TELEMÁTICA
REVISTA DIGITAL de las Tecnologías de la Información y las Telecomunicaciones

Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

SDN AND NFV INTEGRATION IN 5G CORE NETWORK: BENEFITS, CHALLENGES AND SOLUTIONS

Camila Ojito Martín[1], Abel Castillo Travieso[2], Alain Abel Garófalo Hernández[3]

[1]DATYS, Avenida 5ta e/ 34 y 36, Playa, [2]CUJAE, Calle 114 #11901 e/ Ciclovía y Rotando CP, Marianao,
[3]Avangenio, Calle 5ta B esquina 6, Inmobiliaria Almendares, Playa
[1]e-mail: camila.om9805@gmail.com
[2]e-mail: abelcastillot@gmail.com
[3]e-mail: alain@avangenio.com

ABSTRACT

The integration of Network Function Virtualization (NFV) and Software-Defined Networking (SDN) technologies in the 5G Core (5GC) represents a crucial advancement in the telecommunications sector. These innovations offer significant improvements in flexibility, scalability, and operational efficiency. Through virtualization, an effective separation between hardware and software is achieved, which maximizes performance and minimizes dependence on specialized equipment. Despite their advantages, the development of these technologies has mainly been run by large corporations, creating challenges such as high acquisition costs and technological dependence. However, open-source initiatives that allow greater access and encourage innovation and collaboration within the sector have emerged. This article aims to conduct a literature review on the implementation of SDN and NFV in the 5GC and an evaluation of open-source technical solutions for its implementation. The combination of SDN and NFV optimizes available resources and enables the creation of advanced services that benefit various economic sectors. Ultimately, integrating these technologies in 5GC becomes a fundamental step towards a more efficient and adaptable future for telecommunications.

KEYWORDS: SDN, NFV, 5G, virtualization.

1. INTRODUCTION

In recent years, 5G networks have experienced a remarkable growth, which is characterized by their higher capacity and efficiency compared to previous technologies. This advancement has enabled the development of a variety of services and transformed various industries, improving the end-user experience [1][2][3].

The software-based architecture of 5G networks provides opportunities to integrate virtualization technologies, such as Network Function Virtualization (NFV) and Software-Defined Networking (SDN). These innovations enable the separation of hardware and software, thus optimizing the deployment of network components on general-purpose hardware, which maximizes operational efficiency [4][5][6][7]. Despite these advantages, only large corporations focus their research on this arena, resulting in high acquisition costs and technology dependence. To counteract these problems, the open-source community has developed open-source projects for the deployment of 5G network components, which are accessible to any interested party [1][5][8]. These projects, supported by organizations such as Open-Air Interface and the Linux Foundation, focus on cloud environments, enabling management and scalability. Furthermore, they encourage innovation and global collaboration to ensure that technologies continuously evolve to adapt to emerging needs [1][5][8].

This paper proposes a comprehensive review of 5G Core (5GC) innovation, focusing mainly on virtualization technologies such as SDN and NFV. We explore the implications and benefits of these integrations in the current telecommunications environment, as well as the implementation of virtualized 5GC through free and open-source software platforms.

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

2. THE 5G CORE: A PARADIGMATIC SHIFT

Fifth generation (5G) mobile networks are made up of two essential components: The Radio Access Network (RAN) and the Network Core (CN). While the RAN interacts directly with users, the CN operates in the background, providing all the network functions necessary for effective communication. Among the critical functions of the core are user authentication and authorization, as well as location maintenance, which enables appropriate services to be provided [9]. Throughout the various generations of mobile networks, the implementation of these functions has evolved. The standard 5G core has been designed to be quick, flexible, scalable, and customizable, enabling it to support emerging technologies in areas such as agriculture, healthcare, and smart cities, and the Internet of Things (IoT) on a large scale [4][10].

One of the most innovative approaches to the 5G core is the Service-Based Architecture (SBA) adopted by 3GPP. This modular architecture allows network components to register, offer specific services, and subscribe to other services, using these elements as building blocks to create more complex solutions. This modular architecture represents a significant advance over the 4G architecture, which lacked such flexibility. SBA not only improves core adaptability but also facilitates the adoption of virtualization, which is crucial for network performance [9][10][11][12].

Network Segmentation is another key feature that characterizes 5G. This process involves the creation of logically separate and customized networks, with components for each segment. Through this segmentation, a single user device can access multiple network segments through the same radio interface, each optimized for different types of traffic. This is crucial to ensure efficient operation of all devices and networks within the 5G ecosystem [8][10][13].

Likewise, Cloud Native Architecture is one of the outstanding features of the 5G core. Network Functions (NFs) can be implemented in several ways: as a network element on a dedicated device, as a software instance operating on specific hardware, or as a virtualized instance in a cloud infrastructure. This architecture, driven by 3GPP NF, improves programmability, flexibility and automation, while optimizing efficiency in terms of costs and power consumption. For operators, managing the increasing complexity of mobile traffic and delivering new services effectively is essential, and the cloud-native strategy enables agile deployment, reducing technical risks through a gradual and reversible approach [4][10][11][14].

