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The History of the Development of Cellular Communications

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Abstract: This article discusses the development of mobile telephone communication systems and the appearance, problems and solutions of systems based on the GSM standard. In 1946, the first radiotelephone communication system was launched in the USA in St. Louis, which was associated with specific difficulties for early mobile communication. Over the years, technical developments, solving problems associated with frequency resources and their limitations, were implemented through the "cell" principle proposed by the American company AT&T. Each cell operated within a limited radius and allowed for the reuse of frequencies. In the middle, in the late 1980s, the GSM standard was introduced. This expanded the capabilities of digital communication technologies, new services and interfaces for mobile subscribers, such as roaming, encryption and identification. The GSM system provided integration with telephone networks and the transition from analog standards to digital standards, which caused various difficulties. The article also provides an overview of the components of the GSM system and their functions, including mobile stations (MS), base stations (BSS) and network subsystem (NSS). The mobile switching center (MSC) provides call control and routing functions, the HLR maintains permanent registration information about mobile subscribers, and the VLR manages temporary location information. This article aims to help users, operators and researchers to further improve the quality of service of mobile communication systems, which are characterized by the expansion and improvement of mobile communication services.

Keywords: GSM (Global System for Mobile Communications), Digital communication systems, TDMA (Television Division Multiple Access), GMSK (Gaussian Minimum Shift Keying), Signaling and movement, emergency communication, Automatic roaming, Encryption, Mobile stations (MS), Base station system (BSS), Switching center (MSC), Interfaces and communication lines, Frequency bands, Communication channels, DCS 1800, PCS 1900, Satellite communications, Certification and standardization, Modulation technologies, Voice activity detector (VAD), SIM card and authentication, Noise immunity and signal isolation.

Introduction

The first radiotelephone system to offer cellular services to all users began operating in 1946 in St. Louis, USA. The radiotelephones used in this system used simple fixed channels. If the channel was busy, the subscriber manually reconnected to another free channel. The equipment was very large and inconvenient to use. The central radio node transmitted very powerful high-frequency signals over distances of 100 km. The service was also at a corresponding level. The telephone system provided 11 channels operating on the principle of frequency modulation in a frequency band width of 40 MHz. Then two improved systems (IMTS-MJ and –MK) appeared, occupying 11 and 12 channels in the frequency bands width of 152 and 454 MHz, respectively. The technology and use of frequency modulation were improved, and the radio channels became narrower. The earliest mobile phones required a frequency spectrum of 120 kHz to transmit a voice signal with a bandwidth of up to 3 kHz.

With the development of technology, radiotelephone communication systems were improved, the size of devices was reduced, new frequency ranges were mastered, basic and switching devices were improved, in particular, the function of automatic selection of a free channel (trunking) appeared. However, with the huge demand for radiotelephone communication services, problems also arose.

The main one is the limitation of frequency resources. The number of registered frequencies in a certain frequency range cannot increase indefinitely, so radiotelephones with working channels close in frequency begin to interfere with each other.

Scientists and engineers from different countries tried to solve this problem. In the mid-1940s, the Bell Laboratories research center of the American company AT&T proposed the idea of dividing the entire service area into small intervals, which began to be called cells. Each cell was to be served by a transmitter with a limited operating radius and a fixed frequency. This allowed the same frequency to be used repeatedly in another cell without any interference. However, 30 years passed before the principle of such an organization of communication was implemented at the equipment level.

Consequently, the development of the principle of cellular communication in these years was carried out in different directions in different countries.

The Federal Communications Commission (FCC) was entrusted with the task of creating security for mobile phones and PMR (private dispatched mobile radio-personal mobile radio communication), which considered a number of radio transmission services to be the most socially responsible service. Political influence helped fuel the growth of mobile telephony, and in 1968 the commission agreed to consider the possibility of using an additional 70 to 83 high-frequency channels (800 MHz bandwidth) for PMR needs. By this time, there were around 70,000 mobile telephone users in the United States.

