UNIT 2
MAC – 1

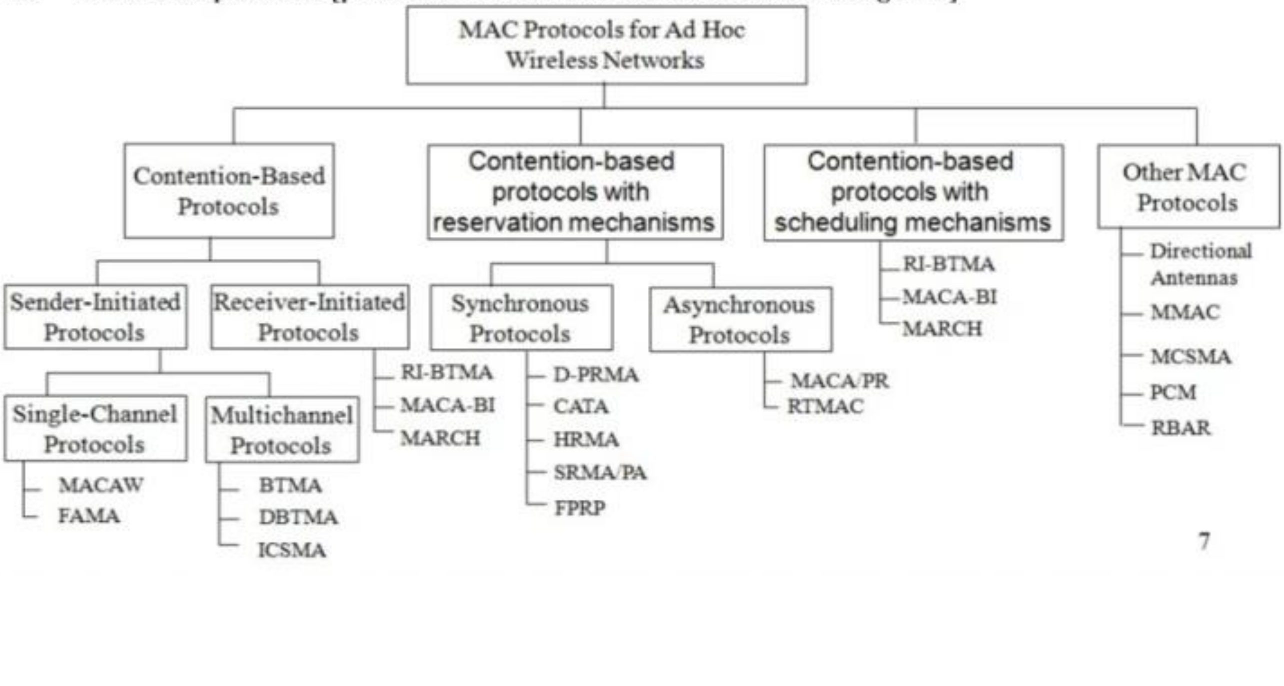
DESIGN GOALS OF A MAC PROTOCOL FOR AD HOC WIRELESS NETWORKS

- The operation of a protocol should be distributed
- The protocol should provide QoS support for real-time traffic
- The access delay, which refers to the average delay experienced by any packet to get transmitted, must be kept low
- The available bandwidth must be utilised efficiently
- The protocol should ensure fair allocation of bandwidth to nodes
- Control overhead must be kept as low as possible
- The protocol should minimise the effects of hidden and exposed terminal problems
- The protocol must be scalable to large networks
- It should have power control mechanisms in order to efficiently manage energy consumption of the nodes
- The protocol should have mechanisms for adaptive data rate control
- It should try to use directional antennas which can provide advantages such as reduced interference, increased spectrum reuse, and reduced power consumption
- The protocol should provide time synchronisation among nodes

CLASSIFICATION OF MAC PROTOCOLS

Ad hoc network MAC protocols can be classified into three basic types:

i. Contention-based protocols
ii. Contention-based protocols with reservation mechanisms
iii. Contention-based protocols with scheduling mechanisms
iv. Other MAC protocols [protocols which do not fall under above 3 categories]



- **Contention-based protocols**
  - ***Sender-initiated protocols***: Packet transmissions are initiated by the sender node.
    - *Single-channel sender-initiated protocols*: A node that wins the contention to the channel can make use of the entire bandwidth.
    - *Multichannel sender-initiated protocols:* The available bandwidth is divided into multiple channels.
  - ***Receiver-initiated protocols***: The receiver node initiates the contention resolution protocol.
- **Contention-based protocols with reservation mechanisms**
  - ***Synchronous protocols***: All nodes need to be synchronized. Global time synchronization is difficult to achieve.
  - ***Asynchronous protocols:*** These protocols use relative time information for effecting reservations.
- **Contention-based protocols with scheduling mechanisms**
  - Node scheduling is done in a manner so that all nodes are treated fairly and no node is starved of bandwidth.
  - Scheduling-based schemes are also used for enforcing priorities among flows whose packets are queued at nodes.
  - Some scheduling schemes also consider battery characteristics.
- **Other protocols** are those MAC protocols that do not strictly fall under the above categories.