Another example of disruptive change in 5G core design is the use of Multi-Access Edge Computing (MEC), which seeks to bring processing capabilities to the edge of the network, where in other generations they were performed directly in the core, especially for applications requiring Ultra Reliable Low Latency Communications (URLLC). Use cases such as image recognition, speech analysis, and large-scale sensor management are becoming increasingly prominent. In these scenarios, any delay in the communication between remote devices and servers can impair the user experience. SCM addresses this need by integrating application servers and content storage directly into local base stations [10][14][15][16].

For its part, 3GPP has also introduced support for Artificial Intelligence (AI) and Machine Learning (ML) through the Network Data Analytics Function (NWDAF). This functionality allows operators to monitor the status of network segments and the performance of third-party applications, thus becoming a central component of analytics at the core of the 5G network and providing valuable information for network optimization [10].

3. INTEGRATION OF SDN AND NFV IN THE 5G CORE

The nature of the 5G network core design, focused on a micro-service and cloud-native architecture, is an attractive way to implement emerging virtualization technologies, such as NFV and SDN. Both technologies share key objectives in 5GC implementation concerning flexibility, scalability, and extensive customizability [3][7][16]. NFV is based on transforming NFs traditionally deployed on dedicated hardware into software deployed on general-purpose servers. This deployment implies a significant change from traditional methodologies of designing, deploying, and managing network services. Similarly, SDN proposes to separate the Control Plane from the Data Plane. The core concept behind SDN allows network developers and administrators to have the same kind of control over network equipment as over x86 servers. This action enables centralized and programmable network flow control based on a global view of the network state [1]][3][5][7][16].

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

TELEMÁTICA
REVISTA DIGITAL de las Tecnologías de la Información y las Telecomunicaciones
Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

3GPP incorporates NFV and SDN technologies in the development of 5GC standards. These technologies decouple the Evolved Packet Core (EPC) network components, implementing NF in a software-based architecture within the 5GC. The 3GPP 5GC architecture adopts the SDN paradigm, separating the User Plane Functions (UPF) from the control plane functions, which include the Session Management Function (SMF) and the RAT Unified Control Core (RUCC) [2]. An SDN controller sits between the user plane function and the control plane component. The Northbound API facilitates communication between network functions, including RUCC and SMF. The Southbound API enables interaction with the UPF, which operates as one or more SDN switches. The SDN controller establishes communication between these elements through the Open Flow protocol [5][17], as shown in Fig. 1.

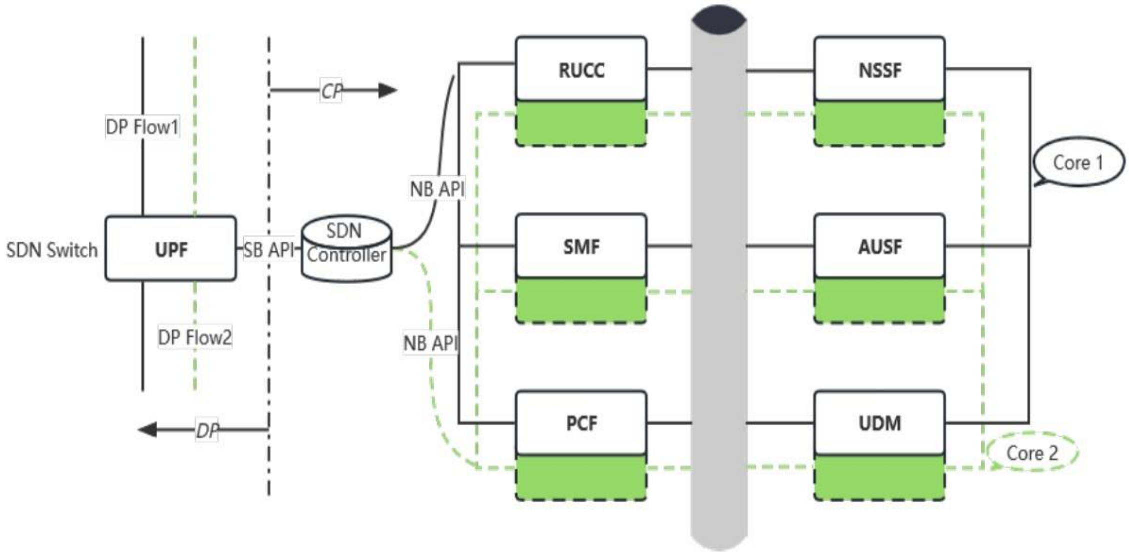

Figure 1: SDN-based 5GC architecture [18].

The red dotted line in Fig. 2 shows the new 5G network architecture after converging 5G and SDN technologies. Referring to Fig. 1, in terms of architectural logic, the UPF is connected to an SDN switch, as is the base station (NB), and the two communicate using the Open Flow protocol. The SDN switches are logically placed between the 5GC and the RAN.

