UDC 004. 05 **doi: 10.26906/SUNZ.2025.3.173-176**

Yuliia Andrusenko[1], Serhii Datsenko[2]

[1] Kharkiv National University of Radio Electronics, Kharkiv, Ukraine
[2] National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine

FEATURES OF PLANNING MOVABLE CLOUD VOIP SERVICE

Abstract. The article discusses approaches to planning a non-stationary cloud VoIP service, which is characterized by dynamic load variations and increased quality of service requirements. Key parameters of effective service operation are analyzed, including traffic forecasting, adaptive allocation of computing resources, infrastructure scalability, load balancing, and fault tolerance. It is shown that the use of cloud technologies ensures flexibility and high availability of VoIP services, while also reducing infrastructure costs. Special attention is paid to challenges related to minimizing network latency and maintaining stable voice call quality. The obtained results can be applied to optimize the processes of designing and managing cloud-based telecommunication systems.

Keywords: VoIP service, cloud, computer system, infrastructure cost, scalability, traffic.

Introduction

The current stage of information technology development is characterized by the widespread use of cloud computing and services that provide scalability, flexibility and high availability of computing resources. One of the most popular areas of application of cloud platforms is the implementation of voice communication systems over the Internet (VoIP), which allows to significantly reduce the costs of telecommunications infrastructure and ensure integration with other digital services [1, 2]. However, unlike stationary solutions, cloud VoIP services have a dynamic nature of the load, which varies depending on the number of users, time of day and external conditions. This necessitates the development of effective planning methods that can take into account the non-stationary nature of traffic and the peculiarities of the cloud infrastructure. Important tasks in this regard are ensuring quality of service (QoS), optimal use of resources and minimizing delays in voice data transmission [3, 4].

Thus, the relevance of the research lies in creating approaches to planning a non-stationary cloud VoIP service that will increase the efficiency of using computing and network resources, as well as ensure high quality communication under variable load conditions.

Main part

Large and small corporations are implementing VoIP technology in their companies to reduce operational costs at the infrastructure level.

It has a simpler connection and requires less hardware. In addition, VoIP is considered a long-term perspective for service development, offering greater flexibility and more capabilities than the traditional telephone network – Public Switched Telephone Network – PSTN. It is able to cope with various workloads, dynamically adapting resources depending on demand. Service provision scheduling depends not only on the properties of the infrastructure handling calls and video conferences, as well as transmitting data, etc., but also on other users sharing the resources.

This problem is complicated by the unpredictable impact of time delays when starting VMs, changing call processing speeds depending on the codecs used, and uncertain call times. Traditional solutions do not adequately account for such uncertainty, infrastructure heterogeneity, and dynamic performance changes inherent in scalable VoIP services.

To better understand the implications of such non-stationarity, this chapter examines the properties of VoIP scheduling proposed in Table 1.

Table 1 – **Key Parameters of Planning a Non-Stationary Cloud VoIP Service**

Parameter	Description	Impact on Service Quality
Traffic Forecasting	Consideration of peak and minimum values of VoIP traffic	Helps avoid overload and packet loss
Resource Allocation	Dynamic distribution of virtual machines, CPU, and memory	Ensures stability and performance
Infrastructure Scalability	Horizontal and vertical scaling in the cloud environment	Increases flexibility and availability
Load Balancing	Distribution of VoIP sessions across different nodes	Reduces delays and probability of failures
Reliability and Fault Tolerance	Use of redundancy and recovery mechanisms	Maintains service continuity
Infrastructure Costs	Optimization of resource usage and cloud services	Reduces financial expenses

Asterisk powers IP Pate Bank Exchange PBX systems in CVoIP solutions. Asterisk runs in VMs to provide calls, voice mail, video/audio conferencing, interactive phone menus, call distribution, etc. In addition to transmitting images and text, users can create new functionalities, opening up a completely new telephony experience. The success of CVoIP largely depends on QoS and price. QoS is the first aspect to be considered in the model because it has more stringent constraints and sensitivities. Call delivery and processing determine QoS in CVoIP. The most important aspect of call delivery is adequate voice transmission over IP network. It depends on the time it takes for packets to travel across the Internet, delays in router queues, time it takes for packets to travel from source to destination, packet delay variations (jitter), packet loss, etc. Adequate voice quality is the most important aspect of call processing. It takes into account the time it takes to set up and tear down a call, as well as to convert the voice portion of the call into packets transmitted over the network.

