Wireless Networks

Cellular Systems - Basic Concepts

- High capacity is achieved by limiting the coverage of each base station to a small geographic region called a cell.
- Same frequencies / time slots / codes are reused by spatially separated base stations.

  larger number of customers
  ↓
  More revenue
  ↓
  sustainability of the system.

- A switching technique called handoff enables a call to proceed uninterrupted when one user moves from one cell to another.
- Resolves problem of limited radio spectrum.
- Neighboring base stations are assigned different group of channels so as to minimize the interference.
  - reuse distance
  - frequency reuse planning
  - If we do not plan well we will face the problem of interference.

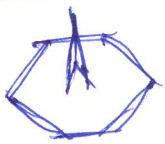
- Neighbory base stations are assigned diffent group of channels so as to minimize the interfence.
- By systematically spacing base stations and the channel groups may be reused as many nmber of times as necessary.
- As demand increases, the nmber of base stations may be increased thereby providing additional capacity.

They are ways expand your services
- reuse factor and limit bandwidth
- reduce the cell size (means reduce the Powr)

How Big the size of the cell is decided by who big Power is.

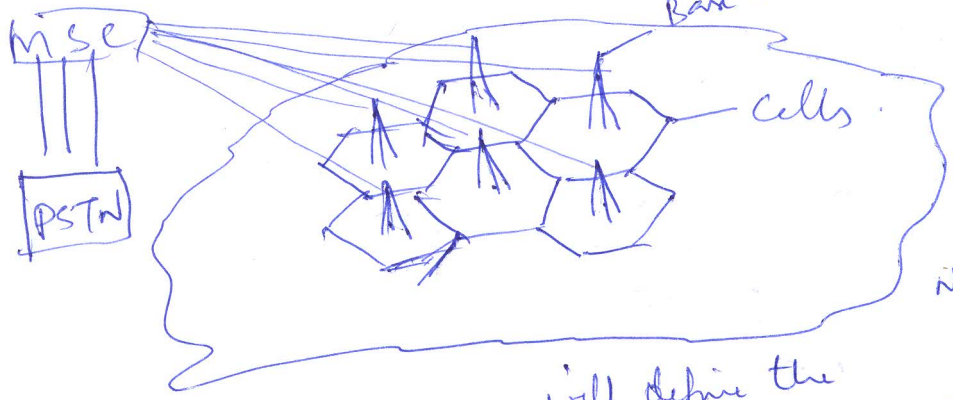
I can increase the $ customers by reducing the Cell Size and Powr under control.

Cellular Telephone Systems



- every cell has a base station
- transmitting antennas
- transmitting unit
- area of coverage.
- Hexagon.

- Why Hexagon is used? Concept in reality there is not Hexagon shaped area of coverage.



Simplicity
- all cells are equal
- In reality no cells are equal
- terrain
- block
- density of people
- traffic.

- will define the size of cell.

- Cell size is made smaller to make higher degree of reuse and high capacity (Provide)

- Base station need to be connected to each other and to the outside world

- MSC mobile switching Centre. Brains coordinate calls between the mobile and land line Phone. Vice versa.

- How to initiate the call, from a landline to mobile Phone, Vice Versa.
- If my mobile is moving over one cell to other while talking we need to provide some handoff. what kind ~~of~~ issues we will discuss
- Cells are neither equal in size, nor ~~not~~ overlapping, nor Hexagonal in Shape
- To establish a call from a mobile to a base station we use channels

frequency bands
time ~~slots~~ slots
codes

Forward and Reverse channels

- Forward voice channels (FVC): used for voice transmission from BS to MS
- Reverse voice channels (RVC): used for voice transmission from MS to BS
- Forward control channel (FCC): used for initiating a call from BS to MS

- Reverse control ~~cont~~ channel (RCC): used for initiating a call from MS to BS.
- The FCC and RCC are also called <u>setup channels</u>.

control channels are not used for sending voice but used for overhead, typically they take 5% of bandwidth

Anatomy of a cellular call

- A cell phone, when turned on, (though not yet engaged in a call) scans the group of FCC to determine the one with the strongest signal.

Talk time and standby time

- continuously monitoring
- If it monitors that channel until it drops below a the usable threshold. it then scans for another channel which is the strongest.
- control channels are defined and standardized over the entire area of service. Typically the control channels are up 5% of the total number of channels.

A call to a mobile user.

- The MSC dispatches the request to all base stations.
  (fiber cable, point to point microwave)
- The mobile identification number (MIN) is broadcast as a paging message over FCC throughout the service area. (MIN is different from the mobile number)
- The MS receives the paging message from the BS it is monitoring. It responds by identifying itself over the RCC.
- The BS conveys the handshake to the MSC, the MSC instructs the BS to move to an unused voice channel.
- MIN ↔ mobile number.
  Hardware number look up table at MSC
  - Sim card has number
  - H/w Number
  - Logical number.

A Call to a mobile user

allocated to open voice channel.

