Cognitive, Multi-Domain Network Slicing: The SliceNet Framework

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***Abstract*— Cognitive, multi-domain network slicing can truly fulfil the diverging requirements of vertical businesses with Quality of Experience (QoE) awareness, as well as improve the quality of operation for network operators and service providers in 5G and beyond networks. This poster presents the latest vision of the ongoing EU 5G PPP SliceNet project in addressing this ambitious goal. The updated SliceNet framework architecture is introduced, and a case study is presented to illustrate some of the key technical approaches.**

Keywords—5G; network slicing; multi-domain; cognitive network management; QoE; verticals

I. SliceNet Framework Architecture

SliceNet addresses a number of highly challenging open issues in network slicing such as integrated FCAPS (Fault, Configuration, Accounting, Performance and Security) management, Quality of Experience (QoE) optimisation, customisable control, cross-plane orchestration, and interoperability across multiple administrative domains to achieve end-to-end (E2E) slice-based service delivery over 4G, 5G and beyond networks.

Fig. 1 shows the updated SliceNet architecture. It is highlighted that SliceNet supports the differentiation of various business roles in 5G architecturally, in line with the vision of 3GPP [1]. Specifically, SliceNet focuses on enabling the role of Digital Service Provider (DSP) to deal with E2E multi-domain network slicing and services, on top of multiple domains administered by corresponding Network Service Providers (NSPs). In each DSP and NSP domain, two major planes, Management plane and Control plane, are concerned. The management plane consists of four sub-planes: Monitoring, Cognition, Information, and Orchestration. These Management sub-planes and the Control plane, when interworking with each other, provide a cognitive autonomous control loop, analogous to the conventional MAPE-K (Monitor-Analyze-Plan-Execute with shared Knowledge) loop, in each DSP or NSP domain respectively. The cognitive autonomous control loop in a DSP domain handles cognitive management and control for E2E multi-domain network slices and services and is primarily concerned with the vertical's QoE and SLA (Service Level Agreement), whilst that in an NSP domain deals with cognitive operation and QoS control for intra-domain network slices (NS) or network sub-slices (NSS). An NSS is created over a network segment such as RAN (Radio Access Network), MEC (Multi-access Edge Computing), Backhaul, Core Network etc. SliceNet is compatible with virtualised 4G/LTE (Long-Term Evolution) and 5G networks, which are considered sliceable thanks to the SliceNet overlay Control plane on top of 4G/5G data plane and control plane. This further facilitates multi-domain network slicing over not only the emerging 5G networks but also existing virtualised 4G networks for extended service coverage. Finally, a One-Stop API (Application Programming Interface) layer exposes the system to verticals.

II. Cognitive, Multi-Domain Network Slice Management: A Case Study

To further explain the key technical approaches and workflows in cognitive, multi-domain network slicing and QoE optimisation and QoS control in network slice management, a case study is presented, as shown in Fig. 2.

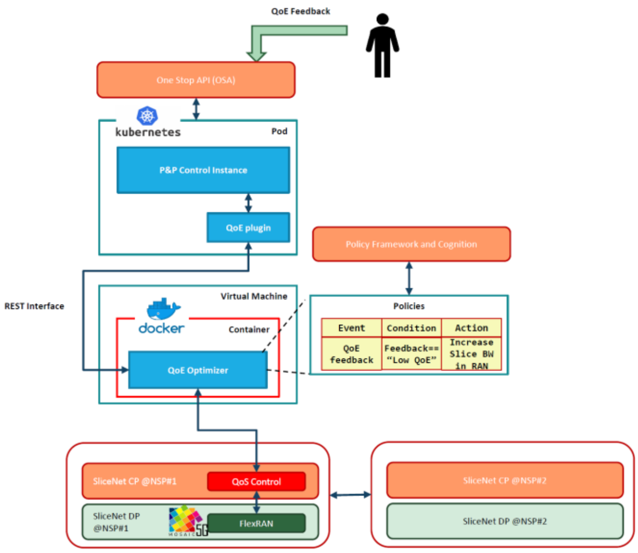

Fig.2 SliceNet case study

In this case, which can be contextualised in an eHealth use case for instance, an E2E multi-domain network slice is required between an ambulance and a hospital for emergency purposes with a wide coverage due to ambulance mobility. The multi-domain slicing can be achieved through the collaboration between two NSPs, via the SliceNet WAN (Wide-Area Network) adaptors in the Control planes.

