**MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE**
**NATIONAL AVIATION UNIVERSITY**
**FACULTY OF AERONAVIGATIONS, ELECTRONICS AND TELECOMMUNICATIONS**
**DEPARTMENT OF TELECOMMUNICATION AND RADIO ENGINEERING SYSTEMS**

ADMIT TO DEFENCE
Head of the Department

_____ Viktor HNATIUK
"____" _____ 2023

# QUALIFICATION WORK

## (EXPLANATORY NOTE)

### MASTER'S DEGREE GRADUATE

**Topic:** «The method of building a virtual 4-5G network operator based on cloud technologies»

**Performer:** _____ Illia VOICHAK
(signature)

**Supervisor:** _____ Roman ODARCHENKO
(signature)

**Consultants from individual chapters of the explanatory note:**

**Consultant of the "Labor Protection" chapter** _____ Batyr KHALMURADOV
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**Consultant of the "Environmental Protection" chapter**
_____ Andrian IAVNIUK
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**Kyiv 2023**

**NATIONAL AVIATION UNIVERSITY**

Faculty of aeronavigations, electronics and telecommunications
Department of telecommunication and radio engineering systems
Speciality 172 «Telecommunications and radio engineering»
Educational professional program Telecommunication systems and networks

ADMIT TO DEFENCE
Head of the Department

Viktor HNATIUK
"_____"_____2023

# TASK
## for execution of qualification work

Voichak Illia
(full name)

1.Topic of diploma work: «The method of building a virtual 4-5G network operator based on cloud technologies»

approved by the order of the rector from «28» September 2023 №_1965/ст.

2. The term of the work: from 02.10.2023 to 31.12.2023.

3.Initial work data: theoretical data for the use of artificial intelligence in the Ukrainian telecom company.

4. Explanatory note content:

- Analysis of convergent networks - what it is does and what services it provides;
- Network positioning and requirements – what is MVO and where it can be implemented;
- Database for a virtual operator – description of Huawei solution;
- Approbation of the project – how this hardware and software can be used on the customer's network;
- Labor protection – how to protect an engineer from injury;
- Environmental protection - how to avoid polluting the environment.

5. List of required illustrative material: pictures, tables

6. Work schedule

| № n/p | Task | Term implementation | Performance note |
|---|---|---|---|
| 1. | Developing a detailed content of chapters of diploma work | 02.10.2023-04.10.2023 | Done |
| 2. | Introduction | 05.10.2023-08.10.2023 | Done |
| 3. | Analysis of convergent networks | 09.10.2023-22.10.2023 | Done |
| 4. | Network positioning and requirements | 23.10.2023-05.11.2023 | Done |
| 5. | Database for a virtual operator | 06.11.2023-20.11-2023 | Done |
| 6. | Approbation of the project | 21.11.2023-30.11.2023 | Done |
| 7. | Labor protection | 01.12.2023-06.12.2023 | Done |
| 8. | Environmental protection | 07.12.2023-17.12.2023 | Done |
| 9. | Elimination of shortcomings and defense of the qualification work | 18.12.2023-31.12.2023 | Done |

7. Consultants from individual chapters

| Chapter | Consultant (position, name) | Data, signature | |
|---|---|---|---|
| | | Issued the task | Task accepted |
| Labor Protection | Ph.D in medicine Batyr KHALMURADOV | | |
| Environmental Protection | Ph.D. in Biol., Andrian IAVNIUK | | |

8. Issue date of the assignment: "29" of September, 2023

Supervisor of Qualification Work_____ Roman ODARCHENKO
(supervisor's signature) (name)

The task has been taken on for execution_____ Illia VOICHAK
(graduate's signature) (name)

# ABSTRACT

Qualification work on the topic «The method of building a virtual 4-5G network operator based on cloud technologies». It contains 102 pages, 17 figures, 15 tables, 11 sources.

CONVERGENT NETWORKS, MOBILE VIRTUAL OPERATOR, CLOUD UDM.

Object of the study is MVNO.

The purpose of the thesis is studying the methods of building a mobile virtual operator based on cloud technologies.

Research of methods –is implementing in the Ukrainian company.

This work presents and how to implement it especially in the Ukrainian telecom market.

Materials of qualification work are recommended to be used in the scientific research, educational process and practical activity in the teaching of undergraduate disciplines.

**CONTENTS**

# LIST OF ABBREVIATIONS

AAA – Authentication, Authorization, Accounting

ACC – Automatic Congestion Control

ACK - Acknowledgement

BE – Back End

CFB – Call Forwarding Busy

CFD – Call Forwarding - Default

CFU – Call Forwarding - Unconditional

CLIP – Calling Line Identification Presentation

CLIR – Calling Line Identification Restriction

EPC – Evolved Packet Core

FE – Front End

FMC – Fixed Mobile Convergence

HLR – Home Location Register

HSS – Home Subscriber Server

IMS – IP Multimedia Subsystem

LTE – Long Term Evolution

MS – Mobile Station

MVO – Mobile Virtual Operator

NGN – Next Generation Network

UDM – Unified Data Management

UE – User Equipment

UMTS -Universal Mobile Telecommunications System

# INTRODUCTION

**Relevance of the topic.** Mobile virtual operators (MVOs) continue to be a hot topic in the telecoms industry. MVOs can offer more flexible tariff plans to meet the specific needs of users. This can be particularly attractive to those looking for customised solutions. In many countries, MVOs are gradually becoming key players in the telecoms market. They are able to compete with traditional operators, which helps to improve the quality of services and reduce costs for consumers. MVOs may be more willing to introduce new technologies and innovations in telecommunications, as they are often smaller and more flexible in their choice of partners and technologies. Many large companies, such as Google, Amazon, or Facebook, are showing interest in the MVO market. They can use their technology and expertise to create unique services for consumers. The development of 5G and other wireless technologies is creating new opportunities for MVOs, which can use these networks to provide high-speed internet and other services. Mobile virtual operators can specialize in specific markets or user groups, allowing them to focus more on the specific needs of their customers.

**Relationship of the work to scientific programs, plans, topics.**

**The purpose and objectives of the study.** Research methods of building and on which networks MVO can be deployed.

To achieve this goal, the following scientific tasks are being solved.

1. Market analysis
2. Network optimization
3. Technical support

***The object of the study*** - is a mobile virtual operator.

***The subject of the study*** – is development of a database for a Ukrainian telecoms company.

***Research methods.*** My work uses an analytical research method. Analytical research methods include a range of techniques and approaches aimed at understanding, analyzing and interpreting data to identify patterns, trends and relationships. These methods play an important role in many fields, including science, business, economics and social research. I

combine two types of analysis: a descriptive analysis, which is a description and identification of the main characteristics of the data set, and a SWOT analysis, a strengths and weaknesses analysis. Assessment of the internal factors of an organization or project. Assessment of opportunities and threats: Analyzing the external environment and identifying opportunities and threats.

**Scientific novelty and practical significance of the results.**

**Scientific novelty of the results:**

1. The data obtained during this qualification work can be used in real life on operator networks.
2. And this data can also be used for some scientific articles and other kinds of research.

**Practical significance of the results:**

The data used in this work was provided to Intertelecom at their request.

**Testing of the results obtained.** The main provisions of the work were presented and discussed at the following conferences:

- Scientific and Practical Conference "Problems of Operation and Protection of Information and Communication Systems", Kyiv, 2023.

# CHAPTER 1
# ANALYSIS OF CONVERGENT NETWORKS

## 1.1. Introduction

Convergence is the process of interpenetration and integration of various telecommunications networks, technologies and services. At the level of network convergence, transport and access networks, fixed and mobile networks, for example, into a single IP/MPLS backbone network that supports a wide range of access methods: traditional telephony, DSL, leased lines, METRO Ethernet, wireless networks (WLAN) and radio access networks (RAN) of mobile operators. The convergence of transport and access networks is the most elaborated stage of the process of merging networks operating on different technologies.

The new technology consists of the convergence of fixed and mobile network backbones, in particular, for the transmission of large volumes of voice traffic from the same IP backbone, which is used to deliver broadband data, GPRS and UMTS services. In the convergence of technologies, the concept of convergence of fixed and mobile communications (Fixed Mobile Convergence, FMC), which, on the one hand, increases operators' revenues, and on the other hand, it meets the increasingly high demands of customers who are focused on mobile and IP technologies. When transmitting traffic from 2.5G and 3G traffic over IP networks, the convergence of technologies provides a depth of penetration up to the mobile operator's access network.

The FMC concept is scalable and provides for distributed functionality (separation of functions). This means that different functions are performed by highly specialised, physically separated network elements: the application server provides services; call processing elements are responsible for signalling; database systems store user data; media servers play announcements; gateways connect different access networks. The functions of these network elements and the interfaces between them are described in the IMS standard.

The corporate market is also a promising area for IMS. The offer of services for business customers can become a starting point for increasing the level of revenues of mobile operators and expanding the subscriber base by employees of companies that use SMS services.

The main factors contributing to the introduction of SMS are as follows:

- availability of intelligent terminals on the market (e.g., dual-mode phones - cellular /802.11);
- high rates of implementation of WLAN technology (wireless home networks, wireless local area networks of enterprises, access points in airports, hotels, etc;)
- popularisation of the Internet of Things.

At the level of service convergence, the main functions are to manage session management. A session is usually understood as a communication session, an active connection between users, a user and a computer, or computers among themselves. Session management involves the sequence of a number of operations, such as setting up and terminating a session; managing the order and mode of data transmission (simplex, half-duplex, duplex), synchronisation, and activity management session activity; reporting on emergency situations, etc.

Session management enables the deployment of converged services, such as such as mobile data access, audio and video conferencing, voice and instant messaging. It provides control over the activity and status of each session, the degree of service availability on any subscriber terminal and through any access method. In addition, for appropriate network resources are allocated for any service without adversely affecting on active sessions, as well as adequate billing.

Consequently, service convergence provides consumers with a convenient service experience by performing data and voice conversion in sessions that are invisible to subscribers as they move between terrestrial and wireless broadband domains. At the same time, the network dynamically adapts its resource allocation and quality of service policies resource allocation and quality of service policies based on the mobility of the terminal and the transmission environment in which the terminal is currently deployed.

In practice, this may look like this: a person makes a call using VoIP telephony. At first,

he or she is in the network of a fixed-line operator, then enters the 3G area, and finally arrives at the office, where his or her phone connects to the corporate Wi-Fi network. The conversation is not interrupted, but at different times it passes through different networks. Similarly, convergence of services can be understood as the assignment of a single number to a subscriber that is available to him/her both on a mobile and a landline phone.

Finally, there is convergence at the device level. For example, a 3G mobile phone supports only services based on the GSM network, while a business smartphone can work in 2-3 standards and, accordingly, use more opportunities for communication. The convergence of services involves the use of intelligent terminal devices (dual-mode phone - cellular/802.11, smartphones, laptops, handhelds, etc.), as well as a converged service delivery platform.

The main indicators of the functionality of the converged are the following:

- awareness of active sessions and the ability to manage them regardless of location of the session participants and their access method;
- ensuring the continuity of the service in case of crossing the boundary between fixed and mobile networks, despite the specifics of its implementation for each type of traffic - voice and types of traffic - voice, data and video.

Summarising the above, it should be noted that the great popularity of converged services gives grounds to predict their priority in communication networks in the near future. Operators should already be preparing for convergence: building a backbone and carrier-grade IP/MPLS edge networks, develop broadband access networks, stimulate the development of WLANs in home and business networks, and spread public access points and enterprise networks, and the expansion of public WLAN access points - all to logically complement the network and the public fixed line network. The creation of such a framework allows operators to successfully implement their convergence strategy in the shortest possible time convergence strategy.

## 1.2. Convergence objectives

Network convergence. At the level of network convergence level provides a reduction in operating costs by converging different networks of fixed and mobile telecommunications into a single IP/MPLS (IP/Multi Protocol Label Switching) backbone network that supports a wide range of access methods: traditional telephony, digital subscriber line DSL (Digital Subscriber Line), leased lines, Ethernet multiservice networks of the Metro Ethernet, wireless networks (WLAN) and broadband radio access networks in the networks of mobile operators.

The convergence of backbone and access networks is the most obvious and elaborate stage of the of the process of merging fixed and mobile platforms. This concept includes the convergence of fixed and mobile backbones, including the transmission of significant volumes of voice traffic over a single IP backbone that carries broadband data, GPRS (General Packet Radio Service) and UMTS (Universal Mobile Telecommunications System), - the so-called transfer of transit traffic to the IP network.

For mobile operators, converged networks usually start with the transfer of SMS (Short Message Service) and MMS (Multimedia Messaging Service) traffic from traditional platforms and signaling networks to the IP network. This accelerates the convergence of signaling protocols with IP.

Convergence of services. At the convergence level services convergence layer is where session management functions are performed. It is this level that makes it possible to deploy high-margin, next-generation services IP-based services, such as mobile data access, video conferencing, voice, and instant messaging. voice and instant messaging. Visibility into and control over each session ensures and control over each session ensures the availability of the service on any subscriber terminal and through any access method, allowing switching between different types of access without negatively affecting active sessions. In addition, it is the level of service convergence that ensures that any IP service is allocated the appropriate network resources, and any service is properly properly charged.

One of the main indicators of the functionality of a converged platform is to ensure continuity of service across the boundary between fixed and mobile networks. The concept of

service continuity is quite specific to each of the areas of voice data and multimedia traffic. However, technologies such as converged voice devices (phones, smartphones, laptops, etc.), voice convergence architectures (e.g. UMA), and sessions convergence architectures (e.g., UMA (Unlicensed Mobile Access) or IMS (IP Multimedia Subsystem)) and data session convergence protocols (e.g, Mobile IP), are the link between fixed and mobile platforms.

Service convergence is the basic level that ultimately provides consumers with the convenience of using services by performing imperceptible transfer of data and voice sessions between terrestrial and wireless broadband domains. At the same time, the network dynamically dynamically adapts its resource allocation and quality of service policies to take into account the fact that the terminal is mobile and in which transmission environment the terminal is currently at the moment.

Application convergence. The level of application convergence includes the actual services that operators enter the market with and that they intend to offer as an end product. In particular, continuous data services, provided over any access network, voice services for businesses with dual-mode terminals (e.g. Wi-Fi/GPRS), and terminals (e.g. Wi-Fi/GSM), etc.

Application convergence is the process of delivering applications over a variety of different transmission media in a format that takes into account the differences in access speeds that these media provide. The converged application domain is supported and enabled primarily by the functionality of the Session Initiation Protocol (SIP) SIP (Session Initiation Protocol), which takes into account subscribers' mobility and dynamic state on the respective servers. One of the examples of converged applications is the simultaneous delivery of a video stream to a 3G terminal and a personal computer via a content distribution network from a single service centre.

More generally, converged applications are is the provision of voice, data and video through all available types of networks using innovative radio technologies (WiFi, WiMax, LTE (Long Term Evolution)) and information technologies.

In particular, the latter has a significant impact on the development of info communications, and convergence in particular, through the so-called cloud information technologies, or "cloud computing", the main paradigm of which is the possibility of

distributed and remote processing and storage of data, which is a further development of the ideas of Grid systems. "The cloud is nothing more than a large data center (or a network of interconnected servers). The use of cloud technologies makes it possible to create convergent multimedia content that serves as a basis for uniting all content providers who digitise their information into digital form and transmit it through existing channels via universal converging devices.

It should be noted that the frequent use of cloud computing is a cheaper and more convenient way to solve the problem of data processing and data storage than maintaining your own Grid systems and solving the problem with their help.

However, solutions for many complex tasks already exist with the use of Grid computing, and it would be convenient to use these ready-made solutions in Cloud systems. It would also be convenient to use Cloud systems with their advantages, such as fast dynamic scaling and an additional level of abstraction, to develop, debug and optimize new Grid applications.

Implementation of each of the above levels provides significant benefits. Network convergence creates opportunities to save operating costs and capital expenditures, while application convergence allows for the offer of new service packages and improvements.

### 1.3. Challenges in implementing the FMC concept

The idea behind FMC is based entirely on packet-based IP networks. Because of this, those mobile operators that have started to implement such solutions will have to adapt their 2G/3G infrastructure to support to adapt their 2G/3G infrastructure to support IP in a short time. Thus, there is a need to switch to WiMAX, LTE or IMS platforms in the coming years. In addition, the current inherent problems with security and support of the network. In turn, the dynamic growth in demand for FMC will be observed only after the appearance converged handsets/terminals and wireless data technologies on the market.

Today, in many cases, the Wi-Fi signal is lost within about 30 m of the house, and the phone switches back to the GSM/3G network, which increases the cost of user support.

Consequently, mobile operators will be forced to cooperate with their fixed-line colleagues and because users need ever faster and cheaper access to the Internet. Today, data transmission, in addition to traditional conversations, is one of the most important activities performed by mobile phone users. mobile phone users. Cooperation between operators in this case is inevitable.

Network convergence based on FMC technology means building a single infrastructure to provide fixed mobile and converged services. On the network FMC network, users connected through both fixed and mobile systems can access all the services offered in a real-time focus on FMC systems related to the construction of broadband networks of the next generation NGN (Next Generation Network) and the implementation of the IP multimedia subsystem (IMS), is driven by the understanding of manufacturers, integrators and telecoms operators that the future is not in technology, but in services and that the subscriber is not interested in the method and means of their delivery, but in the same and high-quality service, provided regardless of the user's location, the type of network used and the client terminal.

The focus of the FMC is focused on services. One of the most obvious services offered under the FMC concept is the organization of a virtual private network VPN (Virtual Private Network), including a geographically distributed, which may include both landline and mobile phones, united by a common dialling plan. As a result, employees of the same company can call the office from a mobile phone to the extension numbers and use shortened dialing when calling from the office to a mobile phone.

An important, but not yet solved, task is to support client terminals of different types with different interfaces in the FMC network, terminals of different types with different interfaces - whether it is a GSM/GPRS mobile phone or a Wi-Fi, LTE or UMTS device, or a smartphone, or a laptop. From each of these devices, an FMC subscriber should be able to get in touch with connection.

Today, most user terminals are specialized devices, which severely limits the idea of large-scale convergence according to the FMC concept. Although some manufacturers of switching equipment are clearly focused to solve this problem and are already providing the possibility of converged communication across devices from several manufacturers. A

modern "converged" phone (FMC terminal) differs from a conventional phone in that it is designed to operate in several modes. With such a device, the user can receive various services regardless of whether he is within the coverage area of a mobile network or a wireless computer network. This means that a single mobile terminal with a single number can be used both inside and outside the home.

