

A Hybrid-FAIL Dynamic Channel Allocation Method in GSM System

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Abstract: Global system for mobile communication (GSM) uses wireless channel to communicate between a mobile stations (MS) to others mobile unit. In GSM the finite number of channel should be efficiently allocated to maximize throughput and avoid co-channel interference. Fixed Channel Allocation (FCA) suffers from the effective channel utilization; whereas Dynamic Channel Allocation (DCA) offers the possibility of capturing unused channel by allocating unused resources to achieve maximize capacity. DCA can reduce the possibility of being a channel idle while a call is waiting to establish. This paper begins by examining channel allocation techniques currently used in DCA. Following this, a solution is proposed that utilize the Hybrid-FAIL algorithm to efficiently allocate channels dynamically from the system. Furthermore, in this paper the main two strategies for channel assignment (DCA and FCA) are briefly discussed and compared. From the simulation of DCA (with the proposed algorithm) and FCA, it is seen that the Grade of Service (GOS) is far better in DCA than that in FCA.

Keywords: Hybrid-FAIL (First Available Interference Least, GSM, DCA (Dynamic Channel Allocation), FCA, Grade of Service (GOS).

1. Introduction

With the advancement of mobile communication the comprehensive study of channel allocation technique had been proposed that was based on the effective use of radio channel. In wireless mobile communication systems, radio spectrum is a limited resource. Efficient use of radio spectrum is also important from the cost point of view as reduction of the base station will deduct the cost by more efficient reuse of radio spectrum. A given radio spectrum is to be divided into a set of disjointed channels that can be used simultaneously while minimizing interference in adjacent channel by allocating channels appropriately. Different technique has been proposed since last few years. Among them Dynamic Channel Allocation (DCA) is the most frequently used researchable area. The pressure is increasing significantly on GSM channel or frequency allocation. GSM uses fixed channel allocation scheme to assign channels to the users, but call blocking and wastage of channels are the major drawbacks. As a way of solving this problem, FAIL (First Available Interference Least) [10] introduces a DCA technique in assigning a channel. There were some limitations like storage capability, computational complexity, and improper channel allocation in the pool system. And also FAIL algorithm was not completed by simulation. The main objective of our paper is to improve FAIL algorithm to maintain a certain level of GOS as well as signal interference because subscribers are increasing drastically. Bandwidth hungry 2.5G, 3G and 4G are putting

load on channel allocation or frequency for Circuit Switch service. So we proposed a Hybrid-FAIL algorithm which divides the total number of available channels into fixed and dynamic sets, where channels used dynamically will be placed on a pool. A channel will be assigned to a cell on demand or request. Our main objective of using the combination of two sets of channel is to maintain a lower GOS and reduce the signal interference.

2. Frequency reuse concept

In GSM frequency reuse implies that in a given coverage areas there are several cells that use the same set of frequencies. The base station antennas are design to achieve the desired coverage within the particular cell. By limiting the coverage area within the boundaries of a cell, the same group of channel may be used to cover different cells that are separated from one another by distances large enough to keep interference level to keep tolerable limits [16]. "The design process of selecting and allocating channel groups for all of the base stations within a system is called frequency reuse or frequency planning [1]." Fig 1 illustrates the concept of cellular frequency re use, where cells labeled with the same letter use the same group of channels. The frequency reuse plan is overlaid upon a map to indicate where different frequency channels are used. The hexagonal cell shape shown in figure 1 is conceptual and is a simplistic model of the radio coverage for each base station but it has been universally adopted since the hexagon permits easy and manageable analysis of a cellular system. The actual radio

coverage of a cell is known as the footprint. When considering geometric shapes which cover an entire region without overlap and with equal area, there are three sensible choices – a square, an equilateral triangle, and a hexagon. A cell must be designed to serve the weakest mobiles within the footprint, and these are typically located at the edge of the cell. For a given distance between the center of a polygon and its farthest perimeter points, the hexagon has the largest area of the three [1].

