Sri Muthukumaran Institute Of Technology
Department Of Electronics and Communication Engineering
Odd Semester July'23-Dec'23
Question Bank

Sub code: EC3501 Sem/Year: V/III
Sub name: Wireless Communication Regulation: R2021

Unit-I THE CELLULAR CONCEPT-SYSTEM DESIGN FUNDAMENTALS
Part: A

1. Writesomeexamplesforwirelesscommunicationsystem.
   Cordlessphones,handheldwalkie-talkies,pagers,mobiles,remotecontrollersforhomeentertainment.

2. Whatisbasestation?
   Afixedstationinmobileradiosystemusedforradiocommunicationwithmobiles.Ithastransmitterandreceiversection.Itislocatedatthe center ofcoveragearea.

3. WhatisMSC?
   Mobile switching centre coordinates the routing of calls in large service area. It connects the base station and mobiles to PSTN. It is also called as MTSO (Mobile telephoneswitchingoffice).

4. Whatdoyoumeanbyforwardandreverse channel?
   Forwardchannelisaradiochannelusedfortransmissionofinformationfrombasestationtomobile.Reversechannelisaradiochannelusedfortransmissionfrommobiletobasestation.

5. Whatisthefunctionofcontrolchannel?Whatarethetypes?
   Controlchannelisusedfortransmissionofcallsetup,callrequest,callinitiation&Control.Types areforwardcontrolchannel, reversecontrolchannel.

6. Definecell
   Eachcellularbasestationisallocatedtoagroupofradiochannelstobeusedwithinasmallgeographicareacalledas cell.

7. Whatisfootprint?
   Actualradiocoverageofacelliscalledasfootprint.Itisdeterminedfromthefieldmeasurementsorpropagationpredictionmodels.

8. Whatischannelassignment?Whatarethetypes?
   Forefficientutilizationofradiospectrumafrequencyreuseschemewithincreasingcapacityandminimizinginterferenceisrequired.Forthischannelassignmentisused
   Types:Fixedchannelassignment,dynamicchannelassignment.

9. Whatisfixedchannelassignment?
   If the channelsin each cell areallocatedto the users within the cell,itwill be called asfixedchannelassignment. Ifallchannels areoccupied,the callwillbe blocked.

10. Whatisdynamicchannelassignment?
    If the voice channels are not allocated permanently in a cell, it will be called as dynamicchannel assignment. In this assignment, channels are dynamically allocated to users by theMSC.

11. Whatishandoff?
    Whenamobilemovesintoadifferentcellwhileconversationinprogress,theMSCautomatically transfers the call from one cell to other cell without any interference. This iscalledas handoff.

12. Definedwelltime.
    The time over which the call may be maintained within a cell without handoff is called asdwelltime.Thistimeisgovernedby factorssuch aspropagation, interference,distancebetweensubscribersandbasestation.

13. Whatissofthandoff?
    InCDMAsystem,MSCselectsreceived signalsfroma varietyofbasestationswiththehelpofsoftware. Thisis calledassofthandoff.

14. Whatisco channelinterference?
    Theinterferencebetweenthesignalsfromcochannelcellsiscalledascocannelinterferen ce.

15. Defineco-channelreuseratio.
    Itisdefineastheratiobetweenthedistancesbetweenthecentersofnearestcochannelcells totheradius ofthe cell.Q=D/R

16. Defineadjacentchannelinterference.
    Interferenceresultingfrom signalswhichareadjacentinfrequencytothedesiredsignaliscalledadjacentchannelinterference.

17. Define Gradeofservice.
    Itisdefinedasthemeasureoftheabilityofausertoaccessatrunkedsystemduringthe busiesthour.

18. Whatisblocked callclearedsystem(BCC)?
    Inasystem,auserisblockedwithoutaccessbyasystemwhennochannelsareavailableinthesystem.The callblockedbythesystemisclearedandtheusershouldtryagain.Thisis

calledBCCsystem.

19. Whatisblockedcalldelayedsystem?
If achannelisnotavailableimmediately,thecallrequestmaybedelayeduntilachannelbecomesavailable.