In 1971, the AT&T Bell Laboratories, Murray Hill, N.J., proposed the cellular system concept as the preferred architecture for the AMPS mobile telephone system. The idea was interesting and involved placing the base station at a high altitude on a mountaintop, with its lower-power stations spread out over a wide area near ground level. Each cell would be a replica of the main radio and would be controlled by a relay center that also controlled the base station function. The reduction in the operating area of each cell allowed for frequency duplication when they were sufficiently far apart. It is known that the effect of cells is not proportional to the distance between them, but to the ratio of this distance to the radius of the cell. In turn, the radius of the cell is proportional to the power of the transmitter, which makes it possible to increase the number of radio channels in the system by simply reducing the power of the cell transmitter, while reducing the size of the cell allows you to fill the empty zones with new cells.

In the late 1970s, work began on creating a single cellular communication standard for 5 northern European countries - Sweden, Finland, Iceland, Denmark and Norway, which was called NMT-450 (Nordic Mobile Telephone) and was intended to operate in the 450 MHz band. The first NMT-450 systems began to be used in 1981, but a month earlier, the NMT-450 standard cellular communication system was launched in Saudi Arabia.

Methodology

Networks based on the NMT-450 standard and their modified versions began to be used in Austria, the Netherlands, Belgium, Switzerland, as well as in the countries of Southeast Asia and the Middle East. Based on this standard, the NMT-900 standard in the 900 MHz band was developed in 1985, which allowed to expand the functional capabilities of the system and significantly increase the subscriber capacity of the system.

In 1983, after a series of field tests in the USA, the AMPS (Advanced Mobile Phone Service) standard network, developed at the Bell Laboratories research center, was put into commercial use. In 1985, the TACS (Total Access Communications System), developed based on the AMPS standard, was adopted as a national standard in the UK. In 1987, with a sharp increase in cellular subscribers, the operating frequency bands were expanded. The new version of this cellular communication standard was called ETACS (Enhanced TACS).

Unlike other European countries, the Radiocom-2000 standard was adopted in France in 1985. Since 1986, the NMT-900 standard has been used in the Scandinavian countries.

All of the above standards are analog standards and belong to the first generation of cellular communication. The use of different cellular communication standards and the high load on the allocated frequency bands began to hinder its widespread use. Sometimes it was even impossible for subscribers in two neighboring countries (especially in Europe) to communicate on the same phone due to interference. The number of subscribers can be increased in only two ways - by expanding the frequency range (for example, as was done in the UK - ETACS) or by switching to rational frequency planning, which allows for more frequent use of the same frequencies.

The use of the latest technologies and scientific discoveries in the field of communications and signal processing by the end of the 1980s allowed a new stage in the development of cellular communication systems – to create second-generation systems based on digital signal processing methods, which include the GSM standard.

In order to create a single European digital communication standard in the 900 MHz band allocated for this purpose, in 1982 the European Conference of Postal and Telecommunications Administrations (CERT), an organization uniting the communications administrations of 26 countries, established the Groupe Special Mobile. The abbreviation GSM gave the name to the new standard (later, due to the widespread adoption of this standard throughout the world, GSM began to spread as the Global System for Mobile Communications.

The result of the work of this group was the requirements for the GSM standard cellular communication system, which used the most modern developments of leading scientific and technical centers, published in 1990 [2].

The system began to operate in full scale in Europe from the beginning of 1993, and the introduction of new service areas continued throughout 1995. Also in 1986, GSM took overall responsibility for managing the development of the entire set of specifications. It remained to involve potential operators, in other words, future developers and network owners. This issue was resolved in September 1987 in Copenhagen when operators from 13 countries signed a Memorandum of Understanding (MoU), which was favorable for the implementation of the project.

