Analysing Channel Allocation Techniques for Minimizing Interference in Cellular Network

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Abstract— for increasing growth of cellular communication services, scary spectrum is efficiently used with reusing channels to achieve cost of service .Channel allocation techniques are employed for reduction of call blocking probability. However today's traffic demands are non uniform & strangely changes according to the timing in day. Minimizing call-blocking probability may raise the interferences, which may increase call dropping probability. The role of channel assignment technique is to allocate channels to cells in such way as to minimize call blocking probability also call dropping probability. . In this paper, the performance of three different channel allocation schemes i.e. Fixed channel allocation (FCA), dynamic channel allocation (DCA) and hybrid channel allocation (HCA) will be analytically compared. HCA is proposed for interference reduction with fair call blocking probability.

Keywords—Fixed channel allocation (FCA) , Dynamic channel allocation(DCA) , hybrid channel allocation (HCA) ,call blocking probability ,Signal to interference ratio (SI)

I. INTRODUCTION

For increasing demand of cellular communication services, scary spectrum is efficiently reused. Utmost use of spectrum & reuse of channels leads to the main three types of interferences i.e. Co site, adjacent &co channel interference. Co site & adjacent channel interference can be suppressed using efficient modulation schemes & deployment of low noise filters and efficient equalizers, however these techniques are not applicable to co channel interference. Minimization of co channel interference & call blocking can be achieved with channel allocation techniques. In cellular communication mainly there are three channel allocation techniques i.e. fixed channel allocation (FCA), dynamic channel allocation (DCA) & hybrid channel allocation (HCA). The main purpose of channel assignment methods is to increase the radio spectrum reuse efficiency with minimum interference. The focus of this article is to provide an overview of different channel assignment methods and compare them in terms of performance, flexibility, and complexity. We first start by giving an overview of Cellular geometry & Interference in cellular systems. Then we proceed to discuss different channel allocation schemes .Here we made an simulation comparison of FCA, DCA, HCA in terms of interference & call blocking probability .

II. CELLULAR NETWORK

According to the definition was given by FCC (Federal Communication Commission), a cellular system is: 'A high capacity land mobile system in which assigned spectrum is divided into discrete channels which are assigned in groups to geographic cells covering a cellular geographic service area. The discrete channels are capable of being reused in different cells within the service area.' [2].
From the above definition it becomes clear that the three basic parameters defining a cellular radio are:

1. High capacity: theoretically, a cellular radio system can be configured and expanded to serve a limitless number of subscribers.

2. Cells are defined as individual service areas, each of which has an assigned group of discrete channels assigned to it from the available spectrum. Subscribers in a particular cell can utilize the channels assigned to that cell. A group of contiguous cells make up the cellular geographic service area served by a specific system, which can grow geographically by adding new cells. The cells are formed in a way that permits the hand-off process. Hand-off is the process of changing the channel, as the user moves from one cell to the other without interrupting the telephone call.

3. Frequency reuse allows the discrete channels assigned to a specific cell to be used again in any cells that are separated from the previous by enough distance to prevent interference. According to the multiple access technique employed by the cellular system, a channel is referred to as a fixed frequency bandwidth (FDMA: frequency division multiple access), or a specific time slot within a frame (TDMA: time division multiple access) or a particular code (CDMA: code division multiple access). According the way in which information is transmitted, (analog or digital), the cellular systems are distinguished in analogy or digital. The digital systems tend to replace the analog ones, mainly because of their greatest capacity.

A basic cellular system consists of the following three parts:

1. *Mobile Telephone Switching Office (MTSO):* The switching office is the central co-ordinating element for all cell sites. It contains a cellular processor, which provides co-ordination, cellular administration, and interfacing with the public telephone cable network Public Switched Telephone Network (PSTN). Its major role is to achieve the integrity and reliability of the whole system

2. *Base Stations or Cell Sites:* The cell site provides interface between the MTSO and the mobile units. Each base station is usually placed in the middle of a cell and has a control unit and one or a combination of antennas.

3. *Mobile units*: A mobile unit contains a control unit, a transceiver and an antenna system [2].

III. INTERFERENCES IN CELLULAR SYSTEM

In tremendous growth of the wireless user population, number of base station required to serve geographical area is an important factor. From the cost-of service point of view efficient use of radio spectrum is also important. A reduction in the number of base stations, and hence in the cost of service, can be achieved by more efficient reuse of the radio spectrum. Same channel from one cell is reused in other cell, which is at reuse distance from itself. Reused distance Dr

$$Dr = \sqrt{3Nc} \ .Re \tag{1}$$

Where Re is cell radius and Nc is the reuse pattern (the cluster size or the number of cells per cluster). Reusing channels fallout in different types of interferences like co channel, adjacent channel, co site. [1, 2]

A. *Co channel Interference*
Co channel interference is the radio interference between channels using the same frequency. The total suppression of the co channel interference is not possible in frequency reuse concept. To obtain a tolerable value of co channel interference the system designer has to maintain a minimum separation distance to the co channel site. Cells may only use the same channels providing that the distance of their centers is equal or multiple of this minimum distance (reuse distance). [3]

B. *Adjacent Channel Interference*
Adjacent channel interference is the radio interference between channels which are using adjacent frequencies in the adjacent cells. This is caused due to leakage of frequencies into the pass band because of imperfect filters The suppression of this kind of interference depends on carefully filtering & use of guard bands , also by proper design of the cellular system by not permitting adjacent channels to be used.

