

# SliceNet Control Plane for 5G Network Slicing in Evolving Future Networks

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**Abstract**— Future networks including the Fifth Generation (5G) and beyond mobile networks shall manage, control and orchestrate the new services for users especially vertical sectors, thereby they shall maximize the potential of 5G infrastructures and their services. Network slicing has emerged as a major new networking paradigm for meeting the diverse requirements of various vertical businesses in virtualized and softwarised 5G networks. SliceNet is a project of the EU 5G Infrastructure Public Private Partnership (5G PPP) and focuses on network slicing as a cornerstone technology in 5G networks. This article describes how the SliceNet Control Plane shall evolve to meet the end-to-end needs of many different vertical businesses. SliceNet Control Plane shall span across multiple administrative domains, by integrating different technologies in each involved segments (RAN, MEC, CN, inter-connectivity). Moreover, SliceNet Control Plane is able to allow verticals to plug their own control logic on top of provisioned slices and specialize their services characteristics while optimizing the use of shared resources, providing dynamic configuration, dynamic management, resource isolation and scalability.

**Index Terms**— network slicing; slice management; cognitive network management; verticals; control plane; softwarization; virtualization.

## I. INTRODUCTION

The Fifth Generation (5G) and beyond mobile networks are expected to meet the diverse service quality requirements from different use cases of various vertical businesses. Typical use cases of different classes of Quality of Service (QoS) requirements can include enhanced Mobile Broadband (eMBB), Ultra-Reliable and Low-Latency Communications (uRLLC), and massive Machine Type Communications (mMTC), as defined by ITU [1]. Towards achieving a cost-efficient solution for supporting the different classes of use cases in the same physical infrastructure, network slicing has emerged as a most promising game changer in the remarkable paradigm shift from the Fourth Generation (4G) to the 5G era, being a crucial enabler for provisioning flexible and tailored services in software-networking based 5G networks. Network Function Virtualization (NFV) and Software-Defined Networking (SDN) are two key enabling technologies and principles for softwarisation in 5G networks, especially 5G network slicing.

Despite the importance of network slicing in 5G networks

and beyond, there is no standardized solution yet for achieving end-to-end (E2E) network slicing, especially across multiple administrative domains. Moreover, QoS support for truly QoS-aware network slicing is still largely missing in existing work, and Quality of Experience (QoE) support for slice-based services has not been considered sufficiently either. In addition, the evolving nature of mobile networks calls for a novel network slicing framework that is compatible with both existing and emerging networks including 4G, 5G and beyond networks.

In light of the above gaps and challenges, SliceNet, a project of the EU 5G Infrastructure Public Private Partnership (5G PPP), has recently defined an innovative architecture for network slicing of 5G and beyond networks. One of the main project objectives is to achieve multi-domain E2E network slicing with controllable QoS/QoE optimization capabilities. This paper focuses on the SliceNet Control Plane (CP) framework as a fundamental enabler of the SliceNet architecture. This novel SliceNet CP framework has advantageous architectural features and components to enable a set of essential or value-added capabilities for network slicing control including Plug and Play (P&P) control for vertical users, QoS support, QoE optimization, SDN-style network segment controllers, adapters and so on, and ensures high extensibility, compatibility, adaptability, and scalability to meet the requirements of evolving future networks in network slicing.

The reminder of the paper is structured as follows. Section II describes the SliceNet CP requirements to achieve the desired characteristics for the future sliced 5G network. Section III presents the SliceNet CP architecture addressing how the architecture can fulfill the identified requirements. Subsections III.A, B and C provide an insight on the SliceNet CP main architectural principles, namely, P&P Control, Slice QoE optimization and Network Segment Controllers. Section IV reviews the project's technical approaches to achieve advances beyond the state of the art. The paper is concluded in Section V, which also provides a perspective of ongoing and future work for SliceNet CP.