At the same time, France began testing various methods of transmitting eight or nine radio signals, as a result of which the TDMA (Time Division Multiple Access) multi-station connection method was chosen, in which the channels are divided by time, in other words, time-demultiplexed. It should be noted that the CNET research institute, later renamed France Telecom, played a decisive role in the development of this method. By February 1988, the reliability of the system had been proven sufficiently to officially invite all operators who had signed the “Memorandum of Understanding” to participate in the project. However, by 1997, it was necessary to complete a huge amount of work on the development and testing of the final specifications, which were to amount to 6,000 pages. It soon became clear that this enormous undertaking had become so large and complex that the planned launch date of 1 July 1991 was being seriously questioned, with potentially disastrous consequences. Given the situation, it was decided to divide the project into two phases, allowing for a phased rollout.

The transfer of responsibility from the GSM group to the European Telecommunications Standards Institute (ETSI), established in France, in 1989 also stimulated a movement towards a level playing field between regulatory authorities, operators and manufacturers. As a result, the "Phase 1" GSM specification was published in 1990 and adopted in the UK-developed DCS 1800 (1800 MHz band).

Later, this system was renamed GSM 1800, and a prototype of the network was presented at the TELECOM 91 exhibition in Geneva. However, due to unresolved compatibility and standardization issues, there were still no GSM phones on the market.

It should be noted that these phones were among the first telecommunications devices to be tested for compliance with a single common European standard, which was not adopted in each country in turn. However, by 1991, the coordination and standardization procedure had not yet been developed. Finally, in April 1992, a temporary sample test procedure was established for compliance with the standard, which allowed the mass production of the first cellular phones to begin, which significantly increased the activity of operators.

In June 1992, the first roaming agreement was signed, allowing British subscribers to use their phones in Finland, and Finnish subscribers to use their phones in England. The pan-European network was operational. By 1993, more than a million subscribers were counted. After the Australian operator Telstra joined the other participants in the Memorandum, the GSM system went beyond the borders of Europe and conquered the whole world.

To date, in France alone there are more than twenty million subscribers served by three operators. GSM mobile phones can be used in more than a hundred countries around the world, and even satellite phones operate according to the GSM standard.

Unlike other widespread digital standards, GSM provides the best energy characteristics, higher communication quality, its security and confidentiality. Satisfactory quality of speech messages received in the GSM standard is ensured at a signal-to-noise ratio of 9 dB at the receiver input (for example, for the D-AMPS standard it is 16 dB), while the energy consumption in real communication channels (signal fading) is 6-10 dB less than in the D-AMPS standard.

The GSM standard provides its users with a number of services that are not used (or not fully used) in other cellular communication standards [3]. These include:

The use of intelligent SIM cards for connecting to channels and communication services;

Encryption of transmitted messages;

The presence of a radio interface closed to eavesdropping;

Subscriber authentication and identification of subscriber devices using cryptographic algorithms;

Short message service transmitted over signaling channels;

Automatic roaming of subscribers of different GSM networks on a national and international scale;

Results and discussion

Inter-network roaming service of GSM subscribers with subscribers of DCS1800, PCS1900, DECT standard networks, as well as personal radio communication networks with satellites (Global star, Inmarsat-P, Iridium).

In accordance with the SERT recommendations of 1980, the frequency spectrum in the 862 - 960 MHz range is allocated for mobile communication in the GSM standard. The 890 - 915 MHz frequency band is used for transmission from a mobile station to a base station, and the 935 - 960 MHz frequency band is used for transmission from a base station to a mobile station (subscriber) [3]. Consequently, the difference between these frequencies during channel reconnection during a communication session does not change and is equal to 45 MHz. The frequency difference between adjacent communication channels is 200 kHz. Thus, 124 communication channels are located in the 25 MHz frequency band allocated for reception/transmission.

The GSM standard uses narrowband time division multiple access (TDMA), which allows up to 8 speech channels to be simultaneously placed on one carrier frequency. The speech codec with regular pulse excitation and a speech conversion rate of 13 Kbit/s RPE – LTP is used as a speech converter.

