An efficient network operation automation scheme using network status information for local 5G networks

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***Abstract*— 5G SA communication technology is being recognized as a crucial technology shaping the future of wireless communication. Compared to previous generations of networks, 5G offers ultra-high-speed, low latency, and massive connectivity, presenting both enterprises and individual users with opportunities for new business models and an enhanced quality of life. One of the most significant changes between the conventional mobile communication environment and 5G is the activation of various application cases in B2B services based on the local 5G network. The local 5G network, tailored to specific sites, requires effective management of high-volume data generated in dense areas and necessitates minimizing manual intervention by administrators. The ZSM (Zero-touch Service Management) technology is gaining attention to meet these requirements. ZSM focuses on automated operations for managing large systems like commercial mobile communication networks. It is anticipated that ZSM will also be applied to the local 5G network for efficient management and operation of tailored services. This paper proposes a network management technique that minimizes administrator intervention in the local 5G network environment. The proposed network management technique collects statistical logs from local 5G network base stations and core systems, supports real-time network status checks as well as traffic predictions using machine learning. Additionally, it offers automated operation techniques for the local 5G network by incorporating functions such as disconnecting network access for devices that are factors of malfunction within the specialized network.**

Keywords*— *Local 5G Networks, Zero-touch Service Management, Automation of operations, Network Management,

I. Introduction

Recently, the infrastructure for 5G SA communication technology has been rapidly expanding, and services based on genuine 5G communication technology, characterized by ultra-high speed, low latency, and hyper-connectivity, are being implemented. Using network traffic control technology grounded on large volume 5G traffic and service priorities, stable 5G B2B services are being realized. As of 2022, 5G communication data traffic is expected to grow annually by 26%, with monthly data consumption anticipated to reach 122EB[1][2]. Specifically, technologies like CPS, which integrates smart factory technology and virtualizes manufacturing plants for inspection and management, can be utilized. With the application of services like the local 5G network, an explosive increase in mobile communication traffic, such as high-capacity and high-quality video services in confined spaces, is anticipated. Research to control the vast traffic of terminals in the local 5G network efficiently is emerging as a significant research challenge, similar to commercial networks. To efficiently manage the exponentially increasing 5G high-volume traffic, research has been conducted on the concept of Zero-touch Network and Service Management (ZSM) for automating network service management. By automating network and service management, ZSM enhances the efficiency of controlling network resources and the visibility of network performance. The ultimate aim of the ZSM concept is to enable an autonomous network system capable of self-configuration, self-monitoring, self-recovery, and self-optimization based on service-level policies and rules. ZSM is defined as a framework that offers and manages services across a network's entire lifecycle without intervention. The primary objective of this technology is to reduce the complexity of network operations, foster efficient utilization of network resources, and contribute to service quality enhancement[3][4][5][6]. Moreover, by supporting automated network management using AI and ML algorithms, it can gather and analyze diverse data such as network status information, user behavior patterns, and traffic analysis, enabling appropriate responses to network failures. This paper proposes a machine learning-based network operation automation solution by applying the ZSM concept to the local 5G network.

II. Proposed Scheme

This paper proposes a technique that integrates 5G specialized network equipment with the ZSM (Zero-touch Service Management) to effectively gather and analyze traffic data based on network status information and extend it to automated responses. The method proposed is structured around NSCP (Network Status Checking Procedure) and ANO (Automated Network Operation) as depicted in Figure 1, providing compatibility with actual network systems. The method periodically inspects the internal status of the network, monitors device connection traffic within the network, detects anomalies, and offers an environment conducive to automated responses.

