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Operational Impacts of Network Slicing

Leveraging network slicing technologies to offer innovative business services

A Technical Paper prepared for SCTE•ISBE by

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Table of Contents

List of Figures

Introduction

Today's networking trends create numerous opportunities for service providers, enterprises, and Mobile Virtual Network Operators (MVNOs). The migration of applications and network functions to a virtualized environment offers tremendous business value - but also requires sophisticated workflow automation across multiple domains to take full advantage and assess success criteria.

Content

One of the most exciting opportunities created by network virtualization and workflow automation is network slicing. As a specific form of virtualization, network slicing allows multiple logical networks to be deployed on top of a shared physical network infrastructure.

5G technology is an essential business transformation enabler for communication service providers. 5G networking standards define capabilities to deliver network slicing in a new and efficient manner. Network slicing allows the same network infrastructure to deliver support for many different network use cases, each managing to different capabilities, such as, performance objectives on the same network at the same time with maximum efficiency. Network slicing takes advantage of virtualization to combine network resources and dynamically build separate logical networks for specific purposes addressing individual use cases, industries, or enterprises. Available application programming interfaces (APIs) are required to efficiently enable and operate this "Network Slice as a Service" (NSaaS) type of business model.

A key benefit of network slicing is that it is intended to provide an end-to-end virtual, distinct, and special-purpose network, including networking, compute, and storage functions. This allows service operators to deliver (slices of) networks which support specific requirements based on customized service characteristics - bandwidth, latency, volume, on-demand capacity, etc. But to ensure full advantages of this, one must re-assess certain processes to enable workflow automation.

With the dynamic nature of network slice lifecycle management, "zero touch" operations (including creation, provisioning, service enablement) and closed-loop assurance (self-healing, predictive, and pro-active network/service management) are expected at the same time as operational expenditures are being reduced. This in turn creates a necessity to modernize today's operational support system (OSS) operations and maintenance procedures and evolve to process transformation, re-engineering, and automation.

Furthermore, as Virtual Machines (VMs) and containers will co-exist for the foreseeable future, a common Management and Orchestration (MANO) solution that manages both VMs and containers running on the same platform will need to be in place. With automated provisioning and insight-driven service assurance, a dynamic orchestration implementation simplifies operations, moving the service provider closer to the zero-touch experience. Additionally, dynamic orchestration enables comprehensive, modular, end-to-end solutions that support automation of all these different executions of Network Slice Instances (NSI) and Network Slice Subnet Instances (NSSIs).

- A single orchestrator for the network – managing physical, virtual and cloud native network functions
- AI-powered closed-loop assurance automatically adapts the network in real time, maintaining Service Level Agreements (SLAs)

- Automated onboarding and continuous deployment accelerating time to market in multivendor environments
- Monetization enablement of new business opportunities facilitated by an integrated converged charging network function

As different 5G applications and services would require different demands for latency, bandwidth, density, Quality of Service (QoS), among other requirements, the dynamic orchestration utilizes different blueprints tailored for different network slice types whether it is addressing critical Machine Type Communication (MTC) and requirements for very low latency with continuously moving devices, or massive MTC (e.g., Smart Metering) with static devices with spurts of data in the form of small messages without latency constraints.

Having dynamic orchestration and its automation in place, this also allows service providers to support and monitor these different SLAs per individual network slice. Management functions provide life cycle functions to compose, create, modify, operate, scale, heal, and monitor, as well as, removing network slices. In certain cases, certain management capabilities can be "exposed" to customers for visibility and control of the network slice instance. Furthermore, as NSIs/NSSIs are successfully implemented and executed, the respective blueprints comprising the Key Performance Indicators (KPIs), SLAs, etc. could become an eco-system library collection of baseline templates to further aid zero-touch, automated time-to-market of new innovative services.

