Network Slicing: North America's Perspective (Current)

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1 Introduction

1.1 Overview

Network Slicing (NS) provides operators with means to vary the service level of the cellular network in such a way that verticals using their preferred slice can benefit from this tailored performance. At the same time, Network Slicing Providers (NSP) can benefit from the system's ability to allocate the invaluable network processing resources according to the need. This is a key difference to the traditional network functionality as the earlier mobile communication systems are limited to the differentiation by QoS settings, whereas NS provides the ability to configure the network tailored to the foundationally diverse set of use cases.

The Network Slicing provides new opportunities to the established as well as completely new stakeholders. Some examples of this are the network equipment manufacturers and service providers that develop and manage Network Slices.

There are many established and totally new verticals that can use network slicing, and they may have rather different requirements. Understanding these requirements facilitates the deployment of global Network Slices, eases the development efforts, supports deployment strategies, and benefits the users in a form of the fluent user experiences also while roaming.

The GSMA has coordinated efforts to establish common set of Network Slices. The work has resulted in a GSMA PRD NG.116 which presents common Network Slice templates and principles to populate them. Based on this work, the North Americas Network Slicing Taskforce (NETSLIC TF) explored indications about regional aspects that may lead into further candidates for the common Network Slice definitions. The NETSLIC TF formed and tested methods to identify new verticals and their needs, and to form practical needs into technical terms that operators can use as a base to consider forming interoperable Network Slices.

This whitepaper presents three sections:

1. The role of the 3GPP in defining network slicing in Release 15 and 16.
2. The role of the GSMA in producing guidelines for interoperability.
3. Summary of practical experiences and ideas related to customer engagement with a description of the process and methods designed and applied during the NETSLIC TF. These activities can help ecosystem research vertical needs and design network slicing accordingly. The presented and tested model of the NETSLIC TF can be used in the communications with enterprises and mobile telecommunications ecosystem.

1.2 Scope

The target audience of this whitepaper are GSMA participants, including operational, technical, and marketing representatives of the mobile telecommunications industry. After the brief introduction to the standardization and common principles of the network slicing, this whitepaper presents experiences, practical examples, and instructions on how to reach out to enterprises, how to understand and assess practical needs, and how to "translate" this information into technical requirements of network slicing.

The aim of this whitepaper is to serve as a guide to apply presented methods and to raise awareness of those interested in converting vertical feedback as an input to the Network Slicing –related planning. This document also aims to raise interest of verticals to engage further with the GSMA to learn jointly more on the opportunities the network slicing may bring along the 5G era and beyond.

1.3 Definitions

Term	Description
Business Customer	Business Customer (BC) tenants the Network Slice, e.g. customers from vertical industries. For instance, a business customer could be an enterprise or specialized industry customer (often referred to as “vertical”). [2]
Network Slice	Network Slice (NS) is a logical network that provides specific network capabilities and network characteristics in order to serve a defined business purpose of a customer. Network Slicing allows multiple virtual networks to be created on top of a common shared physical infrastructure. An NS consists of different subnets such as Radio Access Network (RAN) subnet, Core Network (CN) subnet, and Transport Network (TN) subnet. [2]
Network Slicing Provider	Network Slicing Provider (NSP) is typically a telecommunication service provider, which is the owner or tenant of the network infrastructures from which NSs are created. The NSP assumes the responsibilities of managing and orchestrating corresponding resources that the Network Slicing consists of. [2]
Generic Network Slice Template	Generic Network Slice Template (GST) is a set of attributes that can characterize a type of Network Slice/Service (NSS). GST is generic and is not tied to any specific network deployment. [3]
Network Slice Type	Network Slice Type (NEST) is a GST filled with values. The attributes and their values are assigned to fulfil a given set of requirements derived from a Network Slice customer use case. [3]

1.4 Abbreviations

Term	Description
3GPP	3rd Generation Partnership Project
5G	Fifth Generation of the mobile communications
5GAA	5G Automotive Association
5G-ACIA	5G Alliance for Connected Industries and Automation
APN	Access Point Name
B2B	Business to Business
BC	Business Customer
GST	Generic Network Slice Template
MNO	Mobile Network Operator
NAVA	North America Vertical Application Taskforce of GSMA
NEST	Network Slice Type
NETSLIC	North America Network Slicing Taskforce of GSMA
NF	Network Function

Term	Description
NFV	Network Functions Virtualization
NG	Network Group of GSMA
NS	Network Slice / Network Slicing
NSC	Network Slice Customer
NSI	Network Slice Instance
NSP	Network Slicing Provider
NSS	Network Slice/Service
P-NEST	Private NEST
PRD	Permanent Reference Document of GSMA
RAN	Radio Access Network
SDO	Standards Developing Organization
SLA	Service Level Assurance
S-NEST	Standardized NEST
TS	Technical Specification (3GPP)

