

Intent-Based Network Management in 6G Core Networks

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Abstract—Supporting network intelligence is one of the main goals of 6G core networks. Network intelligence can provide a self-driving network that optimizes and adjusts itself with the least amount of human interaction. Intent-Based Networking (IBN) is an approach that can be combined with 6G core networks to provide automation. The IBN concept provides a closed-loop control architecture that is able to adapt to the status of the network by monitoring data from network functions. Network Data Analytics Function (NWDAF) is proposed by the 3rd Generation Partnership Project (3GPP) to collect monitoring data from multiple network functions. This paper proposes an architecture that combines the NWDAF with the IBN concept to merge it with Artificial Intelligence (AI) and Machine Learning (ML) to analyze the monitoring data. The proposed scheme creates a system that will be able to provide automatic verification and optimization for the 6G core networks.

Index Terms—6G, IBN, network intelligence, NWDAF

I. INTRODUCTION

Due to the constrained functioning of hardware-oriented networks brought on by the arrival of the 5G network era, many academics have been compelled to investigate software-oriented open networking technology. This research on software-oriented open networking technologies led to the development of some technologies, including Software-Defined Networking (SDN) and Network Functions Virtualization (NFV), which enabled the virtualization of network resources and services for the application of artificial intelligence to provide services dynamically based on the state of the networks.

With the current development of computer networks, SDN and NFV have reached a certain maturity point. Lots of academic papers and projects about SDN and NFV existed to improve the networks' quality of service. The separation of the control plane and the data plane allows unique applications to be implemented in the networks. And combined with Artificial Intelligence (AI) and Machine Learning (ML), the self-driving network can be realized with a higher level of confidence.

The combination of AI and computer networks introduces a term called Intent-Based Networking (IBN). IBN allows the networks to be configured by capturing the user's "intent", i.e., an abstract, high-level goal to operate a network. Then, the intent is translated into network configurations that describe

specific rules and actions. IBN is also designed to enable an autonomous network that can adapt and optimize itself by continuously monitoring the real-time status and performance of the network.

The existing 5G architecture does not actually support network intelligence. One of the goals of the future 6G core networks is to provide network intelligence to manage its network service function and the element of the architecture. Merging IBN and 6G architecture will improve the quality of the network by providing dynamic functions and maintenance. In order to perform such monitoring more efficiently, the 3rd Generation Partnership Project (3GPP) proposed Network Data Analytic Function (NWDAF). The NWDAF can monitor network functions using AI/ML. This paper contribution is as follows:

- **An approach to provide network automation to a 6G framework:** This paper proposes an idea that utilizes IBN in 6G core networks to provide network automation. As the IBN system is a concept that supports network intelligence, the 6G core networks can adapt and optimize itself with less human interaction.
- **An architecture of 6G core networks with IBN:** The proposed architecture is utilizing NWDAF in IBN to create a closed-loop control system. The NWDAF can monitor network function data in 6G core networks, and analyze them with AI and ML for network optimization.

The remainder of this paper is composed as follows. Section II summarizes the related work, Section III shows the proposed scheme for network management with IBN. In Section IV, the conclusion is provided along with future work.

II. RELATED WORK

This section introduces the related work in IBN management for 6G core networks.

A. Network Management Research Group (NMRG)

The Network Management Research Group (NMRG) at Internet Research Task Force (IRTF) organize an internet-draft to explain the concept and definition of IBN [1]. The draft discusses the main principles and functionality of IBN.

