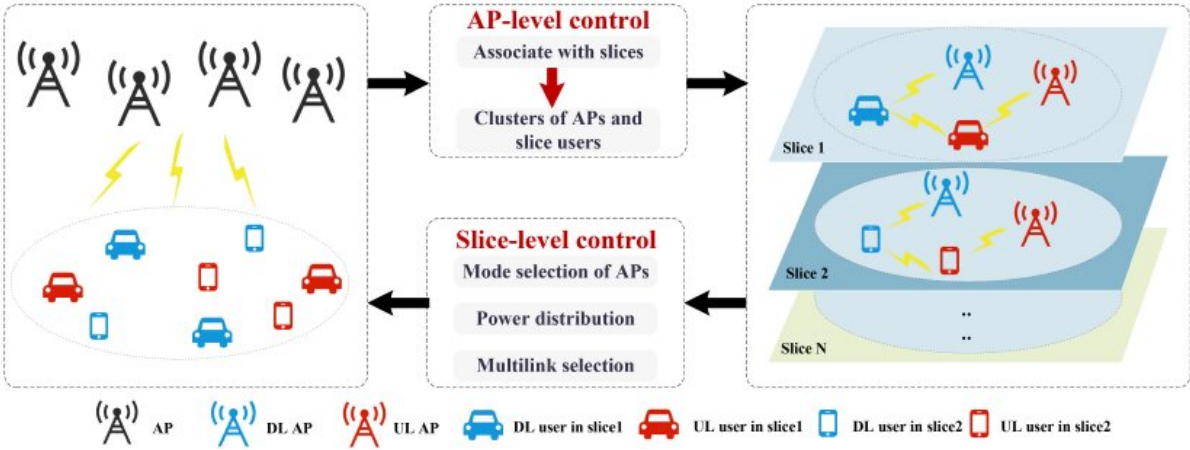


# Slicing capacity-centered mode selection for network-assisted full-duplex cell-free distributed massive MIMO systems

February 15 2023



Slicing capacity-centered NAFD cell-free distributed massive MIMO system.  
 Credit: Science China Press

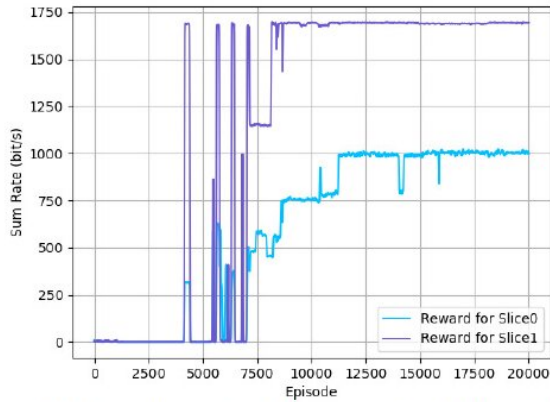
Network-assisted full-duplex (NAFD) systems enable uplink and downlink communications within the same time-frequency resources, so as to avoid the overhead of switching uplink/downlink modes. However, as the number of users and access points (APs) proliferated, mass access brings significant overhead in mode selection.

In addition, the differentiated service demands among users also makes the effective utilization of resources difficult. Combined with network

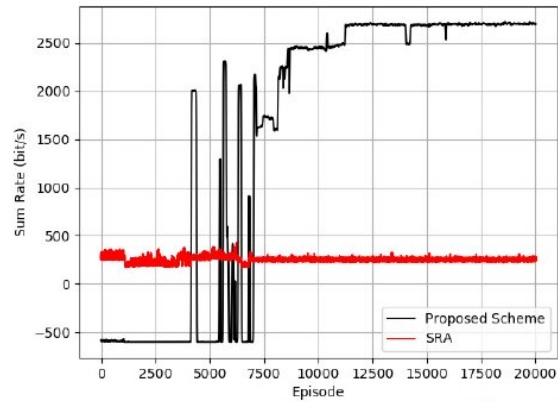
slicing technology, a slicing capacity-centered mode [selection](#) and resource optimization scheme is proposed.

This scheme adopts a double-layer [deep reinforcement](#) learning mechanism, through the clustering cooperation and resource isolation of APs, which not only realizes the adaptive configuration of uplink and downlink resources, but also adapts to the expansion of network scale and responds quickly to environmental changes. Compared with traditional schemes, flexible expansibility and user requirements are effectively taken into account.

