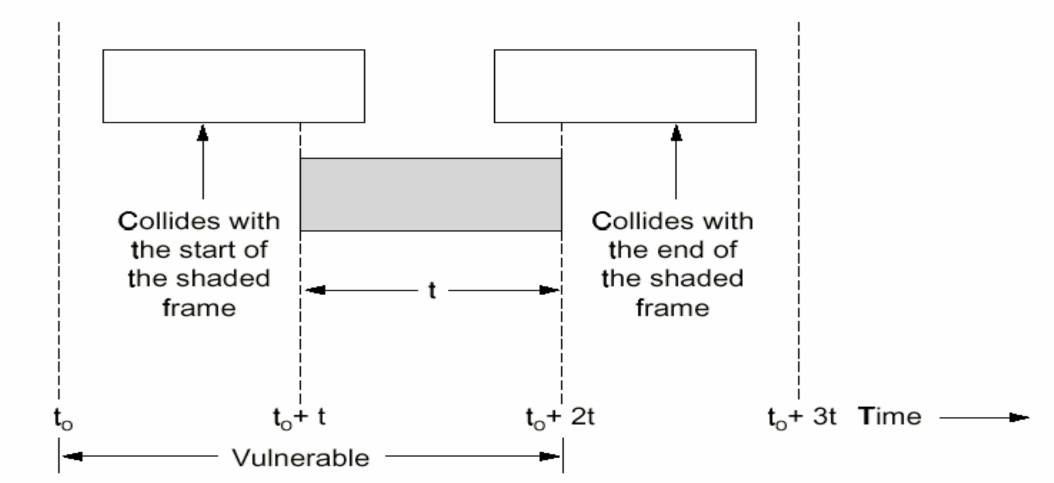
Pure ALOHA

Basic ide

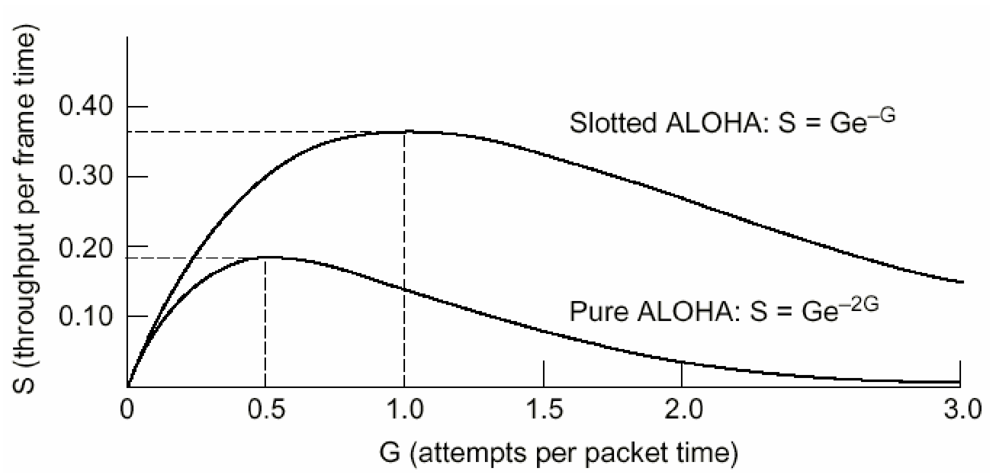


MAC Sublayer(4)

Vulnerable period for the shaded frame:



Throughput versus effective load (traffic) for ALOHA protocols:



MAC Sublayer(5)

Slotted ALOHA

Basic idea: Divide time into discrete intervals, each interval corresponding to one frame time

Properties:

- Vulnerable period is halved
- Throughput is doubled
- Best case:
    - 37% successes (= maximum throughput)
    - 37% of the slots are empty
    - 26% collisions

- Small increases in the effective load can drastically reduce performance

---> **Let us move to *C̲arrier S̲ense M̲edium A̲ccess (CSMA) - protocols***

MAC Sublayer(6)

Types of CSMA protocols

• *1-persistent*

Behavior:

When a station has data to send, it transmits with a probability of 1 whenever it finds the channel idle. If the channel is busy, the station waits until it becomes idle (greedy approach).

