



Review on Network Slicing Optimization: A Machine Learning Perspective

Margi Patel^{1*}, Nitin Rathore², Ramesh R. Naik³, Sashrik Gupta⁴ and Vinod Patel⁵

¹ Indore Institute of Science and Technology
Indore, M.P., India

^{2,3,4,5} Nirma University, Sarkhej,
Ahmedabad, 382483, Gujarat, India

*¹margi.patel22@gmail.com
nitin.rathore@nirmauni.ac.in,
rameshram.naik@nirmauni.ac.in,
22BCE315@nirmauni.ac.in,
vinod.patel@nirmauni.ac.in

Abstract. Investigating how network slicing affects resource allocation and management, the paper explores methods for optimizing network resources in response to current demand and traffic trends. The effect of network slicing on Quality of Service (QoS) measurements is also examined, along with the ways in which different applications and consumers might receive distinct services inside the same infrastructure. Additionally, examined is how edge computing and cloud-native architectures enable network slicing features, emphasizing how crucial they are to providing high-bandwidth and low-latency services. The study also addresses the legal structures and regulatory issues that control the implementation and functioning of network slicing in 5G networks. It emphasizes the need for standardized interfaces and protocols to enable interoperability between different network slices and ensure seamless integration with existing network infrastructures. It advocates for the importance of continued research and development efforts in artificial intelligence (AI), machine learning (ML), and security to realize the promise of network slicing as a key enabler of future digital ecosystems. In conclusion, the paper underscores the transformative impact of network slicing in unlocking the full potential of 5G networks for diverse applications and industries.

Keywords: AI, ML, QoS, Network Slicing, and Software Defined Networking (SDN)

I. INTRODUCTION

Many standard development organizations have achieved network slicing (NS), an important strategic objective in recent years. It is a paradigm change in the telecoms industry. NS instances (NSI) can be described by the Next Generation Mobile Networks (NGMN) alliance as an all-inclusive logical network unit comprising network resources and functionalities. This instantiation is designed to satisfy certain

© The Author(s) 2025

S. Bhalerao et al. (eds.), *Proceedings of the International Conference on Recent Advancement and Modernization in Sustainable Intelligent Technologies & Applications (RAMSITA-2025)*, Advances in Intelligent Systems Research 192,

https://doi.org/10.2991/978-94-6463-716-8_71

network specifications necessary for service instances. NS is organized around three tiers, as shown in Figure 1. The service instance layer provides the interface for business or end-user services, including a wide range of features. In the meantime, the NSI layer is essential to provide network slice instances to meet the exact characteristics needed for related service instances such as mobile broadband, machine-to-machine, enterprise, and industry services [1]. Finally, the resource layer contributes physical or virtual resources vital for deploying and operating network slices. The next subsections illustrate each layer in detail.

1.1 Slicing concept

NS is a groundbreaking framework that divides a single physical network into multiple virtual networks, each operating as an independent slice to meet modern communication services and applications' diverse and continuously developing demands. The NGMN alliance introduces the concept of an NSI, which encompasses network functions and resources necessary to operate a particular NS. This NSI forms a logical network implementation that is precisely tuned to fulfill the precise network characteristics demanded by different service instances [2]. Three primary layers that integrate establishing and controlling network services and resources form the framework of NS. The array of end-user or business services the network's infrastructure needs to support is represented by the service instance layer, which acts as the front-facing interface. This layer encompasses an extensive spectrum of services, including workplace apps, multimedia streaming, Internet of Things (IoT) connectivity, and high-speed internet [1]. At a more detailed level, the NSI layer customizes the network slice instances to provide specific features and capabilities required to meet the needs of the corresponding service instances. For instance, an IoT-focused slice might stress huge interconnectivity and energy conservation, whereas an enhanced mobile broadband slice would prioritize high bandwidth and low latency [2]. The splitting idea is further illustrated in Figure 1.

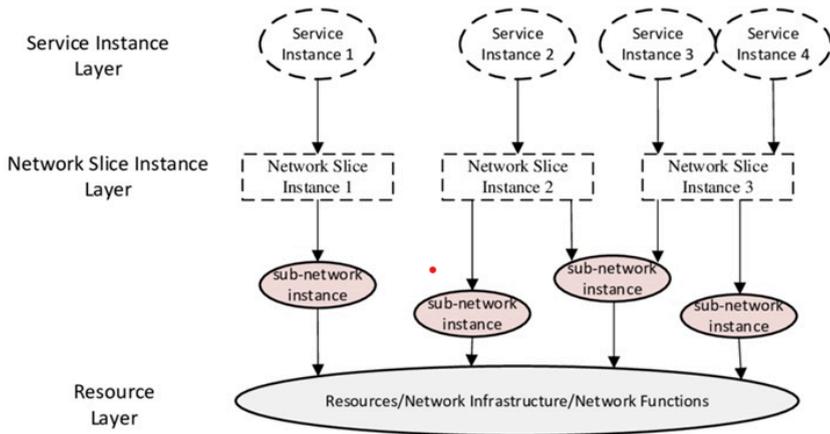


Fig. 1: Networksplitting concept [19]