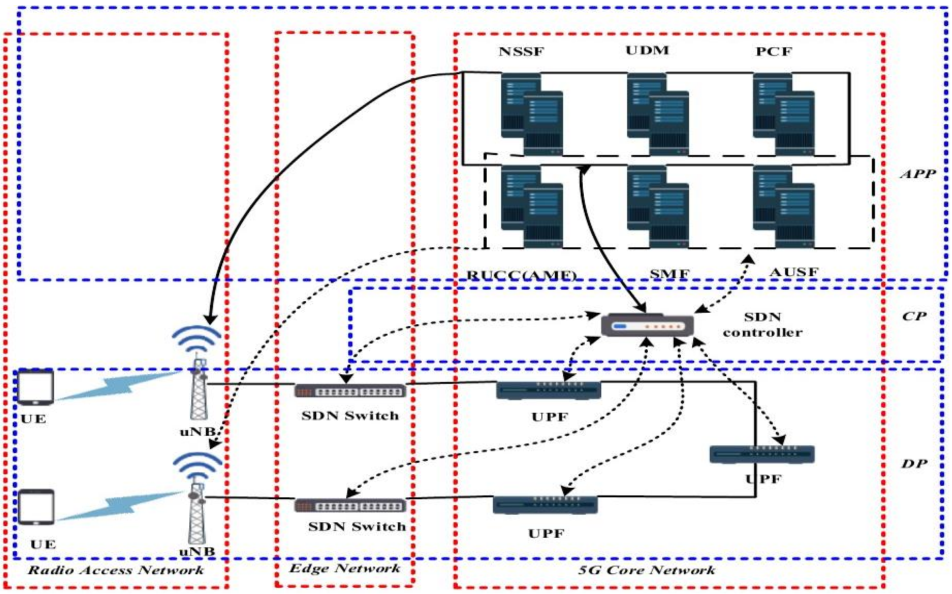

Figure 1: 5G network architecture [18].

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

TELEMÁTICA
REVISTA DIGITAL de las Tecnologías de la Información y las Telecomunicaciones
Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

Decoupling the UPF from the control plane and the SDN controller acts as a relay node between these two elements. Control plane components can have multiple mirrors to manage multiple UPFs through the SDN controller, enabling control of various SDN switches [18].

Leaders in integration implementation.

In the area of 5G network infrastructure for telecom service providers, Gartner's February 2021 [19], 2022 [20], and 2023 Magic Quadrant reports [21] have highlighted several companies as leaders in SDN and NFV integration implementation. These reports, produced by Gartner, an independent IT research and advisory firm, provide a comprehensive assessment of companies' viewpoints and execution capability in this sector. Among the leading companies are:

- Ericsson: A Swedish multinational networking and telecommunications company, offers services, software, and information and communication technology infrastructure to communication service providers (CSPs). In 2021, Ericsson was recognized as a leader in 5G network infrastructure for its ability to execute its vision and technology leadership in the 5G space. Its end-to-end 5G platform includes the Ericsson Radio System, 5G Core, 5G orchestration and transport, and professional services. It has its own Ericsson Cloud Packet Core solution, which supports more than 100 virtual EPC customer business networks [22].

- Nokia: It is a Finnish multinational telecommunication and information technology company. It has the software-defined access platform called Altiplano and Lightspan programmable access nodes to centralize and virtualize NFs. One of the essential features of the platform is the application of SDN and NFV concepts for access networks [23].

- Huawei: It is a Chinese information and communication technology (ICT) provider, and its business includes operator, customer, and enterprise business. This company has implemented solutions such as Huawei Cloud Fabric and Huawei Cloud Edge, which facilitate a seamless integration of SDN and NFV. Huawei Cloud Fabric, an SDN-based data center network solution, enables building a simplified, intelligent, ultra-wide, and open cloud data center network. For its part, Huawei Cloud Edge is a new-generation mobile broadband solution developed on an NFV, service-oriented, and cloud architecture basis [24].

4. BENEFITS OF INTEGRATION

Integrating SDN and NFV into 5G core networks offers several significant benefits. These technologies improve network agility and scalability and contribute to cost reduction and more efficient resource management. Below, we explore these benefits, highlighting how adopting SDN and NFV transforms the telecommunication infrastructure.

Agility and Scalability

Integrating SDN and NFV into the 5G core brings unprecedented agility in responding to market dynamics. This approach enables operators to deploy new features and services in real time, eliminating the long development cycles that characterize traditional infrastructures. The ability to scale resources efficiently optimizes performance in the face of traffic peaks and facilitates the customization of offerings for specific customer segments. This customization is crucial in an era where the demand for digital services continuously expands, forcing companies to innovate to remain competitive constantly. In short, SDN-and-NFV-powered-5G architecture transforms costs into strategic investments while guaranteeing a quick response to the environment's emerging needs [25][26].

Cost Reduction

From an economic perspective, the adoption of SDN and NFV represents a radical change in the operational economy of networks. NFV decreases reliance on specialized hardware and optimizes the use of the existing infrastructure. This adoption drastically reduced and enabled operating costs, consolidating multiple functions in virtualized

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

environments, thus reducing the need to maintain physical equipment. In addition, cloud-based consumption models provide operators with unprecedented financial flexibility, allowing an on-demand capacity adjustment. In the long term, these cost reductions facilitate reinvestment in innovation and continuous improvement, encouraging a virtuous cycle of service development and evolution [7].

