



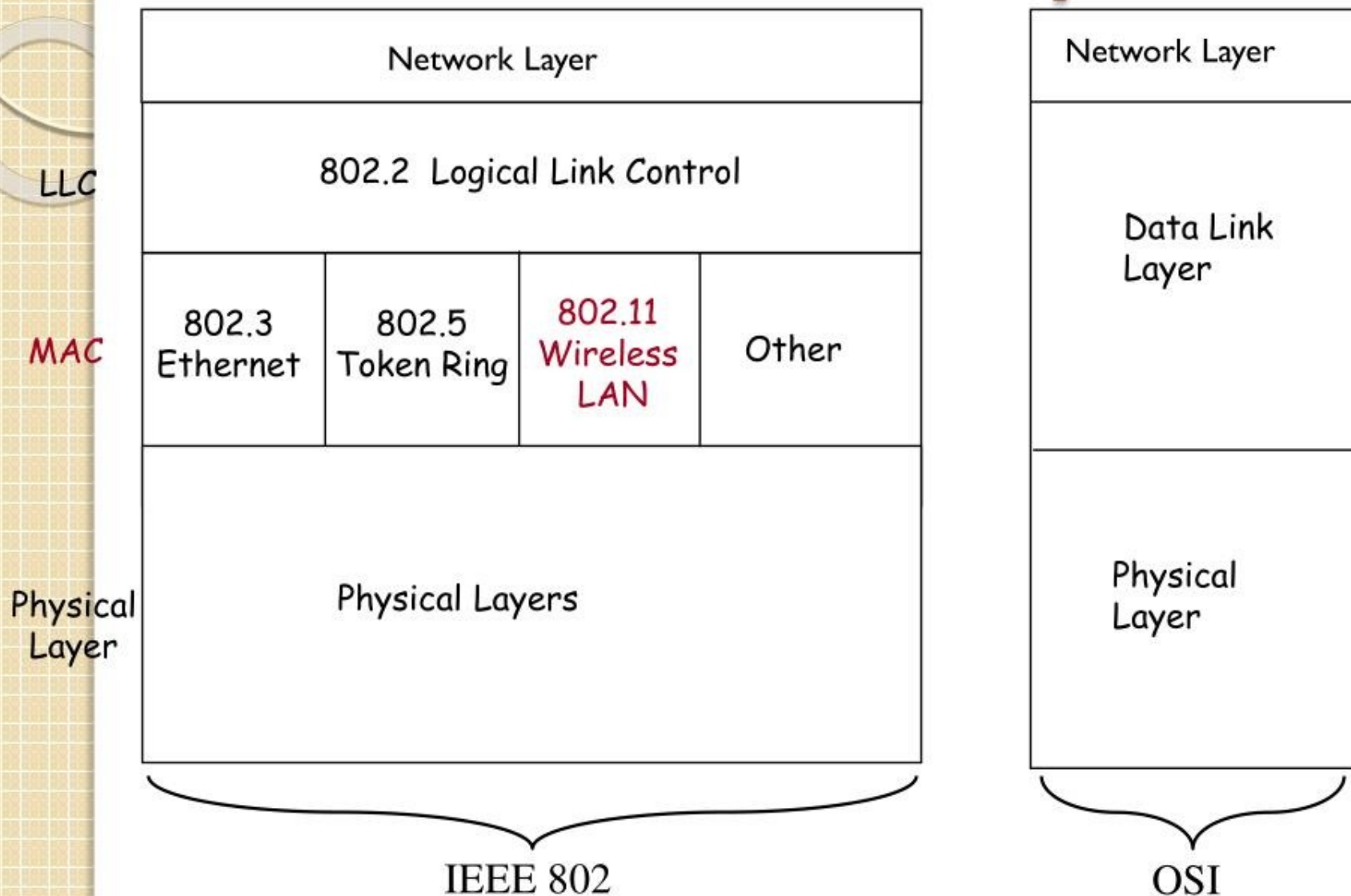
Channel Allocation (MAC)

