UNIT IV

FREQUENCY MANAGEMENT & CHANNEL ASSIGNMENT

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Frequency Management and Channel Assignment.

(7.1)

- The Frequency management in a cellular system divides the entire channels available into the subsets that can be assigned to each cell in two modes. It may be either fixed or dynamic.
- The terms frequency managment and channel assignment are different.

1) Frequency managment includes operations such as
   > Designating set-up channels & the voice channels.
   > Numbering the channels
   > Grouping voice channels into the subset etc.
2) Channel Assignment does the allocation of specific channel to the cell sites and mobile units.

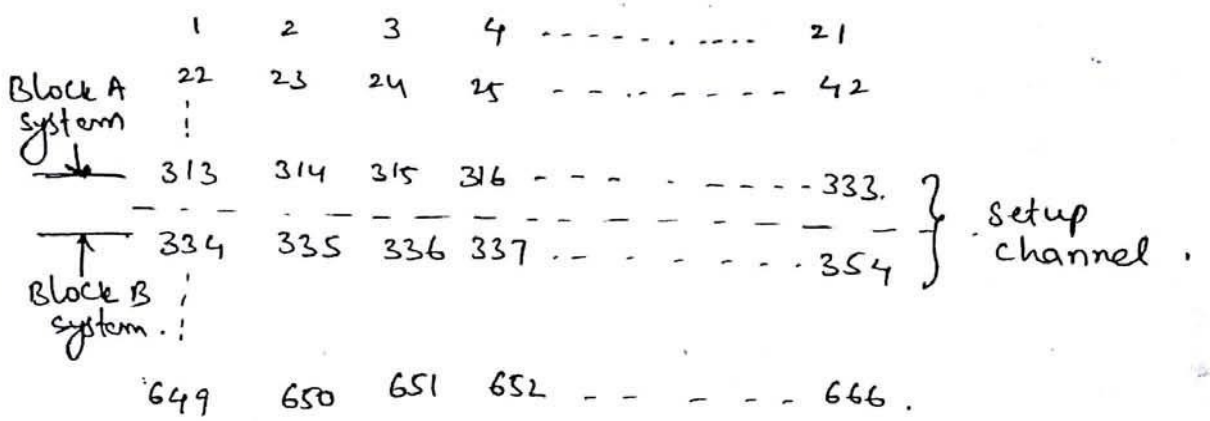
Numbering the Channels.

- The total number of channels is 832 (JAN 1988). But most mobile units and systems are still operating on 666 channels.
- A channel consists of two frequency channel bandwidths, one in the low band and one in the high band.
- Two frequencies in channel 1 are 825.030 MHz (mobile transmit) and 870.030 MHz (cell-site transmit).
- The two frequencies in channel 666 are 844.98 MHz (mobile transmit) and 889.98 MHz (cell-site transmit)
- The 666 channels are divided into two groups; block A system and block B system.
- The 42 - setup channels are assigned as follows.
  - channels 313-333 block A
  - channels 334-354 block B.
- The voice channels are assigned as follows
  - channels 1-312 (312 voice channels) block A
  - channels 355-666 (312 voice channels) block B.

Duopoly System

- A city is assumed as a market. In a market two service Providers are only allowed to compete. This concept is called as 'duopoly' concept:

Frequency management chart



Setup channels:-

- The setup channels also called "Control channels", are the channels designated to setup calls.
- A system can be operated without Setup channels. If we a choosing such a system, then all 333 channels in each cellular System (blockA or blockB) can be voice channels, however each mobile unit must then scan 333 channels continuously and detect the signaling for its call.
- A customer who wants to initiate a call must scan all the channels and find an idle one to use.
- If frequency reuse technique is applied to cellular system the Set-up channels acts as control channels.

In a N=7 frequency reuse pattern with three 120° sectors in a cell. 21 setup channels are present.

