Middle-East Journal of Scientific Research 20 (3): 369-376, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.20.03.11346

GSM Based Analysis of Network Using Mobile Communications

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Abstract: Indian mobile industry has witnessed a dramatic growth. Cheap mobile handsets, affordable airtime rates, low initial cost and affordable monthly rentals made it easy for anybody to go mobile. As per latest statistics India has around 160 million mobile subscribers. In India where the youth constitute majority of the population a war between the service providers is on to capture this market. Students contribute 50% of youth population. The objective of this study is to find the opinion of the student who is already using any of the service provider and the satisfaction level of the service provided. Air Tel, Vodafone, Idea, Cell one are the four companies which are included in study. *Primary source:* A well structured questionnaire is prepared to know the respondents opinion about the service of their service provider. *Secondary Source:* Different web sites, company reports, research company's reports (McKinsey, PWC, etc...). The sample size taken for study is 200. Though the figures show Air Tel has major share in market, study has shown that among student community to which the study is conducted Vodafone has larger share than Air Tel. Reasons like Packages offered by Vodafone are attracting students, which makes it a have a larger share. Services and network of Air Tel is good compare to the other players in the market but it is VODAFONE which offers better packages.

Key words: GSM · Primary Source · Secondary Source

INTRODUCTION

In last decade Indian mobile phone industry has witnessed a dramatic growth. Cheap mobile handsets, affordable airtime rates, low initial cost and affordable monthly rentals made it easy for anybody to go mobile. As per latest statistics India has around 160 million mobile subscribers. If the service providers capture another 10 to 15 % share in untouched market it is huge business for the major service providers in the market.In the Indian population we have 60% youth in that major part is the student community. Now a day 3 out of 5 students are using mobile phones most of the students are going for the mobile phones to stay connected with their parents and friends. The service providers are introducing different packages and they are giving different offers to capture the student community [1]. The subscribers will opt to one service provider if they are satisfied with the service offered is meeting their expectations. In that the network of the service provider will play a vital role. The students are opting for a service provider if they are getting good packages, latest technology and uninterrupted network. NEED FOR STUDY: The mobile industry in India continues to grow at a rapid place. India has about 159.7 million GSM-based mobile subscribers at the end of December 2007, according to figures released by the Cellular Operators Association of India (COAI). The subscriber base represents a significant increase on the 95.7 million GSM customers reported at the same time last year and shows healthy monthly growth. BhartiAirtel consolidated its position as India's largest GSM operator in October, adding over 2 million customers to break the 60 million mark. Numbertwo GSM operator Vodafone Essar, which adopted the Vodafone brand in September, added over 1.5 million customers in October to take its total base to around 40 million.IDEA Cellular has licenses to operate in 11 circles With a customer base of over 17 million.BSNL is the next largest player in the Indian market with 12.74 million customers [2].

Objectives: To compare efficiency and quality of the service providers. To measure the market share of major service providers among student community.

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Methodology of Study: Data is collected from the primary and secondary sources.Primary Source: A well structured questionnaire is prepared to know the respondents opinion.

Secondary Source: Different web sites, company reports, research companies reports (McKinsey, PWC, etc...).

Sample Selection: A sample is known as the subunit of population which shares the similar features. The number of units in the sample is known as the sample size. In this study a sample size of 200. Here, in this context a sample refers to the subscribers of the major GSM service providers in and around Hyderabad covered by the study. After the selection of sample, the sampling was done based on the convenient sampling method [3].

Analysis: The collected data has been coded and represented diagrammatically in the form of bar diagrams by calculating the respondents and percentage. Based on this suitable interpretations were made.

Based on the responses obtained and gathered data suitable recommendations were given which can help the service providers in retaining their subscribers.

Limitations: The responses may vary from one subscriber to another. The responses given may be biased and depend upon the age and experience.

Data collected cannot be asserted to be free from errors, as the sample size is small.

In spite of taking all the necessary measures there is a chance in occurrence of minor errors due to the lack of experience on the part of researcher.