C. *Co site Interference*
Co site channel interference is the radio interference between channels which are using adjacent frequencies in the same cell. The suppression of this kind of interference is done by maintaining proper separation between the channel frequencies. Reuse of channel by maintaining reuse distance & proper frequency separation can suppress these interfaces & this can be achieved by an efficient algorithm for Channel allocation.

IV. CHANNEL ALLOCATION TECHNIQUES

A. *Fixed Channel Allocation (FCA)*
Fixed channel allocation, in which channels are assigned in cells at the beginning of system design. Total channels of cellular system are available to every cluster. In a cluster channel destruction is uniform among cells so every cell uses the same predetermined channels.
Fixed channel allocation has very simple design & work efficiently for uniform channel allocation. However FCA do not adapt to changing traffic conditions and user distribution. Channel barrowing schemes are used in FCA to utilize the channels in non uniform traffic distribution. [4, 5]

B. *Dynamic Channel Allocation (DCA)*
FCA is not able to give high channel efficiency for the short-term temporal and spatial variations of traffic in cellular systems. A dynamic channel allocation (DCA) scheme has been studied to overcome the drawback of FCA. In DCA all the channels are available with the central pool & allocated dynamically to the cells as new call arrives to the cell. DCA schemes can be also divided into centralized and distributed schemes with respect to the type of control they employ. [10, 11, 12] DCA requires more computational efforts for heavy traffic. DCA has poor performance for heavy traffic than FCA.

C. *Hybrid Channel Allocation (HCA)*
In HCA, set of channels is divided into fixed & dynamic set. Fixed set contains a number of nominal channels & these channels allocated like FCA & prefer to be use in respective cell. Channels from dynamic set are shared by users. When all nominal channels are busy then channel from dynamic set is allocated. In HCA fixed to dynamic channel ratio can be changed according to the non uniform traffic & geographical area. [8, 9, 4]

V. SIMULATION MODEL

A. *Proposed cellular traffic model*
The cellular topological model consists of total 24 cells & 12 channels .24 cells comprise of 6 clusters with 4 cells in each .D is 1 X 24 demand vector for 24 cells, F1 to F4 is sets of fixed channels for 4 cells in a cluster, Cep is 24 X 12

channel allocation matrix .The simulation call traffic distribution can be either uniform or non uniform distribution. Uniform cellular traffic distribution indicates that every cell has the same traffic load or demand. On the other hand, non uniform cellular traffic distribution indicates that there is different traffic load in each cell.
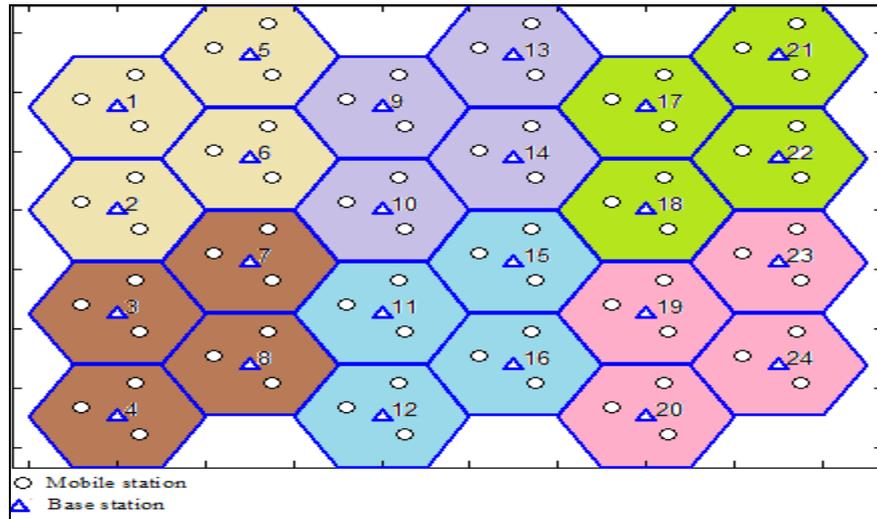

