Layered UAV Slicing Using Machine Learning in SDN-Based UAV Network

Kitae Kim
Kyung Hee University
Email: glideslope@khu.ac.kr

Choong Seon Hong
Kyung Hee Univeristy
Email: cshong@khu.ac.kr

***Abstract*—Unmanned Aerial Vehicle (UAV), originally used for military use, is expected to be used in various fields with the development of communication technology. Research is being actively conducted, such as the deployment of UAV base stations in disaster areas or places where ground base stations cannot be installed, such as at sea and desert. In this paper, we propose a UAV network slice and network slice allocation method for each service type for optimal service provision when a large UAV Swarm is deployed for communication by applying Software Defined Network (SDN) technology to UAV networks.**

***Index Terms*—Unmanned Aerial Vehicle, Software Defined Network, Network Slicing, Q-Learning**

I. Introduction

With the advent of the 5th generation communication, UAV is expected to be used in various fields and research is being actively conducted by many researchers [1] [2]. However, in most UAV studies, the focus is on the optimal placement or trajectory of the UAV, and studies on the method of providing services after placement are insufficient. Therefore, in this paper, we propose a UAV network slicing method and slice allocation method to satisfy various service requirements of users by utilizing UAV Swarm when it is deployed for communication.

A. Two Stage UAV Slicing Method

The system model consists of two layers: UAV SDN Controller and UAV SWARM. The link model between UAVs was modeled with the Free Space Path Loss Model as shown in Equation (1) below. Equation (2) represents the link budget, and Equations (3) and (4) represent the channel capacity and Signal-to-noise ratio(SNR).

$$20log_{10}\frac{4\pi df}{c} \tag{1}$$

$$P_{RX} = P_{TX} + G_{TX} + G_{RX} - PL - L \tag{2}$$

$$C = B\log_2(1 + SNR) \tag{3}$$

$$SNR = \frac{P_{RX}}{\sigma^2} \tag{4}$$

1) First Stage: UAV slicing is performed according to service requirements through data collected from the UAV SDN controller. We consider services that require high bandwidth and low latency.In Equation (3), the channel capacity is larger as the SNR increases. Therefore, the SNR value between UAVs is continuously measured for high bandwidth service. In the case of low-delay service, the transmission delay between links is periodically calculated. Then the SNR and Transmission Delay of the link are set as the weight of the link in the UAV Swarm graph, and UAV slicing is performed through the Traveling Salesman algorithm. In the case of overlapping sections, slice formation for a service with a large service demand has priority.

2) Second Stage: Through Q-Learning, we propose a method to find the location of each UAV that maximizes or minimizes the SNR or Transmission Delay between links within a slice. State for reinforcement learning is composed of each location of UAV and SNR of link and Transmission Delay. The reinforcement learning agent takes the action and creates a policy that derives the optimal position of each UAV in a slice through the process of receiving the reward defined in Equation (5) below according to the service requirements.

$$reward = \begin{cases} SNR, & ServiceType = 0 \\ \\ \frac{1}{TransmissionDelay}, & ServiceType = 1 \end{cases} \tag{5}$$

II. Conclusion

In this paper, we introduce a basic method and concept for hierarchical slicing of SDN-based UAV using machine learning in UAV networks. Through this study, the necessity and importance of UAV Swarm network slicing has been confirmed. In future studies, more detailed research will be conducted in consideration of the actual communication model and KPI that can satisfy the service requirements of 5G.

Acknowledgment

This work was partially supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. No. 2020R1A4A1018607) and by Institute of Information communications Technology Planning Evaluation (IITP) grant funded by the Korea government(MSIT) (No.2019-0-01287, Evolvable Deep Learning Model Generation Platform for Edge Computing). *Dr. CS Hong is the corresponding author.

References

[1] Y. M. Park, M. Lee, and C. S. Hong, "Multi-uavs collaboration system based on machine learning for throughput maximization," in *2019 20th Asia-Pacific Network Operations and Management Symposium (APNOMS)*, 2019, pp. 1–4.

[2] X. Zhang and L. Duan, "Fast deployment of uav networks for optimal wireless coverage," *IEEE Transactions on Mobile Computing*, vol. 18, no. 3, pp. 588–601, 2019.