Voice quality is subjectively perceived by the listener. A common criterion used to determine voice quality is the Mean Opinion Score (MOS). It evaluates the speech quality provided by a codec. Each codec provides a certain speech quality only at a sufficiently low processor load. Theoretically, 100% processor load provides the best expected performance. However, at loads of up to 85%, the processor cannot cope with the load, and jittering and breaks in sound appear [5]. Moreover, additional elements inherent to cloud environments may affect call QoS, such as the deployment time of the virtual infrastructure of the CVoIP system, encryption of VoIP traffic, etc. All these factors must be studied in order to minimize their impact on voice quality and ensure correct call processing. Cost is the second aspect that must be taken into account for the success of the CVoIP model. CVoIP providers must optimize the rental and use of resources in order to offer competitive prices to potential customers. Moreover, inefficient resource management has a direct negative impact on performance and cost. Rental of VMs in the cloud is used as a parameter for assessing the cost of the CVoIP service. It allows providers to measure the cost of the system in terms of resource demand and the time of their use. CVoIP providers can offer the user economical and adequate services if: 1) the rental of resources for providing the service is as low as possible; 2) the use of resources is low enough to guarantee voice quality, and therefore the quality of the service. Both goals are in conflict. The provider should maximize the resource utilization to reduce the infrastructure cost, but this worsens the QoS. On the other hand, reducing the resource utilization guarantees the QoS, but increases the infrastructure rental cost. VoIP providers use load balancing techniques to achieve high QoS and reduce costs. Unfortunately, the existing techniques are ineffective in large-scale systems such as cloud computing. In recent years, various algorithms have been presented to overcome the problems of CVoIP. However, call distribution in CVoIP considering QoS and provider cost optimization is still poorly understood. This chapter formulates the problem of scheduling VoIP services in cloud computing.

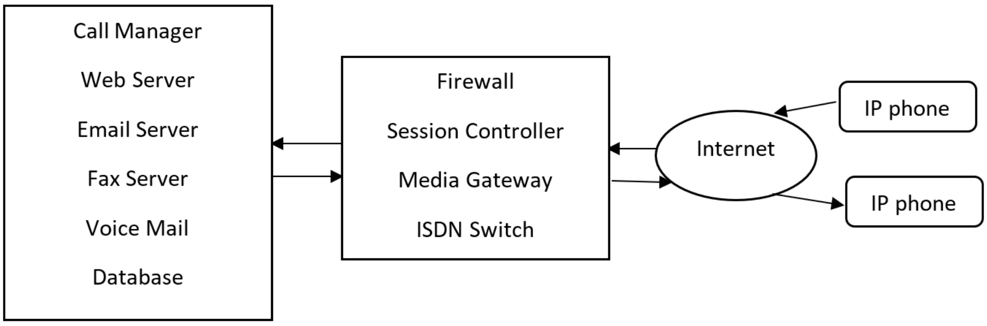

Fig. 1. VoIP architecture

The disadvantage of this architecture appears when the hardware reaches its maximum capacity. Traditional VoIP solutions are difficult to Call Manager Web Server Email Server Fax Server Voice Mail Database Firewall Session Controller Media Gateway Switch ISDN Internet IP Phone IP Phone expand, so to scale the system it is necessary to increase the infrastructure or replace the existing equipment. Redundant equipment and its associated costs are not an effective solution, even taking into account the growing number of customers and the potential security associated with the ability to provide service during peak hours or abnormal system behavior. Moreover, VoIP requires constant availability for any number of users. Providers can invest in a large infrastructure to avoid call loss and therefore users and cope with the growing number of customers. In this case, the infrastructure is usually underutilized. Moreover, servers need to be replaced due to resource degradation. MXop [6, 7] developed the concepts of a voice super node (Supe Node – SN) and a super node cluster (Supe Node C, abbr. – SNC) to enrich the functions of telephone exchanges. An SNC is a set of SNs deployed in the cloud and logically interconnected at the local level. SNCs allow minimizing the path between two local users and improving the voice quality. Such deployment provides redundancy in a given geographic area and guarantees high quality of voice transmission between SNCs over the public Internet. SNCs are deployed in widely distributed geographic locations. The constituent elements of the SN layer are shown in Fig. 2.

