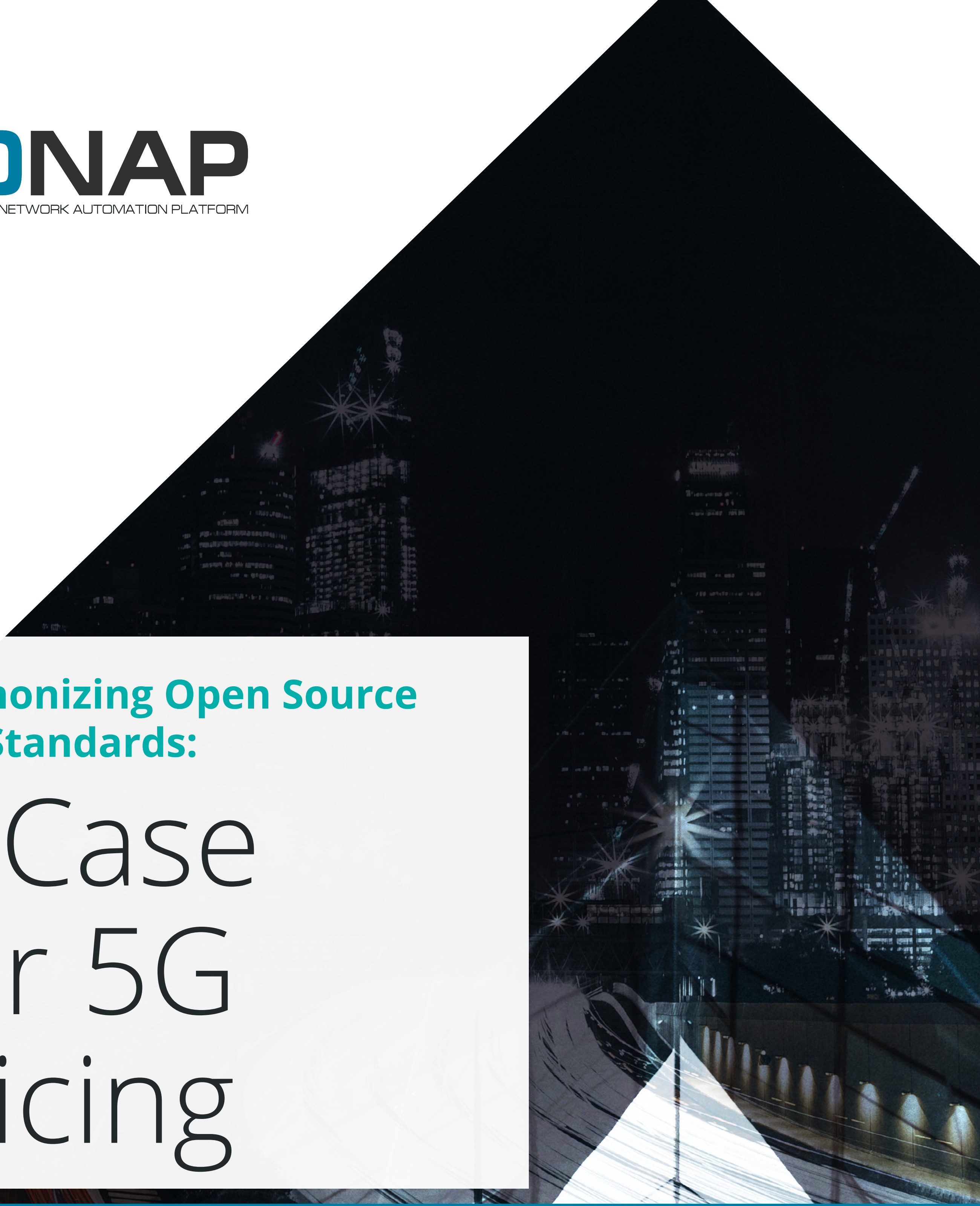
ONAP
OPEN NETWORK AUTOMATION PLATFORM



Harmonizing Open Source and Standards:

A Case for 5G Slicing

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1. INTRODUCTION

As an operator-led open source community for a next generation network automation platform, ONAP has been committed to the convergence of standards and open source since inception, and has promoted cross-organizational industry cooperation by publishing a series of white papers.

Based on the latest version of ONAP Frankfurt, this latest article in the series focuses on solving the core technical issues of the commercial vision of 5G slicing. It analyzes from an industry standards perspective the existing situation of open source implementation and concludes with proposals for future work along this direction.