For quick market launch of new innovative services, dynamic orchestration should be a pre-integrated solution that supports specific business use cases, enabling service providers to launch services which leverage both physical and virtual network functions. By adopting subscription and policy profiles, such solution supports unique QoS profiles for each service or tenant e.g., MVNO. To reap the most benefits of dynamic orchestration, it is essential to have a comprehensive asset management solution to track asset utilization to timely adapt to new demands and requirements in real time. Enabling automation to the operational environment (to quickly respond to traffic and capacity trending, assess end-to-end (E2E) representation of a service, service outages, better forecasting and planning) depends on accurate inventory.

From orchestration perspective, every service/slice would get created with specific characteristics. 3GPP has different roles defined for Mobile Network Operator (MNO), Mobile Virtual Network Operator (MVNO), Mobile Virtual Netwok Enabler (MVNE), respectively. These required service characteristics (e.g., QoS) have to get applied during the service design and provisioning/activation.

To get the required QoS, there are multiple factors (like capacity, location, etc.) which have to be considered during the design. Then for each of the subnetwork slice/service the QoS parameters like bandwidth, latency, jitter, etc. would be applied. Prioritization of the traffic for the slice would have to be classified so that the routing devices can route the traffic with the required priority over the network to get the required latency. In turn, this requires the network to have clear multi-tenant capabilities; subsequently, the system needs to make available a Self-Service Portal and Self-Ordering APIs to MNO customers to allow self-ordering of their slices with SLAs and update them dynamically when needed.