Marketing Research: Marketing research is defined as the "Systematic design, collection, analysis and reporting of data and findings relevant to a specific marketing situation facing the company. Marketing Research is now about a US$16.5 billion industry globally, according to ESOMAR, the World Association of Opinion and Market Research Professionals. A company can hire the services of a marketing research firm or conduct research in creative and affordable ways such as:

- Engaging professors or students to design and conduct studies. Many large companies hire summer trainees from management institutions for cost-effective market research year after year. Awarding live projects to MBA students as part of their course work is also a common practice [4].
- Monitoring published information and actions systematically. This may be done by examining news papers, web sites and industry reports and by visiting competitive outlets [5].

Effective marketing research involves six steps. They are:

Step 1: Define the problem and the research objectives.

Step 2: Develop the research plan.

Step 3: Collect the Information.

Step 4: Analyze the Information.

Step 5: Present the Findings.

Step 6: Make the Decision.

Mobile Industry in India: India's 21.59 million-line telephone network is the largest in Asia, 3rd largest among emerging economies (after China and Republic of Korea) and the 12th largest in the world. India's telecom network comprises of 27,753 telephone exchanges, with a total equipped capacity of 272.17 Lakh lines and 226.3 Lakh working telephones. The Long Distance Transmission Network has nearly 1,70,000 route kilometers of terrestrial Microwave Radio Relay and Co-axial cables and about 171,000 route kilometers of Optical Fiber Cables. Fully automatic International Subscriber Dialing (ISD) service is available to almost all the countries. The total number of stations connected to National Subscriber Dialing (NSD) is over 18,000 and this is increasing fast. Yet the present tele-density is very low at about 2.2 per hundred persons, offering a vast scope for growth. In the field of International communications, tremendous progress was made by the use of Satellite Communication and submarine links. It is therefore not surprising that India has one of the fastest growing telecommunication systems in the world with system size (total connections) growing at an average of more than 20 percent over the last 4 years.

The voice and non-voice telecom services include data transmission, facsimile, mobile radio, radio paging, V-SAT and leased line services to cater to variety of needs, both residential and business. A dedicated Packet Switched Public Data Network (I-NET) with international access for computer communication services is also available. ISDN service has already been introduced in the major cities. Other services like Intelligent Network (IN),

Frame Relay (FR) and Asynchronous Transfer Mode (ATM) for wide band multimedia applications will be introduced in the nearfuture [6].

In the field of international communications, India's overseas service carrier Videsh Sanchar Nigam Ltd. (VSNL) has made tremendous progress by using extensive infrastructure of satellite earth stations, state-of-the-art digital gateways, Optical Fiber Multi Media submarine Cables and Multi Media Data Switches. Fully automatic international subscriber dialing (ISD) service is provided to almost all the countries in the world. In future, VSNL is positioning itself to provide bandwidth on demand, Global Virtual Private Networks, ISDN, B-ISDN, VSATs, Mini-M and hand held Personal Communications.

The telecommunications initiative in the country is led by Ministry of Communications through the Department of Telecommunication and Department Telecom Services and its undertakings for provision of basic telephone services, national and international long distance communications, manufacture of complete range of telecom equipment, research and development and consultancy services [7]. The Telecom Commission performs the Executive and Policy making functions. The Telecom Regulatory Authority of India performs the functions of an independent regulatory body.

Services Offered:

- Telephone Services
- NSD/ISD Services
- Computerized Trunk Services
- Pay Phones
- National and International Leased Lines Circuits
- Telex
- Telegraph Services (Manual and Automatic)
- X-25 based Packet Switched Data Network (INET)
- Gateway Packet Switched Data Services (GPSS)
- Gateway Electronic Data Interchange Service (GEDIS)
- Gateway E-Mail and Store and Forward FAX Service (GEMS-400)
- Concert Packet Service (CPS)
- Satellite-based Remote Area Business Message Network
- Electronic Mail
- Voice Mail
- Audio-Text
- Radio Paging
- Cellular Mobile Telephone
- Public Mobile Radio Trunked Service
- Video-Tex
- Video Conferencing
- V-SAT
- Internet
- ISDN
- INMARSAT Mobile Service
- INMARSAT Data Service
- Home Country Direct Service
- Intelligent Network (IN) Services Cellular and Paging Services

