Advancements in 5G Network Slicing: A Comprehensive Overview of Taxonomy, Requirements, and Emerging Research Prospects

[1] Swarna Kamalam Vaddi
Research Scholar, Department of CSE, Koneru Lakshmaiah Education Foundation,
Vaddeswaram, Andhra Pradesh, India ,swarna.vaddi@gmail.com
[2] Venkata Vara Prasad Padyala
Assoc. Professor, Department of CSE, Koneru Lakshmaiah Education Foundation,
Vaddeswaram, Andhra Pradesh, India, varaprasad_cse@kluniversity.in

ABSTRACT

The emergence of 5G and subsequent generations of networks is expected to offer a wide range of services with diverse specifications. Notably, network slicing has been identified as a key innovation in enabling the provision of many services within 5G networks. By embracing network slicing, a transition is made from a networking-as-an-infrastructure model to a networking-as-a-service model, making it possible to support a multitude of 5G smart services with varying specifications. Despite the extensive coverage of network slicing in assessments and instructional videos, there remains a need for a comprehensive exploration of its taxonomic structure and prerequisites. In this article, we provide a detailed analysis of the most significant advancements in network slicing and how they have facilitated the emergence of numerous intelligent applications in the realm of the Internet of Things (IoT). We establish a taxonomy for network slicing based on the following criteria: fundamental design principles, enablers, objectives for slicing resources, plans for network functionality chaining, physical infrastructure, and security considerations. Additionally, we delve into the essential requirements for implementing innovative services through network slicing. Lastly, we shed light on ongoing research efforts and potential standards related to network slicing.

Keywords: Internet of Things, SDN-software-defined networking, NFV-network function virtualization, and the following technologies: 5G and 6G.

INTRODUCTION:

The rapid evolution of network slicing, often attributed to its acceleration by 5G, introduces a groundbreaking concept: the enhanced flexibility of managing multiple logical end-to-end networks on a single shared infrastructure. In essence, this entails segmenting the network into distinct components tailored for various audiences and use cases. The simplicity of achieving such "slice-ability" is notably improved with the advent of 4G and 5G technologies [1][2][3].

Once 5G infrastructures are established, service providers gain the capability to allocate specific portions of their network to cater to the unique requirements of their customers, thereby adapting their service delivery. Examples of this include enabling industrial applications for the Internet of Things (IoT), isolating AI-driven video streams, and facilitating communication for autonomous vehicles within a fleet. Network slicing enables the connection of smart services with diverse needs across a spectrum of virtual networks built upon the foundation of the physical network infrastructure [4][5][6].

Consider, for instance, the scenario of reporting accidents involving autonomous vehicles in an automated transportation system. To ensure prompt collision reporting and minimize damage, stringent latency requirements must be met. In contrast, smart farming applications typically demand lower latency compared to smart transportation systems. Consequently, the latency sensitivity of intelligent transport slices is higher than that of smart agricultural slices.

Network slicing can be realized through various approaches. One method involves creating dedicated end-to-end networks for each service, but this can significantly raise operational costs. As a result, an alternative option is to allow multiple smart services to share resources on a single physical infrastructure. This physical infrastructure encompasses a range of components, including wireless networks, edge computing servers, cloud-based computing, communication satellites, aerial drones, and wireless internet access points. Establishing effective collaboration among various stakeholders in the infrastructure domain is crucial for enabling smart IoT services through network slicing.

However, numerous challenges must be addressed to facilitate interaction with these diverse physical frameworks through network slicing. These challenges encompass issues related to interoperability, portability awareness, efficient end-to-end orchestration, and the development of innovative business models. Different standardization organizations have outlined network slicing in various ways.

It's important to note that network slicing lacks a universally standardized definition. In essence, network slicing embodies all endeavors aimed at providing network-as-a-service accessibility in accordance with specific customer requirements. Key enabling technologies for network slicing include Network Function Virtualization (NFV), Software-Defined Networking (SDN), cloud computing, and edge computing. NFV allows for the deployment of cost-effective network functions within a generic architecture, while SDN enables the separation of the control and data planes, offering efficient and adaptable resource management. Consequently, it is reasonable to assume that SDN and NFV-based network slicing represent a fundamental advancement in networking for fifth generation (5G), sixth generation (6G), and even higher-speed networks.

In figure 1 end user will connect to tenant to access the network the entire communication information and tracking will available at InP (inut location). User can connect to network based on demand speed using networking clicing which is new era in 5G networks. In general scenario the road will have 3 line with different communication channels which is having paths based on vehicle speed, like in same scenario our network can have path segmentations based on user requirements which was elaborated in Figure:1.