The next functionality of the converged system is to ensure the mobility of the user, provided that he or she is identified at any terminal with the provision of a familiar (for the subscriber) virtual environment VHE (Virtual Home Environment). In this case, the image of the VHE image (menus, information windows, etc.) should be automatically scaled to fit the size and other characteristics of the client device screen. The implementation of such a function is not trivial, especially on a global scale, given the diversity of client devices devices and their wide design diversity.

Mobility and service delivery technology are key infrastructure components for converged FMC services. There are three main technologies - Mobile IP, IMS and UMA. Mobile IP is an open standard defined by the Internet Engineering Task Force (IETF) in RFC 2002. The standard allows you to maintain a constant IP address, avoid disconnection, and ensure uninterrupted operation of applications when users roam between IP networks. Mobile IP technology is scalable on the Internet because it is based on the IP protocol, and any IP-enabled device also supports Mobile IP.

Mobile IP provides ubiquitous connectivity for users, regardless of whether whether they are physically connected to a corporate network or working remotely from home. Mobile IP is an integral part of the IPv4 and IPv6 standards. The principle behind the concept of IMS concept is that the delivery of any service delivery is in no way related to the communication infrastructure (except for bandwidth limitations). The embodiment of this principle of this principle is the multi-tiered approach that used in the construction of IMS. UMA is a solution that allows one terminal to operate both in a GSM mobile network GSM mobile network and a fixed-line IP network (Wi-Fi or Bluetooth).

When such a terminal is within the coverage area of a conventional GSM network, its operation is no different from the operation of any modern mobile phone. But if the UMA-

enabled device enters the coverage area of a Wi-Fi network, for example, in the subscriber's home or at work, then the phone switches to work in an IP network without the user noticing IP network.

Today, many telecom operators choose UMA equipment to implement FMC services, as it is cheaper and simpler compared to IMS equipment. At the same time a number of operators have announced significant investments in IMS equipment. Operators are divided into supporters of IMS technology and supporters of UMA technology. The former believe that UMA technology is not suitable for large-scale implementation of converged services. The main disadvantage of UMA technology is the use of a proprietary protocol for the interaction between user equipment and UNC controllers (UMA Net-work Controller).

The protocol is convenient for mobile operators, but it is difficult to integrate with corporate automatic telephone exchanges stations that operate using SIP. This is one of the reasons why a number of operators focus their FMC services primarily on users in the residential sector rather than the corporate sector. In other words, UMA technology has a limited scope.

In turn, IMS technology is focused on the use of the SIP protocol, which today supported by a wide range of user and network equipment. Therefore, the implementation of IMS technology is preferable in the long run. However, supporters of UMA technology believe that UMA provides a more correct scenario for roaming between networks of mobile systems networks and Wi-Fi. The most significant advantage of UMA technology is the ability of a subscriber to move from a Wi-Fi network to a mobile network and back without losing the connection (for example, without disconnecting a phone call).

This is achieved by using special user equipment compatible with UMA technology. Any user equipment that supports the standard SIP protocol can be used in conjunction with the IMS platform. This means that when a subscriber leaves the service area of the Wi-Fi network, the communication session is interrupted and the user must make a call again.

In addition, the standardization of UMA technology has been completed and the development of the second version - eUMA - has begun, and commercial versions of the equipment are already on the market.

## 1.4. Technologies for implementing converged telecommunications service platforms

The creation of a converged service delivery platform involves, first of all implementation of the FMC concept (convergence of fixed and mobile communications), in which the main role belongs to telecom operators. For example, if an operator owns both fixed and mobile networks, the plan for implementing a converged service delivery platform may be as follows:

- creating a converged IP/MPLS core that provides transit of data, voice, video and signaling information;
- organization of multiservice access networks for the corporate market (for business clients) and the consumer market (for private subscribers).

There are three main technologies for implementing the FMC concept: Mobile IP, UMA, and IMS.

Mobile IP - mobile IP makes it possible to make the procedure for changing IP addresses at the transport layer transparent to the application. The technology is focused on supporting mobile data access in WLAN, 3G, and GPRS networks, including roaming and session preservation when subscribers move. The procedure for saving a session in when a subscriber moves between cells and subnets is called "handover".

UMA (Unlicensed Mobile Access) is a universal mobile access that provides the provision of cellular services via the IP broadband network. This solution actually emulates the operation of the GSM and GPRS over the IP broadband network (both messaging and signaling). In this case, the IP broadband network functions as a subsystem of the GSM base stations, which interacts with a traditional mobile switch (Mobile Switching Centre, MSC) and GPRS service node equipment via conventional interfaces for channel switching and packet services, respectively. This approach allows The UMA can support seamless call handover between the cellular coverage area and the broadband IP area by means of a handover procedure between the base station controllers.

IMS (IP Multimedia Subsystem) is an IP multimedia communication subsystem, which

is a universal IP-oriented, packet-based communication system that provides the ability to create and provide multimedia services, which supports all access technologies, including mobile cellular communication. IMS technology plays a special role: it provides common core functionality that is used by all IMS applications. The common functionality includes user authentication and identification, security, accounting, interaction with the service quality assurance subsystem, service creation, and roaming.

### 1.5. Infrastructure projects based on telecommunications service platforms. Smart home system. Smart city system

Modern telecommunications make it possible to create service platforms that are infrastructure solutions for social facilities and are usually called "smart building" (intelligent or energy-efficient building), "smart city", etc. In this sense, a building is seen as a dynamic system of services of a given level of quality, reliability, safety and economic efficiency, and urban municipal infrastructure is seen as a sustainable system of urban communications and services of a given level of quality, reliability, safety and economic efficiency.

Smart home systems are used in cottages, apartments, offices, shops, yachts, cars, and are entirely based on the telecommunications platforms of these objects. platforms of these objects. There are several standards that can be used to create such systems (EIB, LON, BACNet, Profibus, etc.). The choice of using one or another standard (or several at the same time) or several standards at the same time is determined by the project engineer and depends on the scope of application of a particular system and the tasks set.

## CONCLUSIONS TO CHAPTER 1

The above analysis shows that there are fundamental, profound changes in needs and services, and therefore in the way they are provided. One of the dominant processes in telecommunications is convergence. Convergence is the emergence of similarities in the structure and functions of systems that are initially distant in origin and purpose.

The consolidation of the telecommunications business and the emergence of holdings that combine networks of several specialised operators (fixed-line, mobile and data), as well as fierce competition for subscribers, have led to the emergence of a new class of services. They provide, transparently to the subscriber, the interpenetration of networks and services specific to one particular telecommunications environment into another through gateways.

The convergence process often requires the involvement of intelligence, which is used to coordinate protocols (SDH, ATM, FR, IP) and transmission technologies (VoIP, VoATM, VPN). Multiservice network devices, usually supporting ATM and MPLS, IP and FR, usually play the role of such reconciling devices on operator networks.

Network convergence involves merging several fundamentally different networks into one. This increases network efficiency. Operators move from multiple overlapping networks requiring separate management and maintenance to a single network, usually based on an IP/MPLS network.

Network convergence enables the introduction of modern services. The next wave of the Internet will be shaped by the end user, who needs these innovative applications and services.

# CHAPTER 2
# MVNO NETWORK POSITIONING AND REQUIREMENTS

## 2.1. Introduction

Today, LTE technology is more often implemented around the world by creating a network of a virtual operator MVNO (Mobile Virtual Network Operator), which combines the backbone networks of several existing mobile operators. After all the introduction of a new technology always requires material costs from the operator and involves taking into account various risks regarding the further popularity of the technology and its profitability. Therefore, for the development of the mobile operator's network, it is advisable to implement the LTE technology network based on the shared use of the E-UTRAN (Evolved Universal Terrestrial Radio Access) radio access network by several existing MVNO operators.

The development of LTE technology based on the MVNO virtual operator network requires the construction of a new E-UTRAN radio access network consisting of eNodeB base stations (Evolved Node B) and MME (Mobility Management Entity) mobile modules responsible for solving mobility management tasks. This network will be shared by several existing CN (Core Network)-host-operators, which are merged into MVNOs.

The backbone network uses the S-GW (Serving Gateway) to process and route packet data and the P-GW (Packet Gateway). At the same time for existing operators, the existing subscriber base and already installed equipment are preserved. When implementing LTE/MVNO, an important issue is the study of QoS (Quality of Service) traffic quality characteristics, namely: packet delay time, packet queue length, bandwidth, and the probability of packet loss and delay, which are regulated by the ITU-T Y.2041 recommendation.

This section will be devoted to the description of the solution model, development. The pros and cons will be discussed here.

## 2.2. LTE/MVNO network architecture

It is known that the study of traffic parameters is possible with the help of analytical and numerical methods and methods of statistical modeling. Given the fact that the given task has a rather complex user service algorithm, analytical and numerical methods are not considered expedient Therefore, the use of statistical modeling methods is proposed, with the help of which it is possible to build a mathematical model and implement it in the form of a software implementation. With the help of software implementation, it is planned to obtain the necessary results of solving the given problem.

Consider the functional model of the projected LTE/MVNO network, which is based on the shared E-UTRAN radio access network, which is built on eNodeB base stations, which are accessed by subscribers of two LTE/MVNO operators, the backbone networks are separated, that is, each operator has its own the CN-host-operator backbone network based on the EPC packet core. The functional architecture of the LTE/MVNO network is shown in the figure.

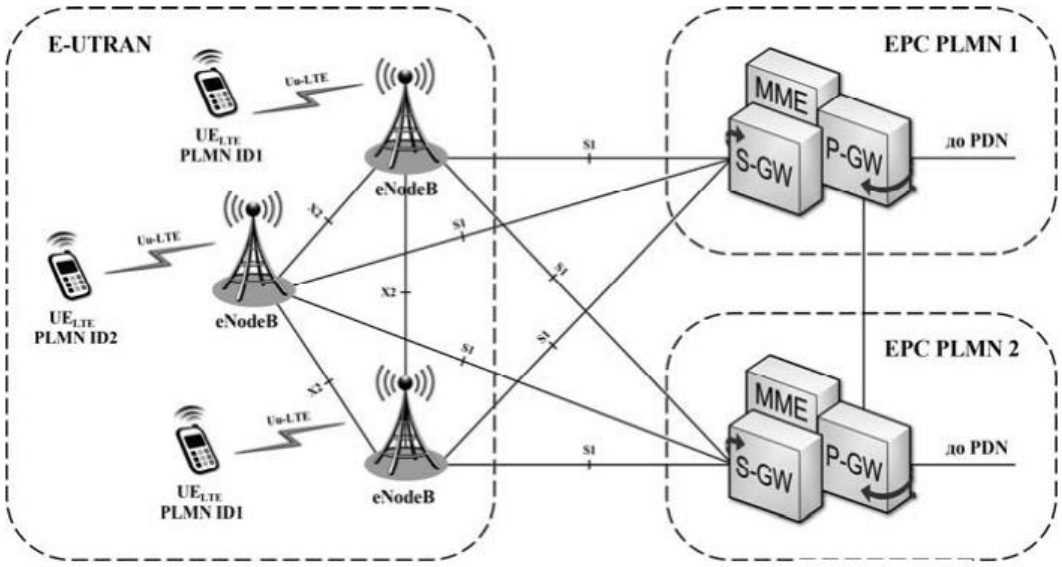


Fig. 2.1. LTE/MVNO network architecture

The main result of the development of the LTE standard was higher speed of access to the IP network. Therefore, it became possible to provide a number of services that were

impossible in the 3G UMTS network due to insufficient access speeds, as well as insufficiently dense network coverage.

The main innovations in the LTE network were the following:

1. Multicast broadcast mode of multimedia streams MBMS (Multimedia Broadcast Multicast Services), which significantly relieved the core network and increased access speed;
2. LTE MIMO (Multiple In Multiple Out): beamforming through multiple antennas, both on the transmitter and receiver. This mode allows you to significantly increase the access speed, as well as increase the reliability of the connection, due to a larger number of directional channels in the beam (beamforming) on one connection;
3. LTE positioning, which allows you to more accurately determine the location of the user's device;
4. General warning system PWS (Public Warning System), which allows you to promptly notify users about the occurrence of any emergency.
5. Optimization of radio frequency spectrum distribution: use of several bands for one channel;
6. Base stations supporting different radio access technologies RAT (Radio Access Technology);
7. eNodeB base stations for home use, femto cells;
8. Self-Organizing Networks SON (Self-Organizing Networks).

The 4G LTE cellular network complements 3G to increase access speeds and the volume of data channels. Therefore, the combination of 3G and LTE access modes is the basis for the development of 4G LTE. The access speed in 4G is increased due to three main factors: channel expansion (from 5 MHz in 3G to 20 MHz), frequency aggregation of channels with a total bandwidth of up to 100 MHz, and an increase in the number of receiving and transmitting MIMO antennas.

The difference between two versions of bidirectional access technology (Duplex). FDD (Frequency Division Duplex) allows you to get wider coverage of one base station. TDD (Time Division Duplex) makes it possible to adjust the ratio of downstream (DL, Downlink)

and upstream (UL, Uplink) bands.

It should be noted that the latest releases of 3G technology – HSPA+ make it possible to obtain speeds close to 4G/LTE in practice. Therefore, some experts say that there are two versions of 4G: HSPA+/HSPA Advanced and LTE/LTE Advanced. Some refer to 4G and WCDMA+. However, this is not true; access speed itself is not the only improvement in LTE.

Network changes in LTE affected not only the access network, but the core network. EPC is an evolutionary continuation of the core of the GPRS/3G network. The main innovations of 4G/EPC are the following:

1. Simpler architecture that reduces operating and capital costs. To increase the throughput of the access network, an upgrade of only two network elements is required: base stations and gateways.;
2. The network is based entirely on packet switching technologies (All-IP). The first 3G releases featured voice over a circuit-switched network. With the general transition of telecommunication networks to packet switching, the EPC architecture is built on the basis of an IP network;
3. EPC has high throughput on the RAN radio access network with a Downlink speed of over 100 Mbit/s;
4. Lower delay in transmitting packets to RAN - about 10 ms;
5. Mobility of the user device between RANs of different types: including networks not developed by 3GPP (for example WiMAX).

### *2.2.1. EPC components*

Mobility Management Entity (MME) - manages user mobility, is responsible for handover (handover of a user device UE between base stations), and selects the SGW for the UE upon initial connection to the network. MME is also responsible for user authentication (when interacting with the user database server HSS (Home Subscriber Server). MME participates in “legal call interception” LI (Legal Interception), in Russian - SORM (system of operational investigative measures), in other words, it gives the ability for intelligence

agencies to monitor (with court approval) the phones of criminal suspects. MME also provides mobility between LTE networks and 2G/3G networks. Together with home HSS, MME also provides roaming of UE devices.

Service Gateway SGW (Serving Gateway) - designed to process and route data packets when they are received from, or sent to base stations. also acts as a mobility anchor for user data during handover between base stations (eNodeBs), as well as a mobility anchor between the LTE network and other networks. When the UE is not in use, the SGW disables the downlink DL channel and periodically polls the UE's presence in the cell (paging) if it needs to transmit data to the UE.

PGW Packet Network Gateway) - provides a connection from the UE to external packet data networks, being the entry and exit point for traffic from the core network for the UE. PGW performs per-user packet security and filtering, call session billing, and data transfer functions. In addition, PGW is involved in mobility management between different networks such as WiMAX, CDMA 1X and EV-DO.

PCRF (Policy and Charging Rules Function) tariff policy installation node - monitors the flow of services and sets a tariff policy for each service and user, depending on its tariff plan.

The interaction diagram of EPC with the LTE access network and the operator’s IP network is shown in the figure.

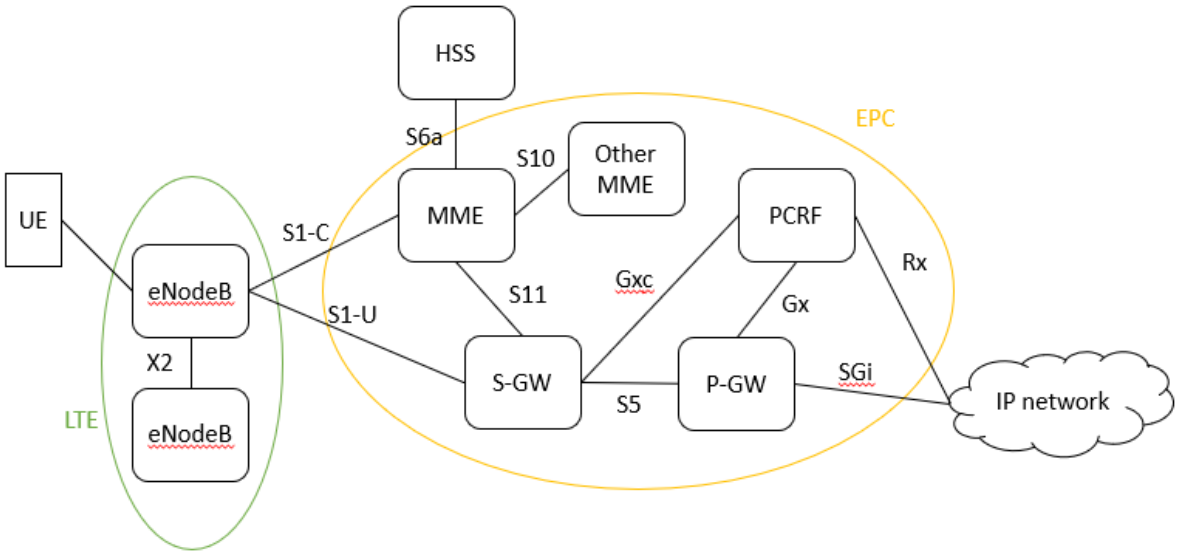


Fig. 2.2. Interaction diagram of EPC with the LTE access network [4]

One of the advantages of 4G LTE over 3G is improved user positioning capabilities, which makes it possible to improve the quality of its service. The LTE positioning method can be based on both satellite signals and signals from nearby base stations, and both methods can work simultaneously.

LTE uses the OTDOA (Observed Time Difference Of Arrival) method, in which the UE measures the TOA (Time Of Arrival) signal from multiple eNodeBs. The more signal delay τ is measured from more base stations, the more accurately the location of the user's device in the MME can be calculated.

Voice transmission over the VoLTE network (Voice over LTE - allows, if you have an IMS (IP Multimedia Subsystem) IP multimedia services subsystem, to transmit voice directly over a packet network. The fact is that in 2.5/3G networks, when making a voice call, it switched to the regular GSM "voice" network. Therefore, if the user was on a 3G network, it took 2-3 seconds for such a switch to occur, and at the same time the mobile Internet became unavailable to him.

VoLTE allows voice services to be delivered as a packet data stream over the LTE radio access network. The sound quality becomes much better. In addition, other data services when making a VoLTE call.