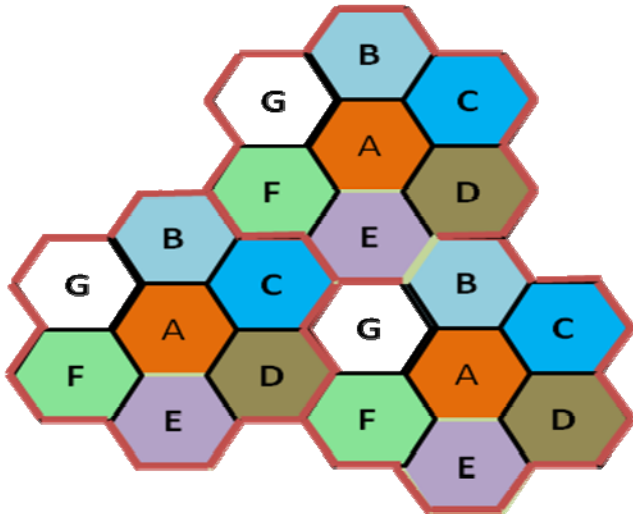


Figure 1. Frequency reuse

Thus, by using the hexagon geometry, the fewest number of cells can cover a geographic region, and the hexagon closely approximates of a circular radiation pattern which would occur for a unidirectional base station antenna and free space propagation.

3. Dynamic Channel Allocation

In dynamic channel allocation strategy voice channels are not allocated to different cells permanently. Instead of each time a cell request is made, the serving base station request a channel from the MSC. The switch then allocates a channel to the requested cell following an algorithm that takes into account the likelihood of future blocking with in a cell, the frequency of use of the candidate channel, the reuse distance of the channel, and other cost function [17]. Dynamic channel assignment reduces the likelihood of blocking which increases the trunking capacity of the system since all the available channels in a market are accessible to all the cells. Dynamic channel assignment strategies require the MSC to collect real-time data on channel occupancy, traffic distribution, and radio signal strength indications (RSSI) of all channels on a continuous basis. This increases the storage and computational load on the system but provides the advantages of increase d channel utilization and decreased probability of a blocked call [14]. DCA schemes can be also divided into centralized and distributed schemes with respect to the type of control they employ.

4. Distributed DCA

It involves the number of controllers scattered across the network (MSCs). Microcell system have shown great potential for capacity improvement in high-density personal communication networks [14]. However, propagation characteristics will be less predictable and network control requirement more intense than in the present systems. Several simulation and analysis results have shown that centralized DCA schemes can produce near-optimum channel allocation, but at exchange of excessive each base station.

The proposed distributed DCA schemes use either local information about the current available channels in the cell's vicinity or signal strength measurements. In the cell based schemes a channel is allocated to a call is initiated. The difference with the centralized approach is that each base station keep the information is updated by exchanging status information between base stations. The cell-based scheme provides near-optimum channel allocation at the expense of status information between base stations, especially under heavy traffic loads.

Particularly appearing are the DCA interference adaptation schemes that rely on signal strength measurements [14], in these schemes a base station uses only local information, without the need to communicate with any other base station in the network. Thus, the system is self-organizing, and channels can be placed everywhere, as needed, to increase capacity or to improve radio coverage in a distributed fashion. These schemes allow fast real time processing and maximum channel packing at the expense of increased co-channel interference probability with respect to ongoing call in adjacent cell, which may leave to undesired effect such as interruption, deadlock, instability. It is based on three parameters. These are [17]: Co-channel distance, Signal strength measurement, Signal to noise interference S/N ratio.

5. Blocking probability in DCA

The blocking probability PB is defined as the probability that the entire server in a system is busy. When the entire server is busy, no further traffic can be carried by the system and the arrival subscriber traffic is blocked. At the first instance, it may appear that the blocking probability is the same measure as the GOS. The probability that all the server are busy may well represent the fraction of calls lost, which is what the GOS is all about. However, this is generally not true. For example, in system with equal number of server and subscriber, the GOS is zero as there is always a server available to a subscriber. On the other hand, there is definite probability that the entire server are busy at a given instant and hence the blocking probability is nonzero. The fundamental difference is that the GOS is measured from the subscriber point of view where the blocking probability is measure from the network or switching system point of view. GOS is arrived at by observing the number of rejected subscriber calls, whereas the blocking probability is arrived at by observing the busy servers in the switching system. The analysis carried out on lost system, that GOS and PB may have different values depending upon the traffic characterization model used. In order to distinguish between these two terms clearly, GOS is called all congestion or loss probability and the blocking probability is called time

congestion. [7]. Cellular system with Dynamic Channel Allocation can be analyzed by Erlang B formula.