1.5 References

Ref	Title
[1]	GSMA, "An Introduction to Network Slicing," GSMA, November 2017. [Online]. Available: https://www.gsma.com/futurenetworks/wp-content/uploads/2017/11/GSMA-An-Introduction-to-Network-Slicing.pdf. [Accessed 26 October 2020].
[2]	GSMA, "Network Slicing Use Case Requirements," GSMA, April 2018.
[3]	GSMA, "NG.116: Network Slice Template, V3.0," GSMA, 2020.
[4]	J. Penttinen, "Network Functions Virtualization," in 5G Second Phase Explained: The 3GPP Release 16 Enhancements, Hoboken, NJ, USA, John Wiley & Sons, Inc., 2021, p. 143.
[5]	3GPP, "TR 28.801 V15.1.0: Study on management and orchestration of network slicing for next generation network (Release 15)," 3GPP, 2018.
[6]	3GPP, "3GPP TS 28.530: Concepts, use cases and requirements (Release 15)," 3GPP, 3GPP.
[7]	3GPP, "3GPP TS 23.501 V16.6.0: System architecture for the 5G System (5GS); Stage 2 (Release 16)," 3GPP, 2020.
[8]	3GPP, "3GPP TS 38.401 V16.3.0: NG-RAN; Architecture description (Release 16)," 3GPP, 2020.
[9]	3GPP, "3GPP TS 28.531 V16.4.0: Services and System Aspects, Management and orchestration; Provisioning; (Release 16)," 3GPP, December 2019.
[10]	GSMA, "NG.116 Generic Network Slice Template v4.0," 20 November 2020. [Online]. Available: https://www.gsma.com/newsroom/resources/ng-116-generic-network-slice-template-v4-0/. [Accessed 11 February 2021].
[11]	J. Penttinen, "5G Release 15 and 16 Network Functions," in 5G Second Phase Explained: The 3GPP Release 16 Enhancements, Hoboken, NJ, USA, John Wiley & Sons, Inc., 2021, p. 147.

Ref	Title
[12]	GSMA, "Network Slicing Survey," GSMA North America, 20 January 2021. [Online]. Available: https://www.gsma.com/northamerica/gsma-north-america/network-slicing-survey/.
[13]	GSMA, "GSMA and GUTMA launch new joint initiative to align mobile and aviation industries," GSMA, 10 June 2020. [Online]. Available: https://www.gsma.com/iot/news/gsma-and-gutma-launch-new-joint-initiative-to-align-mobile-and-aviation-industries/. [Accessed 16 Februray 2021].
[14]	NGMN, "V2X White Paper, V1.0," NGMN, 17 June 2018. [Online]. Available: https://www.ngmn.org/wp-content/uploads/V2X_white_paper_v1_0-1.pdf. [Accessed 17 May 2021].
[15]	5GAA, "C-V2X Use Cases: Methodology, examples, and use service level requirements," 5GAA, July 2019. [Online]. Available: https://5gaa.org/wp-content/uploads/2019/07/5GAA_191906_WP_CV2X_UCs_v1-3-1.pdf. [Accessed 17 May 2021].
[16]	ITU-T, "FG-NET2030 – Focus Group on Technologies for Network 2030," Network 2030 Architecture Framework, June 2020. [Online]. Available: https://www.itu.int/en/ITU-T/focusgroups/net2030/Documents/Network_2030_Architecture-framework.pdf. [Accessed 20 January 2021].
[17]	ITU-T, "FG-NET2030 – Focus Group on Technologies for Network 2030," Network 2030 - Gap Analysis of Network 2030: New Services, Capabilities and Use cases, June 2020. [Online]. Available: https://www.itu.int/en/ITU-T/focusgroups/net2030/Documents/Gap_analysis_and_use_cases.pdf. [Accessed 20 January 2021].
[18]	ITU-T, "Network 2030: A Blueprint of Technology, Applications and Market Drivers Towards the Year 2030 and Beyond," ITU FG-NET-2030, [Online]. Available: https://www.itu.int/en/ITU-T/focusgroups/net2030/Documents/White_Paper.pdf. [Accessed 20 January 2021].

2 Background

2.1 Network Slicing

After years of standardization, concept testing, and piloting, 5G is reality and will be in an increasingly important role throughout the forthcoming years. Nevertheless, the transition to a new era does not happen overnight. While the standards keep evolving, the initial 5G networks are being deployed gradually and the new specifications will be adopted as they will be available.

One of the novelties 5G brings along is network slicing, which can be generalized as a “networks over network” concept. Network slicing is a new technology that allows 5G mobile network operators (MNOs) to use their physical mobile network partitioned into multiple virtual networks. This offers different Network Slices within specific areas, and the providers of the slices (that can be either MNOs or some other entities) can personalize the offered performance for different user types, or verticals, based on their special requirements. This is beneficial for both users and operators in environments involving, e.g., law enforcement, drones, massive sensor networks, and many more use cases. Network slicing accurately shares available networks based on the designed allotments.

This is a ground-breaking difference compared to previous generations that serve the users uniformly. As an example, one Network Slice can serve number of simultaneously communicating, low-bitrate IoT devices, and another may serve latency-critical applications such as Augmented and Virtual Reality (AR/VR).

One of the key differentiators of 5G compared to the legacy systems is its ability to provide tailored support to users of different types of services. By deploying the network slicing feature, the operator may configure each slice in order to better comply with the requirements of different user segments. This will directly benefit different customer segments, or verticals, and the complete ecosystem.

Operators may use network slicing for supporting an "as-a-service" model for the customers. It enhances operational efficiencies and speeds up time-to-market for new services. Network slicing technology is possible thanks to the software-defined networking, network functions virtualization and advanced 5G network orchestration. In fact, these features are essential to apply and manage the network slicing.

An operator can form, manage, and terminate Network Slices upon need in a highly dynamic fashion, and each slice can be optimized for a specific use case. 5G Network Slices can be adjusted to offer different user experiences within a selected area. Furthermore, the 5G user equipment is capable of joining one or multiple Network Slices at the same time supporting different parallel services.

As an example, smart city sensor might not require the highest data speeds but can benefit from the possibility to share low bit-rate resources amongst a big number of other devices communicating simultaneously, so the sensors can subscribe to a massive Machine Type Communications (mMTC) Network Slice that offers such desired performance. Meanwhile, some other users within the very same area, such as critical communications applications, may benefit from the highest reliability, so operator can offer a specifically tailored Ultra-Reliable Low Latency Communication URLLC Network Slice for them. The benefit of this approach is that differently adjusted Network Slices optimize the network resources while providing adequate user experience for all.