Fig. 1 Cellular model with 6 Clusters & 4 cells in each

B. *Algorithm Fix Channel Allocation*

In the fix channel allocation every cell from cluster has fix set of channels. As demand come the channels are allocated from the fix set only. If demand is more than channels available in fix set, then that call is blocked.

```
//D is 1 X 24 demand vector for 24 cells,
//F1 to F4   is sets of fixed channels for 4 cells in a cluster,
// C1 to C4 is set of cells from 6 cluster which can use same frequency.
// Cep is 24 X 12 channel allocation matrix.(24 base stations  & 12 channels )
 For i=1:24
    K=D(i);
      For j=1:k
          For p=1:12
              If  i Є Cₓ & p Є Fₓ
                If cep(i,p)≠0
                  cep(i,p)=1
                    D(i)=D(i)-1;
              End
```

C. *Algorithm Dynamic Channel Allocation*

In the Dynamic channel allocation, all channels are present in centralize pool. One channel is allocated in all clusters. If allocation of that channel is not possible, then second channel is allowed to allocated

```
//D is 1 X 24 demand vector for 24 cells
// c1,c2,c3,c4 are representing  4 cell number
// Cep is 24 X 12 channel allocation matrix .(24 base stations  & 12 channels )

For i=1:12
   For j=1:6
     K= random (c1, c2, c3, c4)
     If  D(k)≠0  & Cep (k,i) ≠0
       Cep (k,i)=1
             D(k)=D(k)-1;
         End
```

D. *Algorithm Hybrid Channel Allocation*

In the Hybrid channel allocation, channels are dived into two sets 1. Fix set 2.Dynamic set
Channels in dynamic set are present in centralize pool. First channels are allocated from fix set & then from centralize pool.

//D is 1 X 24 demand vector for 24 cells,
//F1 to F4   is sets of fixed channels for 4 cells in a cluster,
// C1 to C4 is set of cells from 6 cluster which can use same frequency.
// Cep is 24 X 12 channel allocation matrix.(24 base stations & 12 channels)
// c1, c2, c3, c4 are representing 4 cell number, f is number of channels in dynamic set
For i=1:24
  For p=1:12
    If i ∈ CX & p ∈ FX
      If cep(i,p)≠0 & D(i)≠0
      cep(i,p)=1
        D(i)=D(i)-1;
      End
  For i=1:f
  For j=1:6
   K= random (c1, c2, c3, c4)
    If D(k)≠0 & Cep (k,i) ≠0
      Cep (k,i)=1
      D(k)=D(k)-1;
   End

E. *Propagation Model*

Attenuation in signal can be predicted   using a propagation model .Propagation model is an empirical mathematical formulation for the characterization of radio wave propagation as a function of frequency, distance and   other conditions. Most radio propagation models are derived using a combination of analytical and empirical methods. In general, most cellular radio systems operate in urban areas where there is no direct line-of-sight path between the transmitter and receiver and where the presence of high rise buildings causes severe diffraction loss.
HATA propagation model is used in this simulation.

Hata Model is based on the Okumara's model where some correction factors are included. It works in the frequencies range from 150 MHz to 1500 MHz.. The standard formula for median path loss in urban areas is given by [3].

Attenuation (in dB)= 69.55 + 26.16*log10(fre) - 13.82*log10(hte) + (44.9 - 6.55*log10(hte)) * log10 (dista)-alpha –(1)

Where alpha=46.3502+26.16*log10(fre)+ 35.1797*log10(dista)
fre = frequency from 150 MHz to 1500 MHz,
hte = The effective base station antenna height (30m to 200m),
hre = The effective mobile antenna height (1m to 10m),
d =The transmitter-receiver (T-R) distance in km
dista = distance between receiver & transmitter in km
a(hre) = The correction factor for effective mobile antenna height which is a function of the size of coverage area. For a large city it is given by alpha

VI. SIMULATION RESULT

Simulation is done for cellular traffic model with 6 clusters, 4 cells in each & 12 channels. Simulation is done for FCA, DCA, and HCA .Results are taken for uniform & non uniform traffic demand.

