5G: NETWORK SLICE MANAGEMENT BY SELF-ORGANIZED NETWORK
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$66B
5G slicing market for enterprise verticals including manufacturing, logistics, and transportation by 2026

42%
CAGR for the period 2018 - 2024 for Network Function Virtualization (NFV) and the market will reach $70 billion by 2024

30%
OPEX savings for operators that SON technology is bringing

$123B
Global new services 5G enabled market by 2025

2.5
Billion of 5G users by 2025
INTRODUCTION

Cellular network users and equipment are increasing drastically. We want to use the internet at a very high speed and industries require to improve work efficiency by automating all heavy machinery and ULCC without any delay.

5G introduction in the cellular world claims that these requirements can be fulfilled by deploying a new access node and core in a cloud environment. Use of NFV and SDN is not a new thing but using in communication services (mobile web browsing, VoLTE, Rich Communication Services, Internet access, LAN interconnection, international roaming, and RAN sharing) with network slices will be an effective way to use N/W resources.

As per GSMA Intelligence, there will be 2.5 billion 5G users by 2025, which is 40 percent of the global population. So, network vendors and operators see this as an excellent opportunity to create an agile network which can provide different services to specific industries. The Network slice will be a key enabler to help achieve this in 5G.

In 5G, network slicing is a new method for optimal utilization of RAN and core N/W resources. Each network slice represents a virtual network. It allows the multiple virtual networks on top of shared physical infrastructure (refer Figure 1: 5G Network architecture). Network slice ensures that each user in a network gets the best QoS.

Here are a few examples of communication services offered by Communication Service Providers to customers employing network slices:

- B2C services, e.g., mobile web browsing, VoLTE, Rich Communication Services, etc.
- B2B services, e.g., Internet access, LAN interconnection, etc.
- IoT services, e.g., smart metering, car parking in the mall, etc.
- URLLC services, e.g., Industrial automation, remote healthcare, intelligent transport, etc.
Network slice will be preconfigured at SIM/eSIM per PLMN (subscription-based) and RAN will support the selection of the RAN part of the network slice, by one or more slice ID(s) provided by the UE also by the CN, which is mapped to one or more of the pre-configured network slices in the PLMN.

Figure 1 shows the end-to-end 5G network architecture that explains 5G service (eMBB, URLLC, IOT, etc.), which will be handled by visualized network functions. These services will be accessible via network slices. RAN will support differentiated handling of traffic for different network slices which have been pre-configured. Depending on services, these RAN slices will map to control node slice-ID and user avail that service.
The Orchestration is a continuous process which selects the resources and provides the customer with specific services. Orchestration of slice can be done by automation framework which monitors all network entity (refer Figure 5: Flow of Network slice management by gNB entity (SON) in an NFV framework). But there are a couple of challenges, e.g. isolation of slices, security, etc. There are several means of the orchestration of network slices; in this paper, the SON (part of RAN) module for management of network slices (NS) has been considered. This module will monitor the resources and NS utilization (explained in the later section) and participation in life cycle management of network slices.

The following key aspects which will be managed by SON has been explained.

- Management of network slice when devices get registered for the first time
- In run time network slice re-configuration, SON automatically changes Access Network/Core Network slice IDs to avoid the degradation of services in case of network function overload, dynamic topology change, etc.

Figure 2 explains the flow of the network slice while using network services.

Network slice instance (NSI) contains network function(s) that belongs to CN and AN containing all functionalities and resources necessary to support a certain set of communication services. Network slice subnet instance (NSSI) manages NSI while using communication services.

To access communication service in the network slice concept, one NSI can access multiple services using dedicated NSSI of CN and AN. NSSI can also be shared. In Figure 2, Service 1 and 2 are accessed via NSI A and NSI A dedicatedly uses NSSI1 of CN and AN but while using service 2 and 3 which is accessed by NSI B and NSI C, CN uses dedicated NSSI2 and NSSI3, but at AN, NSSI 2 is being shared.

This shows that there is isolation between the slices. RAN resource isolation may be achieved using RRM policies and protection mechanisms that should avoid that the shortage of shared resources in one slice breaks the service level agreement for another slice.

Figure 2: Network slice in network services

Figure 3: End to End Service via Network Slice

09 - How Network Slices (Dedicated/Shared) are used?
This section explains the management of network slices and how this will be managed in the NFV framework. 3GPP defines three management functions to manage network slices which are as follows.

- **Communication Service Management Function (CSMF):** CSMF is responsible for translating the communication service related requirement to network slice related requirements.
- **Network Slice Management Function (NSMF):** NSMF is responsible for management and orchestration of NSI and derives network slice subnet-related requirements from network slice related requirements.
- **Network Slice Subnet Management Function (NSSMF):** NSSMF is responsible for the management and orchestration of NSSI.

![Network Slice Management in an NFV Framework](image)

**Figure 4: Network Slice Management in an NFV Framework**

Os-Ma reference point will be used for interaction between slicing-related management functions and NFV-MANO. To properly interface with NFV-MANO, the NSMF and/or NSSMF need to determine the type of NS or set of NSs, VNF, and PNF that can support the resource requirements for an NSI or NSSI, and whether new instances of these NSs, VNFs and the connectivity to the PNFs need to be created or existing instances can be re-used.