20. Definecellsplitting.
Cell splitting is the process of subdividing congested cells into smaller cells each with its ownbasestationsandacorrespondingreductioninantennaheightand transmitterpower.Itincreases thecapacityofcellularsystem.

21. Whatissectoring?
Sectoringsatechniquefor decreasingco-channelinterferenceandthusincreasing thesystemperformance byusingdirectionalantennas.

22. Definefrequencyreuse.
Physicalseparationoftwocellsissufficientlywide;thesamesubsetoffrequenciescan beusedinbothcells.Thisis the conceptoffrequencyreuse.

23. Writetheexpressionforsystemcapacityusingfrequencyreuse.Meas ure ofsystemcapacityisgivenby:
C=MkN=MS
whereM isclusterreplicationtimes
k isgroupofchannelsallocatedtoacellN is clustersize
Sistotalchannelsavailablefor use.

24. Whyhexagonshapeisusedascellshape?
Hexagonal cell shape is perfect over square or triangular cell shapes in cellular architecturebecauseitcoveranentireareawithoutoverlappingi.e.theycancovertheentiregeographicalregionwithoutanygaps.

25. Whatis meantbytrunkingandtrunkingefficiency?
Trunkingallowsalargenumberofuserstosharetherelativelysmallnumberof channelsina cellbyprovidingaccess toeachuserondemandfroma poolofavailable channels. Trunkingefficiencyisameasureofthenumberofuserswhichcanbeofferedaparticular Grade OfService (GOS)witha particularconfigurationoffixedchannels.

PART-B

1. Writeshortnotesonfrequencyreuse&channelassignment strategies.

1. Write short notes on frequency reuse ~~Diagram~~ & channel Assignment strategies

FREQUENCY REUSE

Cellular radio systems rely on an intelligent allocation and reuse of channels throughout a coverage area. Each base station is allocated a group of radio channels to be used within a small geographic region called cell. Base stations in adjacent cells are assigned channel groups which is completely different than neighboring cells. The Base station antennas are designed to achieve the coverage within the cell boundaries, because the same channel group may be used in different cells to avoid interference. The design process of selecting and allocating channel groups for all the base stations within a system is called Frequency reuse or frequency planning.

The cell shape is designed in hexagon for the coverage purpose of each base station. The actual coverage area of a cell is known as the foot print. When considering geometric shapes which can cover an entire region without overlap and with equal area, there are 3 possible choices: square, triangle and hexagon. A cell must ~~provide~~ be designed in such a way to provide the weakest mobiles within the footprint which are located at the edge of the cell. For this, the hexagon has the largest area when compared to the other 2 shapes. Thus, using hexagon fewest no. of cells can cover the geographic region. The no. of hexagonal cells required will be planned and then channels are assigned for every cell.

Consider a cellular system with a total of 'S' duplex channels available for use. If each cell is allocated a group of 'K' channels ($K < S$), and if the S channels are divided among 'N' cells, the total no. of available radio channels is

$$S = KN$$

If a cluster is replicated 'M' times within the system, 'C' can be the measure of capacity and is given by

$$C = MKN = MS$$

The frequency reuse factor of a cellular system is given by $f = 1/N$

~~Diagram~~

CHANNEL ASSIGNMENT STRATEGIES

To utilize the radio spectrum efficiently, a frequency reuse scheme that is consistent with the objectives of increasing capacity and minimizing interference is required. To achieve these objectives variety of channel assigment strategies as either fixed or dynamic have been developed. The choice of channel assignment strategy impacts the performance of the system, like cells managing a mobile user when handed off from one cell to another.

Fixed channel assignment strategy:

In this, each cell is allocated a predetermined set of voice channels. Any call attempt within the cell can be served only by the unused channels in that particular cell. If all channel are occupied, the call is blocked and the subscriber does not receive service. To an alternate one approach called borrowing strategy can be performed. In this approach, a ~~cell~~ channel is borrowed from the neighbor cell if all its own channel are occupied. The Mobile Switching Center (MSC) supervises such borrowing procedure and also ensures this does not disrupt (or) interfere with any of the calls in donor cell.