Once the E2E network slice and eHealth service is up and running, the system allows the end user, who is the in-hospital specialist monitoring the patient's conditions via the live video stream, to provide feedback on his/her perceived QoE. Work is also underway to model the QoE with QoS metrics via cognition techniques such as machine learning so that automatic objective QoE feedback can be generated. This QoE feedback is enabled by the Plug & Play (P&P) Control module together with a QoE plugin, and both instances run in a Kubernetes pod, which is connected to the QoE Optimiser in a Docker container within a virtual machine (VM). The QoE Optimiser, based on a policy, which can be dynamically updated by the Policy Framework through cognition, enforces the action indicated in the policy, and calls for the QoS Control module in the Control plane to increase the bandwidth of the RAN NSS for instance to improve the QoE.

The actual action of modifying the slice's bandwidth in RAN is executed by the Mosaic5G FlexRAN component, which is the RAN Controller. Controllers for the other network segments have also been prototyped to allow such QoS control along the E2E data plane to optimise the QoE of slice-based services for verticals in various use cases.

III. Conclusion

SliceNet contributes to cognitive, QoE-informed management and control of multi-domain network slicing. The initial prototyping has proved the key concepts and validated the proposed technical approaches. Ongoing work is further developing the prototypes with more architectural components being integrated.

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References

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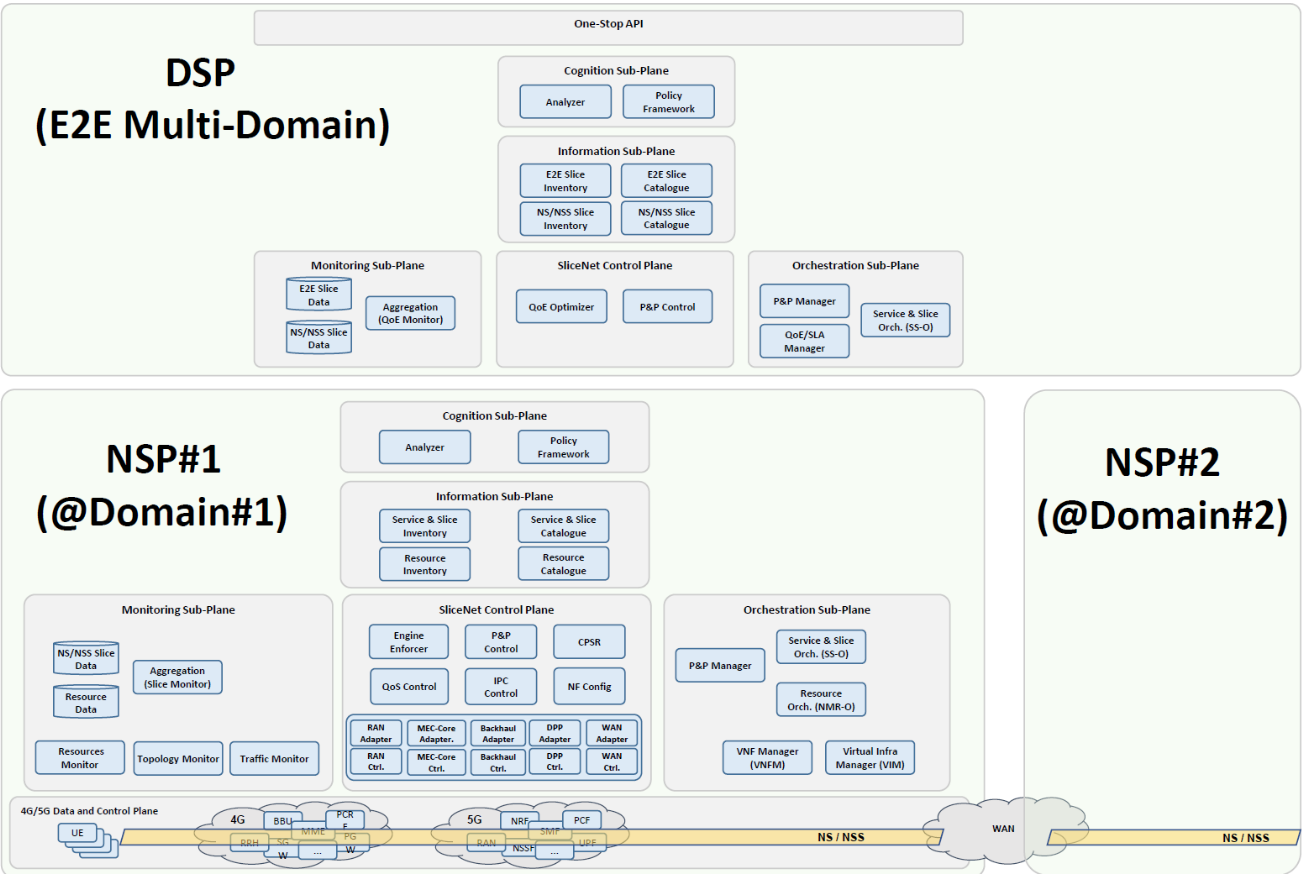

Fig. 1 SliceNet framework architecture