1.2 Higher-Level Functions and Roles

Technical report 28.801, which describes the third-generation partnership project (3GPP) of the telecommunications industry association, closely matches the NGMN definition of NSI. This report describes the network slice lifetime, which includes crucial stages such as setup, implementation, configuration and stimulation, run-time operation, and decommissioning. Additionally, 3GPP adds important management features for coordinating and overseeing NSIs. These include the network slice management function, which is in charge of managing and orchestrating NSIs. The communication service management function translates communication service requirements into prerequisites related to network slices and the network slice subnet management function, which supervises network slice subnet instances. Furthermore, this report also outlines the responsibilities of different parties, such as suppliers, managers, and consumers, in providing and administrating network slices, guaranteeing various functional levels for the various jobs that were previously described.

1.3 Organizations that support Network Slicing

A network service in network file virtualization (NFV) corresponds to a network slice in 3GPP. Additionally, it suggests using the standard reference point to facilitate communication between 3GPP slice management services and the NFV architecture [3,4]. Below are some organizations working to make NS a widespread success.

- The **Internet Engineering Task Force (IETF)** has approved a network-slicing working group to create concepts and norms associated with network slicing. This working group's documents suggest information models for transportation network slicing that are independent of technology. In contrast, other documents discuss how abstraction and control of traffic-engineered networks can be applied to transport network slicing in IETF technological networks [5,6].
- The **broadband forum** primarily concerns end-to-end network slicing needs in SD-406 network slicing. This forum also focused on 5G and wireless-wireline convergence.

- To make network slicing possible, the **Open Networking Foundation (ONF)** explains how important functional components of the software-defined network (SDN) architecture operate. It states that the customer context of the SDN controller offers the entire abstract set of resources needed to form a slice and that the SDN architecture enables the efficient support of many client network instances on a single infrastructure [7].
- The **ITU-T** Focus Group presented the idea of a network slice on IMT-2020, which distinguished between network slice instances (made by slice users) and network slice blueprints (owned by the network provider). Additionally, it differentiates between two kinds of network slice instances according to whether or not apps are part of the slice [8].
- To automate the whole lifecycle of services across numerous provider networks and technological domains, **MEF** is creating lifecycle services orchestration (LSO) specifications with open APIs. With LSO, users can see their network services as virtual segments of the network as a whole.
- To help business clients digitize operations, enhance workflows, and broaden their service offerings, **GSMA** released a white paper introducing network-slicing technology.
- Telecom Italia and other industry participants established the **5G Slicing Association** to promote industry collaboration, validate the ability of 5G networks to be sliced, and engage with standards development organizations on technical matters about slicing [9].

1.4 Network slicing using SDN-based technology

The idea of "network slicing" with SDN-based technologies uses SDN capabilities to build distinct, personalized virtual networks within a shared physical network infrastructure. With its own set of resources, rules, and efficiency parameters, every network slice functions as a separate network instance. SDN controller and Centralized Control: A centralized SDN controller is essential to an SDN-based network slicing architecture. Network slice creation, arrangement, and administration are coordinated and managed centrally. The controller uses protocols like OpenFlow, NETCONF, or REST APIs to interact with SDN-compatible network devices, like switches and routers [10]. Also, the authors present the network slicing concept for 5G and beyond networks in the [48].

Network Slice Creation: Depending on the particular needs of the use case or service, the SDN controller establishes the specifications and features of a newly generated network slice. Service-level agreements (SLAs), security measures, latency standards, bandwidth allotment, and Quality of Service (QoS) regulations are a few examples of parameters [11]. Figure 2 shows data traffic management.