## II. FUTURE (5G) NETWORKS REQUIREMENTS

One of the main challenges with 5G network requirements is that there are many different vertical businesses, each one requiring their own E2E needs to be met by future/5G networks, e.g., video streaming sector requires very high data rates with low latency while Internet of Things (IoT) sector requires low data rate and long battery life times, etc... These conflicting functional requirements lead to the fact that not all of them can be satisfied by one technology/domain and thus anticipate the future system to enable a number of different technologies to operate together, each meeting a set of needs. Coordination across multiple domains is required to render an E2E slice to the verticals, with guaranteed ubiquitous experience for end-users. In this respect, the future system is anticipated to provide a set of capabilities that can offer tailored and optimized services with guaranteed measures for different vertical businesses. Also, as the number of service types grows, the system should be able to support scalability and, possibly, automation at scale to ease the complexity and operability for the operators. Therefore, 5G networks have to be designed to support the traditional operator model, but at the same time be flexible and scalable to support a shared infrastructure model and a CP on top of existing CP to support abstractions that need to be exposed to upper layers.

In 5G network slicing, a service model might involve the participation of multiple domains, in which two or more Network Service Providers (NSPs) or Service Providers (SPs) are associated in the delivery of E2E slices to meet different vertical sectors. To this end, SliceNet CP has been designed to operate on top of an infrastructure spanning across multiple administrative domains, integrating different technologies in each involved segment (Radio Access Network (RAN), Mobile Edge Computing (MEC), Core Network (CN) and Wide Area Network (WAN) for inter-connectivity between domains). Also, softwarisation and virtualization with resource isolation overlay on top of shared physical resources is the key to create many different logic networks (network slices), each with a set of different network characteristics, designed for different vertical sectors. In this respect, SliceNet CP must be able to support optimization in the use of shared resources with guaranteed measures for all verticals. As SliceNet also aims to provide a truly customized environment for offering vertical runtime control and operation of their E2E slice instances, dynamic configuration and dynamic management are required in SliceNet CP to offer vertical-tailored services and enable a high degree of slice customization, allowing verticals to plug their own control logics on top of provisioned slices and specialize their services.

The adoption of technologies such as NFV and SDN are driving the wider utilization of practices such as control and data plane separation as well as workflow and process automation. Consequently, future network architectures

necessitate the introduction of novel practices able to support forward compatibility with respect to easier and faster integration of new features and functionalities. In this respect, the required agility depends among others on the ability of the infrastructures to support the dynamic inclusion of functional elements that are made available after the initial platform setup. This seamless integration scheme requires that high level control and management procedures remain agnostic of the particular technology implementations available in each domain of the managed infrastructure and the related workflows are defined on the basis of abstract, mission specific intents that are enforced in a common way towards each domain, leaving the fine-grained processing and actual enforcement to be adapted and utilized accordingly by the currently active functional resources. E2E network slicing is one of the key capabilities of SliceNet as it enables multiple logical networks to be created on top of a common physical infrastructure.

### III. SLICENET CONTROL PLANE ARCHITECTURE

In this section, the overall SliceNet CP is presented first with the design principles, building blocks and architecture introduced, and subsequently selected key components are described in more details.

#### High-level control plane architecture

Aiming at adequately and effectively coping with the challenges posed by slicing practices tailored to the diversity of vertical needs such as resilience, security, service continuity as well as fast provisioning, SliceNet CP is based on the realization of a Service Based Architecture (SBA) that is quite aligned with the concepts being exercised by Next Generation Mobile Networks (NGMN) and 3rd Generation Partnership Project (3GPP). With continuous evolution as a driving aspect, the SBA allows for dynamic expansion of the managed architecture since pillar adaptors can be onboarded and registered to automate utilization of newly added pillar implementations. Equally, SBA allows several instances of the same implementation to be deployed in different slices as dictated by management practices. The inclusion of new function or resource instances via SBA registration and discovery scheme is enabling scalability both in terms of the number of resources allocated but also in terms of topology rearrangements aiming at effectiveness and optimisation.