CONTENTION BASED PROTOCOLS

Explain in detail MACA for wireless LAN (MACAW) and floor acquisition multiple access protocol (FAMA)

MACAW (MACA for Wireless) is a revision of MACA.

- The sender senses the carrier to see and transmits a **RTS** (**Request To Send)** frame if no nearby station transmits a RTS.
- The receiver replies with a **CTS** (**Clear To Send**) frame.
- The MACAW protocol uses one more control packet called the **request-for-request-to-send (RRTS)**

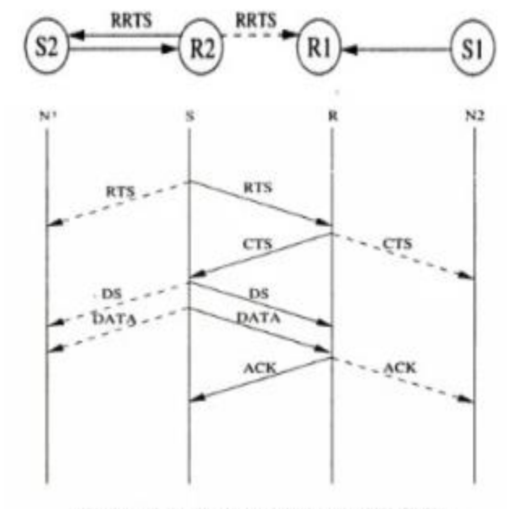


Figure 6.7. Packet exchange in MACAW.

- Neighbors
  - see CTS, then keep quiet.
  - see RTS but not CTS, then keep quiet until the CTS is back to the sender.
- The receiver sends an ACK when receiving an frame.
  - Neighbors keep silent until see ACK.
- Collisions
  - There is no collision detection.

- The senders know collision when they don't receive CTS.
- They each wait for the exponential back-off time.

Floor acquisition Multiple Access Protocols (FAMA)

- Based on a channel access discipline which consists of a carrier-sensing operation and a collision-avoidance dialog between the sender and the intended receiver of a packet.
- Floor acquisition refers to the process of gaining control of the channel.
- At any time only one node is assigned to use the channel.
- Carrier-sensing by the sender, followed by the RTS-CTS control packet exchange, enables the protocol to perform as efficiently as MACA.
- Two variations of FAMA
  - RTS-CTS exchange with no carrier-sensing uses the ALOHA protocol for transmitting RTS packets.
  - RTS-CTS exchange with non-persistent carrier-sensing uses non-persistent CSMA for the same purpose.

CONTENTION BASED PROTOCOLS WITH RESERVATION MECHANISMS

Distributed Packet Reservation Multiple Access Protocol (D-PRMA)

- It extends the centralized packet reservation multiple access (PRMA) scheme into a distributed scheme that can be used in ad hoc wireless networks.
- PRMA was designed in a wireless LAN with a base station.
- D-PRMA extends PRMA protocol in a wireless LAN.
- D-PRMA is a TDMA-based scheme.
- The channel is divided into fixed- and equal-sized frames along the time axis.

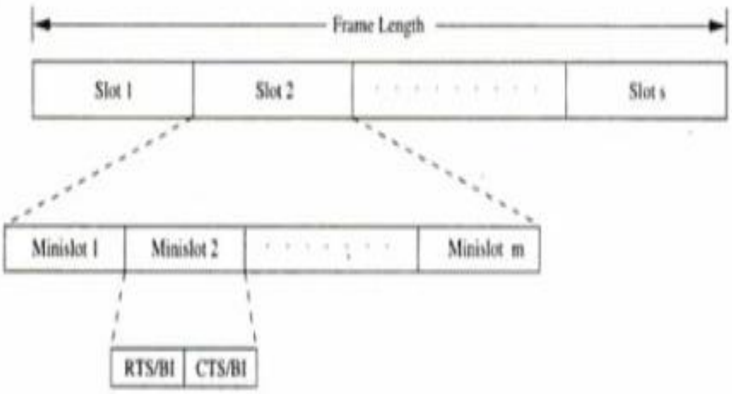


Figure 6.15. Frame structure in D-PRMA.