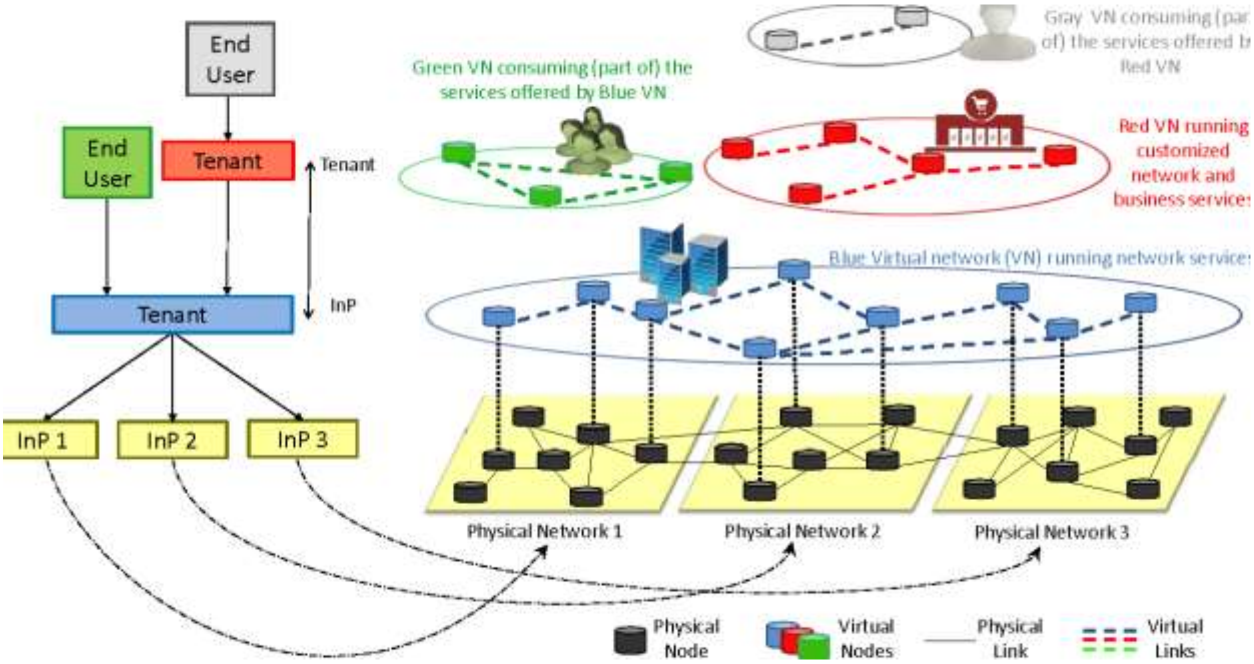

Figure 1: Unlocking Smart Services: Exploring the Role of Network Slicing

Literature Review

The successful implementation of network slicing to support a wide range of smart applications presents significant challenges due to the multitude of stakeholders involved.

These stakeholders encompass telecommunications service providers, distributed computing resources, cloud-based data centers, and Internet of Things networks. Achieving seamless collaboration among these diverse entities is an essential prerequisite for the complex process of implementing network slicing. We consequently need to pay close consideration to how network slicing is designed [7]. The process of isolation, elasticity, and end-to-end effective optimization are the main architectural fundamental concepts of network slicing, [8], [16], [17], [28], [29].

Multiple research studies [8], [16], [17] provided an in-depth discussion of network slicing. A synopsis of network slicing layouts was offered by author Foukas et al. in [8]. The physical infrastructure layer, network operation layer, and service layer are three of the areas where researchers have investigated the greatest amount of recent advancements in network slicing. In addition, the investigation stipulated a number of issues related to open research. Afolabi et al. conducted an in-depth review of network slicing governance and orchestration, fundamental principles of design, and underlying methodologies [16]. Additionally, several kinds of prerequisites for the radio access network (RAN) and core network are set forth in order to enable network slicing. Finally, a few lingering problems in resource allocation and security for slices were highlighted. Another poll in [17] covered the 3GPP network slicing consensus process. The authors focused on a few open research difficulties for network slicing in 5G and also addressed recent research trends. The network slicing vision of offering expansive vehicle-to-vehicle (V2V), vehicle-to-infrastructure (V2X), and better transport services was surveyed by Campolo et al. in [19].

In addition, they presented about the 3GPP-specified V2X services and delivered a brief description of the network slicing that contributes to them possible. In addition, multiple kinds of slices have been offered, such as the ones for the remote diagnostics of automobiles, teleoperated slices, autonomous driving slices, and vehicular infotainment slices. A number of factors, notably radio access technology (RAT) settings, transmission mode, QoS administration, the hybrid automatic repeat request (HARQ) options, scheduling techniques and time of transmission interval (TTI), have to be adjusted for allowing these slices. In order to facilitate V2X communication, [20] proposes a network slicing a framework that simplifies the use of downlink interaction in heterogeneous mobile network environments. The concept of the 5G-TRANSFORMER, that focuses on the emergence of cellular transport networks approaching the use of edge computing, the NFV standard and SDN facilitated 5G mobile transport networks, is put out in [21].

A mobile transport and computing platform (MTP), a service orchestrator (SO), and a vertical slicer (VS) make the core of the 5G-TRANSFORMER concept in which it has been put forth. The supervision of the underpinning physical mobile transport network, the coordination of applications for vertical slices, and the coordination of service function chaining are the roles of the MTP, SO, and VS. The ability to add new functional blocks to the ETSI management and orchestration based design is the proposed 5G-TRANSFORMER's core advantage. The network slicing-based 5G test-bed set up by the Hamburg Port Authority, Deutsche Telekom, and Nokia at the Hamburg sea port has been addressed by Rost et al. in [22].

Theodorou et al. presented up a proposal in [23] for leveraging cross-domain network slicing for facilitating industrial applications. The proposal was put together for the EU-funded VirtuWind project, and this included an industrial wind park scenario into consideration. Supervisory Control and Data Acquisition (SCADA) is utilized in a private network that is positioned next to the actuators and controllers to manage the industrial wind park.

Table 1: Overview of latest research and instructions, accompanied by a summary of their primary ideas

Reference	Internet of Things	Taxonomy	Requirements	Remarks
Foukas et al. , [8]	×	×	×	They highlight the most new developments, an overarching architecture, and unresolved research challenging times for 5G network slicing
Afolabi et al. , [16]	×	×	✓	The design concepts, underlying technologies, network slice orchestration and administration, radio access network and core network slicing demands, and

				more are all covered in-depth by the authors.
Alexandros Kaloxylos , [17]	✗	✗	✗	The authors primarily concentrate on the network slicing standardization efforts of the Third Generation Partnership Project (3GPP).
Our research	✓	✓	✓	Our assessment covers network slicing's most current developments, taxonomy, prerequisites, and open research issues.