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**SON in NFV Framework**

gNB can be functionally split in Central Unit (CU) and Distributed Unit (DU). In below Figure 6, CU is considered as SON which will be VNF and other gNB entity will be PNF. CNs will also be part of VNF. Dotted lines show the flow of Network slice management.

**Step 1 and 2**: EM will monitor the unitization of NS of CN used by multiple ANs.

**Step 3, 4, and 5**: In the initial state (Device registration), SON will initiate the trigger to NFV-MANO (via VNFM) and allocation of NS-ID will be done via NSMF or NSSMF and the element managers associated to SON.

**Step 6**: EM will communicate with NSMF or NSSMF.

**Step 8**: Based on the RRM report (part of DU), in Step 7 SON maps NeS-IDs to achieve best QoS.

At runtime, if a change in NS-ID is required due to overload or traffic change, the NSMF or the NSSMF can change the operational state of those VNFs through an updated NS operation.
Network Slice Instance life cycle

Network Slice Instance (NSI) life cycle is divided into the following phases.
- Preparation phase
- Instantiation, Configuration, and Activation phase
- Run-time phase
- Decommissioning phase
In the preparation phase, NSI is not yet generated. NSI only gets created and verified using Network slice template. This is when 5G UE gets registered with the network for the first time. Once the network service is about to start, the allocation of dedicated/shared resources will be done in three phases namely the Instantiation, Configuration and Activation phase. Due to traffic offload change in NSI, the mapping will be done in the run time phase. Once 5G UE gets detached, resources allocated to NSI will be released, the NSI will be out of service and this phase is called the decommissioning phase.
The 5G SON architecture has been considered as mentioned in Figure 7, which is a part of CU as explained in Figure 5. This SON module will communicate with PHY, RRM, and HeMS/gNB OAM for slice management at AN. PHY and RRM will be a part of DU whereas HeMS will be a part of another VNF. In SON architect, SONMgmt interacts with SON NeSmgmt (sub-module which maintains the database for AN, CN, and UE slice Ids). RRM will configure AN slice Ids via TR file (proprietary files) and these AN slice Ids will be communicated to SON (internally SON NeSmgmt will maintain this entry). Similarly, CN and UE NS entries will also be maintained at SON NeSmgmt, which will be communicated by RRM. SON is responsible to map UE, AN, and CN slice Id(s). In poor RF condition, overload in traffic or due to a fault condition, RRM will instruct to SON, accordingly, SON will change the slice Id mapping to achieve the best QoS.

SON does network slice management during
- Instantiation, Configuration, and Activation phase
- Runtime
- Optimization

The benefits of doing network slice management at SON are
- Instantiation, Configuration, and Activation phase
- Resource isolation will be easy with the help of RRM
- No additional security will be required to protect from DOS or other

[4] 3GPP TR 38.801 V2.0.0 (2017-3)
Figure 7: 5G SON Interfaces

[4] 3GPP TR 38.801 V2.0.0 (2017-3)
This section explains how 5G SON will orchestrate the network slicing in the following two cases.

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**Case 1**

Automatic configuration of an NSI instance with appropriate parameters before activation.

Steps for Case 1 flow:
1. RRM of each gNBs will update AN slice Ids, which will be maintained by SON
2. All CNs will provide their list of supported CN slice Ids in NG setup response to RRC
3. During the first-time registration, UE will inform UEs NeS-Id to SON via RRC and RRM
4. RRM will share UL-SNR, RSSI, and path loss information, so that SON can take the decision of mapping to AN and CN slice Ids to get the best QoS to the requested service

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Figure 8: Case 1
Automatic reconfiguration of NSI parameters to avoid service degradation during network function overload and dynamic.

**Steps for Case 2 flow:**
1. UE utilizing service with CN1 with NS Ids mapped in the previous case
2. The Service of UE is degraded due to the information given by EM (NFV framework) CN1 slice id overloaded and same informed to SON
3. SON (as mentioned in Figure 6) will take the decision based on the high/overload information from RRM
4. SON will change the CN slice Id which is mapped to CN2
5. Security context between UE and CN2 will be updated
6. UE will communicate with CN2 with the existing UE NeS-Id

**Figure 9: Case 2**
CONCLUSION

In 5G, the network slice is a key enabler to provide eMBB, IOT, eMTC, and URLCC services to achieve the best QoS. SON which is a part of RAN ensures the best management of network slice and provides the desired services. As SON is a part of RAN, it acts as a trigger for orchestration of network slice to reduce the latency, isolation of resources, effective utilization of resources and provide secured operation.

About the Author

Shailendra Yadav is a Director-Technology with over eighteen plus years of experience in 5G, LTE, 2.5G, 2G and PSTN technologies. He believes in R&D and sharing knowledge on emerging areas in wireless domain.
About Altran

Altran ranks as the undisputed global leader in Engineering and R&D services (ER&D), following its acquisition of Aricent. The company offers clients an unmatched value proposition to address their transformation and innovation needs. Altran works alongside its clients, from initial concept through industrialization, to invent the products and services of tomorrow. For over 30 years, the company has provided expertise in aerospace, automotive, defense, energy, finance, life sciences, railway and telecommunications. The Aricent acquisition extends this leadership to semiconductors, digital experience and design innovation. Combined, Altran and Aricent generated revenues of €2.9 billion in 2018, with some 47,000 employees in more than 30 countries.

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