Cellular and paging services though not a very old means of communication in India has very rapidly caught the imagination of the people [8]. The revolution that started with pagers soon gave way to Mobile phones. Pagers being one way and with limited application have almost disappeared, as mobiles became the favorite. With more and more innovative offers like prepaid cards from telecom service operators, the mobile culture is growing. With more players entering the market, the competition has grown stronger, catering to the demands of consumers. VODAFONE, Airtel, Idea and Reliance are doing very well and are always coming up with new schemes and plans. SMS is a raging favorite among both the young and the old. A shift towards mobile telephony is apparent from the fact that the share of cellular connections in new connections is Steadily going up and had reached 63% in December 2002.

Cell phones now come cheaper and so does the monthly bill. As a result one can still hear some grudges from service providers as they claim lack of use of enough airtime to make it a profitable business.

Today, India has 22 private companies providing cellular services in 18 telecom circles and 4 metro cities (Delhi, Mumbai, Chennai and Calcutta). Ever since their introduction, cellular services have shown a fair growth with the subscriber base crossing the 1 million mark by the first quarter of 1999 [10-12]. India has adopted the Global System of Mobile Communication (GSM) for provision of cellular services. The cellular services in India operate in the frequency band 890-902.5 MHz / 935-947.5 MHz. In metro cities, each operator has been allocated a frequency spectrum of 6.2+6.2 MHz (except Chennai where 5.8+5.8 MHz spectrum has been allocated), while for other telecom circles a spectrum of 4.4 +4.4 MHz has been allocated.

Cellular Mobile Telephone Service Providers:

- Bharti Cellular Ltd
- Sterling Cellular Ltd
- BPL Mobile Communications Ltd
- VODAFONEison Max Telecom Ltd

- Modi Telstra Pvt. Ltd
- Usha Martin Telekom Ltd
- RPG Cellular Seravices Ltd
- Skycell Communications Pvt. Ltd
- Airtel Digilink India Ltd
- Fascel Ltd
- Hexacom India Ltd
- JT Mobiles Ltd
- Koshika Telecom Pvt. Ltd
- Tata Communications Pvt. Ltd
- Escotel Mobile Comm. Pvt. Ltd
- Bharti Telenet Ltd
- RPG Cellcom Ltd
- Modicom Network Pvt. Ltd
- Birla AT and T Comm. Ltd
- Reliance Telecom Ltd
- BPL Cellular Ltd
- Srinivas Cellcom Ltd

Letters and Telegrams: Letters have been written from ages and the Indian Postal service is one of the biggest and most experienced services. About 90% of the postal outlets are in rural India. On an average a post office covers an area of about 21 sq. km and a population of about 6,600 people. The Indian postal system currently provides 38 services which can be categorized as Communication: letters, postcards, newspapers Transportation: parcels, money orders etc.

Other services: resource mobilization, postal life insurance.

For providing postal services, the whole country has been divided into twenty-two postal circles. Each Circle is coterminous with a State except for some. Besides these twenty-two circles, there is another circle, called Base Circle, to cater to the postal communication needs of the ArmedForces.

Telecommunication infrastructure was established in India 1856. They were telegraphic data communication links principally for government and military use. Telegrams being the fastest means of communication in areas where phone lines did not reach, led to its use by the common man. Even now phone lines do not connect many interior regions of India and the telegram is used to fill in the gap. However it is a fast disappearing means of communication, as connectivity in India both in terms of telephone lines and wireless communication has rapidly grow.

Courier Services: Time was when one had to wait for weeks together to see the other person receive important document. The common man had no access to fax machines nor was he aware of its utility. Then came along the speed post, which too took about a week to deliver. The start of private courier services however changed all that. Documents could now reach within the day or by the next day. Moreover they are more reliable as chances of misplacement are minimal. Today businesses as well as individuals are increasingly dependent on the courier service.