Speech processing in this standard is carried out within the framework of the adopted DTX (Discontinuous Transmission) speech transmission system, which ensures that the transmitter is turned on only when there is a signal, and the transmitter is turned off during pauses and at the end of the conversation. The DTX system controls the VAD (Voice Activity Detector) speech activity detector, which ensures the detection and separation of noisy speech and quiet speech intervals even when the noise level is equal to the speech level.

Interleaved block and convolutional coding are used to protect against errors occurring in radio channels. At low speeds of moving stations, the efficiency of coding and switching is increased by slowly (at a rate of 217 hops per second) re-tuning of the working frequencies during the communication session.

To combat interference fading of received signals caused by multi-beam propagation of radio waves in urban conditions, equalizers are used in communication equipment that provide smoothing of pulsed signals with a mean square deviation of the delay time of up to 16 μs. The synchronization system of the devices is designed to compensate for the absolute time delay of the signals (up to 233 μs). This corresponds to a maximum communication distance of 35 km (radius of the clock).

To modulate the radio signal, spectrally efficient Gaussian frequency shift keying (GMSK) with minimal frequency shift is used. This name is due to the fact that the sequence of information bits passes through a low-pass filter with a Gaussian amplitude-frequency characteristic before the modulator, which leads to a significant reduction in the bandwidth of the emitted signal. The formation of a GMSK radio signal occurs in such a way that the phase of the carrier changes by 90° in an interval corresponding to one bit. This is the smallest phase change that can be detected with this type of manipulation. The output signal, in which the phase changes continuously, is similar to the signal obtained as a result of frequency modulation, in which the frequency changes discretely.

The GSM standard uses modulation with a normalized band value of VT=0.3, where V is the filter bandwidth at -3 dB level; T is the duration of one bit transmission.

The basis of the GMSK signal generator is a quadrature (I/O) modulator, which consists of two multipliers and one adder.

GMSK modulation is characterized by the following properties:

A level-invariant modulator that allows the use of transmission devices with class C power amplifiers;

A narrow bandwidth at the output of the transmission device amplifier, which ensures a low level of extraneous radiation;

Good noise immunity of the communication channel.

In the GSM standard, a high level of message transmission security is achieved, since message encryption is performed using the public key algorithm (RSA).

In general, a communication system operating in the GSM standard is designed for use in various areas. It provides users with a wide range of services and the ability to use various devices for transmitting voice messages and data, calls and emergency signals, and connectivity to the public switched telephone network (PSTN), private data networks (PDN) and integrated services digital networks (ISDN).

Table 1.1. Main characteristics of the GSM standard

In motion of the station transmission frequency and base station reception to do frequency, MHz	890 - 915
Reception of a moving station frequency and basic of the station transmission frequency, MHz	935 - 960
Reception to do and transmission frequencies duplex separation, MHz	45
On the radio channel information transmission speed, kbit/s	270, 883
Speech codec change speed, kbit/s	13
Contact channel of the band width, kgs	200
Contact channels maximum number	124
Basic at the station organization attainable of channels maximum number	16 - 20
Modulation type	GMSK
Modulation index	BT 0.3
Pre-modulation gauss filter of the band width, kgs	81.2
Frequency according to per second jumps number	217
TDMA frame for mobile communication (transmit/receive) to do) at intervals time according to separation	2
Speech codec type	RPE/LTR
Sell maximum radius, km	Up to 35
Channels organization to grow scheme	Combined TDMA/FDMA

For the first time in Tashkent, the Republic of Uzbekistan, NMT-450 standard systems appeared in 1993. The concept of developing land mobile communication networks, which was subsequently adopted, became a powerful catalyst for the further development of cellular communications on a national scale. If with the introduction of the NMT standard and then the AMP standard, Uzbekistan lagged behind by decades, then the announcement of the GSM standard as a republican standard reduced this time gap to three years.

