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Development of IMS Network Structure and Vector Models Integrated with Mobile Communication Networks

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Abstract

The analysis of the IMS network was carried out, its main features, characteristics and advantages were noted, the three-level structure containing the service level, management level, as well as mobile communication networks and their interaction levels and its vector models were developed in this network.

Keywords: IMS network, service layer, control layer, mobile communications and their interaction layer, physical model, structure of IMS, vector model.

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Mobil rabitə şəbəkələrlə inteqrasiya olunmuş IMS şəbəkəsinin strukturunun və vektor modellərinin işlənməsi

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Xülasə

İMS şəbəkəsinin analizi aparılmış, onun əsas xüsusiyyətləri, xarakteristikaları və üstün cəhətləri qeyd olunmuş, bu şəbəkənin özündə xidmətlər səviyyəsi, idarə etmə səviyyəsi, eləcə də mobil rabitə şəbəkələri və onların qarşılıqlı əlaqə səviyyələrini ehtiva edən üç səviyyəli strukturu və onun vektor modelləri işlənmişdir.

Açar sözlər: İMS şəbəkəsi, xidmətlər səviyyəsi, idarə etmə səviyyəsi, mobil rabitə şəbəkələri və onların qarşılıqlı əlaqə səvviyyəsi, IMS-in strukturu, vektor modeli.

Разработка структуры сети IMS и векторных моделей, интегрированных с сетями мобильной связи

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Аннотация

Проведен анализ сети IMS, отмечены ее основные особенности, характеристики и преимущества, разработана трехуровневая структура сети, включающая в себе уровень обслуживания, уровень управления, уровень сети мобильной связи и их взаимодействия, а также ее векторные модели.

Ключевые слова: сеть IMS, уровень обслуживания, уровень управления, сети мобильной связи и уровень их взаимосвязи, структура IMS, векторная модель.

Introduction

IMS (IP Multimedia Subsystem) is a software and hardware complex that is a key component of all new generation IP networks, including SIP - session initiation protocols, and is designed to standardize multimedia services. This network provides integration of various services in real and non-real time during the session and their interaction with each other. Thus, the IMS network performs two main functions such as end-user service integration and service interoperability.

The service integration function includes a dynamic change of the information environment activated during a multimedia communication session. The range of media types used in this function is determined solely by the capabilities of the user terminal. The IMS network "integrates" the various services that are provided today in just one session. The service interoperability feature enables the creation of new capabilities and the packaging of these services to meet the needs of users. When this feature is implemented, the user can browse the website, make voice or video calls with just one click of a button. Thus, the services provided allow users to interact with each other, creating a single working environment.

The high technical level of the IMS network allows you to provide users with the following types of services: voice services, video services, instant data exchange, various games, group conferencing, interactive TV, text chats, etc. Due to its universal architecture, the same IMS network can integrate all mobile networks. Due to the rapid development of the 4th generation LTE network, within the framework of the IMS concept, the main attention of operators is focused on the development of voice (VoLTE) and “enhanced” multimedia services. Therefore, one of the most important factors in the implementation of the IMS concept is the importance of supporting voice services in LTE 4th generation networks.

The main advantages of the IMS network are as follows [1]: the interconnection of different types of networks; provision of services, development of new types of services, including voice communication services, and their rapid implementation, provision of quality services (QoS), reduction of operating capital costs, expansion of the range of services, as well as scale, etc. These advantages make it even more relevant selection of the IMS network as an object of study that implements the integration of all types of mobile telecommunication networks.

Statement of a question

Recently, due to the significant development of multimedia services, there has been an introduction of new technologies in the field of telecommunications, which in turn contributes to the rapid development of telecommunications networks, especially IMS networks. Some time ago, IMS and mobile networks functioned almost independently of each other and were used for different purposes: the IMS network only as a multimedia service delivery platform (CDP-service delivery platform), and mobile networks as voice data., etc. were used to convey such information. Currently, to ensure the provision of various telecommunication services, it is envisaged to ensure the transmission of various types of information (voice, image, data, multimedia information, etc.) between subscriber terminals, as well as the use of integrated multiservice networks that implement their convergence into a single network. Most The advanced service integration technology is the IMS network, which today is characterized by large size, complex structure and flexible functionality. From this point of view, the separate design of IMS and mobile networks is inexpedient from both a technical and an economic point of view. Therefore, in this paper, the question of integrating all mobile networks within the framework of the IMS concept was raised.

