

Network Data Analytics Function for Network Slice Lifecycle Management: a closed-loop approach

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Abstract

Networks slicing in 5G network enables the network operators to accommodate the different quality of service (QoS) to their customers. The orchestration and management of the end-to-end (e2e) network slicing is a critical task. So, for that, we have designed a closed-loop Intent-based Networking (IBN) platform, which ensures the commissioning, activation, run-time monitoring, and decommissioning of the network slices automatically. Moreover, we have integrated the newly proposed 3GPP network data analytics function (NWDAF) with the IBN platform for efficient e2e network slice lifecycle management. By implemented different Machine Learning (ML) models in the NWDAF function, we can predict the slice load, user mobility, traffic forecasts, and anomaly detection from the network slices.

I. Introduction

The main goal of the 5G network is to entertain multi-services with diverse QoS requirements from the users and vertical industries. These services are classified into three major categories: ultra-reliable low latency (URLLC), enhanced mobile broadband (eMBB), and massive machine-type communication (mMTC). The emergence of software-defined networking (SDN) and network function virtualization (NFV) makes it possible to partition the same network into multiple logical networks, known as network slicing. Network slicing in the 5G network enables the network operators NOS to support multi-services requirements [1,2].

The Third-Generation Partnership Project (3GPP) has introduced a network data analytics function (NWDAF) in service-oriented 5G architecture. NWDAF performs intelligence in the network and collects the data from different network functions (NFs) such as PCRF, AMF, UDM, etc. It has different ML models trained on a historical dataset collected from different 5G NFs and predicts the slice load, resource forecasts, load balancing, anomaly detection, user behavior prediction, recommendations, and many more [3]. So, we have proposed IBN-based e2e slice lifecycle management through the NWDAF function. The NWDAF has ML models for prediction and recommendation. The proposed system used the concept of a separate data analytics function (DAF) for each domain, such as core, RAN, and edge domain. So, the NWDAF predictions and recommendations are used for efficient slice lifecycle management.

II. NWDAF for closed-loop automation and network slice lifecycle management

The proposed system consists of the IBN platform, Open-source MANO (OSM) orchestrator, FlexRAN controller, Resource Monitoring module, Data Collection module, and NWDAF. Figure 1 presents the closed-loop architecture of network slice lifecycle management through NWDAF. The working of each component in our system is as follows.

IBN platform: It is a closed-loop system for automating the network slice designing, activation, and deleting. It manages the lifecycle of e2e network slices. IBN platform has a GUI portal, Intent manager, policy store, and policy generation module. GUI portal is a dashboard where users can input their intentions in QoS requirements, e.g., downlink and uplink speed. The intent manager is enabled communication

between different entities of the IBN system. A policy store is a rich database that stores all the information related to the underlying resources, user deployed intents, slice information, etc. After verifying with the policy store, user intents are sent to the policy generation modules with OSM policy configurators and RAN policy configurators. OSM and RAN policy configurators convert the user intents into Json based slice template for deploying core and RAN network VNFs. After that, the resources are activated with the help of OSM and FlexRAN over the infrastructure. The IBN can take the user intention and automatically deploy the slices over the infrastructure [4,5].

OSM MANO: OSM is an open-source NFV orchestrator for activating the core network VNFs developed based on ETSI MANO specifications. It has integrated OpenStack for deploying the network instances over the infrastructure. So, we used OSM for deploying the core network resources for a network slice [6].

FlexRAN controller: FlexRAN is an SDN-based controller for the radio access network domain. It performs the radio access network slicing. So, we are using FlexRAN for slicing the RAN. It takes the JSON slice template generated by the IBN platform and deploys the slices accordingly.

Resource Monitoring: we have used open-source tools to monitor the underlying domains and collect the data from each domain, such as RAN, edge, and core cloud. The Grafana, Prometheus, and ElasticMon tools monitor the core, RAN, and edge domains in our testbed.

Data Collection: The data was collected and stored in a server separately from each network domain through monitoring tools. Each domain has a data exporter such as core data exporter, RAN data exporter, edge data exporter that exports the data from infrastructure and sends it to the server. The NWDAF module will use this collected data.

NWDAF: It has three different data analytics functions (DAFs) such as RAN-DAF (R-DAF), Edge-DAF, and core-DAF (C-DAF). The R-DAF has a hybrid ensemble learning ML model that can train on the historical data from the RAN domain and predict the user mobility patterns of the user. It can also predict radio resource slice load. Based on these prediction results decision engine of the IBN platform decides and notifies the IBN platform for mobility and provides better resources to the user. On the other side, the C-DAF function also has a hybrid ML model for predicting the slice VNFs and forecasts the utilization. The decision engine further decides on scaling the resources. It also has a model DDoS attack detection and mitigation. The E-DAF function works similarly to C-DAF.

