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A Study on Cellular GSM & CDMA -Based for New Generation Mobile Radio System

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Abstract - As the networks improves, demands for rapid data transfer rates for multimedia services grow, operators are seeking new cellular communication solutions based on technologies like CDMA, GSM, and CDMA2000 to cater to these requirements. The paper points out that the increasing popularity of the GSM equipments globally is driving manufacturers to bring phones to market faster with competitive enhancements increased the quality of service and reduced costs. The paper relates that CDMA, Code Division Multiple Access, alternatively signifies a more powerful digital air interface standard, equating about eight to fifteen times the capacity of conventional analog cellular systems. This paper also compares the both GSM and CDMA.

Keyword **- Cellular Communication, multimedia, CDMA, 3GSM.**

1. Introduction

Multiple access schemes are used to allow many mobile users to share simultaneously a finite amount of radio spectrum. The sharing of spectrum is required to achieve high capacity by simultaneously allocating the available bandwidth to multiple users. FDMA, TDMA and CDMA are the three major access techniques used to share the available bandwidth in a wireless communication system. These techniques can be grouped as narrowband and wideband system, depending upon how the available bandwidth is allocated to the users [1].

FDMA assigns individual channels to individual users. Each user is allocated a unique frequency band or channel. During the period of call, no other user can share the same channel. TDMA systems divide the radio spectrum into time slots, and in each slot only one user is allowed to either transmit or receive. In CDMA systems, the narrowband message signal is multiplied by a very large bandwidth signal called the spreading signal. All users in a CDMA system use the same carrier frequency and may transmit simultaneously.

In this review paper we described the two major technologies in the wireless communication these are GSM &CDMA. GSM works on the basis of narrowband TDMA system.

This paper is organized as follows: Section 2 briefly introduction of GSM and CDMA. Section 3 provides advantages and disadvantages of GSM. Section 4 provides advantages and disadvantages of CDMA. Section 5 shows the architecture of GSM& CDMA. Section 6 describes the main point of contention between GSM and CDMA. Section 7 gives the conclusions.

2. Introduction of GSM & CDMA

2.1 GSM

- GSM stands for **Global System for Mobile Communication** and it is open, digital cellular technology used for transmitting mobile voice and data services[2].
- The GSM emerged from the idea of cell based mobile radio systems at Bell laboratories in the early 1970s.The GSM is the name of standardization group established in 1982 to create a common European mobile telephone standard. The GSM standard is the most widely accepted standard and is implemented globally.
- The GSM is a circuit switched system that divides each 200 kHz channel into eight 25 kHz time slots. GSM operates on four separate frequencies: The 900 MHz and 1.8 GHz bands in Europe Asia and the 850 MHz and 1.9 GHz bands in North America and Latin America.
- GSM allows for eight simultaneous calls on the same radio frequency and uses “narrowband” TDMA, the technology that enables digital transmission between a mobile phone and a base station. With TDMA the frequency band is divided into multiple channels

which are then stacked together into a single stream, hence the term narrowband. This technology allows several callers to share the same channel at the same time.

- The GSM was developed using digital technology. It has an ability to carry 64 kbps to 120 Mbps of data rates. Presently GSM support more than 210 countries throughout the world.
- GSM provides basic to advanced voice and data services including roaming services. Roaming is the ability to use your GSM phone number in another GSM network.
- The users of GSM use **Subscriber Identity Module** (SIM) cards for the connection with the service provider. SIM cards are small in size, with removable memories and hold a lot of data and number of identification which are required to access any wireless service provider

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2.2 CDMA

- CDMA stands for **Code Division Multiple Access** has developed by QUALCOMM, Inc. and standardized by telecommunication industry association (TIA) as an Interim standard (IS-95). This system supports a variable number of users in 1.25 MHz wide channels using direct sequence spread spectrum.
- CDMA is the form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth. This technology is used in ultra-high-frequency (UHF) cellular telephone system in the 800MHz and 1.9 GHz bands.
- CDMA employs analog to digital conversion (ADC) in combination with spread spectrum technology. Audio input is the first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code, so it follows exactly along with the transmitter frequency. There are trillions of possible frequency sequencing codes, which enhance privacy makes cloning difficult. Thus multiple calls can then be overlaid on the top of one another across the entire channel.
- CDMA networks use a scheme called soft hand off, which minimize signal breakup as a handset passes from one cell to another. CDMA also allows for nationwide roaming.
- The original CDMA standard, also known as CDMA one and still common in cellular telephones in the US offers a transmission speed of only up to 14.4 kbps in its single channel form and up to 115 kbps in an eight channel form. CDMA 2000 and wideband CDMA deliver data many times faster.
- CDMA allows greater frequency reuse, as well as increasing battery life, improving the rate of dropped calls and offering far greater security than GSM/TDMA. For this reason CDMA has strong support from experts who favor wide spread development of CDMA networks across the globe. Currently CDMA mostly used in the United States, Canada and North and South Korea.
- CDMA does not use SIM card, rather gives a specific serial number to the handsets.

