Chapter 1: Introduction

1.1 Introduction

Ever increasing growth in cellular mobile user population, coupled with scarce radio spectrum has put stringent demand on optimization of channel utilization methodology. An efficient channel reuse scheme will ensure maximum availability of idle channels for new and handoff calls. A mobile phone or a cellular phone can make and receive telephone calls over a radio link on the move. We may draw an analogy with cordless telephone which is used only within the short range of a single, private base station. Modern mobile phones also support a wide variety of other services such as text messaging, MMS, email, Internet access, short-range wireless communications business applications, gaming and photography. Mobile phones that offer more general computing capabilities are referred to as smartphones. The first hand-held mobile phone was made by Motorola in 1973, using approx 1 kg handset. In 1983, the DynaTAC 8000x was the first to be commercially available. In the twenty years from 1990 to 2011, worldwide mobile phone subscriptions grew from 12.4 million to over 5.6 billion, penetrating the developing economies and reaching the bottom of the economic pyramid.

1.2 Background

In this paper we study fixed and dynamic channel allocation schemes. An attempt has been made to propose and evaluate a persistent and aggressive hybrid channel scheme which shows outperformance as compared with dynamic channel allocation scheme. Efficiency of GSM network is directly related to the better management of available channels and their efficient reuse. The proposed scheme is a continuous process which calculates the channel allocation cost for a new call. As soon as new call is allowed, algorithm starts calculating the cost of all available channels and attempts to rearrange them in order of increasing cost of allocation. This algorithm will automatically switchover/ interchange channels in use with lower cost channel, thereby ensuring maximum packing among the cluster of cells. This considers co-channel interference and the constraint of reuse distance.
1.3 **Network architecture** Wireless network coverage is divided into adjoining hexagonal cells. Base station (BS) is considered to be at the Centre of the cell. Mobile stations (MS) are free to move anywhere in the cell. Inside the cell, mobile users are free to move, start and receive a call. Base station makes channels available to the mobile stations. Base stations in AMPS are also called cell site. These cell sites are linked with Mobile Switching Centre (MSC). MSC controls the calls and acts as a gateway for other networks. When any MS reaches boundary of the cell, it needs to change its current frequency channel to another belonging to the neighbouring cell. This procedure is termed as handover.
1.4 **Channel Pools**  

A cell is considered to have a pool of channels. This pool of channels is further divided into two adaptively changing channel sets; one each for new calls and handoff calls. Number of channels allotted to a cell may vary depending upon the cell size, concentration of the MS, previous utilization pattern etc. Whenever call requests are originated by a MS, BS directs the request to central switching centre for completion of the request to the destination. Whenever MS leaves its present cell and enters in to another neighbouring cell, channel switchover occurs. This is referred as handoff. Various multiple access schemes are employed viz time division multiplexing (TDMA), frequency division multiplexing (FDMA) or a combination of both the techniques. Present day heavy traffic requirements make a mandatory demand for efficient reuse all available resources. Hence a channel is to be used to support more than one call simultaneously. Channel reuse gets limited due to interference conditions. Hence, adequate spatial separation is to be maintained while reusing the channel. Other issue could arise due to the use of channels which are very close to each other in terms of frequency. There is a requirement of adding adequate separation between two adjacent channels to ensure interference to be below a threshold. This leads to an efficient use of spectrum as large amount of resources would be utilized as guard band. Hence, an attempt to avoid use of adjacent channels in neighbouring cells can reduce stringent requirement of guard bands and will ensure better utilization of spectrum.

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**Fig. 1.3: GSM Spectrum [1.3]**
1.5 **GSM Physical and Logical Channels.** A physical channel is specified by a specific time slot in a specific channel / carrier frequency. Logical channels run over a physical channel [1.1]. Control channels have to arrange set up, maintenance, tear down of calls. Control channels are interspersed with traffic channels in well-specified ways [1.2].