**Advanced
Computer Networks**

Outline

- Channel Allocation Problem
- Channel Allocation Classification
- FCA,DCA,...
 - TDMA, FDMA
 - Aloha, Slotted Aloha
 - CSMA (non-persistent, I-persistent, p-persistent), CSMA/CD
 - Performance Results

Data Link Sub Layers



Channel Allocation Problem

DEFINITION 1

A network can be modeled as an undirected graph $G < V, E >$, where

- Vertex-set V represents the individual nodes
- Edge set E represents the connection between nodes

Channel Allocation Problem

DEFINITION 2

The demand vector $\Psi = \{\psi_i | v_i \in V\}$ is a function $\Psi: V \rightarrow \mathbb{N}$ where

ψ_i is the required number of connections that must be simultaneously supported for node N_i .

Channel Allocation Problem

DEFINITION 3 The channel separation vector $\Lambda = \{\lambda_{i,j} | \forall e_{i,j} \in E\}$ is a function

$\Lambda: E \rightarrow \mathbb{N}$ where

$\lambda_{i,j}$ denotes the minimum (valid) distance between the channels assigned to host N_i and N_j to avoid interference.

Channel Allocation Problem

DEFINITION 4 The channel assignment problem is modeled by a quintuple $\langle G, \Psi, \Lambda, \mathbb{C}, \mathbb{F} \rangle$, where

- $G \langle V, E \rangle$ denotes an undirected graph representing the network
- $\Lambda = \{\lambda_{i,j} | \forall e_{i,j} \in E\}$ denotes the channel separation vector
- $\Psi = \{\psi_i | v_i \in V\}$ denotes the demand vector
- \mathbb{C} denotes the channel set

Channel Allocation Problem

The channel assignment problem is to find a function $\mathbb{F}: V \rightarrow 2^{\mathbb{C}}$ from the vertex set to the channel set such that

- $|\mathbb{F}(v_i)| = \psi_i$ for all $v_i \in V$,
- $\mathbb{F}(v_i) \cap \mathbb{F}(v_j) = \emptyset$ for all $e_{(i,j)} \in E$, and
- $|c_i - c_j| \geq \lambda_{i,j}$ for all $e_{(i,j)} \in E, c_i \in \mathbb{F}(v_i)$, and $c_j \in \mathbb{F}(v_j)$.

Channel Allocation

Greedy Channel Allocation

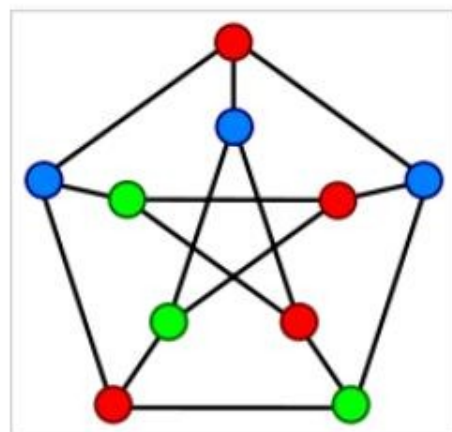
This strategy attempts to handle the channel requests (accept the connection requests) with the minimum number of available channels.