Internet: Once the Internet market space was opened up to private Internet Service Providers (ISPs) in 1998, the market has witnessed phenomenal growth. In certain states there has been a high percentage in penetration, but in others it has been slow due to low telecom penetration, low bandwidth and above all illiteracy. All tourist spots however are more or less connected to the net. Cyber cafes are as common a sight as telephone booths and connectivity in India has arrived for the common man. One need no longer invest in a computer, which is still a costly commodity. Though email and Internet browsing remain the favorite purposes e-commerce and e-business have put their foot in. Banks have now facilitated Internet banking. The Indian Railways offers a computerized reservation system which enables a person to book his tickets online and from anywhere. It also provides other services like railway timetables and ticket availability. Airlines bookings, Movie ticket bookings, hospital appointments and even consultations are widely available. Connectivity is fast spreading in all areas and the Internet is becoming more and more user friendly. Facilities in connectivity are easily available even though not a very high percentage of Indians use these facilities.

The good news is that with improvements in bandwidth and penetration of Internet through PCs as well as cable TV, the Internet user base in India will expand by leaps and bounds. The cable route in fact is being touted as a significant pathway for the proliferation of the Internet in India. India already boasts of 37 million cable connections (expected to jump to 100 million by 2008), which could additionally be converted into Internet connections. Thanks to the wireless application protocol (WAP), Internet is coming to India through mobile phones as well. Voice over IP, a dream so far for India, too is expected to be reality in the future.

History of GSM: During the early 1980s, analog cellular telephone systems were experiencing rapid growth in Europe, particularly in Scandinavia and the United Kingdom, but also in France and Germany. Each country developed its own system, which was incompatible with

everyone else's in equipment and operation. This was an undesirable situation, because not only was the mobile equipment limited to operation within national boundaries, which in a unified Europe were increasingly unimportant, but there was also a very limited market for each type of equipment, so economies of scale and the subsequent savings could not be realized.

The Europeans realized this early on and in 1982 the Conference of European Posts and Telegraphs (CEPT) formed a study group called the Groupe Special Mobile (GSM) to study and develop a pan-European public land mobile system. The proposed system had to meet certain

Criteria: Good subjective speech quality
Low terminal and service cost
Support for international roaming
Ability to support handheld terminals
Support for range of new services and facilities
Spectral efficiency
ISDN compatibility

In 1989, GSM responsibility was transferred to the European Telecommunication Standards Institute (ETSI) and phase I of the GSM specifications were published in 1990. Commercial service was started in mid-1991 and by 1993 there were 36 GSM networks in 22 countries. Although standardized in Europe, GSM is not only a European standard. Over 200 GSM networks (including DCS1800 and PCS1900) are operational in 110 countries around the world. In the beginning of 1994, there were 1.3 million subscribers worldwide, which had grown to more than 55 million by October 1997. With North America making a delayed entry into the GSM field with a derivative of GSM called PCS1900, GSM systems exist on every continent and the acronym GSM now aptly stands for Global System for Mobile communications. The developers of GSM chose an unproven (at the time) digital system, as opposed to the then-standard analog cellular systems like AMPS in the United States and TACS in the United Kingdom. They had faith that advancements in compression algorithms and digital signal processors would allow the fulfillment of the original criteria and the continual improvement of the system in terms of quality and cost. The over 8000 pages of GSM recommendations try to allow flexibility and competitive innovation among suppliers, but provide enough standardization to guarantee proper interworking between the components of the system. This is done by providing functional and interface descriptions for each of the functional entities defined in the system.

Radio Interface: GSM is a cellular network, which means that mobile phones connect to it by searching for cells in the immediate vicinity. GSM networks operate in four different frequency ranges. Most GSM networks operate in the 900 MHz or 1800 MHz bands. Some countries in the Americas (including the United States and Canada) use the 850 MHz and 1900 MHz bands because the 900 and 1800 MHz frequency bands were already allocated.The rarer 400 and 450 MHz frequency bands are assigned in some countries, notably Scandinavia, where these frequencies were previously used for first-generation systems.