2. 5G SLICING VISION

Network slicing, as defined in the NGMN 5G white paper, refers to "A network slice, namely '5G slice', supports the communication service of a particular connection type with a specific way of handling the C- and U-plane for this service". Its main purpose is to provide differentiated network services, using virtualization and other technologies to provide isolated end-to-end virtual private networks to meet the business needs of specific applications and scenarios, and to ensure the SLA of the business. The basic framework of network slicing is shown in Figure 1:

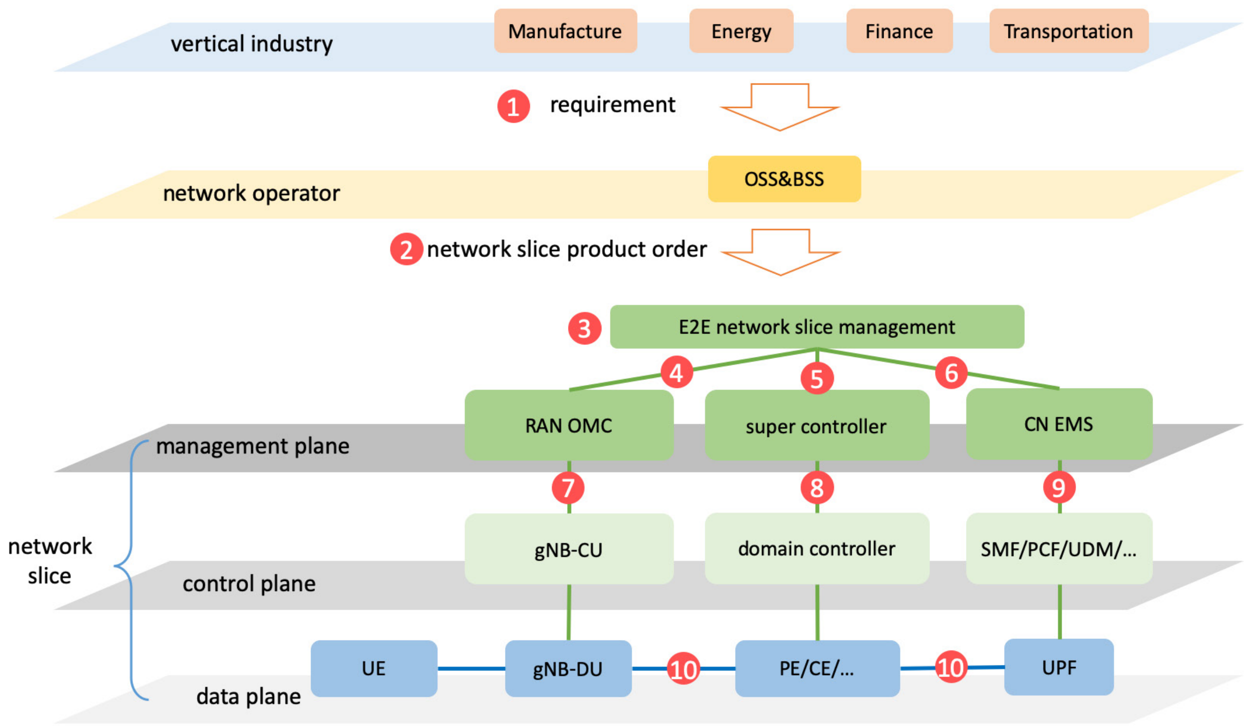

Figure 1 Basic framework and reference points for network slicing

From the perspective of business requirements, network operators customize the design and provide slicing service products according to the needs of vertical industries, and monitor the operation status of slicing services and related network resources through network management and control systems, and make real-time adjustments as needed to ensure that the Service Level Agreement (SLA) of the slice service meets user expectations. From the perspective of resource realization, the newly introduced end-to-end slice management system responds to customer needs by coordinating the corresponding management plane functions to coordinate the corresponding physical or virtual network elements of control data planes and the physical or virtual link connection between them.

The main challenges in the current commercialization of end-to-end slicing services include:

- **Automation: Automate slicing deployment, operation and maintenance**
  The key to realizing the commercial value of the slice business is scale. On the one hand, operators need to work hard to find and expand potential industry users, identify differences in their needs, and provide tailor-made services; on the other hand, they need to efficiently reuse the underlying network resources. The flexible provision of on-demand deployment, provisioning, and Operations and Maintenance (O&M) management of virtual network slices based on a physical network depends on the high degree of automation of the entire slice management system.