6. Grade of Service (GoS)

It measures the strength of a subscriber when it tries to access a trunked system during the heavy traffic on system as well as measure the time duration. The busy hour is based upon customer demand at the busiest hour during a week, month, or year. The busy hours for cellular radio systems typically occur during rush hours [13]. Basically grade of service is a standard to define a performance level of a trunked system that how much it is capable to allow user for access the available channel in the system. When user attempts to make a telephone call, the routing equipment handling the call has to determine whether to accept the call, or reject the call entirely. Rejected calls occur as a result of heavy traffic loads (congestion) on the system and can result in the call either being delayed or lost. If a call is delayed, the user simply has to wait for the traffic decrease, however if a call is lost then it is removed from the system. Grade of service is the used to measure the quality of an ongoing call when a subscriber sends a request. In a loss system, the grade of service is described as the proportion of calls that are lost due to congestion in the busy hour. The exact way to measure the grade of service is to divide all loss calls number with offered calls.

$$GOS = P_R = \frac{A - A_o}{A} \quad (1)$$

Where, A = the offered call and A_o = Carried call.

Grade of service is also known as blocking probability and this blocking probability occurs during communication between mobile and station [7].

7. DCA Algorithm

The selection of different types of dynamic allocation algorithms is little bit tough because of cost and which channel is appropriate for the user. The main function of all algorithms is to assign a cost for allocating each of possible candidate channels, and also select one channel with a small cost. "The cost function can be calculated on the basis of one or more of the following aspects; future call blocking probability; usage frequency of the channel; distance to where the channel is already being used, that is the actual reuse distance; channel occupancy distribution; radio signal quality measurements" and so on [10].

