Case study on Software Defined Network (SDN)

Executive Summary

The next-generation 5G mobile network architecture will support the rapid deployment of new and dynamic network services that are capable of responding to current network conditions and demands. Software-defined Networking (SDN), virtualization technologies, and real-time analytics are the core components that will enable an adaptive and responsive 5G network.

We present a case study of a real-time communications (RTC) service that highlights the manner in which the core components allow a flexible 5G network. Because an end-to-end 5G network does not exist today, we construct one using artifacts from the current 4G/LTE network to host our dynamic network enabled RTC service.

Findings

We identify three main insights from executing our service that could prove beneficial to the 5G network evolution: need for efficient horizontal control, need to limit identifier proliferation, and the existence of control-plane network functions in service network-function graphs.

1. Horizontal SDN controller interactions are common: Today's network is separated into a number of domains both geographically and logically: the radio access network, the core network, and the application data center. We believe that geographic and administrative constraints will continue to dictate separate domains controlled by separate SDN controllers in the 5G network. When the SDN controller begins to handle routing and QoS, as in the 5G network, this cross-domain communication will only increase.

2. Identifier proliferation complicates service development: A second lesson we quickly learned was that identifier proliferation in the current 4G/LTE network dramatically complicates service deployment. SDN will help significantly because the centralization of network control means that all of these identifiers will be available in a single logical entity for easy mapping.

3. Network Function Graphs can contain control-plane elements: Network-function graphs — also known as forwarding chains, forwarding graphs, and service chains — define network services by indicating the interconnections between the different networks elements used to process network flows according to the requirements of the service.

Discussion

A conceptual layered architecture for 5G has been specified by the NGMN Alliance; the architecture makes use of SDN and NFV to virtualize functions and capabilities. Our expanded view of the NGMN Alliance architecture is illustrated in Figure 1.