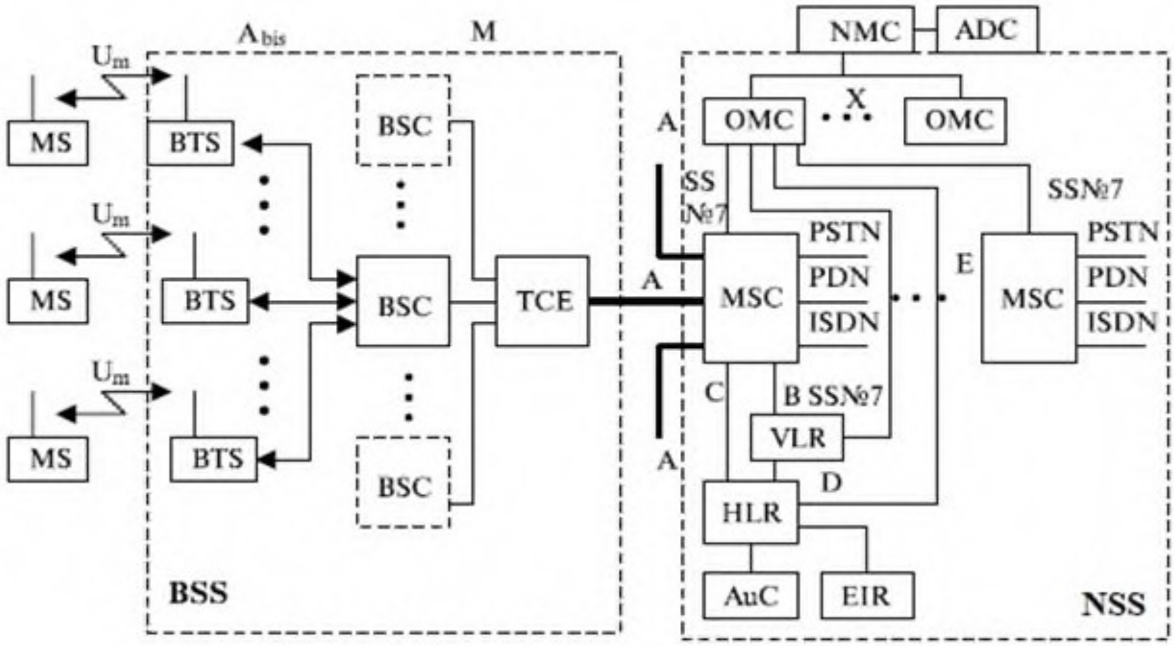
A clear orientation towards advanced world technologies allowed Uzbekistan to keep up with the leading countries of the world in the development of modern mobile communication systems, but the main standard used by subscribers remains the GSM standard.

The GSM network consists of several functional objects, functions and interfaces, which are presented in Figure 1.1 [1-3].

The GSM network includes the following three main parts:

- mobile stations (MS), which move with the subscriber;
- base station system (BSS), which manages the radio link to the mobile station;
- network system (NSS), the main part of which is the mobile switching center (MSC), which performs switching between mobile stations and between mobile or fixed network users. The MSC also manages the work related to the subscriber's mobility.

Figure 1.1 does not show the framework for reliable operation and control of changes in the network. The mobile station (MS) and the base station system (BSS) are connected via the Um interface, which is also known as the "air interface" or radio link. The base station system interacts with the mobile switching center via the A interface.



