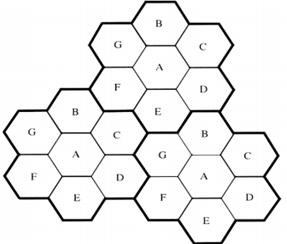
WIRELESS COMMUNICATIONS

ASSIGNMENT – II

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1. **Consider a cellular service provider in London, Ontario is allocated the spectrum bandwidth for 210 channels (210\*50Khz = 10.5Mhz), and its coverage area is divided into 21 cells, as show in Figure 1.**



Cellular communication system for Question 1

**(a) Determine the maximum of active users can be supported at same time when there is NO frequency reuse.**

Each cell can support 10 users, if the distribution of the active users is even.

Therefore, active users supported = 21 x 10 = 210

**(b) Determine the system capacity with cluster size of 7 and 3, respectively.**

For cluster size of 7: All cells are grouped into cluster of 7 cells and each cluster employs all of the frequencies. This means that the capacity is increased by a factor of 3.

Therefore, Capacity = 210 x 3 = 630 channels

For cluster size of 3: All cells are grouped into cluster of 3 cells and each cluster employs all of the frequencies. This means that the capacity is increased by a factor of 7.

Therefore, Capacity = 210 x 7 = 1470 channels

**(c) Explain why the system capacity in (b) is increased, compared with (a). Discuss how to choose the cluster size in a cellular network.**

In the full-duplex mode of operation, a radio channel contains a pair of channel frequencies, each of which is transmitted at a frequency. The radio channel F1 is used to call one cell in the geographical area C1 with the coverage radius R, and F1 can be used again in another cell with the distance D and the coverage radius R.

Theoretically, K should be larger, however, the total number of channels allocated is fixed. If K is too large, the number of channels allocated to each cell in the K cells will decrease, and if the total number of channels in the K cells is divided as K increases, the relay efficiency decreases. Similarly, if a group of channels in the same area is assigned to two different working networks, the system frequency efficiency will be reduced. Therefore, the question now is how to obtain a minimum K value under the condition of satisfying the system performance. To solve it, it is necessary to estimate the co-channel interference and select the minimum frequency reuse distance D to reduce co – channel interference. When the conditions are satisfied, the number of cells constituting the unit radio zone group K = i2 + ij + j2.

**(d) What is link budget analysis in wireless communications? Discuss its applications in wireless communications network deployment.**

When a Signal travels from a transmitter to receiver, there are events like gain and loss during signal transmission through mediums like cable, fiber etc. A Link budget analysis is an account of all such gains and losses. The attenuation of the transmitted signal due to propagation, as well as the antenna gains, feed line and miscellaneous losses are also accounted for. Arbitrarily varying channel gains such as fading are taken into account by adding some margin depending on the anticipated severity of its effects. A link budget equation would look like as follows:

Power Received (dB) = Power Transmitted (dB) + Gains (dB) − Losses (dB)

In practical situations like Deep Space Telecommunications, Weak signal DXing etc. other sources of signal loss must also be accounted for. The transmitting and receiving antennas may be partially cross-polarized. The cabling between the radios and antennas may introduce significant additional loss.

Also, Guided media such as coaxial and twisted pair electrical cable, radio frequency waveguide and optical fiber have losses that are exponential with distance. The path loss will be in terms of dB per unit distance. This means that there is always a crossover distance beyond which the loss in a guided medium will exceed that of a line-of-sight path of the same length. Long distance fiber-optic communication became practical only with the development of ultra- transparent glass fibers. A typical path loss for single mode fiber is 0.2 dB/km, far lower than any other guided medium.

Because of building obstructions such as walls and ceilings, propagation losses indoors can be significantly higher. This occurs because of a combination of attenuation by walls and ceilings, and blockage due to equipment, furniture, and even people.

**Link Budget Applications**

* In communications like Earth-Moon-Earth, link budgets are important. High power and high gain antennas must be used as the path loss is huge over an enormous return distance of 770,000 kilometers.
* The Voyager Program spacecraft have the highest known path loss and lowest link budgets of any telecommunications circuit. Although the Deep Space Network has been able to maintain the necessary technological advances to maintain the link, the received field strength is still very weak.

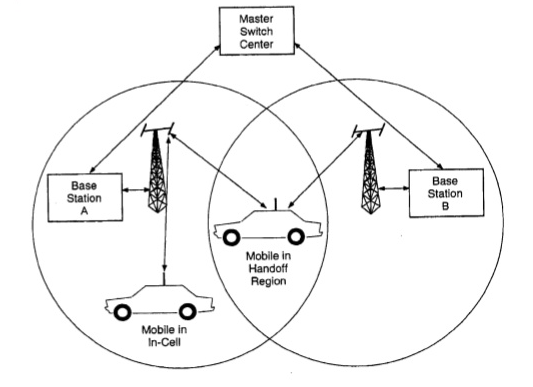
**2. Consider a cellular communication network.**

**(a) Explain the concept of frequency reuse in cellular communication network.**

Frequency reuse is the practice of splitting an area into smaller regions that do not overlap so that each utilizes the full range of frequencies without interference. The introduction of this concept was a major step in the development of mobile phone technology. Before the advent of cellular phones, radio telephones and other mobile communications devices relied on a single, central antenna tower to service an entire city. Each phone required a large antenna powerful enough to transmit a signal over the potentially great distance to that tower. In addition, there was a limit to the amount of phone traffic that could be supported at a given time because each tower only offered a limited number of channels.

