Yang LI, Ziling WEI, Jinshu SU, Baokang ZHAO, 2024. A multi-agent collaboration scheme for energy-efficient task scheduling in a 3D UAV-MEC space. *Frontiers of Information Technology & Electronic Engineering*, 25(6):824-838. https://doi.org/10.1631/FITEE.2300393

# A multi-agent collaboration scheme for energy-efficient task scheduling in a 3D UAV-MEC space



**Key words:** Multi-access edge computing; Multi-agent reinforcement learning; Unmanned aerial vehicles; Task scheduling

Corresponding authors: Ziling WEI, Jinshu SU
E-mail: Ziling WEI, weiziling@nudt.edu.cn;
Jinshu SU, sjs@nudt.edu.cn
ORCID: Ziling WEI, https://orcid.org/0000-0002-7858-1445;
Jinshu SU, https://orcid.org/0000-0001-9273-616X

# Motivation

- Most works usually assume that the flying height of unmanned aerial vehicles (UAVs) is fixed. Nevertheless, higher flying height means a higher probability of establishing a line of sight (LoS) link between UAVs and ground users. Hence, flying height is a significant element in the edge communication environment. Nevertheless, most of existing works omit the impact of flying height.
- Manually navigating the UAVs with a suitable flight and schedule strategies is extremely difficult. The inappropriate strategies consume much energy and increase the task computation delay. Meanwhile, the UAV's energy is a crucial resource, which directly determines the endurance of flight. Therefore, it is necessary to develop an intelligent module for UAVs to adjust their flight and schedule strategies automatically.

# Main idea

- We present a novel UAV-MEC scenario, which aligns with reality. In this scenario, multiple UAVs dynamically fly in a three-dimensional (3D) space to provide edge services to ground users under the circumstance of co-channel interference. During the cruise of UAVs, they flexibly adjust the flying action, select the sub-channel for communication, and generate proper task scheduling strategies.
- We propose a multi-agent reinforcement learning algorithm to facilitate the state exploration and optimize the overall energy efficiency cooperatively. To fully explore the environment state, a discounted intrinsic reward is considered, motivating the curiosity of the agent. Furthermore, we adopt twin critic networks for stable update to tackle the instability problem of Q value in the critic networks. Hence, each UAV can dynamically adjust its flying strategy and its serving task scheduling strategies to maximize the number of fulfilled tasks with the minimum energy consumption.