The VoLTE service architecture is shown in the figure below:

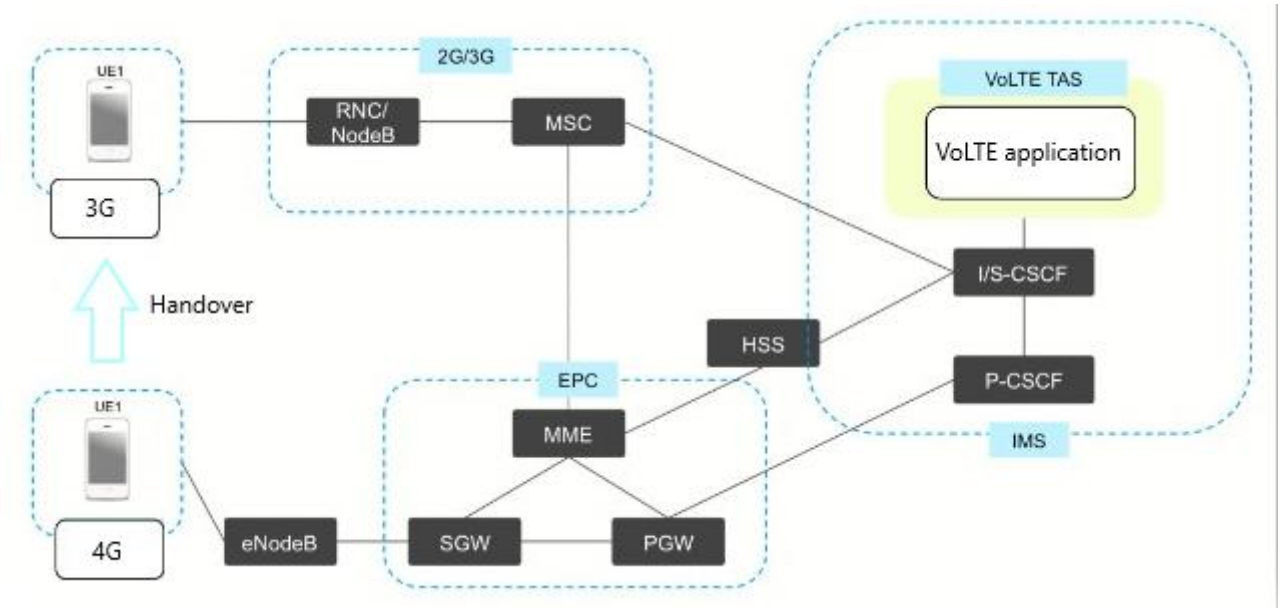


Fig. 2.3. VoLTE architecture [4]

### *2.2.2. NGN components*

Let's consider other domains of the network. NGN (Next Generation Network) is more of a marketing term than a technical one. Really, what does Next mean? When will this “Next Generation” arrive? NGN is a multi-service communication network that supports the integration of voice, data and multimedia services and is based on the IP network (as opposed to ISDN). The main difference between next-generation networks and traditional networks is that all information circulating in the network is divided into two components. This is signaling information that ensures switching of subscribers and provision of services, and directly user data containing useful information intended for the subscriber (voice, video, data). Signal messages and user data paths may not match.

The technical basis of the NGN concept is the so-called. Softswitch, which is often translated as “software switch”. In fact, it is not a switch at all, since it itself does not switch packets, but only controls the transmission of packets at the underlying level in the IP network (and moreover, the word Soft in this case does not mean “software”, but “flexible”). Only protocol control packets pass through the softswitch. And it was assumed that Softswitch would be able to very flexibly manage media streams over the network, assign service policies, and generally very quickly and centrally manage the telecom operator’s network. In practice,

this concept has encountered many problems, first of all, ALL operator networks must be built this way, otherwise it all works ineffectively. However, this was the first attempt to abstract the control plane from the switching layer, which was later developed in IMS, and further in SDN/NFV.

In most regions, the transport network has a number of features that are significant from the point of view of their transfer to IP technologies. The most important of them are the use of outdated transmission lines, excessive remoteness and inaccessibility of some settlements. The quality of the entire network and the number of services provided largely depend on the technologies used at the NGN level. ATM, MPLS, Ethernet and other networks can be used as transport.

ATM technology is more adapted to NGN application, primarily due to the presence of built-in mechanisms for ensuring the given quality of service, the ability to adapt to heterogeneous data traffic, flexible redistribution of bandwidth between different services. This rather expensive technology is used primarily in large networks due to its reliability and flexibility. ATM technology often uses SDH as a transmission medium. This combination makes it possible to achieve the highest reliability and controllability of the transport network.

IP networks based on Ethernet switches and routers are the cheapest solution and therefore quite common in small NGN segments. Such networks are easy to design and operate, easily expanded and modernized, however, they have a number of disadvantages that limit their use as a transport medium for NGN. The main one is insufficient adaptability to pass heterogeneous traffic, especially data streams used by the most demanding applications (VoIP, IP video). When using IP networks, it is very difficult to ensure the required quality of such applications. The only solution is to increase the capacity of highways, which does not always lead to a positive result.

The development of Ethernet technology led to the appearance of a new transport - PoS (Pocket over SDH/SONET), or New Gen SDH (NG SDH). In fact, it is a symbiosis of two well-known technologies, Ethernet and SDH / SONET. This technology has the advantages of the SDH transmission system, which is characterized by high reliability and manageability of the IP network, which allows providing all the necessary packet traffic transmission

services, including such applications as VPN, VoIP, etc.

Another direction in the development of IP networks is the use of optical cables as a direct transmission medium. Increasing the transmission speed to 1 Gbit or 10 Gbit/s implies the use of optical technologies and the creation of the so-called optical Ethernet. In cities, the construction of transport optical networks is justified by the presence of consumer demand for broadband services and the territorial concentration of subscribers. The possibility of building such a transport network in rural areas is quite illusory today. However, even taking into account the huge channel bandwidth, such an IP network methodologically carries all the shortcomings of the "younger" Ethernet. Further improvements in IP networks led to the creation of MPLS.

MPLS technology was originally conceived as a means of reducing the load on routers and adapting IP networks to heterogeneous data traffic. It provided a way to connect IP and ATM networks and naturally became one of the technologies of the NGN transport layer. This happened, first of all, thanks to the applications implemented on its basis: traffic management, such as TE (Traffic Engineering), virtual private networks (VPN), fast recovery of connections - FRR (Fast Re-Route), ensuring quality of service. The MPLS technology consists in the fact that backbone network devices transmit packets only using labels and do not analyze IP packet headers. At the exit point, the labels are removed, and the packets are sent to the destination. Thus, on the basis of the label, packet switching is accelerated in network nodes, traffic is differentiated and the end-to-end quality of IP network services is maintained. MPLS technology allows you to build many virtual private IP networks with their own (isolated) IP addressing system based on a single transport network and, thus, can serve as the basis for building scalable multi-service networks. Today, most NGN equipment manufacturers, one way or another, declare support for MPLS technology.

From an economic point of view, the most optimal solution seems to be the commissioning of equipment capable of being included both in traditional channel-switched networks (via the E1 route via V5.2 and PRI interfaces) and in promising packet-switched networks (using the SIP, MGCP, MEGACO protocols /H.248). One example of this type of equipment can be a multi-service subscriber hub (Media Gateway, MG).

Media Gateway, MG is a representative of a new generation of equipment for providing subscribers with integrated broadband access services. It provides access to traditional TMZK networks, to data transmission networks and to NGN multi-service networks. If one or more technologies of the DSL family are supported, such a hub can be used as an IP DSLAM.

In rural networks, the use of concentrators is more appropriate, given the irrationality of using large PBXs in networks of small capacity.

The main advantage of XDSL technologies is the possibility of simultaneous provision of both telephone communication and high-speed data transmission on one copper pair. One of the most economical DSL technologies is asymmetric ADSL. However, the bandwidth of an ADSL line decreases with increasing distance, as well as due to cable defects or the installation of correction schemes.

As the main technological competitor of ADSL, experts consider symmetric SHDSL access, which uses a more efficient linear code and occupies a narrow frequency band at any speed. Moreover, the spectral density of the SHDSL signal has a shape that ensures its almost perfect compatibility with ADSL signals, which is an extremely important circumstance for ensuring stable operation in the conditions of widespread adoption of XDSL technologies in the future.

Many telecommunications companies are betting big on using WiMAX to provide high-speed communication services. And there are several reasons for that. First, the technologies of the 802.16 family allow not only to provide access to the network to new clients, but also to expand the range of services and cover new hard-to-reach territories more economically efficiently (compared to the leading technologies). Second, wireless technologies are easier to use than traditional wired channels for many. WiMAX and Wi-Fi networks are easy to deploy and scale easily as needed. This factor is very useful when it is necessary to deploy a large network in the shortest possible time. For example, WiMAX was used to provide network access to survivors of the December 2004 tsunami in Indonesia (Aceh). The entire communication infrastructure of the region was disabled and it was necessary to promptly restore communication services for the entire region. In sum, all these advantages will allow to reduce the prices for the provision of high-speed Internet access services for both business

structures and private individuals.

All the variety of devices that broadcast and switch data traffic, transform information embedded in packets into standard telephone signaling and connections, connect digital networks of different nature, terminate different types of traffic, are controlled from one powerful core. This is the third level of NGN - the manager.

This level is often associated with such a concept as SoftSwitch. The main function of the third level of NGN is the management of the connection of subscriber A with subscriber B. This is done by a specialized server, or "connection server" - in SoftSwitch terminology. The high power and performance of such servers is an important condition for uninterrupted network operation. In addition, when designing SoftSwitch, specific factors of IP networks are taken into account - this is the need to ensure the quality of service (QoS) parameters of the VoIP network, the separation of voice and data flow routes, routing management in the presence of a fairly diverse range of devices: routers, signaling converters, border controllers, gateways, proxy servers, subscriber terminals, multiplexers and subscriber access controllers of various nature.

The last level of NGN is considered to be the application level. Its task is to provide the entire range of services available on next-generation networks. The ideology of NGN construction ensures the possibility of providing subscribers with Triple-Play services (transmission of voice, data and video) based on multi-service networks created by modernization of existing telecommunication networks.

The transition to NGN opens up virtually unlimited opportunities for the implementation of services for the corporate sector as well. In traditional networks, such services are provided by local operators, and their connection often requires large time or financial costs. In the case of using a homogeneous IP environment, there is a single set of services for all users. The mechanism of their connection is also significantly simplified: it is enough to select an interesting service from the list and send the corresponding request. Already today, new broadband services are popular: "video on demand", "extended television" (Internet TV), commercial TV, etc [8].

### *2.2.3. IMS components*

IMS (IP Multimedia Subsystem) is a multimedia subsystem based on the IP protocol. Initially, the architecture was developed only as a multimedia service delivery platform (SDP — Service Delivery Platform). But later turned into an architecture that fully controls connections and works with various access networks. The multimedia architecture enables the operator to provide various services to subscribers, thus increasing the average revenue (ARPU). And the use of the IP protocol as a basis gives the operator the opportunity to build a flexible network with low operating costs. In addition, it is based on horizontal architecture, as opposed to the traditional vertical one.

IMS is the next stage of functional separation, abstraction, when network functions are separated from the equipment. In the traditional network (including NGN) there was a "device - function" concept. In IMS, all the various network functions (CSCF, PCRF, MGCF, AGCF, etc., etc.) did not necessarily have to be located in one equipment rack. A single functional unit, such as a CSCF, could be located in different pieces of equipment and even in different locations. Softswitch from NGN was a kind of embryo of the MGCF (Media Gateway Control Function) and AGCF (Access Gateway Control Function) functional blocks in IMS. And specialized powerful servers began to be used as the hardware basis for all these functions. The logical step was the following - why design some specialized servers for the telecom industry, or maybe it would be better to use standard servers from IT and corporate networks? At first, this was somewhat inconvenient, since telecom networks required a higher level of reliability and availability than corporate ones. But increasing the level of reliability and power of standard commercial IT server equipment - COTS (Commercial Off The Shelf, literally - "consumer goods off the shelf") made it possible to solve this problem. The transition to complete virtualization of network functions has become possible, i.e.[2]

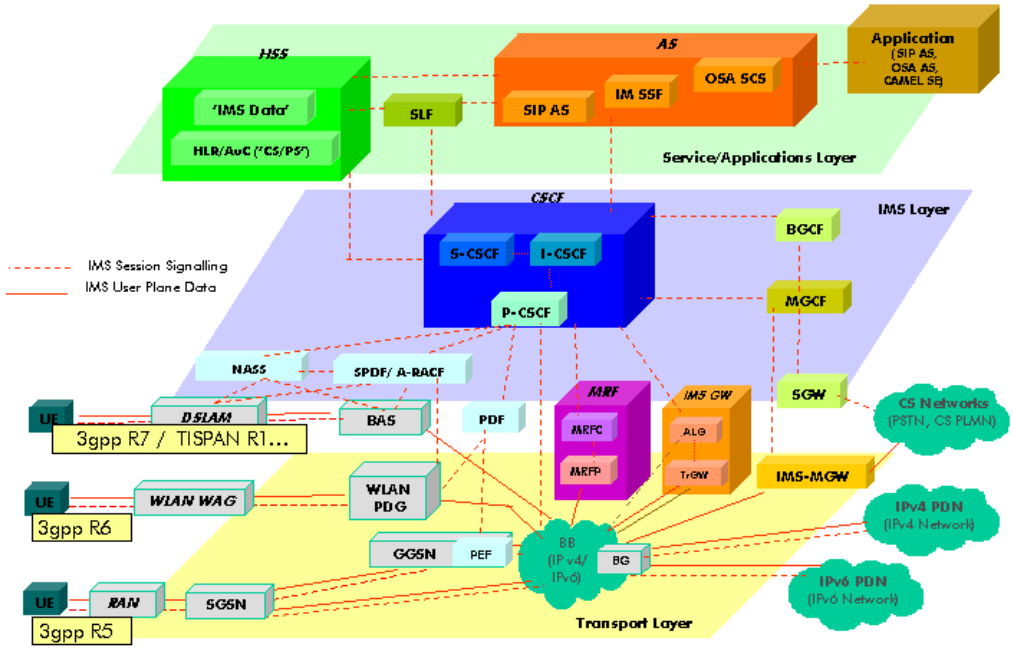


Fig.2.4 IMS architecture [5]

Initially, the idea of building a mobile network based on IP technologies was dealt with by the 3GPP group. It was she who developed the GPRS technology, which subsequently initiated the development of the IP network architecture.

Subsequently, the 3GPP working group was assembled and presented in 2001 Release 4 (initially called Release 2000), in which elements of the ALL-IP architecture appeared. The fifth release introduced an initial version of the architecture called IMS and added High Speed Packet Data Transfer (HSDPA) technology. In the sixth release, changes were made to the IMS architecture, and support for Wireless LAN networks also appeared. Thanks to the work of the TISPAN group, the seventh release of 3GPP added support for fixed networks.

Also, at the moment, the 3GPP2 working group is developing support for CDMA2000 technology in the IMS architecture.

SIP was chosen as the main protocol. An important feature of SIP is extensibility, which consists in the possibility of supplementing the protocol with new functions by adding new headers and messages, which allows adding new functionality to the network without changing the protocol.

The basic elements of the supporting network of the IMS architecture are:

- CSCF (Call Session Control Function) — an element with session management and routing functions, consists of three functional blocks:
- P-CSCF is an intermediary for interaction with subscriber terminals. The main tasks are subscriber authentication and account creation;
- I-CSCF is an intermediary for interaction with external networks. The main tasks are determining the privileges of an external subscriber for accessing services, choosing the appropriate application server and ensuring access to it;
- The S-CSCF is the central node of the IMS network, handling all SIP messages exchanged between end devices.
- HSS is a server of home subscribers, is a user data base and provides access to individual user data related to services. If several HSS servers are used in the IMS network, it is necessary to add SLF (Subscriber Locator Function), which searches for HSS with data of a specific user.
- BGCF is an element that controls call forwarding between the circuit switching domain and the IMS network. Performs routing based on phone numbers and selects a gateway in the circuit switching domain through which the IMS network will communicate with the PSTN or GSM.
- MGCF — Manages transport gateways.
- MRFC — controls the processor of multimedia resources, providing the implementation of such services as conference calls, notifications, transcoding of the transmitted signal.

NFV - Network Fuction Virtualization. We can say that NFV is an implementation of the IMS concept on standard commercial IT equipment, COTS. Concepts, but not technologies. In NFV you will not see IMS functional blocks - all kinds of CSCF, PCRF, etc. Everything there was developed anew, “from scratch.” But conceptually, this is a continuation of IMS.

SDN is a little different, and it came out before NFV. If we talk about abstraction, which runs like a “red thread” through the concepts NGN - IMS - SDN/NFV, then we can say that:

NFV is the separation (abstraction) of functions from hardware.

SDN is the separation (abstraction) of control from execution, the separation of Control Plane and Data Plane, if you use the terminology of IP routing. SDN, Software Defined Network: programmatically configurable network. Network elements are software controlled and can quickly and adapt effectively. Many networks that are logically independent of each other can be deployed on one physical pool of network elements. Such logical networks can carry traffic flows from different business applications without interfering with each other [10].