1.5.1 **Full rate channels** Over a data rate of 22.8 kBit/s:

- **Speech data**: used as 13 kBit/s voice data plus FEC data
- **Packet data**: used as 12, 6, or 3.6 kBit/s plus FEC data
1.5.2 **Half rate channels**

Over 11.4 kBit/s

Speech data: improved codecs have rates of 6.5 kBit/s
Packet data: can be transmitted at 3 or 6 kBit/s

1.5.3 Two half rate channels can share one physical channel. In order to achieve higher packet data rates, multiple logical channels have to be allocated. This is used in GPRS.

1.6 **Broadcast logical channel**

It is subdivided into several sub-channels. BTS announces network specific data containing:

1.6.1 Network identification / operator availability of options like voice activity detection etc.

1.6.2 Frequencies used by the BTS and neighbours and frequency correction / synchronization information.

1.6.3 Paging channel: used only in downlink for handling an incoming call

1.7 **Random access channel**

It is used only in uplink for requesting a connection establishment (a slotted ALOHA random access protocol is used on this channel) [1.3]. Similarly, using access grant channel, the BTS informs a mobile about the outcome of a connection setup request. There are further control channels, e.g. supporting authentication and handover.

1.8 **Channel Coding**

Channel coder output is grouped according to their relevance for speech quality. 3 parity bits are added. A block of 189 bits are distributed as under:-

1.8.1 53 bits of previous stage

1.8.2 132 bits of speech data

1.8.3 Four zero bits to end sequence

1.9 **Modulation**

Each bit of a formatted burst is translated into a waveform and transmitted over the antenna. On the receiver side all steps are inverted.
1.10 **Mobile Generations**  Second Generation mobiles accommodate more number of Subscribers in the same spectrum when compared with first Generation Systems. In 2G system, efficient circuit switched networks were retained. 3rd Generation mobile systems are more efficient with respect to data handling. 3G systems were defined by International Telecommunication Union (ITU). ITU defined International Mobile Telecommunication for year 2000 (IMT –2000) standards for 3G mobile network. IMT clearly outlined the following tenets:-

1.10.1 Voice quality comparable with Public Switch Network (PSTN)

1.10.2 Different data rates

. 144Kbps for fast moving vehicles

. 384 Kbps for pedestrians

. 2.048 Kbps for static use

. Both packet Switch & circuit switched services, hence flexible.

. Efficient use of spectrum network must be scalable.

. Introduction to new series & technologies.

1.11 **Digital Enhanced Cordless Tele Communications (DECT)** DECT and Universal Wireless communications (UWC-136) are TDMA schemes. Radio transmissions technologies (RTT) that were made part of ITUM in 1998 are listed in Table 1.1.
There are three main second generation legacy standards: TIA /E1A-136 and Global System for mobile communications on TDMA principal and IS-95 based on CDMA. There is large base of Advanced Mobile Phone System (AMPS) and second generation GSM already existing. Hence, standards evolution should consider this fact. EDGE came with enhanced data rates for 2G networks. It replaced GMSK with 8-PSK and hence increased data rates ([1.4] and [1.5]).

Fig. 1.6: Block Diagram of GSM Channel [1.5]
1.12 Policies for GSM based IMT 2000 Network

IMT-2000 was propagated by two development groups, the Third Generation partnership project (3GPP) and 3GPP2. 3GPP network comprise of core network (CN) and Radio Access Network (RAN) working on WCDMA. 3G subscribers can be use high data rates even when roaming. 3G network may rely on circuit Switched (CS) and Packet Switch (PS).