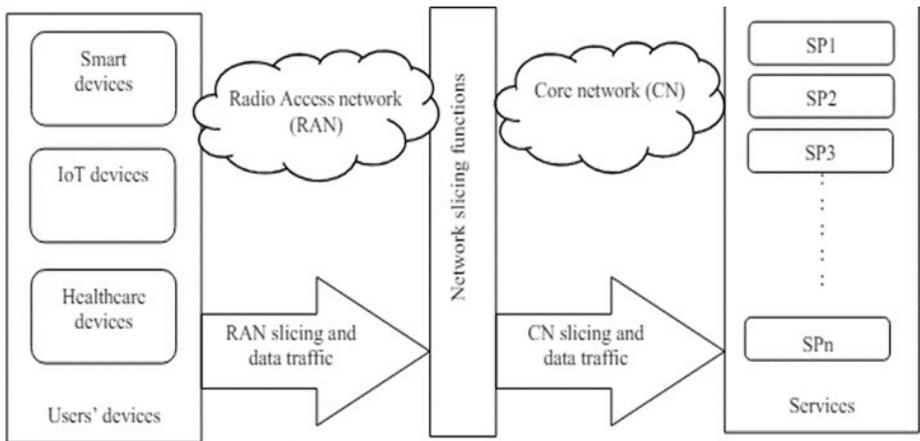


Fig.2:Effective data traffic and service management through network slicing [18]

Network slicing guarantees resource allocation and isolation between several slices, allowing one to function separately from other slices that share the same physical infrastructure. In accordance with the goals and needs set out for each network slice, resource allocation (bandwidth, CPU cycles, RAM) is done by the SDN controller for each individual [11].

Adaptability and Dynamic Change:Flexible and dynamic coping are offered by SDN-based network slicing. In response to altering traffic patterns, service priorities, or demand, resources on the network can be dynamically altered and dispersed among slices. This dynamic flexibility facilitates scalability, resilience to shifting workload conditions, and efficient use of resources. [12].

Quality of Service (QoS) and Service Customization:It is possible to customize each of those network's slice to meet specific service needs. While low latency and high reliability could be the primary requirements for IoT devices, high bandwidth and QoS might be given priority in a network slice meant for multimedia streaming. QoS parameters, including as bandwidth guarantees, traffic shaping, and packet priority, may be set up individually for each slice to guarantee best performance for various applications. [13].

Security and Multi-Tenancy:By allowing several users or tenants to cohabit on the same physical infrastructure while maintaining security and isolation across slices, network slicing, hence facilitating multi-tenancy. In order to protect information and ensure confidentiality at the slice level, security features like access control, traffic segmentation, and encryption can be incorporated [14].

Organizing and managing: An integral component of network slicing management is automated. Processes include establishing, changing, expanding, and terminating slices that are connected to slice lifecycle management may be automated with the cooperation of SDN controllers and orchestration platforms. [15].

Network Traffic and SoDeMa: A system Software Defined Multiple Access(SoDeMa)enhances the efficiency of network usage management by optimizing the access to network resources. It does it by improving overall service availability, decreasing reaction times, andallocating resources in a way that strategically matches demand. One of the key advantages of SoDeMa is its ability to accelerate network access to resources response times. Consequently, SoDeMa dynamically controls resource access to guarantee that vital services or applications are given priority, improving response times and user experience [17]. Network complexity is further reduced through integration with network slices. To properly distribute resources inside each network slice, SoDeMa can be used in conjunction with network slicing methods. Through this integration, network congestion is decreased, traffic management procedures are streamlined, and various services and applications operate at peak efficiency. Additionally, SoDeMa helps network operators optimize and regulate traffic more effectively. It is capable of dynamically modifying accessing protocols, allocating resources according to real-time traffic patterns, and prioritizing traffic based on service requirements [17]. In Figure 3 u1,u2,u3... are user devices capable of supporting 5G connection here priority Pu , limited Lu , energy Eu...Su can be considered with 5G slices.

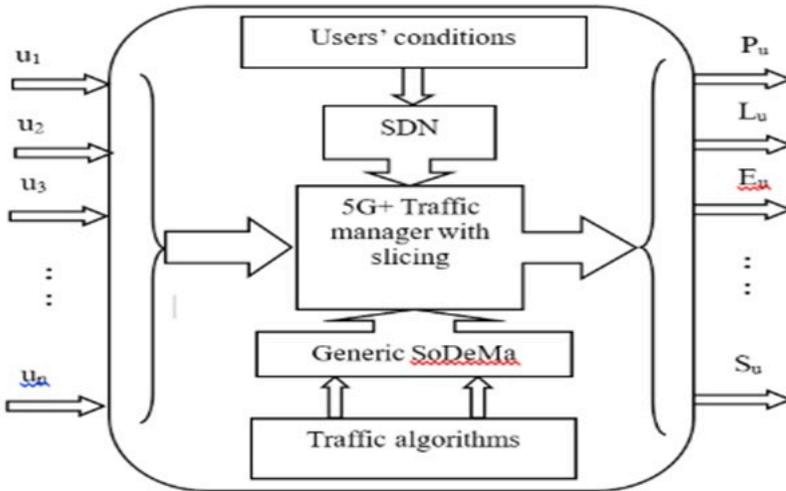


Fig.3: SoDeMa based traffic handling [18]