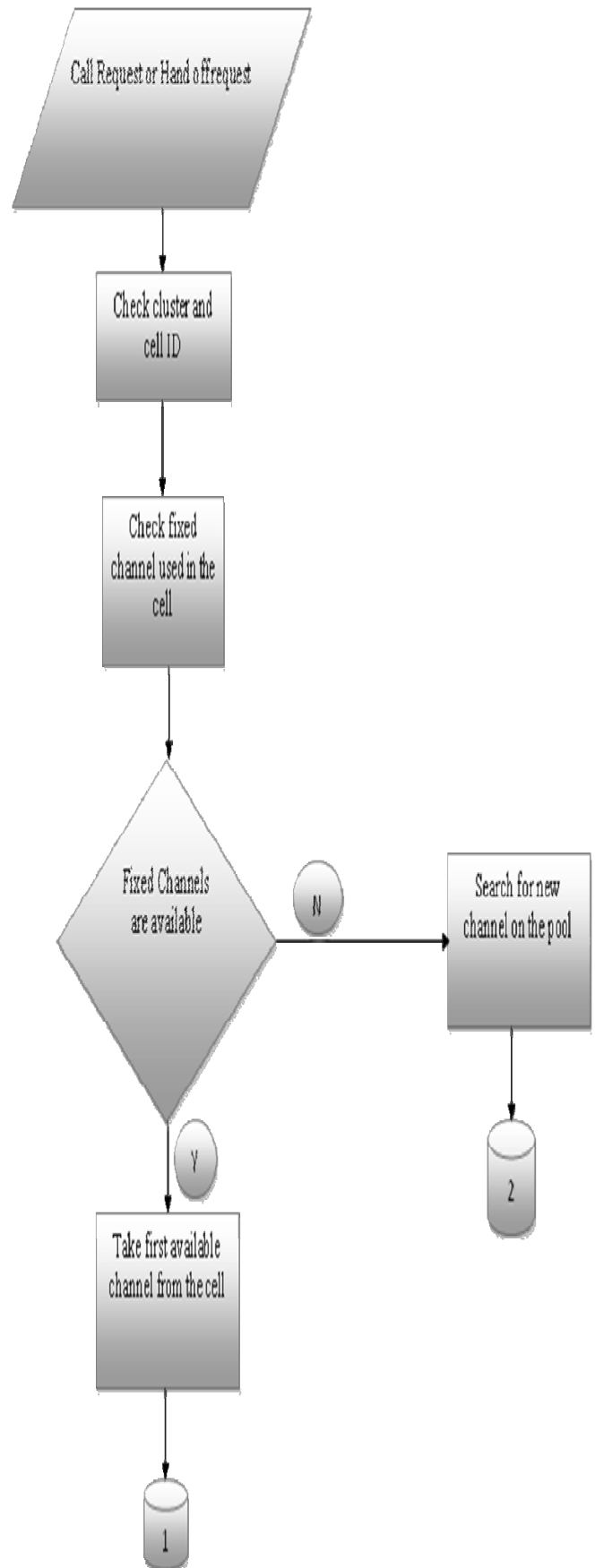
8. Hybrid-FAIL Algorithm

Dynamic channel allocation balances the potentiality in allocating a channel to user against the co-channel interference and the adjacent channel interference. To increase the capacity and maintain the grade of service in dynamic channel allocation an algorithm with the simulation result is proposed named as Hybrid- First Available Interference Least (Hybrid-FAIL). According to the Hybrid-FAIL algorithm the channel is least interfered regarding both adjacent channel and reuse distance of the same channel will be assign to user requesting for a call.

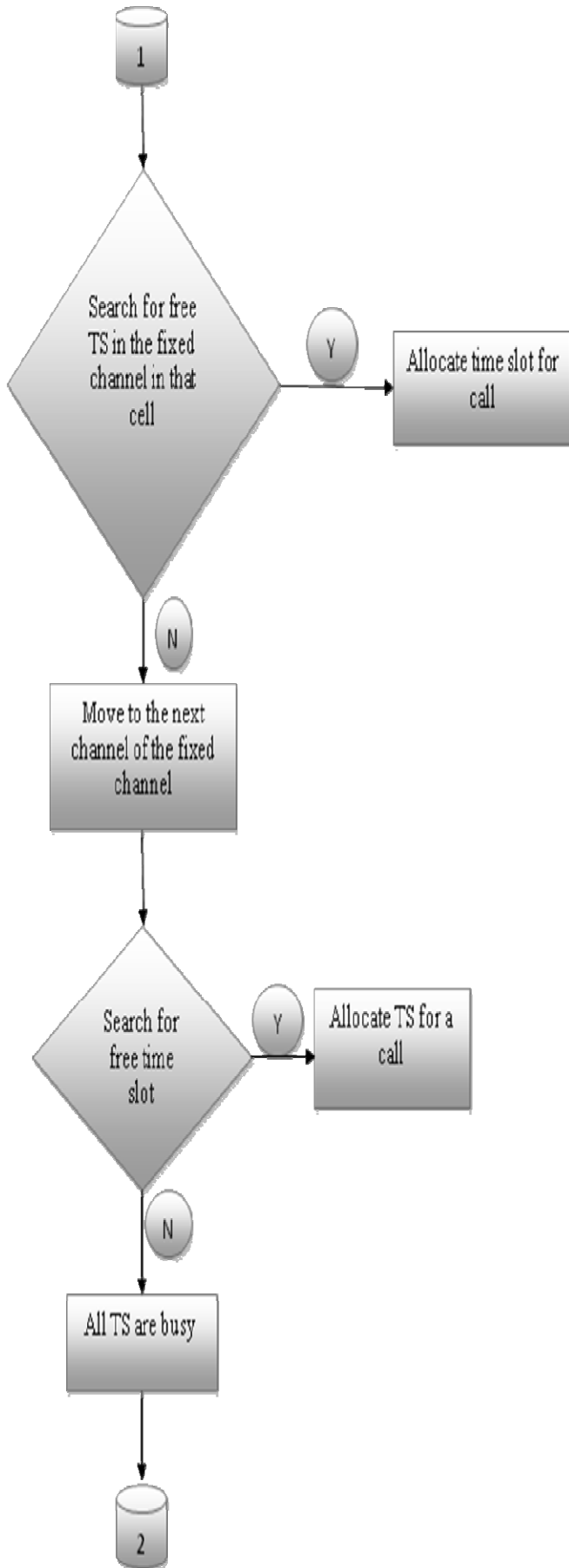
According to the algorithm when a call request or hand-off request is received on the system, the system will take both as a new call. When call is received the system will check from where the call is originated, system will check the cell ID [5]. Cell identity will be checked through synchronization channel, which carries the information of the Base Identity Code (BSIC), synchronization channel is transmitted by the Broadcast Control Channel (BCCH) [5]. After getting the cell ID then system will check that the fixed channels are available or not in that particular cell. The information about the channels in that cell will be provided on synchronization channel, the SCH carries the information to enable the mobile to synchronize to the TDMA frame structure and know the timing of the individual timeslots. If there is no channel available in that cell then the system will search a new channel to allocate for that particular call. If there are channels available in the cell, then take the first channel from the list and search for the free time slot available in that channel to allocate the timeslot for a call, if there is no slot free in that channel then move to next channel in that cell search for the free time slot in next channel, system will search for free time slot in all available channels currently in that cell from where the call is originated. When a free time slot is found in any of channels than the time slot will be assigned to that call. When no channel found in the assigned fixed channel Hybrid-FAIL