Channel Allocation

Graph Coloring Problem in Channel Allocation

Greedy Strategy

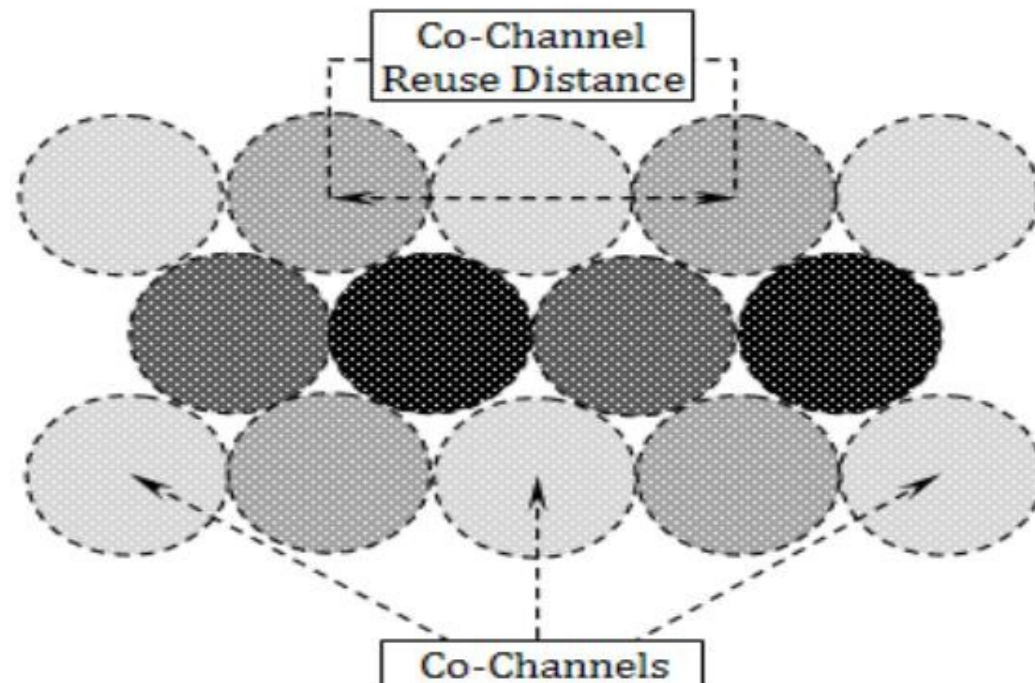
- Vertex coloring Problem
- Edge Coloring Problem
- Multicoloring Problem
- Bandwidth Coloring Problem
- Bandwidth Multicoloring Problem
- ...



Channel Allocation

Co-channel reuse distance:

The minimum distance at which co-channels can be reused with no interferences is called co-channel reuse distance.



Possible Model Assumptions

Collision :: If two frames are transmitted **simultaneously**, they overlap in time and the resulting signal is garbled. This event is a **collision**.

Continuous Time :: frame transmissions can begin at any time instant.

Slotted Time :: time is divided into discrete intervals (**slots**). Frame transmissions always begin at the start of a time slot.

Possible Model Assumptions

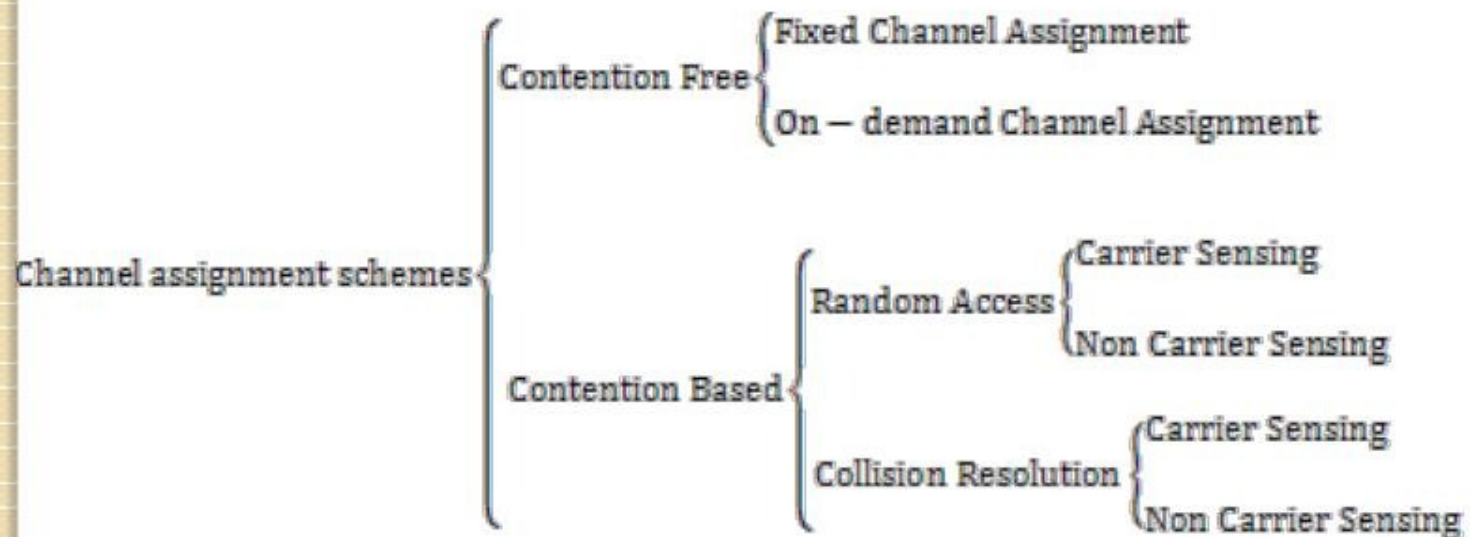
Carrier Sense (CS) ::