CDMA Coding:-
Encoding:
Station A: Bit (-1) × code (+1, -1, -1, +1) = (-1, +1, +1, -1)
Station B: Bit (+1) × code (+1, -1, +1, -1) = (+1, -1, +1, -1)
Combined data: (-1, +1, +1, -1) + (+1, -1, +1, -1) = (0, 0, 2, -2) multiplexed CDMA
Decoding for station A:
Combined data (0, 0, 2, -2) × code of station A (+1, -1, -1, +1) = (0, 0, -2, -2)
Then add all bits (-4) ÷ no. of code bits (4) = (-1) station A

3. Advantages in GSM

- There are numerous handset and service providers available in the market. Hence the buyers can choose from a variety of options.
- They come with a variety of plans with cheaper call rates, free messaging facility, limited free calls and so on.
- The quality of calling in GSM is better and also better secured than CDMA.
- A number of value-added services such as GPRS (General Packet Radio Service) are making GSM a perfect choice.
- The consumption of power is less in GSM mobiles.
- With the tri band GSM, one can use the phone anywhere around the world.
- The SIM card or subscriber recognize unit card which transmits subscriber and exchange info, secures purchaser info.
- SIM cards also permit consumers to handover their subscription info and telephone book info from one receiver to add at any period.
- Clienteles are capable to roam globally without altering their device or their facility plans.
- Less signal distortion inside the building.

3.1 Disadvantages in GSM

- The per unit charge on roaming calls is higher in GSM than in CDMA.

- Calls made through GSM mobiles can be tampered.
- If the SIM gets lost, one can lose all the data, if the same is not saved in the phone.
- GSM has fixed max call site range of 120 km, which is imposed by technical limitations. This is expanded from the old limit of 35 km.
- Many of technology are patented and should be license from QUALCOMM.
- Signal can be detected easily in GSM as compared to CDMA.

4. Advantages in CDMA

- One of the greatest things about CDMA is that the cost of calls is cheaper than in GSM.
- The phone calls are more secured because of the spread spectrum.
- Multipath fading may be substantially reduced because of large signal bandwidth.
- No absolute limit on the number of users, easy addition of more users.
- Impossible for hackers to decipher the code sent.
- CDMA networks use a scheme called soft handoff, which minimize signal breakup as a handset pass from one cell to other.
- Many users of CDMA used the same frequency, TDD or FDD may be used.
- Efficient practical utilization of fixed frequency spectrum.
- Channel data rates are very high in CDMA system.
- CDMA is compatible with other cellular technologies, this allows for nationwide roaming.
- IS-95's variable rate voice coders reduce the rate being transmitted when speaker is not talking, which allow the channel to be packed more efficiently.

4.1 Disadvantages in CDMA

- Self Jamming is the problem in CDMA system. Self Jamming arise from the fact that the spreading sequences of different users are not exactly orthogonal.
- The near far problem occurs at a CDMA receiver if an undesired user has a high detected power as compared to the desired user.
- As the number of users increases, the overall quality of service decreases.
- There is no availability of variety of handset in CDMA as in case of GSM for customers.
- The CDMA services have not yet got the facility for the web based services like messenger, downloading ringtones etc from websites.
- CDMA cover the smaller portion of the world, and IS-95 phones are generally unable to roam internationally.