algorithm will search for a new channel, first of all it will check whether there is any channel available in the pool to allocate for a call or not, if there is no more channel available in the pool to assign for a call than system will block the call. Before searching for a new channel for the call in the cell requesting for channels system will Check the number of channels is in use in that cell. Pool checks that if the number of channel assign to cell is more than threshold 15% then pool will not assign any more channels to that cell and the call will be blocked, if it is less than the given threshold values than search a new channel for that call. The threshold value for the number of channels in one or two cells than the grade of service in these cells will be 0, and grade of service in all other cells will be 100 percent. The advantage of dynamic channel allocation is uniform grade of service, so to achieve the uniform grade of service Hybrid-FAIL defined a threshold value to assign equal maximum number of channels in each cell [5]. After checking the threshold value to assign channels, if it is less than the given value than check availability of channels in the pool, if there is no channel in the pool then the call is blocked. If the channels are available then select a random free channel as a first available channel from the pool and if this channel satisfies co-channel distance then check the interference of that channel. Interference is the major cost to allocate each of possible candidate channels, and one with the lowest cost is allocated. The cost (interference) is calculated using the following aspect: take the first available channel from the pool and compare it with the channels already in use in that cell if there is no channel in use in that cost means interference both adjacent channel interference and co-channel interference take the list of neighboring cells and list of those channels which are being used in the neighboring cells. All the above information will be given by BCCH. BCCH carrier carries the information about neighboring cells, which are monitored by the mobile, cell identity, and the list of frequencies used in the cell [5]. After