1.5 Slicing Algorithm

The goal of the latency computation slicing algorithm is to improve network traffic reaction times. To ensure active data transfer, it first determines whether the slice's throughput is greater than zero. The method divides the network slice's capacity by throughput to determine latency, using functionalities unique to 5G+ network traffic management and SDN. Latency can be calculated using the following formula:

$$\text{Latency} = \text{Capacity} / \text{Throughput}$$

Here capacity is the slice's maximum data handling capability and throughput is the actual data transmission rate. This computation aids in evaluating the network slice's

reaction times, especially for priority services, enabling more efficient resource allocation and higher-quality services.

II. Background

2.1 LSTM Network Slicing Framework

In the context of developing communication technologies like C-V2X, we employ deep learning solutions to improve network performances, dependability, and latency situations. Some methods include:

Slice Classification Using ANN:

Three dense layer Artificial Neural Networks (ANN) were used in the study to classify network slices according to particular criteria. A subset of machine learning algorithms known as ANN models are modelled after the biological neural networks seen in the human brain. Following training, the model was able to classify different kinds of slices through the use of a dataset that included details on network slices; metrics such as accurateness, ability to recall, accuracy, and F1 Score were used to evaluate the slice categorization performance of the ANN model. The given features allow the model to differentiate between different kinds of slices was demonstrated by its exceptional network slice categorization accuracy. The ability to recognize patterns seems to have been achieved by the ANN model and network slice characteristics derived from the training data, as determined by the reduction of training and validation loss.

Slice Anticipations Employing LSTM:

For sequence prediction tasks, one effective sort of recurrent neural network (RNN) architecture is Long Short-Term Memory (LSTM). Within this work, an LSTM was trained leveraging previous information was leveraged to anticipate future network circumstances. LSTM models are appropriate for modeling with predictions and time series forecasting as they are capable of enduring connections in sequential data. The LSTM model sought to enhance resource allocation and anticipate network conditions by examining prior information and anticipated facts. One of the measures that was used to evaluate the precision of the LSTM model, was Training Loss the illustrates the ability of model to predict network future condition. The results of the investigation revealed how LSTM stipulates network circumstances. It also aids in making choices about maximizing network efficiency and allocating resources.

A higher Reliability and Latency:

Improve network latency and trustworthiness is the ultimate goal of this work, primarily when it comes to C-V2X communication. This work tried to predict network parameters by taking into account network slices and expected demand by using Deep Learning approach. This work focused on estimation of slice type and demand in order to optimize resource allocation and improve network efficiency. Through statistical assessment and carefully well-planned resource allocation, network dependability may be raised and latency rates decreased. In order to enhance overall quality of service of network communication with primary focus in C-V2X technology is the ultimate objective of this study.

2.2 Machine learning for traffic analysis

Machine learning is leveraged to predict the patterns of low and normal load in network traffic analysis. Machine-learning methods to operate wireless sensor

networks have been looked into by the authors of [47]. The authors impart a comprehensive overview of the design and implementation of an Internet of Things (IoT)-enabled home traffic monitoring system [16]. In order to classify traffic in a smart home environment, the investigation seeks to use machine learning techniques to sensor data processing. The following literature review is provided in light of the paper's key findings and insights:

Machine Learning and IoT Integration: It focuses on how IoT devices could be incorporated into a smart home employing ZigBee sensor network, which collect data from a range of sensor technologies. This association among IoT and machine learning technology is illustrated using machine learning techniques to analyze the collected data for traffic classification [16].

Useful Execution and Illustration: By providing a practical example of their constructed home traffic analysis system, the authors illustrate its characteristics and effectiveness in real-world scenarios [16]. Comprehensive explanations of the system architecture, data gathering procedure, and traffic categorization mechanism provide insights into the real-world application of machine learning for traffic analysis in smart homes [16].

Contributions to the Field: By illustrating the viability and advantages of applying machine learning for traffic analysis, the research advances the use of machine learning in the smart home sector. The study opens the door for improved network security and performance optimization in IoT-enabled environments by offering a useful framework for putting traffic analysis systems in smart homes [16].

2.3 ML based security analysis

Table 1 gives an overview about the algorithm which should be used to solve a particular challenge. It also cites the paper which uses those algorithms to overcome that challenge.