• *nonpersistent*

Behavior:

It differs from 1-persistent w.r.t. the case where the channel is busy.Then, the station deliberately waits a random period of time before sensing the channel again.

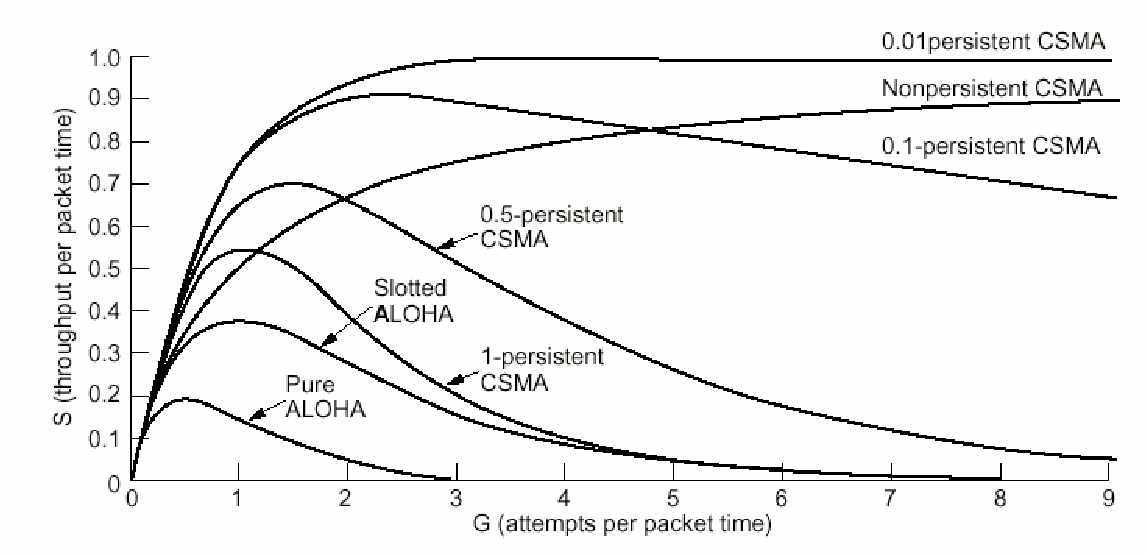
• *p-persistent* (applies to slotted channels)

Behavior:

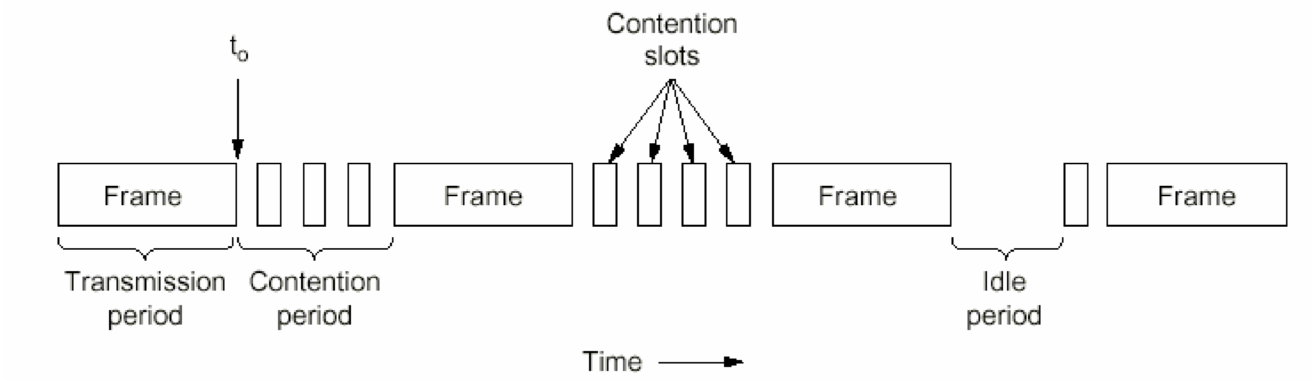
When a station has data to send, it transmits with a probability of p whenever it finds the channel idle. With a probability of q = 1- p it defers until the next slot and the same procedure iterates. If the channel has become busy meanwhile, the station waits a random time and starts again.If the channel is busy when first sensing it, the station waits until the next slot and repeats the procedure.