Stations can tell if the channel is busy (in use) before trying to use it. If the channel is busy, no station will attempt to use the channel until it is idle.

No Carrier Sense ::

Stations do not sense channel before attempting to send a frame. They just go ahead and transmit a frame. The collision is detected and recovered then.

Channel Allocation Schemes

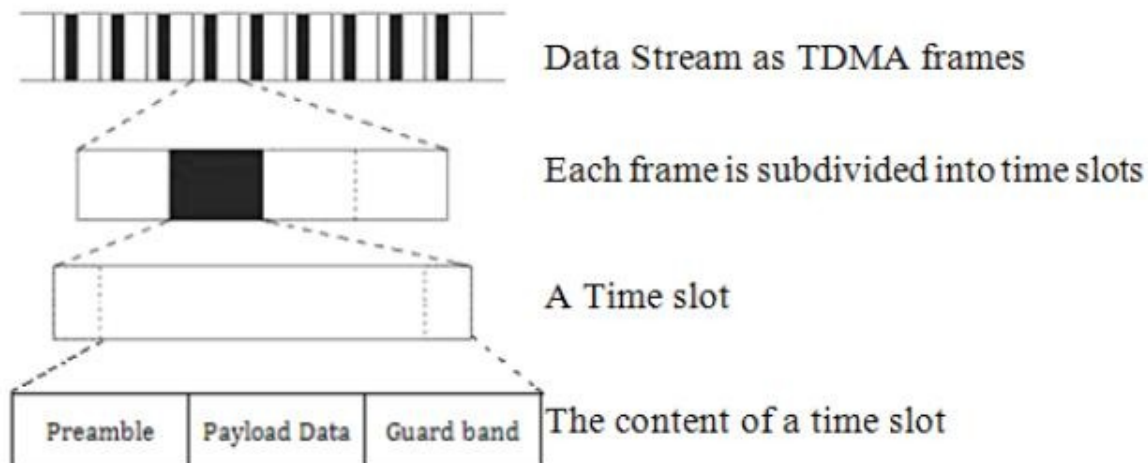


Channel Allocation Schemes

- **Fixed channel assignment (FCA)**
- FCA is the simplest off-line channel allocation scheme in which channels are assigned to the users
 - **Either permanently**
 - **Or for a long time interval**
- In a fixed channel assignment strategy, each user is allocated a predetermined set of channels.
- **No Collision:** FCA protocols assure the users that their transmitting messages will not collide with the messages from the others.
- TDMA, FDMA, and CDMA are typical FCA protocols

Channel Allocation Schemes

- Time Division Multiple Access Scheme (TDMA)





Channel Allocation Schemes

- Time Division Multiple Access Scheme (TDMA)
 - A single channel is time-shared
 - Channel is divided among several users
 - Each users accesses the channel periodically for a small period of time (called time slot)

Channel Allocation Schemes

- Time Division Multiple Access Scheme (TDMA)
 - A set of time slots is known as the TDMA frame
 - During a time slot, the entire bandwidth is available
 - TDMA is a collision-free scheme
 - A guard band is period of time during which the channel is assigned to no host

Channel Allocation Schemes

TDMA: Time Division Multiple Access

- **Unused slots go idle**
- **Example: 6-station LAN, 1,3,4 have pkt, slots 2,5,6 idle**