getting all the information, system will compare that first available channel from the pool with the list of channels are use in that cell and also neighboring cells. Here comparison means system will check the previous (-1) and next channel (+1) of that channel in the pool are in the list of neighboring cells. It means that system will check the status of channel either channel is not assigned to cell available in the pool for request or already allocated to the cell. If any of the conditions not satisfied than system will not assign that channel for a call, because interference is the cost limiting factor. If next channel or the previous channel of the available channel (pool) is in the list of cell, which is requesting for a call it will cause adjacent channel interference. And these conditions are also followed for the list of neighboring cells; here we also check that either available channel is in the list of neighboring cells than it will cause co-channel interference. So, all of the above conditions not fulfill the criteria of Hybrid- FAIL then the first available channel will not be assigned for that call and system will move to the next channel, now this will be the first available channel and check the interference of that channel. The channel that fulfills the above given requirement to check the interference will assigned for the call, not the all time slots of that channel only the first time slot of the first available channel. That's why it is named as Hybrid-First Available Interfered least (Hybrid-FAIL). If all of the channels are not suitable for that call then no channel will be assigned to that call and the call will be blocked.

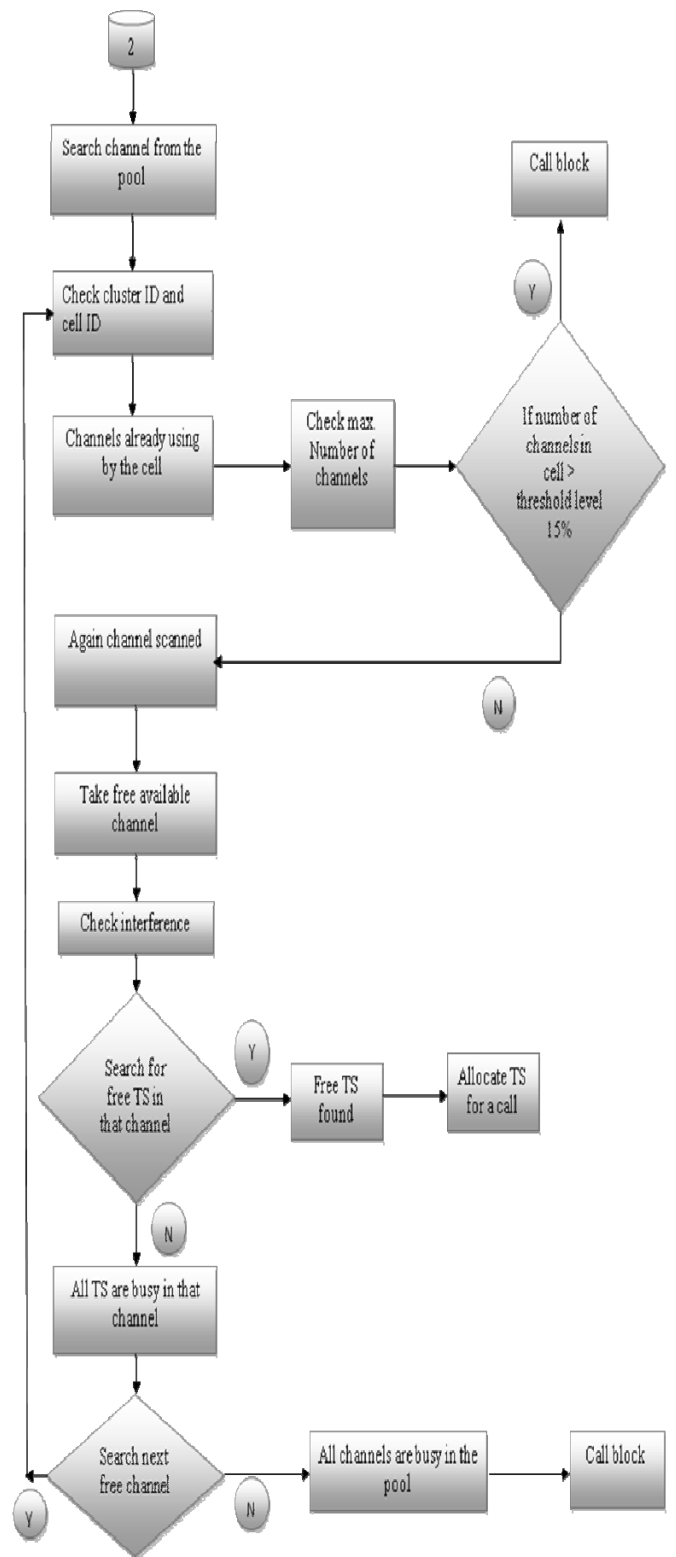
9. Flow Diagram of Hybrid FAIL Algorithm



Flow Diagram 1. Hybrid FAIL Algorithm



Flow Diagram 2. Hybrid FAIL Algorithm



Flow Diagram 3. Hybrid FAIL Algorithm

10. System Parameter

The performance analyzing of FAIL and Hybrid-FAIL channel allocation algorithm is depended on its system parameter. In our simulation two clusters, three cells are used for FAIL and Hybrid- FAIL schemes.

Table 1. System parameter of FAIL vs Hybrid FAIL

Algorithm			
Parameter		Value	
Number of cluster		2	
Number of cell		3	
Number of channel	FAIL		42
	Hybrid-FAIL	Fixed channel	4
		Pool channel	18
Number of time slot in each channel		8	
Time separation between two call generation (ms)		50	
Average holding time per call (ms)		2000	

But in FAIL scheme, all channels are used in the pool and in Hybrid-FAIL scheme four fixed channels are used with a pool system which contains each with eight time slots.

Table 2. System parameter of FAIL Vs Hybrid FAIL Algorithm

parameter	Value	
	FAIL	Hybrid-FAIL
Total number of channel used in the pool	42	18
Number of channel distributed per cell from the pool	15% (threshold)	15% (threshold)

In order to accelerate our simulation, the parameters, which are defined in system is given in table 1 and table 2.

11. Numeric Result of Simulation

The output from our JAVA simulation program, for different offered call, we get different blocked call which is summarized in the table 3. Suppose a call is established between user and cell via MSC. Assuming the holding time per call is 20s and call arrival rate is 20/s. For different offered call, we get different GOS. Suppose if the offered call is 1100 then the blocked call for FAIL and Hybrid-FAIL are 261 and 121 respectively and the GOS are .237 and .11 respectively.

Offered calls	Blocked call	
	FAIL	Hybrid-FAIL
100	0	0
200	0	0
300	60	1
400	95	38
500	100	35
600	101	52
700	111	30
800	153	84
900	144	94
1000	253	77
1100	261	121
1200	344	131
1300	395	111
1400	400	139
1500	445	177
1600	463	182
1700	365	172
1800	416	161
1900	452	212
2000	602	250

Table 3. Simulation Results

The performance curve of FAIL and Hybrid-FAIL is shown graphically in figure 1 which is calculated using MATLAB simulator.