SliceNet CP is challenged by the diversity of technologies that can be potentially utilized for the provision of E2E slicing. This diversity is occurring along two main axes. On the one hand, it is the roadmap with respect to the development of the emerging and future mobile networks specifications and implementation availability, i.e. evolution of 5G systems, enhancements of 4G systems, coexistence of new and old RAN and CN. On the other hand, it is the availability of the enabling technologies that are utilized for

building the network infrastructures. In order to efficiently cope with these challenges, SliceNet has designed a CP architecture around the following principles:

- Infrastructures can span across different Points of Presence (PoPs).
- Infrastructure segments based on their roles in the overall operation are identified as pillars providing RAN, MEC, Backhaul, CN and WAN functions.
- Each pillar functions may be implemented by different technologies (or vendors).
- All implementations for a pillar are providing functionalities from a common set with a minimum subset being mandatory to allow basic integration.
- The same pillar may consist of several instances of the same or different implementations in parallel.

Each implementation requires an adapter that at its southbound interface (SBI) supports the interaction with specific technology/implementation details whereas provides a northbound interface (NBI) according to the model of the common set of functionalities.

The set of adapters provides the first level of abstraction over the pillar functionalities. The functionalities exposed by the different pillars are integrated and exploited in the context of SliceNet CP Services exposing technology agnostic Slice APIs as shown in Figure 1.

1) *CPSR*: The Control Plane Service Register (CPSR) is the software component which allows other CP services to register themselves as a service instance in the SBA framework as well as providing authorization and discovery services capabilities. Other service consumers such as Plug&Play or any other authorized SliceNet component can use any specific CP Service by querying to the CPRS for its reachability.

2) *NF Config*: The NF Config is in charge of the dynamic configuration of the slice Network Functions playing thus, a key role in the initial and run time configuration of the slices.

3) *QoS Control*: The QoS Control is responsible of deploying Quality of Service constraints to the different network segments depending on the input parameters gathered from the exposed interfaces.

4) *IPC Control*: The InterPoP Connections (IPC) is the responsible, for each slice instance, to deliver a proper inter-connection of the slice Network Functions (i.e mostly VNF and MEC applications) deployed in different segments and domains, namely edge (e.g MEC) and Core ones.

The arrangement of functionalities into blocks formulates a Slice Technology/Implementation Agnostic Application Programmable Interface (API) which is the set of SliceNet configuration endpoints.