Improved Resource Management

Effectively managing network resources is a fundamental SDN and NFV framework. Operators can implement optimization methods that significantly increase network performance using advanced monitoring and data analysis techniques. For example, dynamic bandwidth allocation and traffic prioritization improve the user's experience and ensure efficient utilization of available resources. This proactive management reduces latency, increases the speed of connections, and contributes to better interoperability between different services and applications, preparing the network for the requirements of an increasingly interconnected future [25][26].

5. 5G CORE VIRTUALIZATION PLATFORMS: OPEN-SOURCE SOLUTIONS FOR SDN AND NFV IMPLEMENTATION

Open-source platforms play a crucial role in 5G core virtualization, representing an alternative to the offerings of large corporations in the telecommunication sector. These platforms offer a solution with flexible and scalable infrastructure to support the demands of the network core. The following are the leading platforms for implementing the virtualized 5G core.

OAI 5G CN

Open-Air Interface Software Alliance, a non-profit organization founded by EURECOM, is developing the OAI 5G CM project. The project includes members such as Qualcomm, Orange, AMD, NVIDIA, Canonical, Ericsson, Red Hat, and prestigious universities such as King's College London, Chinese Academy of Science, and Universidad Carlos III de Madrid, among others [27]. It offers three deployment modes: Minimalistic5GC, Basic5GC, and Slicing5GC, with documentation including tutorials for different NFs. Its repository is divided by core network functions and shows constant activity in commits [28]. In the last year (2024), the company released version 2.0.0 in January, 2.0.1 in February, and 2.1 in September [29]. In addition, it supports the standalone architecture of the 5G core and functionalities such as N2 Handover, an HTTP/2 API, and support for fully qualified domain Names (FQDN). The company conducted successful tests with commercial-based stations belonging to companies such as Amarisoft and Baicell and open-source RAN simulators such as UERANSIM and Gnbsim [30].

Magma Core

This project is based on the work of Open-Air Interface and belongs to Linux Foundation Projects. It has a Technical Steering Committee of eight members responsible for decisions on the core architecture [31]. Since 2021, the Open-Air Interface Software Alliance and the Open Infrastructure Foundation have partnered with the Magma project to form the Magma Core Foundation. Moreover, the foundation welcomed new members: Aarna Networks, Connect5G, Helium, and Whitestack, which joined members such as Deutsche Telekom and Facebook [32]. Magma provides extensive documentation detailing the 5G SA deployment and configuration processes and the necessary hardware and software requirements [33]. Its repository has low activity, with just 54 commits throughout 2024, and the latest stable version is 1.8.0 (Newberry) from 2022 [34][35]. Magma Core supports 5G NSA and 5G SA architectures distinguished by its orchestrator, which operates as a centralized controller for a group of networks and handles the control plane for various types of gateways in Magma [36][37]. The project includes open APIs integrated with existing operations support and business support systems (BSS/OSS) [38]. Magma Core was the platform selected for the 5G core network implementation of the Plat5G-BR project, which is owned by the Brazilian government [37].

Open5GS

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

A Next EPC-based Project has sponsors such as Mobi, Telet, Coral Telecom, and Kontron [37][39]. It provides extensive documentation with a quick start user's guide describing the steps to install and configure Open5GS as a package on a Linux distribution, in this case, Ubuntu or Debian. It also includes OpenSUSE and CentOS [40][41]. In addition, there is a section for troubleshooting and hardware notes [41]. The repository is moderately active, with about 350 commits so far in 2024 and recent contributions. In 2024, released two stable versions 2.7.1 in April and 2.7.2 in August [42][43][44]. The authors did not find evidence of the use of this platform in projects or tests related to commercial base stations.

Free5GC

This project rests on Next EPC. Currently, the significant contributions to the project come from the National Chiao Tung University (NCTU) [37][45]. Free5GC has extensive documentation with a user's guide that has tested hardware including UE and gNodeB, and information for different configurations and deployments, such as Docker and Kubernetes. It includes a Troubleshooting section and design documents describing the core architecture components. It has a forum for technical support and labs with tutorials to learn how to use the platform [45][46][47]. The repository is at low activity, with less than 100 commits so far in 2024, and in that period 4 versions have been released: 3.4.0 in February, 3.4.1 in March, 3.4.2 in July and 3.4.3 in September [48][49]. It supports the 5G SA architecture [50]. The authors did not find evidence of this platform in projects or tests with commercial base stations.

The following Table 1 is a comparison between the four above-mentioned platforms:

Table 1: Comparison between 5GC virtualization platforms.

Platforms	License	Programming language	Deployment	User's interface
OAI 5G CN	OAI Public License V1.1 [5]	C++ [5]	Containers [5]	No [35]
Magma Core	BSD-3-Clause License. [51]	C++ y Go [51]	Containers and Virtual Machines [37]	Yes [37]
Open5GS	AGPL-3.0 Copy left [5]	C [5]	Containers and Virtual Machines [5]	Yes [5]
Free5GC	Apache 2.0 [5]	Go [5]	Containers and Virtual Machines [5]	Yes [51]

Performance analysis of virtualization platforms.