For the most beneficial network slicing, including national and international roaming between mobile network operators, operators may want to consider common principles that ensure fluent user experiences in a global scale. GSMA is working on forming a Generic Network Slice Template (GST) in the GSMA Permanent Reference Document PRD NG.116 that presents attributes for key services relying on network slicing. These attributes refer to the technical parameters providing desired performance level for the slices. The PRD NG.116 also includes typical examples of respective Network Slice Type (NEST) database and proposes recommended minimum set of attributes and their feasible values to be applied by mobile network operators.

The Network Slicing refers to the ability of the system to operate multiple dedicated networks on a common platform. Network slicing makes it possible to run multiple logical networks as virtually independent business operations on a common physical infrastructure. The Network Slicing is predominately opportunity in the 5G era. The difference with the previous mobile communication systems is that in 5G, a network equipped with the network slicing can adapt to the external environment rather than the other way around. [1]

4G systems can be customized by utilization of multiple Access Point Names (APN) and multi-operator core networks that provide means to differentiate the user experience. Nevertheless, this type of customization is not able to provide the grade of sophistication of 5G. As stated in Ref. [2], Network Slicing is estimated to be a prominent feature of 5G. The 3GPP has designed it as a native 5G function to allow connectivity and data processing that the Mobile Network Operators (MNO) can tailor to specific customers', or verticals' requirements. This, in turn, leverages the mobile communications into new level that can be referred to as smart networks. They can enhance the efficiency and productivity of business processes and will open up opportunities for operators to address the Business to Business (B2B) segment more effectively. Furthermore, Network Slicing facilitates the onboarding of also completely new businesses such as Network Slice providers.

Along with the deployment of the 5G networks, the network slicing concept can offer an optimal solution for the communication link requirements of a variety of verticals by differentiating the service level. The enhanced level of functions and performance combined with the differentiation capabilities of network slicing will permit business customers to rely on tailored connectivity and data processing complying better with the Service Level Assurance (SLA) that the verticals can agree with the MNO. The key customized aspects the network slicing can vary per customer include data speed, quality, latency, reliability, security, and services.

2.2 Vertical Needs

In order to adequately adjust a set of Network Slices, it is of utmost importance for the slice operator to understand the realistic needs. With such a variety and diversity of the requirements per each vertical, the network resource utilization and offering needs to be optimized taking into account the complete picture of the ecosystem. This is a new aspect in the already highly complex optimization tasks of the operators, and automatized methods such as self-organizing network optimization techniques based on Artificial Intelligence may be essential tools to facilitate this task.

For MNOs to assess the vertical needs, the GSMA PRD NG.116 aims to help the ecosystem understand the level of different options, and to select some of the most common slices within MNOs own infrastructure as well as in interoperable environment including roaming scenarios that benefit from the uniform user experience offering cross the operator community. In addition, the GSMA PRD NG.127 is a relevant reference for vertical needs.

3 3GPP Standardizes Network Slicing

Among various SDOs (Standards Developing Organizations), the 3GPP defines Network Slicing as of the 5G Release 15 Technical Specifications (TS).

3.1 Architecture and Functioning

Network slicing relies on Network Functions Virtualization (NFV) so that the slices are isolated from each other, including the security aspects.

Network slicing enables the use of a multitude of virtual networks on top of a physical infrastructure, and it also provides a means for dividing a physical network into multiple virtual networks that can serve various Radio Access Networks (RAN). Yet another benefit of NFV is the possibility to easily scale the functions based on different criteria for optimal performance, e.g., cost or energy consumption. [4]

NFV simplifies the operation of the functions by decoupling them from the traditionally required standalone hardware components. The virtual NFs are deployed on high-volume servers or cloud infrastructure instead of specialized hardware. This model expedites cost-efficient commercial deployments.

3.2 Resources

The 3GPP has standardized the standalone 5G network system supporting the Network Slicing technology since the Release 15. The Network Slicing is presented in the 3GPP Technical Report TR 28.801 [5], and the key Technical Specifications include 3GPP TS 28.530 [6]. The latter presents examples of use cases and communication services instances provided by multiple Network Slice Instances (NSI) to highlight the combination and relationship of Communication Services to Network Slices. Furthermore, the Network Slice deployment involving communication services to UEs must comply with the 5G system architecture defined in TS 23.501 [7] and TS 38.401 [8].

As stated in 3GPP TS 28.531 [9], a Network Slice Type (NEST) is a GST (Generic Network Slice Template) filled with values and their ranges. There are two types of NESTs: 1) Standardized NESTs (S-NEST) that character attributes are assigned ranges of values by SDOs and working groups such as 3GPP, GSMA, 5GAA, 5G-ACIA, etc.; and 2) Private NESTs (P-NEST) that character attributes are assigned ranges of values by the Network Slice Providers, which are different from those assigned in S-NESTs.

As the 3GPP TS 28.531 states, Network Slice Providers can build their Network Slice product offering based on S-NESTs and/or their P-NESTs. As an example, for a certain Standardized Network Slice Type (NST) called "A", the attribute ‘Packet delay budget’ value could be of 1-100 ms. In this example, 3GPP would specify this type and its attribute and value range. Now, a certain Network Slice Provider may consider offering a variety of products based on this NST by differentiating the practical values. Thus, the Provider has an opportunity to commercialize, e.g.:

- Network Slice product "Platinum NST-A", and its attribute ‘Packet delay budget’ value range of 1-10 ms;
- Network Slice product "Gold NST-A" and respective attribute ‘Packet delay budget’ value range of 11-50 ms;
- Network Slice product "Silver NST-A" with the attribute ‘Packet delay budget’ value range of 51- 100 ms.