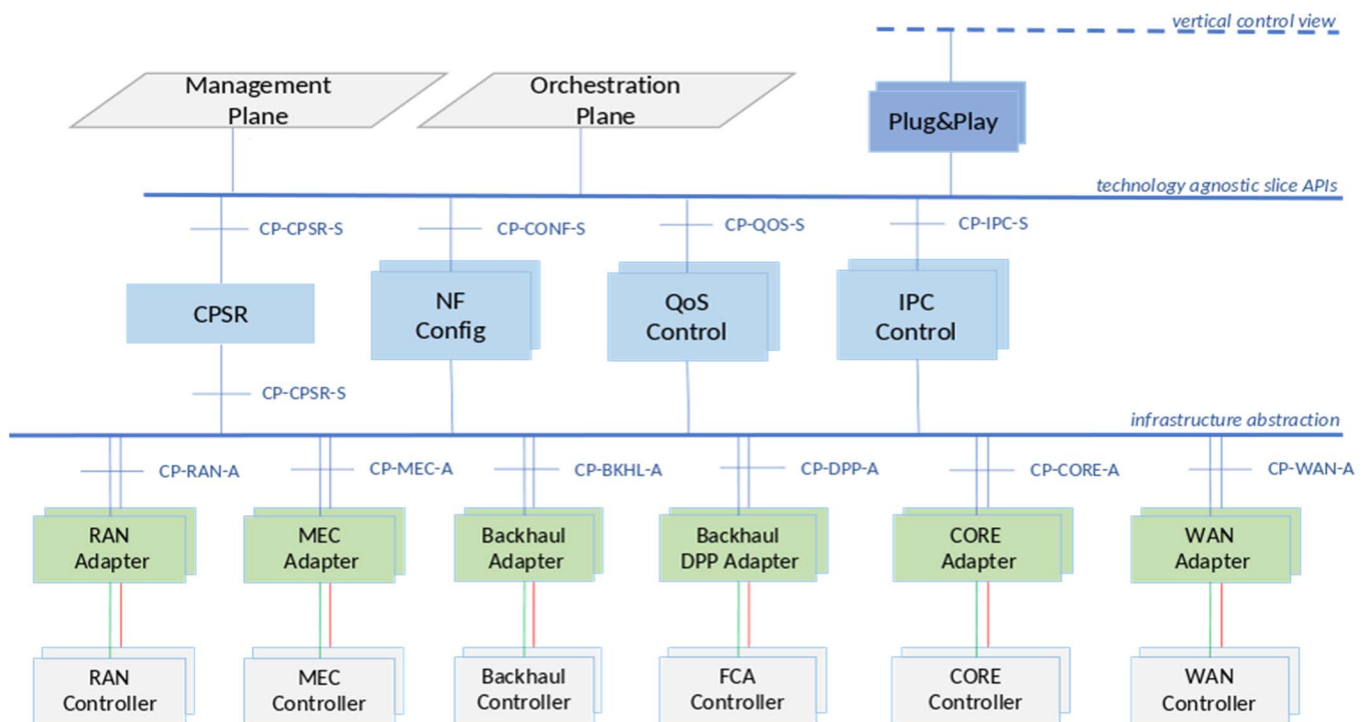


Figure 1 SliceNet Control Plane Architecture

Each CP Service offers a different and specific configuration as well as different control capabilities.

This API provides the control context of a slice.

Finally, the SliceNet CP API abstractions and the SBA approach are enablers with respect to slice isolation, as realized via the control and data plane virtualized functions, due to the fact that they allow high level management decisions to be uniformly enforced over a heterogeneous set of function implementations and the dynamic life cycle of their instances.

In the following subsections, selected key architectural components are elaborated in more details.

### A. Plug & Play Control

With 5G, verticals will require more and more tailored and specialized services, therefore providing them truly customized runtime control, management and operation of E2E slice instances will be key. In this context, the P&P control is one of the key enablers of slice customization, as it aims to offer a novel combination of tailored control functions, APIs and tools to enable to specialize their slice instances according to their unique needs and allow them to even plug their own control logics when required. The ultimate goal is to provide an innovative control environment, dedicated per slice, which offers to the verticals, and in general to slice consumers, significantly enhanced degree of flexibility for deploying services to the end users.

The P&P control functions are conceived to be activated for the runtime operation of slice instances, as a way to expose per-slice instance dedicated and vertical customized control features and capabilities. The P&P control, at least in its concept, has to be considered as agnostic of the specific provider-to-consumer interaction. This way it can be applied to any “slice provider-to-vertical” or “slice provider-to-slice provider” case in support of either single-domain or multi-domain E2E slices. This way, P&P control functions can be exposed to verticals for their customized slices operation, and to other customers in general (like other slice providers) in the context of E2E slices spanning across multiple administrative domains.

The P&P control logically lays on top of the heterogeneous infrastructure composed by the integration of 5G RAN, MEC and CN network segments, including where applicable the vertical enterprise segments, providing those per-slice customization functions needed to accommodate vertical’s requirements. The main goal of the P&P control is therefore to offer verticals with an isolated control environment, specific per slice instance that can be activated on-demand when new E2E slice instances are provisioned. The idea is that each P&P control instance can have access to a limited set of slice control and management primitives, strictly depending on the P&P requirements specified by the vertical and included in the slice templates and descriptors, offering a specific vertical-tailored level of slice control exposure. Moreover, to guarantee isolation, each P&P instance has controlled access

(either direct or indirect) to those physical and virtual network functions (e.g. for configuration purposes) owned and used by the given slice instance for which it is activated, as a way to restrict and limit the allowed operations exposed to verticals.