5. Architecture

5.1 Architecture of GSM[3]

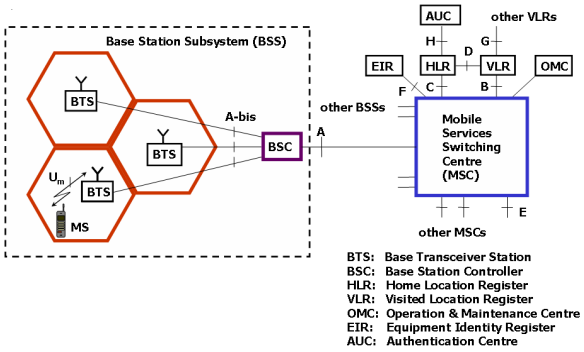


Fig.1 Base Transceiver Station:- (BTS)

The BTS handles the radio interface to the mobile station. The BTS is the radio equipment needed to service each cell in the network. A group of BTSs are controlled by a single BSC.

- Base Station Controllers:- (BSC)

The BSC provides all the control functions and physical links between the MSC and BTS. It is a high capacity switch that provides functions such as handover, cell configuration data and control of radio frequency (RF) power levels in base transceiver stations. A number of BSCs are served by a MSC.

- Network and Switching Subsystem:- (NSS)

NSS performs main switching functions of GSM. The switching system (SS) is responsible for performing call processing and subscriber-related functions. The switching system includes many functional units.

- Mobile Service Switching Center :- (MSC)

Within NSS, MSC performs the necessary switching functions required for the MSs located in an MSC area & to carry out handover functions. The MSC is also involved in the internetworking function to communicate with other networks such as PSTN and ISDN.

- Home Location Register:-(HLR)

A data base used for storage and management of subscriptions. The HLR is considered the most important database, as it stores permanent data about subscribers, including a subscriber's service profile, location information, and activity status. Any administrative action

by the service provider on subscriber data is also performed in the HLR.

- Visitor Location Register:- (VLR)
  The VLR is connected to one or more MSCs. The VLR is the functional unit that dynamically stores subscriber information when it is located in the area covered by VLR. When a roaming MS enters an MSC area, the MSC informs the associated VLR about the MS.

- Operation & Maintenance Subsystem:- (OMSS)
  The OMSS is responsible for handling system security based on validation of identities of various telecommunication entities. These functions are performed in **Authentication Center (AUC) & Equipment Identity Register (EIR).** One OMC can serve several MSCs.

5.2 Architecture of CDMA [4]

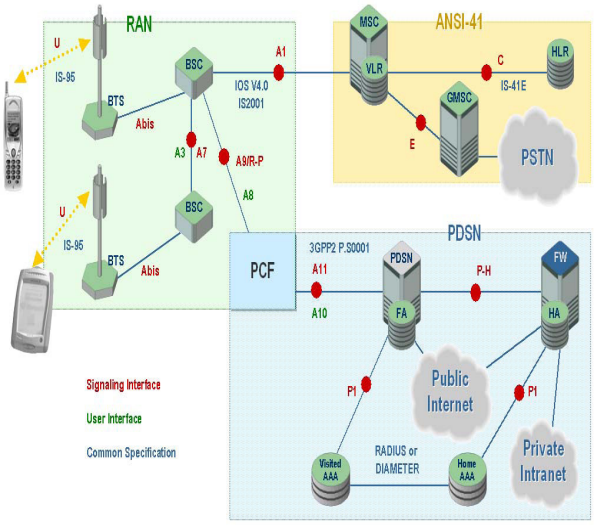


Fig.2 - Achitecture

- **Mobile Station:-**
  The mobile station interacts with the access network to obtain appropriate radio resources for the exchange of packets, and it keeps track of the status of radio resources (e.g. active, stand-by, dormant). It accepts buffer packets from the mobile host when radio resources are not in place or are insufficient to support the flow to the network. Upon power-up, the mobile station automatically registers with the Home Location Register (HLR) in order to:
  - Authenticate the mobile for the environment of the accessed network
  - Provide the HLR with the mobile's current location
  - Provide the serving mobile switching center with the mobile's permitted feature set.

  After successfully registering with the HLR, the mobile is ready to place voice and data calls. These may take either of two forms, circuit switched data (CSD) or packet switched data (PSD), depending on the mobile's own compliance (or lack thereof) with the IS-2000 standard. This document defines protocols for several critical CDMA interfaces pertaining to packet transmission, namely A1, A7, A9 and A11.

- **Radio Access Network:- (RAN)** The RAN has a number of responsibilities that impact the network's delivery of packet services in particular. The RAN must map the mobile client identifier reference to a unique link layer identifier used to communicate with the PDSN, validate the mobile station for access service and maintain the established transmission links.