- **Cross-domain connection: coordinate the user planes, control planes and management planes of a wireless network, transmission network and core network.**
  As 5G network slicing involves multiple domains such as User Equipment (UE), wireless network, transmission network, and core network, we need cross-domain collaboration to achieve complete end-to-end connection, management, operation, and maintenance. However, wireless, transmission, core network elements, networking methods, communication protocols, and management and control methods are all very different. End-to-end management coordination may involve multiple infrastructure providers or network operator Departments. The Standards Development Organizations (SDOs) often only focus on some of these areas or technologies, and they lack coordination with each other.

- **SLA guarantee: Transform the needs of vertical industries into SLA slices and decompose them into various domains to achieve real-time monitoring and dynamic guarantee.**
  The transformation of vertical industry requirements (such as isolation, security, monitoring, bandwidth, delay, etc.) into network business indicators of the communications industry itself involves cross-industry cooperation, and there are certain difficulties. Due to the differences in implementation technologies in the wireless, transmission, and core network fields, how to decompose end-to-end service assurance indicators in various domains and how to cooperate between domains to achieve end-to-end assurance are still open issues. However, the scope of the work of traditional standardization organizations is limited to logical function descriptions and interaction interface definitions, which cannot provide a clear solution to the above problems.

3. ONAP Modelling

SDO	1 Vertical Reqs	2 Product order	3 E2E Slice Mgt	4 E2E Slice Mgt – AN Mgt	5 E2E Slice Mgt – TN Mgt	6 E2E Slice Mgt – CN Mgt	7 AN Ctrl	8 TN Ctrl	9 CN Ctrl	10 AN/CN UP – TN UP
GSMA	NG.116									
TMF		TMF622 TMF641	IG1194 TMF664		TR255					
MEF										MEF 22.3.1
ETSI ZSM			ZSM003							
3GPP RAN							TS38.300			
3GPP SA2									TS23.501 TS23.502	
3GPP SA5			TS28.530	TS28.531		TS28.531				
IETF					design team			RFC8453		
CCSA			Y	Y	Y	Y	YD/T 3618-2019 YD/T 3619-2019	Y	YD/T 3615-2019 YD/T 3616-2019	Y
ONAP Impl.		Y	Y	Y	Y	Y				

Published　Work In Progress　Planned

Figure 2 List of networking slicing related work progress of standard organization

As shown in Figure 2, there are currently multiple standards organizations that research and define standard specifications around network slicing. 3GPP is the focal point for 5G slicing Standards, which are expected to be complementary with GSMA, TMF, IETF and CCSA. ONAP is working on a partial implementation, with the purpose of achieving convergence with SDOs (starting with 3GPP).

This next section will introduce the progress of slicing related work that typically includes organizations such as GSMA, 3GPP, IETF, CCSA, and ETSI.

3.1 GSMA

The main goal of slicing is to provide differentiated services to meet the individual needs of different businesses. The first problem in building end-to-end slicing is to clarify the specific requirements for communication services in different business scenarios. To this end, GSMA established the Network Slicing Taskforce (NEST) working group and released the NG.116 Generic Network Slice Template to describe the characteristics of different types of slice services, corresponding to reference point 1 in Figure 1.

NG.116 released the v2.0 version in October 2019, which includes 35 slice feature attributes, such as delay, bandwidth, deterministic network, energy consumption, isolation, positioning, etc. The follow-up plan is further supplemented and improved.

3.2 3GPP

In 3GPP, there are several working groups involved in the standardization of slices. For example, SA1 describes the use cases and requirements related to slices (Figure 1 reference point 1), SA5 defines the slice management architecture (Figure 1 reference points 2-9), Radio Access Network (RAN) defines the characteristics of support slices on the wireless side, SA2 defines the core network slice infrastructure and control plane processes, and SA3 defines the slice security features.

3GPP SA2 and SA5 have planned to use the slice feature attributes defined in NG.116 as input to study how to convert user needs into mobile network requirements and finally reflect them on network deployment and O&M, corresponding to reference points 1 and 2 in Figure 1.