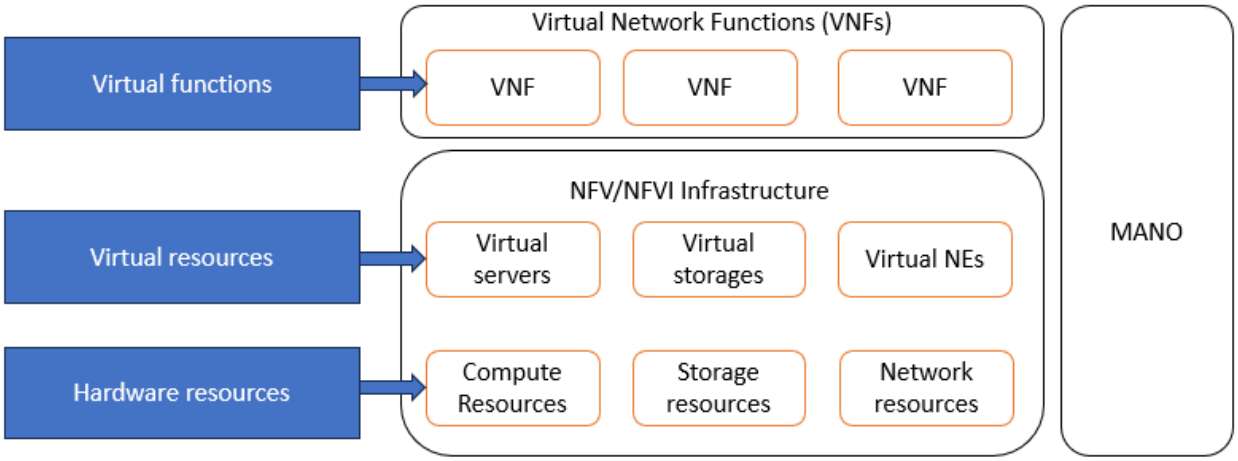


Fig .2.5. NFV architecture

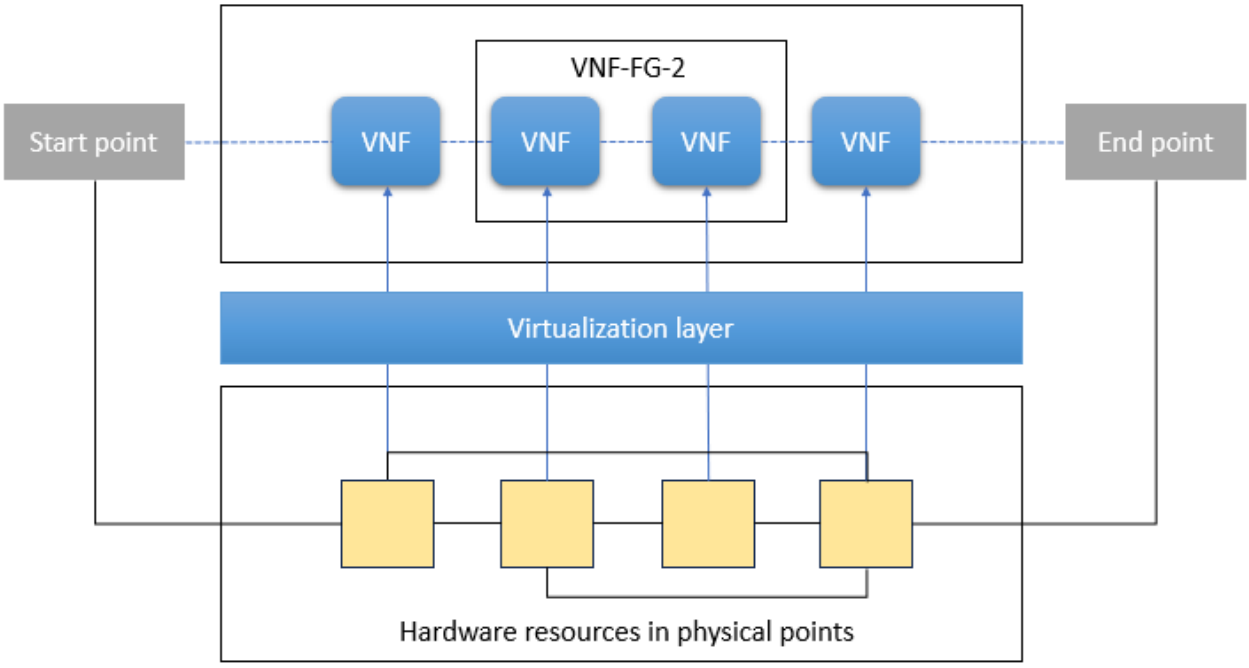


Fig .2.6. Creating a virtual network device from a VNF

On the figure above, you can find, how to create a virtual network device from a VNF.

Table 2.1

Relationship between SDN, NFV and openstack protocols

| **Technology** | **Benefit** |
|---|---|
| Openstack protocols | Creates the foundation for delivering innovative third-party applications |
| SDN | Creates network abstractions to speed adoption of new services |
| NFV | Provides reduction in TCO costs and energy consumption |

It should also be clarified that 4G also includes WiMAX (Worldwide Interoperability for Microwave Access) technology, which is sometimes considered an improved WiFi due to the similarity of names. But that's not true. This technology was developed by the specially

created WiMAX Forum. The developments of this organization were used by 3GPP in LTE, however, the WiMAX technology itself is now practically not used anywhere.

## CONCLUSIONS TO CHAPTER 2

An MVNO (Mobile Virtual Operator) can be deployed in a variety of locations. Technical infrastructure: conclusion of agreements with national or regional network operators to obtain access to the existing infrastructure. Installation of your own or use of existing technical infrastructure, such as equipment for processing calls, data transmission, etc. Licenses and Regulation: obtaining appropriate licenses from national or regional communications regulators. Compliance with all rules and regulations related to mobile operators and networks. Business strategy: defining the target audience and a unique offer for users. Development of a flexible business strategy that takes into account market competition and consumer needs. Marketing and sales: development of an effective marketing campaign to attract customers. Conclusion of partnership agreements for the sale of SIM cards, phones and other devices. Customer support systems: creation of an effective customer support system for resolving issues and providing services. Financial plan: development of a financial plan that takes into account the costs of infrastructure, marketing, technical support and other aspects of the business. Search for investors or financial partners to finance the project. Testing and optimization conducting network and service testing before launch to ensure their reliability and quality. Implementation of changes and optimization of services based on the received test results. Cooperation with other operators: conclusion of agreements with other operators for roaming and traffic exchange.

This is just a general overview of the steps MVNOs can take during deployment. Each case may have its own unique requirements and circumstances.

# CHAPTER 3
# DATABASE FOR A VIRTUAL OPERATOR

## 3.1. Trends and challenges on the telecom market

Mobile communication has changed people lives, but the pursuit of high-performance mobile communication has never stopped. The fifth-generation mobile communication system is introduced to cope with the explosive growth of mobile data traffic, massive device connections and various new services and application scenarios.

5G supports the enhanced mobile broadband (eMBB), ultra-reliability and low-latency communications (URLLC), and machine-type communications (mMTC) use cases to fit service requirements of network capability extremism and differentiation as well as network convergence diversity, enabling a fully connected world.

Traditional core network products are delivered based on the software package of a single product. The development and testing periods are long, the delivery is slow and the impact of the upgrade on the live network is great. These products cannot be cater for diversified, flexible and changeable 5G services. 5G services require a network that supports fast service rollout and on-demand service provisioning.

The increasing service flexibility and complexity bring great challenges to the core network service operations and network governance. The traditional network operations management cannot cope with the development of 5G services. 5G services require a network with full autonomy. Coexistence of 2G/3G/4G/5G networks and network evolution increases O&M difficulties and operating expense.

Rapid growth of service traffic and new services place higher demands on the core network in terms of bandwidth and latency. Evolution towards 5G requires a user-centered, application-driven and highly-autonomous 5G core network.

To cope with all these challenges, Huawei has launched a brand new 5G Core solution. The solution is powered by key technologies, such as Cloud Native, simplified convergence

and multi-access edge computing. It is poised to built an intelligent network delivering a wide range of services on demand, create an open ecosystem and empower thousands of industries.

In this chapter, I would like to describe the solution that we will offer for the operator. The main product offered is CloudUDM. UDM is the Unified Data Management, it includes support for the following: Authentication Credential Processing; User Identification Handling; Access Authorization; Registration/Mobility management; Subscription management; SMS management.

In our case CloudUDM is working as HLR/HSS. It stores all subscriber-relevant data, including identities, authentication data, subscription data and location data. Also it verifies mobile terminals when they attempt to access networks. Huawei UDM prevails other vendors in such criteria: Ultra Reliability, Fully Convergence and Service Boost Enabler. Let's consider each of them separately.

### 3.2. Product highlights

Services are diversified and various requirements are proposed on 5G networks, such as ultra-HD videos, VR/AR, unmanned driving and IoT. The massive volume data must be stored, managed and intelligently analyzed. The advancement of mobile broadband technologies during the evolution of traditional 2G/3G/4G networks towards 5G networks makes the network increasingly complicated. Simplifying networking can efficiently reduce costs. The UDM is functioning as the unified data management center, provides carriers with convergent data management for different networking scenarios. The UDM features efficient subscriber data processing and simplified networking based on which existing services are compatible and 5G services can be expanded. This reduces carrier operating expense and capital expenditure.

The UDM supports the following aspects of network convergence:

- Management convergence: with convergent subscriber data management, unified service provisioning system can be provided to provision network services

through a one time configuration to enable subscribers to quickly register with the services.

- Storage convergence: UDM integrates and stores 2G/3G/4G/5G subscriber data in the HLR/HSS, UDM, AUSF to implement centralized data management and reduce losses during data migration between devices.
- Service convergence: dynamic resources can be shared for different network devices, improving service continuity during handovers between networks.

The full-convergent network design provides the following benefits for carriers:

- Convergent network deployment effectively saves network resources required during the coexistence of 2G/3G/4G/5G networks.
- Convergent data network services ensure service continuity during the evolution from the 4G network to 5G network.
- Unified O&M reduces costs.

To adapt to the scalability and flexibility of the 5G core network, the UDM uses the service-based architecture. Modularization is used to achieve decoupling and integration between NFs. With the service-based architecture, the UDM is divided to multiple different microservices for independent development, deployment, test, upgrade and making the deployment more flexible. The SBA supports agile service policy development and A/B test, allowing for flexible service policy orchestration and combination.

The UDM supports hybrid networking of cloud-based 5G devices and ATCA-based devices on the live network, implementing smooth evolution from ATCA-based architecture to cloud native architecture and protecting carrier investments. UDMs are added to form hybrid-networking with ATCA-based.

Service provisioning data is uniformly delivered from cloud-based 5G devices. Remote provisioning sites are deployed, and routing data is obtained based on the subscriber number and forwarded to the corresponding Bes for processing. Routing data consistency between the 5G and 4G devices is ensured through the reverse generation mechanism and verification mechanism.

Hybrid network signaling can be between FEs. FE receives a signaling request. If the

subscriber data is available in the local partition, the FE processes the request locally. If the subscriber data is available in another partition, the FE forwards the request to another partition's FE, ensuring service continuity.

Newly defined 5G subscribers are migrated automatically, or subscribers can be migrated in batches by number segment. This helps carriers plan the upgrade from 2G/3G/4G networks to 5G networks as required.

### 3.3. System Architecture

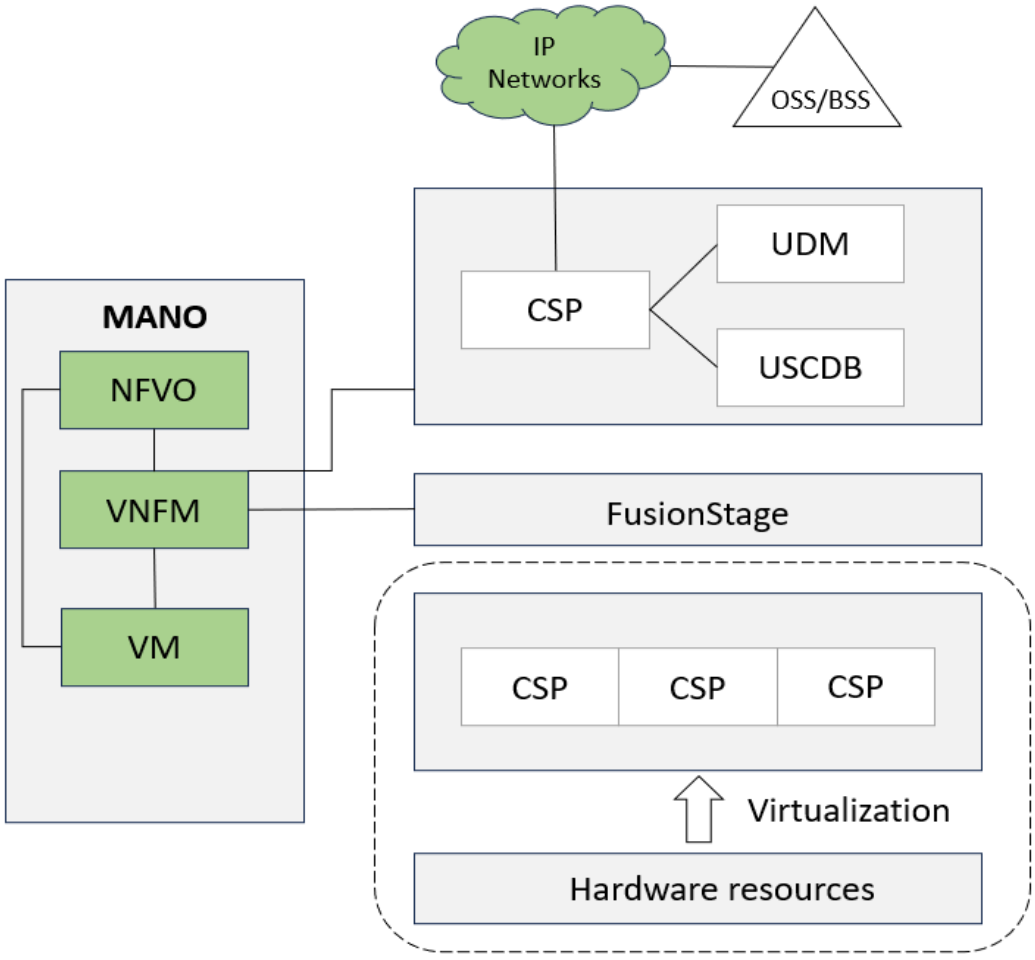


Fig. 3.1. System Architecture

Table 3.1

Key components

| Category | Component |
|---|---|
| Hardware layer | Common COTS devices, including servers, storage devices, network devices |
| Virtualization layer | Support EVS, OVS, SR-IOV |
| VNF layer | EMS: VNF management.<br>VNF: virtual network function entities, that is, service NEs hosted on VMs.<br>CSP: provides unified, efficient O&M functions for applications.<br>USCDB: provides data storage, data management and data services.<br>UDM: integrates and stores 2G/3G/4G/5G subscriber data to implement centralized data management. |
| Operations support layer | Carrier operations support system and service support system. |
| Application management | VNFM: VNF lifecycle management component, implementing VNF instantiation, scaling and rebuilding.<br>NFVO: Orchestrates, schedules and manages all SW resources. |
| Infrastructure management | Container management platform.<br>System which is used to manage the cloud OS and virtual resources. |

A monolithic application is a type of integrated application. One monolithic application for a software package covers the application programs of all involved functions. It is an

inflexible to extend the software package upon an environment change, as the extension may require great resource changes as well as more complex development and maintenance. A service is the minimum functional entity that can be perceived by users. Services are loosely coupled. They communicate with each other and can be independently released, deployed, upgraded, operated. Multiple services together can provide certain service functions.

5G new services can require faster rollout than conventional telecom services to quickly respond to service requirements of different industries. To adapt to ever-changing 5G services, on-demand network orchestration and assembly must be available to fulfill diverse service requirements in different scenarios. Therefore, Huawei UDM introduces the microservice software architecture.

### 3.4. Software Architecture

The UDM uses the service architecture. Services are software entities that can be independently provide a specific function. Service combinations can implement certain service functions.

The UDM consists of the FE, BE and O&M system. The FE functions as the HLR/HSS/UDM/AUSF to process the signaling and services on 2G/3G/4G/5G networks. The BE provides data storage, data management and data services for the FE. The cloud service platform functions as the O&M system. It provides unified and efficient web-based visualized O&M functions for upper-layer applications, including such application lifecycle management and of course routine application O&M.

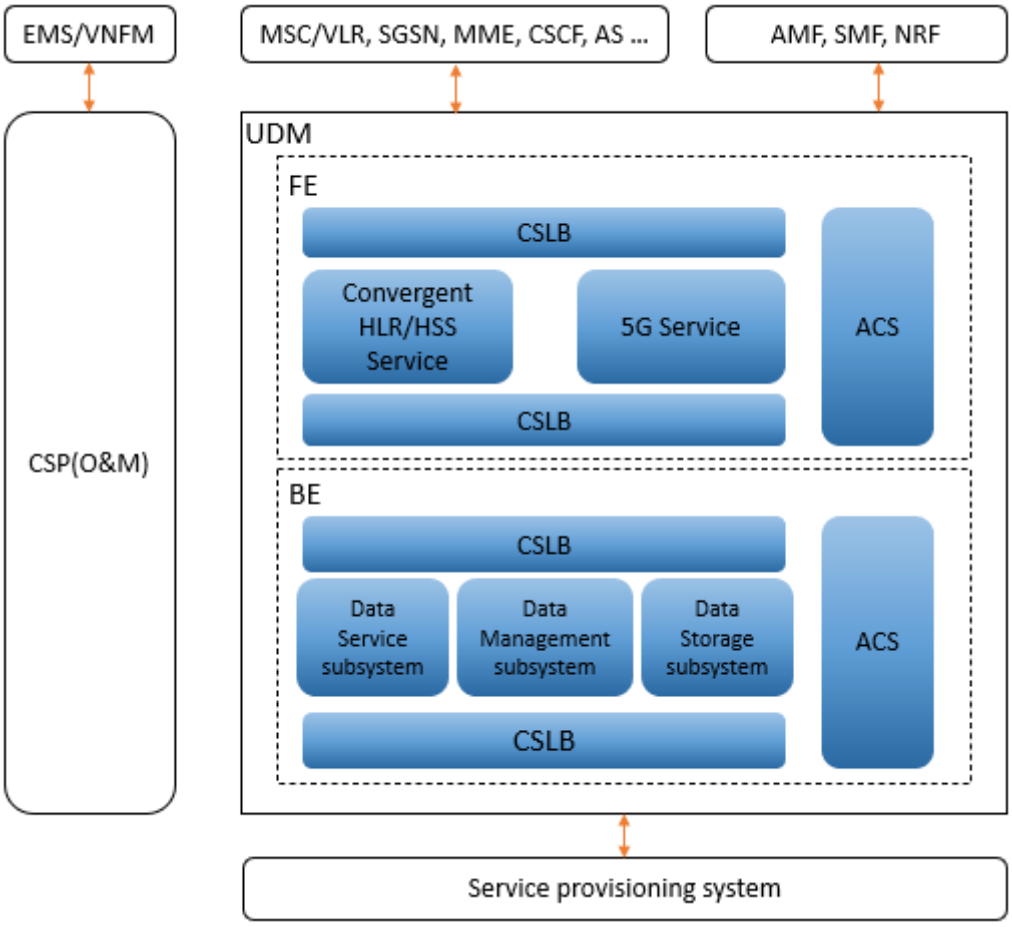


Fig. 3.2. Software architecture

On the figure above, is showed a detailed structure of the software architecture.

Table 3.2

Functional description

| **Category** | **Service** | **Function** |
|---|---|---|
| Service processing | Convergent HLR/HSS | Provides the signaling processing, manages MAP/Diameter signaling. |
| | 5G Service | 5G message processing, unified authentication management, manages the HTTP links status & synchronizes the status to the microservice. |

End of table 3.2

| | | |
|---|---|---|
| | USCDB | Provides the Data Service, Data Management, Data Storage. |
| | ACS | Inter-Service communication policies and CSLB policy delivery within NEs. |
| | CSLB | Provides the forwarding and load balancing of Layer 3(IP layer) and Layer 4(TCP/SCTP/UDP) messages. |
| | CSP | It is a cloud-based, service-oriented, open, unified platform, which provides efficient functions for applications. |

### 3.5. Service functions

The UDM supports flexible subscriber data management and provides carriers with a menu of services in response to the rapidly changing market. Below tables describes describe the key functions and highlighted service functions of the UDM.