I.NOVEL DEVELOPMENTS

The latest advancements in network slicing technology are summarized in this part of the paper. These advancements are classified, critically analyzed, and evaluated by us.

A. HEALTH-CARE

The premise of innovative medical care is the adoption of technological innovation to offer reasonably priced and effective instantaneous fashion medical facilities. A network slicing paradigm leveraging ontologies for taking care of comprehensive slicing periods was put forth by Celdran et al. in [27]. The outlined policy-based development permits dynamic orchestration of resources in order to comply with the wants and needs of a variety of scenarios. Inter-slice and intra-slice initiatives were the two genres of policies that the authors proposed. While an intra-slice policy covers administration of an individual slice, an inter-slice policy specifies the management of transitioning between slices. The research team also took consideration into account the case of multimedia and remote healthcare. Despite being aware that the recommended architecture pitched substantial implementations of network slicing utilizing ontologies with tolerable latency from its inception to the final accreditation. Nevertheless, when it came to the study and gathering of various indicators, the contributors did not take forecasting and continuous analytics into account. In addition to the promoted plan, these kinds of analytics can be utilized to provide ambient computing resources for managing oneself functionalities.

B. SMART GRID

With the objective to streamline standard grids by introducing smart meters, the smart grid concept integrates the latest communications and information technologies with cutting-edge computing innovations. In [26], Kurtz et al. recommended a technique based on queueing methodologies driven by SDN along with NFV. For 5G specs, the authors enhanced the ETSI NFV architecture. A testbed of 13 identical servers with six 1GBaseT Ethernet ports from two Network Interface Cards (NICs), 16GB of RAM, and an Intel Xeon D-1518 CPU is assembled to assess the performance of the suggested scheme. On top of that, Ubuntu Server Version 16.04.3 LTS is the OS that was used in the trials. The open version of vSwitch 2.5.2 is used for setting up three virtual switches. Six servers have been configured to serve as hosts, while four PCs are used for creating SDN controllers. For scenarios including smart power lines and smart transit systems, the authors evaluated their suggested plan. For important communication, the recommended solution offers the advantages of better scalability and minimal delay throughout the process. The orchestration of policy-based slices, which might be necessary for certain services alone, was not taken into account by the authors.

C. SMART HOMES

Modern control and automation systems, like smart safety, and smart lifts, smart plug-in hybrid cars with electric charging, and smart meters, are employed in smart houses.

(1) Smart Home Slicing in a Hierarchical Structure

For IoT-based smart houses, Chaabnia et al. suggested a two-level slicing approach in [24]. The control plane slicing aided by a flowvisor and home gateway slicing are two distinct levels of slicing. Through virtualization, the flowvisor facilitates collaboration of a physical switch between virtual networks that employ various addressing and forwarding systems. Additionally, the suggested slicing architecture took into account employing a single vSwitch for the overall home automation network. Considering upon their bandwidth demands, traffic categorization, and usage, all apps are broken down into four classes in the initial stage of hierarchical slicing. Furthermore, to these slice specifications, buffers have been established for each type of slice in accordance with the data rates and priorities. In accordance to the needed data rates, the network traffic is broken down into different groupings in the second stage of slicing. Similar traffic applications are given the same slices. The proposed approach is then tested in an experimental setting using Mininet.

(2) prototype for a safe smart home

With the two primary supporting technologies for IoT asset administration in smart homes, SDN and NFV were put forward by Boussard et al. in [25] as a secure prototype termed future spaces. For achieving extremely fine supervision of the smart home network, the authors gazed into group-oriented slicing. On top of the shared home automation network, group-based network slicing produces distinct virtual networks. Modern space manifestations connected with different technologies, including 5G, Wi-Fi, and digital subscriber line (DSL), contribute to the speculative future space prototype. These future space instances can communicate within secure tunnels in an ad hoc privatized network and can be perhaps a tangible or virtual implementation environment. Upcoming space scenarios will be utilized to offer an extensive wide variety of data storage, computing, and the gateway capabilities. These running instances are also capable of being set up to operate on several kinds of virtual machines and IoT devices. The notions of vPlace and vSpace have been created in the research paper with the aim to ease slicing-based activities. Resources can be found in vPlace, whereas vSpace enables more precise control over communication and resource access. In more detail, vSpace is a virtual space that enables private conversation among its users. These vSpaces are actually implemented as software defined LAN slices. In addition, the suggested plan uses NFV and SDN to manage the entire network. Although SDN and NFV have been employed by the researchers for offering network isolation and secure operation, SDN has own safety considerations that needs to be meticulously handled.

D. SMART TRANSPORTATION SYSTEM

Autonomous driving, in-car information literacy services, and vehicle-to-infrastructure connection are all made possible by smart transportation systems. In seeking to virtually partition the Air-Ground Integrated VEhicular Network (AGIVEN) infrastructure into numerous slices with good quality of service (QoS) assurance, the service-focused network slicing strategy has been suggested in [18]. High-altitude platforms (HAPs) and widely dispersed roadside units (RSUs) constitute the basis for AGIVEN's physical infrastructure, that makes it possible for active content streaming to vehicles and on-demand high-rate unicast communication services, correspondingly.