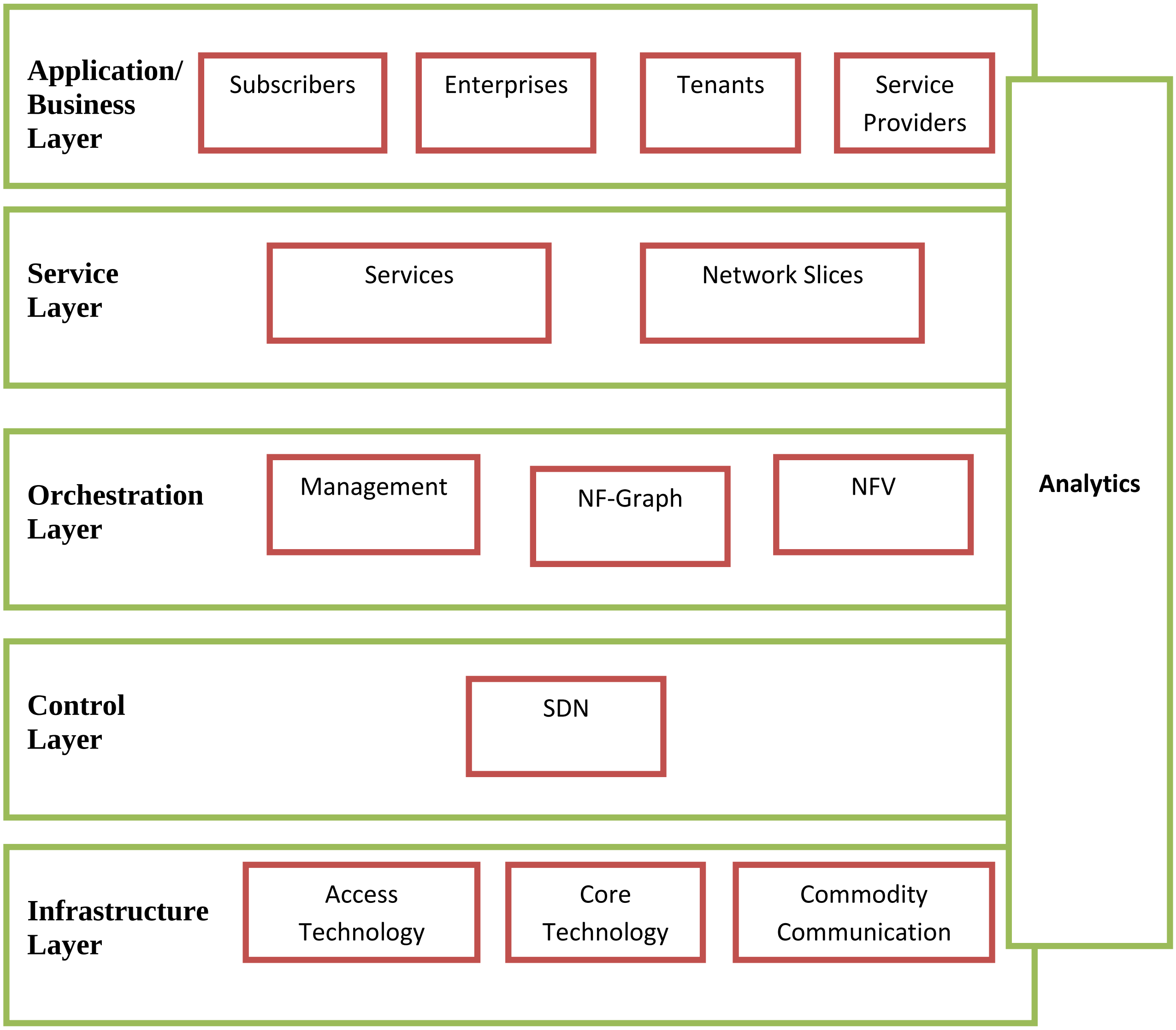

Figure 1: 5G Conceptual Architecture

In this view, the NGMN Business Enablement Layer is expanded into a Services Layer, an Orchestration Layer, and a Control Layer.

- Users and applications at the Business Layer request services. Services are mapped to network slices which are in turn mapped to graphs of virtualized network functions. These virtualized network functions are abstractions of the functions and capabilities provided by the infrastructure layer, orchestrated/managed by the Orchestration Layer, and controlled by the Control Layer.

- The Analytics Layer collects and processes data from the system at all layers to allow for improved performance and personalization.

Recommendation & Implementation

Dynamic network enabled RTC (DNE-RTC): DNE-RTC improves upon Network Enabled RTC (NE-RTC), an existing technology developed by Bell Laboratories. Some background in NE-RTC helps to understand DNE-RTC. NE-RTC is a network service that provides improved and consistent quality of service for webRTC or other real time video calls. NE-RTC addresses the disadvantages of OTT-RTC described in the previous section by leveraging an eNodeB technology called Adaptive Guaranteed Bit Rate (AGBR). Specifically, NE-RTC utilizes an advanced version of the eNodeB scheduling algorithm from AGBR to calculate the resources allocated to each NE-RTC user. This algorithm is designed to protect the throughput of other users in the cell while providing a more stable throughput for NE-RTC users. It accomplishes this by splitting the radio resources into pools for NE-RTC and normal users. These pools are sized in real time by the algorithm based on the number of NE-RTC users and their signal-to-interference-plus-noise ratios (SINRs) and the number of normal users in the cell and their bit rates. The existing implementation of NE-RTC requires the use of Guaranteed BitRate (GBR) bearers for the video flows (a bearer is an end-to-end association of a radio endpoint and the packet gateway). These GBR bearers enable the base station to protect the video streams from adverse fluctuations in wireless channel conditions and result in the video flows being prioritized over other traffic in the network, protecting them from any network congestion.