Table 3.3.

Basic key functions

| **Basic Function** | **Description** |
|---|---|
| Mobility management | Provides the access and mobility capabilities for UEs on a network and the service continuity capabilities for UEs during movement. On the network, UDM stores the subscription data and dynamic data of subscribers, delivers subscription data to MME and MSC and stores the addresses of the MME and MSC serving subscribers. Used to flexibly manage subscriber access to networks. |

End of table 3.3

| | |
|---|---|
| Security management | On 2G, 3G and 4G networks, the UDM supports the following authentication. Carriers can select authentication methods according to their policies.<br>1. GSM authentication: a process of checking the validity of subscribers, who use SIM-cards to access GSM networks, ensuring GSM network security.<br>2. UMTS authentication: provides mutual authentication between UMTS networks and subscribers using USIM cards to access UMTS networks, ensuring UMTS networks security.<br>3. EPS-AKA authentication: provides mutual authentication between EPS networks and subscribers using USIM cards to access EPS networks. It requires that the access network and the core network use different keys, ensuring the security of access stratum and non-access stratum. |
| Subscriber data management | The UDM provides flexible subscriber data management functions, such defining and deleting 2G/3G/4G subscribers, changing SIM/USIM cards, changing MSISDNs, and modifying and querying subscription data. |

In the previous table was shown the basic functions. In the below table the highlighted functions are presented.

Table 3.4

Highlighted service functions

| **Basic Function** | **Description** |
|---|---|
| Auto-provisioning for VoLTE | Enables the HSS to provide voice over Lservices for 2G/3G or LTE subscribers, who have not subscribed to the VoLTE services and attempt to access an LTE or IMS network for the first time. |
| Supporting VoWiFi | Enables non-3GPP subscribers to use IMS services, such as voice, SMS, and supplementary services, over WiFi connections. Provides better indoor coverage and reach voice service experience. |
| Supplementary service data consistency between CS and VoLTE | This feature helps establish the following legacy 2G/3G services in an LTE network to maintain consistent subscriber experience when subscribers move between 2G/3G and LTE networks: supplementary services(SSs), operator determined barring(ODB), customized applications for mobile network enhanced logic(CAMEL), ring back tone(RBT), subscriber category, video call, local RBT, PLMN specific supplementary services. |

Now, let's consider the 5G functions. Below table will show them.

Table 3.5

5G service functions

| **Function** | **Description** |
|---|---|
| Mobility management | Provide the access and the mobility capabilities for UEs on a network and the service continuity capabilities for UEs during movement. On the network the UDM stores the subscription data and registration data of subscribers, delivers subscription data to the AMF, and stores the address of the AMF serving subscribers. |
| Session management | Enables UEs to access packet data networks through a network and enjoy data services. Session management includes the session establishment and release. During the session establishment, the SMF sends registration request to UDM to obtain subscription data of the subscriber and subscribes to the data from the UDM. |
| Security management | Adopts mechanism to prevent transmission of the real identify of a UE over a network. Implements the authentication among the UE, roaming network, and home network, and EAP-AKA implements bidirectional authentication between the UE and home network. |

Continuation of the table 3.5

| | |
|---|---|
| Subscriber data management | Provides flexible subscriber data management functions, such as defining and deleting 5G subscribers, changing SIM cards, changing MSISDNs, modifying and querying subscription data. |
| Subscriber data subscription and notification | Process requests for subscribing to or unsubscribing from subscription data changes. This function enables subscription data changes to be delivered promptly, ensuring data consistency between an NFs and improving system reliability. |
| Network slice management | Provides available slices and the defolt slice list for 5G subscribers. During a service procedure, the AMF/SMF obtains subscribers slice information from the UDM based in subscriber attributes and service types to manage slices on 5G networks. |
| 4G-5G interworking | This function ensures service continuity during handovers between 5G networks and 4G networks, helping improve user experience. There are two modes for 4G-5G interworking: single registration and dual registration. |

End of the table 3.5

| | |
|---|---|
| 5G auto-provisioning | This function allows 4G subscribers using 5G terminals in the 5G signal coverage area to access the 5G core network. With this function enabled, subscribers can use 5G services without changing their SIM cards or MSISDNs. |
| VoNR | Provides the technology of bearing voice over 5G New Radio, which features short call setup time. Key functions are: 5G domain selection, 5G subscriber location and status query, UE reachability management, P-CSCF restoration. |

### 3.6. System reliability

The UDM is based on a distributed structure, which allows multiple identical functional entities to work in load sharing mode.

The UDM distributed architecture has the following characteristics:

- IP forwarding layer: The CSLB implements load balancing for services.
- Signaling forwarding layer: The modules used for forwarding MAP/Diameter/HTTP signaling messages are deployed distributedly. After receiving signaling messages, each signaling module forwards a message to the service processing layer for processing according to the load balancing principle.
- Service processing layer: Multiple modules of the same type provide services for each function based on the load balancing principle. If one module is go down, other modules of the same type take over services from this faulty one to ensure that services provided by the system are not affected.

- Data routing layer: This layer consists of multiple DRU clusters, which store routing data. The routing data indicates the mapping between subscriber identifiers and DSU cluster IDs.
- Data service layer: This layer consists of DSU clusters which store subscription data. The DSU provides functions, such as querying, adding deleting or updating subscriber data. Each cluster consists of master and slave node. If master is faulty, slave will take all traffic.
- Physical storage layer: The physical database stores PGW operation logs. Supports storing data backup files on VM disks or third-party servers.

So, I can make a conclusion that UDM architecture has such advantages as high reliability and smooth expansion. High reliability is because of, when an entity is faulty, the load is automatically distributed to other entities. This ensures service continuity. Smooth expansion: only required entities need to be added. After detecting that the newly added entities start running, the system automatically distributes the load to achieve load balancing. Capacity expansion does not affect service processing.

When the system is running, nodes and pods are error prone. To improve the system reliability uses redundancy deployment and anti-affinity deployment to reduce the possibility of service unavailability caused by a single point of failure.

- Redundancy deployment: At least two nodes of the same type and two pods of the same type are deployed.
- Anti-affinity node deployment: Nodes of the same type are deployed on different hosts.
- Pod anti-affinity deployment: Pods that provide the same service functions are deployed on different nodes.

Distributed working method allows one service to be divided into multiple subservices deployed on different nodes. As an example, a complete system can be divided into independent subsystems based on service functions. These subsystems can run independently and communicate with each other.

A cluster is a collection of similar things that provide similar functions. Multiple nodes

deployed with the same application can constitute a cluster, in which these nodes share workloads and provide services for external systems.

A distributed cluster consists of independent subsystems, each of which is identified as a cluster node. Anti-split-brain cluster, a fault detection cluster, and a service management cluster can be deployed on the UDM to centrally manage all resources in the system.

For some resources that encounter continuous or repeated faults, the UDM provides self-healing measures at multiple levels or of different types to restore the resources, minimizing the impact of resource faults on system reliability. Self-healing is triggered based on fault detection result. For example, if a process-level is detected, the process is reset locally for self-healing and a container-level self-healing starts, if the process fails to be self-healed after the reset. If this again, a pod-level self healing starts. If this still fails, a node-level self-healing starts. The node-level self-healing includes resetting, rebuilding, migrating.

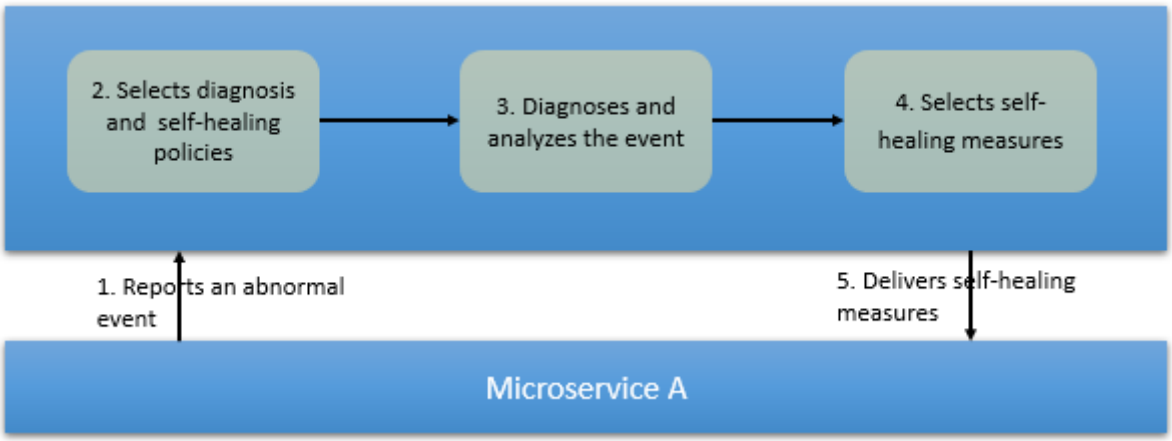


Fig. 3.3. Event self-healing

A microservice determines possible instances that cause a fault based on the fault type and reports the event ID and possible instances to the event message. After receiving the event message, obtains the matching diagnosis and self-healing policies based on the event ID and then analyzes the event according to the policy.

After determining that the reported event meets the diagnosis policy conditions, selects a self-healing measure according to the self-healing policy for the possible instance. It controls the self-healing frequency and quantity within the system's tolerance range. This prevents

false self-healing caused by incorrect report of abnormal events or diagnosis policies for the abnormal events. Protection policies include:

- Avoiding multi-point faults on a single service: Self-healing is performed only when the other cells of the same type as self-healing object are in normal state.
- Avoiding concurrent self-healing: in one period can be performed only for one fault.
- Protection against false self-healing: can be performed for a maximum of three instances within 24 hours.

The storage bypass function decouples VNFs from storage devices. It enables VNFs to run in random access memory disks and provides essential maintenance functions for VNFs in case of a storage fault, reducing adverse impacts on services.

The storage bypass function allows CSP services to keep running for a maximum of 24 hours and VNF services for a maximum of 4 hours. This function also empowers NEs to keep running with essential capabilities when the disk array or distributed storage device is faulty. In this case, don’t restart a service, VM or node.

Backup system data to prevent exceptions such as file and data loss, data damage. You can backup persistent data of the local node, other nodes or remote device. When an exception or emergency occurs, the backup data can be used to restore system in time, minimizing the impacts that the exception or emergency has on services. The system provides the following capabilities:

- Auto backup: to prevent data loss caused by system faults, you can enable the system automatically back up system data to a local node, other nodes, remote server.
- Manual backup: before performing important operations, such as an upgrade, rollback, patching, system restoration, you can manually back up data to a local node or a remote server or a remote server to prevent data loss caused by exceptions. If an exception occurs in the system but the root cause cannot be quickly identified, you can manually back up system data to a local node or a

remote server before implementing the workarounds. The backup data can help you analyze and locate the fault.

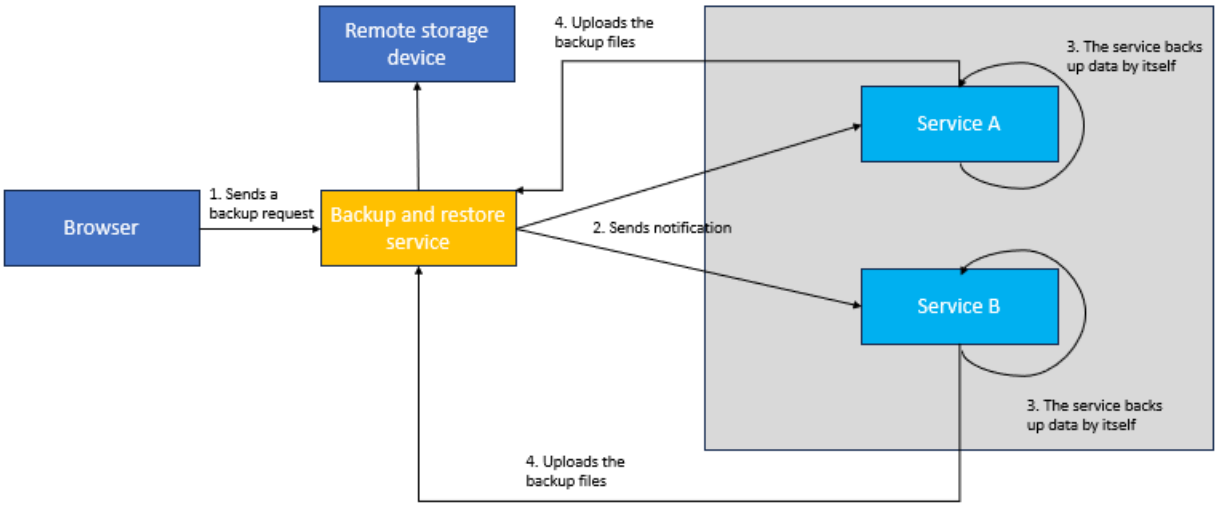


Fig. 3.4. Data backup principle

The below table will help to clarify the differences between different types of backup.

Table 3.6

Types of backup

| Item | Type | Description |
|---|---|---|
| Auto backup | Local automatic backup | The backup and restoration service periodically instructs each service that has been registered to back up data at the configured interval. The services implement the backup as instructed and return the backup package names to the backup and restoration service. |

End of the table 3.6

| | | |
|---|---|---|
| | Remote automatic backup | The backup and restoration service automatically collects backup files from each service node, compresses files and uploads to the remote server. |
| Manual backup | Local manual backup | The backup files are stored on the local nodes where the services are running. |
| | Remote manual backup | If you attempt to upload a manual backup package to remote server, the backup and restoration service automatically collects backup files from each service node, compresses the files and uploads them to the remote server. |

The in-memory database stores data required for service provisioning. To ensure data reliability, the UDM provides the in-memory database backup functions. If an exception or emergency occurs, you can use the backup data to quickly restore the in-memory database to ensure proper system functions and to minimize the impact on live-network services.

The UDM provides the following backup types for in-memory database:

- Master node to same cluster slave node backup: the master node uses data replication to automatically synchronize updated data to the slave node in the same cluster, ensuring the consistency between the two nodes.
- In-memory database to VM disk backup: data stored in the in-memory database is automatically, or manually, backed up to the disks of the VM in the pod.
- VM disk to self-owned space backup: data stored in the in-memory database is automatically or manually backed up to the disks of the VM in the pod. The disks are self-owned space.

Backing up data in the master node to the slave node in same cluster. When the master node updates data in the in-memory database, the master node synchronizes the updated data to the slave node in the same cluster in real time.

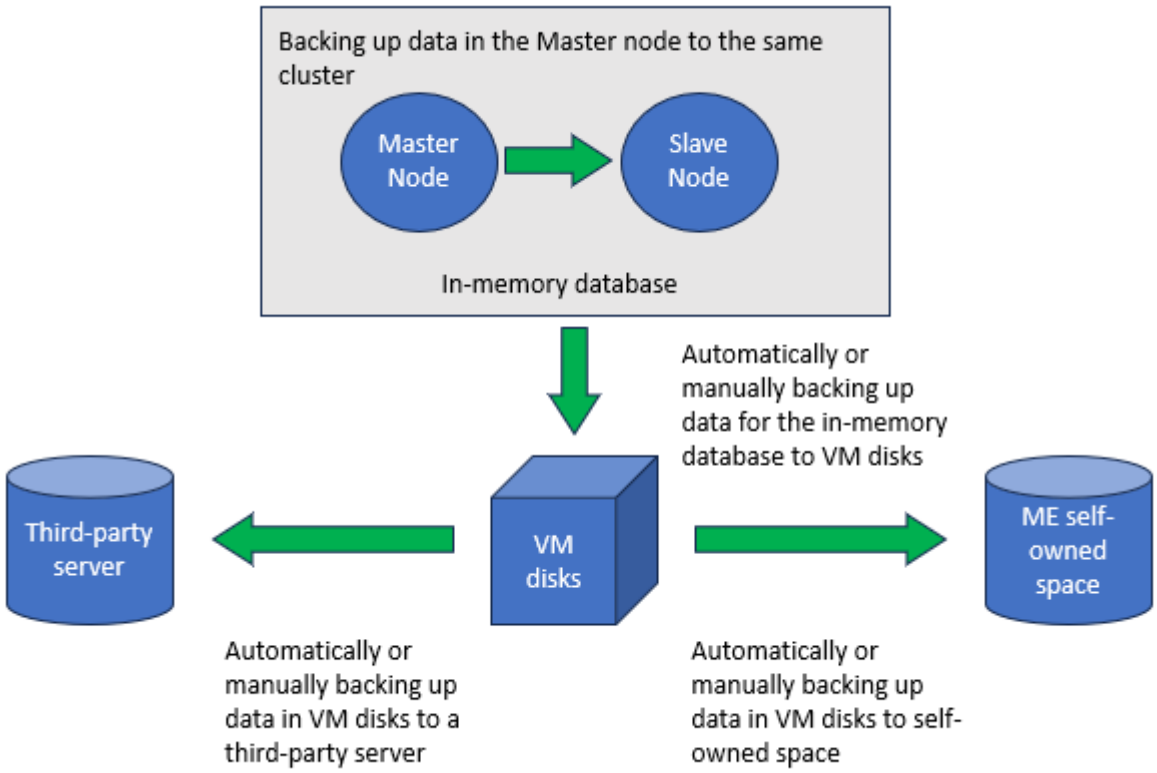


Fig. 3.5. Multi-level data backup

The in-memory database stores the data required for service provisioning. To ensure data reliability and minimize the chance of losing data if there is an incident, the UDM provides the following restore types for the in-memory database:

- Restoring data from the master node: if a slave node fails but the master node for that cluster is working properly, the slave node restarts and loads data from the master node.
- Automatically or manually restoring data from VM disks: if both the nodes in cluster fail but the VM disks are working properly, the node that stores the file containing the Master field preferentially loads data from the directory of the

container where is located and functions as the master node. The other node then loads its data from this new master node.

The USCDB verifies the data consistency between master and slave nodes in the following scenarios:

1. The data of a subscriber is inconsistent between the master and slave nodes in a cluster.
2. Replicating data to a slave node fails.
3. Routing data is inconsistent with subscriber data.