The 3GPP specifications provide Network Slice operators with the means to set up slices and offer the respective services to the ones subscribing to the slices. The correct interpretation of these specifications is one of the important tasks, thus, and the complementing guidelines that consider interoperability and roaming aspects help the ecosystem for common slice setting.

The 3GPP specifications are also important for the equipment providers and device makers in order to facilitate the interoperable network slicing functionality cross the ecosystem.

4 GSMA Ensures Interoperability

The GSMA complements the Network Slicing for the interoperable environment by presenting common Network Slice templates in the GSMA PRD NG.116. In terms of the 3GPP, these templates form a set of Standardized NESTs (S-NEST) for consideration of the Network Slice Providers.

The NG.116 document keeps evolving, and the Version 4.0 presents the latest information on March 2021; along with the later GSMA Network Group's plenary meetings, there will be updated versions available to complement the information and templates. For the most up-to-date version, please see the GSMA resources. [10]

In the practical deployment of the network slicing, the GSMA NG.116 serves as a common guideline for indicating network slicing templates of which the Mobile Network Operators can decide the commonly utilized attributes (e.g., data speed) and their values (e.g., maximum and average values in terms of Mb/s). [3]

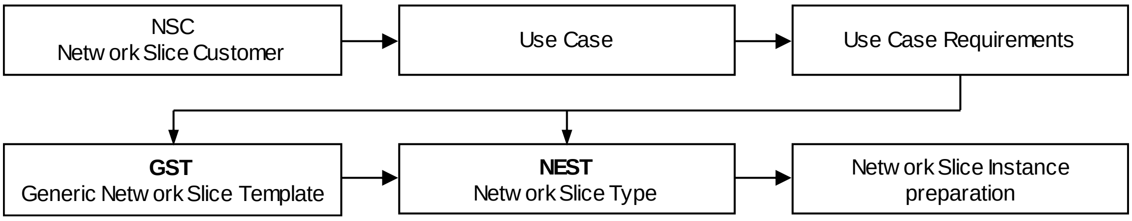

Figure 1 The principle of the GST and NEST. [3]

The NG.116 presents the process depicted in Figure 1. In this process, it is important that the Network Slicing Provider (NSP) understands the practical needs of the Network Slice Customer (NSC). The process outlines thus in high level the importance of figuring out the relevant use cases and respective requirements as a base for the actual Network Slice instance preparation. As per the methodology of the NG.116, the GST (Generic Network Slice Template) lists the relevant attributes related to the use case whereas the NEST (Network Slice Type) presents the values for that GST. The Network Slicing Provider can rely on the GST and NEST in setting up accordingly the Network Slice Instance.

GSMA has produced the NG.116 in order to provide practical means for the already established and new stakeholders interested in being involved in network slicing opportunities. The service-based architecture of 5G combined with the network slicing functionality can facilitate new operational and supporting roles for network and service providers. As this environment is still in its infancy, it is important for the ecosystem to understand the opportunities and how to tackle the related challenges.

The following section of this whitepaper outlines some of the practical ways that the NETSLIC TF designed and tested to identify vertical needs and use case requirements.

5 Enterprises and Verticals as Users

5.1 Benefits for Verticals

Network slicing can be visualized in a common-sense way as “networks over a network.” By forming a Network Slice, its provider can create a single network, or in typical cases, several parallel virtual networks within a physical network to serve a variety of different types of verticals. As an example, a drone-controlling application benefits from ultra-low latency values and mobility capabilities to ensure the fastest possible response for remote commands while the vehicle is in the air. Meanwhile, an intelligent, permanently installed wireless remote sensor may need only a most basic and occasional data transfer service for a telemetric purpose. By setting up separate Network Slices, the MNO can optimize the network resources and provide fluent user experience for all enterprise customers and a variety of device types. [11]

5.2 Interpretation of Needs

Enterprise users have oftentimes special needs for the communications. As an example, some users may want to have additional security on top of the standard level of the mobile network whereas some other groups may prioritize the highest data speeds over other aspects. Based on the evolved capabilities and functions of the new generation, and 5G networks allow the adjustment of such aspects more efficiently than in previous generations. The network slicing is in a key position to make this happen.

The challenge can be, though, that enterprise customers may not be able to express their needs in sufficiently deep technical terms. For a Network Slice Provider wanting to adjust and personalize Network Slices, it is of utmost importance to understand these needs, so, for detailed-level network optimization, systematic approach and process will help operators capture the essential indications from the practical field.

5.3 The Process

The GSMA NETSLIC TF researched regional vertical needs of selected use cases in the North America market area. In this effort, the NETSILC TF designed and applied Network Slicing assessment process as depicted in Figure 2.

Based on the designed process, the NETSLIC TF applied the following practical steps:

1. Regional Priority Verticals: Identify relevant verticals that can benefit from network slicing. Assess the priority of the verticals in terms of, e.g., the timing for the needs, significance of the markets the verticals represent, and other factors. As an outcome, form a priority list of the verticals.
2. Vertical Needs Assessment: Reach out to the priority verticals in order to understand the practical environment and needs for the communications technologies by studying relevant use cases. As a part of this activity, an information gathering process was created.
3. Use Case Assessment: On the selected use cases, by understanding the typical and practical needs and challenges of their communications environment, form each use case into a list of relevant attributes and their value ranges.
4. Network Slice Template Forming: Finally, map the attributes and their values into network slicing templates (GST and NEST).