A comparative study of Free5GC, OAI 5G CN, and Open5GS platforms analyzed the resource utilization and Round-Trip Time (RTT) experienced by user devices in a virtualized environment. The results indicated deployment benefits and a trade-off between load consumption and latency assessment. This study also noted that Open5GS demonstrated the lowest processing load. At the same time, OAI 5G CN had the highest CPU utilization percentage of 1% and 4% in each CPU, respectively, for tests performed with one and up to 8 UEs [5].

Another study focused on the performance difference of critical UE procedures when deploying Open5GS on a Kubernetes platform versus a bare-metal deployment. The results revealed a 7% performance degradation in throughput for UE procedures running on Kubernetes compared to bare metal when handling 300+ initiated user devices. However, for moderate loads (less than 200 UEs), both deployments showed comparable performance in

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

registration and deregistration procedures. This study concluded that while Kubernetes offers benefits in terms of manageability and portability, it introduces a 7% performance overhead, which can affect performance and stability under high loads. The decision to prioritize Kubernetes over bare metal may depend on the operational costs associated with each [52].

In a performance analysis of Magma Core 1.6.1, evaluated through emulation testing with Spirent Landslide and commercial deployments, its ability to handle typical loads (288 UEs with 432 Mbps in RAN) using inexpensive hardware, with acceptable CPU usage on physical/virtual AGWs, was demonstrated. The main bottleneck is the MME component, limiting connection rates to 2 UE/s on physical AGWs and up to 16 UEs on virtual (4 vCPUs). The separation of planes (CUPS) reveals variations in CPU load between connection (control) and data transfer (user) phases. At the same time, flexible resource allocation optimizes the trade-off between data throughput and connection success. Magma scales linearly by adding AGWs, being viable for standard and demanding environments by adapting through additional hardware, combining efficiency, scalability, and low cost in cellular deployments [53]. It is important to note that the microservices-based Core 5G architecture may introduce complexities that affect performance if not managed adequately despite the benefits it brings. Studies conducted on SDN adoption in 5GC showed an 18% to 62% reduction in end-to-end latency compared to traditional 5G architecture in different procedures [54].

Challenges and limitations of open-source platforms in 5G deployments.

- Implementation and Learning Curve: Many open-source implementations of the 5G core present a steep learning curve and require specialized personnel. These implementations are due to the inherent complexity of telecom infrastructures historically associated with vendor-specific solutions [55].

- Real-time scenario evaluations: Evaluating 5GCN traffic in real-time is challenging, as implementing a real 5G network infrastructure is costly and requires careful consideration of complex scenarios and essential hardware components that are often unaffordable for most institutions. Although open-source projects are adopted in the literature, simulation-based validations may not be sufficient to convey real-time 5G scenarios [56].

- Maturity and Community Support: When comparing open-source platforms for 5G core implementation, we consider infrastructure, documentation, developer community involvement, and code maturity aspects. These factors can vary significantly between platforms, affecting the ease of use, availability of support, and software stability. Code maturity and evolution are highly dependent on community activity and contributions. Development may slow down or stop if a community becomes inactive or the project loses sponsors [37]. While functional for testing and development, some platforms may not be mature enough for deployments in production environments.

- Security: decomposing network functions (NFs) into microservices-based architectures, which open-source platforms adopt for Core 5G, may increase the attack surface and potential vulnerabilities. This increment is due to the larger number of interfaces and software components involved [12]. In addition, although open-source platforms are used in research, validations are often based on simulations. They may not fully reflect real-time 5G scenarios, raising doubts about their effectiveness and reliability in real implementations. [56]

6. CONCLUSIONS

After conducting this study, 5GC virtualization, fostered by open-source solutions, plays a key role in modernizing telecommunication networks. This approach remarkably improves telecommunication infrastructures' flexibility, scalability, and operational efficiency. The joint implementation of technologies such as SDN and NFV proves crucial to maximizing the efficiency of these networks by reducing dependency on specialized hardware and helping forward a software-based paradigm that optimizes the use of generic hardware. We analyze open-source platforms, such as OAI 5G CN, Magma Core, Open5GS, and Free5GC, which afford operators and developers significant resources to create fast and adaptive networks. These solutions provide viable alternatives to existing commercial options and

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

stimulate innovation and collaboration within the 5G ecosystem. Modular deployment capabilities and the approach of micro-service-based and cloud-native architectures are presented as key elements that enable customization according to the specific needs of each operator.

In conclusion, 5GC virtualization, supported by SDN and NFV technologies, represents a paradigmatic shift. This transformation reduces costs and opens doors to creating advanced services that positively impact various sectors. Therefore, developing and adopting these solutions represents a significant step towards the future of telecommunications, characterized by greater efficiency and adaptability to emerging market demands.

ACKNOWLEDGMENTS

The authors wish to thank PhD. Alain Abel Garófalo Hernández for his invaluable mentorship and constant support, which have been essential for the development of this research and the preparation of this article.

REFERENCES

[1] A. Pinchuk, R. Odarchenko, V. Samoilenko, y A. Imanbayev, «5G Network Deployment based on Open-source Projects: A Comparative Analysis», *12th IEEE Int. Conf. Intell. Data Acquis. Adv. Comput. Syst. Technol. Appl.*, p. 6, sept. 2023, doi: 10.1109/IDAACS58523.2023.10348675.

