DYNAMIC CHANNEL ALLOCATION IN GSM NETWORK

Submitted by

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ABSTRACT

The rapid evolution of cellular technology and the more user demand for advanced mobile services leads the industry to develop more efficient network structures. The increasing number of cellular subscribers and the demand for cellular networks communication (3rd and 4th generation) drives to the research of the new methodologies for the design of cellular networks and services. This thesis has been generated and complied with the objective of proposing GSM Network Utilizing DYNAMIC CHANNEL ALLOCATION starting with the architecture of GSM Network with system design. In next chapter we define the channels that are transmitted over the Air Interface, leading further towards the Channel Allocation Schemes in GSM. In this chapter we describe the various types of channels are used in GSM Network. Furthermore define the main two strategies for channel assignment, briefly differentiate between the FCA (Fixed Channel Allocation) and (Dynamic Channel Allocation) as well as advantages of both schemes. Then the major is study of (Dynamic Channel Allocation) and the proposed Algorithm for Dynamic Channel Allocation in GSM network is presented and discussed. All channels will placed in a pool and on demand or on request will be assigned to the user for that particular call that will be helpful to maintain the grade of service and increase system capacity.
Chapter 1

1.1 Introduction

Subscribers located within the radio range can access wireless connection which is provided by the cellular radio system. Large numbers of mobile users are bound to use limited frequency spectrum to communicate each other. The techniques FDMA, TDMA, CDMA provide a two-way communication it means users can able to transmit and receive signal at same time which is known as full duplex. Wireless communication enjoys its fastest growth period in history, due to enabling technologies, which permit widespread deployment. Historically, growth in the mobile communication field has come slowly. Cellular telephony is now in its third generation with the fourth on the horizon. The first generation was designed for voice communication using analog signals. Advanced Mobile Phone System (AMPS) is one of the leading analog cellular systems [1]. It uses FDMA to separate channels in a link. Second generation provides higher quality mobile voice communication as compare to first generation, the main motive for designing the second generation is to digitized voice. Global System for Mobile Communication (GSM) is a second generation cellular standard that was developed to solve fragmentation problems of the first cellular systems [2]. GSM was introduced into European market in 1991, till now there are more than 1.7 billion users of GSM all over the world. GSM originally used two 25MHz cellular bands 890-915 MHz from subscriber to base station (uplink) and 935-960 MHz from base station to subscriber (downlink). Early cellular telephone systems provide the subscriber and network operator with many advantages over a standard telephone network, but still there are many drawbacks. The new system GSM overcomes them. Each network component is design to communicate over an interface specified by the GSM standards. This provides flexibility and enables a system operator to utilize system components from different manufacturers. For example Motorola Base Station System equipment may be coupled with an Ericsson Switching System.

“One powerful transmitter located at the highest spot in an area would broadcast in a radius of up to 50 kilometers. The cellular concept structured the mobile telephone network in a different way. Instead of using one powerful transmitter many low power transmitters were placed throughout a coverage area. For example, by dividing a metropolitan region into one hundred different areas (cells) with low- power transmitters using 12 conversations or voice channels using one powerful transmitter to 1200 conversations (channels) using one hundred low-power transmitters”[3].

Increasing the number of users creates a interference problem and it caused due to using the same channel in adjacent area and proved that it is impossible to reuse all channels in every cell because of heavy traffic reusing the same channels can affect the performance of systems.
The most common scheme exists in cellular radio system is fixed allocation scheme and its capacity is low due to increase in cost (Interference and call blocking probability is high).
The advantage of using dynamic channel allocation in GSM Network is that the employment of all carrier frequencies in every cell, thereby ensuring much higher capacity, provided the transceiver specific interference constraints can be met. In dynamic channel allocation, all channels can be used at any base station as long as they satisfy the associated quality parameters. Channels are then allocated from this pool as long as they are required. This solution provides maximum flexibility and adaptability at the cost of higher system complexity.

1.2 Objectives

We proposed an algorithm of dynamic channel allocation in which all channels will be placed in a pool and on demand or on request will be assigned to the user for that particular call. Each cell can assign any channel in the pool after searching the channel from the pool. It will be helpful to reduce the interference and call blocking probability and dropping call probability will be less. There are many algorithms for dynamic channel allocation, but the proposed algorithm is very simple and this will lead the system towards another architectural approach to increase the system capacity.
1.3 Organization of Thesis

Chapter 1

This chapter includes the objective of our thesis and the motivation behind our work and summary of our thesis work.

Chapter 2

This chapter presents a detail description of GSM Network Architecture (hierarchy, elements, connections), as well as system design of GSM.

Chapter 3

Introduction to channels on the Air Interface and also include the brief of all GSM control channels and details about GSM physical and logical channels.

Chapter 4

This chapter consists of detail knowledge of CHANNEL ALLOCATION SCHEMES such as Fixed Chanel Allocation (FCA) and Dynamic Channel Allocation (DCA) and their advantages and disadvantages.

Chapter 5

This chapter describes the interference problem as well as issues of Dynamic Channel Allocation, and brief detail of proposed Algorithm.

Chapter 6

This chapter include the traffic analysis that I have obtained while using erlang B table with different values of GOS (grade of service) in order to see how much traffic is offered when channels are increased.

Chapter 7

It include the conclusion and future work that can be conducted by using the useful information presented in this thesis
Chapter 2

Introduction to GSM

2.1 GSM

The Global System for Mobile Communication (GSM) is developed to replace 1G technology and solve the number of incompatibility and it provides common 2G technology. GSM plays a vital role to enhance the capacity and performance of the system initially introduced in all over Europe.

<table>
<thead>
<tr>
<th>Standard</th>
<th>GSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency wavelength</td>
<td>900 MHz, 1800 MHz, 1900 MHz¹</td>
</tr>
<tr>
<td>Data bandwidth</td>
<td>9.6 kbps</td>
</tr>
</tbody>
</table>

- GSM is the dominant cellular technology today
- GSM offers high quality voice with advanced services
- GSM is stepping-stone to 3G networks

2.2 GSM Network Overview

Each network component is designed to communicate over an interface specified by the GSM standards. This provides flexibility and enables a system operate to utilize system components from different manufacturers. For example Motorola Base Station System equipment may be coupled with an Ericsson Network Switching system are:

- Mobile station
- Base station system
- Network switching system
- Operation and Maintenance system
2.3 Mobile Station (MS)

The Mobile Station is based on combination of main two essential components known as mobile Equipment (ME) and most important an electronic ‘smart card’ called as Subscriber identity Module (SIM). Mobile equipment is used by the subscriber when it needs to access a desirable network and subscriber can used any kind of electronic device such as telephone, fax machine or portable computer ,PDA etc. that hardware has an identity number totally associated with it and unique for that particular device and permanently stored in it. This identity number is called International mobile equipment identity (IMEI).

The SIM is a card which plugs into the mobile equipment. This card identifies the Subscriber and also give information to the user regarding the service that subscriber received. The main function of International mobile subscriber identity (IMSI) is to identify required subscriber. GSM network operator is responsible to provide SIM card to the subscriber.

The SIM card contains several pieces of information these are listed below:

2.4 International mobile subscriber identity (IMSI)

The mobile subscriber is identified by this number. During initialization this number is transmitted over the air.

2.5 Temporary mobile subscriber identity (TMSI)

This number is used to prevent any intruder or unauthorized user to monitor the radio interface. This number also provides a protection which is periodically changed by the system management.
2.6 Location area identity (LAI)

Local area identity is used for identifying the authentication of a subscriber card.

2.7 Mobile station international standard data network (MSISDN)

Basically this is number which is assigned to the subscriber with country code as well as national code.