The aim of the work is the development of physical and vector models of IMS network integrated with mobile networks.

Developed structure of IMS network integration with mobile communication networks. The structure of the integration of IMS (IP Multimedia Subsystem) with mobile communi cation networks includes three levels, such as the level of services, the level of management, as well as the level of mobile communication networks and their interaction. The developed three-level structure of the integration of the IMS network with mobile communication networks is given in Figure.

Level of services. At this level, additional services are provided to users through the SIP AS, which is called a SIP server and an application server.

The SIP server performs the following functions: providing mutual connections between the end points of telephone lines, harmonizing the parameters of each communication session, providing data exchange during the session, correcting their parameters, providing transitions between lines during the session, as well as ending the communication session.

The SIP AS server performs the functions of detection of unknown attacks and malicious anomalies in the signaling process, as well as their elimination.

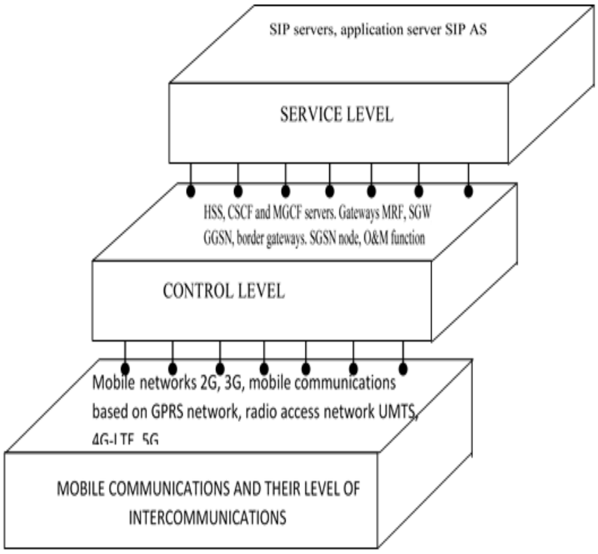

Figure – Developed three-level structure of IMS (IP Multimedia Subsystem) integration with mobile communication networks

Management level. This level includes HSS, CSCF and MGCF servers, MRF, SGW, GGSN and border gateways, SGSN node, as well as O&M-support function, which perform the following functions [2]: the HSS server contains all the necessary information to account for the availability/status and location of subscribers. The "diameter" protocol is used to establish interaction between the HSS server and the CSCF implementing the tariff function. The CSCF server performs the following functions: call session management, processing SIP data exchanged between network endpoints and injecting user traffic into the IMS network, querying the CSCF and determining the centralized routing device, and assigning network policy. The MGCF server is responsible for managing the media gateways.

The MRF Media Gateway is application software that stores media files (video, audio or images) in digital format, makes them available over the network, and processes media streams transmitted between the application server and end devices. The SGW signaling gateway exchanges signaling data between common channel signaling nodes. The signaling data includes call connectivity, specific locations and addresses, and summary information and other service-related information. The GGSN gateway performs the function of correctly forwarding packets to users in the GPRS add-on. Edge gateways are designed to enforce service level agreements between users and service providers. These gateways are located between network boundaries and perform the function of securing SIP sessions.

The SGSN supports the GPRS gateway and is responsible for determining the quality of service based on access points and performing traffic quantification. The O&M function improves network performance by logging network status, monitoring signal information, and monitoring transmission quality.

Mobile communication networks and their level of interconnection. This level includes 2G, 3G, GPRS, UMTS radio access network, 4G-LTE and 5G mobile network. Generally, these mobile networks carry out information exchange between the transmitter and the receiver, as well as among themselves. In the construction of these networks, radio stations are used, each of which resembles a hive and serves a small area.

The core of the 2G mobile communication network architecture is the base station subsystem BSS [3]. The main task of BSS is to provide network coverage in any area, as well as perform radio and mobility functions. In this type of networks, the coverage of each BSS area in several small areas is called a cell. Each cell is served by at least one fixed local transmitter, or base station. 2G digital mobile communication network offers high transmission speed, high level of security, as well as digital and short text data transmission, etc. compared to its predecessor analog networks has advantages.