Table 3.7

Data verification modes

| **Verification Mode** | **Trigger Point** | **Remarks** |
|---|---|---|
| Quick verification | During data replication, if the master node fails to receive the response from the slave node within the specified time or fails the replication, the master node creates a quick verification queue. After that, the master node initiates data verification on the slave node. | 1. If the verification is successful, the master node deletes the quick verification queue.<br>2. If the verification time out or fails, the master node retains the quick verification queue and starts another verification attempt. |

End of table 3.7

| | | |
|---|---|---|
| Periodic verification | Data consistency verification in a single USCDB.<br>If a record is available in a master node but unavailable in the slave node, the master node initiates horizontal forward verification. The data record in the master node is used for synchronization.<br>If a record is available in slave node, but unavailable in the master node, the slave node initiates the horizontal backward verification. The data record in the master node is used for synchronization. | Intra and inter-location data verification can be performed concurrently |
| Single subscriber verification | After receiving a single subscriber verification message from FE, the node verify the routing data and subscriber data of the subscriber stored in slave nodes against the data stored in master nodes. | Vertical verification is performed prior to horizontal verification. |

After global data is modified on the PGW, periodic data verification is required to notify the service or module of global data changes. Exceptions, such as data synchronization failures or data processing failures, may occur when global data is modified on the PGW. These exceptions will cause global data inconsistency, and the global data must be periodically verified to ensure consistency.

The cellular technology advances, the adoption of 5G is ramping up all over the world. 5G is not just about higher data rates but is an ecosystem of technologies expected to

accommodate a wide range of use cases and requirements. mMTC is an important use case of 5G. It is aimed at supporting an extremely high connection density of online devices. Centrally controlled by software or servers, these devices tend to behave similarly in similar situations, which can easily give rise to a signaling storm on the network.

With the centralized deployment of 5G control plane NFs, resource sharing may cause potential global failures, broadening the fault impact scope and increasing the signaling impact during service restoration. Due to longer communication paths, communication faults systems in sub-optional conditions will cause excessive signaling messages for batch service restoration and service retry. These severe signaling storms will have a significant impact on the 5G network. Consequently, devices will be overloaded or break down and can even disrupt the entire network, deteriorating user experience. External factors are classified into two types: centralized user behavior and signaling exception on networks. Internal factors are mainly NF or communication faults. For example:

- Traffic surge on the network redundancy plane due to NF faults caused by outage or natural disasters
- Heavy traffic caused by NF communication faults, intermittent disconnections and recovery

During a message burst, the UDM processes as many messages as possible within its processing capability and discards those beyond its processing capability. The flow control function of the UDM brings the following benefits for carriers:

1. Enables the system to process maximum messages within its capability and keep running properly when traffic surges.
2. Enables the system to prioritize messages based on their types, sources and protocols they use. Allows operators to configure thresholds for the CPU usage, queue usage rate and message delay. Manual flow control has priority over automatic flow control. After manual flow control is configured, automatic flow control is also required to determine whether to start or stop flow control according to the CPU usage.

To improve the reliability of microservices for providing services, UDM is allowed to

set the status to *Not ready* or *Unavailable* when the microservice cannot properly provide services.

*Microservice Not Ready:* After a microservice instance starts, the system automatically initializes the microservice instance. During the initialization, the UDM monitors the initialization process in real time. If the microservice fails to load global data or no lower layer microservices are available, the microservice is not ready and cannot provide services. When the microservice successfully loads global data and lower layer microservices are available, the microservice becomes ready. In this case, the alarm is automatically cleared.

*Microservice Unavailable:* UDM uses client to check whether the status of the distribution microservice. If no service is available, the UDM reports NF unavailability to the NRF. After receiving UDM or AUSF unavailability the NRF stops sending heartbeat messages to the registered UDM or AUSF, and the unregistered UDM or AUSF is not registered any more.

A redundancy system consists of at least two sets of equipment having the same functions in different locations. When one of them is shut down due to accidents, such as fire or earthquakes, the other will take over its services. The redundancy system is designed to improve product availability in the event of disasters.

Let’s consider two cases:

1. A redundancy site is not configured

   A major natural disaster has just happened in city A. I want to call my families to let them know the time safe, but calls cannot be connected. I heard that a major natural disaster has just happened in city A. I want to call my son working in city A to make sure he is safe, but calls cannot be connected. I am so worried.

2. A redundancy site is configured

   A major natural disaster has just happened in city A. I called my families to let them know that I am safe. I received a call from my son working in city A. I am relieved to know that he is safe.

To improve network security and reliability, Huawei provides the UDM geographic redundancy solution to add an UDM to work as a backup of the existing UDM on the network.

In normal conditions, the active UDM processes signaling messages and other services. If the active UDM is faulty, the redundancy UDM takes over services from the active UDM to ensure proper running of the network.

Table 3.8

Comparing the reliability of the redundancy solutions

| **Redundancy Solution** | **Advantages** | **Disadvantages** |
|---|---|---|
| Active/StandBy 2x(FE+BE) | An automatic switchover can be performed the active and redundancy sites. Data consistency between the active and redundancy sites can be ensured. The system is highly reliable. | Data synchronization is affected by the QoS and bandwidth of the IP bearer network. The system cannot adequately protect against traffic surges. |
| Load-sharing 2xFE+Active/StandBy 2xBE | An automatic switchover can be performed between the active and redundancy sites. Data consistency between the active and redundancy sites can be ensured. The system is highly reliable and can adequately protect against traffic surges. | Data synchronization is affected by the QoS and bandwidth of the IP bearer network. |

End of table 3.8

| | | |
|---|---|---|
| Active/StandBy 3x(FE+BE) | An automatic switchover can be performed between the active and redundancy sites. Data consistency between the active and redundancy sites can be ensured. One more redundancy site is deployed, making this redundancy solution higher reliable than the redundancy solutions between two geographically separate locations. | Data synchronization is affected by the QoS and bandwidth of the IP bearer network. The system cannot adequately protect against traffic surges. |
| Load-sharing 3xFE+Active/StandBy 3xBE | An automatic switchover can be performed between active and redundancy sites. Data consistency between the active and redundancy sites can be ensured. One more redundancy site is deployed, making this redundancy solution higher reliable than the redundancy solutions between two geographically separate locations. The system cannot adequately protect against traffic surges. | Data synchronization is affected by the QoS and bandwidth of the IP bearer network. |
| Load-sharing 3x(FE+BE) | | |

### 3.7. Security Principle

With the evolution from 2G/3G/4G to 5G, more and more carriers have now come to realize the importance of convergence and centralized management of subscriber's service data. The telecommunications industry shifts towards centralized rollout of subscriber data convergence. The UDM has been transformed into ALL-IP architecture. It provides basic network functions, such as mobility management, access authentication and service authorization.

The UDM faces unprecedented security challenges due to the IP network openness, subscriber access authentication and authorization. If the data is stolen by unauthorized users, illegal communication interception, service theft and charging fraud may occur. The UDM is developing with a large-capacity and distributed system. If the system is under attacks, such DoS or DDoS attacks, system exceptions occur. The exceptions will cause service outages, negative impacts on the carrier's reputation and profit losses.

After UDM is deployed on a carrier's IP network, hackers may use the Internet attack tools to attack the UDM. The UDM stores a large volume of subscriber data. Therefore, attacks on the UDM may cause subscriber data disclosure or loss.

*Destruction:* attackers destruct various information or resources of the UDM to lower or disable the capability of providing services. An attacker sends a large number of packets to the UDM within a short period of time, causing the UDM to run out of resources and become unable to process services. An attacker can also sends malformed packets that do not comply with standard protocols.

*Interruption:* an attacker maliciously attacks the UDM, causing service interruptions. DDoS attacks and malformed packet attacks are common methods used by attackers.

*Disclosure:* attackers disclose information, such as a subscriber numbers and authentication data, stored on the UDM, causing threats to subscriber privacy or key asset information disclosures. Information scanning and information interception are common methods used by attackers. An attacker uses a scanning tool to probe information, such as IP address, port and service process type of the UDM. Also an attackers can use unauthorized

software to intercept key information, such as subscriber numbers, authentication data, subscriber passwords.

*Deletion:* attackers may maliciously delete information that is stored on the UDM, such as operation logs and system files. Implanting malicious software, such as viruses and Trojan horses. An attacker implants unauthorized software to the operating system or database to obtain the account and password of the super administrator. With the account and password, the attacker deletes data from the OS or database.

*Tampering:* attackers tamper with software during release or transmission of the software, such as viruses and Trojans. Using the malicious software, an attacker can destruct the system or obtain confidential information, such as passwords used to access the system, subscriber numbers and so on. During transmission on IP network, malicious individuals can intercept and tamper with management information, service provisioning information and signaling messages to accomplish forgery and attacks.

To ensure system security against existing threats, the UDM uses hierarchical security protection policy and constructs a hierarchical security protection mechanism that addresses security concerns in various aspects, such as networking, service applications and operation management.

### 3.8. Hardware part

E9000H servers are next-generation carrier-grade hardware servers based on the Telco Cloud Engine (TCE) hardware platform. TCE is developed based on the diversified supply and built to be a carrier-grade platform.

The positioning of platform is like that:

- Supports multi-service scenarios, flexible hardware combination.
- Features strong forwarding and simplified networking.
- Uses Huawei-developed components and purchased components to enable diversified supply, meeting the requirements of various deployments of telecom equipment rooms.

Table 3.9

E9000H-8 components

| **Name** | **Description** |
|---|---|
| Management module | Two management modules, which support Active/StandBy switchovers and hot swaps as well as manage components of the chassis. |
| Fan module | Sixteen fan modules |
| PSU | Eight PSUs |
| E9000H-8 | Support standard cabinets. Eight full-width compute blade slots are at the front, and two management module slots, eight PSU slots and 16 fan module slots are at the rear. |
| Compute blade | Eight full-width general-purpose compute blades. |

Huawei E9000H-8 servers have such features and functions:

- Eight full-width compute blades can be horizontally installed in the front of the chassis.
- Each compute blade supports a maximum of six PCIe slots for installing NICs, AI cards, and SSD cards. A maximum of two drive slots are supported for installing NVMe or SATA drives.
- Sixteen fan modules and eight PSUs can be installed in the rear of chassis.
- Two management modules for chassis device management work in active/standby switchovers, hot swaps and protocols.

Compute blades can be three types: CN221, CN221 V2, CM221. Below table will describe their functions.

Table 3.10

Compute blades comparison

| **Blade's name** | **Function description** |
|---|---|
| CN221 | Full-width compute blade that uses the Intel Purley Cascade Lake SP x86 processor, providing powerful computing capabilities and flexible scalability. The mainboard of the CN221 adopts the full width form factor without heat cascading. It supports 16 DIMMs and CPU evolution with higher power consumption. |
| CN221 V2 | Uses Intel Whitely series Ice Lake-SP x86 processors, providing powerful computing capabilities and flexible scalability. The mainboard of the CN221 V2 adopts the full width form factor without heat cascading. It supports 16 DIMMs and CPU evolution with higher power consumption. |
| CM221 | It is a full-width compute blade powered by Kunpeng 920 processor. The mainboard of the CM221 adopts the full width form factor without heat cascading. It supports 16 DIMMs and CPU evolution with higher power consumption. |

### 3.9. OSS System

The mobile network features multiple frequency bands, RATs, channels and types of services. The network complexity increases sharply. In the future, mobile services will be available everywhere for homes, enterprises and governments. QoS for diversified services requires flexible network resource assurance, which poses higher requirements for automatic service O&M.

MBB automation engine (MAE) provides automatic O&M capabilities to power

network automation. The customer-oriented production process of MAE provides scenario-based apps based on the life cycle of network deployment, maintenance and optimization and service provisioning. MAE is located at the element management layer according to the Telecommunication Management Network (TMN) model.

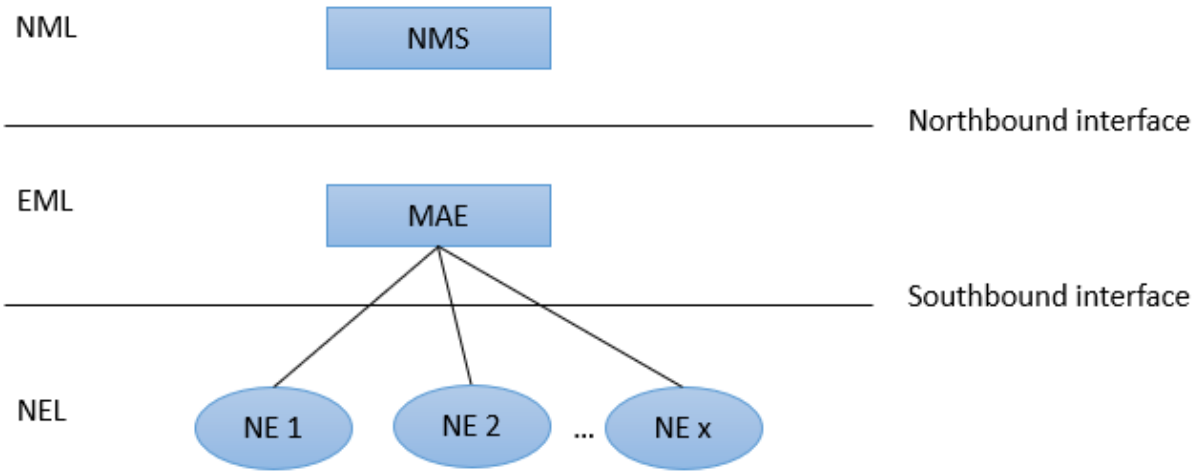


Fig .3.6. Network position of MAE

MAE consists of such subsystems:

- MAE-Access
- MAE-Deployment
- MAE-Optimization
- MAE-Evaluation

Let's consider each subsystem separately.

MAE-Access supports independent deployment and release. This subsystem centrally manages Huawei MBB devices, including WRAN, GBSS, SingleRAN, LTE, NR, WLAN and auxiliary networking devices used on MBB networks. MAE-Access provides basic network management functions, such as configuration management, performance management, fault management, security management. MAE-Access also provides external interfaces for interoperability with non-Huawei systems or vendors. It provides a web portal for unified O&M.

MAE-Deployment provides wizard, template and GUI-based data configuration. It

provides the functions of network-wide data check and configuration data comparison against the baseline cell. This ensures that the E2E data configuration of the entire radio access network is implemented in a secure and efficient manner. MAE-Deployment implements remote batch site deployment, quick network expansion, efficient network optimization and convenient base station reparenting, significantly improving configuration efficiency and accuracy.

MAE-Optimization provides automatic planning and optimization for multiple RATs, such as GSM, UMTS, LTE, NR and automatic coordination and optimization between RATs, improving O&M efficiency and reducing costs.

With the development and promotion of SingleRAN and HetNet as well as gradual large-scale deployment of 5G networks, hybrid networking scenarios integrated with different RATs are becoming increasingly popular. In such a complex wireless environment, operator requires a product that can help them gain insight into MBB network quality, implement agile O&M and open innovation and achieve precise investment. MAE-Evaluation centrally manages network devices such as GSM BSS, UMTS RAN, LTE RAN, SingleRAN and NR RAN, and also provides evaluation visualization and service O&M capabilities, improving O&M efficiency and reducing O&M costs.

The MAE hardware typically consists of MAE server and MAE clients and some networking devices. Taishan 200 server is a dual-socket rack server developed based on Huawei Kunpeng 920 processors. It features high-performance computing, large-capacity storage, low power consumption, easy management and deployment.

Based on the cloud platform, MAE implements logical modules such as network management, deployment, assessment, optimization and data analysis and various scenario-based applications as services and components. This allows customer to flexibly deploy MAE in modular manner to meet their requirements.

## CONCLUSIONS TO CHAPTER 3

Cloud Native has become one of the most heard concepts when people talk about 5G. In this section, the software and hardware required to build a database for a virtual operator were considered. As it turned out, it is quite possible to combine information about all 2G, 3G, 4G and 5G subscribers in one database. CloudUDM does all this. In this section, the main advantages of the solution were considered and it was described how reliably it can be used in operators' networks.

# CHAPTER 4
# APPROBATION OF THE PROJECT

## 4.1. About operator

"Intertelecom" is one of the mobile operators of Ukraine. Since its foundation, the company has become the undisputed leader among companies that offer their customers mobile 3G Internet.

The 3G Internet coverage area of the "Intertelecom" company is the largest in Ukraine. In addition to all regional centers, it covers more than 14,000 settlements. Also, 3G Internet from "Intertelecom" is available on all major highways and railways. Thanks to the introduction of innovative services and technologies, "Intertelecom" daily increases the number of customers.

Features of the service and competitive advantages of the company:

- services are provided in the CDMA standard. This ensures high quality of communication and its confidentiality. Also, this standard is much safer for health than others;
- 3G Internet has a wide coverage area, profitable unlimited tariffs, high speed;
- voice services provide a unique opportunity to use a mobile and landline number in one device. Subscribers can experience all the advantages of mobile and fixed communication at the same time;
- the home Wi-Fi Internet service allows you to use the worldwide network where it is impossible to connect leading technologies. At the same time, the tariffs are available to everyone.

During its activity, the company was repeatedly awarded prestigious prizes, became the winner of All-Ukrainian competitions.

The types of work performed by the operator are listed below:

- Activities in the field of wireless telecommunications

- Provision of other auxiliary commercial services
- Electrical works
- Non-specialized wholesale of food products, beverages and tobacco products
- Leasing of other machines, equipment and goods
- Repair of communication equipment
- Non-specialized wholesale trade
- Retail trade of telecommunications equipment in specialized stores
- Retail trade carried out by mail order firms or via the Internet
- Warehousing
- Activities in the field of wired telecommunications
- Activities in the field of telecommunications
- Activities in the field of information technologies and computer systems
- Data processing, posting of information on web sites
- Leasing and exploitation of own or leased property
- Professional, scientific and technical activity
- Installation and assembly of machines and equipment
- Construction of residential and non-residential buildings

### 4.2. Analysis of customer requirements

The customer asks to prepare a commercial proposal for the supply of HLR/HSS for 100,000 subscribers with an optional expansion for 200,000. With the use of the cloud platform as well as the requirements for alternative cloud service providers, in the calculations to indicate the average statistical load per subscriber available to Huawei, this decision is necessary for the organization of work on the light MVNO scheme with one of the GSM operators in Ukraine. For the proposed products, it is necessary to provide a full description of the functionality, as well as to indicate the basic and optional functions.

Specify a complete list of required interfaces in accordance with current ZTV standards for this type of network elements, specify the cost of integration in this direction.

### 4.3. The choice of solution

Before choosing the solution, I had to ask several questions for clarification from the regional experts and HQ.

They are:

- How many sites we will offer?
- What product we will choose?
- What kind of subscribers will be supported?
- Which business models are up to date?
- What is the price?

After a kick-off meeting was decided to propose 2 sites which will work in Active/StandBy mode. It means that all traffic will be on Active site, but when this site will go down, StandBy site will keep all traffic from the Active site. I hesitated, which product to choose, but the region experts helped me. They suggested to use CloudUDM as the main product for our database, because this product makes it possible to support 5G subscribers in the future. The main requirement was to deploy the solution on a cloud platform and this product fits perfectly. This product can support absolutely all subscribers including 2G, 3G, 4G and 5G. So, we can confidently say that this makes our product unique.