In addition to them, onboard cache is available for automobiles that enhanced speeds of data by lowering RSU requests. Despite AGIVEN provides numerous benefits, it has a difficult time managing its resources owing to the wide array of its traffic flow and resources. The recommended approach utilizes service-based slicing for creating numerous logical connections for distinct slices on atop of the common infrastructure that is physical in order to handle such elevated management sophistication. High resolution map for navigation (MaNa) slices, file of common interest (FoCI) slices, and on-demand transmission (ODT) slices are the three different types of slices that have been developed. Additionally, there are two kinds of SDN controllers: In AGIVEN, the two local and centralized controllers are employed. Local HAPs and RSUs are controlled by controllers, although Local controllers are observed by the central controller. The local controllers' specific responsibility is to keep an eye on mobile the central controller about the traffic demands. The local devices are given information that help with the allotment of resources that are physical, whereas the central controller administers virtual resource slicing while providing QoS guarantee. Using information from statistics on traffic requests, content visual appeal, and movement of vehicles, the contributors examined into huge-scale provisioning of resources in enormous detail. In order to use adaptive slicing to enhance its performance, it is advantageous to utilize account of small-scale information.

E. SMART INDUSTRY

The industrial automation is anticipated to be rendered feasible by intelligent industries by utilizing innovations includes artificial intelligence, cloud computing, computing on the edge, the Internet of Things, and cyber-physical structures, regarding others. The network slicing-based 5G test-bed installed by the Hamburg Port Authority, Deutsche Telekom, and Nokia at the Hamburg seaport was addressed by Rost et al. in [22]. First, the three most important design elements—dynamic management of standalone slices, resiliency, as well as encouragement for service diversity—are determined. Additionally presented are the 5G test-bed scenarios used at the Hamburg port (traffic light control, live remote site assistance, and sensor observations). The test-bed has been created using 3GPP LTE Release 14, that gives an option for creating dedicated logical networks by customizing an enhanced Decor (eDECOR) in order to satisfy particular standards. The investigators also observed the possibility of challenges in future investigations while offering proposals concerning how to deal with them.

TAXONOMY

In this section, a classification of the research literature is developed using the criteria of key design concepts, resource levels, key enabling factors, service functionality chaining initiatives, physical infrastructure, and security.

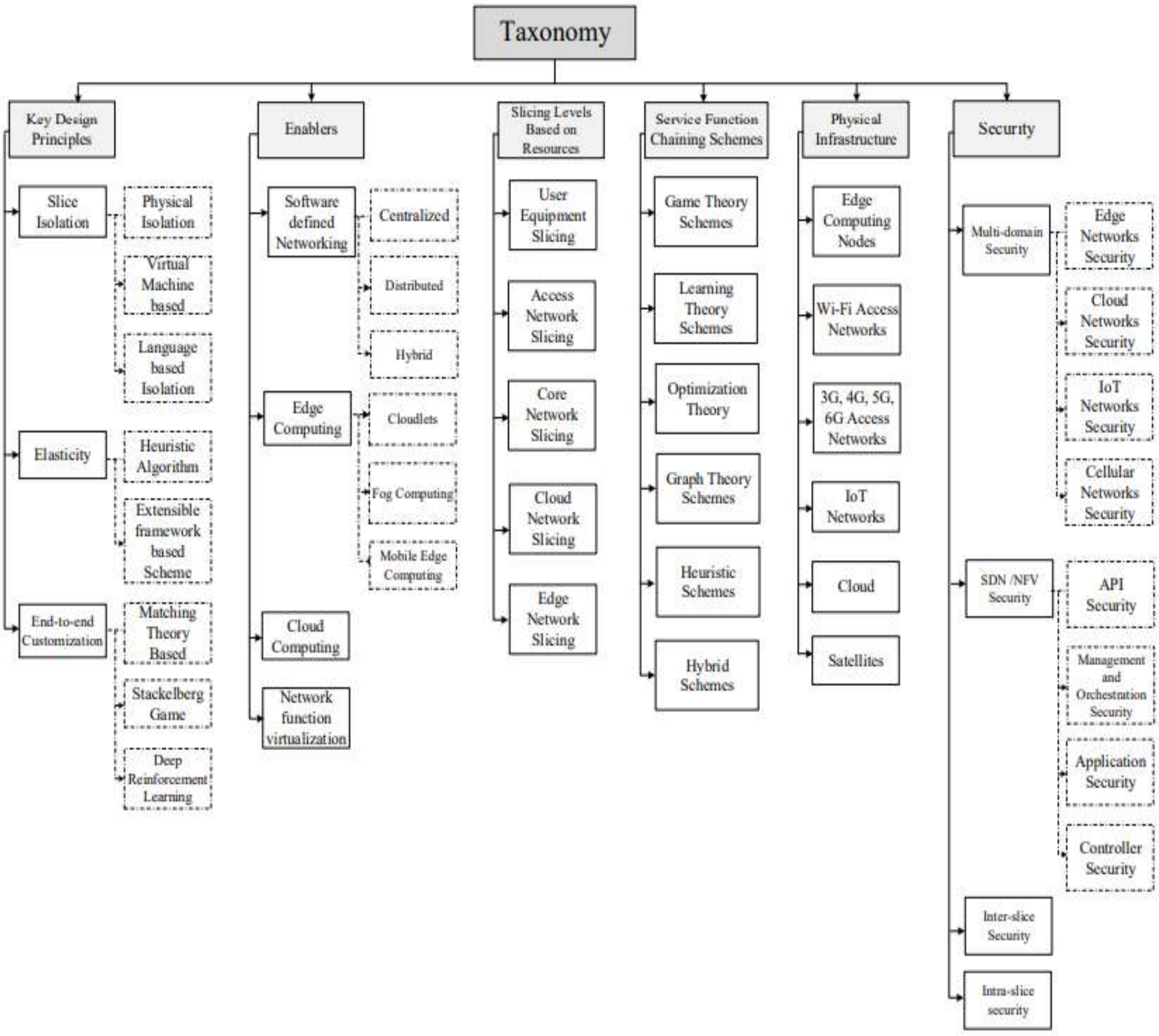

Figure 2: Taxonomy

a) Key Design Concepts:

Due to the huge number of respondents, facilitating network slicing for assisting a wide range of innovative applications raises crucial hurdles. These stakeholders include telecommunication service providers, distributed computing, cloud-based computing, and internet of things (IoT) networks. Adequate communication among these parties needs to occur for performing network slicing, which is a challenging endeavor. We should therefore pay particular focus to the way network slicing is designed [7]. The process of isolation, elasticity, and end-to-end optimization are the main structural tenets of network slicing [8], [16], [17], [28], [29].

As illustrated by Figure 4 [30], the network slicing infrastructure is usually composed of three layers: a network's infrastructure layer, a network slice instance layer, and the service instance layer.

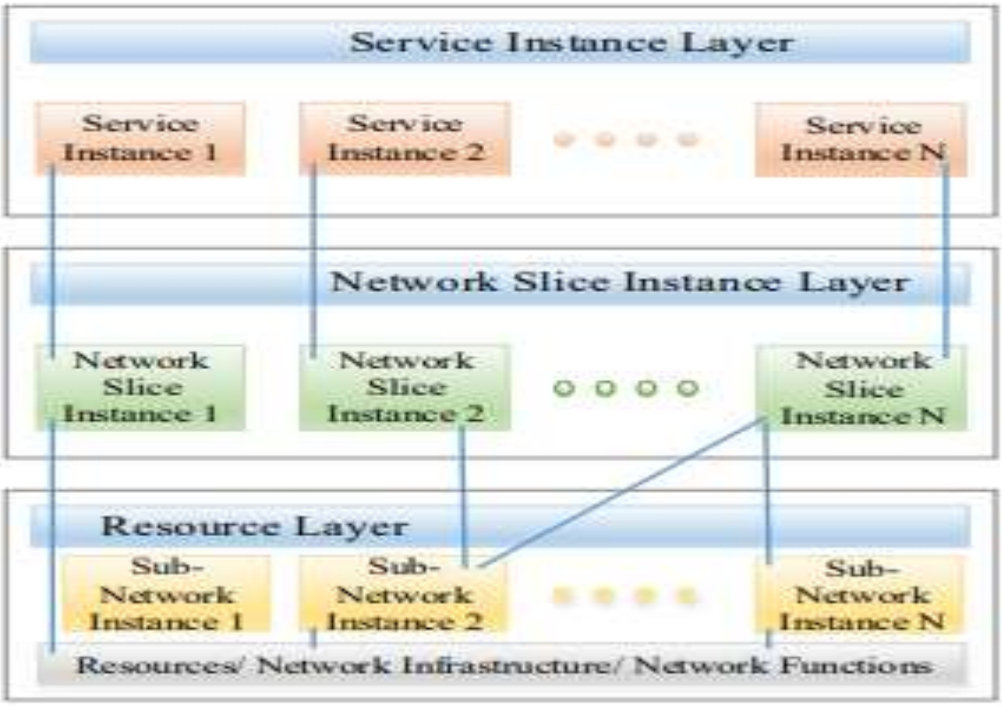

Figure 3: Network Slicing Layered Architecture

Elasticity involves having the ability to customize the readily accessible of slice resources in order to satisfy demands from users. Due to oscillations in user needs, the affordability of certain resources in a slice can result in under- and excessive utilization of resources [7]. As an outcome, network slicing must be implemented with an elastic characteristic to simultaneously attain user quality of service and maximize overall network spending.

b) Key Enabling Factors

There are plenty of limitations pertaining to networking architecture that are caused by a wide variety of software applications and their tremendously varying requirements. Some of these challenges include the setting up of network functionalities using generic programmable hardware, operational network orchestration, with and computing resources that are on-demand for services. The use of cloud computing, the use of edge computing, NFV, and SDN must all be implemented enabling the network in order to be able to leverage network slicing in order to conquer these obstacles, [37]–[40]. SDN allows for controlling the network's operations less complicated and more productive. A centrally managed control plane, a geographically dispersed control plane, or a hybrid control plane may be utilized for establishing the SDN control plane. The capacity for expansion of a standard centralized controller has been significantly affected by the single controller abilities. The ability to scale is further impacted by the signaling expense between the switching devices and controller. More precisely, the network's resilience is influenced with the flow configuration with the statistics collecting the samples. Due to the processing of all flow setup requests and subsequent transmission of flow establishment communications by a single controller, the scaling potential of a single controller is hindered. In addition to transmitting installations and flow configuration messages, the controller carries out periodical state inquiries to find forth the available resource states of each of the switches that are currently underneath its control. The challenge of sustainability is not well addressed through centralized control since tremendous networks exhibit significant latency. On the contrary hand, distributed and hybrid controllers incorporate numerous controllers to deliver scalable operation. Therefore, the network's features have a significant effect on the decision-making process of an SDN controller. Edge computing decreases the delay by pushing cloud computing resources to the network's end [1]. The idea of "pushing resources for computing to the network edge" is currently used in research to denote several kinds of technologies, including cloudlets, cloud computing, fog computing, and edge computing for mobile devices. In order to carry out network functions in an adaptable fashion, NFV facilitates the use of universal hardware with virtual machines operating on it [37], [45], [46]. If one wants to implement novel capabilities, the hardware might not have to be completely redesigned. On the already-existing hardware, these new functions can be accomplished through virtual machines [47].