2.8 Base station subsystem (BSS)

It performs a major role in GSM base station sub-system is the equipment found at the cell site. It comprises a combination of digital and RF equipment. The BSS provides the link between the mobile equipment and the mobile services switching centre. The BSS communicates with the mobile station over the digital air interface and with the mobile services switching centre (MSC) with 2 Mbit PCM links.

The BSS consists of three major hardware components.

2.9 Base station controller (BSC)

The BSC provides control for the BSS. One BSC may control approximately 40 BTS. Any information required by the BTS for operation will be received via the BSC. Likewise any information required about the BTS (by the OMC for example) will be obtained by the BSC. The BSC switching matrix allows the BSC to perform “handover” between radio channels on separate BTS, under its control, without involving the MSC.

2.10 Base transceiver station (BTS)

BTS provides the air interface connection with the Mobile and the Network, it has also a limited amount of functionality this reduce the amount of traffic which needs to pass between the BTS and BSC and so makes it fast. Each BTS cabinet will provide between 3 and 5 RF (Radio Frequency) carriers which in turn will provide between 20 and 40 simultaneous calls.
2.11 Transcoder (XCDR)

The Transcoder (XCDR) is required to convert the speech or data output from (64Kb /S) into the form specified by SMG specifications for the transmission over the air interface, that is between the BSS (Base Station Subsystem) and MS (Mobile Station). The 64kb/s pulse code modulation (PCM) circuits from the MSC, if it is transmitted on the air interface without modification would occupy an excessive amount of bandwidth radio. The required bandwidth is therefore reduced by processing the 64kb/s circuits so that the amount of information required in transmit digitized voice falls to 13kb/s. The transcoder may be located with the MSC, BSC or BTS. If it is located at the MSC the 13kb/s channels will be transmitted by the BSS by “bit stuffing” them to data transfer rate of 16kb/s and then fitting four of them into each 64kb/s terrestrial circuits. Thus each 30 channel 2Mb/s PCM link can carry 120 GSM specified channels, with obvious cost savings from the system operator.

2.12 The Network Switching System (NSS)

The main switching function of the GSM network includes the network switching system. The main function of NSS is to store the data of required subscriber and all kind of mobility management (database).

The components of NSS are listed below

- Mobile switching centre - (MSC)
- Home location register – (HLR)
- Visitor location register – (VLR)
- Equipment identity register-(EIR)
- Authentication centre - (AUC)
- Interworking function - (IWF)
- Echo canceller (EC)

2.13 Mobile Switching Centre (MSC)

The MSC (mobile switching centre) is a part of a GSM network that is equivalent of an exchange in a fixed network, plus everything extra needed to handle mobile stations. Basically MSC is a main source of BSS its major jobs is location, registration, handovers, authentication, routing, and handovers of calls to move from one MS to another. The MSC controls the switching and handoffs between cells, providing commands to each BS which is near for dropping the current call from old BS and arrange the new one. In order to make it sure that current call should active as much as possible. Voice channel
is given to handoff calls over new calls. Mobile switching centre organize the process of creating new calls. MSC will initiate the call by using a reserve control channel to make request. The MSC has to then grant the request, after which a pair of voice channels are assigned for the calls.

2.14 Home location register HLR

The network consists of more than one HLR and the data is easily accessible for all required MSCs and the VLRs in the network. HLR is the responsible to store a whole data and contains the master database of the total numbers of subscriber to a GSM PLMN. Subscriber has option to access either from the IMSI or the MSISDN number. The parameters stored in the HLR are listed below:

- Subscriber ID (IMSI and MSISDN)
- Current subscriber VLR (current location)
- Supplementary services subscribed to
- Subscriber status (register/unregistered)
- Authentication key and AUC functionality
- Temporary mobile subscriber identity (TMSI)
- Mobile Subscriber Roaming Number (MSRN)

2.15 Visitor location register VLR

The main function of VLR is to store data temporary of the subscriber only as long as the user is active in the region which is covered by the VLR. The data which is stored at the HLR is taken by the temporary data storage VLR. The VLR provides a local database for the subscriber wherever he is physically located within a PLMN; this may or may not be the home system.

The additional data stored in the VLR is listed below:

- Mobile status (busy/free/no answer etc)
- Location Area Identities (LAI)
- Temporary Mobile Subscriber Identities
- Mobile Station Roaming Number
2.16 Equipment Identity Register EIR

The EIR contains a centralized database for validating the International Mobile Equipment Identity (IMEI). This database is remotely accessed by the MSC in the network [3]. The EIR database consists of lists IMEIs (or arrange of IMEIs) organized as follows:

- **WHITE LIST** contains those IMEIS which are known to have been assigned to valid mobile equipment.
- **BLACK LIST** contains IMEIs of mobiles which have been accepted stolen.
- **GREY LIST** contains IMEIs of mobile which have (eg Family software).

2.17 Authentication Centre (AuC)

The AUC is a processor system it performs the “authentication” function. It will normally be co-located with the Home location register (HLR) as it will required to continuously access and update as necessary, the system subscriber record. The Authentication process will usually take place each time the subscriber “initializes” on the system.

In the authentication process secure data stored on the SIM card is manipulated and compared with data held in the HLR database. This data is entered into the SIM and the system database (HLR) at the time the SIM card is issued.

2.18 Interworking Function (IWF)

GSM system is to enable to make connection with the various types of private and public networks which transfer or receive all the data currently available. This main function is provided by the Interworking Function (IWF).

The basic featured of IWF are given below:

- Rate Conversion
- Protocol Adaption

Some system require more IWF capability than others, this depend upon the network to which it is connected.
2.19 Echo Canceller

An Echo canceller is used on the PSTN side of the MSC for all voice circuits. Echo control is required at the switch because the GSM inherent system delay can cause an unacceptable echo condition even on short distance PSTN circuit connection. During a normal PSTN land to land call, no echo is apparent because the delay is too short and the user is unable to distinguish between the echo and the normal telephone “side tone”. However, with the GSM round trip delay added and without EC, the effect would be very irritating to the MS subscriber, disrupting speech and concentration. The standard EC (Echo Canceller) will provide cancellation of up to 68 milliseconds on the “trail circuit” (the tail circuit is the connection between the output of EC and the land phone).

2.20 Operation and Maintenance System

The operation and maintenance sub-system provides a capability to manage the GSM network remotely. This area of the GSM network is not currently tightly specified by the SMG specifications. It is left to the network operator to decide what capabilities they wish it to have. The operation and maintenance system comprises of two parts:

- Network Management Centre- NMC
- Operation and Maintenance Centre- OMC

2.21 Network Management Centre (NMC)

The network management centre offers the ability to provide hierarchical regionalized network management of complete GSM system. It is responsible for operation and Maintenance is the network level supported by the OMCs which are responsible for regional network management. The NMC therefore singles logical facility at the top of the network management hierarchy. The NMC has a high level view of the network as serried of network nodes and interconnecting Communication facilities. The OMC, on the other hand is used to filter information from the network equipment for forwarding to the NMC thus allowing it to focus on issues requiring national coordination. The NMC also can coordinate issues regarding interconnect to the other networks.
Functionality of the NMC

- Monitor trunk routes between nodes on the network
- Monitor high level Alarms
- Passes on knowledge from one OMC region to another to improve problem solving strategies.
- Monitor OMC regions and provides assistance to OMC staff
- Enables long term planning for the entire network

2.22 Operations and Maintenance Centre (OMC)

The OMC provides a central point from which to control and monitor the other network entities (i.e. base stations, switches, database, etc) as well as monitor the quality of service being provided by the network as a whole. At the present equipment manufacturer have their own OMCs which are not compatible in every aspect with those of other manufacturers. This is particularly the case between Radio base station equipment suppliers, where in some cases the OMC is a separate item and digital switching equipment supplier, where in OMC is an integral, but functionally separate, part of the hardware.

