An Implementation Study of Network Data Analytic Function in 5G

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***Abstract*—Network automation and intelligence are evolutionary directions in 5G, and network data analytic function (NWDAF) plays a key role to realize this vision. In this work, we present an implementation result of NWDAF in free5GC that is an open software for 3GPP mobile core networks. The implemented NWDAF module consists of 1) model training logical function (MTLF) to train the model and 2) analytics logic function (AnLF) to provide analytic results based on the trained model. We have verified the operability of NWDAF and released it through Github. Extensive experimental study will be conducted in our future work.**

***Index Terms*—5G Network, 3GPP, Network data analytic function, Network intelligence, Network automation**

I. Introduction

5G is a key technology to provide various services. Service types provided by the 5G network include 1) enhanced mobile broadband (eMBB) 2) ultra reliable low latency communications (URLLC) 3) massive machine type communications (mMTC). As 5G service types are diversified, the 5G network management has also become complicated. As a result, technologies that can facilitate complex network management are needed. Network automation and intelligence technologies analyze collected data and automatically optimizes complex network management based on artificial intelligence (AI). The 3rd generation partnership project (3GPP), a mobile communication system standardization organization, defines network data analytics function (NWDAF) as a new network function (NF) in the 5G core network and develops specifications for NWDAF to apply network automation and intelligence technologies in the 5G network [1]. NWDAF collects information from nodes in 5G networks, such as access and mobility management function (AMF) and session management function (SMF), and analyzes it based on trained models to provide analytic information in the statistical or predictive form. However, the development of detailed functions of NWDAF and the application of NWDAF to real networks are at early stages, and it requires continuous development. As a result, the need for testbeds to develop and validate network automation and intelligence technologies for 5G networks is increasing.

Open source projects are used as a testbed for verification at the development stage by complying with standards and providing public access to code. Typical open source projects related to the 5G core include OpenAirInterface (OAI) developed by Eurocom, Open5GS developed by NextEPC, and free5GC developed by NCTU [2]–[4]. Currently, open source projects for the 5G core have implemented some essential features for 5G services. However, in all projects, NWDAF is not developed or has no development plan.

In this paper, we propse an implementation of NWDAF based on free5GC. The implemented NWDAF consists of a model training logical function (MTLF), which provides a trained model or can train the model, and an analytics logic function (AnLF), which provides analytic information based on the trained model at the request of an analytic consumer. We share the code of the implemented NWDAF on Github to be used for future research [6]. In addition, we design the testbed architecture in which the implemented NWDAF can work jointly with free5GC and UERANSIM.

The rest of this paper is structured as follows. The development trends of open source projects related to the 5G core and free5GC are described in Section II. NWDAF implementation based on free5GC and testbed architecture for implemented NWDAF are described in Section III. Finally, the concluding remarks are presented in Section IV.

II. 5G Core Open Source Projects

In this section, we present typical open source projects for the 5G core network. First, OAI is a C language-based open source project for the 5G core network developed by Eurecom that provides a 5G full-stack development environment based on 3GPP Release 15 [2]. Second, Open5GS is a C language-based 5G core open source project compliant with 3GPP Release 16, and the commercial license is held by NextEPC [3]. Open5GS has implemented core elements such as AMF, SMF, and user plane function (UPF), fundamental to the 5G core.

Free5GC is a Go language-based open source project for the 5G core network developed by NCTU, which provides the 5G core development environment based on 3GPP Release 15 [4]. Free5GC consists of three stages of development of the 5G core network. Stage 1 is the 5G non stand-alone (NSA) architecture that defined only AMF, SMF, and UPF, which are basic elements of 5G cores and operate based on 4G elements. Stage 2 is the 5G stand-alone (SA) architecture that implements additional 5G core elements, which operates