So, these all modules work together and ensure closed-loop orchestration and management for the slice lifecycle.

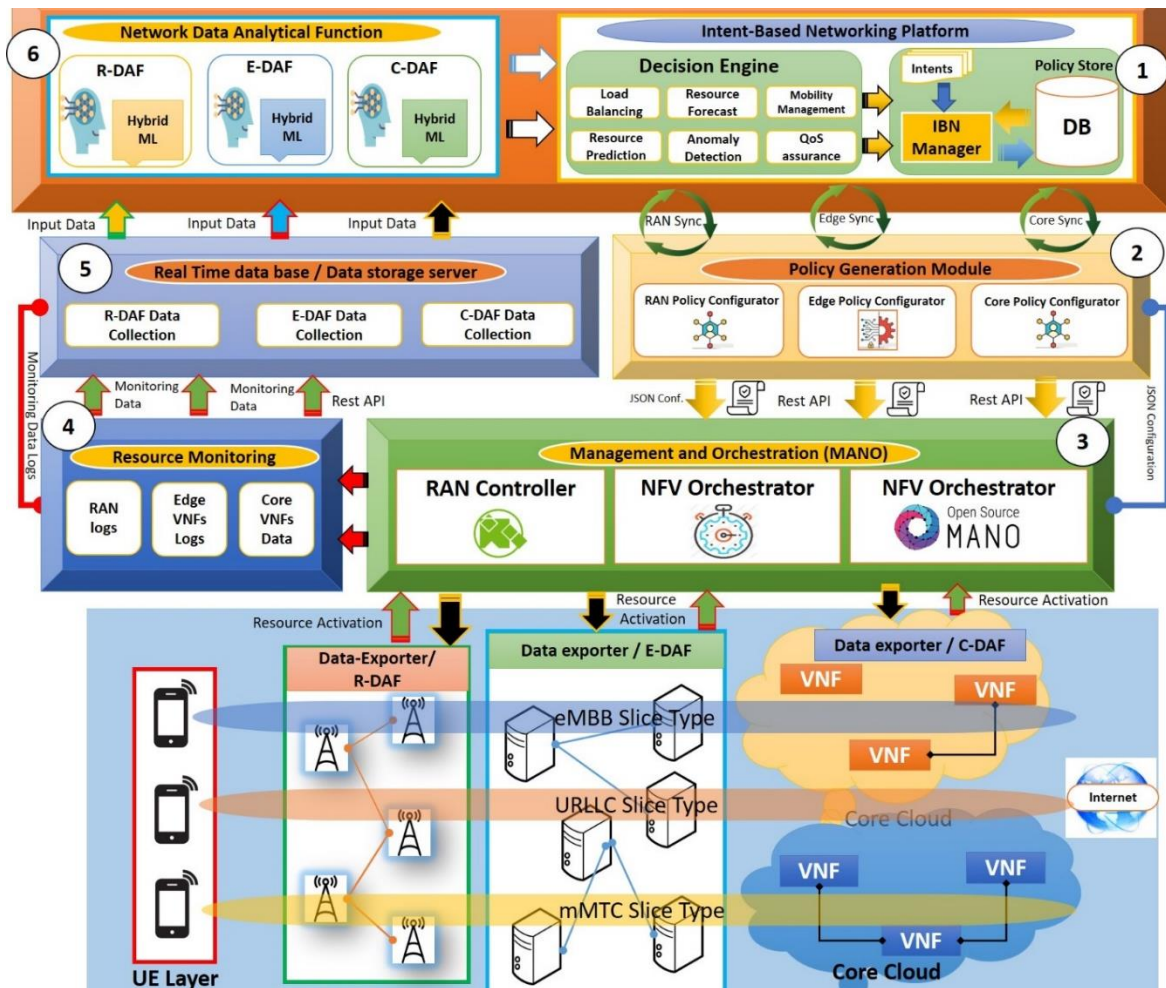


Figure 1: Closed-loop architecture of network slice lifecycle management through NWDAF

III. Conclusion

This paper focuses on the closed-loop mechanism for the orchestration and management of e2e network slices through the IBN mechanism. The users input their intents and automatically create, activate, monitor, and delete the network slices in the returns system. Moreover, it introduces the intelligence by implementing the NWDAF, where the system prepares the resources in advance in slice overload. It facilitates the NOs to performs load balancing, mobility management, attack detection, and QoS assurance. This system also ensures security for the users by implementing DDoS attacks detection and mitigation mechanism in network slices.

ACKNOWLEDGMENT

This research was supported by the MSIT (Ministry of Science and ICT), Korea, under the ITRC (Information Technology Research Center) support program (IITP-2021-2017-0-01633) supervised by the IITP (Institute for Information and communications Technology Planning and Evaluation). This research was supported by Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (NRF-2016R1D1A1B01016322).

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