MAC Sublayer(7)

Comparison of channel utilization versus load for the various random access protocols:



Conceptual model of CSMA with Collision Detection (CSMA/CD):



MAC Sublayer(8)

How to resolve the contention for the channel without any collisions at all, i.e. including the contention period?

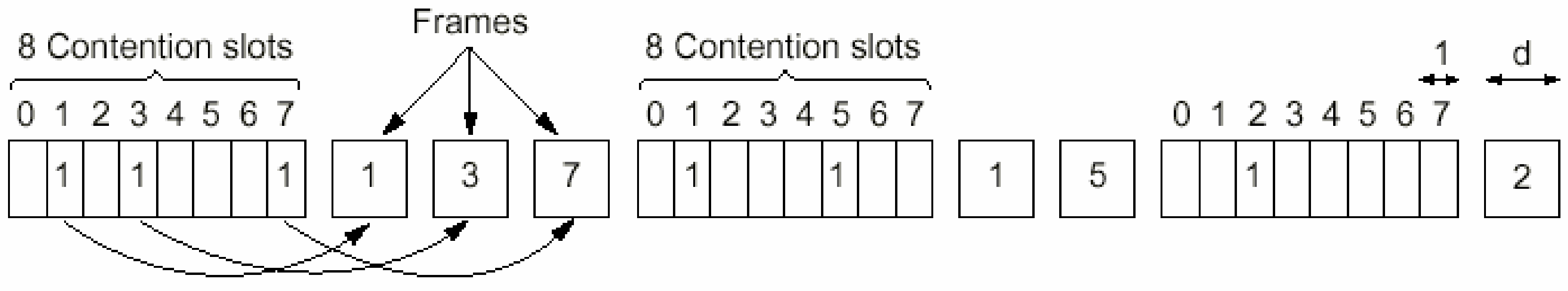
Assumptions:

- There are N stations, each with a unique address
- The contention interval is modeled as discrete contention slots with slot width 2∂

Basic question:

Which station gets the channel after a successful transmission?

The basic Bit - Map Protocol



This protocol belongs to the class called **reservation protocols.**

MAC Sublayer(9)

Performance analysis

Assumptions:

- time is measured in units of the contention bit slot
- data frames consist of *d* time units

waiting time T of a station:= time from being ready to sent until beginning of sending its contention bit

Under conditions of low load (0 or 1 station ready to send)

- for low-numbered stations (<N/2): T = 1.5 N slots
- for high-numbered stations (>N/2): T = 0.5 N slots

---> mean T = N slots

per frame :

- overhead = N bits
- amount of data = d bits

---> channel efficiency = d / (N + d)

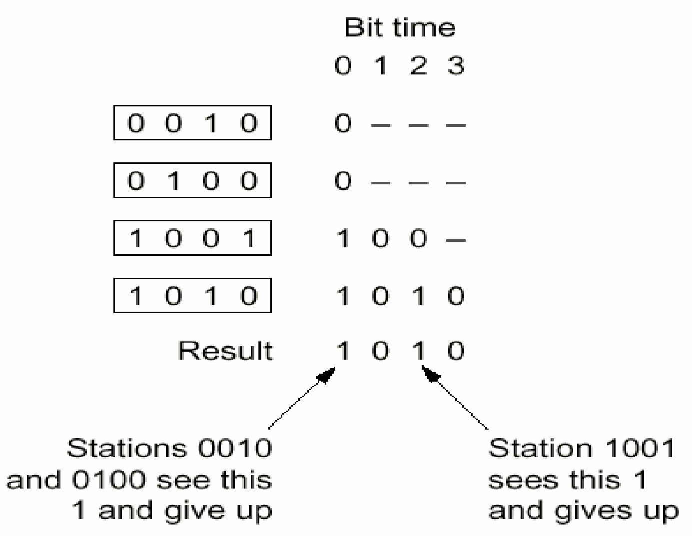
Under conditions of high load (all stations have something to send all time):

channel efficiency = d / (d + 1)

mean delay for a frame = N (d + 1) / 2 after getting to the head of the internal queue