- The set-up channels can be classified into two types
  1) Access channels 2) paging channels.
- An Access channel is used for the mobile originating call (outgoing w.r.t subscriber)
- Paging channel is used for the land originating call (incoming w.r.t subscriber)
- In low traffic conditions, access channels & paging channels are same; for these reason, the set-up channels sometimes are called as "access channels" and sometimes "paging channels."
- One set-up channel is specified by forword setup channel and reverse set-up channel operation
  The forward Set-up channel is transmitted at the Base Station
  The reverse Set-up channel is transmitted at the mobile unit
- Access channels
- In mobile originating calls, the mobile unit scans its 21 setup channels and choose the strongest one. Because each setup channel is associated with one cell, the strongest setup channel indicates which cell is to serve the mobile originating calls.
- The mobile unit detects the system information transmitted from the cellsite. Also, the mobile unit monitors the Busy/Idle states bits over the desired forward setup channel. when the Idle bits are received, the mobile unit can use the corresponding reverse set-up channel to initiate a call.
- Freauently only one system operates in a given city, for instance, blocke B system might be operating and the mobile unit could be set to "preferable A system"
  when the mobile unit first scan the 21 setup channels in block A two conditions can occur.

1) If no set-up channels of block A are operational, the mobile unit automatically switches to Block B.

2) If a strong set-up signal strength is received but no message can be detected, then the scanner chooses the second strongest set-up channel. If the message still cannot be detected, the mobile unit switches to block B and scans to Block B set-up channels.

Operational functions

(i) Power of a forward set-up channel [or forward control channel - FOCC]

- Power of a setup channel plays a major role in controlling the number of incoming calls that cell can serve
- In case of heavy traffic, the power of a setup channel is reduced to reduce the coverage of the cell for the incoming calls originating from the mobile unit.
- However this situation gives rise to force the mobile units to originate calls from other cell sites.

(ii) Setup Channel Received Level

The reception at the Reverse control channel (RCC) is controlled by the setup channel received level. If the received power is greater than the given setup level then the call request is accepted.

(iii) Change power at the mobile unit

The strongest signal from all the setup channels is selected to receive messages. There are three kinds of messages

1) Mobile station control 2) System parameter overhead
3) Control filler message.

(iv) Direct call retry

Direct call retry message is sent when a cell site does not have any voice channels. setup channel is used to send this message.

Paging channel

- Each cell site has been allocated its own set-up channel (control channel). The assigned forward set-up channel (FOCC) of each cell site is used to page the mobile unit with some mobile station control message.
- The transmission of this message can be done in many different ways. They are
(i) All the cell sites page to the concerned mobile unit. But this is not preferred because it induces a high traffic load.
(ii) The cell site pages only in a specific area which corresponds to the phone number of the mobile unit. This is continued in steps of all areas until a response is received from the mobile unit.
- The mobile unit on receiving the page message responds on the reverse setup channel to the cell site; The cellsite when receives this response signal checks its strength. According to the signal strength it allocates a voice channel ensuring least interference to the mobile unit.

Definition of channel Assignment

(i) Channel Assignment to the cell sites - fixed channel Assignment.

- In a fixed channel Assignment, the channels are usually assigned to the cell site for relatively long periods.
- Two types of channels are assigned : set-up channel & voice channels.

Setup channel : There are 21 set-up channels Assigned each cell in a K=4, K=7 or K=12 frequency reuse pattern.

- If the setup channel Antennas are omni-directional, then each cell only needs one set-up channel.
- The set-up channels of blocks A & B are adjacent to each other. In order to avoid interference between two systems, the set-up channels in the neighborhood of channel 333 (block A) & channel 334 (block B) are preferbly unused.

Voice channel :

- The assignment of certain sets of voice channels in each cell site is based on causing minimum cochannel and adjacent-channel interference.

Supervisory audio tone (SAT) :

- This consists of three SATs. Based on the assignment of each SAT in each cell.

(ii) channel assignment to traveling mobile units

- If the traffic density is uniform, the unsymmetrical mobile-unit antenna pattern doesnot affect the system operation much. However, when the traffic becomes heavier as more cars approach the city, the traffic pattern becomes nonuniform & the sites closest to the city, or in the city, can't receive the expected number of calls or handoffs in the morning because of the mobile unit antenna patterns.
- At night, as the cars move out of the city, the cell sites closest to the city would have a hard time handing off calls to the sites away from the city.
- To solve these problems, we have to use less transmitted power for both set-up & voice channels for certain cell sites we also have to raise the threshold level for reverse set-up channel & voice channel at certain cell sites in order to control the acceptance of incoming calls & handoff calls.

Three methods can be used.

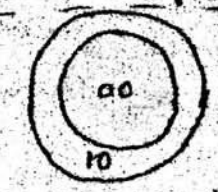
a) Underlay-Overlay
b) Frequency assignment
c) Tilted antenna.