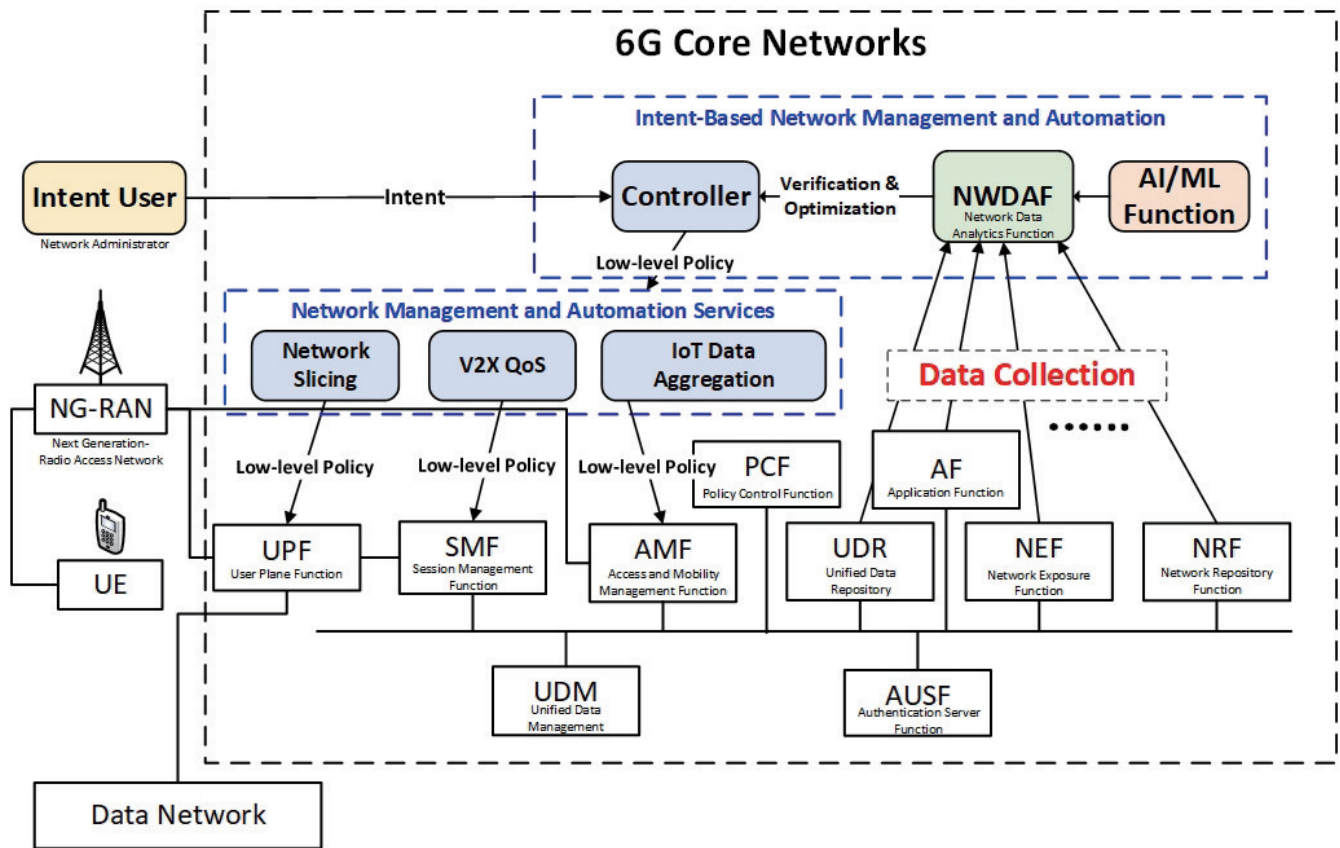


Fig. 1. An Architecture of Intent-Based Management System in 6G Core Networks

It is mentioned that an Intent-driven network has the characteristics: a single source of truth, one-touch but not one-shot, autonomy and supervision, learning, capability exposure, abstract and outcome-driven. To achieve the characteristics, the network needed to support two functionalities, i.e., Intent Fulfillment and Intent Assurance.

The Intent Fulfillment Function allows users to communicate intent to the network and perform the necessary actions to ensure that intent is achieved. To meet this functionality, an Intent Translation is needed to automatically translate user intent into a set of policies that will be deployed to the network. Intent Assurance is concerned with the functions that are necessary to ensure that the network indeed complies with the desired intent. The necessary function to ensure the desired intent is deployed properly is by Monitoring the network for events and performance. The information received will be used to assess the network status and behavior. If corrective actions are needed, the network should self-update its policy and bring the network back to compliance.

The NMRG also introduces another internet draft to classify the Intent created by the users [2]. Intent classification provides a benefit in several different areas such as the orchestration of cognitive autonomous RANs and intent network verification with new intent language. The internet draft explains the classification for three iterations, i.e., carrier network intent solution, data center network solutions, and enterprise intent

solution. The specific intent users, intent types, intent scope, network scope, abstractions, and life-cycle requirements are identified for each intent solution.

B. Intent-Based Networks for 6G: Insights and Challenges

Wei et. al. [3] present a thorough analysis of IBNs deployment in 6G networks. The authors provide insights that cover the system architecture, important methodologies, as well as the present state of the IBNs with the virtualization-based network frameworks. The paper also includes discussions on the challenges and directions to provide intelligence and autonomous 6G networks with the latest information about existing commercial solutions for IBN, such as Cisco's Application-Centric Infrastructure (ACI), Huawei cloud fabric solution, and Juniper contrail.

III. NETWORK MANAGEMENT WITH IBN TECHNOLOGIES IN 6G CORE NETWORKS

A. System Architecture

Fig. 1 shows the architecture of IBN technologies in 6G core networks. The proposed architecture provides IBN Management and Automation system that can reflect user intent with AI/ML technologies on top of the traditional 5G framework. The main components are as follows:

- **Intent User:** Manages the 6G core network and delivers requested intent to the controller with high-level policies.