Following the CP principles defined above, the P&P implements the second level of abstraction oriented to expose to the verticals a simplified view of E2E slice instances. On the one hand it can be aligned and compliant with each vertical logic and needs, and on the other it hides and further abstracts the slice technology agnostic APIs according to the agreements with the slice provider in terms of control exposure. Moreover, the P&P follows the described SBA approach, and therefore each P&P control instance can be considered as a dedicated per-slice CP service exploiting the slice technology agnostic APIs. It provides specialized per-slice control exposure capabilities, which are loosely coupled to other CP services (i.e. either other P&P control instances dedicated to other slices or other control plane services) and deployed on-demand through independent management workflows.

Each P&P instance is an independent logical run-time component which has access to multiple control and management logics and APIs by means of dedicated drivers and plugins, each with specific hooks to monitoring, runtime control and orchestration platform primitives. The restriction and selection of the tailored subset of these primitives is performed by P&P management features during the activation phase. Dedicated P&P management functions in the management plane are responsible for each P&P control instance lifecycle management (activation, plug of specific tailored drivers, configuration of proper abstraction features, deactivation).

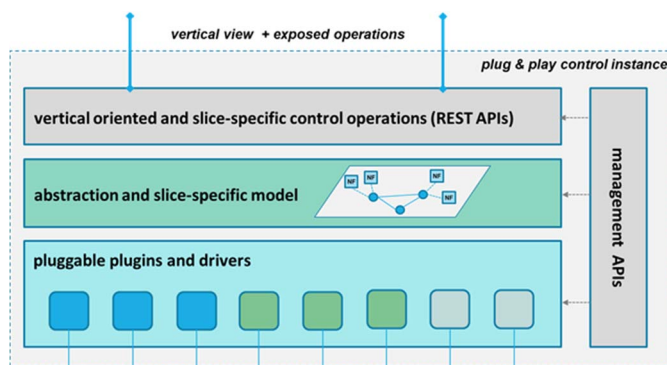


Figure 2 P&P control instance high-level decomposition

Figure 2 presents the functional decomposition of a P&P control instance, which follows a layered approach built by three main high-level components and targeting an high degree of flexibility and customization in creating customized views of slice instances for the verticals. In particular, the P&P is built around a generic, common and technology agnostic slice information model to be specialized in the

context of each E2E slice (thus for each P&P instance) according to vertical needs and control exposure level. This generic slice model has to be considered as a kind of topology-like abstract view of a slice. Its specialization provides the customized view of the slice instance for a given vertical, based on the provisioning of a specific slice-context to each element in the slice view, together with allowed control operations for each of them. In particular, the technology independent information model proposed in an IETF Common Operations and Management on network Slices Internet-Draft (COMS I-D) [2] is considered as reference to model properties, attributes and operations on each slice entity. The three main components of the P&P control instance can be briefly described as follows:

- *Pluggable plugins and drivers*: it includes the set of plugins and drivers that provide the required adaptation between the P&P generic slice model and the monitoring, control plane and orchestration framework primitives. These are pluggable modules providing access to specific control and management logics, and P&P driver exposes its capabilities to the abstraction layer to enable its dynamic pluggability and usage by the P&P logics.
- *Abstraction and slice-specific model*: it provides the specialization of the generic slice information model into the customized vertical view of a given E2E slice instance. The slice-specific model produced implements an abstracted and vertical friendly view enabling the second level of abstraction.
- *Vertical oriented APIs*: they implement the set of control and management APIs that are exposed to the vertical, offering tailored control operations over the slice-specific model and view, following the slice control exposure level agreed by slice consumer and slice provider and described as part of the slice template or descriptor.

## B. Slice Quality of Experience Optimization

QoE guarantees when provisioning services is one of the focal aspects of future 5G networks. To properly address such requirement, a key feature of SliceNet CP is the QoE/QoS-driven slice provisioning tailored to the specific needs of the slice customers and applications/services running on top. The Slice QoE Optimizer module is the responsible of such task. The scope of such module is to maintain the required slice QoE levels over the time and under dynamic conditions, triggering necessary (re-)configuration actions at the infrastructure level, both virtual and physical.