MAC Sublayer(10)

The Binary Countdown Protocol



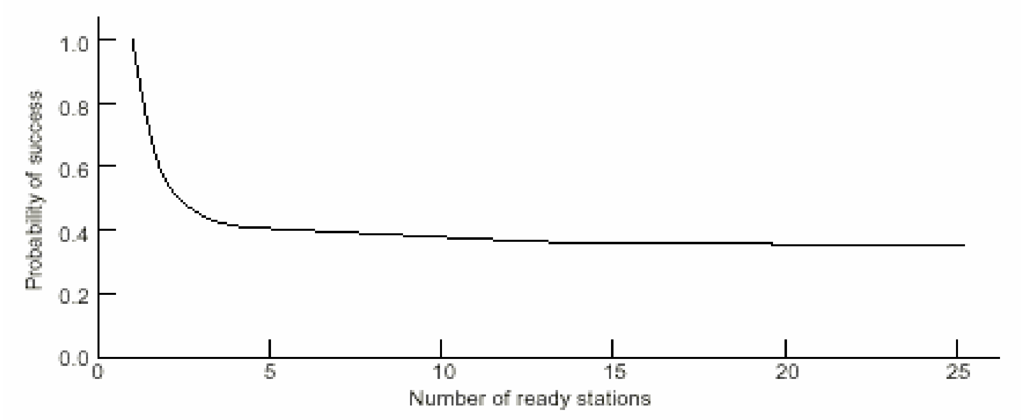
If the sender´s address id the first field in the frame, **channel efficiency is 100 % !**

Limited Contention Protocols

Idea:
Combine the best properties of the contention and the collision-free protocols

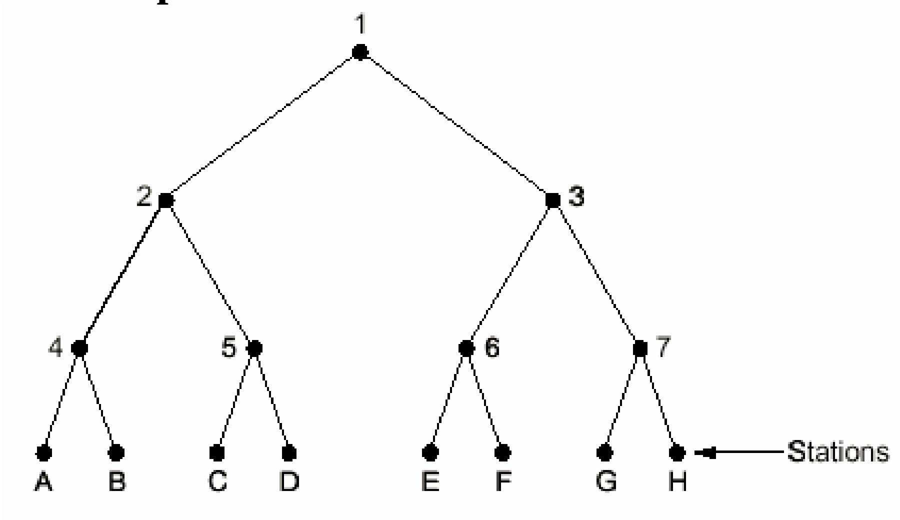
MAC Sublayer(11)

Probability of channel acquisition for a symmetric contention protocol



Consequence: Dynamic station assignment to slots depending on the load.