Table 1: State of AI/ ML measures to increase the security

Refereenc e	Algorith m	Accuracy	Scalability	Efficiency	Potential Solutions
[21] [22][26] [32][36]	CNN (Convolut ional Neural Networks)	Inaccuracyin network slice orchestration and optimization and DDoS attack detection using deep learning.	Difficulties in securing multiple network slices on one time	Poor material utilizati on for dangers on mitigati on	Reinforcement learning approaches can be integrated with CNNs to address difficulties associated with accuracy, scalability, and resource utilization in secure 5G network slicing, covering network slice orchestration, DDoS attack detection, and simultaneous security of multiple network slices.

[23][30][33][38]	RL (Reinforcement Learning)	Inadequate precision in the strategic distribution of resources	Challenges in scaling up network slices due to dependencies	Poor management during IP exchange processes	Multi-agent reinforcement training enables precise, expandable, and effective secure 5G network slicing for sophisticated resource distribution, intricate dependencies, and IP reordering procedures.
[24][32][35][37]	SVM (Support Vector Machine)	Accurate end-to-end security in network slices presents challenges	Scalability intricacies in managing secure network	Poor management of security handling	Multi-agent reinforcement training allows for accurate, scalable, and efficient secure 5G network slicing for complex dependencies, IP reordering, and resource distribution.
[25][34][25][36]	DQN (Deep Q-Network)	Challenges with accuracy in context-aware authentication handover for safe network segmentation	Scalability concerns in utilizing authentication handover across slices	Poor management for allocation and authorization procedure	Application of advanced deep reinforcement learning techniques, such as hierarchical or multi-agent DQN, to improve accuracy, scalability, and resource allocation for context-aware authentication handover in secure 5G network slicing.
[21][22][39]	LSTM (Long Short-Term Memory)	Lack of accuracy in network slice orchestration and optimization	Scalability challenges in utilizing aslice	Poor resource assignment	In secure 5G network slice orchestration, enhancedLSTM-based deep learning with RL/attention increases accuracy, scalability, and resource allocation.
[27][40]	FL (Federated Learning)	Insufficient local data in network slices reduces the accuracy and performance of the model.	Scalability is hampered by limited processing resources in network slices, which affects Federated Learning.	System performance and efficiency can be impacted by suboptimal resource allocation and use.	Enhance system efficiency in secure 5G network slicing through employing effective scheduling tactics, improving resource allocation for scalability, and improving model performance using data augmentation and transfer learning.

[29]	K-means clustering, Naive Bayes classifier	Automatic machine learning for network slice automation: Accuracy concerns	Scalability issues when organizing and overseeing numerous network slices	Poor management of automated procedure	Enhancing automated machine learning model accuracy; developing scalable orchestration frameworks; and optimizing automated procedures to use such more effectively
[31]	GAN (Generative Adversarial Networks)	Adversarial machine learning accuracy challenges for flooding assaults in network slicing	Problems with scalability arise when trying to identify and stop flooding assaults across several network slices.	Poor data management while security handling	Increasing the precision of adversarial machine learning models; developing scalable techniques for recognizing flooding attacks; and making effective use of resources while mitigating attacks
[28]	DBN (Deep Belief Networks)	Complicated network slices, a lack of labeled data, and challenges in capturing complicated patterns all contribute to accuracy problems.	Scalability problems in effectively managing several slices and coping with rising computational and communication overhead	Poor data management, communication and connection procedure	Accuracy, scalability, and resource usage can be strengthened by data augmentation, transfer learning, appropriate parallelization, optimum resource allocation, and adaptive techniques.

III. Challenges and Opportunities:

3.1 Advantages of Network Slicing:

Customization: With network slicing, logical networks that are suited to particular requirements can be created. Communication service providers (CSPs) can supply customers with networking solutions that are customized to match their unique needs thanks to this Customization.

Resource Optimization:By segmenting the network into distinct parts, network slicing enables efficient resource distribution across different services and applications. Augmented reality, real-time analytics, and automobile autonomy are just a few of the use cases that this optimization allows by enhancing the network's quality of service (QoS) [6].

Security and Isolation:It keeps each network slice isolated from the others, making sure it is secure and independent. Because of this geographic separation, each of the slices may be individually supervised and maintained, which enhances security and protects data privacy [41].

Scalability and Flexibility: Network slicing gives operators the ability to group system elements according to parameters like latency, capacity, security, and service

level agreements. Because of this adaptability, network managers may dynamically scale resources to match fluctuating demand [42].

Income Potential: Network slicing gives CSPs additional sources of income by enabling them to provide customized services to companies and sectors. CSPs with network slicing have a significant market potential due to the opportunities they present in several industries and the anticipated rise in revenue [43].