[2] C. S. Choudhari, Dr. R. A. Patil, y S. Saraf, «Deployment of 5G Core for 5G Private Networks», *2022 Int. Conf. Ind. 40 Technol. I4Tech*, p. 6, sept. 2022, doi: 10.1109/I4TECH55392.2022.9952900.

[3] A. A. Abdul Ghaffar, A. Mahmoud, T. Sheltami, y M. Abu-Amara, «A Survey on Software-Defined NetworkingBased 5G Mobile Core Architectures», *Arab. J. Sci. Eng.*, vol. 48:2313–2330, p. 18, 2023, doi: https://doi.org/10.1007/s13369-022-07183-9.

[4] R. Botez, A.-G. Pasca, y V. Dobrota, «Kubernetes-Based Network Functions Orchestration for 5G Core Networks with Open-Source MANO», *2022 Int. Symp. Electron. Telecommun. ISETC*, p. 4, 2022, doi: 10.1109/ISETC56213.2022.10010246.

[5] R. Reddy, M. Gundall, C. Lipps, y H. D. Schotten, «Open Source 5G Core Network Implementations: A Qualitative and Quantitative Analysis», *Int. Black Sea Conf. Commun. Netw. BlackSeaCom*, 2023, doi: 10.1109/BLACKSEACOM58138.2023.10299755.

[6] N. M. Akshatha, P. Jha, y A. Karandikar, «A Centralized SDN Architecture for the 5G Cellular Network», en *2018 IEEE 5G World Forum (5GWF)*, Silicon Valley, CA: IEEE, jul. 2018, pp. 147-152. doi: 10.1109/5GWF.2018.8516960.

[7] V.-G. Nguyen, A. Brunstrom, K.-J. Grinnemo, y J. Taheri, «SDN/NFV-Based Mobile Packet Core Network Architectures: A Survey», *IEEE Commun. Surv. Tutor.*, vol. 19, n.º 3, pp. 1567-1602, 2017, doi: 10.1109/COMST.2017.2690823.

[8] E. Sivaraman y P. Honnavalli, «Private 5G networks: a survey on enabling technologies, deployment models, use cases and research directions», *Springer Science*, p. 24, nov. 2022, doi: https://doi.org/10.1007/s11235-02200978-z.

[9] D. Lake *et al.*, «Virtualising and orchestrating a 5G evolved packet core network», en *2017 IEEE Conference on Network Softwarization (NetSoft)*, Bologna, Italy: IEEE, jul. 2017, pp. 1-5. doi: 10.1109/NETSOFT.2017.8004215.

[10] *5G Core Network*, 8.ª ed. TELECOMMUNICATION ENGINEERING CENTRE KHURSHID LAL BHAWAN, JANPATH NEW DELHI - 110001 INDIA: TEC, 2021. [Online]. Available at: https://www.tec.gov.in/studypapers#

[11] «A Cloud-Native Based Access and Mobility Management Function Implementation in 5G Core», *2020 IEEE 6th Int. Conf. Comput. Commun. ICCC*, p. 6, 2022, doi: 10.1109/ICCC51575.2020.9345262.

[12] S. Robitzsch *et al.*, «Prospects on the adoption of a microservice-based architecture in 5G systems and beyond», *Elsevier B V*, vol. Computer Networks 237, p. 10, oct. 2023, doi: https://doi.org/10.1016/j.comnet.2023.110058.

[13] H.-M. Chen, Y.-F. Lu, S.-Y. Chen, C.-J. Chang, y Z.-X. Zheng, «Design of an NFV MANO Architecture for 5G Private Network with 5G CN Cloud-Edge Collaborative Mechanism», *2022 8th Int. Conf. Appl. Syst. Innov. ICASI*, p. 4, 2022, doi: 10.1109/ICASI55125.2022.9774446.

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

[14] Y.-C. Chan, L.-H. Yen, T.-H. Wang, y C.-C. Tseng, «MEC Implementation in NFV Architecture Supporting 5G End-to-End Network Slicing», en *2023 2nd International Conference on 6G Networking (6GNet)*, Paris, France: IEEE, oct. 2023, pp. 1-4. doi: 10.1109/6GNet58894.2023.10317750.

[15] P. Vanichchanunt, I. Yamyuan, P. Sasithong, L. Wuttisittikulkij, y S. Paripurana, «Implementation of Edge Servers on an Open 5G Core Network», *2023 Int. Conf. Inf. Netw. ICOIN*, p. 4, 2023, doi: 10.1109/ICOIN56518.2023.10049000.

[16] T. Choi, T. Kim, W. TaverNier, A. Korvala, y J. Pajunpaa, «Agile management of 5G core network based on SDN/NFV technology», en *2017 International Conference on Information and Communication Technology Convergence (ICTC)*, Jeju: IEEE, oct. 2017, pp. 840-844. doi: 10.1109/ICTC.2017.8190795.

[17] F. Eichhorn, M.-I. Corici, T. Magedanz, P. Du, Y. Kiriha, y A. Nakao, «SDN Enhancements for the Sliced, Deep Programmable 5G Core», *IFIP*, 2017.