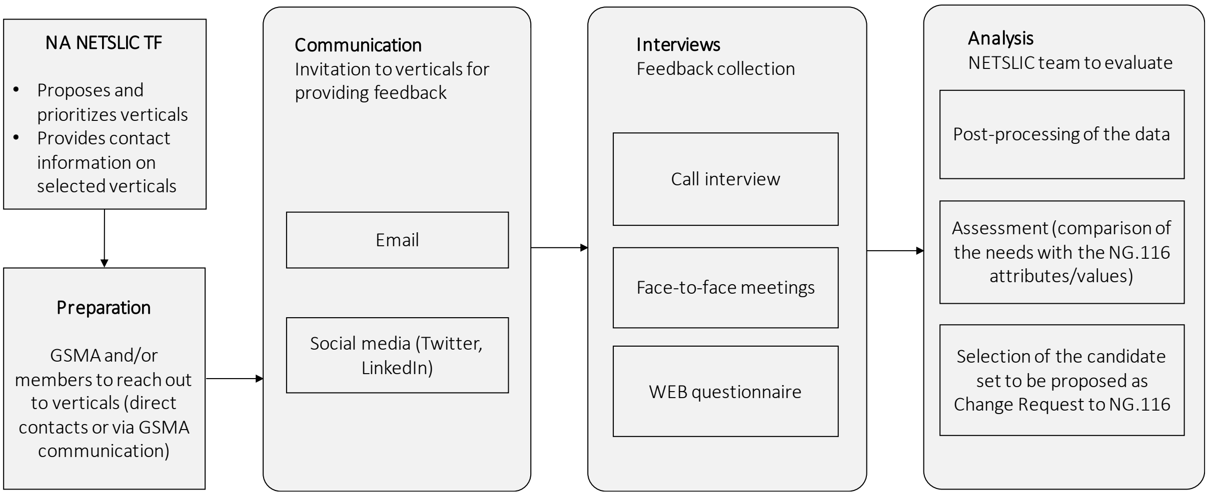

Figure 2 The process of the NETSLIC TF for vertical engagement and requirements assessment.

The GST and NEST are the essential information elements for the stakeholders that set up and manage the Network Slices, technically and commercially. The MNOs wanting to ensure fluent user experience and service level throughout the environment, considering the home operator's network and well as the roaming scenarios, can use similar settings within the considered area.

The following sub-sections summarize examples of the process described above that were applied during the work of the NETSLIC Taskforce.

5.4 Regional Verticals

The NETSLIC TF considered potential North America's verticals based on various information sources such as regional business types and their activities, and evaluating the relevance of the list of verticals that the Global GSMA Network Slicing workgroup had produced prior to NETSLIC initiative. Of a rather large set of vertical types, Table 1 summarizes the ones that were considered as primary candidates in the North America region.

Vertical	Category
AR/VR Providers	Applications with interaction
Automotive	Map and location -related applications; infotainment; connected vehicles; sensors (sensor sharing), IoT communications; road warning and safety; cooperative driving, autonomous driving, V2X; Software Over-the-Air / Firmware Over-the-Air; emergency action; services; manufacturing
Critical Communications	Natural disasters; disaster management
EDGE	Cloud services
Energy	Smart grid; power grid security; blockchain in energy distribution
Gaming	eSports; educational gaming
Government & Public Safety	Port connectivity and safety; closed network infrastructure; mission-critical services

Vertical	Category
Healthcare	Health and wellness monitoring; remote healthcare, assisted / remote surgery; hospital, emergency communication; hospital, telemetry; hospital, data transfer
Industrial IoT; Critical Comm.	Critical infrastructure industries; factory automation & process control
Industrial/Manufacturing	Factory automation, manufacturing IoT, monitoring, maintenance
Media & Entertainment	Programme-making and special events
Public Safety	Mission-critical IoT / Push-to-Talk; mission-critical data / video; Smart City; communication technologies for special situations
Security	Critical safety (locations of special protection); personal safety; IoT, data for crime prevention
Smart Cities	Public safety, emergency service; smart grid, connected lighting; internet of things, virtual and augmented reality experience; waste management; smart parking; overall Smart City concept (various sub-verticals)
Special needs	Communications and IoT for citizens with limited mobility
Special vehicles	Aviation / Unmanned Aerial Vehicles (UAV) / drones; high-mobility vehicles
Transport & Logistics	Port use cases; aeronautics; autonomous driving; asset tracking
Utilities	Water / gas meter data
Others	Smart provisioning of subscriptions

Table 1 Examples of regional verticals studied by the NETSLIC TF

The NETSLIC TF reached out to variety of verticals to establish channel for information sharing.

5.4.1 Vertical Needs Assessment

The team designed practical questions for the face-to-face communications in order to provide template for the interested ones to express the utilization, needs and challenges in their environment today and foreseen future.

The Taskforce also designed a web-based GSMA questionnaire and invitation to fill it in via professional social media. The ANNEX of this document presents the web questionnaire and accompanying information of the effort. [12]

5.4.2 Use Case Assessment

As a result of the responses via the web questionnaire, the Taskforce prioritized an avionics / telematics use case for a closer look as it represented an area that was not assessed in the previous efforts of the GSMA. The Taskforce had also opportunity to look at an additional High-performing MTC presented and proposed by ATIS as a slice type.

5.4.3 Network Slice Template Forming

The mapping of the technical attributes and their values took place based on the available information, complemented by the interviews and questionnaires. The following section presents the respective example based on the avionics / telematics and High-Performing MTC use cases.

5.5 Slice Type Examples

5.5.1 Avionics: Commercial Flight Telematics

The NETSLIC Task Force studied a telematics case related to the commercial flights. This commercial flight telematics use case represents an automated machine-to-machine type communications (MTC). In this use case, the aircraft-mounted device collects telematics data during the flight on weather conditions, the performance of the equipment, and other relevant environmental and aircraft-related information.

