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TAXONOMY OF CELL PLANNING

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ABSTRACT

An extensive literature survey for cell planning has been provided in the manuscript with certain pros and cons of the discussed architectures. In addition the paper concentrates on the cell planning to reduce the cost of implementing the certain systems in the field of mobile communication with better efficiency and quality of service.

Keywords: *Cell Planning, GSM, CDMA, 1G, 2G, 3G, 4G, 5G, BSC, BSS, MS.*

1. INTRODUCTION

In recent few years, telecommunication has been a fast-growing industry. This growth can be seen in the increasing revenues of major telecommunication carriers and the continued entry into the marketplace of new competitive carriers. For last 15 years, an explosion has been noticed in the number of mobile communication subscribers and it appears that this growth is likely to continue well into the future. The growth in the number of mobile subscribers is expected to continue for some years, with the number of mobile subscribers surpassing the number of fixed network subscribers at some point in the near future. Although it may appear that such predictions are optimistic, it is clear that the future is bright for mobile communications.

1.1. GSM and CDMA

A GSM network is made up of three subsystems: the Mobile Station, the Base Station Subsystem- comprising of BSC and several BTSs, and the Network and switching subsystem- comprising of an MSC and associated registers.

The interface defined between each of these subsystems include 'A' interface between NSS and BSS, 'Abis' interface between BSC and BTS (within the BSS) and 'Um' air interface between BSS and the MS.

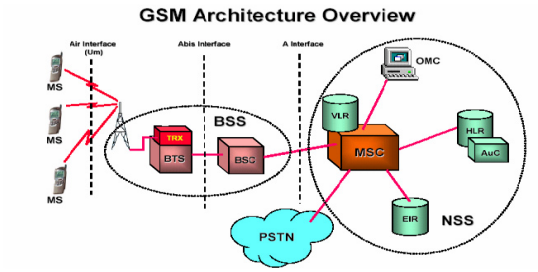

Figure-1: GSM Architecture Overview

Network structures as shown in figure-1 are same in GSM and CDMA addition feature available in CDMA is coding scheme.

CDMA is a technique whereby all users share the same frequency at the same time. Obviously, since all users share the same frequency simultaneously, they all interfere with each other. The challenge is to pick out the signal of one user from all of the other signals on the same frequency. This can be done if the signal from each user is modulated with a unique code sequence, where the code bit rate is far higher than the bit rate of the information being sent. At the receiving end, knowledge of the code sequence being used for a given signal allows the signal to be extracted. Although CDMA had been

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considered for commercial mobile communication services by several bodies, CDMA system was standardized as IS-95 in 1993 by the U.S. Telecommunications Industry Association (TIA). Since then, many IS-95 CDMA systems have been deployed, particularly in North America and Korea. Although some of the initial claims regarding capacity improvements were perhaps a little overstated, IS-95 CDMA is certainly a significant improvement over AMPS and has had significant success.

In North America, IS-95 CDMA has been deployed in the 800-MHz band and a variation known as J-STD-008 has been deployed in the 1900-MHz band. The CDMA system utilizing the Qualcomm technology utilizes a chip rate of 1.228 MHz. The chip rate is the rate at which the initial data stream, the original information, is encoded and then modulated.

1.2. GSM Vs. CDMA

GSM is a 2nd generation widely spread standard, its users are almost 8 times in number than CDMA users worldwide. GSM is far better than CDMA in voice quality. The GSM base stations consume more power than CDMA does and also cover a less distance. The cell size in GSM is smaller to that of CDMA. It covers a large area of more than 25 Kms. It offers slower data download. User cannot go beyond a short distance charging area (SDCA) - which is roughly a radius of 25 km. On a GSM phone account information along with your contact list and other personal data is stored on a SIM card. Maximum download speed of 384kbps (around 140kbps in practice) and it uses TDMA technology. It was started in 1991 and it permits roaming worldwide. The Battery life of GSM is very good due to simple protocol, good coverage and power efficient chipsets. It is hard handoff. Europe, South Africa, Australia, and many Middle and Far East countries have chosen to adopt GSM. CDMA is a 3rd generation patented technology. CDMA users are almost 8 times less in number than GSM users worldwide. CDMA is poor than GSM in voice quality. The CDMA base stations consume less power than GSM and also cover a large distance. The cell size in CDMA is larger compared to that of GSM. It offers faster data download. On a CDMA phone, your account information is programmed into your cellular phone. Maximum download speed is about 2mb/s, It uses CDMA technology, It was started in 2000 and roaming is limited. The battery life is lower due to high demands of CDMA power control and young chipsets. It is Soft Handoff. CDMA is mostly used in America and some parts of Asia,

2. GENERATION OF CELL PLANNING

2.1 1G

The first generation, 1G wireless mobile communication system was introduced in the early 1980s and completed in the early 1990s. 1G was analog and supported the first generation of analog cell phones with the speeds up to 2.4kbps.