[18] L.-Y. Chen, C. Chen, J.-C. Chen, P.-Y. Ho, y C.-C. Wang, «Design and Implementation of a Redundant Transmission Technique for Ultra-Reliable Communication in 5G Core Networks», *23rd Asia-Pac. Netw. Oper. Manag. Symp. APNOMS*, p. 4, 2022.

[19] «Ericsson nombrado Cuadrante Mágico 5G Líder-Gartner», ericsson.com. Accessed: September 17, 2024. [Online]. Available at: https://www.ericsson.com/es/press-releases/2021/2/ericsson-named-a-leader-in-the-2021-gartner-magic-quadrant-for-5g-network-infrastructure-for-communications-service-providers-report

[20] «Gartner 2022 Magic Quadrant 5G Network Infrastructure for CSPs», ericsson.com. Accessed: September 17, 2024. [Online]. Available at: https://www.ericsson.com/en/press-releases/2022/3/ericsson-named-aleader-in-the-2022-gartner-magic-quadrant-for-5g-network-infrastructure-for-communications-serviceproviders-report

[21] «Ericsson a Leader in 2023 Gartner Magic Quadrant 5G Network Infrastructure for CSPs», ericsson.com. Accessed: September 17, 2024. [Online]. Available at: https://www.ericsson.com/en/pressreleases/2023/3/ericsson-named-a-leader-in-the-2023-gartner-magic-quadrant-for-5g-network-infrastructurefor-csps-report

[22] M. Sundarum, «More than 100 reasons to celebrate Ericsson's 5G Cloud Core», 5G Americas. Accessed: September 17, 2024. [Online]. Available at: https://www.5gamericas.org/more-than-100-reasons-to-celebrateericssons-5g-cloud-core/

[23] S. Hardy, «Nokia unveils Altiplano software-defined access platform, Lightspan programmable access nodes», Lightwave. Accessed: September 17, 2024. [Online]. Available at: https://www.lightwaveonline.com/network-automation/article/16673840/nokia-unveils-altiplano-softwaredefined-access-platform-lightspan-programmable-access-nodes

[24] «Gartner-Magic-Quadrant-for-Network-Firewalls-Sep-2019.pdf».

[25] Y. Zhang, *Network Function Virtualization. Concepts and Applicability in 5G Networks.*, This edition first. USA: John Wiley & Sons, Inc., 111 River Street, Hoboken, Nj07030, 2018.

[26] W. Stallings, *Foundations of Modern Networking: SDN, NFV, QoE, IoT and Cloud.* United States of America: Pearson Education, Inc.

[27] «Members – OpenAirInterface». Accessed: September 17, 2024. [Online]. Available at: https://openairinterface.org/osa-members/

[28] «docs/DEPLOY_HOME.md · master · oai / cn5g / oai-cn5g-fed · GitLab», GitLab. Accessed: September 17, 2024. [Online]. Available at: https://gitlab.eurecom.fr/oai/cn5g/oai-cn5g-fed//blob/master/docs/DEPLOY_HOME.md

[29] «oai / cn5g / oai-cn5g-fed · GitLab», GitLab. Accessed: September 17, 2024. [Online]. Available at: https://gitlab.eurecom.fr/oai/cn5g/oai-cn5g-fed

[30] «5G CORE NETWORK – OpenAirInterface». Accessed: September 17, 2024. [Online]. Available at: https://openairinterface.org/oai-5g-core-network-project/

[31] «Governance – Magma». Accessed: September 17, 2024. [Online]. Available at: https://magmacore.org/governance/

[32] «Magma Project Accelerates with Establishment of Magma Core Foundation and New Members Under Open Governance - Linux Foundation». Accessed: September 17, 2024. [Online]. Available at: https://www.linuxfoundation.org/press/press-release/magma-project-accelerates-with-establishment-of-magmacore-foundation-and-new-members-under-open-governance

[33] «Introduction · Magma Documentation». Accessed: September 17, 2024. [Online]. Available at: https://magma.github.io/magma/