These are two types of OMC:
- OMC (R)- OMC assigned specially to the base station system
- OMC (S)- OMC assigned specially to the Network switching system

Function of OMC

The OMC should support the following function.
- Event/ Alarm Management
- Fault Management
- Performance Management
- Configuration Management
- Security Management
2.23 The Cell

Dividing a large area into short regions involves cellular radio called cells. Each cell has its own equipment to transmit, receive and switch and it provides a facility for any subscriber within the region of radio coverage area. By using the cells it reduced the area which is covered by a single user or subscriber and also it doesn’t require a high transmission power. Cells are normally regarded as being hexagonal but if we see in practical not a regular shaped .the cell shape depend on the surrounding area e.g. building hills etc.

2.24 Frequency Reuse

Intelligent allocation and reuse of channels in a required coverage region is main assets of cellular radio systems. Utilizing a group of radio channels in each cellular base station within a small geographic area called cell. All cells which are near to each other contain completely different channels and the base stations in bordering cells are assigned channel groups. The main reason of designing a base station antenna is to achieve the desired coverage within a particular cell. Same group of channels is also used for those cells which are situated at large enough distance to maintain acceptable limits of interference level. “The design process of selecting and allocating channel groups for all of the cellular base station within a system is called frequency reuses” [4].

FIGURE OF FREQUENCY RE-use

![Figure 2.3 Frequency Reuse Concepts](image)
2.25 Hand Off

Allocation of radio and fixed links are temporary during the ongoing call and it is known as handover or handoff. The technique is used when a user is move from cell to other cell a long distance without terminating the ongoing call. The implementation and capacity required for handover form and one of essential functions of the RR.

Four types of handover that involves transfers an ongoing call in the GSM system.

- Base stations controller (BSCs) directly belonging to the same Mobile service Switching centre (MSC) [2].
- Base transceiver stations of different location under the control of different MSCs.
- Each cell is assigned a number of channels (time slots).
- Base station controller (BSC) control the cells called in telecom terminology (base transceiver stations).

MSCs using first two types to manage all handover requested calls and it is known as external handover. Last two types are controlled by single Base Station in order to save the bandwidth and these types are known as internal handovers. Handovers can be initiated by either the mobile or the MSC (as a means of traffic load balancing). The mobile always scans the broadcast control channels approximately 16 neighboring cells, during its inactive timeslots and categorically select the six best Candidates for possible handover and it totally based on received signal strength. After completing this process the message is forwarded to BSC and MSC, at least once per second and finally it is used by the handover algorithm.

Fig 2.4 Handoff Concept
2.26 Hard Hand off

Signal strength of ongoing call exceeds of the current cell. The mobile is constructed to switch to a new frequency band that is within the allocation of new cell. The channel in the source cell is released then the channel in the target cell is engaged. It is also known as break-before-make.

2.27 Soft Hand off

In modern wireless system, when a mobile moves into a different cell while a conversation is in progress. Soft hand-off occur only change of base station but no change in actual channel when MSC transfer the ongoing call to a base station. In GSM there is concept of Mobile Assisted Hand-off (MAHO). The power levels of all base stations which are situated in certain area are measured continually by mobile station and report to the serving base station. The power level of BS of neighboring cell increase than the current cell as far as certain time or level is concerned and then hand-off begins. It is also known as break-before-make.

2.28 Interference

"Interference is a major limiting factor in the performance of cellular radio systems"[4]. Sources of interference area another mobile in the same cell, call in progress in a neighboring cell, other base stations in the same frequency band, or any non-cellular system which advertently leaks energy into the cellular frequency band. Cross talk causes by interference on voice channels and this happen only because of undesired transmission and the interference listened by users in the background. Interference cause a major problem in shape of numbers of missed and blocked calls and this is because of error in digital signaling. Users or subscriber face lots of interference problem in big cities due to great signal-to-noise (SNR) ratio or RF noise floor and also plenty of base stations and great quantity of mobiles. Interference plays a major role in block the increasing capacity and is directly proportional to drop ongoing calls. If we study more about interference we should go through its major two types are co-channel and adjacent channel interference.

2.29 Co-channel Interference (C/I)

Cells located on different locations in a given area use same frequencies known as frequency reuse implies. Main factor of using same frequencies is interference between
these cells called as co-channel interference. It is not possible to overcome co-channel interference just increasing transmitter carrier power. This is because an increase in carrier transmits power increases the interference of neighboring co-channels. In order to decrease co-channel interference all cells must be located at a distance to provide limited isolation due to broadcast. The GSM specification recommends that the carrier-to-interference (C/I) ratio is greater than 9 decibels (dB).

According to the figure, if the size of every cell is same then co-channel interference is free to transmit a power and become a function of radius of the cell (R), and distance between radius and the nearest co-channel cell (D). Increasing the ratio of D/R is directly proportional to the increasing space between co-channel cells related to the coverage distance of a cell. It improves the isolation of RF energy effects on the reduction of interference from the co-channel cell. Parameter Q called the co-channel reuse ratio.

\[ Q = \frac{D}{R} = 3N \]

This C/I ratio is influenced by the following factors:

- The location of the MS
- Local geographical and type of local scatters
- BTS antenna type, site elevation and position

### 2.30 Adjacent Channel Interference

Interference resulting from signals which are adjacent in frequency to the desired signal is called adjacent channel interference [4]. The outcome of adjacent channel interference from imperfect receiver filters which permit nearby frequencies to seep out the pass band. The problem will be severe if an adjacent channel subscriber is transmitting in very limited range. The GSM specification states that carrier-to-adjacent ratio (C/A) must be larger then -9Db.

### 2.31 Improving Capacity in Cellular System

Improvement depends on the increasing of channels in the cells when the numbers of subscriber increased in order to expand the network of wireless system in a large area. Allocating as many channels as possible to the every cell is more appropriate way to
increase to capacity. This technique will be helpful for increasing the performance and capacity of cellular system. Splitting the cells and sectoring are the proper solution of this problem.

2.32 Cell splitting

The jam-packed cell divided into smaller cells and each cell has its own base station and equivalent decrease in antenna height as well as transmitter power this process is known as cell splitting. The solution provides by the cell splitting gives advantage to increase the capacity of a cellular system directly proportional number of times that channels are reused. By defining new cells which have smaller radius than the original cells and installing these smaller cells (called micro cells) between the existing cells, capacity increase due to the additional number of channels per unit area.

2.33 Sectoring

This technique increase the performance of cellular system in order to use directional Antennas as well as adding single omni-directional antenna at the base station with several directional antennas and cell receive little bit interference of the available co-channel cells this phenomena known as sectoring. This technique decrease co-channel interference. The main reason to reduce co-channel interference totally depends on the numbers of time using of sectoring. A cell is normally partitioned into three 120 degrees sectors or six 60 degrees sectors [4].

![Figure 2.5](image)

2.34 Microcell Zone Concept

By zoning the microcell in order to advance the coverage and capacity in cellular it totally based on microcell concept. All zones of different areas are connected to a single base station and share the same radio equipment. These zones are linked either by fiber optic cable, microwave link or coaxial cable to the base station, and strongest signal will
be received by the mobile if it travels within the cell which comes in a required zone. This come closer to the peak of sectoring where antenna is located at the outer edges of the cell, and channel of any BS may be assign to any near zone by the base station.