- The BS signals the MS to change over to an unused FVC and RVC. (both are to be available for the call to be established).
- An data message (called alert) is transmitted over FVC to instruct the mobile to ring.
- All of these sequence of events occur in just a few seconds, are not noticeable to the user.
- you may find some (gap/blank/beep) sound before the phone may ring. slients.
- while the call is in Progress, the MSC adjusts the transmitted power in order to maintain the call quality.

(modern systems the control part is taken care at BS)

(even handset are becoming are powerful, Power control mechanisms are also used at MS).

102
101
055
096
129
128

A Call from a mobile user

- every time a ~~mob~~ MS is always in touch with any one BS.
- A call initiation request is sent to the RCC.
- Along with this, the MS transmits its MIN, Electronic Serial Number (ESN) and the phone number of the called party.
- The MS also transmits the station class mark (SCM) which indicates the maximum transmitter power level for the particular user.
- The BS forwards the data to the MSC, which validates the data and makes connection to the called party through the PSTN.

Frequency reuse : The need

limited bandwidth.

Eg:
- fixed telephone network runs wires to every household.
- Suppose we give every household their own allocation of radio spectrum for analog speech (wireless) of 4 kHz bandwidth.
- 12.5 million households (say Delhi) × 4 kHz
  = 50 GHz !

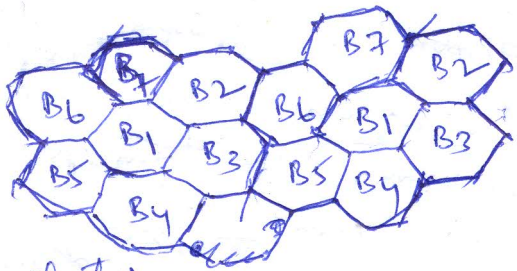
- clearly impractical
  - no other services possible using radio transmission
  - most of the spectrum unused most of the time.
    (I cannot do adaptive reallocation).
    (this calculation is only used for voice, if you want allow them for data, downloads we cannot do.)

So we need reuse of frequencies.

- Cellular radio systems rely on intelligent allocation and reuse of channels throughout the coverage area.
- Each base station is allocated a group of radio channels to be used within the small geographic area of its cell. (it not the frequency its frequency band)
- neighboring base station are given different channel allocation from each other.
  (avoid interference).
- By the design of antennas, the coverage area is limited within the cell, and the same group of frequencies is reused to cover another cell separated by a large enough distance to keep co-channel interfere within limits

Example of frequency reuse

- Cell - of 3 to 5 km



Cluster

Distance between any two co-channel is same

i.e B4 to B4 is same
B6 to B6

All the frequency bands are suffered from same co-channel interference.

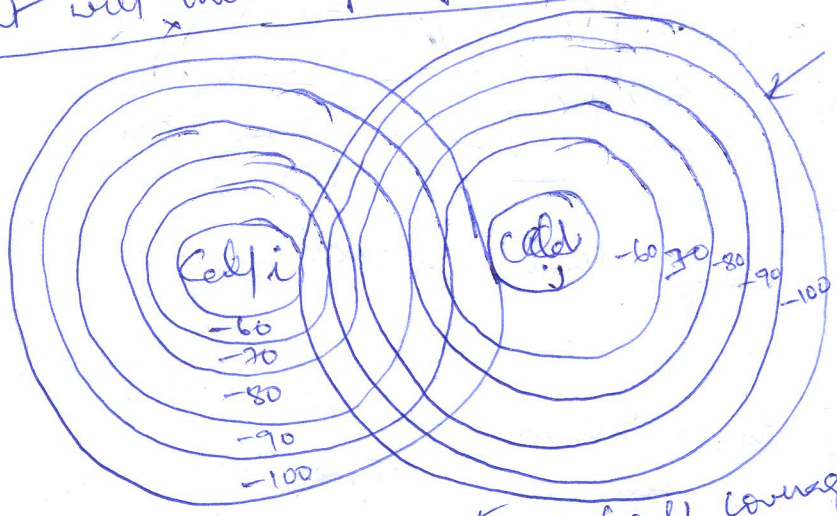
- why the distance should be same.

take one cluster and rotate
some cells have less distance other have large distance. So some cells have poor quality of signal because of high co channel interference.
so we use same distance to use affordable size if co channel interference.

- If cluster size is small say size=4
reuse distance go down, capacity will go up.
we need to tradeoff b/w reuse distance and capacity.

In the above figure we use reuse factor of 1/7

what will be the shape of the cell? How can we regulate



Base station at the Centre as we move away strength of signal goes down.

ideal signal strength / cell coverage

- I need to decide certain reuse distance
- If cells can tolerate certain interference

Interference mitigation techniques are available using signal processing which allows high interference.

Concrete image

- Signal strength contours indicating actual / cell coverage.
- This depends on terrain, presence of obstacles and signal attenuation in the atmosphere.
- applicability of Hexagonal shape

Rain
Fog
Buildings