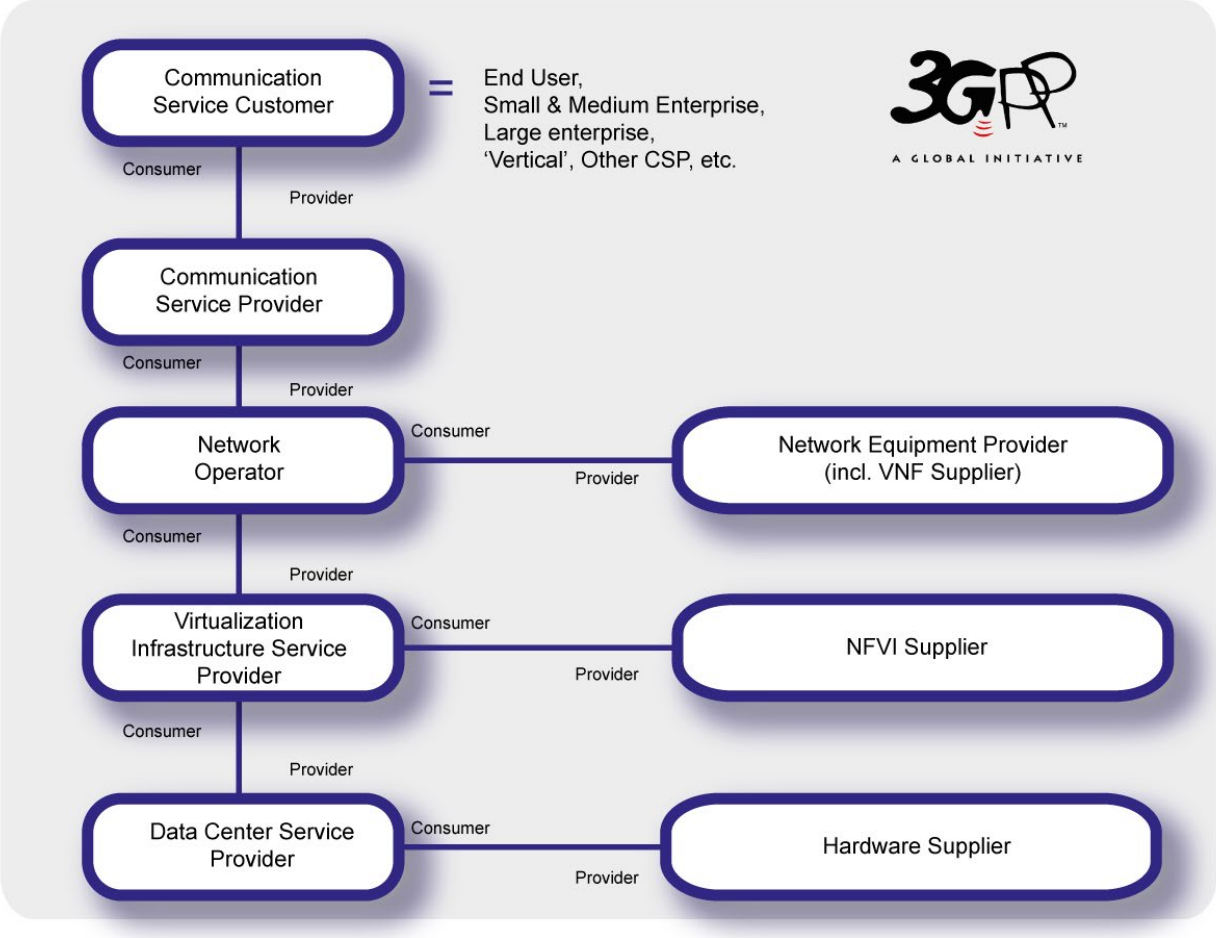

Figure 1 – Roles related to 5G networks and network slicing[1]

Enterprises, MVNOs, or any other customer consuming the services from the MNOs can be considered a Communication Service Customer (CSC). An MVNE can share the CSC and some of the Communication Service Provider (CSP) depending on the sharing of areas or concerns based on the type of services (B2B, B2C, etc.). Some of the functions of management functions CSMF, NSMF and NSSMF ought to have accessibility via multi-tenant portals. A dynamic service orchestration would need to be able to differentiate the slices created for the customers of MNOs, distinguishing between Enterprises and MVNO customers.

End-to-end service orchestration interprets and translates service definition (Service Design) into configuration of resources (physical and virtualized) needed for service establishment. The configuration of resources may be for actual amount of resources or the policy of their allocation at a later time, when the service is activated. The E2E Service orchestration further triggers the components of the management and orchestration system (ETSI NFVO, VNF Manager, VIM, SDN Controller, legacy OSS) to dynamically apply the configuration of the required resources which for some resources may result in their actual allocation.

[1] As defined by 3GPP

With new re-engineered workflow automation, network slices can be instantiated, and subsequently modified, upgraded, scaled, or terminated in real time. Thus, 5G with network slicing will enable communication service providers to tailor their network on-demand to the needs of different industries, enterprises, and consumers and to rapidly develop new business models in co-operations with various industry verticals. This enables traditional communication service providers to evolve beyond traffic-based business models to become Digital Service Providers (DSPs). Enterprises can choose dedicated or shared slices with dynamic orchestration assuring the respective SLAs and KPIs are met, enabling monetization of the respective slices of services.

To fully exploit the benefit of optimized, on-demand created network slices, it is required that the slicing concept allows for efficient usage of common resources such as radio resources and infrastructure, and transport links such as fronthaul and backhaul. This is particularly challenging in the Radio Access Network (RAN), which is limited by the amount of available spectrum.

Similarly to the core network, RAN can be slice-aware and apply specific policies in the RAN to different users based on the service/slice type. The 5G RAN is capable of treating different slices uniquely and/or offering different services within multiple slices. It also supports protection mechanisms for slice isolation so that events (such as congestion) within one slice do not have a negative impact on another slice.

The isolation and independence of network slices enable the service provider to offer attractive new possibilities to industry, enterprise customers, or MVNOs. Each network slice can be used as an entirely self-sufficient and autonomous 'container' with all the functions and resources required for independent service. With this new NSaaS business model, customers can be granted visibility of their network slice, and then modify it to suit their changing needs, or create new network slices quickly to seize a new business opportunity. Compared to today's 4G MVNO business model, the NSaaS business model is expected to be more powerful in terms of flexibility, automation, and the ability to customize the services delivered. For on-demand capacity increase needs, a NSaaS customer would be able to perform the required service changes themselves within the network slice itself. In certain business models, the NSaaS customer may even take full operational responsibility for this service, using in-slice management functions. As NSaaS evolves, Continuous Delivery and Deployment for software updates will play a key role in expanding possibilities and automation as quickly as possible through regular, incremental functionality upgrades.