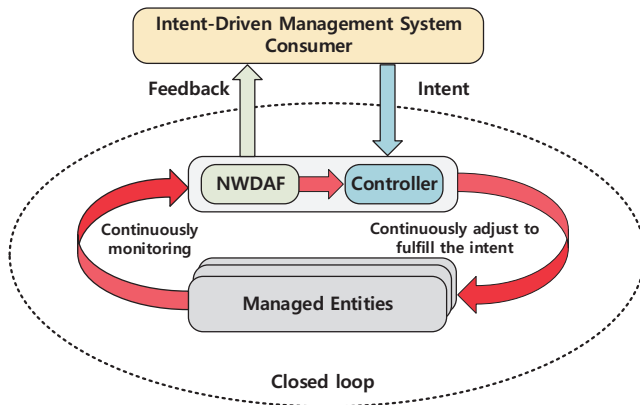


Fig. 2. Intent-Driven Closed-Loop Control

- **Controller:** Converts the intent delivered by the Intent User into a low-level policy for providing the service corresponding to the ability requested by the user and delivering it to the corresponding Service Functions. It also translates network management solutions delivered via NWDAF and passes them to corresponding service functions for automated management of networks.
- **NWDAF:** Receives monitoring data from 6G network functions to manage the network in real-time, and find contextual solutions for verification and optimization with the help of network analysis from AI/ML functions.
- **AI/ML Function:** Analyzes surveillance data delivered from NWDAF to find situational solutions.

The intent requested by the Intent User (i.e., Network Administrator) is delivered to the controller in the IBN Management and Automation in a high-level language. The controller translates the high-level intent delivered by the Intent User into a low-level policy to provide a service corresponding to the capability requested by the user within the controller and delivered to Network Management and automation service functions. After that, it is deployed to the functions responsible for the corresponding capability.

Fig. 2 shows the structure of the intent-driven closed-loop control proposed by 3GPP TS 28.312 [4]. In the proposed closed loop, the intent from the Intent-Driven Management System Consumer is transferred to the Controller. The policy corresponding to the intent is translated to a lower-level configuration, and the translated policy is distributed to the Management Entities, i.e., network functions. After that, it provides an automated network management function suitable for the situation through continuous monitoring.

For example, in our suggested structure, an intent user can express expectations including an intent about delivering radio service (e.g., radio network as service). In this scenario, the intent user delivers an intent containing the expectations for delivering radio service to the manager (i.e., Controller). The delivered intent includes coverage area information (e.g., geographical areas) and supported service capacity information (e.g., Maximum number of connectable users).

According to the delivered intent, the controller decides

the radio network slice using delivered information (e.g., area information and supported service capacity information)

In order to provide closed-loop control services in the 6G core network according to real-time network state changes, NWDAF collects event information from the selected network functions using the NWDAF analytics subscription method [5]. NWDAF can derive a network management solution corresponding to the network situation by using the AI/ML function with the transmitted monitoring data. After receiving the network management solution from NWDAF, the controller translates it and delivers it to the service functions that match the capabilities required for network management. This process continuously occurs as the network optimizes itself.

IV. CONCLUSION

To realize self-adapting and self-optimizing networks in the 6G core networks, an architecture with IBN-based management automation is proposed. The proposed scheme provides automatic configuration by translating an intent from the Intent User into the corresponding lower-level policy. The architecture is also designed to adjust itself to the status of the network by utilizing NWDAF to collect monitoring data from network functions and analyze such data using AI/ML functions. The result of the analysis will be given back to the controller as feedback for network optimization. To fulfill this concept, many challenges such as intent translation, data collection with NWDAF, and AI/ML function for data analysis will be researched as future work.

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REFERENCES

- [1] A. Clemm, L. Ciavaglia, L. Z. Granville, and J. Tantsura, "Intent-Based Networking - Concepts and Definitions," Internet Engineering Task Force, Internet-Draft draft-irtf-nmrg-ibn-concepts-definitions-09, Mar. 2022, work in Progress. [Online]. Available: <https://datatracker.ietf.org/doc/draft-irtf-nmrg-ibn-concepts-definitions/09/>
- [2] C. Li, O. Havel, A. Olariu, P. Martinez-Julia, J. C. Nobre, and D. Lopez, "Intent Classification," Internet Engineering Task Force, Internet-Draft draft-irtf-nmrg-ibn-intent-classification-08, May 2022, work in Progress. [Online]. Available: <https://datatracker.ietf.org/doc/draft-irtf-nmrg-ibn-intent-classification/08/>
- [3] Y. Wei, M. Peng, and Y. Liu, "Intent-based networks for 6g: Insights and challenges," *Digital Communications and Networks*, vol. 6, no. 3, pp. 270–280, 2020. [Online]. Available: <https://www.sciencedirect.com/science/article/pii/S2352864820302418>
- [4] 3GPP, "Management and orchestration; Intent driven management services for mobile networks," 3rd Generation Partnership Project (3GPP), Technical Specification (TS) 28.312, 6 2022, version 17.0.1. [Online]. Available: <http://www.3gpp.org/DynaReport/28312.htm>
- [5] 3GPP, "Architecture enhancements for 5G System (5GS) to support network data analytics services," 3rd Generation Partnership Project (3GPP), Technical Specification (TS) 23.288, 6 2022, version 17.5.0. [Online]. Available: <http://www.3gpp.org/DynaReport/23288.htm>