ADC – Administration Center	Ma`muriy markaz
AuC – Authentication	Autentifikatsiyalash markazi
BTS – Base Transceiver Station	Bazaviy qabul qilish-uzatish stansiyasi
BSC – Base Station Controller	Bazaviy stansiya kontrolleri
BSS – Base Station System	Bazaviy stansiyalar nimtizimi
EIR – Equipment Identification Register	Qurilmalarni identifikatsiyalash registri
HLR – Home Location Register	Xizmatlar integratsiyalangan raqamli tarmoq
ISDN – Integrated Service Digital Network	Mobil stansiya
MS – Mobile Station	Mobil aloqani kommutatsiyalash markazi
MSC – Mobile Switching Center	Tarmoqni boshqarish markazi
NMC – Network Management Center	Ishlatish va texnik xizmat ko`rsatish markazi
OMC – Operation and Maintenance Center	
PDN – Packet Data Networks	Paketlar kommutatsiyalanadigan tarmoq
PSTN – Public Switched Telephone Network	Kommutatsion nimtizim
NSS – Network Switching Subsystem	Transkoder
TCE – Transcoder Equipment	Mobil stansiya
VLR – Visit Location Register	Joylashish o`rni registri

Figure 1.1. GSM network architecture and interfaces

A mobile station (MS) consists of a mobile device (terminal) and an integrated circuit card containing a microprocessor called a Subscriber Identification Module (SIM). The SIM card provides access to paid services when the user is mobile, regardless of the terminal used. By inserting the SIM card into another GSM terminal, the user can receive calls, make calls from this terminal, and receive other services [1-3].

The mobile device is identified by its International Mobile Equipment Identity (IMEI). The SIM card is connected to the International Mobile Subscriber Identity (IMSI), which is used to identify the subscriber, a secret code, and other information. IMEI and IMSI are independent of each other, which allows for the most reliable identification of the subscriber when moving. The SIM card can be protected against unauthorized use by a password or personal number.

Three types of mobile station end devices are used:

➢ MT0 (Mobile Termination 0) – a multifunctional mobile station, which includes a data terminal capable of transmitting and receiving data and speech;

➢ MT1 (Mobile Termination 1) – a mobile station capable of communicating with ISDN via a terminal;

➢ MT2 (Mobile Termination 2) – a mobile station capable of connecting a terminal for communication according to the MKKTT V- or X-series protocol.

A terminal device can consist of one or more types of devices, such as a non-remote telephone set, data transmission equipment (DTE), telex, etc.

There are the following types of terminals:

1. TE1 (Terminal Equipment – a terminal device that provides communication with ISDN

2. TE2 (Terminal Equipment – a terminal device that provides communication with any device via MKKTT V- or X-series protocols (does not provide communication with ISDN). TE2 terminal can be connected as a load to the MT1 device (a mobile station with ISDN communication capabilities) or via a TA adapter.

A simplified diagram of the mobile station transceiver is shown in Figure 1.2.

The transmitter and receiver include the following blocks. The speech signal is converted into an electrical signal in the microphone, the spectrum of which is limited by a filter and is 4 kHz.

The analog-to-digital converter (ADC) converts the signal at the microphone output to digital form, and all subsequent speech signal processing and transmission is performed in digital form, up to the inverse digital-to-analog conversion (DAC) at the receiver.

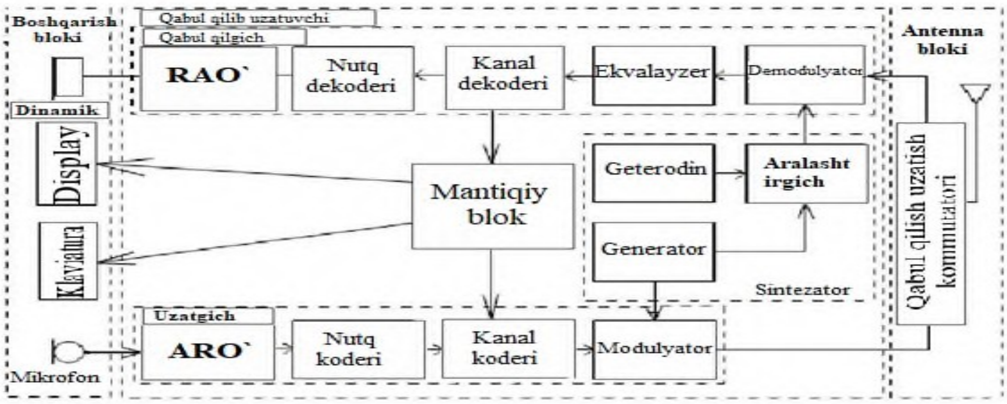


Figure 1.2. Simplified block diagram of a mobile station transceiver

The speech encoder encodes the speech signal into digital form in order to reduce the amount of data transmitted over the communication channel. The speech decoder reconstructs the encoded speech signal received upon reception.