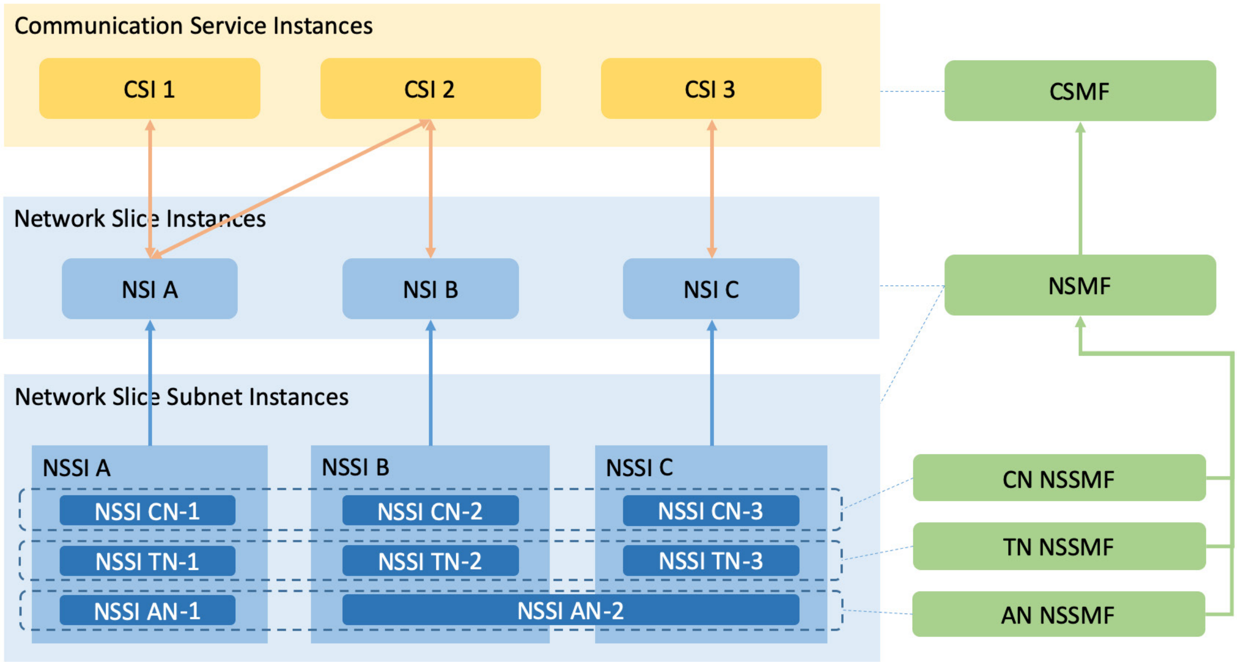

Figure 3 3GPP network slice concept and management architecture

3GPP SA5 further defines the slicing concept and slicing management architecture for the network management side as shown in Figure 3: Operators provide users with communication services (CSI 1, 2, 3), which can be based on one or more network slice instances (NSI A, B, C).

Network slice instances carry the business requirements of end-to-end slicing. The deployment information is described by the associated Network Slice Subnet Instances (NSSI A, B, C). NSSI allows nesting. As shown in the figure, an end-to-end NSSI can be composed of three sub-NSSIs: wireless, transmission, and core network NSSI. Corresponding to the management architecture, there are three layers of functional entities: Communication Service Management Function (CSMF), Network Slice Management Function (NSMF), and Network Slice Subnet Management Function (NSSMF). Among them, CSMF manages communication services, NSMF manages NSI and its associated end-to-end NSSI, and NSSMF can deploy multiple entities according to technical domains. The entities are responsible for the management and orchestration of each inside NSSI of domains (wireless, transmission, core) respectively.

Based on the above architecture, 3GPP SA5 defines a series of specifications related to network slice management: TS28.530 specifies the management system and requirements for network slices. TS28.531 defines interfaces such as NSI / NSSI allocation / deletion. TS 28.541 specification defines the network resource model for network slicing and the SLA requirements related for end-to-end slicing are described by ServiceProfile, and the deployment resource requirements for slicing subnets are described by SliceProfile, covering parameters such as bandwidth, delay, and maximum UE number.

3GPP SA2 defines the relevant architectures and procedures of core network element support slice in TS23.501, TS23.502.

3GPP RAN defines the RAN side network slicing principles, slice selection, UE context processing, mobility and other signaling procedures in TS38.300.

3.3 IETF

The IETF is mainly concerned with the management scheme of the transmission slice subnet. Currently, a design team is considering the design of the management model and interface between the 3GPP NSMF management system and the transmission slice management system, and the technologies, protocols and enhancements required for the transmission slice subnet.

In addition, the IETF has developed many transport layer protocols, such as Segment Routing (SR), L3VPN, and the northbound interface of network controllers, such as the ACTN framework defined by RFC8453, which can be used to support slice deployment.