In this regard, the Slice QoE Optimizer provides a per-slice optimization framework in which performance metrics at multiple layers are collected to derive QoS metrics of the slice. Then, such metrics are employed to determine current QoE levels. A decision-making engine analyses if the monitored levels are satisfactory or not and, if needed, the most optimal

actions to be taken to re-establish desired quality levels. Actions are carried out through an actuation system which interacts with core CP functionalities through the Technology Agnostic APIs layer to request actions at specific infrastructure segments onto which the slice is realized or the modification/re-configuration of PNF and/or VNF instances. These specific actions to re-configure the underlying infrastructure level (physical and/or virtual) are enforced by core CP functionalities through the specific segment controllers.

From a design perspective, the Slice QoE Optimizer is based on two main principles. First, Machine Learning (ML) techniques are employed for QoE analysis and derivation. Particularly, ML models specially adapted to the type of services that current instance is materializing (e.g. uRLLC, mMTC) are employed to learn the relationship between monitored QoS metrics and QoE ones. These ML models are constructed thanks to the analysis of past experience and data. Then, during slice runtime, the slice model is employed to determine QoE levels from the monitored information. The executed model may be adapted given current insights to reflect in the most reliable way how QoE is determined.

Second, actuation to optimise QoE leverages on a policy-based system for resource configuration. Policies that dictate resource configuration for both system-wide and slice-specific items are generated and then distributed across policy decision points (PDP) and policy execution points (PEP), being the Slice QoE Optimizer a PDP and PEP at the same time. Once QoE metrics are determined and given monitored QoS metrics at the different segments composing the slice, the Slice QoE Optimizer analyses current active policies and determines which ones should be applied. The selected policies will mandate the imperative actions to be carried out, which will be executed through the actuation system abovementioned.

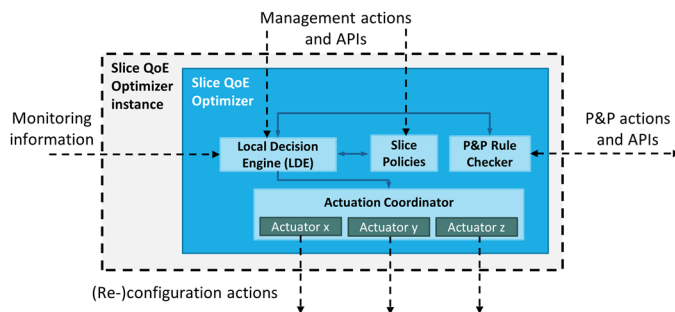


Figure 3 Slice QoE Optimizer instance high-level decomposition

Given these design principles, Figure 3 exemplifies the structure of a Slice QoE Optimizer instance, providing a high-level functional decomposition. As said before, QoE optimization is conceived in the form of a per-slice optimization framework, meaning that, for each provisioned

slice, an instance of the Slice QoE Optimizer is also being provisioned to deal with the QoE maintenance/optimization within the slice. Functionally, all Slice QoE Optimizer instances have the same internal modules/functions, however, they are particularized for the slice they are responsible of. The core of a Slice QoE Optimizer is the Local Decision Engine (LDE), which is the responsible to receive external monitoring information with the actual QoE. This derivation is made thanks to already trained ML models. The LDE also is the responsible to decide when a (re-)configuration of resources/functions is needed to meet desired quality levels.

Once such decision is taken (based on the monitored information), possible actions are analyzed from the Slice Policies module, which acts as a PDP from upper layers, such as management. It essentially contains a list of available actuations, which take the form of complex sets of atomic actions at slice or segment level to be carried when specific events happen, such as an increase of packet loss or latency, which may affect the QoE. Thus, the LDE also acts as a PEP, fetching the available actions and selecting the one that must be carried out. Both the LDE and Slice Policies may be updated (e.g. QoE model, actuations list) through a set of management actions and APIs. In the last step of the process, the Actuator Coordinator is the responsible to instantiate/call the different actuators provided the decisions taken at the LDE. The different actuators are conceived as standalone micro-services which encapsulate the list of actions and their parameters to be carried out through core SliceNet CP functionalities to trigger the desired (re-)configurations.