c) Physical Infrastructure

Diverse networks of communications and technology for computers are used in network slicing to support different smart service offerings at the infrastructure layer [2]. The technologies involved include satellites, cloud services, Internet of Things (IoT) networks, communication networks, and advanced computing technologies. As needed resources for computing and storage can be offered by technological advances in computing like edge and cloud [1], [7]. Edge computing lowers resources and has a lengthier delay than cloud computing. For applications that require high latency like autonomous vehicles, virtual and augmented reality, and smart forest fire recognition, edge computing is a better option. A multitude telecommunications standard, including 3G, 4G, 5G, and 6G, can be used for physical interactions in addition to computational techniques [4].

d) Slicing Levels Based on Resources

The infrastructure's physical components can be segregated at multiple tiers, including the level of equipment used by users, accessible networks, core networks, and edge networks. Telecommunications between devices are made possible by user equipment. Additionally, personal equipment caching provides instantaneous content access. An alluring scheme for incentives must be developed to enable devices used by users to provide caching and interaction between devices. The core network, cloud, and computing resources at the edge must be shared efficiently across many different tenants while maintaining the design's general requirements, ranging from the user equipment level with and radio access network.

e) Security

Slice protection is frequently surrounded into inter- and intra-slice security [6]. Whereas intra-slice security is related to slices of certain applications, inter-slice security encompasses safety rules implementing to all slices across different smart apps. Unique smart application slices possess distinct security requirements. For instance, in comparison to smart infotainment slices, intelligent health-care slices raise supplementary security issues. Consequently, robust safety measures need to be implemented for intra-slice security. On the contrary hand, SDN and NFV involve several different networks that facilitate network slicing for multiple tenants with specific demands using an array of physical infrastructures. There are a number of risk factors that arise from enabling network slicing, including multi-domain security issues related to edge computing, cloud computing, telephony networks, and IoT networks.

DEMANDS

The vital requirements for empowering network slicing have been emphasized in this section. Scalability, dynamic network slicing, extensibility, recursion, effective end-to-end orchestration, and a dynamic and secure business model represent a few of these criteria.

A. SCALABILITY

How ought to effective slices of networks with isolation be rendered possible throughout an interconnected physical framework to accommodate an upward trend in user numbers? It is constantly noted that novel nodes are frequently introduced in a wide range of smart environments, including smart commerce, smart transportation, and smart health care [7]. For these cognitive environments, the addition of additional nodes represents another challenge in terms of QoS degradation. On the other hand, the network slicing encompasses plenty of network segments with different attributes. A distinctive array of representations and abstractions have been implemented for processing each network segment. Therefore, administering the network as a whole via a single management unit (orchestrator) delivers the benefit of minimizing management complexity but arrives at an extra cost of inadequate control over resources. Additionally, using a single orchestration unit adds to the complexity and time. For enormous ultra-reliable low latency communication in the impending 6G wireless systems and massive machine-type communication in the current 5G wireless systems, this type of delay increase will be more noticeable. We can lessen the complexity to address these problems by using numerous network orchestrators. Each orchestrator has been embedded for operating specific segments of the network. An additional entity designated as a hyperstrator, whose duty it is for overseeing the overall network distribution of resources, then administers these innumerable orchestrators. Through the aid of such a framework, network slicing-based operations can be scaled. In addition to employing multiple orchestrators, network slices need to be addressed elastically to prevent resource underuse. By mitigating resource underutilization, the framework may accommodate extra users.

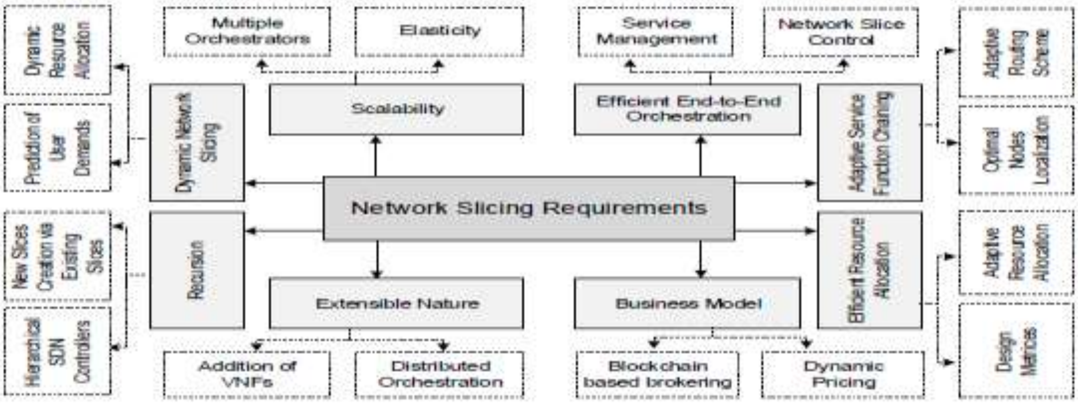

Figure 4: Smart city requirements enabled by network slicing

B. DYNAMIC NETWORK SLICING

How can we create network slicing possible so that resources are distributed in real time depending on user demands? A user's demand has been assumed to remain continuous over the process of managing resources in [3], [7]. However, throughout the resource management procedure, there are frequently wide variations among user requests. Users possess the option of joining and abandon the system on demand. Thus, it must automatically assign resources in addition to facilitate network slicing for smart urban areas with an abundance of user needs. Accurate user demand prediction and dynamic resource allocation are required to enable dynamic network slicing [22]. For the prediction of user traffic, a variety of theory-of-learning frameworks, include deep learning and reinforcement learning, can be applied. Effective methods for distributing resources can be relied on for facilitating dynamic network slicing after correct prediction.