Each of the various 1G wireless system has its own unique advantage and disadvantages, depending on the spectrum available and the services envisioned for delivery. The prominent ones among 1G systems were Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS). All of the 1G systems shown in the table utilize a Frequency Division Multiple Access (FDMA) scheme for radio system access.

- AMPS is the cellular standard that was developed for use in North America. This type of system operates in the 800-MHz frequency band. AMPS systems have also been deployed in South America, Asia, and Russia.

- Narrow Band AMPS (NAMPS) is a cellular standard that was developed as an interim platform between 1G and 2G systems and was developed by Motorola. Specifically, NAMPS is an analog radio system that is very similar to AMPS, with the exception that it utilized 10-kHz-wide voice channels instead of the standard 30-kHz channels.

- TACS is a cellular band that was derived from the AMPS technology. TACS systems operate in both the 800-MHz band and the 900-MHz band. The first system of this kind was implemented in England.

- Nordic Mobile Telephone (NMT) is the cellular system that was designed to operate in the 450-MHz and in the 900-MHz frequency bands. These are noted as NMT 450 and NMT 900. NMT systems have also been deployed throughout Europe, Asia, and Australia. The basic service offering for 1G systems was voice communication. These systems have been extremely successful and many of them are still in service offering 1G services only. 1G system, however, suffered from a number of difficulties. Some of those difficulties were addressed by additional technology added to the network and some of the difficulties have required the implementation of 2G technology.

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2.2.1 Pros and cons

The basic service offering for 1G systems was voice communication. These systems have been extremely successful and many of them are still in service offering 1G services only. 1G system, however, suffered from a number of difficulties. The biggest problem that led to the introduction of 2G technology was the fact that the 1G systems had limited system capacity. This became a serious issue as the popularity of mobile communication grew to a level that far exceeded anyone's expectations. The technologies did not initially include security mechanisms, which allowed the chances of fraud. Finally, some limitations in the technologies led to the difficulty in searching the "lost mobiles," where a subscriber is located at one MSC and the network thinks that the subscriber is elsewhere.

2.2 2G

The second generation, 2G system, finished in the late 1990s, was planned mainly for voice transmission with digital signal and the speeds up to 64kbps. GSM and CDMA IS 95 were prominent technologies.

2G phones using global system for mobile communication (GSM) were first used in the early 1990s in Europe. GSM provides voice and limited data services, and uses digital modulation for improved audio quality.

The existing mobile network consists of the radio access network (comprising cells and backhaul communications) and the core network (comprising trunks, switches, and servers). Mobile switching centers (MSCs) are intelligent servers and the whole network is data-driven, using subscription and authentication information held in the home location register (HLR) and authentication centre (AuC). The standard services include circuit-switched voice, fax, and data, as well as voicemail and voicemail notification. Additional services include wireless application protocol (WAP), high-speed circuit- switched data (HSCSD), mobile location services (MLS), and cell broadcast. You can change to a new operator keeping your old phone number. Second-generation mobility involves a variety of technology platforms as well as frequency bands. The issues regarding 2G deployment are as follows:

- Capacity
- Spectrum utilization
- Infrastructure changes
- Subscriber unit upgrades
- Subscriber upgrade penetration rates

The fundamental binding issue with 2G is the utilization of digital radio technology for transporting the information content. It is important to note that while 2G systems utilized digital techniques to enhance their capacity over analog, its primary service was voice communication. At the time 2G systems were being deployed, 9.6 Kbps was more than sufficient for existing data services, usually mobile fax. A separate mobile data system was deployed in the United States called Cellular Data Packet Data (CDPD), which was supposed to meet the mobile data requirements. 2G systems were deployed to improve the voice traffic throughput compared to an existing analog system.

Several competing digital techniques are being deployed in the cellular arena. The digital techniques for cellular communication fall into two primary categories: AMPS and the TACS spectrum. For markets employing the TACS spectrum allocation, the Global System for Mobile communications (GSM) is the preferred digital modulation technique.