Table 2.1 Differentiate the parameters between Macro cell and Micro cell

<table>
<thead>
<tr>
<th>Item</th>
<th>Macro Cell</th>
<th>Micro Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell Radius</td>
<td>1 to 20 km</td>
<td>less than 1 km</td>
</tr>
<tr>
<td>Transmitter Power</td>
<td>1 to 10 W</td>
<td>less than 1 W</td>
</tr>
<tr>
<td>Channel fading</td>
<td>Rayleigh</td>
<td>Ricean</td>
</tr>
<tr>
<td>RMS delay spread</td>
<td>0.1 to 10 µsec</td>
<td>10 to 100 ns</td>
</tr>
<tr>
<td>Bit Rate</td>
<td>0.3 Mbps</td>
<td>1 Mbps</td>
</tr>
</tbody>
</table>

Table 1
Chapter 3

CHANNELS ON THE AIR INTERFACE

3.1 Introduction

Air interface uses two types of channels in GSM. One is Physical channel and the other is Logical channel. The physical channel is the one which carries information and in the case of terrestrial interface it works as a cable. The logical channel is the one which carried information over physical channel.

3.2 GSM Physical Channel

GSM RF has the ability that it can support up to eight mobile subscribers. Each channel occupies carrier for one eighth of the time. This is called time division multiple access. It is divided into discrete time periods called time slot. The time slots work in a sequence order and it is numbered from 0 to 7. The repetition of each sequence is called is TDMA frame. Mobile telephone of each call occupies one time slot (0-7) within the frame until the call is disconnected or handover occurs. According to the type of channel, the TDMA frames are then built into further frame structures.

For the system to work the timing of the transmission to and from the mobiles is intricate. It is necessary that the mobile or base stations must transmit the information related to one call at exactly the right moment else the time slot will be missed.

Burst is defined as the information carried in one time slot. Time slot is allocated for each data within the successive TDMA frame.

Between the MS and BTS it provides a single physical channel and many varying logical channels.

3.3 GSM Logical Channels

There are two main types of GSM logical channels, named Control channels and traffic channels.

3.4 Traffic Channels

The channel which carries data information and speech is known as Traffic channel. It has two different types which are listed below.

3.5 Full Rate (TCH)

Full Rate traffic channel uses one physical channel for transmitting (13 kb/s) speech.

TCH/FS: Speech (13kb/s net, 22.8 kb/s gross)
TCH/F9.6: 9.6 kb/s-data
TCH/F5.8: 4.8kb/s-data
TCH/F2.4: 2.4kb/s-data
3.6 Half Rate

One physical channel is shared by two Half Rates TCHs; it makes two times greater capacity of cells. It transmits half rate speech (6.5 kb/s).

- **TCH/HS**: Speech (6.5kb/s net, 11.4 kb/s gross)
- **TCH/H4.8**: 4.8kb/s –data
- **TCH/H2.4**: 2.4kb/s –data

---

**Figure 3.1 Logical Channels**

---

25
3.7 Control Channels

Control channel consist of four channels.

- Dedicated Control Channels.
- Common Control Channels.
- Broadcast Control Channels.
- Associated Control Channels.

3.8 Broadcast Control Channels

At all frames by the BTS the broadcast channel is transmitted. The BCCH carrier is being transmitted by RF. The mobile monitors the information which is on BCCH, periodically when it is on and not in a call.

- It carries the following information.
- Location area identification
- List of neighboring cells which should be monitored by the mobile.
- List of frequencies used in the cell.
- Call identity.

At all times BCCH is transmitted at constant power. And mobiles measure its signal strength which may seek to use it. When there will be no BCCH carrier traffic DUMMY burst are used to ensure continuity.

Multiplexing of phase 2 system information messages on BCCH norm

<table>
<thead>
<tr>
<th>TC</th>
<th>7</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>0</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Multiframe</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
<th>B</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>System Information Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>GSM 900</td>
</tr>
<tr>
<td>GSM 1800,</td>
</tr>
<tr>
<td>Multiband</td>
</tr>
<tr>
<td>Multiband</td>
</tr>
</tbody>
</table>

TC = (FN DIV(51)) MOD 8
3.9 Frequency Correction Channel

Mobile can easily detect the transmitted frequency than SCH. When the FCCH detection has been occurred the mobile corrects the frequency of its internal time base. Then it will be able to detect SCH which contains the précised information it requires.

3.10 Synchronization Channel

To synchronize the mobile, the SCH carries information to make it enable by TDMA frame structure, individual timings of timeslots are known. SCH also carries the frame number and base station identity code. From the surrounding cells the BCCH information is monitored by the mobile. And the information is stored from the best six cells. When the mobiles enter in a new cell it quickly resynchronizes the information stored in SCH also.

3.11 Common Control Channels

Basically it is used for transferring control information between the BTS and all mobiles. Call origination and call paging are the necessary things for common control channels. It has following two types.

3.12 Random Access Control Channel (RACCH)

To gain access to the system, RACH is transmitted by the mobile. When mobile starts a call responds to the page it usually occurs. MS answers paging message on the RACH by requesting a signaling channel. BTS receives access-request from MS for call setup, location update or MS receive a paging message for SMS.

3.13 Mapping of Logical Channels onto Physical Channels

Logical channels are transmitted on physical channels. The method of placing logical channels on physical channels is called mapping. While most logical channels take only one time slot to transmit, some take more. If so, the logical channel information is carried in the same physical channel time slots on consecutive TDMA frames. Because logical channels are short, several logical channels can share the same physical channel, making the use of time slots more efficient.
3.14 Paging Channel (PCH)

To contact a specific mobile it is transmitted by the BTS.

1. Paging
2. Channel request
3. Description of the allocated channel

3.15 Access Grant Control Channels (AGCCH)

BTS transmits the ACGH to the mobile station. The basic purpose is to assign the dedicated resources to a MS. Such as Standalone Dedicated Control Channel (SDCCH)

3.16 Cell Broadcast Channel (CBCH)

With in a cell it is used to convey messages to be broadcast to all mobile. For example traffic information. The time will be stolen by CBCH from SDCCH. Active mobiles (i.e. switched on or attached to the system) continuously monitor both BCCH and CCCH. The CCCH will be transmitted on the RF carrier with the BCCH.
3.17 Dedicated Control Channels

Single mobile connection assigns Dedicated Control channels for call purpose or for handover purpose.

3.18 Standalone Dedicated Control Channels (SDCCH)

It is used for transferring of data to and from the mobile during call setup. Information is also carried by SDCCH for the forwarding of call and transmission of short messages.

3.19 Associated Control Channels

SDCCH and TCH associates these channels that are why it is named as associated control channels. It usually carries information which is linked with the process being carried out on either the SDCCH or TCH.

3.20 Slow Associated Control Channels (SACCH)

It gives the timing information and conveys power control towards the direction of RSSI and MS and link quality reports in the uplink direction.

3.21 Fast Associated Control Channels (FACCH)

Instead of TCH, FACCH is transmitted. It has the ability that it inserts its own information and steals the TCH burst. It is used to carry out user authentication and handover.