Making money from network slicing is very dependent on flexible and powerful business support systems, to enable the rapid creation of completely new services and offers. With the "Network as a Service" business model, new capabilities could mean providing capabilities to partners (e.g., MVNOs) to help them manage and monetize their relationship with their customers. Capabilities might include providing access to location information or usage analytics, or a more complete offering involving rating, charging, and billing for partners' services. All of these types of requirements can be supported by Business Support Systems (BSS) using adaptive logic to enable a platform for business innovation on a massive scale as is expected with NSaaS.

As 5G network slicing matures and evolves, it can open opportunities to embrace business models into more of an eco-system partnership where the traditional MNO and MVNO could facilitate individual aspects of services offered by eco system partners, e.g. private enterprises. This in turn will put a focus on monetization and service-based converged charging network function – where value of the offering could be a key aspect of differential pricing, rather than simple volume/usage-based pricing. The opportunity is for both the MNO and the MVNO to increase the "value" in the value chain, and smartly monetize the network with differential pricing that reflects the

"value of the bit"; consequently, a charging solution must be device-aware, network-aware, service & app-aware all at the same time to be able to properly reflect the value of the NSaaS.

Addressing charging capabilities, a convergent charging system for multiple lines of businesses, supporting network-convergence, service-convergence and subscriber-convergence should be introduced – designed to support real-time and offline charging for multiple lines of businesses of service providers' environments. Its 5G charging capabilities would include:

- Slice-based charging
- DNN-based charging
- QoS flow-based charging
- Mobile phone location
- Connection-based charging

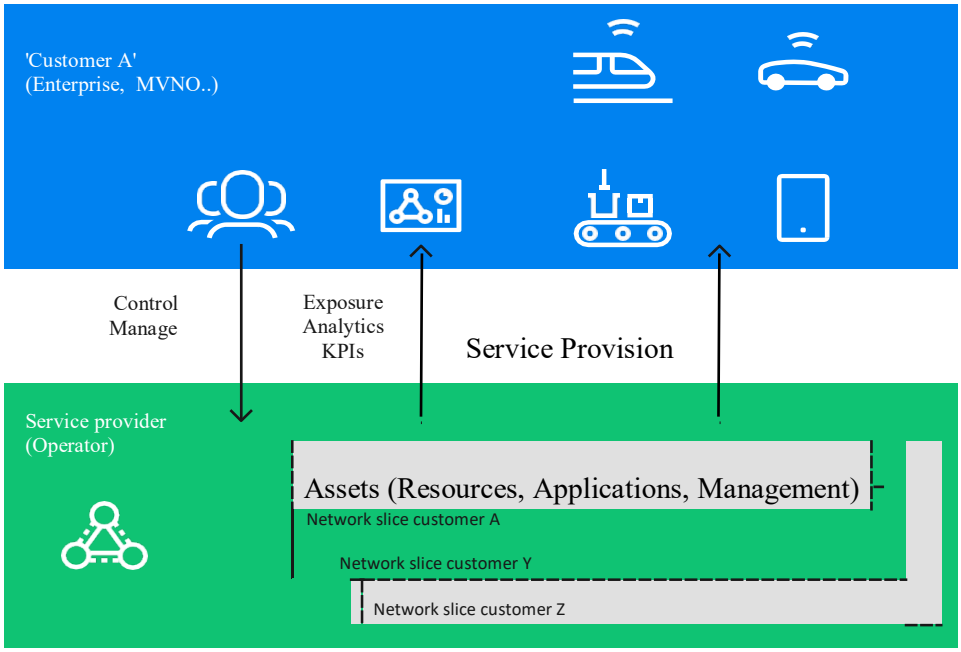

Figure 2 – Providing customer control over network slices

As requirements to distribute network resources to the edge, an Edge NFV cloud infrastructure (NFVi) solution aids the service providers with a compact platform, system-designed to run cloud native applications and virtual network functions managed by orchestration. Edge NFVi solutions shifted closer to the network edges would be used to optimize data traffic flow, addressing on-demand increased capacity needs for end-user services like HD live video streaming, Virtual Reality, etc. These solutions fit well in with the cable initiatives such as Head End Re-architected as a Data Center (HERD), Fiber Deeper, Distributed Access Architecture, and Generic Access Platform (GAP).