The main components of the layers are: the operating system OS, the security system, the monitoring system and the voice node. The OS runs the VoIP Aste sk software. LINUX distributions are used as the main option, but other OS can also be used. The security level determines access to the server, for example, a user can access the phone through his login and password, using SSH and FTP sessions. Monitoring checks resource usage and reports problems with voice nodes. Voice Node (VN) contains the functions of the telephone system: voice mail, call transfer, music on hold, conference function, etc. This distributed architecture distributes computations across several nodes, reduces the risk of failures and limits the cost of purchasing equipment.

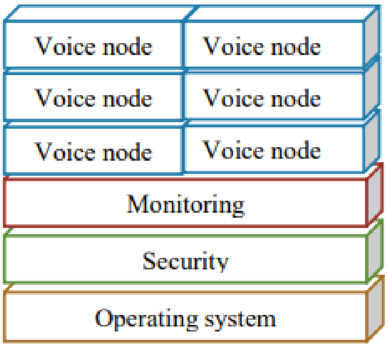

Fig. 2. Super Node Voice Architecture

MIX uses the concept of SNs and SNCs to increase capacity and provision services. In this model, SNs are deployed by multiple cloud providers using the IaaS model. Hyb d VoIP HVoIP model is an improvement on the traditional SNs-based VoIP model. HVoIP uses the traditional VoIP infrastructure and VMs to deploy VoIP services when the installed servers reach their maximum capacity. HVoIP provides several advantages over traditional VoIP: it improves system scalability and reduces over-provisioning, granularity, and cost. Unfortunately, HVoIP also has disadvantages: It is an expensive model because providers still need to lease offices and facilities and maintain the resources to provide the service. In addition, it can lead to an increase in unused resources; the provider must use its own resources as much as possible Operating system Security Monitoring Voice node Voice node Voice node Voice node Voice node Voice node use less rented resources. A fully cloud-based model is a possible improvement of HVoIP. In cloud VoIP CVoIP, the infrastructure is rented in local clouds. This allows VoIP providers to reduce infrastructure costs and idle resources. In addition, CVoIP allows for increased redundancy over a geographical area and provides high-quality voice transmission between SNs. Similar to HVoIP, SNs run in VMs in some cloud environment. In addition, CVoIP adds new features and capabilities, provides simpler implementation, and integrates dynamically scalable services. Other advantages include availability, integrity, and security of data transmission. Figure 3 shows a cloud solution to this problem. Voice nodes provide various services such as call transfer, voice mail, conference function, music on hold, etc. The advantage of this architecture is increased scalability, since VMs can be distributed across multiple processors.