3.22 Channel Combination

The grouped different logical channel types are mentioned here are called channel combinations. The four most important channels are listed below.

```
+----------------------+
| TDMA Frames          |
| 0 1 2 - - - - 7 0 1 2 - - - - 7 0 1 2 - - - |
+----------------------+
```

```
+----------------------+
| TCH (TS1) Downlink   |
| T T T T T T T T T T T T A T T T T T T T T T T T T T T T T I |
+----------------------+
```
3.23 Full Rate Traffic Channel Combination
TCH8/FACCH+SACCH

Broadcast Channel Combination
BCCH+CC

Dedicated Channel Combination
SDCCH8+SACCH8

Combined Channel Combination
BCCH+CCCH+SDCCH4+SACCH4

The half rate Channel combination is similar to full rate channel combination

Half Rate Channel Combination
TCH16/FACCH+SACCH

3.24 Channel Combination and Timeslots

In a selected time slots the channel combinations are sent over the air interface. Some channel combinations can be sent over any time slots but some combinations must be sent over specific time slots. Table maps the channels combinations to their respective timeslots.

TABLE 3.1

<table>
<thead>
<tr>
<th>Channel Combination</th>
<th>Time slots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic</td>
<td>Any timeslot</td>
</tr>
<tr>
<td>Broadcast</td>
<td>0,2,4,6 (0 must be used first)</td>
</tr>
<tr>
<td>Dedicated</td>
<td>Any timeslot</td>
</tr>
<tr>
<td>Combined</td>
<td>0 only</td>
</tr>
</tbody>
</table>
Chapter 4

CHANNEL ALLOCATION SCHEMES

4.1 Introduction

For efficient utilization of the radio spectrum, a frequency reuse scheme that is consistent with the objectives of increasing capacity and minimizing interference is required. To achieve these objectives a variety of channel assignment strategies have been developed. It can be used as either fixed or dynamic. The performance of the system is impacted by the choice of channel assignment strategy. How calls are managed when a mobile user is handed off from one cell to another.

4.2 Types of Channel Assignment Strategies

It has three main types which are listed below.

- Fixed Channel Allocation
- Channel Borrowing
- Dynamic Channel Allocation

4.3 Fixed Channel Allocation

A fixed set of voice channels are allocated by each cell. Any call attempt within a cell can only be serve by the free channels in that particular cell where subscriber sent a call request. If channels in that cell are occupied, the call is blocked and the subscriber does not receive service.

Figure 4.1 Fixed Channel Allocations
In above figure, we have cluster of seven cells and each cell is allocated fixed number of channels and each channel can serve within a given number of channels to accommodate subscriber to initiate a call. Many numbers of cells exist in fixed Assignment Channel Allocation (FA). The channels are divided and allocated permanently to required cells so that it is possible for all channels to use at the same time without any kind of interference. But the problem is that if any channel which is assigned to cell is not in use and simultaneously new call arrives and the same channel is assigned to it then ongoing call will be blocked. No rearrangement is done when a call terminates. The FCH are sometimes not able to maintain high quality of service and capacity due to short term fluctuations in the traffic. Solution is to borrow free channels from the neighboring cells.

4.4 Channel Borrowing

In Channel Borrowing Schemes, cell (acceptor cell) that has used all its nominal channels can borrow free channels from its neighboring cell (donor cell) to accommodate new calls. Borrowing can be done from an adjacent cell which has largest number of free channels (borrowing from the richest). Select the first free channel found for borrowing using a search algorithm (borrow first available scheme) return the borrowed channel when channel becomes free in the cell (basic algorithm with reassignment) to be available for borrowing, the channel must not interfere with existing calls.

Donor cell for Sector X

1

2 X Y

Cell 3

Figure 4.2 Channel Borrowing Scheme

A call initiated in the sector X of cell 3 can borrow a channel from adjacent cells 1 or 2.
The above flow chart defines the strategy of Fixed Channel Allocation, that every cell is given a constant number of voice channels. When subscriber within the range of this cell is send a call request is served by the unused channel and if all channels of this particular cell are busy then the cell send a request to MSC for borrowing channels from its adjacent cell to allocate that call MSC forward this message to the all cells which are located in same area of that cell where call is originated, if all channels are busy because
of heavy traffic then cell where call is initiated will not receive any acknowledgement message from MSC regarding borrowing channels at the end call will be blocked. FCA strategy is useful for those areas with a limited numbers of users and it’s simpler than the DCA. FCA follows a borrowing strategy, according to that whole process of borrowing channel from the adjacent cell is handled by single MSC; it prevents the collision of borrowing channel with new requested call and reduces the interference.

4.6 Channel Borrowing Schemes

4.7 Simple Borrowing (SB)

In this strategy, each cell is assigned a set of nominal channel. When these all nominal channels are used, borrow an available channel from a neighboring cell in order to ensure that the channel must not interfere with existing calls. Borrowing channel can reduce call blocking but can create an interference problem in the donor cells and also block future calls in this cell. Simple borrowing strategy is more suitable for low and moderate traffic and gives a less blocking probability as compare to FCA. The main role of this scheme is to reduce the number of locked channels cause by channel borrowing.

4.8 Borrow From The Richest (BFR)

Channels that are used for borrowing are the available channels normally assigned to one of the adjacent cells of the acceptor cell. If an adjacent cell has many number of unused channel so borrow channels for that cell as many as possible in order to prevent blocking probability.

4.9 Basic Algorithm (BA)

SBR is the improved version which takes channel, when selecting a candidate channel for borrowing in the locking account. This scheme tries to minimize the future call blocking in the cell which is more affected by the channel borrowing.

4.10 Basic Algorithm with Reassignment (BAR)

From a borrowed cell it provides the transfer of call to a nominal channel whenever it becomes available.

4.11 Borrow First Available (BFA)

The purpose of this algorithm is to finds the candidate and selects the first candidate. Before assigning the channel directly to cells, the channels are divided into sets, and each set is assigned to cells to reuse distance $\alpha$ [7]. These sets are numbered in sequence. When setting up a call, channel sets are searched in a prescribed sequence to find a candidate channel.
The Mobile Switching Centre (MSC) is responsible and handles the channels borrowing between cells and ensures that this process will not create any kind of interference when a call is connected in the donor cell.

Table 4.1   Comparison between BFA, BFR, BA and BAR

<table>
<thead>
<tr>
<th>Schemes</th>
<th>Dropping probability</th>
<th>Blocking probability</th>
<th>Traffic intensity</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAR</td>
<td>A lot</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>BFA</td>
<td>Very few</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>BA</td>
<td>A Lot</td>
<td>High</td>
<td>Moderate</td>
</tr>
<tr>
<td>BFR</td>
<td>Few</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

4.12 (FCA) Fixed Channel Allocation and Its Few Advantages

- Performance is not effected due to limited traffic
- Maximum possibility of reusing channels
- Provide a good strength capacity to cover a large area (cells)
- All channels are covered properly by all active radio equipment
- Short delay period for call connection
- Face a less complexity during implementation
- Minimum level of signaling load
- Highly centralized control

4.13 Dynamic Channel Allocation

In Dynamic Channel Allocation strategy, channels are dynamically allocated to different cells. When a call is requested the base station which serves all calls will request a channel from MSC whenever it is required. “Channel is allocated to the request cell following an algorithm that takes into account the likelihood of future blocking within the cell, the frequency use of the candidate channel, the reuse distance of the channel, and other cost functions” [2].
If frequency of cell is free this is allocated by the MSC, or any other cell with a limited distance of frequency reuses is helpful for avoiding co-channel interference.
The main advantage of implementation of a central pool is that when a new call arrives automatically channel is assigned to that call from the central pool as long as call is terminated after completion of call channel will back to its original position in the pool.

It straightforwardly selects the channel which is a more appropriate channel for any call based on current traffic and current allocation.

The channels in the pool are easily accessible to all cells within that region. It plays a major role to reduce the blocking probability and the effects positively on the performance of system due to increase trunking capacity. The key achievements are real time data, traffic distribution and radio signal strength (RSSI), proper utilization of channel, provide accurate calculated load on the system.