Huawei has many different business models, but the headquarters advised to use ASRF. Therefore, the customer was offered exactly this model, which includes permanent licenses and subscription.

After it is finally decided what will be offered, the question becomes what will be the price. The price is based on special discounts, they are different for each country and differ by region.

## 4.4. Solution description

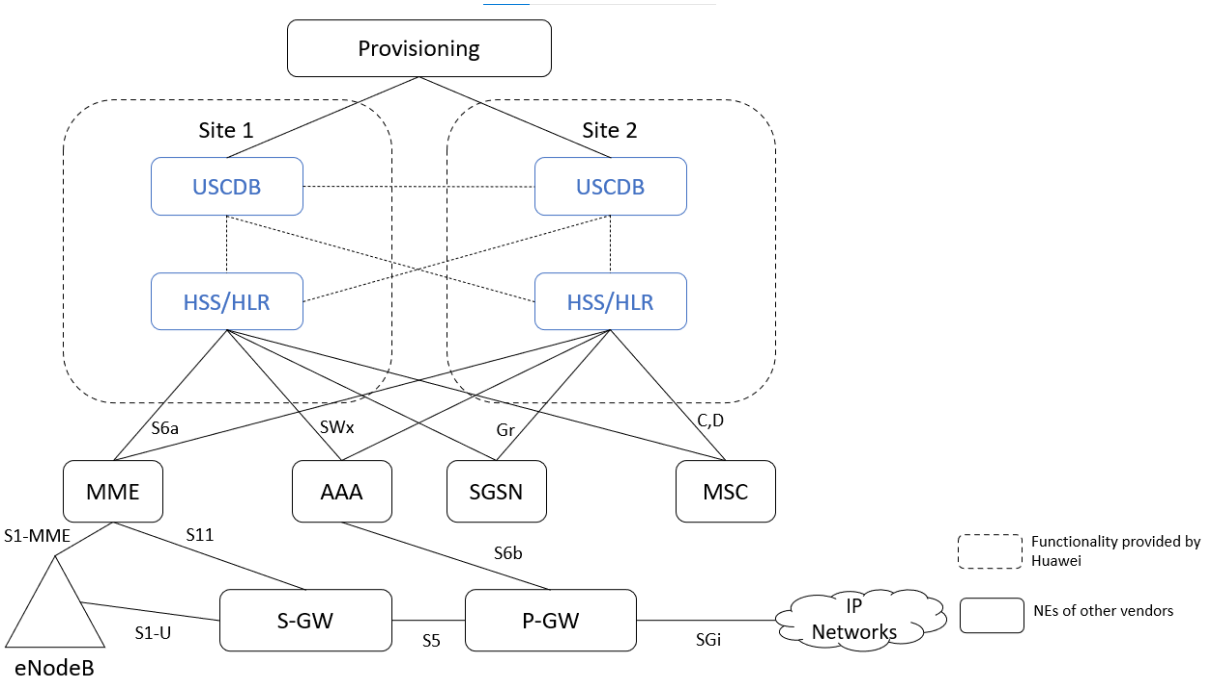


Fig. 4.1. Scheme of the solution

- Huawei offers UDM, which is a convergent solution that can operate with different domains, including such functionality as HLR/HSS.
- UDM is divided on FE and BE. HSS/HLR is responsible for FE and USCDB is for BE.
- Huawei offers 2 sites, which work as Active/StandBy redundancy mode

Table 4.1

Proposed solution

| Area | Product Type | Site 1 | Site 2 | SW Version | Logical Functions | Platform | Type |
|---|---|---|---|---|---|---|---|
| VNF | UDM | 1 | 1 | 22.1.0 | HLR/SAE-HSS | NFV | New build |
| | MAE-CN Access+LCM | 1 | 1 | V100R022C10 | OSS | NFV | New build |

End of table 4.1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| NFVI | FusionSphere | 1 | 1 | 22.1.0 | | NFV | New build |
| | eSight | 1 | 1 | 21.2 | - | NFV | New build |
| | E9000H-8 | 1 | 1 | | - | - | New build |
| | CM221 | 7 | 7 | | - | - | New build |
| | CE6881 (TOR Switch) | 2 | 2 | | - | - | New build |
| | CE6881 (EOR Switch) | 2 | 2 | | - | - | New build |
| | CE6863 (TOR Switch) | 2 | 2 | | - | - | New build |
| | NetEngine 8000 F1A (DCGW) | 2 | 2 | | - | - | New build |

The table below show the license distribution between the different generations.

Table 4.2

License Distribution

| **Site** | | **Site 1** | **Site 2** |
|---|---|---|---|
| **HW Capacity** (minimal configuration) | | >200 000 | >200 000 |
| **License Quantity** | **2G** | 8 000 | 8 000 StandBy |
| | **3G** | 42 000 | 42 000 StandBy |
| | **4G** | 50 000 | 50 000 StandBy |

| Site 1_Rack01 | | |
|---|---|---|
| 46 | DC-PDU 3U | 3U |
| 45 | | |
| 44 | | |
| 43 | Assembled Rail 1U | 1U |
| 42 | Dummy panel 1U | 1U |
| 41 | DC-PDU 3U | 3U |
| 40 | | |
| 39 | | |
| 38 | Cabling Slot 1U | 1U |
| 37 | Dummy panel 1U | 1U |
| 36 | Cabling Slot 1U | 1U |
| 35 | Dummy panel 1U | 1U |
| 34 | Cabling Slot 1U | 1U |
| 33 | Dummy panel 1U | 1U |
| 32 | Cabling Slot 1U | 1U |
| 31 | Dummy panel 1U | 1U |
| 30 | CE6881-48S6CQ_TOR02 | 1U |
| 29 | Cabling Slot 1U | 1U |
| 28 | CE6881-48S6CQ_TOR01 | 1U |
| 27 | Cabling Slot 1U | 1U |
| 26 | CE6881-48S6CQ_EOR02 | 1U |
| 25 | Cabling Slot 1U | 1U |
| 24 | CE6881-48S6CQ_EOR01 | 1U |
| 23 | Cabling Slot 1U | 1U |
| 22 | 5300 V5(Controller Enclosure) | 2U |
| 21 | | |
| 20 | Cabling Slot 1U | 1U |
| 19 | 5300 V5(Controller Enclosure) | 2U |
| 18 | | |
| 17 | Cabling Slot 1U | 1U |
| 16 | 5300 V5 (Disk Enclosure) | 2U |
| 15 | | |
| 14 | 5300 V5 (Disk Enclosure) | 2U |
| 13 | | |
| 12 | 5300 V5 (Disk Enclosure) | 2U |
| 11 | | |
| 10 | Cabling Slot 1U | 1U |
| 9 | E9000H-8U | 8U |
| 8 | | |
| 7 | | |
| 6 | | |
| 5 | | |
| 4 | | |
| 3 | | |
| 2 | | |
| 1 | Assembled Rail 1U | 1U |

Fig. 4.2. 1-st subrack for Site 1

| Site 1_Rack02 | | |
|---|---|---|
| 46 | DC-PDU 3U | 3U |
| 45 | | |
| 44 | | |
| 43 | Assembled Rail 1U | 1U |
| 42 | Dummy panel 1U | 1U |
| 41 | DC-PDU 3U | 3U |
| 40 | | |
| 39 | | |
| 38 | Cabling Slot 1U | 1U |
| 37 | NetEngine 8000 F1A-8H20Q_02 | 2U |
| 36 | | |
| 35 | Cabling Slot 1U | 1U |
| 34 | NetEngine 8000 F1A-8H20Q_01 | 2U |
| 33 | | |
| 32 | Cabling Slot 1U | 1U |
| 31 | CE6863E-48S6CQ_TOR | 1U |
| 30 | Cabling Slot 1U | 1U |
| 29 | CE6863E-48S6CQ_TOR | 1U |
| 28 | Cabling Slot 1U | 1U |
| 27 | Dummy panel 1U | 1U |
| 26 | Cabling Slot 1U | 1U |
| 25 | Dummy panel 1U | 1U |
| 24 | Cabling Slot 1U | 1U |
| 23 | Dummy panel 1U | 1U |
| 22 | Cabling Slot 1U | 1U |
| 21 | Dummy panel 1U | 1U |
| 20 | Cabling Slot 1U | 1U |
| 19 | Dummy panel 1U | 1U |
| 18 | Cabling Slot 1U | 1U |
| 17 | Dummy panel 1U | 1U |
| 16 | Cabling Slot 1U | 1U |
| 15 | Dummy panel 1U | 1U |
| 14 | Cabling Slot 1U | 1U |
| 13 | Dummy panel 1U | 1U |
| 12 | Cabling Slot 1U | 1U |
| 11 | Dummy panel 1U | 1U |
| 10 | Cabling Slot 1U | 1U |
| 9 | Dummy panel 1U | 1U |
| 8 | Cabling Slot 1U | 1U |
| 7 | Dummy panel 1U | 1U |
| 6 | Cabling Slot 1U | 1U |
| 5 | Dummy panel 1U | 1U |
| 4 | Cabling Slot 1U | 1U |
| 3 | Dummy panel 1U | 1U |
| 2 | Cabling Slot 1U | 1U |
| 1 | Assembled Rail 1U | 1U |

Fig. 4.3. 2-nd subrack for Site 1

### 4.4. Features description

Table 4.3

Short-list feature description

| Feature | Description |
|---|---|
| Provisioning system interface | Enables the USCDB to manage data for third-party applications over XML/SOAP interface. |
| Subscriber management | Stores and manages all subscriber-related data, includes subscriber identities, authentication data, subscription data, and location information. |
| AuC data management | Allows carriers to efficiently manage international mobile subscriber identities. After subscriber data has been migrated to a new HLR, the independent AuC can promptly identify the serving HLR based on the mapping between IMSIs and HLR numbers and forward messages to the serving HLR for processing. |
| Storing and managing transparent data | Simplifies data management on As by enabling IMS-HSS to store repository data for it. Reduces the amount of data configured and facilitates data maintenance and access by enabling multiple IMPUs to share alias repository data. |

Continuation of the table 4.3

| | |
|---|---|
| Speech/Telephony | Enables mobile subscribers to communicate with the subscribers in the PSTN, ISDN and PLMN over telephones. Enables carriers to increase the operation revenue. |
| Emergency call | Enables subscribers to make emergency calls without a SIM/USIM card. |
| Short Message Service | Allows subscribers to send and receive a small number of characters through the short message center. |
| CFU service | Allows the incoming calls to addressed to a subscriber to be forwarded to a third-party, regardless of status of the subscriber's MS. |
| CFB service | Allows the incoming calls addressed to a subscriber to be forwarded to another number or a voice mailbox when the subscriber is engaged in a call or service. |
| Call waiting/Call hold | Enables a mobile subscriber to be notified of an incoming call notification in such scenarios:<br>1) There is no idle service channel for the incoming call.<br>2) The subscriber is already engaged in a call.<br>3) The subscriber has a call on hold. |
| MPTY service | Enables a subscriber to originate a multi-connection call. |

End of table 4.3

| | |
|---|---|
| AoC service | Provides the real-time call charge display function. |
| CLIP service | Enables callees to determine whether to answer calls based on the calling numbers presented on MSs. |

Together with Intertelecom, we calculated the number of subscribers to be used on the network and how this traffic should grow using Huawei's internal software.

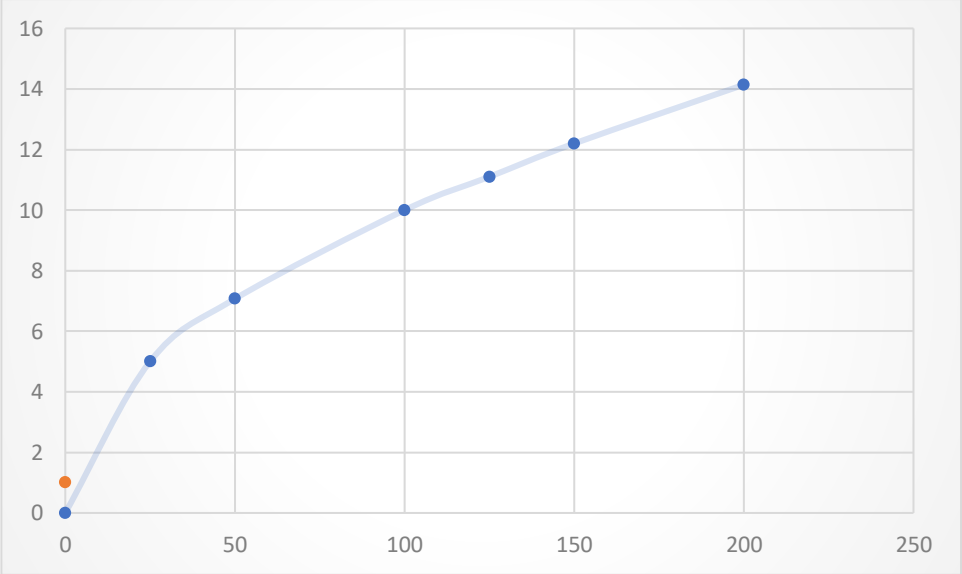


Fig. 4.4. Projected growth of subscribers on the Intertelecom network

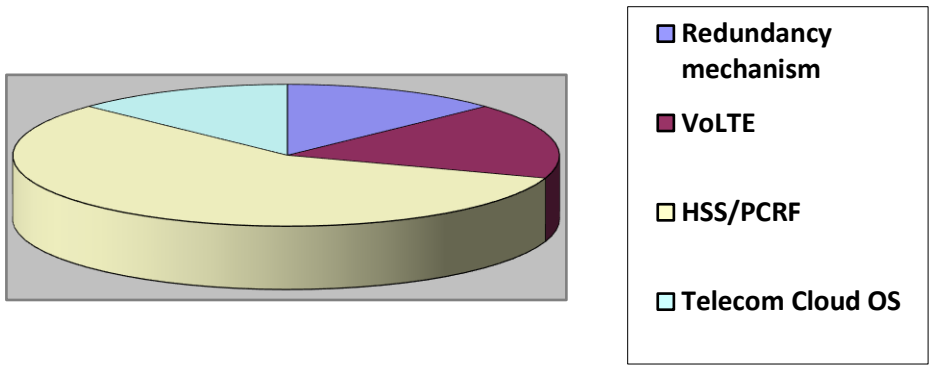


Fig. 4.5. Analyzes of possible errors

The diagram above, shows the most common errors that occur due to converged data errors on customer's network, especially they are occurred by Signaling Storm.

If you purchase the CloudUDM solution, these errors will decrease to 5%.

## CONCLUSIONS TO CHAPTER 4

In this section, we got acquainted with the Intertelecom company, what services it provides, and also discussed in more detail what exactly will be offered to Intertelecom by the Huawei company.

# CHAPTER 5
# LABOR PROTECTION

In this section, I will describe in more detail the working conditions and the factors that can affect an employee at work. Ensuring security when installing equipment such as servers and routers is a critical step for an efficient and uninterrupted network. Before you perform any action, you need to familiar with all instructions, especially the dangers, warnings and cautions mentioned in product documents. This can avoid damaging devices or hurting human bodies, and can minimize the risk accidence. Before you install and maintain the devices, be sure to read all documents on safety information shipped with the devices. If the contents in this document are not consistent with the information mentioned in those documents, refer to the documents shipped with the devices. When you perform operations, observe the local safety directives. If the safety preventive measures in this document conflicts with the local safety directives, follow the local safety directives. Only the qualified professionals can install and maintain the devices. They must be trained and familiar with correct operations skills and all safety preventive measures.

## 5.1. General security precautions

**General Instructions:**

- Comply with the local laws and regulations when installing the hardware. The safety instructions in this document are only supplements to the local laws and regulations.
- The "CAUTION", "WARNING", and "DANGER" notices in this document are only supplements to the safety instructions in this document.
- To ensure personal and device safety, follow all safety instructions on device labels and in this document when installing the hardware.

- Only personnel (such as electricians and forklift operators) who are certified by the local government or official organizations are allowed to perform hardware installation.
- The product is a class A device. Operation of this product in a residential area is likely to cause radio interference in which case users will be requested to correct the interference by taking protective measures.

**Basic Requirements:**

Installation and maintenance personnel must understand basic safety precautions to avoid hazards.

- Only trained and qualified personnel are allowed to install, operate, and maintain Huawei equipment.
- Only qualified professional engineers can remove security facilities and troubleshoot equipment.
- Only personnel certified or authorized by Huawei are allowed to replace or modify Huawei equipment or components (including software).
- Operators are required to notify the related owners in a timely manner of any faults or errors that may cause security problems.

**Grounding Requirements:**

The following requirements are only applicable to the equipment that needs to be grounded.

- To install the equipment, connect the PGND cables first. To uninstall the equipment, remove the PGND cables last.
- Do not damage grounding conductors.
- Do not perform operations on the equipment before grounding conductors are installed.

- The equipment must be grounded permanently. Before performing operations on the equipment, check the electrical connection of the equipment to make sure that the equipment is grounded reliably.

**Personal Safety:**

- To avoid electric shocks, do not connect safety extra-low voltage (SELV) circuit terminals to telecommunication network voltage (TNV) circuit terminals.
- Do not look into the optical port without eye protection. This protects your eyes from being burnt.
- Before the operation, wear the antistatic uniform, wrist straps, and gloves, and remove conductive objects such as ornaments and the watch to avoid electric shock or burn.
- In case of fire, leave the buildings or equipment room and press the fire alarm bell or call the fire department. Do not enter a building on fire again in any situation.

**Equipment safety**

- Before performing operations, place the equipment firmly on the ground or other stable objects, such as walls or installation racks.
- During the running of the system, do not block the intakes.
- When installing a panel, use a tool to tighten the screws.
- After installing the equipment, clear the empty packaging materials from the telecommunications room.

## 5.2. Electrical safety

### High Voltage

- The high voltage power supply provides power for the device operation. Direct or indirect contact (through conductive objects) with high voltage power supply may result in fatal danger.
- Non-standard and improper high voltage operations may result in fire and electric shock.

### Thunderstorm

Do not perform any operation, including high voltage and AC operations, on a steel tower or mast during a thunderstorm.

### High Electrical Leakage

Ground the device before powering it on. Otherwise, personal injury or device damage may be caused by high leakage current.

### Power Cable

Do not install or remove power cables when the device is on. Transient contact between the core of the power cable and the conductor may generate electric arcs or sparks, which may cause fire or hurt human eyes.

- Use power cables dedicated for the server to ensure equipment and personal safety.
- Do not use power cables dedicated for the server on other devices.
- Before installing or removing the power cable, turn off the power switch.

