Perspective

The automation of network slice lifecycle management and orchestration is critical to deliver 5G slicing at scale

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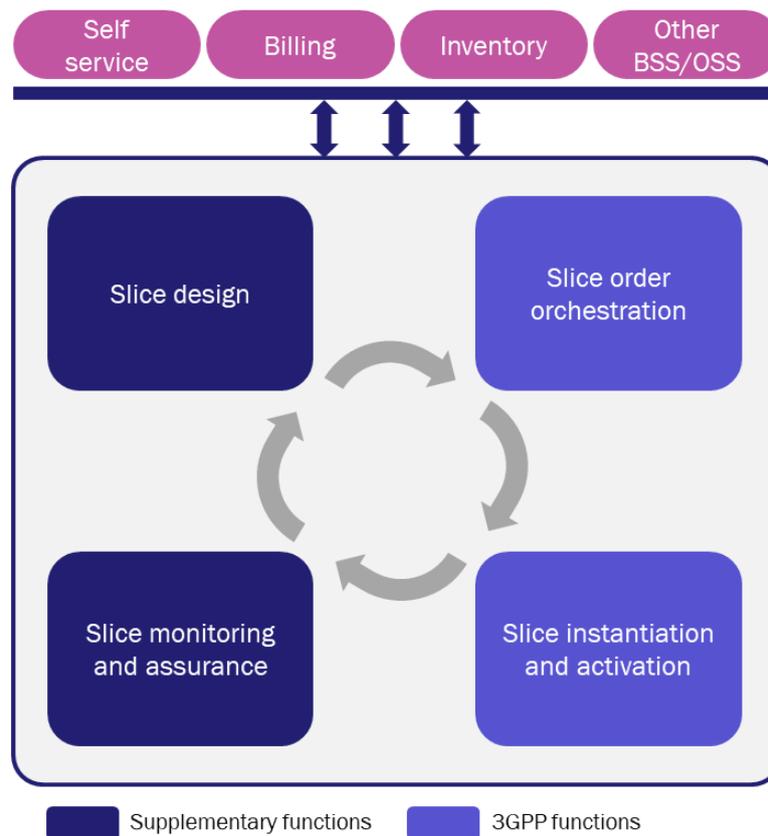
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1. Executive summary

5G is being developed as a network platform that combines new radio, edge clouds, programmable transport and the cloud-native core to deliver differentiated, on-demand IoT and ultra-low-latency use cases to enterprises. End-to-end network slicing makes this possible by providing logically separate network partitions with end-to-end management and control over the network performance. Latency characteristics can be tailored to a particular use case or enterprise.

However, to achieve this level of granular control over the network sources and to deliver network slicing at scale, communications service providers (CSPs) must have highly automated network slice lifecycle management capabilities. The slice design, order and orchestration functions must be seamlessly integrated with the slice instantiation, monitoring and closed-loop automation functions to enable full, end-to-end automation in order to deliver a self-service digital experience to customers and enterprises. Furthermore, the end-to-end cross-domain slice orchestration must be based on multi-layer, model-driven, platform-oriented architecture that provides multi-vendor support to enable CSPs to deploy a best-of-breed network slice management solution.

2. Extreme automation is essential for operationalising network slicing at scale

CSPs will need to have a highly efficient and cost-effective way of ordering, instantiating, provisioning, monitoring and managing the lifecycle of network slices as the adoption of network slicing increases. The cost of network slide lifecycle management at scale is determined by the economics of deploying a slice and the extent to which CSPs can control the incremental cost of deploying tens or hundreds of slices. Enterprise customers expect to have high levels of control when procuring and managing their own slices, similarly to when they procure cloud infrastructure and software. Extreme automation of the network slice management processes and operations is therefore critical to achieve the requisite economies of scale from a CSP perspective, and to deliver a 'cloud-type' digital experience to enterprises.

Figure 1 shows a framework for network slice lifecycle management that CSPs can use to achieve extreme end-to-end network slice lifecycle management automation. This framework extends the 3GPP's proposed network slice management architecture and consists of four key components.

Figure 1: Framework for network slice lifecycle management[1]

- **Slice design.** CSPs should use 'slice templates' for their end-to-end network slices. Templates enable product managers to quickly design new slices and make them available as new products in the product catalogue. Automated design functions can also be used to define both slice characteristics (such as the quality of service, path-forwarding policy and connectivity endpoints) and the assurance functions that are needed to meet SLAs. Tens or hundreds of slice instances can be automatically instantiated using a limited set of slice types when taking this approach.

- **Slice order orchestration.** Once slices have been designed and made available as products, customers are able to simultaneously order their network slices and configure their characteristics. This should ideally be done via a self-service portal so that customers have a truly one-click digital experience. The slice order is decomposed into constituent service orders and an orchestration workflow (the slice orchestration function) is then executed in a highly co-ordinated fashion in conjunction with a plethora of network slice domain orchestrators. This slice orchestration function is defined by 3GPP as the communications service management function (CSMF).