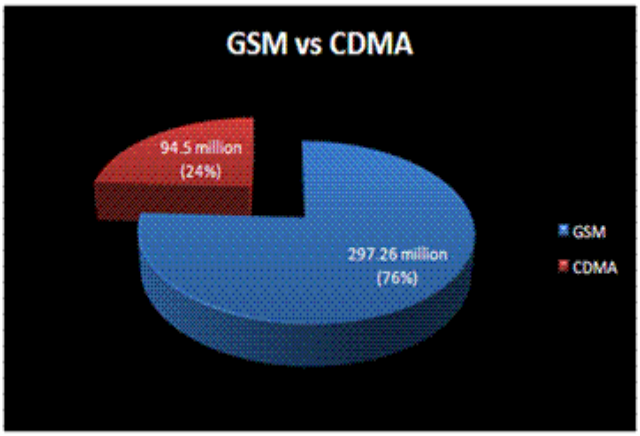
- The **Base Station Transceiver Subsystem** (BTS) controls the activities of the air link and acts as the interface between the network and the mobile. RF resources such as frequency assignments, sector separation and transmit power control are managed at the BTS. In addition the BTS manages the back-haul from the cell site to the Base Station Controller (BSC) to minimize any delays between these two elements. Normally a BTS connects to the BSC through un-channelized T1 facilities or direct cables in co-located equipment. The protocols used within this facility are proprietary and are based on High-level Data Link Control (HDLC).

- The **Base Station Controller** (BSC) routes voice and circuit- switched data messages between the cell sites and the MSC. It also bears responsibility for mobility management, it controls and direct handoffs from one cell site to another as needed. It connects to each MTX using channelized T1 lines for voice and circuit switched data; and to un-channelized T1 lines for signaling and control messages to the PDSN using the 10Base T Ethernet protocol.

- The **Packet Control Function** (PCF) routes IP packet data between the mobile station within the cell sites and the Packet Data Serving Node (PSDN). During packet data sessions, it will assign available supplemental channels as needed to comply with the services requested by the mobile and paid for by the subscribers.
  The PCF maintains a "reachable" state for between the RAN and the mobile station, ensuring a consistent link for the packets; buffers packets arriving from the PDSN when radio resources are not in place or insufficient to support the flow from the PDSN; and relays packets between the MS and the PDSN.

Packet Data Serving Node / Foreign Agent (PSDN/FA)
The PDSN/FA is the gateway from the RAN into the public and/or private packet networks. In a simple IP network, the PSDN acts as a standalone Network Access Server (NAS), while in a mobile IP network it can be configured as a Home Agent (HA) or a Foreign Agent (FA).
The PSDN does the following activities:

- Manage the radio packet interface between the BSS (Base Station Subsystem= BTS+BSC) and the IP network by establishing, maintaining and terminating link layer to the mobile client.
- Terminate the PPP session initiated by the subscriber.
- Provide an IP address for the subscriber (either from an internal pool or through a DHCP server or through an AAA server)
- Perform packet routing to external packet data networks or packet routing to the HA which optionally can be via secure tunnels.



- Collect and forward packet billing data.
- Actively manage subscriber services based on the profile information received from the SCS server of the AAA server.

- Authenticate users locally or forward authentication requests to the AAA server.

- **AAA Server:-**
  The AAA (Authentication, Authorization and Accounting) server is used to authenticate and authorize users for network access and to store subscriber usage statistics for billing and invoicing.

- **Home Agent:-**
  The Home Agent (HA) supports seamless data roaming into other networks that support 1×RTT. The HA provides an anchor IP address for the mobile and forwards any mobile-bound traffic to the appropriate network for delivery to the handset. It also maintains user registration, redirects packets to the PSDN and (optionally) tunnels securely to the PSDN. Lastly, the HA supports dynamic assignment of users from the AAA and (again optionally) assigns dynamic home addresses.

6. Main Points of Contention Between GSM and CDMA is as Below:

- **Technology:-**
  The CDMA is based on spread spectrum technology which makes the optimal use of bandwidth. It allows each user to transmit over the entire frequency spectrum at all time.
  On the other hand GSM operates on the wedge spectrum called a carrier. This carrier is divided into the number of time slots and each user assigned a different time slot so that until the ongoing calls is finished, no other subscriber can have access to this[8].