Dynamic channel assignment strategy:

In this, voice channels are not allocated to different cells permanently, rather when a call is made ~~requested~~ the serving base station request channel from the MSC. The MSC allocates a channel to the requested cell taking into consideration the likelihood of future blocking within the cell, the candidate channel frequency, reuse distance of the channel and other cost functions. Accordingly, the MSC allocates a given frequency if it is not in use presently (or) any other cell which falls within the minimum restricted distance of frequency to avoid co-channel interference. DCA reduces the likelihood of blocking and increases the trunking capacity. DCA requires MSC to collect real-time data on channel occupancy, traffic distribution and radio signal strength indication (RSSI) of all channels on a continuous basis to increase the storage and computational load on the system and provides the advantage of increased channel utilization and decreased call blocking probability.

2. Writeindetailabouttheinterferencesystemandcapacity.

2. Write in detail about interference system & capacity.

INTERFERENCE AND SYSTEM CAPACITY:

Interference on voice channels causes cross talk, where the subscriber hears interference in the background due to an undesired transmission.

Two types of Interference:

Intracell Interference: caused in the same cell

Intercell Interference: caused from other cell.

Two types of system generating Interference:

1. Co-channel Interference (CCI)
2. Adjacent channel Interference (ACI)

1. Co-channel Interference and system capacity.

Cells having channel that use the same set of frequencies are called co-channel cells.

Interference between the signals from co-channels is called co-channel Interference.

To reduce CCI co-channels must be physically separated by minimum distance in order to provide sufficient isolation due to propagation.

CCI ratio is a function of radius of the cell (R) and distance between centers of the nearest co-channel cells (D)

By increasing the ratio of D/R, coverage distance of a cell gets increased. Then the co-channel reuse ratio (Q) is $Q = \frac{D}{R} = \sqrt{3N}$ → cluster size

Let i_o be the number of co-channel interfering cells, then the signal to Interference is,

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{i_o} I_i}$$

S — signal power from B.S

I_i — Interference from i^{th} co-channel B.S

Average power received at distance 'd' from transmitting antenna is

$$P_r = P_o\left(\frac{d}{d_o}\right)^{-n}$$

(d — distance from tx antenna; n — path loss exponent; d_o — small distance; P_r — received power; P_o — power received at close interference point)

In terms of dBm,

$$P_r(dBm) = P_o(dBm) - 10n\log\left(\frac{d}{d_o}\right)$$

When transmit power of each B.S is equal and the path loss exponent is same throughout the coverage area, then S/I is

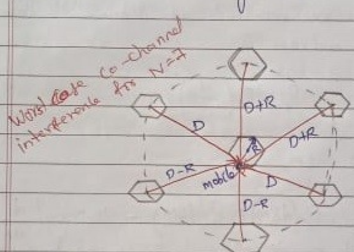
$$\frac{S}{I} = \frac{R^{-n}}{\sum_{i=1}^{i_o}(D_i)^{-n}}$$

(D_i → Distance b/w i^{th} interferer & mobile)

If all the interfering B.S are equidistant from desired station and it is 'D' distance between the cell centers then,

$$\frac{S}{I} = \frac{(D/R)^n}{i_o} = \frac{(\sqrt{3N})^n}{i_o}$$

Consider, that the mobile is at the cell boundary, where it experiences worst case CCI. Then the mobile is at distance D−R from the two nearest co-channels and D+R/2, D, D−R/2 from the other interfering cells



The S/I ratio for the worst case can be given as,

$$\frac{S}{I} = \frac{R^{-n}}{2(D-R)^{-n} + 2(D+R)^{-n} + 2D^{-n}}$$

If D/R = Q & n = 4, then:

$$\frac{S}{I} = \frac{1}{2(Q-1)^{-4} + 2(Q+1)^{-4} + 2Q^{-4}}$$

2. Channel planning for wireless system

Channels are made up of control channels and voice channels. Typically 5% of the entire spectrum is for control channels (for initiating, requesting or paging a call) which carry data messages and 95% of the spectrum is dedicated to voice channels (for revenue and generating traffic)

When a cell is overloaded, the CDMA allows to offload subscriber traffic to neighboring cells by changing the geographic size of the service area. This is called Breathing Cell Effect.