Example: The Adaptive Tree Walk Protocol



MAC Sublayer(13)

Wireless Networks

New trend in information technology: **Mobile Computing**

Aspects of mobility:

– *User mobility*: Users communicate via wireless infrastructure
(wireless phones, laptops, Personal Digital Assistenants)

– *Device mobility*: devices can be connected via wireless links to surrounding IT infrastructure
(computer peripherials, machines,mobile robots)

Example applications

- Replacing wired networks in home / office environments
- Traffic control applications
- Data collection / diagnosis (hospitals, damage assesment)
- Hot spots (airports, hotels etc)
- Mobile robots, manufacturing

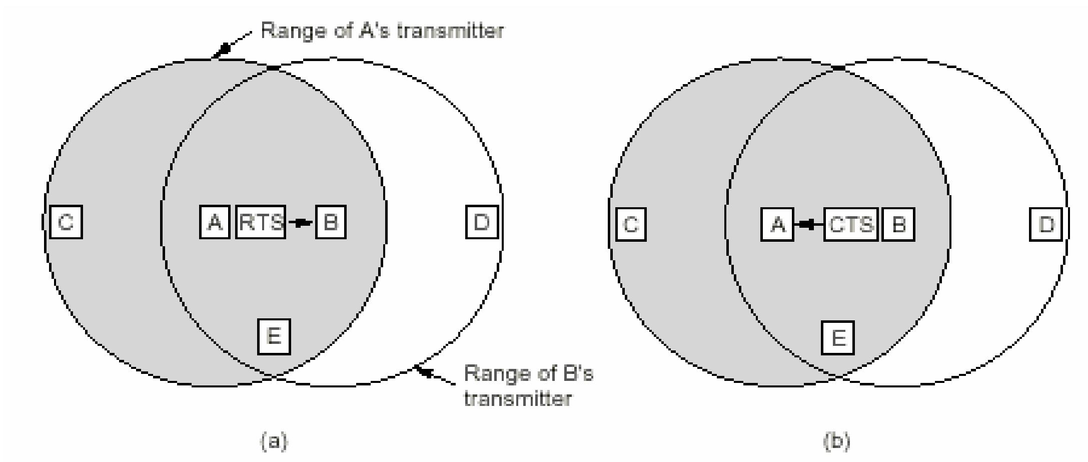
MAC Sublayer(13a)

The Wireless LAN Protocols for the MAC layer

Overlapping radio transmitter ranges:

- hidden station problem
- exposed station problem

Solution Example: The MACA (Multiple Access with Collision Avoidance) protocol

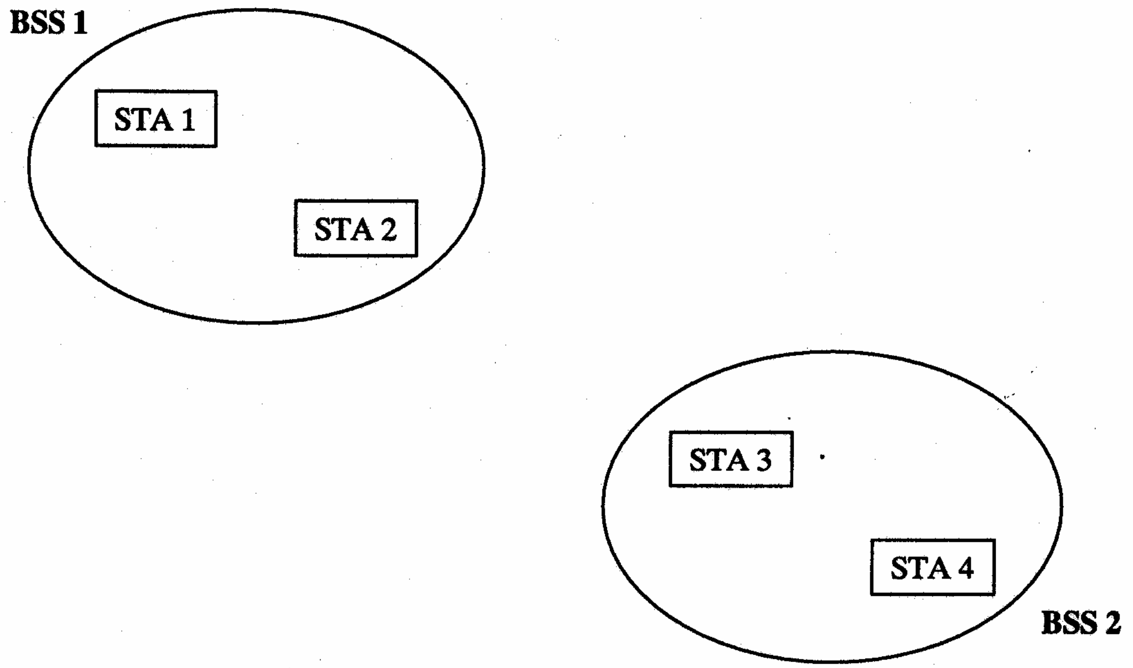


MAC Sublayer(14)