2.2.1 Pros and cons

The introduction of 2G mobility systems, whereas focused on voice transport, brought about numerous improvements or enhancements for the mobile wireless operators and their customers. The major benefits associated 2G system are:

- Increased capacity over analog
- Reduced capital infrastructure costs
- Reduced capital per subscriber cost
- Reduced cellular fraud
- Improved features
- Encryption

The benefits, when looking at this list, were geared toward the operator of the wireless system. The implementation of 2G was a reduction in operating costs for the mobile operators either through improved capital equipment and spectrum utilization to a reduction in cellular fraud. The improved features were centered around SMS services, which the subscriber benefited from.

2.3 2.5 G (GPRS)

2.5G is used to describe 2G-systems that have implemented a packet switched domain in addition to the circuit switched domain. 2.5 G can provide

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data rate, up to 144 kbps. GPRS, EDGE and CDMA 2000 were 2.5 technologies.

2.5G enables the wireless operators whether they utilize in cellular, PCS, or Universal Mobile Telecommunications System (UMTS) spectrum to deploy digital packet services prior to the availability of 3G platforms. The specific technology and implementation path that each operator must make or has made follows a similar decision path. The 2.5G platforms are meant to provide the bridge between the existing 2G systems that have already been deployed and those envisioned for 3G. Several platforms are leading the 2.5G effort; they are as follows:

■ General Packet Radio Service (GPRS)/High Speed Circuit Switched Data (HSCSD)

■ Enhanced Data Rates for Global Evolution (EDGE)

■ Code Division Multiple Access (CDMA2000)

2.3.1 Pros and cons

The introduction of 2.5G has many enhancements over the present 2G systems that are in place. The specific advantages of each 2.5G system are directly related to the market and services that the wireless operator currently serves and wants to serve in the near future. The enhancements lie primarily in the use and delivery of packet data services with speeds exceeding the existing 14.4K barrier with 2G systems. The reference used for the 2G to 2.5 platform is not a prerequisite. For example, the deployment of GPRS can be enabled with an underlay system using IS-136 or even CDMA, provided the spectrum is available and the required infrastructure is deployed properly.

2.4 3 G

The third generation, 3G wireless system, was developed in late 1990s and might be well done in late 2000s. 3G not only provided the transmission speeds from 125kbps to 2Mbps, but also included many services, such as global roaming, superior voice quality and data always add-on. UMTS, CDMA2000, HSPA are 3G technologies. The 3G technology adds multimedia facilities to 2G phones by allowing video, audio, and graphics applications. The idea behind 3G is to have a single network standard instead of the different types adopted in the US, Europe, and Asia [1, 2, 3, 4].

3G cellular services, known as Universal Mobile Telecommunications System (UMTS) or IMT-2000, will sustain higher data rates and open the door to many Internet style applications. The main characteristics of IMT-2000 3G systems are:

1. A single family of compatible standards that can be used worldwide for all mobile applications.

2. Support for both packet-switched and circuit-switched data transmission.

3. Data rates up to 2 Mbps (depending on mobility).

4. High spectrum efficiency.

IMT-2000 is a set of requirements defined by the International Telecommunications Union (ITU). 'IMT' stands for International Mobile Telecommunications, and '2000' represents both the scheduled year for initial trial systems and the frequency range of 2000 MHz. The most important IMT-2000 proposals are the UMTS (W-CDMA) as the successor to GSM, CDMA2000 as the successor to interim-standard '95 (IS-95), and time-division synchronous CDMA (TDSCDMA) and UWC-136/EDGE as TDMA based enhancements to D-AMPS/GSM. UMTS increases transmission speed to 2 Mbps per mobile user and establishes a global roaming standard.

Until UMTS is fully implemented, users can have multi-mode devices that switch to GPRS or EDGE technology where UMTS is not yet available. The higher bandwidth of UMTS also promises video conferencing and the virtual home environment. In virtual home environment, a roaming user can have the same services as at home or in the office, through a combination of transparent terrestrial and satellite connections. 3G promises increased bandwidth, up to 384 kbps when the device holder is walking, 128 kbps in a car, and 2 Mbps in fixed applications. A new air interface called enhanced data GSM environment (EDGE) has been developed specifically to meet the bandwidth needs of 3G. EDGE is a faster version of GSM wireless service. But the outlook for 3G is neither clear nor certain.

The IMT-2000 provides following services:

■ Global standard

■ Compatibility of service within IMT-2000 and other fixed networks

■ High quality

■ Worldwide common frequency band

■ Small terminals for worldwide use

■ Worldwide roaming capability

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■ Multimedia application services and terminals

■ Improved spectrum efficiency

■ Flexibility for evolution to the next generation of wireless systems

■ High-speed packet data rates

■ 2 Mbps for fixed environment

■ 384 Mbps for pedestrian

■ 144 Kbps for vehicular traffic

IMT2000/3G can be described as:

■ Being used to reference a multitude of technologies covering many frequency bands, channel bandwidths, and, of course, modulation formats.