The channel encoder adds additional information to the encoded speech signal designed to protect against errors in the radio range. The channel decoder checks the received data for errors and corrects the detected errors as much as possible.

The modulator converts the data to a carrier frequency. The demodulator extracts the carrier information from the modulated radio signal.

These processing steps will be discussed in detail in the following description of the material.

The base station system consists of two types of devices - a base transceiver station (BTS) and a base station controller (BSC) [1] (they interact via a standardized Abis interface (Figure 1.1).

The base transceiver station is located in a base station, which uses radio link protocols with a mobile station for a given time. In a large city, a large number of BTSs are usually located. Therefore, the main requirements for BTSs are robustness, reliability, portability and minimum cost.

The base station controller manages radio resources for one or more BTSs, selecting and establishing a link on the radio channel, frequency hopping and handover (reconnection).

The BSC is connected between the base transceiver station (BTS) and the mobile switching center (MSC).

The central component of the network system is the mobile switching center (MSC) [1]. It acts as a simple switching node of the public switched telephone network or integrated services digital network (PSTN). In addition, it provides all the functionality of subscriber mobility, such as registration, authentication, location update, handover, and call routing.

These functions are provided jointly by several functional entities that together form the network architecture. The MSC provides connectivity to the designated networks (PSTN or ISDN). Signal transmission between functional entities in the network architecture uses a separate signaling channel - SS7, as used for ISDN and public network switching.

The mobile switching center serves a group of subscribers and provides all the types of connections that a mobile station needs during its operation. MSC is similar to ISDN switching station and acts as an interface between fixed networks (PSTN, PDN, ISDN, etc.) and mobile communication network. It provides call routing and call control functions.

In addition to performing the functions of a regular ISDN switching station, MSC is assigned radio channel switching functions. These include “handover”, which ensures continuity of communication when a mobile station moves from cell to cell and reconnects working channels in the cell in the event of interference or malfunction.

Each MSC provides service to mobile subscribers located within a certain geographical area (Tashkent and Tashkent region). MSC manages call setup and routing procedures. For the public switched telephone network (PSTN), MSC provides signaling according to the UKS No. 7 protocol, call transfer, or the use of other types of interfaces in accordance with the requirements of a specific project.

The MSC generates the information necessary for billing for communication services provided in the network, collects information on the conversations that have taken place and transmits it to the billing center. The MSC also generates statistical information necessary for monitoring and optimizing the operation of the network. It also provides security procedures for managing connections to radio channels.

The MSC is not only involved in call management, but also manages the location registration and control transfer procedures, in addition to transferring control to the base station system (BSS). Location registration of mobile stations is necessary to ensure that calls are delivered to mobile subscribers from subscribers of the public telephone network or from other mobile subscribers.

The call transfer procedure allows a mobile station to maintain a connection and ensure the continuation of conversations when it moves from one service area to another. In cells controlled by a single base station controller (BSC), call handover is performed by this BSC. If call handover occurs between two networks controlled by different stations, then primary control is performed by the MSC. The GSM standard also provides for call handover procedures between networks (controllers) belonging to different MSCs. The switching center performs constant monitoring of mobile stations using the Home Location Register (HLR) and the Visit Location Register (VLR). The HLR stores information about the location of a mobile station, which allows the switching center to deliver a call from a specific mobile station. In practice, the HLR is a repository of information about subscribers permanently registered in the network. It contains allocation numbers and addresses, as well as subscriber authentication parameters, the composition of communication services, and special information about routing. Information about the subscriber's location change and roaming is registered, including the Temporary Mobile Subscriber Identity (TMSI) of the mobile subscriber and, accordingly, the Visit Location Register (VLR). The HLR contains the International Mobile Subscriber Identity (IMSI), the content of communication services, and special routing information. It is used to identify the mobile station in the authentication center.