3.4 ETSI

ETSI ZSM is positioned for cross-domain management automation use case requirements (ZSM001), reference architecture (ZSM002), and conducts in-depth research on the case of end-to-end slicing cross-domain management, and outputs the ZSM003 project document, which is based on the 3GPP slice management architecture, with reference to TMF open API for the north bound interface, and gives how the wireless, transmission, core network and other management domains cooperate with ZSM cross-domain management to achieve end-to-end slice management processes.

3.5 CCSA

CCSA is a regional standardization organization similar to ETSI in China. CCSA has newly established an ad hoc working group on network slicing to formulate relevant standards for the basic functions and requirements of slicing cross-domain interworking and the data plane interworking plan among the transmission network, wireless network and the core network.

In addition, the TC7 working group in CCSA plans to formulate management systems, processes, models for network slices with reference to 3GPP SA5 related specifications, and add enhanced functions such as template design on the basis. The TC5 working group has formulated a series of specifications including YD / T 3615-2019, YD / T 3616-2019, YD / T 3618-2019, YD / T 3619-2019, etc. with reference to the relevant specifications of 3GPP SA2 and RAN. These specifications formulated by TC5 define the core network and wireless support network slicing functional requirements and related processes. The TC3 and TC6 working groups plan to develop a northbound interface API for transmitting NSSMF to support slice management in the TN domain.

3.6 TM FORUM

TM Forum is pursuing a generalized intent-based approach, where the clients of an API don't need to understand the complexities of the resource layer but instead interact with the resource layer through more abstract capability features. Complementing this is the separation and mapping of the service layer abstraction, including service specifications and configurations (e.g., simplified slice templates), to the resource layer, including resource function specifications and configurations (e.g., as described in 3GPP's 5G network resource model). The definition of a Connectivity Service Domain in TM Forum TR255 allows 5G enabled services to be represented with a common service abstraction. In addition, TM Forum IG1194 entitled, Focus on Services Not Slices, proposes the hiding of network complexity by adding service-aware constructs to the slice definitions. In TMF664, the Resource Function Activation and Configuration API Specification, network slicing concepts such as: Network Slice, Network Slice Subnet, and 3GPP NRM managed functions are managed through an open API.

3.7 MEF FORUM

The MEF Forum created Draft Standard MEF 22.3.1, Transport for 5G Mobile Networks. Support for Network Slicing in Carrier Ethernet Network (CEN) services can be accomplished using CEN services already defined, combined with best fit Class of Service (CoS) and other service parameters. In this Draft Standard MEF considers the necessity of mapping the RAN Network Slice Identifier to the Ethernet Virtual Connection (EVC) plus CoS by using the appropriate C-TAG VID (VLAN Identifier) + PCP (Priority Code Point) in the Ethernet Frame. Many Network Slices may be mapped to a single EVC. Such EVCs and related service parameters may be managed by using the MEF defined Lifecycle Service Orchestration (LSO) APIs.

4. ONAP REFERENCE IMPLEMENTATION

In 2019, China Mobile united Tencent, and Huawei to demonstrate the ONAP D-version based 5G end-to-end slice management prototype system for the first time at the ONS EU event, and formally incorporated it into the community R & D plan in November 2019. This chapter will introduce the related work schemes and analyze the corresponding standards from the three aspects of functional architecture, model design, and implementation architecture.

As shown in Figure 2, from the perspective of published standards, 3GPP SA5, GSMA, and TMF are the core subjects for the formulation of the currently published slice management standards, so they are the main targets of our benchmarking analysis.

4.1 FUNCTIONS OVERVIEW

The ONAP Frankfurt version to be released in 2020 will include the open source reference implementations of CSMF and NSMF. Through northbound docking with industry customers and southbound docking with NSSMF, end-to-end slicing services and instances of full lifecycle management and O&M monitoring will be implemented for three types of users:

Operator business designers: based on in-depth understanding of the communication network and the classification of industry customers' needs, design end-to-end slicing templates, slicing business templates by combining information from subnet slicing templates. Establish the mapping relationships between slicing business templates and the end-to-end slicing templates then encapsulate it into sliced products and publish them to the sliced mall.

Operator network O&M engineers: they can monitor and manage the status of all running slicing services, slicing networks, and subnet slicing instances; in addition, depending on the operator's business O&M needs, engineers may need to use the NSMF Portal manually to confirm / modify candidate slice instances and candidate subnet slice instances (optional) recommended by the system automatically to respond to and process slice business orders from customers.