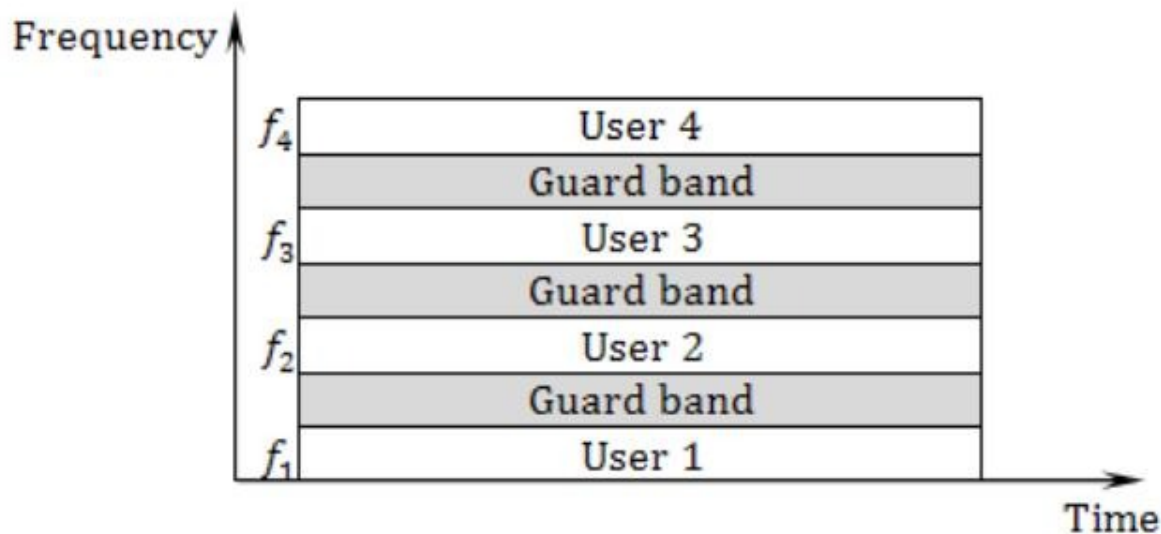
Channel Allocation Schemes

FDMA: Frequency Division Multiple Access

- . Spectrum is divided into a number of equal frequency channels.
- . One or more channel is assigned to each user.
- . Frequency subchannels are sufficiently separated (via guard bands) to prevent co-channel interference.
- . A significant portion of channel is wasted by the guard bands.
- . FDMA Provides simultaneous packet transmissions without collision.

Channel Allocation Schemes

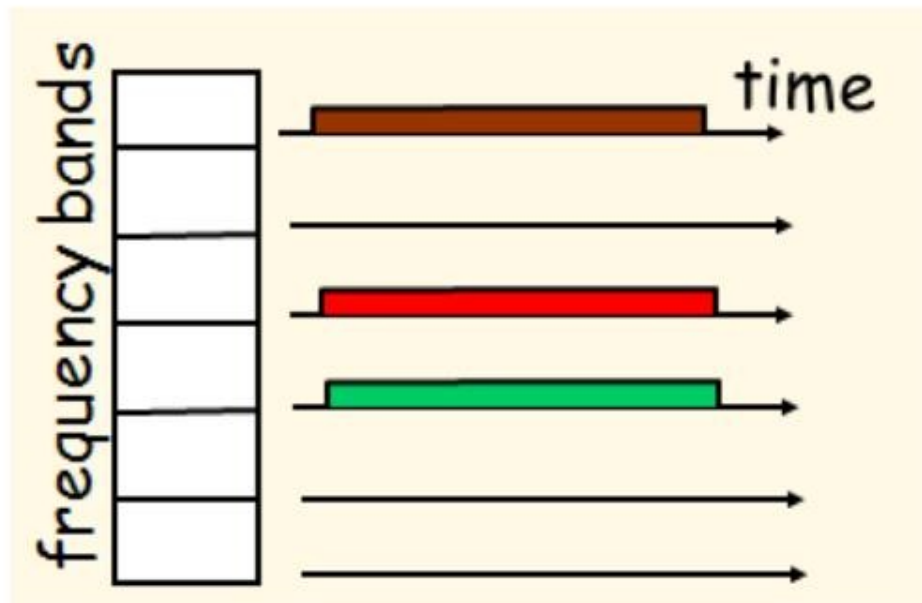
FDMA: Frequency Division Multiple Access