The difference between the 3G mobile network and the 2G network is that information transmission is organized on the basis of packet switching technology and has a high transmission speed. The 3G mobile network is based on UMTS, FOMA, and CDMA technologies, which transmit data at data rates of 2048 kBit/s, 384 kBit/s, and 144 kBit/s, respectively.

GPRS (Public Packet Radio Service) uses the existing CSM network to deliver packet switched services. GPRS technology is a relatively cost-effective mobile data system compared to the SMS network and enables faster and more efficient data transfer. One of the main features of GPRS technology is that radio services can be exchanged between voice and mobile services depending on traffic load and user preferences. Another feature of GPRS is that by incorporating GPRS functionality into an existing GSM system, providers can provide web access to their customers' Internet services, as well as to the Internet services of other organizations. Radio networks are used to support a network of public packet radio services, resulting in flexible distribution of channels. At this time, one to eight time slots can be allocated to a consumer, or one time slot can be allocated to several active participants, but in this case, the transition from the lower part to the upper part of the network and the transition from the upper part to the lower part may be different from each other [4]. Unlike SMS networks, GPRS technology is a convenient mobile information system that allows for higher speed and significantly more efficient transmission of information. The global system for mobile communications (GSM) and public packet radio service (GPRS) were developed to transmit packet-switched data and provide web access to wireless cellular networks. Both systems are equipped with packet-switched data transmission devices that provide web access to wireless cellular networks.

As GPRS is a packet-based wireless data platform, it provides both "56 to 114 Kb/s" download speed for mobile use and uninterrupted internet speed. GPRS technology makes accessing the Internet easier by replacing the cable connection. This technology transmits user data packets between flexible channels of CSM and existing packet communication channels through packet radio protocol. GPRS has the following advantages: high transmission speed, the calculation of service tariffs does not depend on the duration of the connection, fast and stable connection, simultaneous transmission of all types of information without disconnection, as well as efficient use of the phone's energy resources during the connection.

Currently, there are various types of radio access networks according to the standards of mobile communication networks [5]. Examples of these types of networks are CSM-GERAN (GSM EDGE Radio Access Network), UMTS-UTRAN (UMTS Terrestrial Radio Access Network) and LTE-E-UTRAN (Evolved Universal Terrestrial Radio Access Network).

The GERAN network is a GSM/EDGE standard mobile radio access network, which includes the base station BTS and the base station controller BSC [5]. A GSM operator's network typically consists of several GERAN segments that carry voice service traffic and data transmission to the PSTN and Internet networks. When the voice traffic of the GSM network is symmetric, the frequency duplex method is used in the radio access network, when the number of users increases, the channel switching method and the SS7 protocol are used, and when the demand for additional types of communication services increases, asymmetric types of traffic such as flow and background are used.

The UMTS (Universal Mobile Telecommunica tions System) network reflects the 3G network developed to modify the CSM network [5]. UMTS also includes the UTRAN radio access network, which is a network access domain with appropriate technical and software tools. The main feature of this network is its sensitivity to the power of the received signals, so this network is used for adaptive control of the radiated power of the radio signal. Increasing the spectral efficiency of UMTS is ensured by the inclusion of frequency reserve, which ensures high barrier resistance and stability of multidirectional distribution. UMTS has the following features:

• introduction of transport channels to increase the use of the physical environment;

• managing the quality of subscriber services;

• using different speech codecs;

From IP protocol and MGW media gateway etc. optimization of different types of traffic in the backbone network using.

The next stage of development of mobile communication networks was due to the introduction of the fourth generation LTE (Long Term Evolution) standard [5], which was designed to provide subscribers with access to multimedia services using the IP protocol. The LTE standard uses algorithms and mechanisms used to transmit data between a base station (BS) and a mobile terminal (UE) to improve the efficiency of any radio network. In this case, two options such as TDD (time) and FDD (frequency) are used for duplex data transmission between BS and UE. E-UTRAN (UMTS Terrestrial Radio Access Network) uses OFDM (Orthogonal Frequency Division Multiple Access) in lower communication lines and SC-FDMS (Single Carrier Frequency Division Multiple Access) in upper communication lines.