**Types of DCA**
It can be centralized or distributed.

**4.14 Centralized DCA**

For the selection of the channel for each cell it involves a single controller. It also provides the best performance. Huge amount of calculation and communication between different BSs leads to extreme system weakness and make centralized DCA schemes impractical. It also provides a standard way for comparing practical decentralized DCA schemes. From the central pool a new channel is selected for a new call that would maximize the number of members in its co-channel set.

**Centralized DCA Schemes**

**4.15 First Available (FA)**

The simplest one is FA. Within the reuse distance encountered, the first available channel during a channel search is assigned to the call. It minimizes the system computation time.

**4.16 Locally Optimized Dynamic Assignment (LODA)**

Future blocking probability is a very important factor for the channel selection in a new call so the locally optimized dynamic assignment examines this probability in order to assign in a new call.

**4.17 Selection With The Maximum Usage on The Reuse RING (RING)**

A candidate channel is selected when is in use in the most cells in the co-channel set. If more than one channel has this maximum usage, an arbitrary selection among such
channel is made serve the call. If none is available, then the selection is made based on the first available (FA) scheme.

4.18 Mean Square (MSQ)

The MSQ scheme selects the available channel that minimizes the mean square of the distance among the cells using the same channel. The Nearest Neighbor (NN) strategy selects the available channel occupied in the nearest cell in distance $\geq \alpha$, while the NN + 1 scheme selects an eligible channel occupied in the nearest cell within distance $\geq (\alpha + 1)$ or distance $\alpha$ if an available channel is not found in distance $(\alpha + 1)$ [7].

4.19 1-Clique

“A set of graphs is used by 1-clique scheme, and assign to every channel [7]”. The main function using graph is to design a non-co-channel interference structure over the whole service area for that channel [7]. In each graph a vertex represents a cell and every cell are connected with edges. Each graph gives the accurate results of a possible channel assignment. A channel is assigned from the several possibilities such that as many vertices as possible still remain available after the assignment. Scheme provides a low blocking probability, but when the numbers of cell increased the required computational time makes rapid channel selection difficult [7].

4.20 Channel Reuse Optimization Schemes

The main objective of any mobile system is to maximize the efficiency of the system as much as possible. Maximum efficiency is equivalent to maximum proper utilization of every channel in the system. It is known that the shorter the channel reuse distance, the greater the channel reuse over the whole service area. “The cost functions selected in the following schemes attempt to maximize the efficiency of the system by optimization the reuse of a channel in the system area [7]”.

4.21 Distributed DCA

It involves the number of controllers scattered across the network (MSCs).

It is based on three parameters.

- Co-channel distance
- Signal strength measurement
- Signal to noise interference S/N ratio
4.22 Advantages of DCA

- Flexible channel allocation
- Not always maximum channel reusability
- Insensitive to time and time spatial changes
- Stable grade of service per call in an interference cell group
- Low to moderate forced call termination probability
- High flexibility
- No frequency planning
- Centralized, distributed control depending on the scheme.

<table>
<thead>
<tr>
<th>Table 4.2 Comparison between DCA schemes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control Cell-based Distribution DCA</td>
</tr>
<tr>
<td><strong>Advantages</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Disadvantages</strong></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>
Chapter 5

DYNAMIC CHANNEL ALLOCATION ALGORITHM

5.1 Introduction

Limited bandwidth creates a lot of problem in wireless communication so that’s why cellular system theory prove to get free from this problem by getting smaller radio cells but after some period when subscribers numbers goes up so the smaller dimension cells cannot able to give best utilization of system resources. The most common scheme exists in cellular radio system is one and only fixed allocation scheme and its capacity are high due to increasing in cost. The use of dynamic channel allocation allows the employment of all carrier frequencies in every cell; thereby much higher capacity is possible, so that it prevents the interference during transmission of signals. Therefore, it is feasible to design mobile radio system, which configures itself to meet the required capacity demands as and when they arise.

In dynamic channel allocation typically all channels can be used at any base station as long as they satisfy the associated quality parameters. Channels are then allocated from this pool as long as they are required. This solution provides maximum flexibility and adaptability at the cost if higher system complexity.

5.2 Interference in DCA

Dynamic channel allocation is better suited to microcellular systems because it can handle the more non-uniform traffic distribution. DCA is better than fixed channel allocation because it provides a proper way to check the maximum number of handover request and the more variable co-channel interference.

The majority of DCA algorithms choose the channel to be used based on receiving signal quality measurements. This information is used to decide which channel to allocate or whether to allocate a channel at all. Sometime channel allocation can create more interference on another user, terminating existing calls or prevents the setup of other new calls [6]. Ideally, the channel quality measurements should be made at both the mobile or at base station. If measurements are taken at base station or only at the mobile, the channel allocation is partially blind [6]. Channel allocation that are based on blind measurements can cause interference problem, leading to the possible termination of the new call as well as restrict another user’s call, who is using the same channel [5].

Probably the simplest dynamic channel allocation algorithm is not allocating the least interfered channel available to users requesting a channel. By measuring the received power within unused channel, effectively the noise plus interference on that channel can be measured.
By allocating the least interfered channel, new channel is not likely to encounter interference and due to reciprocity, it is not likely to cause too much interference to channels already allocated. This works well for highly loaded systems.

### 5.3 Issues of Dynamic Channel Allocation

The physical implementation of DCA is more complex than FCA. However, with DCA the complex and labor-intensive task of frequency planning is no longer required. Even though much research has been carried out into channel allocation algorithms, particularly dynamic channel allocation, many unknown remain. “For example, the trade-offs and ranges of achievable capacity gains are not clearly understood” [5]. Furthermore, it is not known how to combine even two simple algorithms in order to produce a hybrid that has the best features of both. One reason that the issues of dynamic channel allocation are not well understood is the computational complexity encountered in investigation such algorithms. “In addition, algorithm has to compare to the others in variety of scenarios [5]”. Furthermore, changing one algorithm parameter in order to improve the performance in one respect usually have some effect on another in order to improve the performance, due to the parameters highly interrelated nature. This is particularly true, since experience show that some handover algorithms are better suited for employment in certain dynamic channel allocation algorithm. Therefore the various channel allocation algorithms have to compare in conjunction with a variety of handover algorithms in order to ensure that performance is not degraded significantly by a partially incompatible handover algorithm [5]. The large parameters and the associated high computational complexity of implementing channel allocation algorithms complicated study of the trade-offs of the various algorithms.

The call setup is longer in DCA algorithms than in FCA due to the time required to make channel quality measurements should be made at both the mobile and base station. If measurements are made at both mobile and the base station, then the measurements need to compared, requiring additional signaling, which increases the call setup time. This can be a problem, when, for example a handover is urgently required.

### 5.4 Dynamic Channel Allocation 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 [6].
5.5 FAIL (First Available Interfered Least)

The dynamic channel allocation algorithm has to balance for allocation a new channel to user against the potential co-channel interference and adjacent channel interference [6]. To increase the capacity or maintain the Grade of service in dynamic channel allocation an algorithm is proposed named as First Available Interfered Least (FAIL). According to the FAIL algorithm the channel that 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 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 [6]. 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) [6]. After getting the cell ID then system will check the list of channels that are in use 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 scratch for the free time slot in next channel, system will search for free time slot in all available channels currently in use 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. If there is no timeslot found in any of that channels than the system will search for a new cell.