3.2 Challenges of Network Slicing:

Complexity: Due to the complex automation and orchestration methods required, network slicing acceptance demands significant logistical and technological investment. Operations and maintenance may become more complex when managing several network slices.

Interoperability: Assuring interoperability across different network slices can be challenging, especially when numerous producers and technologies are involved. Network slices' ability to cooperate may be impacted by compatibility issues [44].

Security Issues: It is more crucial than ever to ensure that each network slice has robust security measures in place as the number of slices increases. Managing security risks and vulnerabilities in a multi-slice system requires ongoing monitoring and mitigation strategies [45].

Quality of Service (QoS): When numerous network slices are providing different applications and services, it can be tricky to maintain a consistent quality of service. Ensuring that each slice meets performance requirements while optimizing resource use might be difficult [45].

Regulatory Compliance: It may be challenging to implement network slicing while conforming to regulatory requirements and standards. Ensuring adherence to data privacy rules, network security standards, and industry-specific legislation makes network slicing systems more difficult [18].

IV. Conclusion and Future Scope

In the context of 5G networks, the article provides an in-depth examination of network slicing, emphasizing its transformational impact on resource allocation, QoS metrics, and support for a broad spectrum of applications and industries. It examines network slicing's effects, strategies, and challenges, stressing the importance of security measures, standardized interfaces, and regulatory concerns. In order to provide network slicing capabilities, edge computing, cloud-native architectures, and ML-based optimization are explored. This highlights the need for further research and development efforts in AI, ML, and security. The study highlights the transformational potential of network slicing beyond standard mobile communications and calls for further investigation into how to fully utilize 5G networks for a variety of industries. The paper's conclusion highlights the importance of network slicing as a crucial enabler of upcoming digital ecosystems and calls for teamwork to overcome obstacles and take advantage of opportunities in the rapidly changing telecom and networking technology landscape.

Smart IoT has amazing prospects thanks to network slicing, but there are still issues. In order to meet customer demands and organizational objectives, network operators must guarantee seamless communication between various infrastructures and divide resources like bandwidth effectively. With several individuals engaged,

security becomes more complicated, necessitating the development of new techniques to guarantee slice integrity and analyze threats. Dynamic spectrum slicing that adjusts to traffic patterns is essential since fixed spectrum allocation might be inefficient. Solutions like mobile-friendly slicing, dynamic spectrum allocation, and intelligent service management for efficiency portend a bright future.

References

1. Subedi, P., Alsadoon, A., Prasad, P. W. C., et al. (2021). Network slicing: A next generation 5G perspective. *EURASIP Journal on Wireless Communications and Networking*, 2021(1), 102.
2. Napolitano, A., Giorgetti, Alessio, Kondepu, et al. (2018). Network Slicing: an Overview. 1-4. 10.1109/RTSI.2018.8548449.
3. Network, E. U. T. R. A. (2011). 3rd generation partnership project; technical specification group services and system aspects; general packet radio service (gprs) enhancements for evolved universal terrestrial radio access network (e-utran) access. EUTRA Network.
4. Alenezi, M., Almustafa, K., & Meerja, K. A. (2019). Cloud based SDN and NFV architectures for IoT infrastructure. *Egyptian Informatics Journal*, 20(1), 1-10.
5. Baldini, L., Wang, Q., Calero, J. A., Weiss, M. B., et al. (2019, June). Slicenet control plane for 5G network slicing in evolving future networks. In 2019 IEEE Conference on Network Softwarization (NetSoft) (pp. 450-457). IEEE.
6. Alfoudi, A. S. D., Newaz, S. S., Otebolaku, A., et al. (2019). An efficient resource management mechanism for network slicing in a LTE network. *IEEE Access*, 7, 89441-89457.
7. Ordonez-Lucena, J., Ameigeiras, P., Lopez, D., et al. (2017). Network slicing for 5G with SDN/NFV: Concepts, architectures, and challenges. *IEEE Communications Magazine*, 55(5), 80-87.
8. Yoshinori, G. (2017). Activity Report of ITU-T Focus Group on IMT-2020. *NTT Technical Review*, 15(6), 42-47.
9. Chahbar, M., Diaz, G., & Dandoush, A. (2019, October). Towards a unified network slicing model. In 2019 15th international conference on network and service management (CNSM) (pp. 1-5). IEEE.
10. Salman, O., Elhajj, I. H., Kayssi, A., & Chehab, A. (2016, April). SDN controllers: A comparative study. In 2016 18th mediterranean electrotechnical conference (MELECON) (pp. 1-6). IEEE.
11. Gao, Z. (2023). Research on 5G Network Slicing Strategy for Urban Complex Environment. *Wireless Communications and Mobile Computing*, 2023.
12. Rost, P., Mannweiler, C., Michalopoulos, D. S., Sartori, C., et al. (2017). Network slicing to enable scalability and flexibility in 5G mobile networks. *IEEE Communications magazine*, 55(5), 72-79.
13. An, N., Kim, Y., Park, J., Kwon, D. H., & Lim, H. (2019). Slice management for quality of service differentiation in wireless network slicing. *Sensors*, 19(12), 2745.
14. Oladejo, S. O., & Falowo, O. E. (2017, October). 5G network slicing: A multi-tenancy scenario. In 2017 Global Wireless Summit (GWS) (pp. 88-92). IEEE.
15. Devlic, A., Hamidian, A., Liang, D., Eriksson, M., Consoli, A., & Lundstedt, J. (2017, May). NESMO: Network slicing management and orchestration framework. In 2017 IEEE