- Each frame is composed of s slots and each slot consists of m minislots
- Each minislot is further divided into two control fields, RTS/BI and CTS/BI
- These control fields are used for slot reservation and for overcoming the hidden terminal problem
- All nodes having packets ready for transmission contend for the first minislot of each slot
- The remaining (m-1) minislots are granted to the node that wins the contention.
- Also, the same slot in each subsequent frame can be reserved for this winning terminal until it completes its packet transmission session
- Within a reserved slot, communication between the source and receiver nodes takes by means of either time division duplexing (TDD) or frequency division duplexing (FDD)

- Any node that wants to transmit packets has to first reserve slots
- A certain period at the beginning of each minislot is reserved for carrier sensing
- In order to prioritize nodes transmitting voice traffic over nodes transmitting normal data traffic, two rules are followed in D-PRMA
    - 1st rule → voice nodes are allowed to start contending from minislot 1 with probability p=1. Others with p<1
    - 2nd rule → only if the node winning the minislot contention is a voice node, it is permitted to reserve the same slot in each subsequent frame until the end of the session
- In order to avoid the hidden terminal problem, all nodes hearing the CTS sent by the receiver are not allowed to transmit during the remaining period of that same slot
- In order to avoid the exposed terminal problem, a node hearing the RTS but not the CTS is still allowed to transmit
- Requirement 1 → when a node wins the contention in minislot 1, other terminals must be prevented from using any of the remaining (m-1) minislots in the same slot for contention
- Requirement 2 → when a slot is reserved in subsequent frames, other nodes should be prevented from contending for those reserved slots
- D-PRMA is more suited for voice traffic than for data traffic applications

Collision Avoidance Time Allocation Protocol (CATA)

- It is based on dynamic topology-dependent transmission scheduling
- Nodes contend for and reserve time slots by means of a distributed reservation and handshake mechanism.
- Support broadcast, unicast, and multicast transmissions.
- The operation is based on two basic principles:
    - The receiver(s) of a flow must inform the potential source nodes about the reserved slot on which it is currently receiving packets. The source node must inform the potential destination node(s) about interferences in the slot.
    - Usage of negative acknowledgements for reservation requests, and control packet transmissions at the beginning of each slot, for distributing slot reservation information to senders of broadcast or multicast sessions.
- Time is divided into equal-sized frames, and each frame consists of S slots.
- Each slot is further divided into five minislots.
- The first 4 minislots are used for transmitting control packets and are called control minislots (CMS)
- The last minislot is called data minislot (DMS)

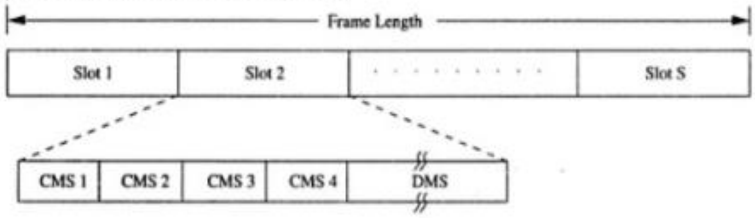


Figure 6.16. Frame format in CATA.

- Each node that receives data during the DMS of the current slot transmits a slot reservation (SR) packet during the CMS1 of the slot
- This serves to inform other neighbouring potential sender nodes about the currently active reservations
- The SR packet is either received without error at the neighbouring nodes or causes noise at those nodes, preventing them from attempting to reserve the current slot
- Every node that transmits data during the DMS of the current slot transmits a request-to-send packet
- The receiver node of a unicast session transmits a clear-to-send packet
- On receiving this packet, the source node clearly understands that the reservation was successful and transmits data during the DMS of that slot until unicast flow gets terminated

- Once the reservation has been made successfully in a slot, from the next slot onward, both the sender and receiver do not transmit anything during CMS3 and during CMS4 the sender node alone transmits a not-to-send (NTS) packet
- The not-to-send (NTS) packet serves as a negative acknowledgement
- A potential multicast or broadcast source node that receives the NTS packet or that detects noise, understands that its reservation request has failed & does not transmit during DMS of current slot
- The length of the frame is very important in CATA
- The worst case value of the frame-length = $Min(d^2+1, N)$, where d is the maximum degree of a node in the network and N is the total number of nodes in the network
- CATA works well with simple single-channel half-duplex radios
- It is simple and provides support for collision-free broadcast and multicast traffic