In the 900 MHz band the uplink frequency band is 890-915 MHz and the downlink frequency band is 935-960 MHz. This 25 MHz bandwidth is subdivided into 124 carrier frequency channels, each spaced 200 kHz apart. Time division multiplexing is used to allow eight full-rate or sixteen half-rate speech channels per radio frequency channel. There are eight radio timeslots (giving eight burst periods) grouped into what is called a TDMA frame. Half rate channels use alternate frames in the same timeslot. The channel data rate is 270.833 kbit/s and the frame duration is 4.615 ms.The transmission power in the handset is limited to a maximum of 2 watts in GSM850/900 and 1 watt in GSM1800/1900.GSM has used a variety of voice codecs to squeeze 3.1kHz audio into between 6 and 13kbps. Originally, two codecs, named after the types of data channel they were allocated, were used, called "Full Rate" (13kbps) and "Half Rate" (6kbps). These used a system based upon linear predictive coding (LPC). In addition to being efficient with bitrates, these codecs also made it easier to identify more important parts of the audio, allowing the air interface layer to prioritize and better protect these parts of the signal.

GSM was further enhanced in 1997 with the GSM-EFR codec, a 12.2kbps codec that uses a full rate channel. Finally, with the development of UMTS, EFR was refactored into a variable-rate codec called AMR-Narrowband, which is high quality and robust against interference when used on full rate channels and less robust but still relatively high quality when used in good radio conditions on half-rate channels.

There are four different cell sizes in a GSM network - macro, micro, pico and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average roof top level. Micro cells are cells whose antenna height is under average roof top level; they are typically used in urban areas. Picocells are small cells whose diameter is a few dozen meters; they are

mainly used indoors. Umbrella cells are used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells.Cell horizontal radius varies depending on antenna height, antenna gain and propagation conditions from a couple of hundred meters to several tens of kilometers. The longest distance the GSM specification supports in practical use is 35 km or 22 miles. There are also several implementations of the concept of an extended cell, where the cell radius could be double or even more, depending on the antenna system, the type of terrain and the timing advance.Indoor coverage is also supported by GSM and may be achieved by using an indoor picocell base station, or an indoor repeater with distributed indoor antennas fed through power splitters, to deliver the radio signals from an antenna outdoors to the separate indoor distributed antenna system. These are typically deployed when a lot of call capacity is needed indoors, for example in shopping centers or airports. However, this is not a prerequisite, since indoor coverage is also provided by in-building penetration of the radio signals from nearby cells.

The modulation used in GSM is Gaussian minimum shift keying (GMSK), a kind of continuous-phase frequency shift keying. In GMSK, the signal to be modulated onto the carrier is first smoothed with a Gaussian low-pass filter prior to being fed to a frequency modulator, which greatly reduces the interference to neighboring channels (adjacent channel interference).A nearby GSM handset is usually the source of the "dit dit dit, dit dit dit, dit dit dit" signal that can be heard from time to time on home stereo systems, televisions, computers and personal music devices. When these audio devices are in the near field of the GSM handset, the radio signal is strong enough that the solid state amplifiers in the audio chain function as a detector. The clicking noise itself represents the power bursts that carry the TDMA signal. These signals have been known to interfere with other electronic devices, such as car stereos and portable audio players. This is a form of RFI and could be mitigated or eliminated by use of additional shielding and/or bypass capacitors in these audio devices, however, the increased cost of doing so is difficult for a designer to justify.