# Framework

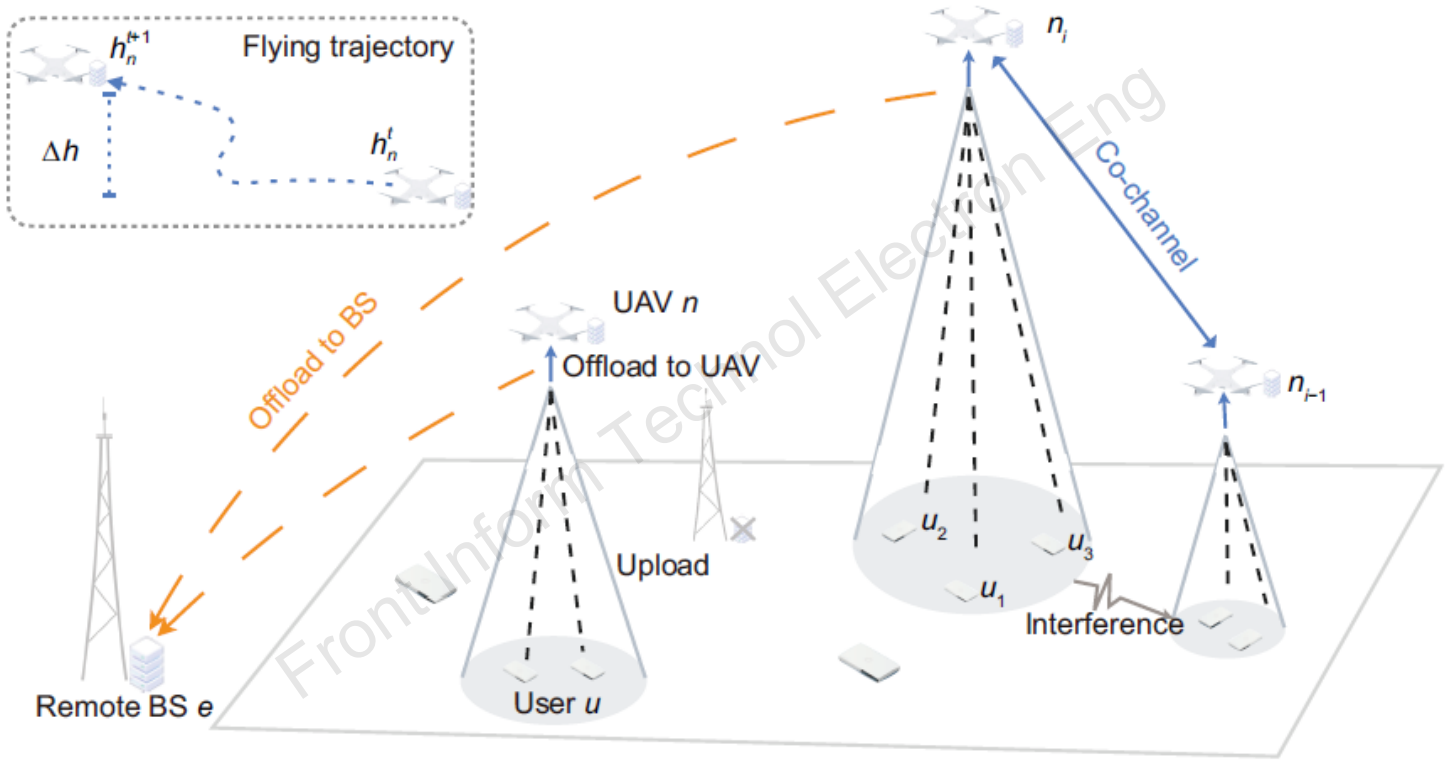


Fig. 1 Schedule scenario of UAVs' flight and users' tasks in a 3D space

# Method

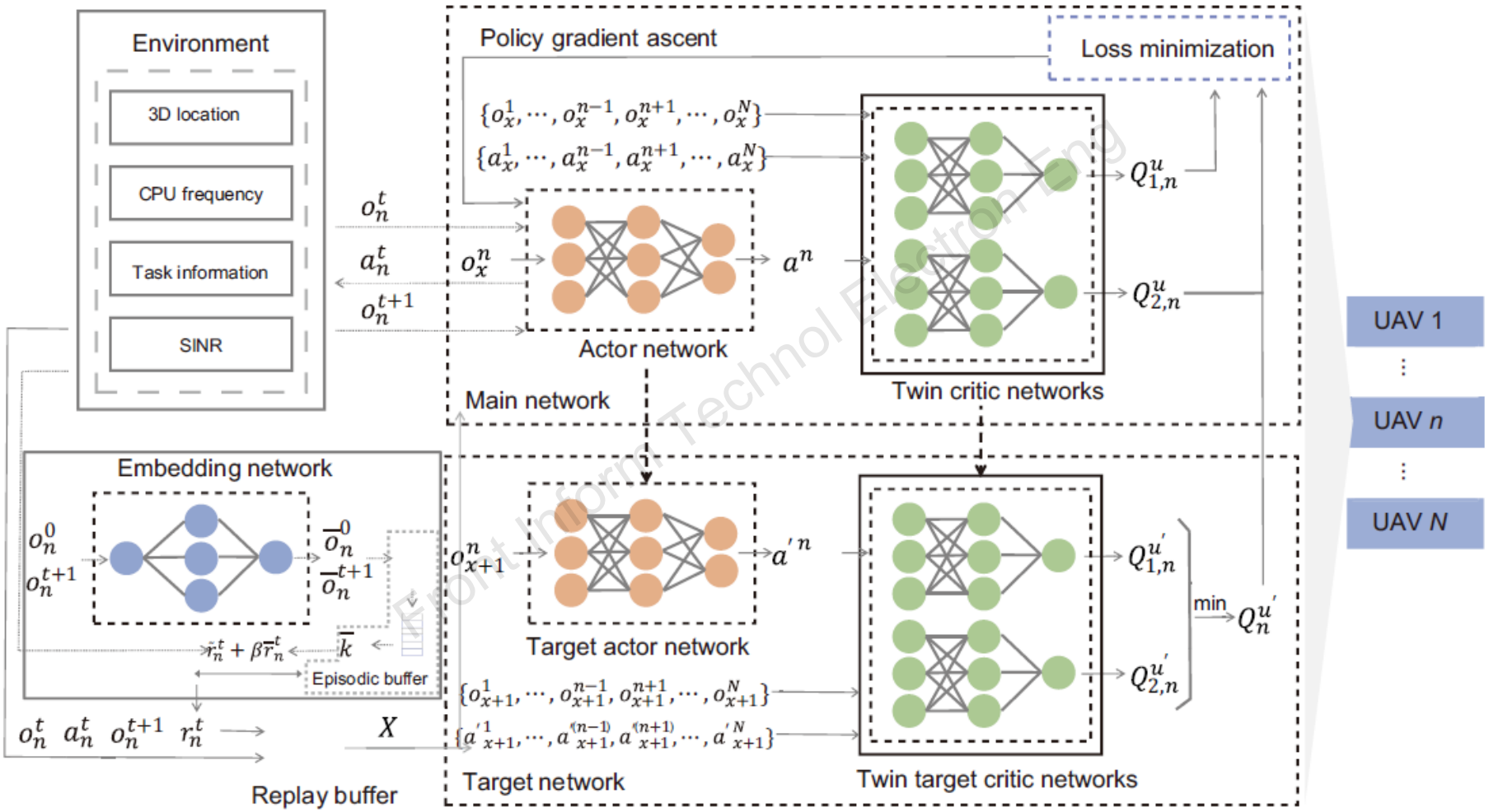


Fig. 2 Procedure of the CTMADDPG algorithm

# Conclusions

In this paper, we present a novel scenario in which the UAVs flexibly fly in a 3D space. They can select their flight actions related to the flying plane, flying angle, and flying velocity. Since the UAVs are deployed to provide computational services to the ground users, they need to make schedule strategies for these users. Besides, the available sub-channels are limited in this UAV-MEC scenario. There exists interference between UAVs, which has an adverse effect on the communication time.

To improve the overall performance, we propose a multi-agent reinforcement learning algorithm, CTMADDPG, to maximize the system energy efficiency. To facilitate the state exploration, we impel agents' curiosity to fully explore the state space, which involves the inner reward. In addition, we adopt the twin critic networks to stabilize the update of the Q value.

Yang LI received her BS degree in software engineering from Fujian Normal University, Fuzhou, in 2016. She received her MS degree in computer science and technology from China University of Petroleum, Qingdao, in 2019. She is now pursuing her PhD degree in College of Computer, National University of Defense Technology (NUDT), Changsha. Her research interests include reinforcement learning and edge computing.

Ziling WEI received his BS and MS degrees in computer science from NUDT, Changsha, China, in 2012 and 2014, respectively, and the PhD degree in electrical engineering from the University of Alberta, Edmonton, AB, Canada, in 2019. He is currently an associate professor with NUDT. His research interests include network security and intelligent network.

Jinshu SU received his BS degree in mathematics from Nankai University, Tianjin, China, in 1985, and the MS and PhD degrees in computer science from NUDT, Changsha, China, in 1988 and 2000, respectively. He is a professor with the College of Computer, NUDT. His research interests include Internet architecture and network security.

Baokang ZHAO received his BS, MS, and PhD degrees in computer science from NUDT, Changsha, China, in 2002, 2004, and 2009, respectively. He is currently an associate professor with the College of Computer, NUDT, Changsha. His current research interests include computer networks, artificial intelligence, distributed computing, and information security.