Channel Allocation Schemes

FDMA: Frequency Division Multiple Access

- Unused transmission time in frequency bands go idle
- Example: 6-station LAN, 1,3,4 have pkt, frequency bands 2,5,6 idle



Channel Allocation Schemes

CDMA: Code Division Multiple Access

- . In CDMA, transmitter spreads the information signal in a wide frequency band by using a spreading code.
- . Receiver uses the same code to retrieve the received signal
- . Each group of nodes can be given a shared code
- . Several codes occupy the same channel

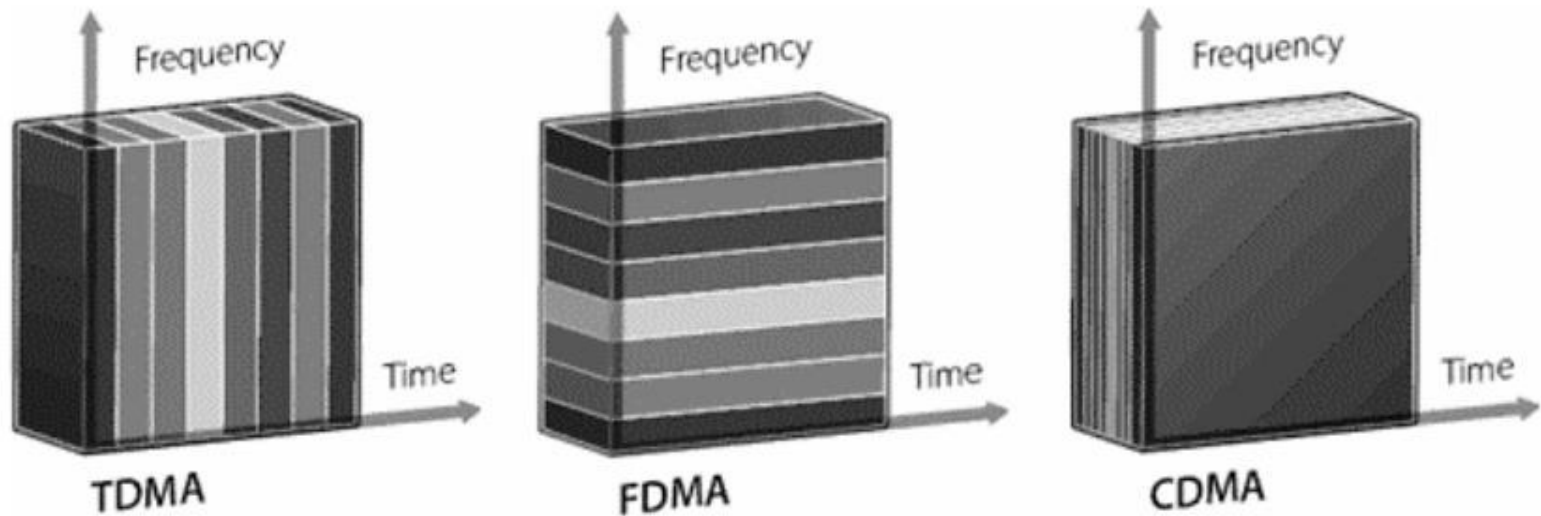
Channel Allocation Schemes

CDMA: Code Division Multiple Access

- Only nodes associated with a particular code can understand each other.
- Simultaneous transmissions can be isolated by using different spreading codes

Channel Allocation Schemes

CDMA, TDMA, and FDMA



Channel Allocation Schemes

Hybrid Multiple Access Scheme

- CDMA-TDMA

- Assigning a code to a group of nodes
- TDMA intergroup

- FDMA-TDMA

- Assigning a band to a group of nodes
- TDMA intergroup

- CDMA-FDMA

- Assigning a code to a group of nodes
- FDMA intergroup



Channel Allocation Schemes

- On-Demand Channel Assignment Schemes (ODCA)