Subscriber Identity Module: One of the key features of GSM is the Subscriber Identity Module (SIM), commonly known as a SIM card. The SIM is a detachable smart card containing the user's subscription information and phonebook. This allows the user to retain his or her information after switching handsets. Alternatively, the user can also change operators while retaining the handset simply by changing the SIM. Some operators will block this by allowing the phone to use only a single SIM, or only a SIM issued by them; this practice is known as SIM locking and is illegal in some countries.In the United States, Canada, Europe and Australia, many operators lock the mobiles they sell. This is done because the price of the mobile phone is typically subsidised with revenue from subscriptions and operators want to try to avoid subsidising competitor's mobiles. A subscriber can usually contact the provider to remove the lock for a fee, utilize private services to remove the lock, or make use of ample software and websites available on the Internet to unlock the handset themselves. While most web sites offer the unlocking for a fee, some do it for free. The locking applies to the handset, identified by its International Mobile Equipment Identity (IMEI) number, not to the account (which is identified by the SIM card). It is always possible to switch to another (non-locked) handset if such other handset is available.

Some providers will unlock the phone for free if the customer has held an account for a certain period. Third party unlocking services exist that are often quicker and lower cost than that of the operator. In most countries removing the lock is legal. Cingular and T-Mobile provide free unlock services to their customers after 3 months of subscription.

In countries like India, Pakistan, Indonesia, Belgium, etc., all phones are sold unlocked. However, in Belgium, it is unlawful for operators there to offer any form of subsidy on the phone's price. This was also the case in Finland until April 1, 2006, when selling subsidized combinations of handsets and accounts became legal though operators have to unlock phone free of charge after a certain period (at most 24 months).

GSM Security: GSM was designed with a moderate level of security. The system was designed to authenticate the subscriber using shared-secret cryptography. Communications between the subscriber and the base station can be encrypted. The development of UMTS introduces an optional USIM, that uses a longer authentication key to give greater security, as well as mutually authenticating the network and the user - whereas GSM only authenticated the user to the network (and not vice versa). The security model therefore offers confidentiality and authentication, but limited authorization capabilities and no non-repudiation.GSM uses several cryptographic algorithms for security. The A5/1 and A5/2 stream ciphers are used for ensuring over-the-air voice privacy. A5/1 was developed first and is a stronger algorithm used within Europe and the United States; A5/2 is weaker and used in other countries. A

large security advantage of GSM over earlier systems is that the Key, the crypto variable stored on the SIM card that is the key to any GSM ciphering algorithm, is never sent over the air interface. Serious weaknesses have been found in both algorithms and it is possible to break A5/2 in real-time in a ciphertext-only attack. The system supports multiple algorithms so operators may replace that cipher with a stronge.

Services Provided by GSM: From the beginning, the planners of GSM wanted ISDN compatibility in terms of the services offered and the control signalling used. However, radio transmission limitations, in terms of bandwidth and cost, do not allow the standard ISDN B-channel bit rate of 64 kbps to be practically achieved. Using the ITU-T definitions, telecommunication services can be divided into bearer services, teleservices and supplementary services. The most basic teleservice supported by GSM is telephony. As with all other communications, speech is digitally encoded and transmitted through the GSM network as a digital stream. There is also an emergency service, where the nearest emergency-service provider is notified by dialing three digits (similar to 911). A variety of data services is offered. GSM users can send and receive data, at rates up to 9600 bps, to users on POTS (Plain Old Telephone Service), ISDN, Packet Switched Public Data Networks and Circuit Switched Public Data Networks using a variety of access methods and protocols, such as X.25 or X.32. Since GSM is a digital network, a modem is not required between the user and GSM network, although an audio modem is required inside the GSM network to interwork with POTS.

Other data services include Group 3 facsimile, as described in ITU-T recommendation T.30, which is supported by use of an appropriate fax adaptor. A unique feature of GSM, not found in older analog systems, is the Short Message Service (SMS). SMS is a bidirectional service for short alphanumeric (up to 160 bytes) messages. Messages are transported in a store-and-forward fashion. For point-to-point SMS, a message can be sent to another subscriber to the service and an acknowledgement of receipt is provided to the sender. SMS can also be used in a cell-broadcast mode, for sending messages such as traffic updates or news updates. Messages can also be stored in the SIM card for later retrieval Supplementary services are provided on top of teleservices or bearer services. In the current (Phase I) specifications, they include several forms of call forward (such as call forwarding when the mobile subscriber is unreachable by the network) and call barring of outgoing or incoming calls, for example when roaming in another country. Many additional supplementary services will be provided in the Phase 2 specifications, such as caller identification, call waiting, multi-party conversations.