In this specific use case, the transmission of the telematics data log transfer is triggered upon the landing of the plane at the airport. The communications link may be any available one such as Wi-Fi hotspot within the landing area, or cellular system of any of the commercially available generations. This use case is characterized by the following aspects:

- Upon landing, in-built IoT device of the aircraft can initiate a connection autonomously with a ground server, by default via a cellular technology.
- In order to optimize the rather short period the plane stays on the ground, the aircraft starts sending the stored telematics data to the server for further processing immediately after establishing the connection.
- The IoT device can also receive SW updates and data contents, such as entertainment system’s audio and video, as well as flight plan –related information.
- Being isolated system for the data transmission in uplink and downlink, there is no person-to-person communication channel involved.
- It can be assumed that the current solutions are largely based on 4G connectivity although also legacy technologies may be involved, as well as Wi-Fi and satellite communications.

This use case involves the following special requirements.

- Security of the communications links and systems is the most important aspect in this use case. For this reason, as is typical in the avionics domain, all the solutions need to be certified, which requires rater long time.
- Along with the potential sun-setting of legacy cellular systems in certain areas, there is a need to consider future-proofed technologies with the focus of at least 15 years in the future. Based on the current trend of the sunset of many 2G and 3G networks, the future-proofed technology needs to be thus selected between, or as a combination of 4G and 5G.
- The potential issues are related to the interferences, outage areas and congestion of the Wi-Fi or cellular networks that requires special arrangements such as specific Wi-Fi access, cellular repeaters, etc. Due to the aircraft’s short duration on land, the ability to maintain the connectivity is important.

Assessing these aspects, we can select the most relevant Network Slice attributes and their typical value ranges based on the GSMA PRD NG.116 V3.0. Table 2 presents the outcome in a form of a Generic Network Slice Template (GST) and Network Slice Type (NEST).

GST	NEST
3.4.1. Availability	Amount of time service delivered divided by amount of time system expected to deliver service: High (in a range of 95-99.95%).
3.4.2. Area of service	List of countries and areas the airline is operating in. The list is specific to Network Slice providers and their roaming agreements.
3.4.5 Downlink throughput per Network Slice	Guaranteed and maximum – Preferred guaranteed: 1 Gb/s (total of the Network Slice at the airport). Please note that the value depends on the typical total time the plane is able to receive data in downlink, and the total quantity of the data during that time in downlink per plane, as well as the number of the planes receiving data simultaneously at the airport. The dedicated Network Slice needs to support the total capacity accordingly.
3.4.9 Isolation level	Physical isolation of the resources of the Network Slices (highest level). Please note: if the data transmission is protected separately at the application level, the highest Network Slice isolation might not be needed.
3.4.24 Session and service continuity	Session and Service Continuity (SSC) mode (1, 2, 3) – Preferably SSC 3 for highest assurance (changes to the user plane can be visible to the UE, while the network ensures that the UE suffers no loss of connectivity).
3.4.28 Supported device velocity	Vehicular, i.e., 120 km/h (data transmission starts automatically upon planes taxing and continues when they are parked at the gate). Please note: if the data transmission can be initiated already earlier upon landing, with higher velocity of the plane, 5G allows maximum of 500 km/h terminal speed.
3.4.31 Uplink throughput per Network Slice	Guaranteed (and maximum) – Preferred guaranteed data capacity for the planes transmitting data to ground servers, the whole slice 1 Gb/s. The value depends on the typical total time the plane is able to send data in uplink, and the total quantity of the data during that time in uplink per plane. Taking into account the total number of planes sending data simultaneously at the airport, the slice would need to support the total capacity accordingly.
3.4.34 User data access	No traffic transferred via public Internet. 1: Termination in the private network. 2: Local traffic (no internet access).
3.4.35 V2X communication mode	3: YES – via 5G New Radio (NR) and 4G radio access network (E-UTRA).

Table 2 Commercial Flight Telematics Use Case requirements

NOTE: Commercial Flight Telematics Use Case requirements presented in a form of GST and NEST. Please note that the numbering and value ranges presented in the table are aligned with the GSMA NG.116 V3.0. The GST refers to the Generic Network Slice Template attributes whereas the NEST refers to the Network Slice Type value ranges.

5.5.2 Advanced IoT

ATIS (Alliance for Telecommunications Industry Solutions) has produced a whitepaper "IOT Categorization: Exploring the Need for Standardizing Additional Network Slices" in 2019, and indicated to GSMA an opportunity to form a specific Network Slice for respective high-performance MTC (Machine Type Communications) use case.

The Network Slice types of the Version 3.0 of the GSMA NG.116 do take into account the MCT (i.e., the generic massive IoT slice has common aspects with the proposed new slice), but the overall assumption of it is that the respective IoT devices are either static or slow-moving. In the high-performing MCT, the GST designed for specifically IoT communications would require an additional attribute for supporting higher maximum velocity of the device. This is thus an example of the continuous need for evolving the common network slicing definitions as they benefit the ecosystem in the efforts to provide fluent user experiences cross networks.

Please note that for the ones interested in similar activities, GSMA receives contributions and Liaison Statements (LS) via the generic GSMA LS email address GSMALiaisons@gsma.com.