3. Adjacent Channel Interference (ACI)

Interference resulting from the signals which are adjacent in frequency to the desired signal is called ACI

Reduction of ACI:

It can be minimized through careful filtering and channel assignment. In practice, the B.S receivers are preceded by a high Q cavity filter in order to reject ACI.

4. Power control for reducing Interference.

In particular cellular radio and personal communication systems, the power transmitted by every subscriber unit are under constant control by the serving B.S.

This is done to ensure that each mobile transmits the smallest power necessary to maintain good quality link on the reverse channel.

Power control not only helps to maintain prolong battery life for the subscriber unit, but also dramatically reduces the reverse channel S/I in the system

3. Withneatdiagramdiscussabout handoffstrategies.

3. With neat diagram discuss about Hand off strategies

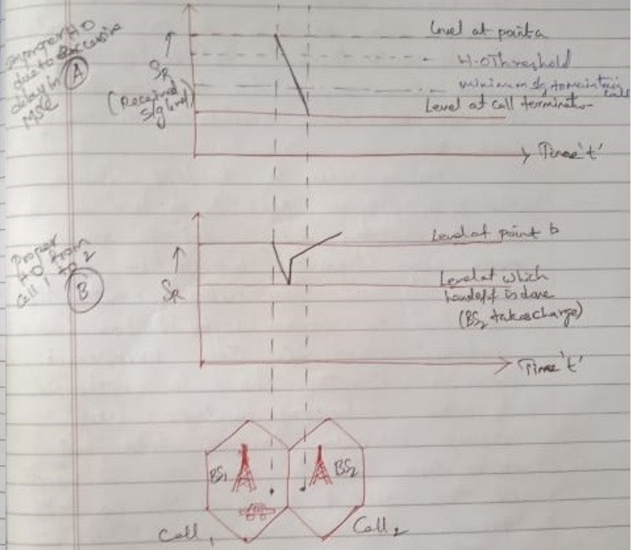
Hand OFF strategies

When a mobile moves from one cell to the other during the conversation, the MSC automatically transfers the call to the new channel belonging to the new base station. This handoff operation involves identifying a new base station requires voice and control signals be allocated to channels in the new base station.

Handoff process is an important task in any cellular radio system. Many handoff strategies prioritize handoff requests over call initiation requests when allocating unused channels in a cell. Handoff must be performed successfully and as infrequently as possible and be imperceptible to the users. To satisfy these requirements, system designers must specify an optimum s/g level at which to initiate a handoff. Once a particular signal level is specified as the minimum usable s/g for acceptable audio quality at the base station receiver (-90dBm to -100dBm), a slightly stronger s/g level is used as a threshold at which handoff is made. This threshold is given by

$$\Delta = P_{r\,handoff} - P_{r\,minimum\ usable}$$

Δ cannot be too large, for unnecessary handoff and cannot be too small, for insufficient time to handoff call before termination



In the given figure, shown, it is shown that handoff is not made and the s/g drops below the minimum acceptable level to keep the channel active. This is due to an excessive delay in MSC in assigning handoff (or) too small threshold for handoff time. Excessive delay may be due to high traffic at MSC (or) no channels available in the nearby base station.

In deciding when to handoff, ensure that the drop in measured s/g level is not due to momentary fading and the mobile is moving away from the base station. To ensure this, the base station monitors the s/g level for certain period of time before initiating hand off. This measurement of s/g strength should be optimized to avoid unnecessary handoffs while ensuring necessary handoff before call termination due to poor s/g. The length of time needed to decide for handoff depends on the speed of the moving vehicle.

The time over which a call is maintained within the cell without handoff is called dwell time. The dwell time of a user is governed by factors such as propagation, interference, distance b/w the user and base station and other time varying effects.