A. *Call Blocking Probability*

Call blocking probability is calculated by ratio of new call blocked to the total call arrived. Fig 2 shows the comparison call blocking probability of FCA, DCA & HCA for uniform & non uniform traffic demands.
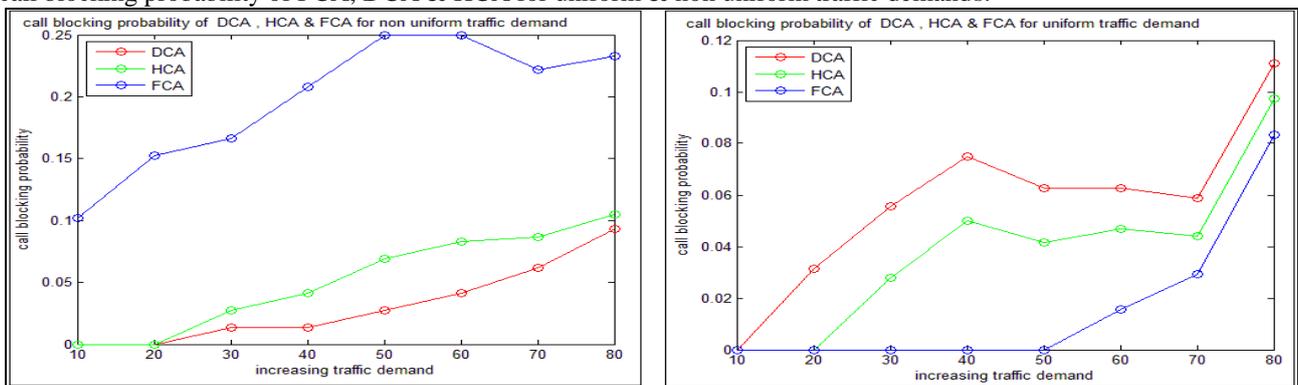

Fig. 2 Comparison Of FCA,DCA,HCA Based On Call Blocking Probability For Uniform & Non Uniform Traffic Demands

For non uniform traffic DCA has lowest call blocking probability, on the other hand it has highest call blocking probability for uniform traffic demands .FCA has lowest call blocking probability for uniform traffic & highest call blocking probability for non uniform traffic . HCA has restrained call blocking probability for uniform & non uniform traffic.
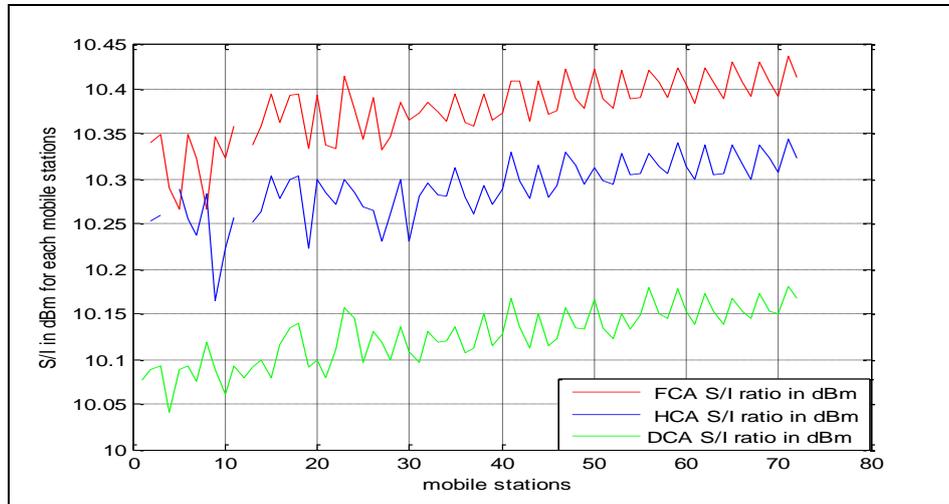
B.   *Signal To Interference Ration (SI)*

Fig. 3 Comparison Of FCA, DCA, HCA Based On Signal to interference ratio (SI ratio)

Formula for Signal to interference ration (SI) is ratio of desired signal power level at the receiver and the sum of co-channel interference power level at receiver. Received power is equal to difference between   transmitted power & attenuation in signal. Attenuation in signal can be predicted using a propagation model. HATA propagation model is used in this simulation. Comparison of FCA, DCA, HCA based on CIR is done for full demand of simulation model. For full demand all the channels are reused in all clusters. In FCA, DCA, HCA channel are allocated in different manner, but in all these three method same no. of channels are reused for full demand. Fig. 3 shows the comparison of FCA, DCA, and HCA based on S/I ration. In the full demand of simulation model 72 mobile stations & 12 channels are used. Every channel is reused in every cluster for all three methods. Channel allocation methods are allocating the channels by different way & it will affect the S/I ration to each mobile station.

Results in Fig.3 illustrate that FCA gives highest S/I however DCA gives lowest S/I. HCA gives approximate S/I ratio to FCA.

VII.   CONCLUSIONS

Comparison of FCA, DCA, and HCA is done for uniform & non uniform traffic demands. HCA has restrained call blocking probability for uniform & non uniform traffic both. However DCA gives high call blocking probability for uniform & low call blocking probability for non uniform traffic. FCA gives high call blocking probability for non uniform & low call blocking probability for uniform traffic. FCA gives highest S /I, DCA gives lowest S/I. HCA gives approximate S /I ratio to FCA. HCA is precise channel allocation method to achieve S/I & endurable call blocking probability for uniform & non uniform traffic demands .use of optimization techniques like genetic algorithm, particle swarm optimization can perk up performance of HCA to minimize call blocking probability.

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