GSM Subscriber Services: There are two basic types of services offered through GSM: telephony (also referred to as teleservices) and data (also referred to as bearer services). Telephony services are mainly voice services that provide subscribers with the complete capability (including necessary terminal equipment) to communicate with other subscribers. Data services provide the capacity necessary to transmit appropriate data signals between two access points creating an interface to the network. In addition to normal telephony and emergency calling, the following subscriber services are supported by GSM:

Dual-tone multifrequency (DTMF)- DTMF is a tone signaling scheme often used for various control purposes via the telephone network, such as remote control of an answering machine. GSM supports full-originating DTMF. Facsimile group III—GSM supports CCITT Group 3 facsimile. As standard fax machines are designed to be connected to a telephone using analog signals, a special fax converter connected to the exchange is used in the GSM system. This enables a GSM–connected fax to communicate with any analog fax in the network.

Short message services—A convenient facility of the GSM network is the short message service. A message consisting of a maximum of 160 alphanumeric characters can be sent to or from a mobile station. This service can be viewed as an advanced form of alphanumeric paging with a number of advantages. If the subscriber's mobile unit is powered off or has left the coverage area, the message is stored and offered back to the subscriber when the mobile is powered on or has reentered the coverage area of the network. This function ensures that the message will be received.

Cell broadcast—a variation of the short message service is the cell broadcast facility. A message of a maximum of 93 characters can be broadcast to all mobile subscribers in a certain geographic area. Typical applications include traffic congestion warnings and reports on accidents.

Voice mail—this service is actually an answering machine within the network, which is controlled by the subscriber. Calls can be forwarded to the subscriber's voice-mail box and the subscriber checks for messages via a personal security code.

Fax mail—with this service, the subscriber can receive fax messages at any fax machine. The messages are stored in a service center from which they can be retrieved by the subscriber via a personal security code to the desired fax number.

GSM supports a comprehensive set of supplementary services that can complement and support both telephony and data services. Supplementary services are defined by GSM and are characterized as revenue-generating features. A partial listing of supplementary services follows.

Call forwarding—this service gives the subscriber the ability to forward incoming calls to another number if the called mobile unit is not reachable, if it is busy, if there is no reply, or if call forwarding is allowed unconditionally.

Barring of outgoing calls—this service makes it possible for a mobile subscriber to prevent all outgoing calls.

Barring of incoming calls—this function allows the subscriber to prevent incoming calls. The following two conditions for incoming call barring exists: baring of all incoming calls and barring of incoming calls when roaming outside the home PLMN.

Advice of charge (AoC)—The AoC service provides the mobile subscriber with an estimate of the call charges. There are two types of AoC information: one that provides the subscriber with an estimate of the bill and one that can be used for immediate charging purposes. AoC for data calls is provided on the basis of time measurements.

Call hold—this service enables the subscriber to interrupt an ongoing call and then subsequently reestablish the call. The call hold service is only applicable to normal telephony.

Call waiting—this service enables the mobile subscriber to be notified of an incoming call during a conversation. The subscriber can answer, reject, or ignore the incoming call. Call waiting is applicable to all GSM telecommunications services using a circuit-switched connection.

Multiparty service—the multiparty service enables a mobile subscriber to establish a multiparty conversation—that is, a simultaneous conversation between three and six subscribers. This service is only applicable to normal telephony.

Calling line identification presentation/restriction- These services supply the called party with the integrated services digital network (ISDN) number of the calling party. The restriction service enables the calling party to restrict the presentation. The restriction overrides the presentation.

Closed user groups (CUGs)—CUGs are generally comparable to a PBX. They are a group of subscribers who are capable of only calling themselves and certain numbers

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