When 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 25% 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 FAIL defined a threshold value to assign equal maximum number of channels in each cell [6]. 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 [6]. 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 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 be 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 First Available Interfered least (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.
Figure 5.1(a) SYSTEM POOL
Master thesis “Dynamic Channel Allocation In GSM Network”

1. Search For Free Time Slots (TS) in that Channel
   - Y: Allocate TS for Call
   - N: Move To Next Channel

2. Check maximum number of channels
   - Y: If numbers of channels in cell > threshold level 25%
   - N: Call Blocked

3. Again Channel scanned
   - Y: Search For Free TS in Channel
   - N: All TS are Busy

4. Free TS found
   - Y: Allocate TS for a Call
   - N: Check maximum number of channels

5. Y: Allocate TS for Call
   - N: Call Blocked
Master thesis “Dynamic Channel Allocation In GSM Network”

3

Channel in the pool

N
Call Blocked

Y
Random select one free channel

Satisfy co-channel cell distance

N
Call Blocked

Y
Check Interference from Channel

System checks the current position of channel

If channel is already use in that cell or in neighbouring cells

N
Channel is least Interfered

Y
Channel cause interference

Move To Next Channel In Pool

Allocate First TS for that Call
5.6 Algorithm for Channel Re-assignment

Channel assignments are based on the lowest interference level available even though partial interference channels is not enough to give the channel quality between the mobile and the switching device [6]. FAIL algorithm gives the idea of reassignment of the channel that the system processing requirements by reassigning a service from pre-assigned channel to a second channel based on the interference level or measure the channel quality of the pre-assigned channel. If there are more than one channel are in use in one cell and most of the slots are free in any of that channel than reassign the calls of other channels into the channel. After reassignment the channel that becomes free will be placed back into the pool and available for other requests. “The channels divided into bands of interference and categories can be stored in system that is utilized during reassignment [6]”. Service is reassigned such that a new channel is chosen, based on the characteristics of the pre-assigned channel. This algorithm includes a setup in which interference measurements are taken on uplink side and used to separate the available channels into time slots based on the measured levels of interference [6]. When subscriber send a call request the system assign a channel to a first transmission channel and the service is reassigned to a free time slots of second channel and the location of the interference band associated with the second channel can be a variable distance away from the location of interference band associated with pre-assigned channel. This will improve the capacity and maintain the grade of service. Fail algorithm proposed a reassignment of channel in dynamic channel allocation to vacate more resources in the pool to maintain grade of service. “The channel which is pre-assigned to subscriber request based on the interference level of the channel and if quality of channel becomes unacceptable than reassign the call to second channel [6]”. If necessary, the service is reassigned to a second channel using variable reassignment to select a second channel that is a variable distance from the pre-assigned channel. The first two channels are taken because average mean holding time for one call is approximately 20 seconds. According to algorithm, if there is more than one channel is allocated to any of the cell then reassign the calls of one channel to that channel in which the more free time slots found. After reassigning the calls the free channel will be placed back into the pool and available for other call requests. The channels that are assigned for a long time will cause interference both adjacent channel interference and co-channel interference. So the first two channels will be taken then count the free timeslots of the channel are greater or equal to the busy time slots of the second channel then re-assign the calls of first channel into second channel and first channel will become free and send back into the pool of channel. If the above given condition is not true than count the free time slots of first channel is greater or equal to the busy time slots of the second channel than reassign the calls of second channel into the first channel and the second channel will be send into the pool. This process repeats again and compares all channels until and unless it avoids the call blocking and provides a more resources for more users. The reassignment algorithm will be start when there are more than one channels in the cell are allocated for calls. All of the reassignments of calls from one channel to another
channel will be performed on Frequency Correction Channel (FCCH) of the Broadcast Control Channel (BCCH). FCCH is transmitted frequently and is more easily detected by the mobile. When the FCCH has been detected the mobile corrects the frequency of its internal time base. It is then able to detect SCH which contains the precise synchronization information it require.
Figure 5.1 (b) channel reassignment flow diagram

1. Count if channels >1 in that cell
   - N: STOP
   - Y: Take the channel no. 1 (a) in that cell
     2. Count the busy TS (a)
     3. Take the Channel no. b = (a+1) in that cell
     4. Count the free TS (b)
     5. If free TS of (b) >= busy TS of (a) channel
        - Y: Reassign the calls of (a) channel into (b) channel
        - N: Back to Step 2

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1. If free TS of (a) channel >= busy TS of (b) channel
   - Y: Reassign the calls of (b) channel into (a) channel
   - N

2. Check (b)= no. of max channels in that Cell
   - Y: a++
   - N: b++

3. a = max no. of channel in that cell
   - N

4. (Process continues)
5.7 Algorithm for Sectored System

The biggest advantage of dividing the cells into different sectors is that it is more helpful to reduce interference from co-channel cells. The channels which are used in the cell are divided into small sectored groups and they work only for a particular sector by using directional antennas. A cell is normally partitioned into three 120 degrees sectoring or six 60 degree sectors. As demand for wireless system increases the number of channels assigned to a cell eventually becomes insufficient to support the required number of users. At this point cellular system designed techniques such as sectoring is employed everywhere to expand the capacity and to avoid interferences.

According to FAIL, it takes all new calls and hand-off requests as a new call. So, where sectoring is employed the algorithm will work as it is defined. The only change is that where the system checks the cell id or channels in the cell the system will check the sector id or the channels in that sector. All other functions will be performed as they are mentioned in the flow chart of assigning a channel.
5.8 Traffic Case 1

This algorithm will be helpful to assign channel and timeslot when a subscriber moves from one cell to another and the handover between cells controlled by the same BSC. When performing handover between two cells controlled by the same BSC, the MSC/VLR is not involved. However, MSC/VLR will be informed when a handover has taken place. If handover is involves different LA’s, location updating is performed once the call is finished.

1) The BSC orders the new cell to activate a TCH then system checks the availability of channels and the free time slots. If all channels are used and no time slots are free then call will be blocked.

2) The BSC send a message to the MS, via the old cell, containing information about the frequency and the time slot to change which is allocated by the system and also the output power to use. This information is sent to the MS using FACCH.

3) The MS tunes to the new frequency, and transmits handover bursts in the free time slot. Since the MS has no information yet on TA (Timing Advance), the handover are very short (only 8 bits of information).

4) When the new cell detects the handover bursts, it sends information about TA. This is also sent via FACCH.

5) The MS sends a Handover Complete message to the BSC via the new RBS.

6) The BSC tells the old RBS to release the old channel and that channel will back to the system pool.
5.9 Traffic Case 2

Handover between cells controlled by Different BSC’s with the same MSC/VLR. When another BSC is involved in a handover, the MSC/VLR must be involved to establish a connection between the two BSC’s.

1) The serving (old) BSC sends a Handover required message to the MSC containing the identity of the target cell.

2) The MSC knows which BSC controls this cell and sends a Handover Request to this BSC.

3) The new BSC orders the target cell to activate a TCH. Here system will check the numbers of channels assign to target cell if it less then the given threshold system will assign to new channel to the target cell

4) The new BSC sends a message to the MS via the MSC and old cell.

5) MS tunes and allocates to the new frequency and transmits handover access bursts in the correct time slot.

6) When the new cell transmits information about TA (Timing Advance).

7) MS transmit the handover complete message to MSC via the new BSC.

8) MSC sends the old BSC an order release the old TCH and time slot of that channel then channel will back to pool system.
Chapter 6

TRAFFIC ENGINEERING

6.1 Trunking theory

The concept of trucking allows a large number of users to share the relatively small number of channels in a cell by providing access to each other, on demand, from a pool of available channels [4]. Single channel is assigned to an every subscriber for an ongoing call and when call is disconnected the channel which is allocated to a user is move back to pool of the available channel.