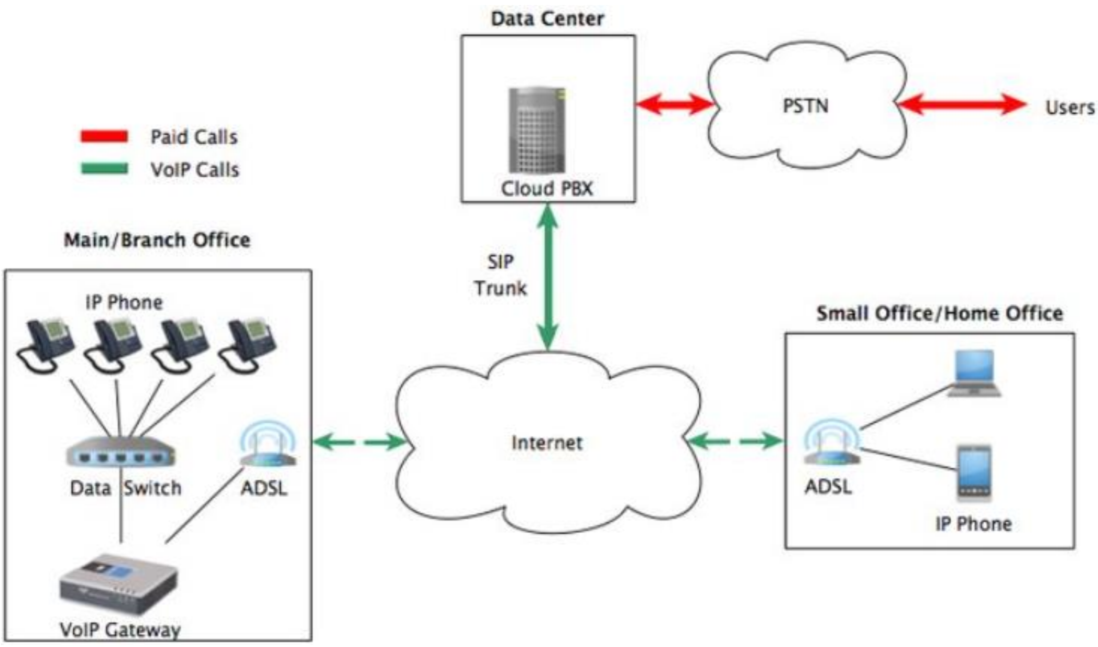

Fig. 3. VoIP cloud architecture

The following advantages of supernodes in CVoIP can be distinguished:

Granularity. Supernodes reduce conflicts between user workstations and the central infrastructure when updating the Internet IP phone IP phone Internet O.S. Security Monitoring Voice node Voice node DB Central performance data center. They have full compatibility between phone manufacturers and telephone exchanges and manage several versions of phone software. Scalability In case of saturation, the infrastructure can increase the number of nodes without changing the existing architecture or affecting customer service.

Spreadability. Supernodes can be deployed in other geographical areas, while providers do not need to physically install servers and equipment, they just need to rent infrastructure in local clouds.

Resilience The distribution of nodes makes it possible to achieve greater fault tolerance. CVoIP can detect failed nodes and automatically redirect traffic to healthy instances until the failed instances are restored.

Cost reduction. The use of cloud systems reduces the cost of infrastructure and investment in equipment. Providers pay only for used resources. In the CVoIP system, the distributed architecture assumes that VNs are distributed geographically, therefore, they are grouped in different locations in data centers. For the deployment and effective management of telephones through the cloud, it is necessary to improve various characteristics of the system, the most important of which is the use of infrastructure. To optimize the overall performance of the system, it is necessary to balance the workload of the voice signal processing processor over IP. Overloading the processor reduces the quality of the voice in the call. A similar problem may arise with network bandwidth. In addition, the idle time of the processor increases the useless expenses of the provider. Call distribution maximizes CVoIP performance by reducing the number of active resources and keeping their idle time to a minimum. To minimize quality degradation, all resources must contain the same amount of computational work without exceeding the threshold guaranteeing QoS. Thus, the advantages of CVoIP technology will be used only when using effective planning methods.

Conclusion

The article considered the features of planning a non-stationary cloud VoIP service, which is characterized by dynamic load changes and high requirements for quality of service. The analysis showed that the key aspects of the effective functioning of such a system are adaptive allocation of computing resources, traffic forecasting and timely scalability of the infrastructure.

The use of cloud technologies allows to ensure flexibility and resilience of the service to peak loads, reduce infrastructure maintenance costs and increase the level of availability. At the same time, to achieve stable operation, it is necessary to take into account the risks associated with network delays, load balancing and system fault tolerance. Thus, effective planning of a non-stationary VoIP service in a cloud environment is a complex task that combines technical, organizational and economic approaches. Further research in this direction can be focused on the application of artificial intelligence and machine learning methods to optimize forecasting processes and dynamic resource management.