The IEEE 802.11 Standard

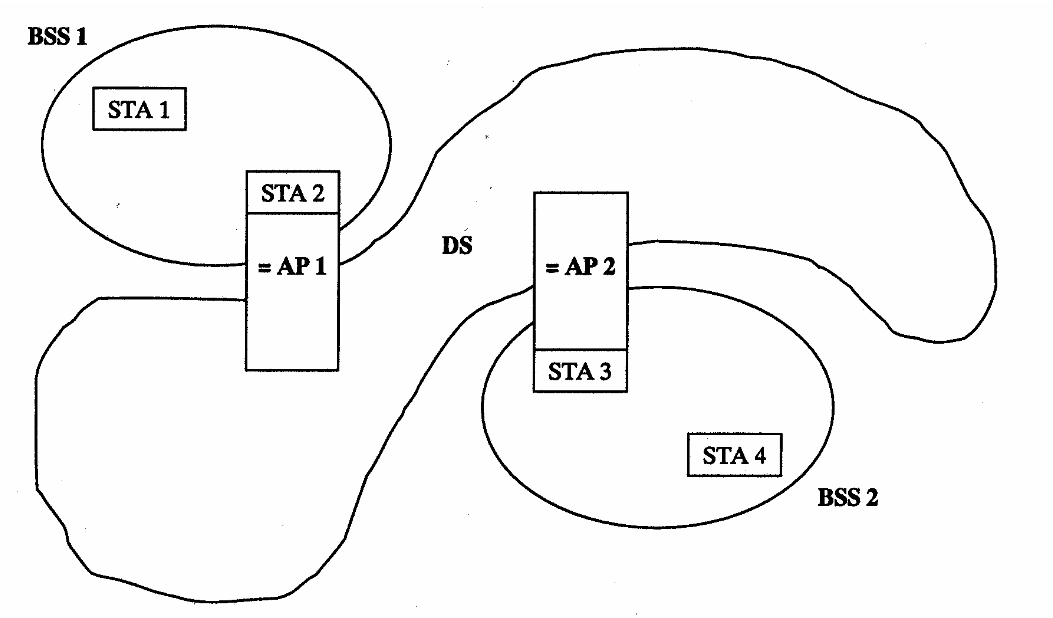
- 1997 cleared by IEEE, 1999 adopted as international standard by ISI□O/IEC
- specifies MAC layer on top of 3 variants for physical layer (1 infrared, 2 radio)

Ad-Hoc networks



MAC Sublayer(15)