After some good amount of research, it was realized that they could increase the cap on the number of simultaneous users by applying their current technology to a smaller scale. Accordingly, they introduced frequency reuse. Mobile communications providers increased the total number of towers and reduced the size of each one's service area. Although each tower had a limited number of channels, the non- overlapping nature of the service areas allowed the same frequency to be used in each one without interference. By doing so, mobile communications providers greatly expanded the number of potential users.

**(b) Explain the need for handoff process in cellular communications and discuss how to choose a proper handoff threshold.**



In Cellular communication, when a mobile user is on a call and travels from one area of coverage or cell to another cell, the call should be transferred to the new cell’s base station. Failing which, the call will be dropped because the link with the current base station becomes too weak as the mobile recedes. This ability for transference in cellular communication is called handoff

Two types of handoff:

**Hard handoff**

With hard handoff, the link to the prior base station is terminated before or as the user is transferred to the new cell’s base station. That is to say that the mobile is linked to no more than one base station at a given time. Initiation of the handoff may begin when the signal strength at the mobile received from base station 2 is greater than that of base station 1. The signal strength measures are really signal levels averaged over a chosen amount of time. This averaging is necessary because of the Rayleigh fading nature of the environment in which the cellular network resides. A major problem with this approach to handoff decision is that the received signals of both base stations often fluctuate. When the mobile is between the base stations, the effect is to cause the mobile to wildly switch links with either base station. The base stations bounce the link with the mobile back and forth. Hence the phenomenon is called ping- ponging.

**Soft handoff**

Soft handoff technology is used by code-division multiple access (CDMA) systems. Older networks use frequency division multiplex (FDM) or time division multiplex (TDM). In CDMA, all repeaters use the same frequency channel for each mobile phone set, no matter where the set is located. Each set has an identity based on a code, rather than on a frequency (as in FDM) or sequence of time slots (as in TDM). Because no change in frequency or timing occurs as a mobile set passes from one base station to another, there are practically no dead zones. As a result, connections are almost never interrupted or dropped.

**Comparison**

Soft handoff is advantageous over hard handoff because the mobile does not lose contact with the system during handoff execution. Ping ponging is eliminated and an extra measure of performance is obtained through diversity combining to mitigate fading. Furthermore, more control may be given to the mobile in handoff decisions. This autonomous handoff decision ability, selection diversity, and inherent improvement of reliable handoffs with fewer unnecessary decisions, make soft handoff an attractive choice meriting further study as it is being used in third generation CDMA.

**(c) Discuss all possible interferences in cellular communications network and their causes.**

Anything which modifies, or disrupts a signal as it travels along a channel between a source and a receiver is called interference. The term typically refers to the addition of unwanted signals to a useful signal. The term typically refers to the addition of unwanted signals to a useful signal. Interference is at least an occasional problem with most types of radio equipment, including wireless microphones. The effects of interference range from being a minor annoyance to making the wireless system completely unusable. Serious interference is not as common as is sometimes assumed, especially when some simple precautions are taken.

Types of interference:

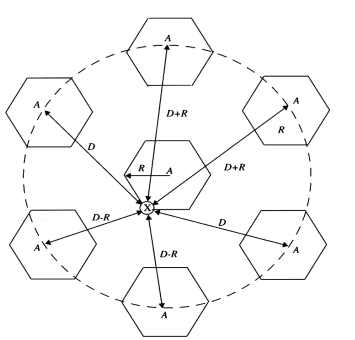
*Radio frequency interference* is caused by radio and TV transmitters, communications equipment, cable television systems and other types of equipment that generate radio frequency energy as part of their operation.

*Electrical interference* is caused by computers and digital equipment, heavy electrical equipment, lighting systems, faulty electrical devices, etc.

*Inter modulation* is a type of interference caused by the internal combination of strong radio signals in wireless receivers.

Simply knowing which type of interference is present helps avoid wasting time on unproductive approaches and greatly simplifies the process of finding the real source of the problem.

**(d) Use the following figure and explain the worst scenario of co-channel interference in cellular communication. Discuss how the frequency reuse ratio of a cellular network is determined. The free space signal propagation model can be used.**



The first tier of co-channel cells for a cluster size of N = 7. When the mobile is at the cell boundary of point X, it experiences worst case co-channel interference on the forward channel. The marked distances between the mobile and different co-channel cells are based on approximations made for easy analysis.

For N = 7, the co-channel reuse ratio Q is 4.6, and the worst-case S/I is approximated as 49.56 (17 dB) whereas an exact solution yields 17.8 dB

Hence for a seven-cell cluster, the S/I ratio is slightly less than 18 dB for the worst case.

To design the cellular system for proper performance in the worst case, it would be necessary to increase N to the next largest size,

This obviously entails a significant decrease in capacity, since 12-cell reuse offers a spectrum utilization of 1/12 within each cell, whereas seven-cell reuse offers a spectrum utilization of 1/7. In practice, a capacity reduction of 7/12 would not be tolerable to accommodate for the worst- case situation which rarely occurs. From the above discussion, it is clear that co-channel interference determines link performance, which in turn dictates the frequency reuse plan and the overall capacity of cellular systems.