Cloud-native SDN network management for beyond 5G networks with TeraFlow

Ricard Vilalta*, Raul Muñoz*, Ramon Casellas*, Ricardo Martínez*, Juan-Pedro Fernández-Palacios†, Georgios P. Katsikas‡, Thomas Zinner§, Harald Øverby§, Sergio Gonzalez-Diaz¶, Håkon Lønsethagen‖, José-Miguel Pulido**, Daniel King††, Nicola Carapellese‡‡

*Centre Tecnològic de Telecomunicacions de Catalunya (CTTC/CERCA), Castelldefels, Spain
†Telefónica I+D, Madrid, Spain
‡UBITECH, Athens, Greece
§Norwegian University of Science and Technology, Norway
¶Atos, Madrid, Spain
‖Telenor, Fornebu, Norway
**Volta Networks, Barcelona, Spain
††Old Dog Consulting, Llangollen, UK
‡‡SIAE Microelettronica, Milano, Italy

***Abstract*—TeraFlow proposes a novel secured transport Software Defined Networking (SDN) controller based on a micro-service architecture. The objective is to foster innovation around SDN controller and evolve them to be suitable for beyond 5G networks. This paper presents two TeraFlow scenarios that involve automated network management to demonstrate its feasibility. The first scenario focuses on the necessary transformation of a network operator to support beyond 5G technologies. From edge, up to the transport network, SDN controllers need to include more dinamicity to support operator requirements for new types of connectivity services. The second scenario demonstrates inter-domain connectivity services in an automotive scenario. In this scenario, novel techniques for domain inter-connection will be studied, as well as the load balancing of the connectivity service requests will be evaluated at cloud-scale.**

I. Introduction

The TeraFlow SDN Controller will support operator-driven use cases and workflows to fix integration issues in commercial networks. Moreover, TeraFlow provides an autonomous and secured cloud-native SDN controller that changes the way networks are controlled. The proposed micro-service architecture provides increased flexibility to cope with the high dynamic request loads for connectivity services.

This paper introduces two scenarios in which the TeraFlow SDN controller is demonstrated and analysed. The first scenario transforms an operator's network to support Beyond 5G (B5G) services [1]. The second scenario presents inter-domain connectivity services to support vehicular communications [2].

II. Proposed TeraFlow Beyond 5G networks scenario

The advent of 5G networks brings the opportunity to deploy new services in the network. Each service and/or network slice may require specific resources from the network. When moving towards B5G scenarios, we expect that the network will deliver any service that end users or applications request with certain guarantees by consuming network resources. This means that the network must be able to provide such adaptation capabilities, relating the requested services to the specific underlying network resources that are offered. These network resources need to be orchestrated to provide multi-layer multi-domain services.

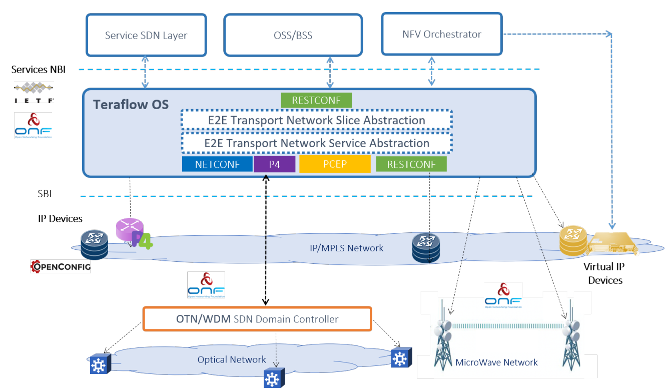

Fig. 1: Beyond 5G networks scenario

Moreover, there is a need to deploy software capabilities in the network to deal with the explosion of flows in B5G scenarios. The reason is that, with today's procedures, it is not possible to provide the levels of adaptation and flexibility that B5G scenarios requires. Network operators can migrate to 5G based on a set of templates for services and network slices hard coded in their systems. However, this approach does not scale for B5G scenarios, in which the network has to adapt to the end users' needs. Network automation is the only way to deal with such adaptive environments. SDN promised the capability to program the network with dedicated tools, however, each tool has its own APIs and integration is a costly and time-consuming process.

This scenario will be used to evaluate multiple standard interfaces and it will contribute to the communities with a gap analysis and standardization proposals based on the findings. To do so, this scenario will select the most relevant use cases and demonstrate them using the developed TeraFlow SDN Controller. This effort towards a holistic B5G SDN solution is unique. Implementation guides will be produced by the partners in the consortium with two objectives. First, to enable the capabilities of the TeraFlow OS to deal with network elements' programmability, and second, to develop agents in the devices to cope with the interface requirements.

Figure 1 shows the multiple integrated network elements to support the provisioning of a L3VPN. An optical network domain will be included, which might be managed using OpenConfig terminal device data model. Moreover, a microwave transport network will also be included, following ONF/IETF data models. Physical and virtual L3 routers will be controlled using OpenConfig data models. TeraFlow SDN Controller shall be able to provide requested L3VPNs.