In first generation cellular systems s/g strength measurements are made by the base stations and supervised by the MSC. Each base station monitors the s/g strength of all voice channels to determine the relative location of user w.r.to base station tower. Also, a locator receiver (a spare receiver) is used to determine the s/g strength of users in neighboring cells. This locator receiver is controlled by the MSC and based on the information from locator receiver MSC decides for handoff if necessary or not.

In second generation cellular system handoff decisions are mobile assisted. In mobile assisted handoff (MAHO) every mobile station measures the power received from surrounding base stations and continuously report to the serving base station. Hand off is initiated when power received from the base station of neighboring cell exceeds the current base station in a certain period of time. MAHO method enables handoff faster than the 1st generation system.

MAHO is suitable for microcellular environments where handoffs are more frequency.

During a call, if a mobile moves from one cell to a different cell which is controlled by different MSC an intersystem handoff is required. An MSC opts for an intersystem handoff when a mobile s/g is weak in a given cell and cannot find another cell within its system to transfer the call.

PRIORITIZING HANDOFFS

One method of giving priority to handoffs is called guard channel concept.

→ A fraction of total available channels in a cell is reserved for handoff for the ongoing calls.

Disadvantage: Reduce the channels allocated for ongoing calls.

Another method: — Queuing Handoff

→ decreases the probability of forced termination of call due to lack of available channels.

→ Possible only when there is a finite time interval b/w the time and received s/g level drops below the handoff threshold and the time the call is terminated due to insufficient signal level.

→ Queuing does not guarantee zero probability of call termination. If the delay is large the received s/g drop below the minimum required level to maintain communication and lead to forced termination.

PRACTICAL HANDOFF

In practical, several problems arise when designing a wide range of mobile velocities.

High speed vehicles pass through the cell fastly whereas pedestrian users may never need hand off.

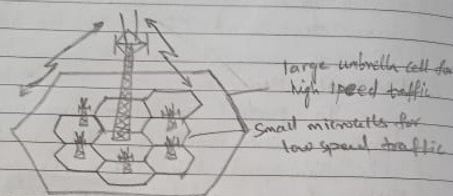
To provide capacity, microcells can be added but it burdens the MSC if the user frequently moves between very small cells.

Umbrella cell Approach:

Providing (or) increasing the capacity through additional cell sites in practical is also difficult in urban areas.

Zoning laws, ordinance and other nontechnical barriers make it attractive for a cellular provider to install additional channels and base station in existing cells rather than finding new site location.

Using different antenna heights and different power levels, it is possible to provide large & small cells in a single location. This is called umbrella cell approach.



Advantages of umbrella cell approach:

* Increases radio coverage
* Reduces number of Hand offs.
* Provides more number of channels
* Less MSC intervention

Cell Dragging:

It is the another practical H.O problem in microcell system.

In an urban environment, when a pedestrain user is provided a very strong signal because of the Line of Sight (LOS) path between the subscriber and base station, cell dragging occurs.

As the user travels away from the base station at a very low speed, signal strength does not decay rapidly and when the user traveled beyond the cell, the received signal at base station may be above H.O threshold, thus a H.O may not be made.

This creates potential difference and traffic management problem. To solve cell dragging problem, H.O threshold and radio channel parameters must be designed carefully.

Types of Hand off:

1. Hard H.O: If MSC monitors strongest signal base station and transfer call to that B.S, it is called Hard H.O
2. Soft H.O: Mobile communicates with 2 (or) more cells at the sametime and finds the strongest signal B.S then it automatically transfers call to that B.S, it is called soft H.O

Advantages of H.O:

(i) Fast and lossless
(ii) Minimal number of control signal exchange
(iii) Scalable with network size
(iv) Capable of recovering from link failures
(v) Efficient use of resources.

4. Explaintrunkingandgradeofservices incellularradiosystem.

4. Explain trunking & grade of service in cellular radio system

TRUNKING AND GRADE OF SERVICE

Trunking – allows large no. of users to share small no. of channels in a cell by providing access to each user on demand.

Pool of channels: When a call is requested, a channel from the pool is allocated to the user and returned back to the pool once the call is over.

The Telephone company uses trunking theory to determine the number of telephone circuits that need to be allocated for office buildings with hundreds of telephones and this same principle is used in designing cellular radio system.