- Before connecting a power cable, check that the label on the power cable is correct.

**Fuse**

If a fuse is to be replaced, the new fuse must be of the same type and specifications.

**Electrostatic Discharge**

The static electricity generated by human bodies may damage the electrostatic-sensitive components on boards, for example, the large-scale integrated (LSI) circuits.

- Human body movement, friction between human bodies and clothes, friction between shoes and floors, or handling of plastic articles causes static electromagnetic fields on human bodies. These static electromagnetic fields cannot be eliminated until the static is discharged.
- To prevent electrostatic-sensitive components from being damaged by the static on human bodies, you must wear a well-grounded ESD wrist strap when touching the device or handling boards or application-specific integrated circuits (ASICs).

**Laser**

When handling optical fibers, do not stand close to or look at the optical fiber outlet directly with unprotected eyes.

Laser transceivers or transmitters are used in optical transmission systems and associated test tools. The laser transmitted through optical fibers has very high power density and is invisible to human eyes. A beam of light causes damage to the retina.

Looking at an un-terminated fiber or damaged fiber with unprotected eyes at a distance greater than 150 mm (6 inches) does not cause eye injury. Eye injury, however, may be caused if an optical tool such as a microscope, magnifying glass, or eye loupe is used to view the

energized fiber end.

## 5.3. Working at heights and mechanical safety

### *5.3.1. Working at heights*

Avoid object falling when you work at heights.

When working at heights, fulfill the following requirements:

- Only trained personnel can work at heights.
- Prevent the devices and tools that you carry from falling down.
- Take safety and protection measures, for example, wear a helm and safety belt.
- Wear warm clothes when working at heights in a cold region.
- Before working at heights, check that all the lifting facilities are in good condition.

Do not walk below the cantilever or hoisted objects when heavy objects are being hoisted.

1. Only trained and qualified personnel can perform hoisting operations.
2. Before hoisting heavy objects, check that the hoisting tools are complete and in good condition.
3. Before hoisting heavy objects, ensure that the hoisting tools are fixed to a secure object or wall with good weight capacity.
4. Issue orders with short and explicit words to avoid misoperations.
5. Ensure that the angle formed by two cables is not larger than 90 degrees.

**Using a ladder**

*Checking a Ladder*

- Check whether the ladder is damaged. Only the ladder in good condition can be used.

- Check the maximum weight capacity of the ladder. Avoid overweighing the ladder.

*Placing a Ladder*

The recommended gradient of ladders is 75 degrees. You can measure the gradient of the ladder with an angle square or your arms. See Figure Slant angle. When using a ladder, ensure that the wider feet of the ladder are downward, or take protection measures for the ladder feet to prevent the ladder from sliding. Ensure that the ladder is placed securely.

*Climbing up a Ladder*

When climbing up a ladder, note the following:

- Ensure that the center of gravity of your body does not deviate from the edges of the two long sides.
- To minimize the risk of falling, hold your balance on the ladder before any operation.
- Do not climb higher than the fourth rung of the ladder (founted from up to down).
- If you want to climb up a roof, ensure that the ladder top is at least one meter higher than the roof.

### *5.3.2. Mechanical safety*

**Drill holes**

Do not drill the cabinet at will. Unqualified drilling deteriorates the electromagnetic shielding performance of the cabinet and damages the internal cables. In addition, metal filing generated by unqualified drilling will cause short circuits in the cabinet.

- Before drilling holes, remove internal cables from the cabinet.
- Wear an eye protector when drilling holes. This is to prevent your eyes from being injured by splashing metal scraps.

- Wear protective gloves when drilling holes.
- Ensure that the scraps caused by drilling do not enter the cabinet. After drilling, clean the metal scraps immediately.

**Carrying Sharp Objects**

Before you hold or carry a kevice, wear protective gloves to avoid getting injured by sharp edges of the device.

**Handling Fans**

- When replacing a component, place the component, screws, and tools in a safe place. Otherwise, if any of them fall into the operating fans, the fans may be damaged.
- When replacing a component near fans, do not insert your fingers or boards into the operating fans until the fans are switched off and stops running.

**Lifting Heavy Objects**

When moving heavy objects, wear protective gloves to avoid hurting your hands.

- Exercise caution to avoid injury when moving heavy objects.
- Be careful when pulling a chassis out of the rack to avoid any injury to the human body caused by unstable or heavy devices.
- Do not move a heavy chassis by yourself. Work with your partner. When moving a chassis, keep your back straight and move smoothly to avoid any injury.
- Hold the chassis handles or bottom edges when moving or lifting a chassis. Do not use the handles on any component, such as fan modules, PSUs or boards.

**5.4. Other**

### Installing and Removing a Board

When installing a board, wear ESD gloves or an ESD wrist strap, use proper force to prevent the pins on the board from being leaned.

- Insert the board along the guide rails.
- Prevent the surface of a board from contacting the surface of another board. This is to prevent the boards from being short-circuited or scratched.
- To prevent electrostatic-sensitive devices from being damaged by the ESD, do not touch the circuits, components, connectors, or connection slots on boards.

### Binding Signal Cables

Do not bundle signal cables with high current cables or high voltage cables.

### Laying out Cables

When the temperature is extremely low, violent strike or vibration may damage the cable sheathing. To ensure safety, comply with the following requirements:

- Cables can be laid or installed only when the temperature is higher than 0°C.
- Before laying out cables which have been stored in a temperature lower than 0°C, move the cables to an environment of the ambient temperature and store them at the ambient temperature for at least 24 hours.
- Handle cables with caution, especially at a low temperature. Do not drop the cables directly from the vehicle.

## CONCLUSIONS TO CHAPTER 5

In order to avoid any injuries, the engineer must comply with all safety measures. Location of server rooms in accordance with standards. Restrict access to server rooms using biometric systems or key cards. Use of antivandal-proof and waterproof equipment. Setting up network firewalls to filter traffic. Use strong passwords and change them regularly. Encrypt communications between servers and routers. Regularly update software on servers and routers. Applying security patches to close identified vulnerabilities.

# CHAPTER 6
# ENVIRONMENTAL PROTECTION

## 6.1. Analysis of the impact of man-made factors on the environment

Man-made factors can have a significant impact on the environment. This impact can be either negative or positive, depending on the nature and level of management of the anthropogenic processes. Now I will describe the negative and positive impacts.

Table 6.1

Description of impacts on the environment

| **Type of impacts** | **Description** |
|---|---|
| Air pollution | Emissions of harmful gases and particles from industrial sources can lead to air pollution, which has a negative impact on air quality and human health. |
| Water pollution | Waste and emissions from industrial facilities can enter water sources, causing water pollution and potentially damaging ecosystems. |
| Biodiversity | The loss of natural areas due to infrastructure development, resource exploitation and other activities can lead to a decrease in biodiversity and species extinction. |

End of table 6.1

| | |
|---|---|
| Soil contamination | Emissions of toxic substances and the use of chemicals can lead to soil contamination and negatively impact agriculture. |
| Global warming | Greenhouse gas emissions from industrial sources can contribute to global warming and climate change. |

It is important to note that the rational management of technogenic processes, resource use and the introduction of environmental technologies can contribute to a balanced development in which the environment and economy exist in harmony.

### 6.2. Operation of base stations and cellular devices and their impact on the environment

Base stations and cellular devices play an important role in wireless communications and provide coverage for the mobile network. They are used to transmit signals between mobile devices and to provide mobile services. However, their use can also have some negative impacts on the environment.

Base stations are the equipment that receives signals from mobile devices and transmits them through the network to other base stations or to the network operator's central office. They are located on towers or special masts to ensure optimal coverage and connectivity.

Cellular devices are mobile phones, smartphones, tablets and other devices that use base stations to communicate on the network. Each area is served by a specific base station and devices automatically connect to the strongest signal.

Wireless networks, such as mobile networks, emit electromagnetic fields. There is currently no consensus on whether electromagnetic radiation at the levels that exist from base stations and mobile devices can be harmful to human health. Base stations and cellular devices require electricity to operate. A large number of such devices can cause significant electricity

consumption. The installation of base stations can have an impact on the natural environment and local wildlife. This may include changes in animal behaviour or the destruction of some plants. A large number of towers and masts for base stations can affect the landscape and visual aspect of nature, especially in sparsely populated areas. Old, obsolete base stations and mobile devices can become a source of e-waste that needs to be disposed of responsibly. To reduce the negative impact on the environment, it is important to consider alternative energy sources, improve energy efficiency technologies and take into account environmental aspects when placing base stations.

Ukraine has one of the most stringent standards for electromagnetic radiation in residential and public buildings. The maximum permissible level of electromagnetic radiation in Ukraine is 2.5 μW/cm$^2$, while in Russia, Belarus and Hungary it is 10 μW/cm$^2$, and in Scandinavian countries it is 100 μW/cm$^2$.

According to Article 31 of the Law of Ukraine "On Telecommunications", business entities engaged in the construction of public telecommunications networks may install telecommunications equipment in premises owned by them on a lease basis, use roofs and technical premises to install antennas and necessary equipment on the basis of an agreement with the owner of the premises. Instrumental measurements showed a maximum energy flux density of 0.45 μW/cm$^2$, while the norm is 2.5 μW/cm$^2$.

The antennas are installed at the highest point in the area and are directed in such a way that the main energy (more than 90%) is concentrated in a rather narrow "beam" (similar to the light from a flashlight). This energy beam is always directed away from the base structure and above the surrounding buildings. For this reason, antennas cannot directly affect human health.

It's not the antenna that's harmful, it's the phone. The fear of base stations is mostly psychological. They are visible everywhere and look threatening. Because of this, a person subconsciously finds himself or herself with a sore, allegedly acquired due to radiation from the antenna. In fact, mobile phones cause much more harm to people, especially young people as the main users. More precisely, it is their misuse.

The fact is that at the moment of connection, powerful electromagnetic radiation is

emitted. It is much higher than normal, so you should not hold the phone to your ear at this time. In areas with poor coverage, the phone uses maximum power during operation. The situation is similar when travelling in transport, where the metal frame also reflects and concentrates the radiation.

You can reduce your exposure to electromagnetic radiation by wearing a headset. This prevents you from holding the phone to your head, reducing your exposure to mobile phone waves. Also, do not carry your mobile phone in your pocket or put it in a belt case. It is best to keep it away from your body, for girls and women in bags, for boys and men in a backpack or purse. Do not use your phone as an alarm clock by placing it close to you at night. People with cardiovascular diseases and people with a pacemaker should use their mobile phones with great care.

### 6.3. Methods and means of protecting the environment from the impact of man-made factors

Protecting the environment from the impact of anthropogenic factors is a critical task for ensuring sustainable development and preserving ecosystems. Reducing the use of traditional energy sources and switching to renewable energy sources, such as solar, wind, and hydroelectric power. Promote energy efficiency in industry and households. Developing and implementing effective waste sorting and recycling systems.

Minimize the use of disposable materials and packaging. Use of energy-efficient materials and technologies in construction. Designing green roofs and walls to increase the amount of green space in cities. Efficient water management and reduction of water pollution from industrial and agricultural waste. Use of water purification technologies and restoration of aquatic ecosystems. Forestry and reforestation by planting trees to compensate for deforestation. Protecting ecosystems and biodiversity through the zoning of protected areas. Introducing cleaner production technologies and emission treatment systems. Development and implementation of innovative technologies aimed at reducing emissions. Use of energy-efficient light-emitting diode (LED) light sources and low-intensity lighting systems in public

facilities and on the streets. Encourage public and private enterprises to adopt environmental practices and standards.

Provide financial incentives for research and development in the field of sustainable development. Developing and implementing environmental standards and regulations for various industries and activities. Conducting regular monitoring to identify negative environmental impacts and respond to potential problems in a timely manner. Due to the increasing negative impact on the environment of all types of human activity in recent years, there has been a need to organize periodic and continuous long-term observations and assessments of the overall situation. The following are monitored environmental conditions both around individual polluting facilities and within districts, regions, continents, and the entire planet. A whole system of such research, observation and operations, which is called environmental monitoring. The main purpose of monitoring is to objectively assess the state of the environment and its components within the studied areas, in order to make the right decisions on nature protection and rational decisions on nature protection and rational use of its resources.

In 1975, a global monitoring system was established under the auspices of the United Nations. Today, environmental monitoring (from the Latin monitor - warning, caution) is understood as a system of observations, assessment and control of the state of the environment to develop measures for its protection, rational use of natural resources, anticipation of critical environmental situations and preventing them, forecasting the scale of possible changes.

The organisation, collection, processing and dissemination of monitoring data should provide the necessary information for solving management tasks at different levels

- from a single facility (chemical plant, livestock farm, airfield, etc.) to a large region or the entire planet, as the three levels are interconnected.
- a large region or the entire planet, as all three levels are interconnected.

Environmental monitoring data become an effective tool for nature protection only if they are available to the general public through the media (as evidenced by the experience of media (this is confirmed by the experience of Germany, the USA, Sweden, Japan, Norway and other countries).

Monitoring data should help to find ways to optimise the relationship between humans and nature. At the local level, this means monitoring specific objects, their resource and energy consumption, composition and volume of environmental pollution, control over compliance with environmental protection laws, the state of landfills, storage of mineral fertilisers and pesticides, prohibited (secret) emissions and waste discharges.

At the regional level (basins of large rivers, reservoirs, geographical or economic districts or regions), it is the identification of pollutant migration routes (air water), determining the amount of migrating toxicants, the main sources of pollution the environment in the region, selecting permanent environmental monitoring stations, identifying of priority environmental tasks, and the preparation of regional environmental protection plans.

At the global level, this includes monitoring the state of the ozone layer, the development of the greenhouse effect, the formation and fall of acid rain, the state of the hydrosphere of the planet (especially in the event of accidents on the seas and oceans), forest fires, the formation and movement of hurricanes, sandstorms and other natural and man-made catastrophic events on a global scale.

Monitoring stations are located in environmentally friendly areas. Observations of the state of the environment can be carried out on the ground (by direct contact) and by aircraft and with the help of aeroplanes, helicopters, satellites, spacecraft, meteorological rockets. They may differ in tasks, methods, scope of work.

Today, all types of environmental monitoring are carried out at all levels around the world. International cooperation helps to carry out global environmental monitoring, and its data is processed in special international centres and transferred for study and decision-making to special environmental and decision-making to special environmental international organizations under the UN and to the governments of governments of the world's largest countries.

The concepts of sound absorption and sound insulation are often equated, although there is a fundamental difference between them that must be taken into account when solving practical noise control problems. The sound absorption method is most often used in industrial premises. Sound absorption is the reduction of the energy of sound waves reflected from

oncoming obstacles by converting sound energy into heat. Sound absorption is used when it is impossible to reduce noise at the source.

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The sound absorption method is most often used in industrial premises. Sound absorption is the reduction of the energy of sound waves reflected from oncoming obstacles by converting sound energy into heat. Sound absorption is used when it is impossible to reduce noise at the source. Soundproofing is designed to reduce the penetration of noise into an isolated room or residential area from a source located in a neighbouring room or open space.

The acoustic effect of such structures is mainly due to the sound barrier from surfaces made of dense solid materials (concrete, brick, steel, etc.). Sound-absorbing materials and structures are used to absorb sound both in the room of the noise source itself and in rooms isolated from noise. In the latter case, sound absorption and sound insulation methods are used simultaneously.

The method of sound insulation is most often used to determine the amount of reduction of noise penetration into the atmosphere from fan installations, production equipment and other noisy objects. For this purpose, various designs of soundproofing enclosures, screens, covers and cabins are used. Many studies have shown that for more effective sound insulation, it is necessary to use enclosures with a high acoustic resistance. Acoustic theory tells us that when sound incident at a normal (90°) angle on the boundary of two media with different acoustic impedances

Protecting against electromagnetic radiation (EMR) is an important task because a variety of devices and technologies, such as mobile phones, computers, microwaves, wireless networks, etc., generate electromagnetic fields. Although some studies do not provide conclusive evidence of the harmfulness of low-frequency electromagnetic fields, many people are concerned about possible health effects.

Use electronics that meet electromagnetic compatibility (EMC) requirements. Purchase mobile phones and other devices that are labelled as "Low SAR" (Specific Absorption Rate),

which indicates a low level of energy absorption. Use narrowband devices, such as corded phones, instead of cordless phones whenever possible. Keep wireless devices away from your body, especially when in use. Avoid prolonged proximity to sources of electromagnetic fields, such as microwaves. Switch off mobile phones, wireless networks and other wireless devices when not in use. Switch off electronics in the bedroom when sleeping. Use offline modes when you do not need active wireless communication. Use interference screens on mobile phones that can reduce electromagnetic radiation. Choose power cords and adapters that comply with EMC and EMC safety standards. Use shielded cables to connect devices to the network to reduce radiation. Consider electromagnetic safety issues when building and designing your living spaces by using environmentally friendly materials and technologies. Avoid prolonged exposure to strong sources of electromagnetic radiation, such as high-voltage power lines.

## CONCLUSIONS TO CHAPTER 6

Environmental protection is one of the most important areas of activity in the modern world, as ensuring sustainable development and preserving natural resources are key tasks for the well-being of society. The intensive development of electronics and radio engineering has caused pollution of the environment with electromagnetic radiation (fields).

Their main sources are radio, television and radar stations. They are located near every regional centre, many district centres, and large cities are located television centres or repeaters, radio centres, radio communication facilities for various radio centres, and radio communications equipment for various purposes. In order to reduce the impact of electromagnetic fields on personnel who are in the area of operation of some radio electronic equipment, a number of protective measures are required: organisational, engineering, technical and medical and preventive measures.

# CONCLUSION

In this diploma work, my goal was to show where a virtual operator can be deployed and to develop a database for it.

In the CHAPTER 1, I have considered the expediency of convergent networks and what a mobile virtual operator is.

In the CHAPTER 2, my mission was to understand in more detail and show the architecture of the virtual operator, where exactly it can be deployed and what network elements are required for this, with which interfaces the interaction takes place.

In the CHAPTER 3, I considered deeply the CloudUDM solution, which can be applicable for the carriers. With the help of this solution, it becomes possible to deploy a database that can work on two sites in Active/StandBy mode.

In the CHAPTER 4 the approbation of the project is shown, namely a real case that happened to me when the Intertelecom operator asked to develop the HLR/HSS functionality and specifically according to the MVNO scheme.

In the CHAPTER 5 was described how to avoid the injury of an engineer.

In the CHAPTER 6 I mentioned about processes, how to avoid environmental pollution.

So, in my opinion, the goal has been achieved, now Intertelecom is considering our offer and I hope that a tender will begin in which Huawei will win and become a vendor for an operator with which it will have excellent partnership relations

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