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

[34] «Releases · magma/magma», GitHub. Accessed: September 17, 2024. [Online]. Available at: https://github.com/magma/magma/releases
[35] «Contributors to magma/magma», GitHub. Accessed: September 17, 2024. [Online]. Available at: https://github.com/magma/magma
[36] «Overview · Magma Documentation». Accessed: September 17, 2024. [Online]. Available at: https://magma.github.io/magma/
[37] F. J. de Souza Neto, E. Amatucci, y P. A. Marques Farias, «Analysis for Comparison of Framework for 5G Core Implementation», *2021 Int. Conf. Inf. Sci. Commun. Technol. ICISCT*, 2021, doi: 10.1109/ICISCT52966.2021.9670414.
[38] «Magma – Linux Foundation Project Accessed: September 17, 2024. [Online]. Available at: https://magmacore.org/
[39] «https://open5gs.org/». Accessed: September 18, 2024. [Online]. Available at: https://open5gs.org/
[40] S. Lee, «Documentation», Open5GS. Accessed: September 18, 2024. [Online]. Available at: https://open5gs.org/open5gs/docs/
[41] S. Lee, «Quickstart», Open5GS. Accessed: September 18, 2024. [Online]. Available at: https://open5gs.org/open5gs/docs/guide/01-quickstart/
[42] *open5gs/open5gs*. (18 de septiembre de 2024). C. Open5GS. Accessed: September 18, 2024. [Online]. Available at: https://github.com/open5gs/open5gs
[43] «Contributors to open5gs/open5gs», GitHub. Accessed: September 18, 2024. [Online]. Available at: https://github.com/open5gs/open5gs
[44] «Releases · open5gs/open5gs», GitHub. Accessed: September 18, 2024. [Online]. Available at: https://github.com/open5gs/open5gs/releases
[45] «Index - free5GC». Accessed: September 18, 2024. [Online]. Available at: https://free5gc.org/guide/
[46] «Index - free5GC». Accessed: September 18, 2024. [Online]. Available at: https://free5gc.org/support/
[47] *free5gc/free5GLab*. Go. free5GC. Accessed: September 18, 2024. [Online]. Available at: https://github.com/free5gc/free5GLab
[48] «Contributors to free5gc/free5gc», GitHub. Accessed: September 18, 2024. [Online]. Available at: https://github.com/free5gc/free5gc
[48] «Release v3.4.3 · free5gc/free5gc», GitHub. Accessed: September 18, 2024. [Online]. Available at: https://github.com/free5gc/free5gc/releases/tag/v3.4.3
[49] «Features - free5GC». Accessed: September 18, 2024. [Online]. Available at: https://free5gc.org/guide/features/
[50] *magma/magma*. C++. Magma. Accessed: September 18, 2024. [Online]. Available at: https://github.com/magma/magma
[51] T. Mukute, M. S. de Brito, J. Mwangama, A. A. Lysko, y T. Magedanz, «A Brief Performance Comparison of Bare-Metal and Kubernetes Deployments for 5G Core Control Plane Network Functions using Open5GS»
[52] S. Hasan *et al.*, «Building Flexible, Low-Cost Wireless Access Networks with Magma», September 20, 2022, *arXiv*: arXiv:2209.10001. doi: 10.48550/arXiv.2209.10001.
[53] A. Abdulghaffar, A. Mahmoud, M. Abu-Amara, y T. Sheltami, «Modeling and Evaluation of Software Defined Networking Based 5G Core Network Architecture», *IEEE Access*, vol. 9, pp. 10179-10198, 2021, doi: 10.1109/ACCESS.2021.3049945.
[54] D. Scotece, A. Noor, L. Foschini, y A. Corradi, «5G-Kube: Complex Telco Core Infrastructure Deployment Made Low-Cost», *IEEE Commun. Mag.*, vol. 61, n.º 7, pp. 26-30, Jul. 2023, doi: 10.1109/MCOM.006.2200693.
[55] R. Patil, Z. Tian, M. Gurusamy, y J. McCloud, «5G core network control plane: Network security challenges and solution requirements», *Computer Communications*, vol. 229, p. 107982, Jan. 2025, doi: 10.1016/j.comcom.2024.107982.

AUTHORS SECTION

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele

TELEMÁTICA
REVISTA DIGITAL de las Tecnologías de la Información y las Telecomunicaciones
Revista Telemática. Vol. No. 23, 2024, p. 65- 75 ISSN 1729-3804

Camila Ojito Martín. Engineer in Telecommunications and Electronics at the Technological University of Havana "José Antonio Echeverría" (CUJAE). Specialist in data transmission networks Av of the company DATYS. E-mail: camila.om9805@gmail.com. https://orcid.org/0009-0007-8294-4775

Abel Castillo Travieso. Undergraduate student at the Faculty of Telecommunications and Electronics Engineering, Universidad Tecnológica de La Habana "José Antonio Echeverría" (CUJAE). E-mail: abelcastillot@gmail.com. https://orcid.org/0009-0006-1699-0274

Alain Abel Garófalo Hernández: Engineer in Telecommunications and Electronics. Doctor of Technical Sciences and Adjunct Assistant Professor at CETI of the Faculty of Telecommunications and Electronics at CUJAE. https://orcid.org/0000-0002-1643-8918

CONFLICT OF INTEREST

There is no conflict of interest of the authors or the institutions to which they belong in relation to the content of this article.

CONTRIBUTIONS OF THE AUTHORS

- **Autor 1:** Was responsible for conceptualizing and drafting the article, as well as researching the integration of SDN and NFV in the 5G core network. Her contribution accounts for 50% of the work, which includes preparing the initial sections and the overall organization of the document. She also participated in the critical review of each draft version and approved the final version for publication.
- **Autor 2:** Collaborated in the research and writing of the article, contributing ideas and content equally with Author 1. His contribution also represents 50% of the work, focusing on the literature review and developing specific document sections. Like Author 1, he participated in the critical review of each draft and approved the final version.
- **Autor 3: A**s a mentor and advisor, provided essential guidance in shaping the article. His contribution focused on thoroughly reviewing the content and offering precise suggestions to enhance the document's quality. While his participation is not quantified in percentage terms, his support was crucial for the completion and approval of the article's final version.

Received: 12-01-2025, Approved: 04-05-2025
Sitio web:http://revistatelematica.cujae.edu.cu/index.php/tele