5.5.3 Other Use Cases

During the NETSLIC Taskforce lifecycle, various verticals were discussed and explored. Some of the most concrete cases were evaluated based on the North Americas Regional Interest Group (RIG NA) workshops that the GSMA Technology Team coordinated at the RIG 78 (Chicago, IL, 2019) and RIG 79 (Newport Beach, CA, 2019). The following list summarizes the key findings of the most relevant use cases:

The Uncrewed Aerial System (UAS) and related Uncrewed Traffic Management (UTM) are beginning to provide a concrete base in many environments such as automated packet delivery to the end-customers, aerial surveillance for law enforcement, and many other applications for the consumers and companies. The special needs for the UAS vary depending on the environment they are applied to. Some examples, based on the GUTMA (Global UTM Association) and GSMA ACJA (Aerial Communications Joint Activity) Work Task discussions, are the requirements for the LTE Aerial Profile, and need to align the terminology and common understanding on the special technologies and requirements among the mobile communications industry and avionics. [13]

As an example, 4G LTE and 5G serve as a base for low altitude aircraft, enabling the traffic services, fleet management, and business systems integration necessary to scale autonomous aircraft. Specifically 5G features for aviation can include flight data/video (high bandwidth); navigation/control (low latency); safety (high reliability); secure communications (virtual network slicing); navigation (multi-access edge computing); multimodal transmission (with C-V2X).

The market outlook indicates that the Uncrewed Aerial Vehicles (UAV) will evolve from 1 pilot per 1 drone to 1 pilot per many drones, as well as from unlicensed to licensed spectrum and from low range (0.25 miles) line of sight (LOS) to beyond visual line of sight (BVLOS). In general, 5G will be important enabler for drones, and the use cases may include autonomous drone deployment; urban air mobility (taxi), UAV delivery, infrastructure inspection, public safety, and content generation. The technological capabilities and needs for network slicing are derived from variety of use cases such as telemetry, waypoints, UTM services, varying bandwidth from basic telemetry to demanding real-time video streaming and real time C2 (command and control) and C2 autonomous navigation infrastructure.

V2X is becoming increasingly important along with the development of the car manufacturers' new solutions such as more concrete technologies for drivers' assistance and self-driving vehicles. The ecosystem is evolving at present. As an example, the favoring of previously established IEEE 802.11p –based technology for the V2X in Europe needs to be taken into account in the assessment of the further exploration of the suitability of the 5G V2X into practical environment as the existence of the requirements depend completely on business decisions for the practical deployment.

As for specifically 3GPP technologies, the V2X has been introduced in Release 14 whereas the Release 16 presents 5G NR Sidelink for advanced use cases and Release 17 brings along further advancements. The Rel. 14 performance is comparable with the IEE 802.11p (Dedicated Short Range Communication, or DSRC) and LTE Sideline (Cellular V2X, or CV2X, as of Release 14). More information on the V2X can be found, e.g., at the NGMN Alliance V2X Task-Force's WG1 whitepaper [14], and 5GAA has produced related requirements. [15] The 3GPP TR 22.886 presents service handling with network exposure function. In general, automotive vertical requires much more rigorous requirements compared to consumer markets. Some special aspects of this environment include impacts of the vehicle's antenna performance, and C-V2X terminal needs to support a wide temperature and frequency ranges. For the Network Slice –specific requirements of the most demanding use cases such as self-driving vehicles, latency, mobility and security are some of the most important aspects.

Many other verticals and respective use cases still benefit from further assessment of communication requirements, such as EDGE (as an enabler for verticals), fraud prevention, Smart Cities, and public safety, as presented at the RIG workshops coordinated by the GSMA Technology Team at Chicago, IL, and Newport Beach, CA, in 2019, whereas other important use cases can relate to healthcare (which has increased its priority along the COVID-19) and critical infrastructure (which is increasingly important as the modern cyber security threats are evolving).

The NETSLIC Taskforce has concluded the ongoing work in March 2021. Nevertheless, the exploration of the vertical requirements for network slicing is a continuous effort of the ecosystem, and ideally involves Network Slice service providers, operators, and customers alike. As the 3GPP Release 15 and 16 –based specifications open up the new enablers, including the network slicing thanks to the new service-based architecture model, the forthcoming decisions of the standardization and practical deployments pave the way for the longer-term future.

The next, 6th generation is already under active research, and e.g., ITU has already discussed the forthcoming requirements for the respective networks at their NET-2030 Focus Groups including aspect on the forthcoming network slicing, too. [16] [17] [18] As an example of the future opportunities is the satellite component. The ITU-T NET-2030 has stated that while the traditional network operators' business model for network slicing has been relatively clear, advanced scenario of satellite operator involvement has not been previously elaborated. In this scenario, a terrestrial MNO may rent virtual network resources provided by a satellite operator in order to build a dedicated backhaul link for connecting its point of presences while terrestrial network operator is able to create end-to-end slices for supporting different application types.

6 Interested in Participating?

GSMA continues supporting the ecosystem in the research of the vertical needs. In order to design the template according to the realistic needs of the users, the GSMA North America Technology Team and the Regional Interest Group welcome still all the feedback from the verticals. This cooperation ensures that the operators have needed insights to the real needs of the field, and verticals can thus influence in the efforts of the operators to deploy the most useful services for their 5G networks.

Also, if you are interested in providing the vertical needs as described in this whitepaper via the web questionnaire of the GSMA North America, please feel free to send the indications and feedback directly via this link:

https://www.gsma.com/northamerica/gsma-north-america/network-slicing-survey/

Please note that for the next steps during January 2021 – June 2022, the GSMA with its participating members and associate members have established North America Vertical Application (NAVA) Taskforce that continues exploring the enablers of the 3GPP systems for supporting the users and developers taking advantage of the new network functions and performance. If you wish to have information on this activity, or any additional information on network slicing, please do not hesitate to contact Jyrki Penttinen, Senior Technology Manager, jpenttinen@gsma.com.

For generic information on 5G Network Slicing, please also feel free to download the following document of the GSMA:

https://www.gsma.com/futurenetworks/wp-content/uploads/2018/09/5G-Network-Slicing-Report-From-Vertical-Industry-Requirements-to-Network-Slice-Characteristics.pdf

Further references of the details of the Network Slicing can be found from the GSMA whitepaper “Network Slicing: Use Case Requirements” (April 2018) [2], and the latest version of the PRD NG.116 [3].