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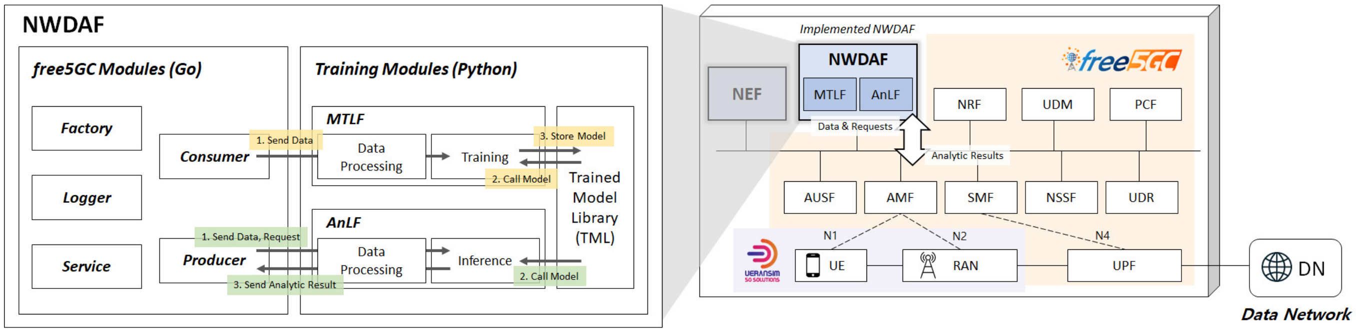

Fig. 1. Implemented NWDAF and Testbed architecture.

based on the service-based interface (SBI). Finally, stage 3 adds uplink classifier (ULCL) and non-3GPP interworking function (N3IWF), which is core elements that support non-3GPP access to stage 2. Currently, free5GC has completed development up to stage 3. The open source radio access network (RAN) solution that can work jointly with free5GC includes UERANSIM [5]. We used free5GC for implementation because other projects have an NSA architecture or because implementation is ongoing.

III. Open Source based NWDAF Implementation

Figure 1 describes the implemented NWDAF architecture and the testbed architecture for the implemented NWDAF. The testbed consists of as follows. The 5G core network is configured based on free5GC. The gNodeB and UE are configured based on UERANSIM. The implemented NWDAF works jointly with the core network. The implemented NWDAF collects data from other NFs for analysis or provides the analytic results in the statistical or predictive form upon request. In addition, we implemented the network exposure function (NEF) so that the implemented NWDAF can receive requests from the application function (AF) included in the 3rd party. The implemented NWDAF has the following architecture and modules.

Free5GC modules are based on the Go language with reference to the modules of NF implemented by free5GC. Free5GC modules mainly link the implemented NWDAF with the free5GC-based core network, receive data used for training the model, and receive requests and send analytic results. The detailed configuration of the free5GC modules is as follows. The factory module receives configuration information when executing NWDAF. The logger module stores the logs that occur during NWDAF operation. The service module executes NWDAF in the form of a server and registers it at the core network. The consumer module receives the data used for training the model from other NFs and provides them to MTLF. Finally, the producer module receives requests and data used for analytic inference from other NFs and delivers it to the AnLF. When the analysis operation at AnLF is done, the producer module delivers the analytic results to the NF from AnLF.

Training modules are based on Python to facilitate interworking with models mainly based on Python, such as Pytorch and Tensorflow. Training modules train the model through the data from other NFs or provide the analytic results to other NFs based on the trained model. The detailed composition of the training modules is as follows. First, MTLF receives the data for training the model from the consumer module, calls and trains the model in the trained model library (TML), and stores the trained model back in the TML. The data processing module in MTLF converts the received data into a form suitable for the model training. The training module in MTLF trains the model with the converted data. Second, AnLF calls the model from the TML when it receives requests from the producer module and provides analytic results based on the trained model. The data processing module in AnLF converts the received data into a form suitable for the model inference. The inference module in AnLF generates the analytic result, based on the trained model, in the statistical or predictive form according to the request. We open the code of the implemented NWDAF and the testbed for future research [6].

IV. Conclusion

In this paper, we implemented NWDAF to build the open source-based testbed for 5G network automation and intelligence. In addition, we invested the ongoing trend of open source-based 5G core network projects. Finally, we built a testbed based on the implemented NWDAF and shared the code on Github. As the future work, we will define 5G network intelligence and automation scenarios through NWDAF, such as edge caching and traffic management, and collect data to train the model from the implemented testbed.

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REFERENCES

[1] 3GPP Technical Specification (TS) 23.288, Architecture enhancements for 5G System (5GS) to support network data analytics services. V.17.1.0, June 2021.

[2] OpenAirinterface, [Online]. Available: https://openairinterface.org/

[3] Open5GS, [Online]. Available: https://open5gs.org/

[4] free5GC, [Online]. Available: https://www.free5gc.org/

[5] UERANSIM, [Online]. Available: https://github.com/aligungr/UERANSIM

[6] mnc_NWDAF, [Online]. Available: https://github.com/net-ty/mnc_NWDAF