The Home Location Register, together with the MSC, provides call routing and mobile station location change (roaming) and contains all administrative information about each subscriber registered in the corresponding GSM network, as well as the current location of the mobile station. The location of the mobile station is usually stored in the form of the address of this mobile station in the VLR. The actual routing procedure will be described later.

Although logically it can be implemented as a distributed data repository in a GSM network, there is only one HLR. All MSCs and VLRs of the network have remote access to the data contained in the HLR, and if there are several HLRs in the network, there is only one record about the subscriber in the data repository, therefore each HLR is a certain part of the general data repository of the network about subscribers.

Connection to the data repository about subscribers is carried out by the IMSI (IMSI - International Mobile Station Identity) number, by the MSISDN-number (MSISDN - Mobile Station ISDN Number) of the mobile station in the ISDN network. MSCs and VLRs belonging to other networks can receive a connection to the data repository within the framework of ensuring inter-network roaming of subscribers.

The second main device that provides control over the movement of a mobile station from zone to zone is the VLR location visit register. It is used to enable the mobile station to operate outside the area controlled by the HLR. When a mobile station moves from the area of operation of one base station controller (BSC) to the area of operation of another BSC, which unites a group of base stations, it is registered in the new BSC and information about the number is entered into the communication area, which ensures the delivery of calls from the mobile station to the VLR. In order to preserve the information in the HLR and VLR in case of interruptions, the memory devices of these registers are protected.

The VLR and HLR contain the same information, but this information is only available in the VLR when the subscriber is located in the area controlled by the VLR.

In the GSM mobile communication network, cells are grouped into geographical areas (LA - Location Area), which are assigned their own identification number (LAC - Location Area Code). Each VLR has information about subscribers in several LAs. When a mobile subscriber moves from one LA to another, his location information is automatically updated in the VLR. If the old and new LAs are under the control of different VLRs, then the entries in the old VLR are deleted after being moved to the new VLR. The current VLR address of the subscriber in the HLR is also updated.

The VLR also provides for the assignment of a number (MSRN - Mobile Station Roaming Number) for mobile station roaming services. When a mobile station receives an incoming call, the VLR selects its number and forwards it to the MSRN, which routes the call to base stations in the vicinity of the mobile subscriber.

Conclusion

During movement, a mobile station may leave the service area of one MSC/VLR and enter the service area of another MSC/VLR. In this case, the MSC/VLR participates in the transfer of control from one MSC/VLR to another. It also assigns a new TMSI (Temporary Mobile Subscriber Identity) to the station and forwards it to the HLR. The new MSC/VLR performs the procedure for establishing the authenticity of the subscriber and the unique device.

Except when the mobile subscriber changes location, the temporary number may be changed periodically at the operator's discretion to protect the participants in the conversation from unauthorized access to their numbers. In this case, the change procedure is also carried out using the VLR, the IMSI, TMSI and MSRN identification numbers can be used to connect to the VLR. In general, the VLR can be considered a local data repository in this area, which contains information about the mobile subscriber. The use of the VLR allows you to reduce the number of requests to the HLR, which reduces network traffic and shortens the service time.

In conclusion, the article analyzes the development of mobile communication systems and the importance of the GSM standard. In the field of mobile communication, starting from the initial analog systems, major changes have occurred through digital technologies and the GSM system. The GSM system, with its high security, efficiency and global integration capabilities, has ushered in a new era in mobile communication. The innovative technologies and developments that led to the successful operation of this system play an important role in improving the quality of mobile communication services today. With its widespread global distribution, the GSM system has established itself as a modern and reliable system for mobile communication.

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