Intent–Based Network Slice Life Cycle Management
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Abstract
5G networks have to accommodate a diverse set of services with different performance, latency, bandwidth, and reliability requirements. It is not possible to handle multi–services needs with legacy cellular networks due to the same physical infrastructure. The programmable and virtualized nature of the 5G network makes it possible to manage these multi–services by providing different resources to each service. Network slicing is a promising solution to support the multi–services environment where the same physical network is partitioned into isolated multiple logical networks. This research paper has proposed an end–to–end (e2e) network slicing through an intent–based network (IBN) approach. Our system can manage the life cycle of the network slice in an automated fashion. It can also monitor, update, and manage the slices by using deep learning.

I. Introduction
The main goal of the 5G network is to handle diverse use cases with differentiated service requirements. The legacy cellular networks cannot fulfill the different quality of services (QoS) requirements. So, 5G networks handle these multi–service requirements efficiently because of its innovative and promising feature network slicing. Network slicing is creating multiple isolated logical networks over the same physical infrastructure. This is possible due to adopting the programmability and network function visualization (NFV) technologies [1]. The 5G network beauty is network slicing, which provides isolated resources to each service type for handling multiple service requirements. The 3GPP (third generation partnership project) has categories three kinds of main classes for network slicing, such as enhanced mobile broadband (eMBB), massive mobile communication (mMTC), and ultra–reliable low latency (URLLC). These network slicing classes will also ensure the data transmission in terms of latency, bandwidth, and reliability for mission critical, high data rate, and low latency applications [2][3].

Many research studies are related to e2e network slicing in the literature, but managing the network slice life cycle is challenging [4]. According to 3GPP standard network slice, LCM (life cycle management) consists of four major modules: commissioning, activation, run time monitoring and decommissioning [3]. In the slice commissioning phase, the preparation and design for a slice is handled, e.g., the slice template for a slice is created in the first phase. This slice template contains information about the user requirements and resources to be deployed. After that, the designed slice template is deployed on the underlying infrastructure with NFVO and network controllers: the specified resource should be assigned to a slice and activated. The activated slice resources are monitored continuously through the monitoring tools, and in case of any failure, it will be notified to the NFVO orchestrator to resolve the error. In the decommissioning phase, the created slice would be deleted automatically at the specified time [5].

This paper has proposed an intent–based approach that can automatically orchestrate and manage the end–to–end network slices. It can also perform the LCM of the network slice in an automated fashion. Our system consists of four major modules: IBN platform, NFVO OSM, RAN controller FlexRAN, and deep learning module. IBN platform can automate slice configurations/slice template generation procedure by getting input from the users in the form of user intents/requirements for a slice. The IBN system generates the slice template in JSON format and sends it to the NFVO orchestrator OSM and FlexRAN to activate a slice over the infrastructure. The OSM, with the help of VNF manager (VNFM) OpenStack, can deploy the Core network functions vHSS, vMME, vSPGW for the slice. On the other side the FlexRAN controller will be responsible for activating the requested slice over the RAN. Hence, our system can create e2e network slices and performs LCM of the network slices. The next section contains the details of the IBN based LCM for a network slice and its components.

II. Intent–based Network Slice Life Cycle Management
Figure 1 presents the design and architecture of Intent–based LCM of network slice that consists of IBN platform, NFVO OSM MANO, SDN based RAN controller FlexRAN and deep learning module. All these modules work together and perform the LCM of a slice. The IBN platform is the main module of this work that can automatically generate the network slice policies/template. It works similar to the first module of the LCM slice design and preparation phase defined by the 3GPP. IBN platform has the graphical user interface (GUI), Intent manager, catalog repository, policy configurators for RAN and OSM, and deep learning–based update engine. The GUI is for the users to input their intentions/requirements for a slice. On the other side, the intent manager is the central entity that provides a way to interact with other IBN modules. It can take the user inputs/slice requirements, check the catalog repository resources, and forward them to policy configurators.
All the information about the underlying resources, VNFs, images, architectures, LCM parameters, and service types are stored in the IBN system catalog repository. The intent manager forwards the user intents/requirements to the policy configurators for further processing. Policy configurators can convert the higher-level user requirements into an orchestrator acceptable format: for example, OSM and RAN policy configurator convert the requirements into a JSON format–based slice template for OSM and FlexRAN. The intent manager sends these templates to OSM and FlexRAN for the activation of a slice. The OSM, with the help of OpenStack, deploys the VNFs vHSS, vMME, vSPGW for the Core network, and the FlexRAN controller creates the slice over the RAN eNB. After that, the system provides the dedicated vMME to the created RAN slice. In this manner, our system deploys the e2e slice automatically. The OpenStack monitoring tool ceilometer is used to monitor the states of the VNFs and the ELK (Elastic, LogStash, Kibana) monitoring tool with the FlexRAN controller to monitor the RAN slices. After fetching the data from these monitoring tools, we have trained a deep learning model that predicts resource usage in the future. We have used GAN (Generative adversarial network) and LSTM models for prediction. Hence, our system can automatically create, update, monitor, and delete network slice instances with the IBN system.

### III. Conclusion

This paper presents an e2e network slicing mechanism through intent–based networking where the user needs to input the QoS in the forms of data rate. In returns, the system can deploy the slices dynamically. It can manage the life cycle of core and RAN network slices efficiently. The IBN system can automate the slice template/configuration generation process and forwarded the slice configurations to OSM and FlexRAN to activate a network slice. It is one step forward to the automation, self–healing, and self–assurance of the future generation network. Also, deep learning is used to control and update the network dynamically.

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