- International Conference on Communications Workshops (ICC Workshops) (pp. 1202-1208). IEEE.
16. Xie, F., Wei, D. & Wang, Z. Traffic analysis for 5G network slice based on machine learning. *J Wireless Com Network* 2021, 108 (2021). <https://doi.org/10.1186/s13638-021-01991-7>
 17. Singh, M. K., Vittal, S., & Franklin, A. A. (2020, September). SERENS: Self regulating network slicing in 5G for efficient resource utilization. In 2020 IEEE 3rd 5G World Forum (5GWF) (pp. 590-595). IEEE.
 18. Alotaibi, D., Thayananthan, V., & Yazdani, J. (2021). The 5G network slicing using SDN based technology for managing network traffic. *Procedia Computer Science*, 194, 114-121.
 19. Napolitano, A., Giorgetti, A., Kondepu, K., Valcarengi, L., & Castoldi, P. (2018, September). Network slicing: an overview. In 2018 IEEE 4th International Forum on Research and Technology for Society and Industry (RTSI) (pp. 1-4). IEEE.
 20. Singh, R., Mehbodniya, A., Webber, J. L., Dadheech, P., Pavithra, G., Alzaidi, M. S., & Akwafo, R. (2022). Analysis of network slicing for management of 5G networks using machine learning techniques. *Wireless Communications and Mobile Computing*, 2022, 1-10.
 21. Thantharate, A., Paropkari, R., Walunj, V., & Beard, C. (2019, October). DeepSlice: A deep learning approach towards an efficient and reliable network slicing in 5G networks. In 2019 IEEE 10th Annual Ubiquitous Computing, Electronics & Mobile Communication Conference (UEMCON) (pp. 0762-0767). IEEE.
 22. Thantharate, A., Paropkari, R., Walunj, V., Beard, C., & Kankariya, P. (2020, January). Secure5G: A deep learning framework towards a secure network slicing in 5G and beyond. In 2020 10th annual computing and communication workshop and conference (CCWC) (pp. 0852-0857). IEEE.
 23. Jiang, W., Anton, S. D., & Schotten, H. D. (2019, September). Intelligence slicing: A unified framework to integrate artificial intelligence into 5G networks. In 2019 12th IFIP Wireless and Mobile Networking Conference (WMNC) (pp. 227-232). IEEE.
 24. Liu, Q., Han, T., & Ansari, N. (2020). Learning-assisted secure end-to-end network slicing for cyber-physical systems. *IEEE Network*, 34(3), 37-43.
 25. Shi, Y., Sagduyu, Y. E., Erpek, T., & Gursoy, M. C. (2022). How to attack and defend nextg radio access network slicing with reinforcement learning. *IEEE Open Journal of Vehicular Technology*, 4, 181-192.
 26. Kuadey, N. A. E., Maale, G. T., Kwantwi, T., Sun, G., & Liu, G. (2021). DeepSecure: Detection of distributed denial of service attacks on 5G network slicing—Deep learning approach. *IEEE Wireless Communications Letters*, 11(3), 488-492.
 27. Bandara, E., Liang, X., Shetty, S., Mulkamala, R., Rahman, A., & Keong, N. W. (2022, September). Skunk—A blockchain and zero trust security enabled federated learning platform for 5G/6G network slicing. In 2022 19th Annual IEEE International Conference on Sensing, Communication, and Networking (SECON) (pp. 109-117). IEEE.
 28. Benzaid, C., Taleb, T., & Song, J. (2022). Ai-based autonomic and scalable security management architecture for secure network slicing in b5g. *IEEE Network*, 36(6), 165-174.
 29. Kafle, V. P., Fukushima, Y., Martinez-Julia, P., & Miyazawa, T. (2018, November). Consideration on automation of 5G network slicing with machine learning. In 2018 ITU Kaleidoscope: Machine Learning for a 5G Future (ITU K) (pp. 1-8). IEEE.
 30. Yoon, S., Cho, J. H., Kim, D. S., Moore, T. J., Nelson, F. F., et al. (2020, April). Moving target defense for in-vehicle software-defined networking: IP shuffling in network slicing with multiagent deep reinforcement learning. In *Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications II* (Vol. 11413, pp. 617-626). SPIE.