Operator slicing business customers: purchase self-service slicing products through the slicing mall service ordering interface, and activate and deactivate the slicing service in real time according to their own time and space requirements, and terminate the service at any time. At the same time, during the entire lifecycle of the slicing business, enterprise customers can also monitor the real-time performance indicators of the slicing business ordered in real time, which is convenient for enterprises to make timely and flexible adjustments according to their own business needs.

4.2 MODEL DESIGN

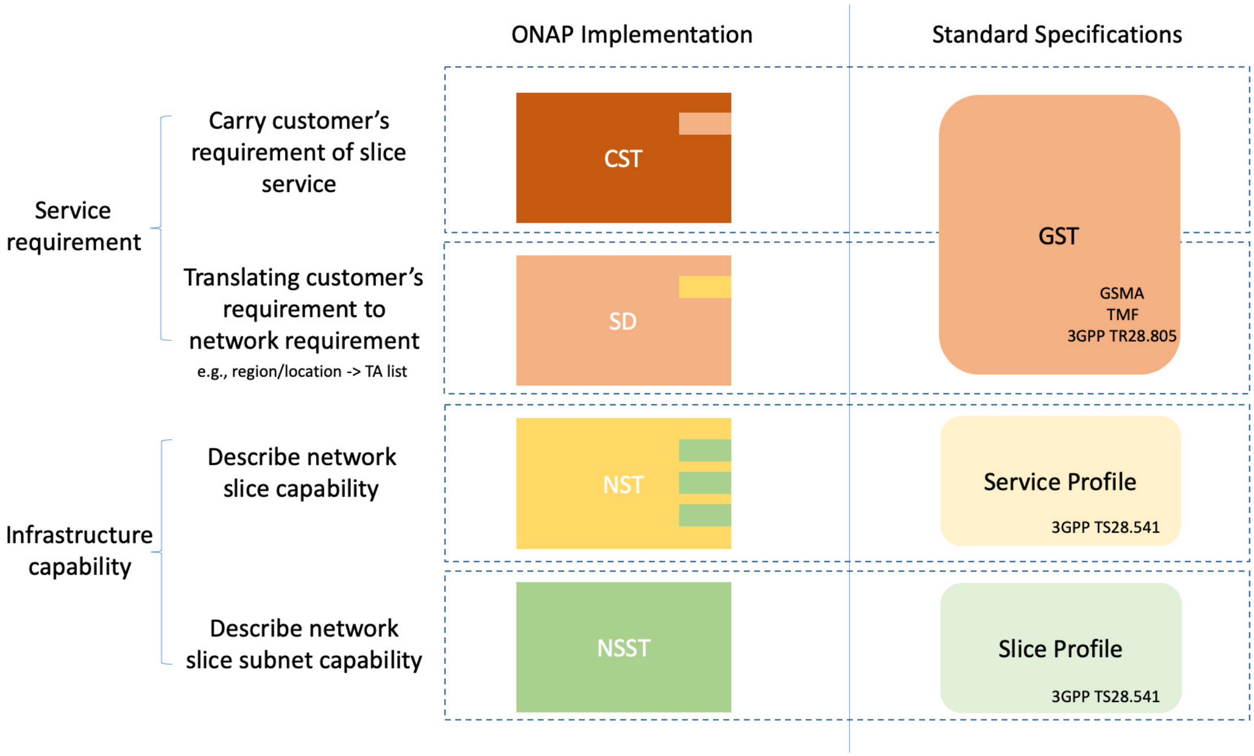

Figure 4 ONAP design state template and the corresponding relationship with the standard

As shown Figure 4, ONAP design mode provides four types of template design, which are:

- **CST (Communication Service Template):** Used to collect SLA requirements entered by users from the Portal, which includes basic parameters for vertical industrial requirements.
- **SD (Service Descriptor):** It is used to record the user requirements collected by CST and convert them to the network requirements understood by the management system, and apply for creating an end-to-end slicing service instance based on this.
- **NST (Network Slice Template):** It is used to describe the deployment information of NSI, and is used to create new slice instances and / or subnet slice instances accordingly.
- **NSST (Network Slice Subnet Template):** used to deploy NSSI, describes the sub-domain network slice and subnet capability information, and associates the virtual resource (NSD) information required to deploy NSSI.