The fourth generation mobile communication network (4G) includes TD-LTE and FDD-LTE systems, which combine a combination of 3G and WLAN networks [6]. LTE technology is an improved version of the third generation mobile communication network (3G), which does not comply with the 4G standard. LTE technology is the standard form of 4G Advanced technology, which is fully compliant with the International Telecommunication Union's 4G standard. Therefore, LTE technology is considered a new stage in the development of GSM mobile communication networks. LTE Advanced, the most important protocol of 4G network, includes two standards, TD-LTE and FDD-LTE, which operate in two different duplex modes, TDD and FDD, respectively. TDD operates in time-division duplex mode, while FDD operates in frequency-division duplex mode.The advantage of the TDD mode is the efficient use of spectrum resources, and the advantage of the FDD mode is the transfer of information at a higher speed. The 4G network has the following advantages over its predecessors:

- transmission of digital information at very high speed;
- transmission of digital information in the form of video, audio and images;
- transfer of digital information at a speed of 100 Mbits, which is equivalent to a download speed in the range of 12.5 Mb/s-18.75 Mb/s;
- bringing great convenience to the masses in communication, entertainment and business.

Deploying the 4G network in areas not covered by DSL and CATV modems and then being able to deploy it throughout the region.

5G networks are the main driving force of the development of the digital economy, being the strategic center of leading global technology and industrial competition. The difference of these networks from the previous generation of mobile communication networks is that they have advantages such as high transmission speed, low energy consumption, very small delay time, and the ability to affect people's lives and the development of all layers of society [7]. 5G networks have technical characteristics such as an average data transfer speed of 1Gbit/s, a latency of 1ms, and an average number of simultaneous connections of 1 million/km^2.

Vector model of the IMS network structure. The simplest approach to expanding the structure of the IMS network from a mathematical point of view is to describe this structure in the form of a vector [8, 9]. For this purpose, the vector base model of the structure of the IMS network given in figure can be written as follows:

$$W = [X, I, M] \tag{1}$$

where X, I, and M are subsystems representing service, control, and cellular networks and their interconnection layer subsystems, respectively.

The subvector X can be written as (2):

$$X = [V_{SIP}, V_{SIP\ \ AS}] \ , \qquad (2)$$

where V_{SIP} and $V_{SIP\ \ AS}$ indicate subsets of SIP and SIP AS servers, respectively.

Subvector (3) I is equal to:

$$I = [V_{HSS}, V_{CSCF}, V_{MRF}, V_{SGW}, V_{MGCF}, V_{CSCF}, V_{SN}, V_{SGSN}, V_{GGSN}, V_{O\&M}] \qquad (3)$$

where $V_{HSS}, V_{CSCF}, V_{MRF}, V_{SGW}, V_{MGCF}, V_{CSCF}, V_{SN}, V_{SGSN}, V_{GGSN}$ and $V_{O\&M}$ - HSS server, CSCF server, MRF media gateway, SGW signaling gateway, MGCF gateway, CSCF function, VSN edge gateways, respectively, are subsets SGSN node and GGSN node and $V_{O\&M}$ are subsets of the support function.

The subvector (4) M is determined by the following formula:

$$M = [V_{2G}, V_{3G}, V_{GPRS}, V_{4G}, V_{5G}] \qquad (4)$$

where $V_{2G}, V_{3G}, V_{GPRS}, V_{4G}$ and V_{5G} are subsets of 2G mobile network, 3G mobile network, 4G mobile network, and 5G mobile network, respectively.

Conclusion

The characteristics of the IMS network were analyzed and noted that it performs two main functions such as service integration and service interworking. This network offers voice communication services, video services, instant data exchange, various games, collective conference – organization of communication, interactive television, text chats, etc. it has been shown to be capable of providing such services. Thanks to the universal architecture of the IMS network, its features such as the implementation of the integration of all mobile networks and the provision of their interconnections were emphasized.

A comparative analysis of the IMS network with networks that existed before it was carried out, as a result of comparing the development of new types of services, including IMS voice services, their prompt implementation, the provision of quality services (QoS), as well as the reduction of capital costs for commissioning, a variety of services and it was noted that it has advantages such as scaling up.

The issue of developing the structure of the IMS network was considered and a three-level structure was developed, which includes the services level, management level, mobile communication networks and their interaction level. In order to expand the developed structure of the IMS network from a mathematical point of view, a vector base model and, based on this model, its subvector models were proposed.

Conflict of Interests

The authors declare there is no conflict of interests related to the publication of this article.

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