<table>
<thead>
<tr>
<th></th>
<th>GSM</th>
<th>TIA / EIA 136</th>
<th>IS-95</th>
<th>PDC (Personal Digital Communication)</th>
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<tr>
<td>Frequency Range uplink</td>
<td><strong>GSM 900</strong></td>
<td>Cellular</td>
<td></td>
<td>940-960</td>
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<td>Down link</td>
<td>935-960</td>
<td>869-894</td>
<td></td>
<td>810-826</td>
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<td></td>
<td>890-915</td>
<td>824-849</td>
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<td>1429-1453</td>
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<td><strong>GSM 1800</strong></td>
<td>PCM</td>
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<td>1477-1501</td>
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<td>1805-1880</td>
<td>1930-1990</td>
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<td></td>
<td>1710-1785</td>
<td>1850-1910</td>
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<td><strong>GSM 1900</strong></td>
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<td>Channel Spacing (KHz)</td>
<td>200</td>
<td>1250</td>
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<td>Min Number of channels</td>
<td>125</td>
<td>832</td>
<td>20</td>
<td>1600</td>
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<td>User per channel</td>
<td>8</td>
<td>3</td>
<td>&lt;63</td>
<td>3</td>
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<td>Multiple Access Technique</td>
<td>FDMA/TDMA</td>
<td>FDMA/CDMA</td>
<td></td>
<td>FDMA/TDMA</td>
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</table>

Table 1.1: Comparison of cellular System [1.4]
1.13 Contribution

Various strategies have been employed for the allocation of channel in GSM network. In Fixed Channel Allocation (FCA), channel is permanently allocated to each cell for its exclusive use. FCA could follow a uniform pattern if traffic is uniformly distributed, else number of nominal channels allocated to each cell may be decided based on traffic profile in that cell.

Dynamic Channel Allocation (DCA) schemes propose allocation of channels to a central pool and these is no fixed relationship between channels and cells. Central channel pools are assigned dynamically to new calls as they arrive in the system. The main idea of DCA schemes is to evaluate the cost of using each candidate channel and select one with minimum cost. Selection of cost of a channel may depend on future blocking of calls in the vicinity of cell, the frequency of a candidate channel re use distance channel occupancy distribution blocking, probabilities, type of quality of service requirements, queuing requirements etc. DCA can be adaptive to respond to varying traffic patterns. As the traffic intensity keeps rising, DCA gives way because of intensive cost calculation requirements and performance deteriorates. In such cases, a Hybrid Channels Allocation scheme (HCA) which is a combination of FCA and DCA that is to say that few of the nominal channels may be permanently allotted to a cell as in FCA and few of channels can be allotted centrally for dynamic borrowing. Whenever a new call arrives in a cell and all its nominal channels are busy a channel from dynamic set can be allotted.

A channel allocation scheme can be modeled to attain a low blocking probability with limited spectrum availability ensuring co channel and adjacent channel constraint. A theoretical assessment is also available in [1.6] to compute minimum number of channels to be made available to achieve certain blocking probability. There are performance bounds that can be defined for cellular network with different channel allocation constraints. Thus, performance comparison of various schemes could be done by relating to these bounds. Performance bounds can also be analytically modeled. A system of M cells which share common pool of m channels is considered. An asymptotic traffic property (ATP) proposed in [1.7] was found to satisfy traffic models with common Poisson arrival rates and exponential call holding times. The analytical model aims at maximizing the sum of carried traffic over the complete system.
It is considered that signal to MS is transmitted through nearest BS. Any signal received from other BS is treated as noise. Users within a cell access a channel orthogonally and do not cause any interference to each other. Efficiency of any channel reuse scheme will depend on reuse factor. As discussed in [1.8], a reuse factor of $\frac{1}{2}$ would imply that half of the available bandwidth can be used in a cell N and remaining half bandwidth can be allocated to N-1 and N+1 cell. MS, when moving closer to the cell boundary, also receives signal from neighboring cell. Decreasing reuse factor, improves co-channel interference but the loss of bandwidth is much pronounced. Reuse factor also depends on the type of channel whether additive wide Gaussian noise (AWGN) of fading channels.

Fig. 1.7: Cellular Network Structure
References