4.3 IMPLEMENTATION ARCHITECTURE

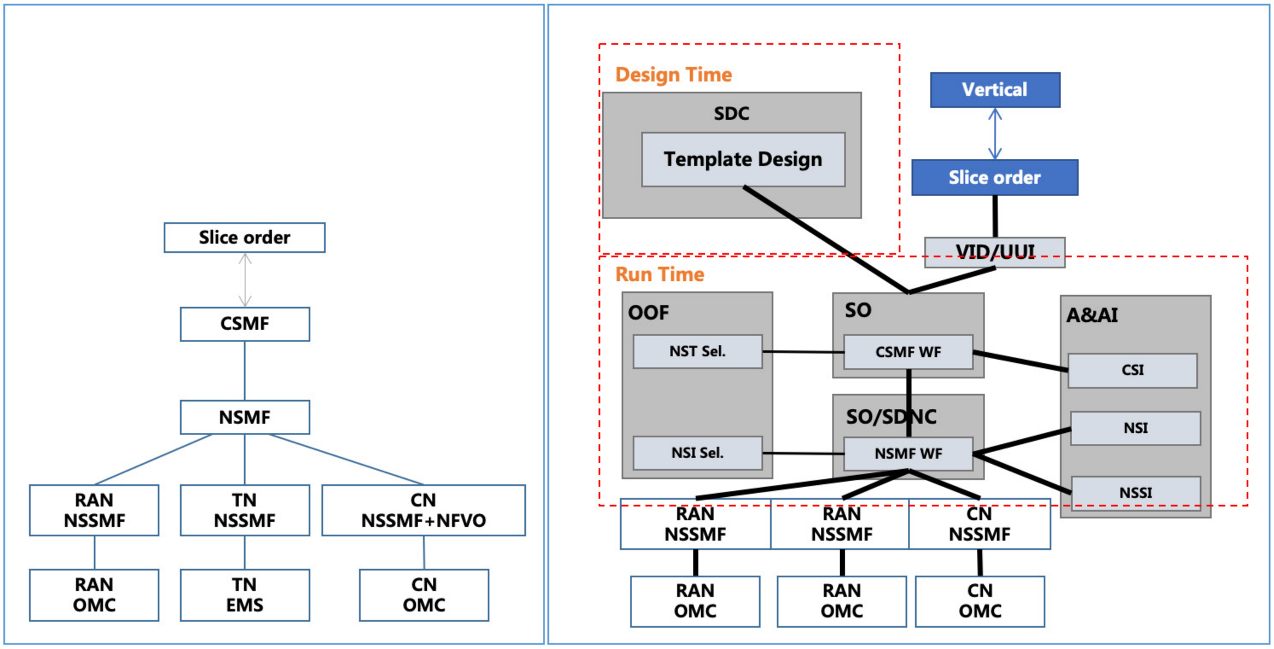

Figure 5 Mapping between ONAP (Frankfurt) and 3GPP specifications

As shown in Figure 5, the standard function mapping aspects are as follows:

- CSMF, corresponding to the SO, A&AI, and U-UI modules, implements the corresponding slice business lifecycle management workflow, slice business instance information storage, and slice customer interaction interface.
- NSMF, corresponding to the SO, A & AI, OOF module, and U-UI module, implements the slice instance lifecycle management workflow, slice instance mapping relationship storage, slice instance optimization selection function implementation, and O&M user interface.
- Functions in SO module:
    - The CSMF workflow collects user requirements through CST, generates S-NSSAI, and converts the original user requirements into network requirements understood by the management system, records them in the ONAP business template, and applies to the NSMF workflow to create an end-to-end network slicing instance based on the SD.
    - The NSMF workflow instantiates the Service Instance object according to the SD template information, and maintains the relationship between the slice service identified by S-NSSAI and the network slice instance (NSI).

Functions not involved in standards include:

- E2E slicing and slicing subnet design (including four types of templates), which are implemented by the SDC module.
- E2E slice indicator monitoring is implemented by the micro-services extended on DCAE by aggregating the underlying network element business indicators from NSSMF and reporting directly to the monitoring portal or northbound opening.

5. PROPOSALS FOR FUTURE WORK

At present, the concept of end-to-end 5G network slicing and the standard of the basic architecture have been basically mature. Open source practice has also been carried out in ONAP. It also provides a reference for commercial deployment while verifying the standard. But in terms of the main challenges in the commercialization of the slicing business, further work on standards and open source is still needed.