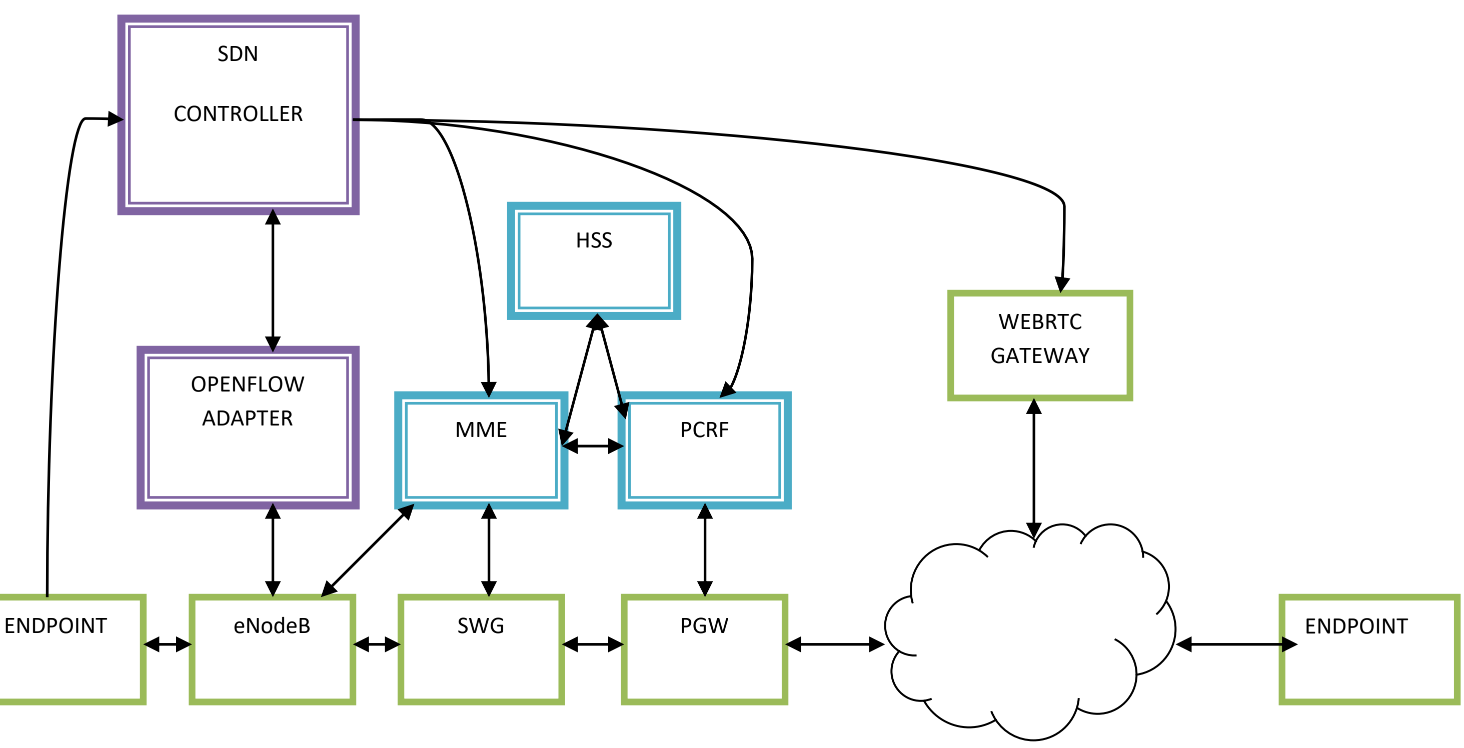

Figure 3: Concept of DNE-RTC

We refer to NE-RTCs traffic allocation scheme as the Target Bitrate Calculator Function (TBRCF) because it calculates the maximum throughput a flow should use in the cellular network. The TBRCF calculates a throughput called the Target BitRate (TBR), and for each flow the TBR is exported from the eNodeB to an external application running on the Janus webRTC gateway. This application combines the TBR with other data, like endpoint type or maximum bitrate, to establish an optimum bitrate that is ultimately used to set a bitrate cap on the video encoder via the appropriate RTCP messages. Each device receiving these RTCP messages adjusts its video codec related parameters, if necessary, to send the highest quality video possible without exceeding its available bandwidth.

Conclusion

The goal of the 5G network is not only to support even more 4G/LTE-like broadband services, but also enable next generation applications and use cases. End users want personalized service delivery with higher capacity and better QoS, network operators want to effortlessly transform their end- to-end infrastructure to meet current needs and offer novel value-added services, application and content providers seek insights into the end-to-end network's capabilities and real-time condition to adapt and provide better user experiences. All of this creates a large diversity of service needs and complexities and a need for personalization in the network. To overcome these obstacles, the next generation network must be flexible, elastic, and dynamically adaptive to individual needs.

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