- Efficient usage of the available spectrum
- Reassigning the unused channels to the users
- Channels are not pre-allocated to any user
- Channels are dynamically assigned as the calls arrive
- ODCA is also called dynamic channel assignment (DCA)

Channel Allocation Schemes

• On-Demand Channel Assignment Schemes (ODCA)

- DCA schemes attempt to optimize the system performance by adapting to the traffic variations
- All channels can be used by all users as long as the co-channel constraints are satisfied
- ODCA Schemes are collision-free
- ODCA algorithms are generally time consuming
- ODCA schemes need more complex control

Channel Allocation Schemes

- On-Demand Channel Assignment Schemes (ODCA)

- Polling technique,
- Reservation method,
- and Trunking
- are several wellknown ODCA Schemes

Channel Allocation Schemes

. Polling Scheme

- . Centralized controller queries nodes in a cyclic predetermined order
- . Whether they have data to transmit or not, Controller polls (one by one) the nodes to give them an opportunity to access the medium
- . The node with no packet decline the request

Channel Allocation Schemes

. Polling Scheme

- . Others begin the packet transmission upon receiving the query
- . Polling is a collision-free scheme
- . The entire bandwidth is available for nodes which is permitted to transmit data
- . Polling is able to adapt to the user traffics

Channel Allocation Schemes

. Reservation

- . The basic idea is to set some time slots for carrying reservation messages.
- . Requires a controller device to reserve a communication channel prior to transmission
- . Time is subdivided into super-frames
- . Each super-frame is divided into a reservation period and a data-transmission period
- . Reservation period is divided into frames one for each node

Channel Allocation Schemes

• Reservation

- In reservation frame, each user sends a signal indicating
 - whether or not it has message traffic
 - the number of data-transmission slots it requires
- Controller computes a transmission schedule
- Schedule is sent to all nodes at the end of reservation period
- This avoids the collisions since each host sends only in its assigned time slot.

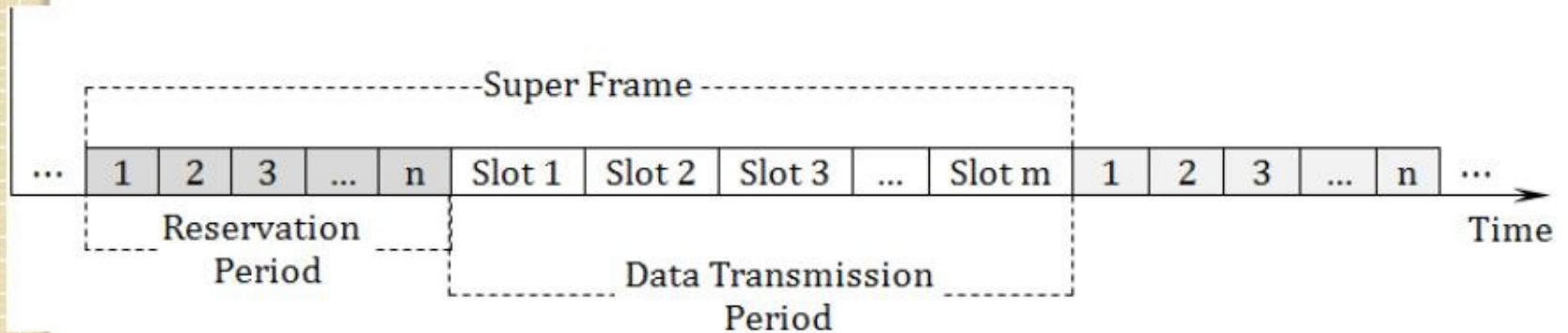
Channel Allocation Schemes

• Reservation

- This method is not fair, since
- There are a finite number of available slots
- Hosts request slots in a preferred order
- Initial hosts (in predefined order) are always able to transmit
- The last ones can send if the initials have left some for them.
- What's the solution (?)

Channel Allocation Schemes

- Reservation



Channel Allocation Schemes

- Trunking





End