■ No single 3G-infrastructure platform, technology, or application exists.

■ 3G is applied to mobile and stationary wireless applications involving high-speed data.

3G is a mobile radio and network access scheme that enables high-speed data to be utilized, allowing for true multimedia capabilities in a mobile wireless system. Presently, voice has been the primary wireless application with the use of the short message service (SMS) being the largest packet data service. Today's wireless cellular and personal communications services (PCS) systems have the same radio bandwidth allocated for both voice and data. Some of the 2.5G transition or migration plans call for the use of a dedicated spectrum just for data applications. The IMT-2000 specifies that data speeds of 144 Kbps for vehicular, 384K for pedestrian and 2 Mbps for indoor applications are the desired goals and have been built into the specifications. The platforms that are listed in both Wideband Code Division Multiple Access (WCDMA) and CDMA2000 are the two 3G platforms.

2.4.1 Pros and cons

The 3G technology adds multimedia facilities to 2G phones by allowing video, audio, and graphics applications. Over 3G phones, you can watch streaming video or have video telephony. It supports for both packet-switched and circuit-switched data transmission with data rates up to 2 Mbps High spectrum efficiency. With the help of 3G, we can access many new services too. One such service is the GLOBAL ROAMING. Another thing to be noted in case of 3G is that Wide Band Voice Channel that is by this the world has been contracted to a little village because a person can contact with other person located in any part of the world and can even send messages too. Then the point to be noted is that 3G gives clarity of voice as well can talk without any disturbance. Not only these but also have entertainments such as Fast Communication, Internet, Mobile T.V, Video Conferencing, Video Calls, Multi Media Messaging Service (MMS), 3D gaming, Multi-Gaming etc are also available with 3G phones.

2.5 4 G

4G mobile communications will have transmission rates up to 20 Mbps, higher than that of 3G. The technology is expected to be available by the year 2010. Presently, NTT DoCoMo and Hewlett-Packard are on their agenda to make it available by the year 2006.

The speeds of 4G can theoretically be promised up to 1Gbps. LTE is considered as 4G technology. 4G is being developed to accommodate the QoS and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB), minimal services like voice and data, and other services that utilize bandwidth. The definition of 4G is to provide adequate RF coverage, more bits/Hz and to interconnect all wireless heterogonous networks to provide seamless, consistent telecom experience to user [3, 4].

4G is being developed with the following objectives:

1. Speed up to 50 times, higher than that of 3G. However, the actual available bandwidth of 4G is expected to be about 10 Mbps.

2. Three-dimensional virtual reality imagines personal video avatars and realistic holograms, and the ability to feel as if you are present at an event even if you are not.

3. Increased interaction between corroborating technologies; the smart card in your phone will automatically pay for goods as you pass a linked payment kiosk, or will tell your car to warm up in the morning as your phone has noted to you to leave the house.

Other 4G applications include high-performance streaming of multimedia content based on agent technology and scalable media coding methods. 4G will solve problems like limited bandwidth in 3G when people are moving and uncertainty about the availability of bandwidth for streaming to all users

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at all times. One of the key requirements is to realize a wireless 4G IP-based access system. The ultimate objective is to create a protocol suite and radio communication schemes to achieve broadband mobile communication in 4G wireless systems [3, 5, 6]. A new protocol suite for 4G wireless systems supported by Department of Defense (DoD) contains:

1. Transport-layer protocols
2. Error-control protocols
3. Medium-access protocol
4. Mobility management
5. Simulation testbed
6. Physical testbed
7. Protocol suite in the mobile terminal
8. Protocol suite in the base station

2.5.1 Pros and cons

One of the main concerns about 4G is that due to high speed of the frequency, it will experience severe interference from multipath secondary signals reflecting off other objects. To counter this problem, a number of solutions have been proposed, including use of a variable spreading factor and orthogonal frequency code-division multiplexing. Next comes the problem of non-compatibility of various applications. 4G will provide better-than-TV quality images and video-links. The communications model has new developed versions of HTML, Java, GIF, HTTP, and many more. New standards will need to be developed for use in 4G.

4G provides higher transmission rates than previous generations and hence some features like Multi-Media Newspapers, also to watch T.V programs with the clarity as to that of an ordinary T.V. are possible.

It is very sad to say that the 3G services had reached only to some towns of china. Hence, it may take time to reach to other countries. Another major defect of this is that Wide Band Frequency Spectrum, which is needed for 3G, is lacking. Another reason for this is that it is a costly item especially for sending data. So, for us, it is an expensive one which could be used only by upper class consumers. To make it acceptable among all customers, it should be made available at a lower rate. For that, the rate of spectrum should be declined.