As it is envisaged, with more nodes distributed on the edges of the network (closer to the customer), it is important that functionality and management is software-defined with built-in flexibility to centrally adapt to new requirements and demands quickly. Edge NFVi computing provides execution resources (compute and storage) with sufficient connectivity (networking) at close proximity to the data sources,

typically within or at the boundary of access networks. It opens up opportunities for the service providers to distribute their resources to where demand exists enabling the most beneficial solutions for requirements such as low latency for VR/AR optimum user experience. To optimize such user experience, the Edge NFVi solution needs to be a distributed cloud solution – providing one execution environment for cloud application optimization across multiple sites, including required connectivity in between, managed as one solution and perceived as such by the applications. It is an end-to-end approach to edge computing allowing each individual use case to "decide" the specific edge location. Distributed cloud goes along with automated deployment of applications at just the right location in the network to optimize resource efficiency and user experience. For that reason, end-to-end orchestration for hybrid clouds is a key capability providing end-to-end management of networking, cloud infrastructure, and workload placement.

Dynamic orchestration, service-based converged charging, and Edge NFVi platforms are different ways to support multiple cable industry initiatives and leverage network function virtualization to offer more flexibility and customization of network operations. Through network slicing, these capabilities can be segmented to different customer groups to meet their specific use case requirements.

To support network slicing implementation in a multi-vendor environment with open interfaces and standardized architectures, re-engineered workflows and automation is needed to fully take advantage of new business opportunities and models. Having experience and skills in system integration and consultancy to execute and support such workflow automation initiatives and life cycle management efforts required for new service launch, software release upgrades, etc., could be a key differentiator for success.

Independent of access network (DOCSIS/HFC, 4G/5G/Private LTE, etc.), solutions and service expertise is available to support implementation and instantiation of virtual network slices for both enterprises and consumers, as well as providing unique SLAs and KPIs to manage service assurance.

Conclusion

5G network slicing is a new paradigm, and it introduces a completely new way of specifying services and delivering them in a flexible, agile, and automated manner. For an MVNO, working with a partner that can provide a complete solution, including the orchestration, converged charging, and network edge capabilities needed to implement, streamline, optimize, and automate network slice creation, and then to enable new and emerging business opportunities quickly, is going to become crucial for future success.

Abbreviations

3GPP	3rd Generation Partnership Project
4G	4th Generation
5G	5th Generation
AI	Artificial Intelligence
API	Application Programming Interface
AR	Augmented Reality
B2B	Business to Business
B2C	Business to Consumer
BSS	Business Support Systems
CSC	Communication Service Customer

CSMF	Communication Service Management Function
CSP	Communication Service Provider
DNN	Data Network Number
DOCSIS	Data Over Cable System Interface Standard
DSP	Digital Service Provider
E2E	End-To-End
eMBB	enhanced Mobile Broadband
ETSI NFVO	European Telecommunications Standards Institute NFV Orchestrator
GAP	Generic Access Platform
HERD	Head End Re-architected as a Data Center
HFC	Hybrid Fiber Coaxial
HD	High Definition
KPI	Key Performance Indicator
LTE	Long Term Evolution
MANO	Management And Network Orchestration
MNO	Mobile Network Operator
MTC	Machine Type Communication
NFV	Network Function Virtualization
NFVi	Network Function Virtualization infrastructure
NSI	Network Slice Instance
NSSI	Network Slice Subnet Instance
NSSMF	Network Slice Subnet Management Function
NSMF	Network Slice Management Function
MVNE	Mobile Virtual Network Enabler
MVNO	Mobile Virtual Network Operator
NSaaS	Network Slice as a Service
OSS	Operational Support System
RAN	Radio Access Network
SDN	Software Defined Network
SLA	Service Level Agreement
UE	User Equipment
URLLC	Ultra-Reliable and Low Latency Communications
VIM	Virtual Infrastructure Manager
VM	Virtual Machine
VNF	Virtual Network Function
VR	Virtual Reality
QoS	Quality of Service

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