Fig. 3

- **Global Reach:-**
  GSM is in use over 80% of the world's mobile network in over 210 countries as compared to CDMA [8]. CDMA is almost exclusively used in United States and some part of Canada and Japan. As the European Union permission GSM use, so CDMA is not supported in Europe. In North America, especially in rural areas, more coverage is offered by CDMA as compared to GSM.

  In India Vodafone, Hutch and BSNL are on GSM whereas Reliance and Tata Telecom are on CDMA networks.

- **Data Transfer Speed:-**
  CDMA has faster data rate as compared to GSM as EVDO (CDMA 2000) data transfer technology is used in CDMA which offers a maximum download speed of 2 mbps. EVDO ready mobile phones are required to use this technology.GSM uses EDGE (Enhanced Data Rates for GSM Evolution), data transfer technology that has a maximum download speed of 384 kbps which is slower as compared to CDMA. For browsing the web, to watch videos and to download music CDMA is better choice as compared to GSM. So CDMA is known to cover more area with fewer towers.

- **Security:-**
  More security is provided in CDMA technology as compared with GSM technology as encryption is inbuilt in CDMA. A unique code is provided to every user and all the conversation between two users is encoding ensuring a greater level of security for CDMA users. The signal cannot be detected easily in CDMA as compared to the signals of GSM, which are concentrated in the narrowband width. Therefore the CDMA phone calls are more secure than the GSM calls. In term of encryption the GSM technology has to be upgraded so as to make it operate more securely.

- **Subscriber Identity Module (SIM) Cards:-**
  In most of the countries only GSM phones use SIM cards. SIM card, the on board memory device that identifies a user and store all of his information on the hand held. You can swap GSM SIM cards between handsets when a new one is necessary, which enables you to carry all of your contact and calendar information over to a new handset with no hassle.
  CDMA operators answer this flexibility with their own service that stores user data, including phone book and scheduler information, on the operator's data base. This service makes it possible to not only swap over to a new handset with little trouble, but it also gives users the ability to recover contact data even if their phone is lost or stolen.

- **Roaming:-**
  For the most part, both networks have fairly concentrated coverage in major cities and along major highways. GSM carries, however, have roaming contracts with other GSM carries, allowing wider coverage of more rural areas, generally speaking, often without roaming charges to the customer. CDMA network may not cover rural areas as well as GSM carries, and though they may contract with GSM cells for roaming in more rural areas, the charge to the customer will generally be significantly higher [4].

- **International Roaming:-**
  Where international business travel is an issue, GSM leaps forward in the race for the title of "Most Accessible". Because GSM is used in more than 74% of the market as the globe, user of tri band or quad band handsets can travel to Europe, India and most of Asia and still use their cell phones. CDMA offers no multiband capability, however and therefore you cannot readily use it in multiple countries[6].

- **Handover:-**
  As mobile subscriber move about a network, their calls are "handed over" from one cell to the next. In GSM all handover are considered to be "hard handover". As a user approaches a new cell and its signal becomes stronger than the current cell, handling of call is switched from the old cell to new cell. The like hood of a dropped call increases at the moment control is being transferred to the new cell.

  In CDMA, frame erasure rates which are analogous to bit error rates, are used to determine when handover should occur. Throughout the duration of a call the mobile subscriber compares the frames of signals from multiple cells/sectors and triggers handoff to those with the lowest frame erasure rates.

CDMA uses "soft handovers" which use the resources of up to three base stations to continue facilitation of calls. Additionally, transfer of control between two sectors of the same cell is accomplished with "softer handovers". The soft and softer handover minimize the risk of a dropped call while control is being transferred. CDMA also use hard handover, generally for handover between carriers of different frequencies and carriers of different technology[7].

- **Power Control:-**

Power control in GSM is managed by the BSS (Base Station Sub-system) which regulates the signal strength generated from the base station. The BSS also provides each subscriber unit with commands that regulate the signal strength generated by each subscriber unit. Power control level are determined by balancing the current power and quality measurements at the BTS (Base transceiver station) and mobile station with the objective of minimizing power without degrading call quality. CDMA is concerned with managing RF power to maximize capacity. The technology works most effectively when all mobile signals reach the base station with the same overall signal strength. The power level should also be as low as possible, while still maintaining a high quality call. The closer all the mobiles are to their ideal power levels, the less interference will be present on the CDMA channel. The less interference the higher capacity. Power control in CDMA is implemented by the cell site continually measuring the received signals from the mobile, comparing it to the desired level, and instructing the mobile to increase/reduce transmit power up to 800 times per second (up to 84 increments of 1 dB each). This high power adjustment ensures that no matter how close a far a mobile is from the cell site (even when fading occurs), each mobile will be received by the cell site at the same power level (minimizing interference and maximizing capacity)[7].