7 Conclusions

5G is already reality, and the ecosystem has high expectations on the new technology especially as for its ability to optimize use case –based performance. Network Slicing is one of the very key functions that differentiates 5G from the earlier mobile communication generations. Network Slicing provides the operators with means to better dedicate the invaluable network resources depending on the use cases instead of offering merely uniform performance for all the users as has been traditionally the case in previous generations.

To adequately adjust the Network Slices, it is of utmost importance for Network Slice Providers to understand the environment of the verticals that may want to utilize slices in their communications. During the work of the NETSLIC Taskforce it became obvious that there is still room for systematic ways for Network Slice Providers to better understand the realistic needs of verticals and how to convert those indications into technical Network Slice templates in a form of attributes and their value ranges.

This Whitepaper presents key findings and experiences, and suggests ways for the interested entities in their efforts to interpret the needs and adjust Network Slices. The efforts focused on the North America region, yet the results are applicable in the global environment.

As a next step, GSMA NAVA Taskforce will explore the practical aspects on the manners the ecosystem can take advantage of the standardized enablers of the mobile networks. All the interested ones are welcomed to contribute to this work and guidelines.

Annex A Vertical Questionnaire

NETSLIC designed and applied the following network slicing survey for vertical discussions. The template presents a series of questions about the connectivity requirements of the vertical representatives to capture wireless communications needs and challenges, and to identify essential aspects related to Network Slice planning. The estimated length of the questionnaire was designed to be around 10 minutes.

For the purpose of this questionnaire, "vertical" refers to a practical environment of a company or organization using the mobile communications networks. An example of the vertical could be “Edge Computing”, and the respective use case could be “Low latency virtual reality application”. The open questions are included for the relevant additional information, and there are multiple selections where the vertical can chose the options that best describe the use cases.

This questionnaire can be used as a handout in interviews, as well as stand-alone web form.

It should be noted that this questionnaire maintained confidentiality of the responses and the results are only published in an aggregated manner.

Use case title:		
Use case description:		
Company name:		
Industry and business:		
Contact information (for requirements discussions):		
Typical operations (local, national, international):		
Communication technologies and services applied today (terminals, applications, potential own or outsources infrastructure):		
Challenges in today’s communications capabilities (coverage, service level, etc.):		
Needs for future communications (e.g., increased data utilization, better applications, new applications like real-time video, etc.):		
Needs for future communications technologies performance (e.g., faster connectivity, faster data rates, better coverage, etc.):		
Overall notes on today’s and future needs (any special events or occasions requiring temporarily better performance for communications, etc.):		
Operations	How dynamic your communication service would need to be? E.g., do you need to change the maximum data rate suddenly?	Dynamic | Static | Other (description)
Connectivity	Needed data rate (Throughput) – typical / minimum / maximum	Not of importance | Very low (less than 100 kbps) | Low (100 kbps – 1 Mbps) | Moderate (1 Mbps – 10 Mbps) | High (10 Mbps-1 Gbps) | Very high (more than 1 Gbps)
	Data Volume per device	No Cap | High data volume: 100GB – 1TB per month | Low Data Volume: ~1GB | High frequency of small data packets, 200 bytes every 5ms gives ~1GB per month
	Latency (the response time)	Ultra-low (<1 ms) | Low (1-10 ms) | Moderate (10-100 ms) | Not critical (more than 100 ms)
	Reliability	Uptime critical at any time | Extremely high (>99.999 %) | High (>99.9) | Moderate (>90 %) | Not critical
	Typical number of simultaneously communicating devices within the area of operations	Typical number [value]
	Data security: How critical the data protection (encryption, integrity, identity, etc.) is?	[description]
	Isolation: Does the use case require isolation for security reasons	Network Resource allocation: Shared with other use cases/enterprises | Dedicated for this use cases | Hybrid depending on latency and bandwidth

	Coverage	Are devices typically within: Limited areas | State-wide | National | International | Other areas [description]?
	Energy efficiency of the devices	Are terminals transmitting actively (active calls / data transmission vs. idle): Always | Often | Rarely | Other [description]
	Traffic type	Are devices: Transmitting mostly (uplink traffic) | Receiving mostly (downlink traffic) | Receiving and transmitting about the same (such as voice and video calls) | Varying: Bursty traffic patterns (Uplink and downlink) [Random burstiness; Predefined (e.g. based on time of day)] | Other [description]
	Typical data profile	Traffic of typical usage mostly: Voice | Video | Text / messages | Telematics data | Other type of contents
	Other features: Any other technical characteristics and values used / needed in typical communications.	[description]
Enterprise specific infrastructure needs	Features	Data storage systems | Cloud computing | Edge computing | Big data analytics | ID/asset management | Positioning platform | Other features [description]
Business	Service Level Agreement (SLA) for own infra or outsourced: Is there high reliability required by contract, or is it best-effort basis?	[description]
Device	Type of devices: Smart phones | Sensors | IoT modules | Special devices | Others [description]	
	For each type of device indicate mobility and power requirements	
	Identify Mobility patterns for each type of device	Are majority of the type of devices: Moving [typical velocity range of mobiles?] | In static location | Other [description]
	Identify one or more power requirements for each type of device	Typically battery-only powered, such as remote sensors? [description] | Is device critical for energy consumption (located long time remotely without human intervention)? [description]Are these special low power devices (such as solar panel -powered)? [description]
	Device uses more than one type of communication service at a time?	Number and type of parallel services (such as simultaneous surveillance video and voice)? [description]
Other aspects	Any other requirements / needs in typical and exceptional cases	[description]

Annex B Document Management

B.1 Document History

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B.2 Other Information

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Your comments or suggestions & questions are always welcome.