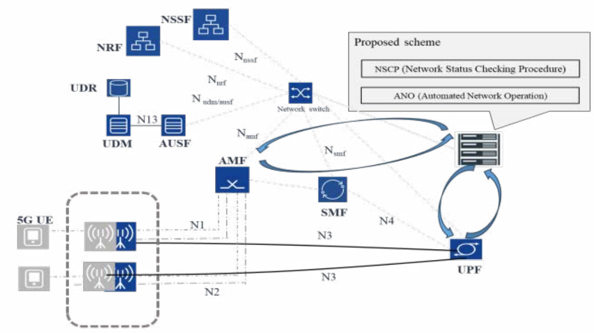

Fig. 1. Network architecture of the porposed scheme

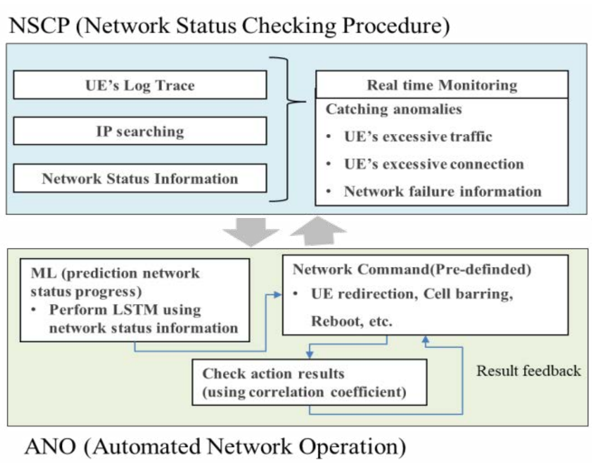

Fig. 2. Definition of each detailed function of the proposed scheme

The intricate workings of the proposed method can be portrayed as shown in Fig. 2. Local 5G network operators can access related data from network equipment, enabling the method's realization through real-time network monitoring. The technique is built upon two functionalities: NSCP and ANO. The NSCP collates information essential for verifying network status and conducts real-time monitoring, while the ANO executes automatic network controls based on NSCP's data. NSCP operates real-time monitoring using IP details of devices interfaced with the local 5G network, and it outputs extracted network traffic data and status information. Leveraging these results, anomalies can be identified through real-time monitoring. Using ANO, the network status is diagnosed based on the execution of LSTM (Long Short-Term Memory) based machine learning from this network status data. The network's status is used to check whether it's deteriorating or improving. After a certain period, the status prediction can be categorized into three values: deterioration, improvement, or maintenance. Utilizing the network status information from NSCP and the LSTM result values, predefined corresponding 5G network commands are automatically input and conveyed to the network system. The correlation coefficient is derived by examining both positive indicators (such as network connection success rate, authentication success rate, PDU session establishment success, etc.) and negative indicators (such as network connection failure rate, authentication failure, PDU session establishment failure, etc.) from the network status information. Table 1 displays the state inspection according to the NSCP of the proposed method.

Table 1. NSCP and ANO algorism of the porposed scheme

NSCP (Real time monitoring procedure)

Network Status Checking():
if UE's traffic > Threshold **and** UE's service is low priority **then**
return network status ← anomalies(UE's excessive traffic)
elif network congestion *(VS.AmfAuthInfoAtt)* > Threshold **then**
return network status ← anomalies(UE's excessive connection)
elif network failure (*VS.UePduSessEstInitReqFail)* > Threshold
return network status ← anomalies(Network failure)
else
return network status ← normal state

ANO (Automated Network Operation procedure)
Automated Network Operation(network status)**:** Machine Learning(network status information): **return** predicted state ← Mitigate or deteriorate **if** network_status = normal state **and** predicted state = deteriorate **then** network command ← corresponding action(pre-defined) get_result_feedback(network_command) **elif** network_status == anomalies(Network failure) **and** network status == relief **then** network command ← corresponding action(pre-defined) after few_minutes get_result_feedback ← positive or negative using (correlation coefficient)

In this way, the proposed technique can optimize the network status and environment for network operation by local 5G operators by interacting with the network system to efficiently automate the network.