Finally, a Slice QoE Optimizer instance also provides the capability to expose its functionalities for exploitation by the vertical user through the P&P instance of the slice, following the plugin approach explained in previous section. The P&P Rule Checker is employed to constrain the actions of the vertical towards slice QoE optimization procedures, in order to limit the impact on the resource configuration and the overall system.

### C. Network Segment Controllers

An SDN controller is envisioned to decouple processing between the CP and the user plane as well as to control the underlying network in a centralized manner. There are several open source implementations for that purpose such as OpenDayLight (ODL) and ONOS, which are designed for networks of any size and for any network segments.

However, unlike other segments, the RAN segment control must comply with hard real-time requirements. For instance, the real-time scheduler in Long-Term Evolution (LTE) networks has to respect the 8ms Hybrid Automatic Repeat Request (HARQ) round trip time constraint, which is expected to be more stringent for uRLLC in the 5G era due to a much shorter transmission time interval.

In order to enable the SDN concept in the RAN segment for the software-defined RAN (SD-RAN) vision in SliceNet, we can apply a hierarchical scheme according to which control functionalities can be distinguished between centralized and distributed ones based on time-criticality and a requirement (or not) for a centralized approach. To this end, FlexRAN [3] realizes an SD-RAN platform and implements a customized RAN south-bound API through which programmable control logics can be enforced with different levels of centralization, either by the controller or local RAN agent, as depicted in Figure 4.

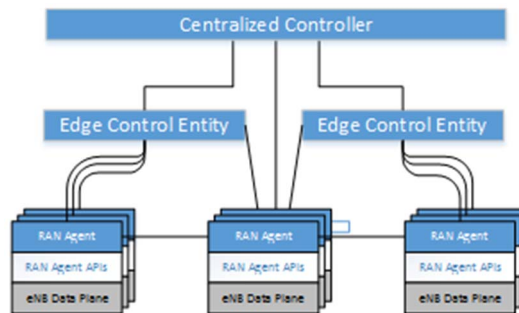


Figure 4 Disaggregated controller design for the RAN segment

Figure 4 portrays three main components: (i) a centralized controller entity; (ii) an edge entity, and (iii) a local RAN agent. The local RAN agent is essentially a local controller with a limited view of the RAN segment that it is delegated with a control authority by an edge control entity. The latter entity is responsible for a small network area (i.e., an edge), being in charge of time-critical and/or small time-scale operations in the order of milliseconds. Sitting on top of every edge entity, lies a centralized coordination and control unit (i.e., the centralized controller component of Figure 4) that is responsible for a larger network area, taking soft real-time decisions on a larger time-scale, e.g. in the order of some hundreds of milliseconds. In addition, we note that FlexRAN has evolved to support multiple agents among each disaggregated RAN entity, so as to be controlled by a centralized controller, following an evolution trend according to which the RAN segment has departed away from being a monolithic infrastructure (e.g., eNB of LTE) and moved towards incorporating disaggregated entities (e.g., gNB-CU, gNB-DU, RU of 5G) [4]. In a nutshell, such a RAN segment controller can enable the deployment of versatile control applications, as introduced in Section III-B, to enable the (soft/hard) real-time or non-real-time control for QoE purpose stated in Section III-C.

Finally, unlike the case of RAN segment controller in 5G, the CN and the MEC segment controllers can follow the common SDN centralized controller design principle and still benefit from the real-time RAN information to adjust its

control logic. For instance, a radio-aware video content optimization control application deployed at the MEC segment can rely on the real-time per-user Channel Quality Indicator (CQI) to adjust the video quality to maintain the QoE. Optionally, there can be an overall controller entity sitting on the top of a controller hierarchy that coordinates all segment controllers, including the disaggregated/hierarchical controller for the RAN segment and the CN segment with the purpose to provide E2E controller functionalities, i.e., E2E network slicing.