12. Performance Analysis of Hybrid-FAIL DCA and FAIL

There are many algorithms for DCA but our proposed Hybrid-FAIL algorithm will lead the system towards another architectural approach to increase the system capacity. Our proposed algorithm is implemented in java in order to create very high performance simulating environment. The Hybrid-FAIL algorithm is implemented in small scale to show the performance. Traffic handling matter was Lost call cleared (LCC) model that means the traffic. In our algorithm we used 18 channels on the Pool form the total 42 channels rest are fixed in the base station. These values can be changed according to our desirability. From the changing values the simulation result shows different performance. Our intention was to optimize the performance of Hybrid-FAIL algorithm. There was a threshold value by which the program indicates the capability of taking maximum number of channel for individual cell, rejected by one set of resources may be cleared by another set of resources in the network. The

performance employs a simulation approach to study the Improvements for different channel allocation schemes which is between FAIL and Hybrid-FAIL algorithm.

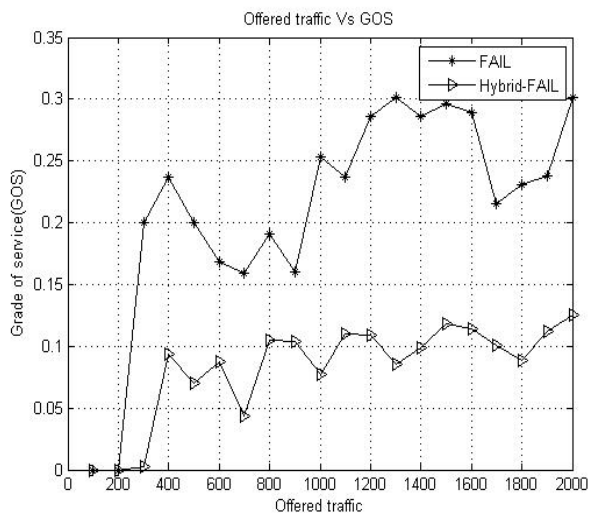


Figure 2. Performance analysis of Hybrid FAIL DCA and FAIL Algorithm

The usage of Hybrid- FAIL algorithm shows lower GOS than the FAIL. If one channel is already using in one cell can't borrow previous and next channel from the pool. This restriction might degrade the efficiency of Hybrid-FAIL algorithm, but this restriction safe the system from the greater order of interference.

13. Conclusion and discussion

We are undergoing a major telecommunication revolution that will provide ubiquitous communication access to citizens, where they are. So we are always facing bandwidth limitation, computational complexity and storage-capability along with interference problem.

The available solution of above problems is deployment of time and space diversity systems, use of low noise filters and efficient equalizers, deployment of efficient modulation schemes and strategic movement on channel allocation. In general, GSM uses fixed channel allocation scheme to assign channels to users. By considering entire conditions, limited bandwidth and limited architectural approaches of GSM we move towards the dynamic channel allocation scheme to increase the system capacity. But as in FAIL algorithm all channels are placed in the pool, computational complexity and storage capability is the burden in overall system performance. So we have proposed an algorithm of dynamic channel allocation in which all channels will be placed in a pool and BTSs. On demand or on request channel will be assigned to the user for that particular call.

Here, more than one performance variables like offered calls, threshold value, holding time, call generating time are considered. The maximum traffic load measured in terms of the number of users in the system. The Figure 2 Shows results for Grade of service (GOS) and offered traffic distributions. However, the users in our investigation generate a high traffic, making on average about 12 calls in every 1 second. The simulation result we have obtained for

2 cluster 3 cell for both two systems as well as with the same number of channel.

By plotting the simulation result the comparison curve shows that the Hybrid-FAIL algorithm provide better performance than that of FAIL algorithm. Moreover, this proposed algorithm has lower complexity and computational load. So, this can be said that Hybrid-FAIL Dynamic channel allocation is a better solution to achieve better performance and efficiency than that of FAIL algorithm.

14. Other recommendations

In our paper we did two types of arrangement of channel. The next step to move forward with our paper is to consider the frequency. In case of assigning the channel it is possible to propose a new algorithm that will calculate and allocate the best channel to the different BTS. At that time the new simulation coding will be more complex. So we think that will be better work.

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