- **Interference Management:-**

Multipath fading or interference is a phenomena in which a generated signal is disrupted (scattered off mountains, building, vehicles etc) such as to arrive as multiple occurrences of the original signal, at slightly different times. GSM as well as other TDMA and analog base systems are susceptible to multipath fading. These reflected signals, combined with the transmitted signal, create a moving pattern of signal peaks and nulls. When a narrowband receiver moves through these nulls, there is a sudden drop in signal strength. This fading will cause lower, noisier speech quality or, if the fading is serve enough, the loss of signal and a dropped call. CDMA is not negatively

impacted by multipath fading; rather it is designed to take advantage of it. CDMA utilizes a rake receiver with individual "fingers" to separately from the different paths are all time shifted with respect to each other, due to differences in distance each signal must travel, each signal must be time shifted at the receiver to align the signals. Once the time shifting has taken place, the signals can be combined to result in a stronger signal than any that was individually received at the antenna [7].

- **Voice Activity Detection (VAD):-**

The human voice activity cycle is 35%. When users assigned to a cell are not talking, VAD will allow all other users to benefit due to reduced mutual interference. Thus interference is reduced by a factor of 65%. CDMA is the only technology that takes advantage of this phenomenon. It can be shown that that the capacity of CDMA is increased by about 3 times due to VAD.

GSM does not take advantages of this phenomenon. Thus GSM has lower capacity than CDMA[7].

- **Radiation Exposure:-**

Various studies indicate that the emissions from a cell phone can be extremely harmful, causing genetic damage, tumors, memory loss, increased blood pressure and weakening of the immune system. The fact that this radiation is invisible, intangible and enters and leaves our bodies without our knowledge makes it even more intimidating [10].

GSM phones emit continuous wave pulses, so there is a large need to reduce the exposure toelectromagnetic field focused on cell phones with "continuous wave pulse". On the other hand CDMA cell phones do not produce these pulses. GSM phones emit about 28 times more radiation on average as compared to CDMA phones. Moreover, GSM phones are more biologically reactive as compared to CDMA. Although dozens of international studies have been conducted over the past decade, some of which point to higher incidences of certain types of brain cancers in people who use cell phones heavily, the negative side effects of cell phone usage remain undetermined. Researchers compared brain scans of people talking on GSM phones and CDMA phones and found that the former stimulated much more brain activity than the later. Although it's still unclear what that extra brain activity is, how it's caused or whether it's bad, other studies have also shown varying health consequences of using GSM versus CDMA phones. Of 37 studies that have examined GSM phones, 43% have found harmful biological effects from the phones- such as a decrease in the expression of genes that help suppress tumors- Moskowitz said, while only 15% of the 33 studies that looked at CDMA phones have identified harmful effects. The FDA (Food and Drug Administration) states: "Although evidence shows little or no risk of brain tumors for most long- term users of cell phones people who want to reduce their RF exposure can reduce the amount of time spent on the cell phone, and use speaker mode or a headset to place more distance between the head and the cell phone" [9].

7. Conclusion

To conclude, the present day fluctuating business environment is generating intense competition among the corporations. The markets are fluctuating more rapidly presently than that in any other time. New and new products are being entering into the market within short span of time and old ones are equally outdated this throws the business community to global cutthroat competition. The employees are necessitated to spend more time with their customers so as make their organizations more competitive.

CDMA is best in terms of **large capacity, less interference** because of **unique coding technique, more secure**, minimize the risk of dropped call when a mobile subscriber move from one cell to the next because of **soft handoff**, data transfer speed is also very high, takes advantage of VAD technology and in terms of radiation CDMA is less harmful for health.

GSM is best in terms of that its **infrastructure is inbuilt**, it is used in **210 countries**, **capable for international roaming** and also for GSM numerous handset and service providers available in market. This necessitates them to be detached from their land phones. The market conditions presently thus necessitate the entrepreneurs to assess the mobile technology as a substitute to the conventional landline telecommunications services to make their corporations more competitive. The modern cellular technology incorporating GSM, CDMA and 3GSM extends the limits of the capabilities that the existing communication infrastructure extends

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