#### IV. COMPARISON WITH RELATED WORK

The proposed SliceNet CP provides a set of advanced control functionalities for network slicing and offers an architecturally innovative approach by introducing a novel adaptive overlay layer, beyond the state of the art as explained in the following aspects.

Firstly, the SliceNet approach leverages the benefits of decoupling the CP from the data plane, following the generic SDN principle especially in the Network Segment Controllers. Numerous works related to SDN are existing especially in the area of SDN controllers such as ODL [5], ONOS [6], and Ryu [7]. However, none of them is specifically designed for the purpose of network slicing control over 5G networks. Meanwhile, the Open Networking Foundation (ONF) proposes an SDN-based slice abstraction model [8], where an SDN Client Context is considered equivalent to a network slice, comprising a set of resources managed/controlled by an SDN controller. More specific definition of this model, especially on top of the 5G control plane, is yet to be proposed though.

Secondly, the proposed SliceNet CP comprises a set of networks slicing specific components that have not been incorporated in other related 5G projects. In particular, the QoE Optimizer and the P&P Control modules are novel and advanced CP elements. For example, the SESAME project [9] features a Service Level Agreement (SLA) Monitoring component yet lacks the QoE optimization control loop as in SliceNet. The SELFNET [10] and CogNet [11] projects emphasize autonomic/cognitive network management with cognition loops although they do not target to deal with cognitive QoE optimization for network slicing. In addition, the 5GNORMA project [12] focuses on intra- and inter-slice control, the 5GEx project [13] considers multi-domain network slicing, whilst traffic steering and resource allocation techniques for network slicing are highlighted in the COHERENT project [14]. Nevertheless, none of these projects have integrated P&P control or QoE optimization.

Thirdly, the proposed overlay layering approach is decoupled from and thus fully compliant with the 5G standard control and data planes. This assures higher interoperability and wider applicability of the proposed architecture, in contrast to more radical approaches that replace the existing

5G control plane with brand new ones. For instance, a new 5G CP was proposed in [15], which assumes an all-SDN network architecture.

Finally, it is noted that the proposed SliceNet CP operates over the existing CP of 5G networks. This is in contrast to an alternative approach that adds new components and interfaces to the 5G CP directly or modifies existing standard 5G/4G CP components or procedures directly such as the proposals in [16], [17] and [18], respectively. The SliceNet architectural design enables the control framework to extend the functionalities of 5G CP to achieve network slicing without compromising the modularity and standard compliance of the existing 5G CP. Moreover, with the introduction of adapters between the SliceNet CP and the underlying system, the SliceNet framework enables the mobile networking technology agnostic capability in terms of supporting the CP of 5G and that of 4G and potentially additional variants, thereby achieving backward compatibility.

To sum up, the SliceNet CP advances the state of the art in enabling adaptive, advanced, standard-compliant and interoperable network slicing architecture.

#### V. CONCLUSION

The network slicing paradigm in 5G and beyond networks is expected to meet the diverging QoS/QoE requirements imposed by a range of verticals' use cases. The SliceNet Control Plane proposed in this paper introduces a novel overlay control framework for 5G and beyond network slicing. The proposed framework is built on a Service-Based Architecture, which allows high extensibility and scalability. The overlay approach together with a set of adapters enables its high adaptability and inclusiveness/compatibility regarding existing and emerging networks in line with the evolving nature of future networks. A set of control plane components are proposed to achieve essential or value-added functionalities for advanced QoS/Overoptimized network slicing with plug & play control capabilities exposed to the vertical users, QoE optimization capabilities for slice-based services, and controllers based on the SDN principle to realize the slicing in different network segments along the end-to-end path, among others.

Ongoing research and development work are currently focusing on prototyping the proposed control plane components and the framework. Future work will then integrate this control plane with the SliceNet infrastructure including a programmable data plane to demonstrate the QoS/QoE-optimized network slicing. Moreover, the multi-domain network slicing scenario is being prototyped.

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