- **Automation:** There are many steps in the current network slicing deployment and operation and maintenance that require manual intervention, and the degree of automation needs to be improved. In this regard, we can see that ONAP is already using a model-driven approach to attempt to automate the process of issuing and deploying slice services. Further work is needed to support the automation of the operation and maintenance process.
- **Cross-domain interworking:** As can be seen from Figure 2, the current slice identification and implementation technologies in the wireless, transmission, and core network domains are relatively mature, but in terms of cross-domain data plane interoperability, especially how to identify the connection between the transmission and wireless and core networks and how to map slices identifications in each domain and how to manage cross-domain connections still require standardized solutions. At present, CCSA and other organizations are already discussing related cross-domain interconnection schemes, and open source can further explore related practices.
- **SLA assurance:** SLA assurance includes the definition of SLA indicators, the decomposition of end-to-end indicators into indicators in each domain, indicator monitoring, and dynamic guarantee. At present, in addition to SLA indicators supported by some standards, other aspects need to be further improved. Open source plans to develop and enhance the network slice monitoring function in the ONAP Guilin release, which will help promote this aspect of practice.
    - In terms of definition of SLA indicators, it is necessary to clarify the performance, alarm indicators that can be supported by the wireless, transmission, and core network domains, and to associate them with end-to-end slicing. GSMA and 3GPP plan to further refine vertical industry requirements and introduce them into slice information models.
    - In terms of SLA indicator decomposition, 3GPP, CCSA and others plan to discuss to give specific solutions on how each domain supports end-to-end SLA.
    - In terms of SLA monitoring and protection, the current network element-based indicator collection, aggregation, and reporting mechanism has been relatively complete. It has also been verified in ONAP. It can be enhanced on the basis of the current solution, expanding the functions of DCAE micro-services, and increasing required monitoring indicators or calculation methods, and co-operate with modules such as Policy and Controller to realize the real-time guarantee function of slice SLA.

- In order to collectively address the above challenges, closer collaboration between SDOs and open source communities is expected.
- On the one hand, open source focuses on improving the maturity and stability of core modules, as well as aligning standards using model artifacts.
- On the other hand, the SDOs are encouraged to build synergy on the basis of a model-driven platform:
    - for organizations related to specific fields, such as 3GPP RAN, SA2, it is recommended to continue to focus on the design of specific business function modules and interaction process design;
    - for standard organizations that are positioned as end-to-end pull-through general orchestration management platforms, such as ETSI ZSM, MEF LSO, etc. it is recommended to design the functional architecture and interface specifications in accordance with the model-driven approach of open source implementation.

6. LIST OF ACRONYMS

Abbr.	Description	Abbr.	Description
A&AI	Active and Available Inventory	NSSI	Network Slice Subnet Instance
AN	Access Network	NSSMF	Network Slice Subnet Management Function
BSS	Business Support System	NSST	Network Slice Subnet Template
CCSA	China Communication Standards Association	NST	Network Slice Template
CE	Customer Edge	ONAP	Open Networking Automation Platform
CEN	Carrier Ethernet Network	OMC	Operation and Maintenance Center
CN	Core Network	ONSEU	Open Networking Summit Europe
CoS	Class of Service	OOF	ONAP Optimization Framework
CSI	Communication Service Instance	OSS	Operation Support Systems
CSMF	Communication Service Management Function	O&M	Operation and Maintenance
CST	Communication Service Template	PCF	Policy Control Function
CU	centralized unit	PCP	Priority Code Point
DCAE	Data Collection, Analytics and Events	PE	Provider Edge
DU	distributed unit	RAN	Radio Access Network
EMS	Element Management System	SD	Service Descriptor
E2E	end to end	SDC	Service Design and Creation
ETSI	European Telecommunications Standards Institute	SDN	Software Defined Network
EVC	Ethernet Virtual Connection	SDO	Standards Developing Organization
gNB	next generation Node B	SLA	Service Level Agreement
GSMA	Groupe Spécial Mobile Association	SMF	Session Management Function
GST	Generic Network Slice Template	SO	Service Orchestrator
ID	Identifier	SR	Segment Routing
IETF	The Internet Engineering Task Force	TMF	TM Forum
KPI	Key Performance Indicator	TN	Transport Network
LSO	Lifecycle Service Orchestration	TS	Technical Specification
L3VPN	Layer 3 Virtual Private Network	UDM	Unified Data Management
MANO	Management And Orchestration	UE	User Equipment
MEF	Metro Ethernet Forum	UPF	User Plane Function
NEST	Network Slicing Taskforce	U-UI	Use case User Interface
NGMN	Next Generation Mobile Networks	VID	VLAN identifier
NSI	Network Slice Instance	ZSM	Zero touch network & Service Management
NSMF	Network Slice Management Function	3GPP	The 3rd Generation Partnership Project