When a phone line increases call blocked (or) denied.

Trunking theory: is developed by Erlang in 19th century. Erlang's theory represents amount of traffic intensity carried by a channel that is completely occupied.

To design trunked radio systems that can handle specific capacity at a specific "Grade of Service" it is essential to understand trunking theory (or) queuing theory

Grade of Service: measure of the ability of a user to access a trunked system during busiest hour.

Peak time: how a user gets connected to a call (or) call is blocked (or) call delayed by Queuing.

Set up time: Time required to allocate a trunked radio channel to a requesting user.

Blocked call: Call which cannot be completed at the time of request due to congestion (also called lost call)

Holding Time: Average duration of a call, denoted by H.

Traffic Intensity: Measure of channel utilization time (denoted by A)

Load: Traffic Intensity across the entire trunked radio system

Request rate: Average no. of call request per unit time (λ/sec)

Each user generates a traffic intensity of A_u Erlangs and it is given by :

$$A_u = \lambda H$$

$\lambda \rightarrow$ Average no. of call request per unit time

$H \rightarrow$ Average duration of a call.

For a system containing 'U' users and an unspecified number of channels, the total traffic intensity offered is

$$A = U A_u$$

In a 'C' channel trunked system, if the traffic is equally distributed among the channels then the traffic intensity per channel is

$$A_c = U A_u / C$$

Types of Trunked systems

(i) Blocked calls cleared

(ii) Blocked calls delayed

Blocked calls cleared.

If no channel available currently, the request is blocked without access & is free to try again later. It offers no queuing for call requests.

This type of trunking is called blocked calls cleared.

Probability of blocking interms of traffic intensity A is,

$$Pr[\text{blocking}] = \frac{A^C / C!}{\sum_{k=0}^{C} \frac{A^k}{k!}} = GOS$$

$C \rightarrow$ no. of trunked channels offered by a trunked radio system

$A \rightarrow$ Total traffic offered.

Blocked calls delayed

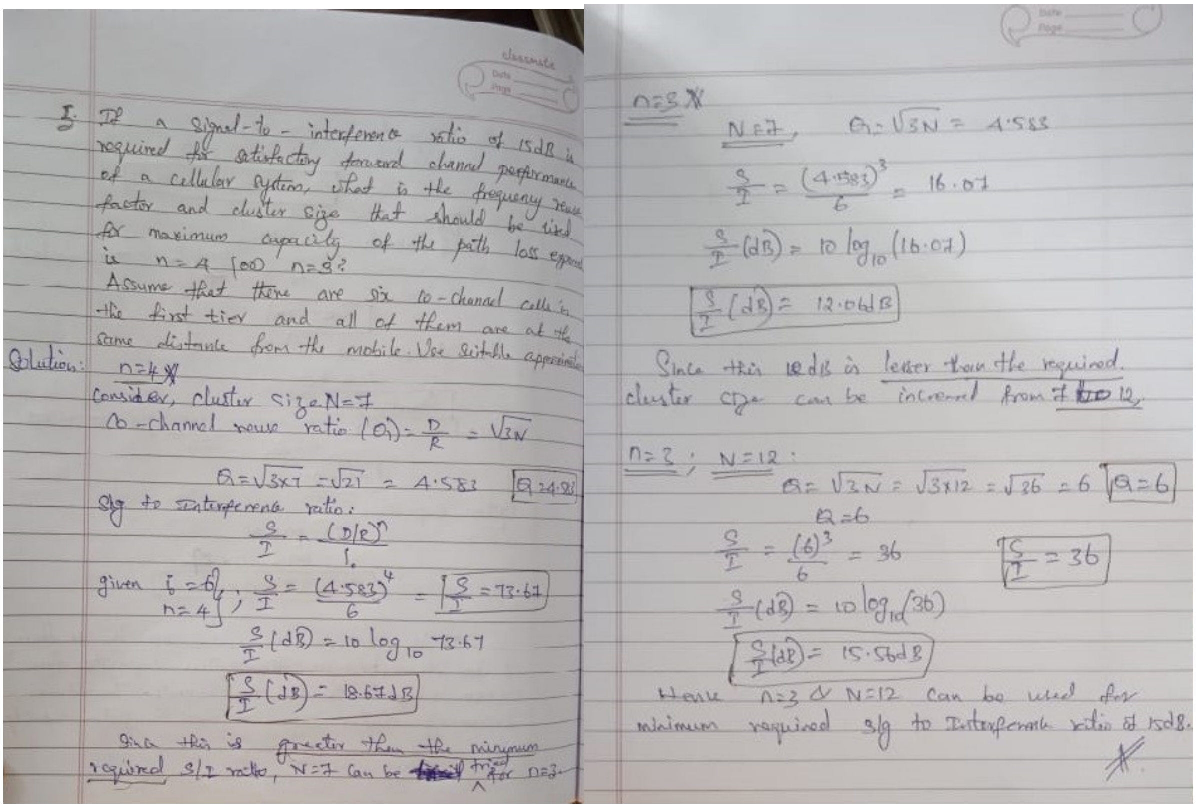
If channel is not available immediately, request may be delayed until it becomes available. This trunking is called blocked calls delayed.