- **Slice instantiation and activation.** At this stage, the cross-domain network slice orchestration function (defined by 3GPP as the network slice management function (NSMF)) provisions the end-to-end slice onto the network by commanding each of the network slice domain orchestrators (defined by 3GPP as network slice subnet management functions (NSSMFs)) to instantiate and activate the networking resources across

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[1] For more information, see Analysys Mason's 5G network slicing: an end-to-end framework for slice lifecycle automation.

the RAN, edge, transport network and core on a domain-by-domain basis. This approach allows for the instantiation and activation of network slice resources for three use case types (eMBB, mMTC and uRLLC) in each subnet and domain, dictated by the end-to-end network slice intent (defined during the design stage) and governed by the cross-domain slice orchestrator.

- **Slice monitoring and assurance**. Once the slices have been provisioned, the slice monitoring and assurance function monitors the slices for the predefined intent and drives self-healing at each layer (network resource layer, domain layer and end-to-end slice layer). Network slices will need to be tested end-to-end after activation; this must include validating that all of the associated network resources were accurately instantiated. 'Live' slices must be continually monitored at each layer; this includes monitoring the underlying resources (including VNFs and infrastructure), monitoring domain-level slices across the RAN, edge, transport network and core and monitoring the end-to-end slice performance. Such monitoring will provide an aggregated view of the entire network slice from the customers' perspective in terms of service quality and SLAs. AI/ML-based analytics will be required to generate the insights necessary to drive closed-loop automated actions for slice self-healing and resolution.

The four functions listed above must also interface with other BSS/OSS functions such as billing systems (for monetisation purposes) and inventory systems (to maintain a real-time view of the network and service models). However, these systems will first need to evolve to support network slice-based business models. They will then be able to interwork in a closed-loop manner to deliver a truly digital experience to customers and achieve the requisite economies of scale for network slice management and operations.

3. The framework for network slice lifecycle management also has requirements related to architecture and design

In addition to the four key functional modules discussed above, the framework for network slice lifecycle management has the following requirements related to architecture and design.

- **Multi-layer architecture**. The ability to provide multi-layer control at both the domain and cross-domain level is one of the foundational capabilities of any network slice lifecycle management solution. A multi-layer orchestration solution will ensure abstraction and operational demarcation in highly distributed network architecture with multiple networking, data centre and cloud domains (including the RAN, WAN, edge and core). The lower-layer domain orchestrators will perform the individual domain-level orchestration processes and will have software-defined control of each of these domains. The cross-domain orchestrator will perform the role of 'orchestrator of orchestrators' and will provide the higher-layer abstraction and end-to-end cross-domain service orchestration.

- **Model- (or intent-) driven.** The mobile network environment will consist of a mix of network infrastructure (ranging from the traditional physical network functions to VM-based network functions) and new container network functions for 5G standalone (SA), and each component will have a mixed level of maturity. The orchestration solution should therefore support a model-based approach that provides a high level of customisation in order to cater for various network function type permutations and requirements. This will enable service providers to develop new services and use cases without a significant dependence on the individual components of the underlying network.

- **Platform-oriented and open API-driven.** Adopting a platform approach will enable the solution to be built in a modular form based on microservices architecture. This will make it easy to introduce new capabilities, make the solution composable and allow service enhancements with minimal disruption in the run-time environment. It is also critical that the solution complies with open, industry-standard APIs for frictionless solution composition and easier integration with third-party software components, thereby resulting in a best-of-breed orchestration solution. Additionally, the platform should be developed using a highly curated set of tools for managing the DevOps and CI/CD pipelines to automate the build, test and deployment processes. This will prevent 'tool sprawl' and will increase the automation efficiency of solution development and deployment.

- **Multi-vendor support.** The cross-domain network slice orchestration solution (NSMF) must have multi-vendor capabilities. That is, it must easily integrate with any third-party domain-level slice orchestrator (NSSMF). Similarly, the domain-level orchestrators must also be vendor-agnostic and must have the ability to orchestrate a network formed of equipment from multiple vendors, as well as VNFs and CNFs. As networks become more virtualised, it is likely that some network functions will be hosted in a hybrid-cloud environment (private and/or public). This will require multi-cloud slice orchestration capabilities spanning the private cloud environment within the service providers' data centres and the public cloud (supplied by providers such as AWS, Azure, Google and Oracle via Oracle Cloud Infrastructure (OCI)).

4. Vendor solution brief: Oracle Service and Network Orchestration (SNO) solution

Oracle has developed its SNO solution using its cloud-native service fulfilment product suite. The SNO solution brings together key functional modules such as customer and service order orchestration, network resource orchestration and service and resource inventory. It enables CSPs to automate the order-to-activation process of network slices at scale. The SNO solution puts Oracle in a strong position with its CSP customers that are planning to launch network slice based B2B services to monetise 5G.

5. About the author

Anil Rao (Research Director) is the lead analyst on network and service automation research that includes the Network Automation and Orchestration, Automated Assurance and Service Design and Orchestration research programmes, covering a broad range of topics on the existing and new-age operational systems that will power operators' digital transformations. His main areas of focus include service creation, provisioning and service operations in NFV/SDN-based networks, 5G, IoT and edge clouds; the use of analytics, ML and AI to increase operations efficiency and agility; and the broader imperatives around operations automation and zero touch networks. In addition to producing both quantitative and qualitative research for both programmes, Anil also works with clients on a range of consulting engagements such as strategy assessment and advisory, market sizing, competitive analysis and market positioning, and marketing support through thought leadership collateral. Anil is also a frequent speaker and chair at industry events, and holds a BEng in Computer Science from the University of Mysore and an MBA from Lancaster University Management School, UK.

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