Infrastructure networks

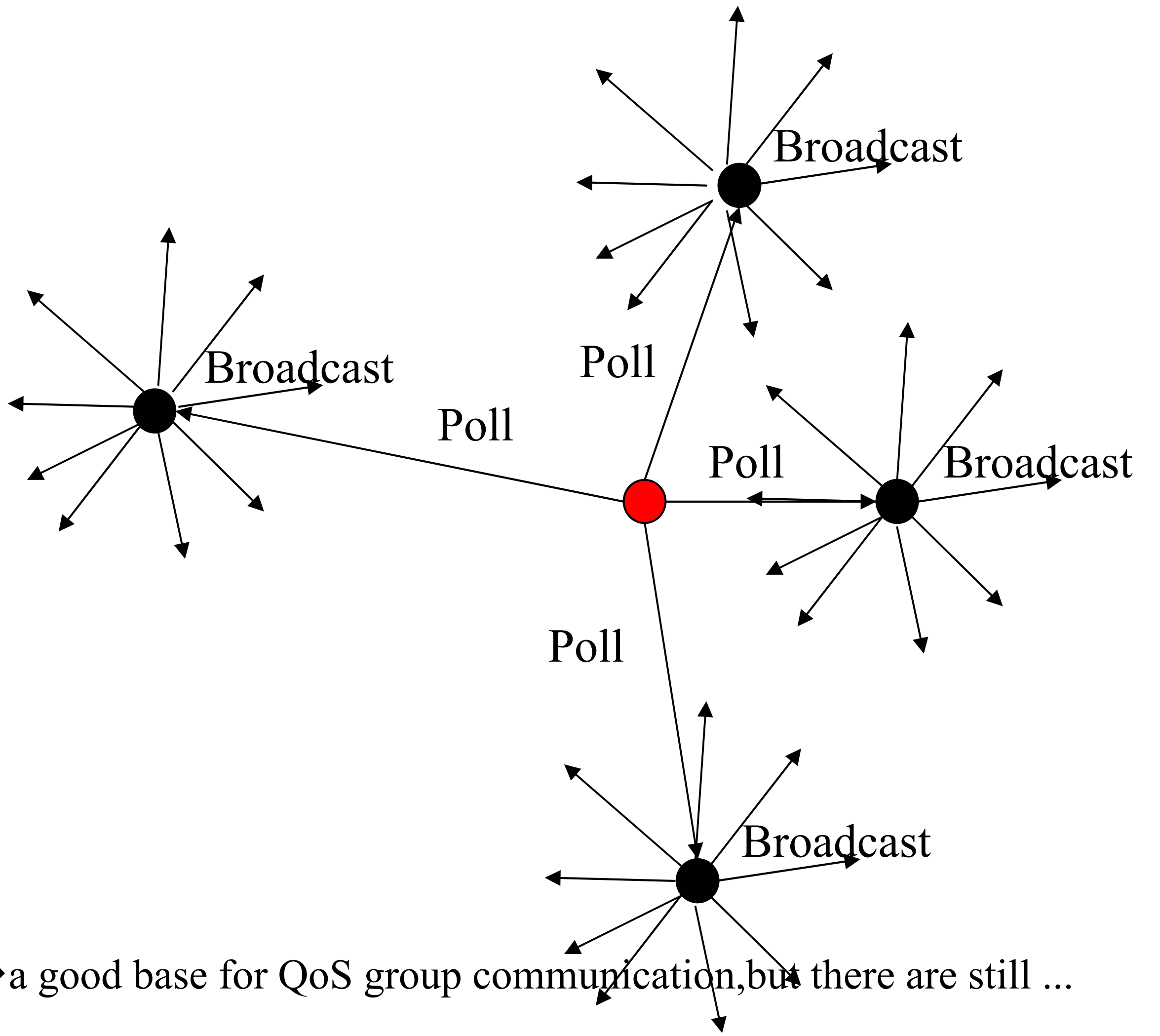


Medium access: CSMA/CA

- DCF (Distributed Coordination Function)
- PCF (Point Coordination Function), optionally

MAC Sublayer(17)

PCF: A central access point grants access to the medium by polling the stations



➔a good base for QoS group communication,but there are still ...

MAC Sublayer(18)

Distinguishing aspects of wireless LAN networks:

- no exact range limits for receiving messages
- no protection against unfriendly environment
- dynamic topologies
- not completely connected

But

High potential for many industrial applications

MAC Sublayer(19)

The Problem:

- Usage of WLAN for reliable, real-time or even safety-critical applications, e.g.
  - Automotive applications
  - Robotics
  - Industrial automation
- General Problem:
  - Is it possible to give QoS (timing and reliability) guarantees for WLAN communication?
- Especially:
  - Is it possible to give any QoS guarantees for WLAN communication in the presence of other interfering wireless communication?

MAC Sublayer(20)

Remaining problems to be solved (w.r.t. reliable wireless communication on the MAC layer):

- Messages can be lost, even worse:
- Some stations may receive a message, some others may not
- Stations can crash
- Stations can be out of reach
- No timing guarantees are given

➔ Must make specific fault assumptions for giving any kind of guarantees