C. EXTENSIBILITY

How can network slicing be rendered practicable such that its functionality can be expanded? Smart application slices have been engineered to be extensible, which permits the inclusion of novel functionality by tweaking already-existing virtual network functions. Using a hierarchical orchestrators-based layout is one procedure for developing an extendable network slicing architecture. A collective of orchestrators are employed in this network slicing paradigm to oversee network segments with associated characteristics. The first-level orchestrators are then managed by the second-level orchestrators. By employing the linked virtual network functions, first-level orchestrators might offer more capabilities to second-level orchestrators.

D. RECURSION

How is it feasible to develop a new slice using one that already exists? A network slicing planning with recursion functionality is capable of creating new slices from older ones. Building one from preexisting slices is easy than constructing a new one from beginning. Therefore, when constructing the network slicing architecture, this key criterion must be met. Recursion in network slicing can be delivered through changes to the SDN control plane through using several hierarchical controllers. Numerous level server/client communications can be set up using these hierarchical controllers. A controller has the ability to utilize resources (like other SDN controllers) via the server's context to construct new slices for its client [8] owing to such structured connections.

E. EFFICIENT RESOURCE ALLOCATION

How can the computational power, spectrum, and the amount of links bandwidth be efficiently redistributed in network slicing while improving both user experience and operator profit? There are a few distinct conditions that require being met to be able to turn on various smart services. All resources, nevertheless, have constraints. Therefore, network slicing building design faces severe constraints by smart services. Correctly estimating the amount needed of slices, followed by resource allocation, is essential for enabling optimal network slicing. Unique design patterns may be employed to allocate resources. The energy, delay, QoS, and user-defined utility are some of these matrices. For effective QoS, resource distribution throughout network slices must be adaptable. For instance, tight latency limitations apply to smart vehicle slices. In order to cut down on delay, more resources must be directed to smart transportation.

F. DYNAMIC AND SECURE BUSINESS MODEL

In the presence of several smart services and multi-vendor systems, how do we enable safe and dynamic business models for network slicing? Various suppliers offer the resources needed to allow various smart services, including edge server providers, cloud providers, and communications service providers. It is necessary to create incentives for the service providers to offer their services through a network slice provider.

To efficiently enhance the overall profit without reducing QoS, these incentives must be dynamic. In one instance, many smart services could inquire for resources from the edge to get low-latency, upon request computing resources. For such a type of interaction between users and edge computing service providers, we demand a powerful dynamic pricing model. The expenditure of computing resources needs to account for the total amount of requests, the amount of time spent using them, and the total number of active requests throughout a certain time period. The execution of resource buying and selling by the network slice provider enables such interactions. Brokering is a particular technique for ensuring secure transactions between sellers and purchasers. One strategy involves the use of a secure brokering mechanism built on a block chain for purchasing and trading resources among participants in network slicing.

VII Emerging Research Opportunities

This section lists an assortment of open research problems and potential remedies for network slicing. Radio access network virtualization, service composition with fine-grained network features, end-to-end slice orchestration and management, network slicing techno economics aspects, radio access network slicing and traffic isolation, security, slice optimality, and user equipment slicing are the challenges covered in the existing surveys of network slicing [8], [16], [17].

Challenges	Causes	Guidelines
Intelligent service function chaining	1. Optimal node localization 2. Low-latency routing	1. Deep learning-based intelligent service function chaining 2. Reinforcement learning-based scheme
Adaptive security scheme	1. Significant variations in latency requirements of smart applications 2. Security requirements diversity of different smart applications	1. SDN ochestrator based adaptive security scheme 2. Novel light weight authentication schemes for strict latency application slices
Mobility-aware slicing	1. Handover across different radio access networks 2. Ultra-high density of future 5G and 6G networks along with high mobility	1. Lagrangian dual decomposition based solution 2. Matching theory-based slicing schemes
Network slicing Forensics	1. Serious vulnerability to attacks 2. Wide variety of	1. Forensic Models 2. Forensic tools

	infrastructure providers	
Dynamic Spectrum Slicing	1. Spectrum scarcity 2. Variations in users demands	1. Policy based dynamic slicing spectrum slicing scheme
Federated learning based network slicing	1. Large variety of tunable parameters in 5G and beyond systems transceivers 2. Privacy leakage in a traditional machine learning enabled networks	1. Double deep Q-learning agents-based edge intelligence for computational offloading and caching. 2. Federated learning-based radio resource allocation
Adaptive Business model-driven Network Services	1. Involvement of multiple players in network slicing 2. Profit reduction due to variations in users traffic	1. Dynamic service level agreements between network slicing players

Table-2: Emerging Research Opportunities

VIII CONCLUSION:

In this paper, we reviewed the latest advances in network slicing, taxonomy, demands, use cases, and open research problems for providing IoT-based smart environments. We have come to conclude that network slicing is essential for implementing a variety of 5G and 6G systems. Network slicing will also be an essential component in transitioning today's cities into an intelligent environment that takes advantage of the latest innovations to vastly enhance quality of life.

IX FUTURE RECOMMENDATIONS:

For the purpose of enabling various smart applications, machine learning has been seen as a crucial component of 6G and beyond networks. For effective resource management in 6G and future networks, machine learning is anticipated to be applied to enable intelligent cognitive radio. Extensive simulations are necessary to fine-tune the machine learning model parameters prior to training. With the help of meta-learning, we may speed up the process of a machine learning model learning new parameters. Contrarily, the type and complexity of various machine learning models varies. To enable network slicing with machine learning, it is necessary to create unique Meta learning models.