III. Cloud-scale inter-domain connectivity scenario

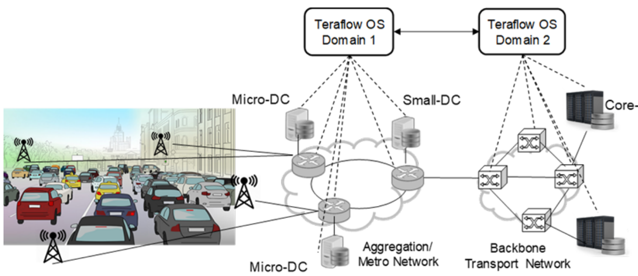

Fig. 2: Cloud-scale inter-domain connectivity scenario

The automotive industry is evolving towards a vision where cars are becoming autonomous and wirelessly connected to cooperate with each other for safer and more efficient driving. Connectivity offers a good complement to the on-board sensors by extending vision and detection range even when visual line-of-sight is not available, while deploying cooperative, connected, and automated mobility (CCAM) services. For the success of a connected car, it is necessary that the telecom and the automotive industry cooperate to shape the future by addressing all the challenges that CCAM brings.

To extend sensor capabilities in a CCAM scenario, each connected car subscribes to the topics of interest and gets the information when an update happens (for example, hazard information to be shown in a map, generate a warning in the car's display, or brake the car). Thus, it is expected that a large number of flows requiring low-capacity and, optionally, low-latency (for mission-critical applications) will be generated. Moreover, the CCAM scenario considered for B5G is even more challenging in terms of requirements. The objective is to take full advantage of the sensors deployed in a vehicle to collect telematics and driver behaviour data and analyse it, in order to ensure the vehicle's performance, efficiency, and safety. In this scenario, it is expected that each car will send 25 gigabytes of data to the cloud every hour. The huge scale and diversity of CCAM services imposes three main requirements for transport services: low-latency, high-capacity, and massive flow management. The generation of large numbers of flows or huge aggregated volumes of data from the edge of the network to the core to make use of the cloud services will congest the network. To overcome this scalability issue, the solution that is proposed is to also deploy computing and storage resources at the edge of the network (i.e., MEC) and distribute the functionalities between the MEC and the cloud, located in the core network. Such a solution would enable reduction of the number of flows and lower capacity required between the edge and the core of the network, as data is processed where it is generated, thereby lower E2E latency. This approach creates a model that eliminates bottlenecks, thus scales by offloading the network and the cloud. However, it requires the unified management of computing, storage, and networking resources as proposed by the TeraFlow SDN Controller to deploy integrated services (e.g., provision of cloud & edge computing resources and connectivity between them) and optimize the cloud and network resources (e.g., packet/optical) in an integrated way.

In this use case the multi-domain approach of the TeraFlow SDN Controller is addressed, deploying several per-domain instances, in order to validate a more realistic scenario. Another key feature of the TeraFlow OS that will be validated is network virtualization through the request of multiple network slices. In the proposed multi-domain scenario, per-domain connections will need to be interconnected in order to compose multiple end-to-end connectivity across different domains.

Figure 2 depicts the target CCAM scenario. At the infrastructure layer, it is composed of several packet and optical transport networks for the metro and core segments providing connectivity to the distributed cloud and edge computing infrastructure. It can be deployed in micro-DCs at the edge nodes (e.g., cell sites, street cabinets, lampposts), small-DCs (e.g., in a central office) for low/moderate-computation capacity and low response time, and core-DCs in the core network for high-computational capacity and moderate response time. In general, virtual machine (VM)-based virtualization technologies are used in the large DCs, and the container-based virtualization technologies in the micro/small-DCs. Transport and cloud infrastructure is administratively partitioned into different domains, each controlled by a TeraFlow SDN Controller.

IV. Conclusion

TeraFlow fosters and drives a new wave of innovation in SDN controllers. This paper has presented two TeraFlow scenarios that will showcase the novel characteristics of TeraFlow.

Acknowledgment

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References

[1] C. Manso, P. Alemany, R. Vilalta, R. Muñoz, R. Casellas, and R. Martínez, "End-to-end sdn/nfv orchestration of multi-domain transport networks and distributed computing infrastructure for beyond-5g services," *IEICE Transactions on Communications*, vol. 104, no. 3, pp. 188–198, 2021.

[2] A. Kousaridas, M. Fallgren, E. Fischer, F. Moscatelli, R. Vilalta, M. Mühleisen, S. Barmpounakis, X. Vilajosana, S. Euler, B. Tossou *et al.*, "5g vehicle-to-everything services in cross-border environments: Standardization and challenges," *IEEE Communications Standards Magazine*, vol. 5, no. 1, pp. 22–30, 2021.