III. IMPLEMENTATION

To verify the proposed method, we use the Nokia network system to implement and verify the proposed method. For the implementation of the proposed technique, the function is verified in a line that does not affect the network. Network log collection was performed by first acquiring 15-minute statistical information within AMF and UPF of the Nokia core

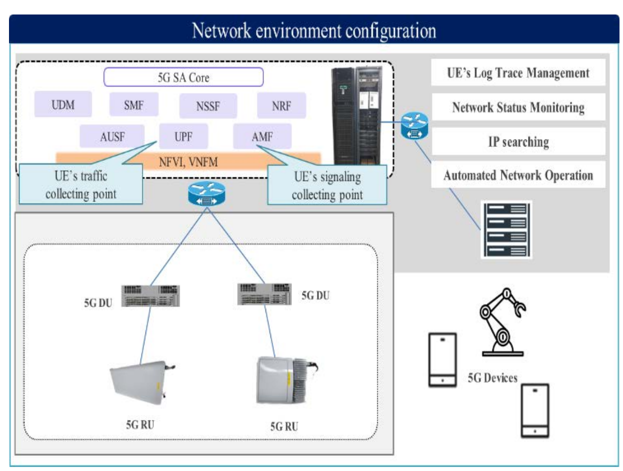

Fig. 3. Network environment cofiguration for implementation

system, and anomaly detection captures anomalies based on information indicating a specific network state. For example, based on status information on traffic and access (VS.AmfAuthInfoAtt, VS.UePduSessEstInitReqAtt, VS.numberOfUsers) and status information on failures in the network, automation when a certain threshold (50%) or more increases compared to the same time the previous day. As a response, the network system implements a trace collection method for a specific terminal in the network. Figure 3 is a network environment configuration using the Nokia network system for the implementation of the proposed scheme.

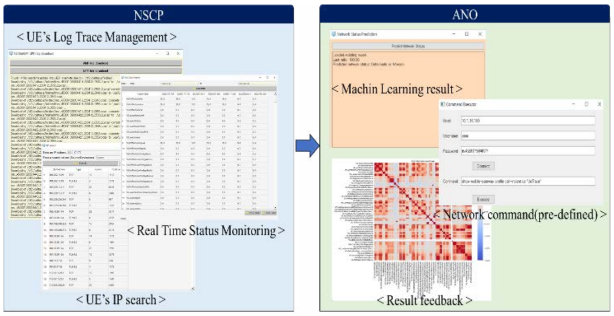

Fig. 4. Screen capture of the network implementation of the proposed scheme

The proposed method was verified in conjunction with the actual Nokia network system, and screens capturing the execution of individual functions could be captured as shown in Figure 4. However, for the LSTM machine learning proposed in this paper, since the AMF and UPF logs are collected at 15-minute intervals, proper learning could not be sufficiently supported, limiting the verification to system linkage and operation. It is assessed that there will be a need for systematic learning in the future to fully implement the functionality.

IV. Conclusion

This paper introduced a novel scheme that combines 5G specialized network equipment with Zero-touch Service Management (ZSM) to enhance the efficiency of traffic data gathering and analysis based on network status information, ultimately leading to automated responses. Key functionalities like the Network Status Checking Procedure (NSCP) and Automated Network Operation (ANO) were depicted, enabling these operations to integrate seamlessly with real-world network systems. Through real-time monitoring, the method can identify anomalies in network traffic, device connections, and overall network status. The machine learning approach employed, LSTM (Long Short-Term Memory), is utilized to diagnose the current state of the network and make predictions about its future status (deteriorating, improving, or maintaining). To facilitate automated responses, predefined 5G network commands are generated based on the analyzed data, which in turn is derived by evaluating both positive and negative indicators from the network status information. A practical implementation was carried out on the Nokia network system, where it was found that while the proposed method could be successfully integrated and certain functions executed, there were limitations in fully realizing the LSTM machine learning technique due to data collection intervals. Consequently, for the future robustness and full-scale application of the proposed method, a more systematic approach to learning is essential.

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