X ACKNOWLEGEMENT:

We are very thankful to the research group head, Guide and RPAC for providing the best resources to do research work. And thank you to Vice Chancellor and KLEF management for good research environment to complete work.

XI REFERENCES:

[1] L. U. Khan, I. Yaqoob, N. H. Tran, S. M. Kazmi, T. N. Dang, and C. S. Hong, "Edge computing enabled smart cities: A comprehensive survey," arXiv preprint arXiv:1909.08747, 2019.

[2] Y. Wang, C. Xu, Z. Zhou, H. Pervaiz, and S. Mumtaz, "Contract-based resource allocation for low-latency vehicular fog computing," in 29th IEEE Annual International Symposium on Personal, Indoor and Mobile Radio Communications, Bologna, Italy, September 2018, pp. 812–816.

[3] M. Sookhak, H. Tang, Y. He, and F. R. Yu, "Security and privacy of smart cities: a survey, research issues and challenges," IEEE Communications Surveys & Tutorials, vol. 21, no. 2, pp. 1718–1743, August 2018.

[4] F. Qi, X. Zhu, G. Mang, M. Kadoch, and W. Li, "Uav network and iot in the sky for future smart cities," IEEE Network, vol. 33, no. 2, pp. 96–101, March 2019.

[5] F. Samie, L. Bauer, and J. Henkel, "Edge computing for smart grid: An overview on architectures and solutions," in IoT for Smart Grids. Springer, 2019, pp. 21–42.

[6] Y. Mehmood, F. Ahmad, I. Yaqoob, A. Adnane, M. Imran, and S. Guizani, "Internet-of-things-based smart cities: Recent advances and challenges," IEEE Communications Magazine, vol. 55, no. 9, pp. 16–24, September 2017.

[7] S. M. A. Kazmi, L. U. Khan, N. H. Tran, and C. S. Hong, Network slicing for 5G and beyond networks. Sprigner Nature, 2019.

[8] X. Foukas, G. Patounas, A. Elmokashfi, and M. K. Marina, "Network slicing in 5G: Survey and challenges," IEEE Communications Magazine, vol. 55, no. 5, pp. 94–100, May 2017.

[9] H. Xiang, W. Zhou, M. Daneshmand, and M. Peng, "Network slicing in fog radio access networks: Issues and challenges," IEEE Communications Magazine, vol. 55, no. 12, pp. 110–116, December 2017.

[10] S. E. Elayoubi, S. B. Jemaa, Z. Altman, and A. Galindo-Serrano, "5G ran slicing for verticals: Enablers and challenges," IEEE Communications Magazine, vol. 57, no. 1, pp. 28–34, January 2019.

[11] R. Ferrus, O. Sallent, J. Perez-Romero, and R. Agusti, "On 5G radio access network slicing: Radio interface protocol features and configuration," IEEE Communications Magazine, vol. 56, no. 5, pp. 184–192, January 2018.

[12] C. Bektas, S. Monhof, F. Kurtz, and C. Wietfeld, "Towards 5G: An empirical evaluation of software-defined end-to-end network slicing," in IEEE Global Communications Conference Workshops, Abu Dhabi, United Arab Emirates, 2018, pp. 1–6.

[13] M. Condoluci, F. Sardis, and T. Mahmoodi, "Softwarization and virtualization in 5G networks for smart cities," in Springer International Internet of Things Summit, Rome, Italy, October 2015, pp. 179–186.

[14] Markets and Markets, https://www.marketsandmarkets.com/pdfdownloadNew.asp?id=120515704, [Online; accessed Jan. 10, 2019].

[15] Smart city infographic. [Online, Accessed March. 23, 2019]. [Online]. Available: https://www.postscapes.com/anatomy-of-a-smart-city/

[16] I. Afolabi, T. Taleb, K. Samdanis, A. Ksentini, and H. Flinck, "Network slicing and softwarization: A survey on principles, enabling technologies, and solutions," IEEE Communications Surveys Tutorials, vol. 20, no. 3, pp. 2429–2453, March 2018.

[17] A. Kaloxylos, "A survey and an analysis of network slicing in 5G networks," IEEE Communications Standards Magazine, vol. 2, no. 1, pp. 60–65, April 2018.

[18] S. Zhang, W. Quan, J. Li, W. Shi, P. Yang, and X. Shen, "Air-ground integrated vehicular network slicing with content pushing and caching," IEEE Journal on Selected Areas in Communications, vol. 36, no. 9, pp. 2114–2127, August 2018.

[19] C. Campolo, A. Molinaro, A. Iera, and F. Menichella, “5G network slicing for vehicle-to-everything services,” IEEE Wireless Communications, vol. 24, no. 6, pp. 38–45, December 2017.

[20] H. Khan, P. Luoto, M. Bennis, and M. Latva-aho, “On the application of network slicing for 5G-v2x,” in 24th European Wireless Conference, Valencia, Spain, June 2018, pp. 1–6.

[21] A. de la Oliva, X. Li, X. Costa-Perez, C. J. Bernardos, P. Bertin, P. Iovanna, T. Deiss, J. Mangues, A. Mourad, C. Casetti, J. E. Gonzalez, and A. Azcorra, “5G-transformer: Slicing and orchestrating transport networks for industry verticals,” IEEE Communications Magazine, vol. 56, no. 8, pp. 78–84, August 2018.

[22] Venkata Vara Prasad Padyala, KVD Kiran, “Improved handoff mechanism for infiltrating user equipment’s in composite networks” International journal of Electrical and computer Engineering, pp 2600-2606, 2014.