References

1. Adjardjah, W., Kumassah, F., Abdallah, D. M. & Addor, J., 2023. “Performance Evaluation of VoIP Analysis and Simulation”. *Journal of Engineering Research and Reports*, 25(7), pp.176-191. DOI: https://doi.org/10.9734/jerr/2023/v25i7951
2. Petrovska, I. and Kuchuk, H. (2022), “Static allocation method in a cloud environment with a service model IAAS”, *Advanced Information Systems*, vol. *6*, *is.* 3, pp. 99–106, DOI: https://doi.org/10.20998/2522-9052.2022.3.13
3. Singh, A., 2022. “Enhancing VoIP Quality in the Era of 5G and SD-WAN”. *Journal of Artificial Intelligence & Cloud Computing*, 1(2), pp.1-6. DOI: https://doi.org/10.47363/JAICC/2022(1)E253
4. Kuchuk, N., Shefer, O., Cherneva, G. and Alnaeri, F.A. (2021), “Determining the capacity of the self-healing network segment”, *Advanced Information Systems*, vol. 5, no. 2, pp. 114–119, Jun. 2021, DOI: https://doi.org/10.20998/2522-9052.2021.2.16
5. Jaish, A. A. & Al-Shammari, B. K. J., 2023. “Quality of Experience for Voice over Internet Protocol (VoIP)”. *Wasit Journal of Engineering Sciences*, 11(3), pp.96-105. DOI: https://doi.org/10.31185/ejuow.Vol11.Iss3.460
6. Kuchuk, N., Mozhaiev, O., Semenov, S., Haichenko, A., Kuchuk, H., Tiulieniev, S., Mozhaiev, M., Davydov, V., Brusakova, O. and Gnusov, Y. (2023), “Devising a method for balancing the load on a territorially distributed foggy environment”, *Eastern-European Journal of Enterprise Technologies*, 1(4 (121), pp. 48–55. DOI: https://doi.org/10.15587/1729-4061.2023.274177
7. Kumar, V. & Roy, O. P., 2021. “A survey on voice over internet protocol (VoIP) reliability research”. *IOP Conference Series: Materials Science and Engineering*, 1020(1). DOI: https://doi.org/10.1088/1757-899X/1020/1/012015

Received (Надійшла) 16.05.2025
Accepted for publication (Прийнята до друку) 06.08.2025

Відомості про авторів / About the Authors

Андрусенко Юлія Олександрівна – асистент кафедри Електронних обчислювальних машин, Харківський національний університет радіоелектроніки, Харків, Україна;
Yuliia Andrusenko – Assistant Professor of Department of Electronic Computers, Kharkiv National University of Radio Electronics, Kharkiv, Ukraine;
e-mail: yuliia.andrusenko@nure.ua; ORCID Author ID: https://orcid.org/0000-0001-7844-2042;
Scopus Author ID: https://www.scopus.com/authid/detail.uri?authorId=59412400500&origin=resultslist.

Даценко Сергій Сергійович – аспірант кафедри комп’ютерної інженерії та програмування, Національний технічний університет «Харківський політехнічний інститут», Харків, Україна;
Serhii Datsenko – PhD candidate of Department of Electronic Computers, National Technical University «Kharkiv Polytechnic Institute», Kharkiv, Ukraine;
e-mail: Serhii.Datsenko@gmail.com; ORCID Author ID: http://orcid.org/0009-0004-4372-1913.

Особливості планування нестаціонарного хмарного VOIP сервісу

Ю. О. Андрусенко, С. С. Даценко

Анотація. У статті розглянуто підходи до планування нестаціонарного хмарного VoIP сервісу, що характеризується динамічними змінами навантаження та підвищеними вимогами до якості обслуговування. Проаналізовано ключові параметри ефективного функціонування сервісу, серед яких прогнозування трафіку, адаптивний розподіл обчислювальних ресурсів, масштабованість інфраструктури, балансування навантаження та забезпечення відмовостійкості. Показано, що використання хмарних технологій дозволяє забезпечити гнучкість і високу доступність VoIP-сервісів, а також знизити витрати на інфраструктуру. Особлива увага приділяється викликам, пов’язаним із мінімізацією мережевих затримок і підтриманням стабільної якості голосових з’єднань. Отримані результати можуть бути використані для оптимізації процесів проектування та управління хмарними телекомунікаційними системами.

Ключові слова: VoIP сервіс, хмара, комп'ютерна система, вартість інфраструктури, масштабованість, трафік.