(a) Underlay-Overlay

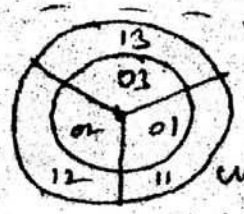
- The traffic capacity at an omnidirectional cell or a directional cell can be increased by using the underlay-overlay arrangement.
- The underlay is the inner circle, and the overlay is the outer Ring.
- The transmitted powers of the voice channels at the site are adjusted for these two areas. Then different voice frequencies are assigned to each area.

- In an omnidirectional cell, the frequency-reuse distance of a seven-cell reuse pattern is $D = 4.6R$, where 'R' is the radius of the cell. one overlay and one underlay

- Because of the sectorization in a directional cell, the channel assignment has a different algorithm in six regions. i.e. three overlay regions & three underlay regions.



underlay-overlay in omni-directional cell



underlay-overlay in sectorized cell.

(b) frequency assignment

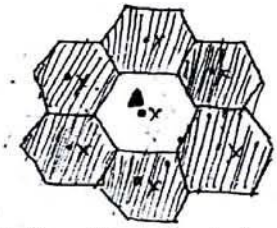
- we assign the frequencies by a set of channels or any part of a set or more than one set of the total 21 sets
- Borrowed frequency sets are used when needed.
- On the basis of Coverage Prediction, we can assign frequencies intelligently at one site or at one sector without interfering with adjacent cochannel sectors or cochannel cells.

(c) Tilted Antenna.

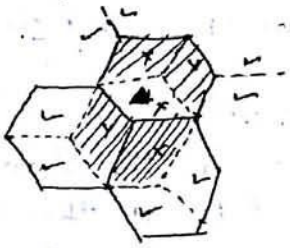
- The tilted directional Antenna arrangement can eliminate interference.
- Sometimes antenna tilting is more effective than decreasing antenna height, especially in areas of tall trees or at high sites.
- when the tilting angle become 22° or greater, the horizontal pattern creates a notch in the front of the antenna, which can further reduce the interference.

fixed channel Assignment.

(i) Adjacent-channel Assignment includes neighboring-channel assignment and next-channel assignment.



omnidirectional Antenna cells.



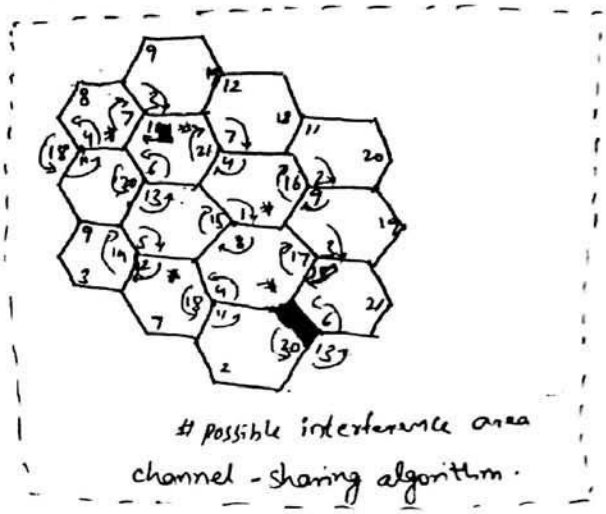
directional-Antenna cells

- The near-end-far-end (ratio) interference can occur among the neighboring channels. Therefore, within a cell we have to be sure to assign neighboring channels in an omnidirectional-cell system and in a directional-antenna-cell system properly.
- In an omni-directional-cell system, if one channel is assigned to the middle cell of seven cells, next channels cannot be assigned in the same cell. Also no next channel should be assigned in the six neighbouring sites in the same cell system area.
- In a directional-antenna-cell-system, if one channel is assigned to a face, next channels cannot be assigned to the same face or to the other two faces in the same cell. Also the next channels can't be assigned to the other two faces at the same cell site.
- Sometimes the next channels are assigned in the next sector of the same cell in order to increase capacity. Then performance can still be in the tolerance range if the design is proper.

Channel sharing & borrowing.

(i) Channel sharing.

- Channel sharing is a short-term traffic-relief scheme.
- There are 21 channel sets, with each set consisting of about 16 channels.
- When a cell needs more channels, the channels, the channels of another face at the same cell site can be shared to handle the short-term overload.
- To obey the adjacent-channel assignment algorithm, the sharing is always cyclic.



possible interference area

channel-sharing algorithm.