It is a measure of GOS and defined as "the probability that a call is blocked after waiting for a specific length of time in the queue".

$$Pr[\text{delay} > 0] = \frac{A^C}{A^C + C!\left(1 - \frac{A}{C}\right) \sum_{k=0}^{C-1} \frac{A^k}{k!}}$$

Trunking efficiency is a measure of the number of users which can be offered a particular GOS with a particular configuration of fixed channels.

5. Ifasignaltointerferenceratioof15dBisrequiredforsatisfactoryforwardchannelperformance of a cellular system, whatis the frequency reuse factor and cluster size thatshould be used for maximum capacity of the path loss exponent is (a) n=4 (b) n=3?. Assumethat there are six co-channel cells in the first tier, and all of them are at the same distance fromthe mobile.Usesuitable approximation.



5. If a signal-to-interference ratio of 15dB is required for satisfactory forward channel performance of a cellular system, what is the frequency reuse factor and cluster size that should be used for maximum capacity of the path loss exponent is n=4 (or) n=3?
Assume that there are six co-channel cells in the first tier and all of them are at the same distance from the mobile. Use suitable approximation.

Solution: n=4

Consider, cluster size N=7

Co-channel reuse ratio $(Q) = \frac{D}{R} = \sqrt{3N}$

$$Q = \sqrt{3\times7} = \sqrt{21} = 4.583 \quad \boxed{Q = 4.583}$$

Sig to Interference ratio:

$$\frac{S}{I} = \frac{(D/R)^n}{i_0}$$

given $i_0 = 6$, $n = 4$; $\frac{S}{I} = \frac{(4.583)^4}{6} = \boxed{\frac{S}{I} = 73.67}$

$$\frac{S}{I}(dB) = 10\log_{10} 73.67$$

$$\boxed{\frac{S}{I}(dB) = 18.67dB}$$

Since this is greater than the minimum required S/I ratio, N=7 can be tried for n=3.

n=3

N=7, $Q = \sqrt{3N} = 4.583$

$$\frac{S}{I} = \frac{(4.583)^3}{6} = 16.07$$

$$\frac{S}{I}(dB) = 10\log_{10}(16.07)$$

$$\boxed{\frac{S}{I}(dB) = 12.06dB}$$

Since this 12dB is lesser than the required, cluster size can be increased from 7 to 12.

n=3; N=12:

$$Q = \sqrt{3N} = \sqrt{3\times12} = \sqrt{36} = 6 \quad \boxed{Q=6}$$

$Q = 6$

$$\frac{S}{I} = \frac{(6)^3}{6} = 36 \qquad \boxed{\frac{S}{I} = 36}$$

$$\frac{S}{I}(dB) = 10\log_{10}(36)$$

$$\boxed{\frac{S}{I}(dB) = 15.56dB}$$

Hence n=3 & N=12 can be used for minimum required sig to Interference ratio of 15dB.