“Trunking exploits the statistical behavior of user so that fixed number of channels may accommodate a large, random number of channels that need to be allocated for hundreds of users [4]”. There is trade-off between the number of available channels and the likelihood of a particular user finding that no channels are available during the peak calling time [4]. If users get all channels busy it means that all the selected number of channels decreases.

The traffic intensity offered by each user is equal to the call request rate multiplied by the holding time. That is, each user generates a traffic intensity of \( A_u \) Erlangs (traffic load unit) given by:

\[
A_u = \mu H
\]

Where \( \mu \) is the average number of call requests per unit time and \( H \) is the average duration of a call. For a system containing \( U \) subscriber and an unspecified number of channels, the total offered traffic intensity \( A \), is given as:

\[
A = U A_u
\]

Furthermore, in a \( C \) channel trunked system, if the traffic is equally distributed among the channels, then the traffic intensity per channel, \( A_c \), is given as:

\[
A_c = \frac{U A_u}{C}
\]

Note that the offered traffic is not necessarily the traffic which is carried by the trunked system, only that which is offered to the trucked system. When the offered exceeds the maximum capacity of the system, the carried traffic becomes limited due to the limited capacity. The maximum possible carried traffic is the total number of channels, \( C \), in Erlangs [4].
6.2 Types of Trunked Systems

There are two types of trunked systems which are commonly used:

6.3 Blocked Calls Cleared

It provides the easy way to access the service by user and it will automatically inform user for accessing the available channel in short time. If channels are not available user is not able to access and its request is blocked but user can send a request for accessing again. It selects the random users for call request.

6.4 Blocked Calls Delayed

This kind of trunking provides a queue for holding calls which are already blocked and waits an ongoing call until the availability of channel.

6.5 Grade of Service

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 “[4]. 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.

The other way to measure the grade of service is to utilize the different parts of the network. When a call is routed from one end to another; it will pass through several exchanges. If the Grade of Service is calculated based on the number of calls rejected by the final circuit group, then the grade of service is determined by the final circuit group blocking criteria. If the Grade of Service is calculated is determined by the exchange-to-exchange blocking criteria.

Grade of service is also known as blocking probability and this blocking probability occurs during communication between mobile and station. During a radio transmission Low blocking probability is possible but it doesn’t effect on system performance.
Where $C$ is the number of trunked channels which are offered by a trunked ratio system, and $A$ is the total offered traffic. While it is possible to model trunked systems with finite users, the resulting expressions are much more complicated than the Erlang B result, and the added complexity is not warranted for typical trunked systems which have users that outnumber available channels by orders of magnitude. Furthermore, the Erlang B formula provides a conservative estimate of the GOS, as the finite user results always predict a smaller likelihood of blocking [4].

### 6.6 Traffic Analysis

Cell planning starts with traffic coverage analysis. The analysis produces information about the geographical area, expected capacity (traffic load). The collected data types are:

- Pool traffic channels
- Capacity
- Cost
- Grade of Service (GOS)
- Coverage
- Available frequencies
- Speech quality
- System growth capability

The cell planning depends on the traffic demand, i.e. total strength of subscribers is engage with the network and how much traffic they generate. The Erlang ($E$) can be calculated with the following formula:

\[
A = \frac{n \times T}{3600} \text{ Erlang}
\]

Here, $A$ represents the total traffic available for subscribers, $n$ gives the estimate number of calls per hour and $T$ is an average call time per second.

The number of subscribers and the Grade of Service (GOS) has to be known for calculating number of cells. Capacity of networks depends on the total numbers of subscribers, available frequencies, cell pattern, GOS, and traffic per subscriber, if we know the exact figure of all above data then we can able to calculate the total strength of capacity like how much frequency is allocated to each cell by a network operator, available traffic channel allocated by the pool system, i.e. If 14 TCH are allocated by a pool with a 2% GOS the total traffic intensity per cell will be 8.2 Erlangs (see Table 6.1). The total numbers cells in one area can be calculated by dividing the total numbers subscribers with the subscribers of one cell.
For cellular circuit groups 2% GOS is acceptable. It means that two subscriber of the circuit group out of a hundred with encounter a call refusal during busy hour at the end of planning period. If GOS is 5% then one call in 20 will be blocked during the busiest hour the overloaded traffic on the cell. Suppose call is established between user and cell via MSC. Assuming a continuous connection and date rate transfer rate at 30 kbit/s, and then call will terminated after 50 minutes so the total offered traffic intensity will be 0.833. Here offered traffic intensity depends on the holding time. If MSC receives 240 calls/hr and the average time of terminating calls is 5 minutes so the outgoing offered traffic intensity of MSC to subscribers will be 20 Erlangs. Total 20 hours of circuit talk time is required for every hour of elapsed time. An average of voice circuit busy at any time is 20. (20 channels are continuously for 20 hours).
Chapter 7

Conclusion

The world is undergoing a major telecommunication revolution that will provide ubiquitous communication access to citizens, where they are. Considering the wireless telecommunication industry requirements, to develop new wireless systems, make meaningful comparison of competing systems, and understand the trade-offs that must be made in any system. Such understanding is achieved in this thesis to provide better solution to fulfill today’s requirements (cumulative growth of 30% per year) of increasing demand of wireless communication industry by proposing an algorithm of Dynamic Channel Allocation to achieve the increasing system capacity.

GSM has a limited bandwidth available, and the demand is increasing day by day. The service providers are facing problems to control the grade of service. GSM has limited architectural approaches to increase the capacity; these are cell sectoring and cell splitting. In cell sectoring we can achieve the most re-use distance of channel and to minimize the interference, but regarding today’s demand sectoring is not enough to control the grade of service. Now cell splitting is the other approach to increase the system capacity, in cell splitting the large cells are subdivided into smaller cells. Cells splitting increase the capacity but the cells have limited small size.

GSM uses fixed channel allocation scheme to assign channels to users, every BTS available a specific number of channels to assign the users for a call if there is no channel available than the call will be blocked. This will increase the grade of service. So, considering entire conditions, limited bandwidth and limited architectural approaches of GSM we move towards the dynamic channel allocation scheme to increase the system capacity. We proposed an algorithm of dynamic channel allocation in which all channels will placed in a pool and on demand or on request will be assigned to the user for that particular call. Each cell can assign any channel in the pool after searching the channel from the pool.

There are many algorithms for dynamic channel allocation, but the proposed algorithm is very simple and this will lead the system towards another architectural approach to increase the system capacity.

Dynamic channel allocation is a best solution to achieve better performance and efficiency than that of fixed channel allocation. By allocating channels dynamically the system can have additional number of channels. Dynamic channel allocation is better suited to micro cells systems because it can handle the more non-uniform traffic distributions, the increased handover requests, and the more variable co-channel interference better than fixed channel allocation due to its higher flexibility.

With dynamic channel allocation the complex and labor-intensive task of frequency is no longer required. According to our point of view, dynamic channel is better suited for equidistant cells. We make cells of different sizes in a fixed channel allocation because of congestion and to control grade of service. So in dynamic channel allocation if all cells are the same size it does not affect the grade of service every channel will be available in each cell.
By using dynamic channel allocation system expected capacity can be increased around 30% to 40%. Due to shortage of time it’s very complicated to prove analytically that how much system capacity will be increased. In future if any student wants to continue this project to prove the exact figure of increasing the system capacity, they do not have to reinvent the wheel. They can continue this project afterwards.

Although the proposed algorithm will increase the complexity of the system but by getting the additional number of channels this will increase the system capacity and to control the grade of service. In short subscriber density will be increased by using dynamic channel allocations.
Master thesis “Dynamic Channel Allocation In GSM Network”

References