2.5.2 Evolved Packet Core (EPC)

Evolved Packet Core is the IP-based core network defined by 3GPP for use by LTE and other access technologies. The goal of EPC is to provide simplified all-IP core network architecture to efficiently give access to various services such as the ones provided in IMS (IP Multimedia Subsystem). EPC consists EPC network theory. FLAT IP ARCHITECURE essentially of a Mobility Management Entity (MME) and access agnostic Gateways for routing of user datagram. EPC will be completely new architecture for wireless operators, one that emulates the IP world of data communication rather than the voice-centric world of wireless. EPC is based on flat IP Premise of 4G, and is resting on All IP architecture. Mobile networks have been designed up to this for circuit-switched

3. CELL PLANNING

It can be observed clearly that every generation; 1G, 2G or 3G got improved by cell planning and the current generation 4G is also having the scope to be improved further by cell planning [7, 8, 9, 10, 11, 12].

Cell planning is regarded as the process of selecting the locations of base stations in the wireless network. Cell planning is a fundamental and challenging part of cellular network design process. A simplified form of cell planning problem is the assumption of similar geometric form and size for all cells. Due to non-uniform users' locations and traffic fluctuations, the automatic techniques that locate base stations in a specified area are necessary. Several parameters exist for cellular network design. The minimum required coverage of cell, the network traffic, the topography of test area, the specification of propagation and system desired capacity are common criteria for wireless system design. The most effective parameters are the number of cells and the coverage area of each cell supported by each cell.

Cell planning is the foundation of the mobile network planning and is of great importance for Quality, Performance and Accuracy in the mobile network and can be achieved by frequency, capacity and coverage planning.

3.1 Frequency Planning

Frequency planning is an important area to increase the efficiency and quality of the service by optimally using the frequency band. It may have certain components to achieve the same, as under-

- Intra-Network Network Interference

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It includes co-channel interference (CCI) such as BS-MS, MS-BS, but not BS-BS or MS-MS in FDD-systems adjacent channel interference (ACI).

- Inter-Network Interference

It should be checked before license is granted.

- Impact of Radio-Wave Propagation

It includes average path loss as function of distance, antenna height, and environment, shadow fading, multipath fading (fast fading margin often included in the protection ratio) etc.

- Impact of Equipment Non-Idealities

Under this non-linearity and cross-modulation distortion, oscillator phase noise, receiver blocking etc. can be considered.

Figure-2 shows one of the ways to the reusability of the frequencies to increase the usage of frequency band.

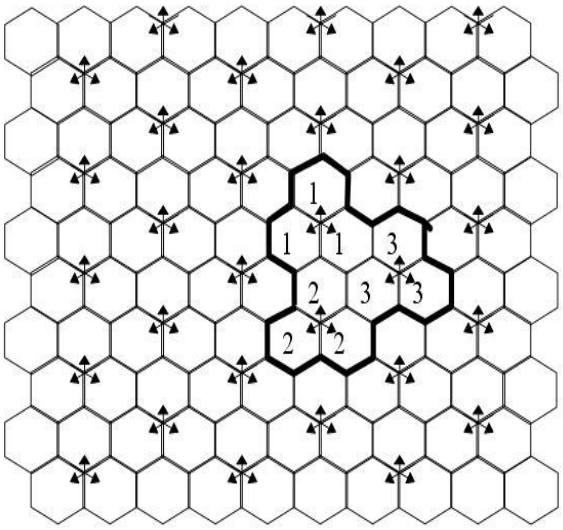

Figure-2: 3/9 Frequency Reuse Model

3.2 Capacity Planning

Cell planning problem with capacity expansion is examined in wireless communications. The problem decides the location and capacity of each new base station to cover expanded and increased traffic demand. The objective is to minimize the cost of new base stations [7, 8, 13, 14, 15]. The coverage by the new and existing base stations is constrained to satisfy a proper portion of traffic demands. The received signal power at the base station also has to meet the receiver sensitivity.

3.3 Coverage Planning

It considers the following major question to answer-

1. Where to put the cell border to fulfill the coverage probability target with given radio link parameters?
2. How to choose the radio link parameters to fulfill the coverage probability target for a given cell size?

4. CONCLUSION

The text provides the extensive survey of cellular networks with its different generations and their pros and cons. In addition a proposal has been suggested to improve the efficiency and quality of service by using any of the field from frequency planning, capacity planning or coverage planning.

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