- Sharing always increases the trunking efficiency of channels. Since we can't allow adjacent channels to share with the nominal channels in the same cell, channel set 4 & 5 can't both be shared with channel sets 12 & 18 as indicated by the grid mark.

Channel borrowing.

- Channel borrowing is usually handled on a long term bas
- The extent of borrowing more available channels from other cells depends on the traffic density in the area.
- Channel borrowing can be implemented from one cell-site face to another face at the same cell site.
- In addition, the central cell site can borrow channels from neighboring cells.
- The channel-borrowing scheme is used primarily for slowly-growing systems.
- It is often helpful in delaying cell splitting in peak traffic ang since cell splitting is costly, it should be implemented only as a last resort.

Sectorization

- The total number of available channels can be divided into sets (sub-groups) depending on the sectorization of the cell configuration; the 120° sector system, the 60° sector system, 45° sector system.
- (i) In this 120° sector cell is used for both transmission and reception. Different frequencies are assigned to each sector and in order to change the sectors while calling it requires handoffs.

(ii) In this 60° sector cell is used for both transmission and reception. It also requires handoffs to change sectors while calling. Compared to 120° sector more handoffs are expected here

(iii) Here the transmitting antenna is omnidirectional and 60° or 120° sector cell is used for reception. No handoffs are required in this case, as no channel is divided for each sector.

➤ Underlay - Overlay arrangement

- In actual cellular systems cell grids are seldom uniform because of varying traffic conditions in different areas and cell-site locations.

Overlaid cells:- To permit the two groups to reuse the channel in two different cell-reuse patterns of the same size, an "underlaid" small cell is sometimes established at the same cell site as the large cell.

- The "doughnut" (large) & "hole" (small) cells are treated as two different cells. They are usually considered as "neighboring cells."

* Diff... use of either an omnidirectional antenna at one side to create two subring areas or three directional antennas to create six subareas.
- A set of frequencies used in an overlay area will differ from a set of frequencies used in an underlay area in order to avoid adjacent-channel & co-channel interference.

Reuse partition
- The reuse partition is applied for cellular system that employed underlay-overlay arrangement. In the conventional underlay-overlay arrangement, the two cells [underlaid & overlaid] use a common frequency reuse pattern
- In reuse pattern scheme two different frequency reuse patterns are used for the two cells.
- The use of two different reuse patterns to the two cells though serves the same traffic as the conventional one but provides an improved spectrum efficiency. Therefore, each cell is capable of serving more customers at a time.
- Hence, even if there is an increase in the number of customers the system is well capable of serving them efficiently. Also, the coverage area can be expanded covering large areas.
- The no. of cell sites can be reduced by using this scheme for example, for this scheme is the most conventional frequency reuse pattern K=7.
- This can be replaced by a underlay-overlay arrangement using reuse partition scheme with K=9 assigned to overlaid cells & K=3 assigned to underlaid cells increases the spectrum efficiency by 20% while serving the same traffic capacity.

➤ Non-fixed channel Assignment.

They are various types of non-fixed channel assignments algorithms.

1) Fixed channel 2) Dynamic channel 3) Hybrid channel
4) Borrowing channel 5) Forcible borrowing channel algorithm

(1) Fixed channel: In this algorithm, each cell assigns its own radio channels to the vehicles within the cell.

(2) Dynamic channel: In this Algorithm, each cell assigns its own radio channels to the vehicles within its cell. In composite of 312 radio channels, any radio channel can be assigned directly to a mobile unit.

(3) Hybrid channel Algorithm

Hybrid channel Algorithm assignment is the combination of fixed channel algorithm & dynamic channel Assignment.

(4) Borrowing Channel Algorithm

Borrowing channel Assignment uses fixed channel algorithm as a normal assignment condition. when all the fixed channels are occupied, then the cell borrows channels from the neighboring cells.

5) Forcible Borrowing channel Algorithm.

In these channel assignment, channels must be borrowed from the neighboring cells and at the same time, another voice channel will be assigned to continue the call in the neighbouring cell. The Forcible borrowing channel assignment is used to reduce the co-channel assignment in a reuse cell pattern.

- There are two problems that typically occur with non-fixed channel assignment. They are.

(i) This method typically has a degree of randomness associated with them and this leads to the fact that frequency reuse is often not maximized unlike the case for FCA systems in which cells using the same channel are seperated by the minimum reuse distance.

(ii) This method often involves complex algorithms for deciding which available channel is most efficient. These algorithms can be computationally very intensive and may require large computing resources in order to be real time.