31. Shi, Y., & Sagduyu, Y. E. (2021, June). Adversarial machine learning for flooding attacks on 5G radio access network slicing. In 2021 IEEE International Conference on Communications Workshops (ICC Workshops) (pp. 1-6). IEEE.
32. Khan, S., Khan, S., Ali, Y., Khalid, M., Ullah, Z., & Mumtaz, S. (2022). Highly accurate and reliable wireless network slicing in 5th generation networks: a hybrid deep learning approach. *Journal of Network and Systems Management*, 30(2), 29.
33. Cheng, X., Wu, Y., Min, G., Zomaya, A. Y., & Fang, X. (2020). Safeguard network slicing in 5G: A learning augmented optimization approach. *IEEE Journal on Selected Areas in Communications*, 38(7), 1600-1613.
34. Abdulqadder, I. H., & Zhou, S. (2022). SliceBlock: Context-aware authentication handover and secure network slicing using DAG-blockchain in edge-assisted SDN/NFV-6G environment. *IEEE Internet of Things Journal*, 9(18), 18079-18097.
35. Abdulqadder, I. H., & Zhou, S. (2022). SliceBlock: Context-aware authentication handover and secure network slicing using DAG-blockchain in edge-assisted SDN/NFV-6G environment. *IEEE Internet of Things Journal*, 9(18), 18079-18097.
36. Chowdhury, D., Das, R., Rana, R., Dwivedi, A. D., Chatterjee, P., & Mukkamala, R. R. (2022, December). Autodeepslice: A data driven network slicing technique of 5g network using automatic deep learning. In 2022 IEEE Globecom Workshops (GC Wkshps) (pp. 450-454). IEEE.
37. Tam, P., Math, S., Lee, A., & Kim, S. (2022). Multi-Agent Deep Q-Networks for Efficient Edge Federated Learning Communications in Software-Defined IoT. *Computers, Materials & Continua*, 71(2).
38. Kim, Y., & Lim, H. (2021). Multi-agent reinforcement learning-based resource management for end-to-end network slicing. *IEEE Access*, 9, 56178-56190.
39. Wang, J., & Liu, J. (2022). Secure and reliable slicing in 5G and beyond vehicular networks. *IEEE Wireless Communications*, 29(1), 126-133.
40. Li, R., Wang, C., Zhao, Z., Guo, R., & Zhang, H. (2020). The LSTM-based advantage actor-critic learning for resource management in network slicing with user mobility. *IEEE Communications Letters*, 24(9), 2005-2009.
41. Wijethilaka, S., & Liyanage, M. (2022, December). A federated learning approach for improving security in network slicing. In GLOBECOM 2022-2022 IEEE Global Communications Conference (pp. 915-920). IEEE.
42. Olimid, R. F., & Nencioni, G. (2020). 5G network slicing: A security overview. *IEEE Access*, 8, 99999-100009.
43. Rost, P., Mannweiler, C., Michalopoulos, D. S., Sartori, C., Sciancalepore, et al. (2017). Network slicing to enable scalability and flexibility in 5G mobile networks. *IEEE Communications magazine*, 55(5), 72-79.
44. Arora, R. (2021). 5G Network Slicing-Revenue by Slice. *Telecom Business Review*, 14(1), 29-34.
45. Kim, D., & Kim, S. (2019). Network slicing as enablers for 5G services: state of the art and challenges for mobile industry. *Telecommunication Systems*, 71, 517-527.
46. Shu, Z., & Taleb, T. (2020). A novel QoS framework for network slicing in 5G and beyond networks based on SDN and NFV. *IEEE Network*, 34(3), 256-263.
47. Paul, S. A Comprehensive Review on Machine Learning-based Approaches for Next Generation Wireless Network. *SN COMPUT. SCI.* 5, 468 (2024). <https://doi.org/10.1007/s42979-024-02831-3>.
48. Hamdi W., Ksouric, Bulut H., and Mosbah M., Network Slicing-Based Learning Techniques for IoV in 5G and Beyond Networks, *IEEE Communications Surveys & Tutorials*, Vol. 26, No. 3, Third Quarter (2024).

Open Access This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