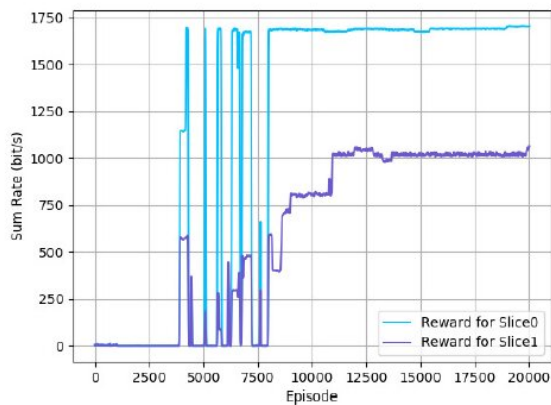
A paper published in *Science China Information Sciences* proposes a slicing capacity-centered mode selection and resource optimization scheme. The combination of network slicing and NAFD technology not only further improves the utilization rate of limited resources, but also satisfies customized services of users. In addition, APs and slices form different subsystems to create a new paradigm for mode selection, which can reduce the cost of collaboration.



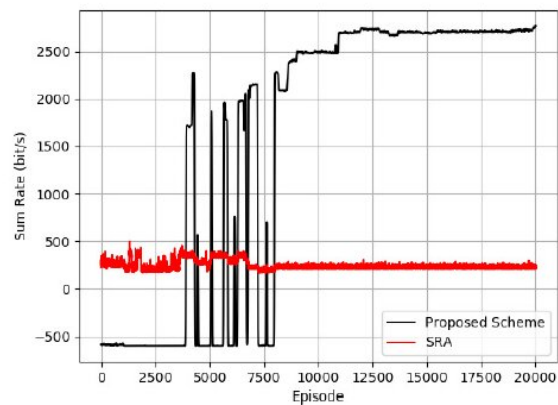
(a) Sum rate per slice (APs associated with slices 2:4)



(b) Sum rate of system (APs associated with slices 2:4)



(c) Sum rate per slice (APs associated with slices 4:2)



(d) Sum rate of system (APs associated with slices 4:2)

Results of the lower-layer control policy under different association schemes between APs and slices in the upper-layer control. Credit: Science China Press

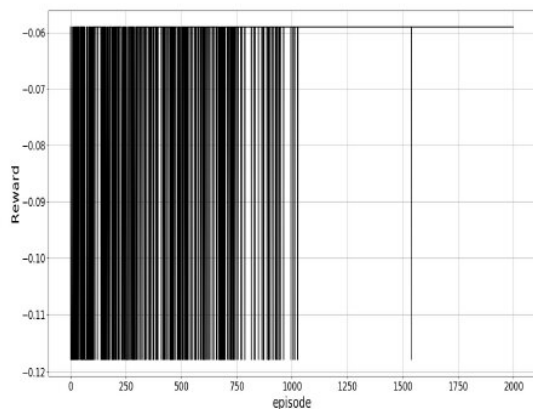
In order to effectively implement the scheme, this paper proposes a double-layer deep reinforcement learning mechanism which can adapt to the long-term trend of slicing demand. The upper-layer uses DQN algorithm to obtain the association scheme between APs and slices according to the feedback information of the lower layer and the traffic state.

The lower-layer realizes mode selection and [resource allocation](#) in each subsystem by MADDPG algorithm according to the upper-layer

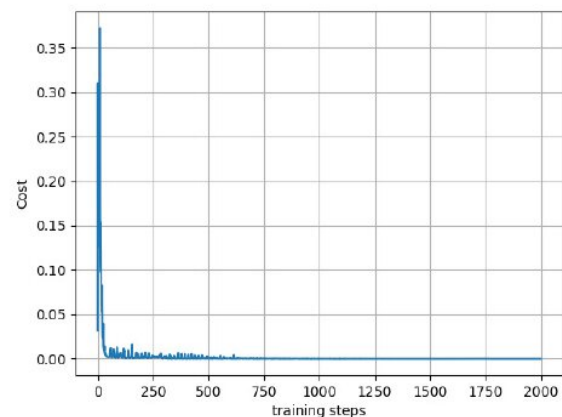
association scheme and local network state. The double layers are coupled and feedback to each other.

The innovations of this paper are as follows:

1. Network slicing is introduced to assist NAFD technique so as to reduce the pressure of contention for resource through resource isolation among users.
2. APs are motivated by slicing requirement to associate different slices to form different subsystems, and mode selection and resource allocation are jointly optimized within each subsystem.
3. Double-layer deep reinforcement learning mechanism is proposed. The upper-layer control policy uses DQN to form flexible duplex AP-slice subsystems. The lower-layer control policy uses MADDPG to select working mode cooperatively and perform radio resources allocation in each subsystem.



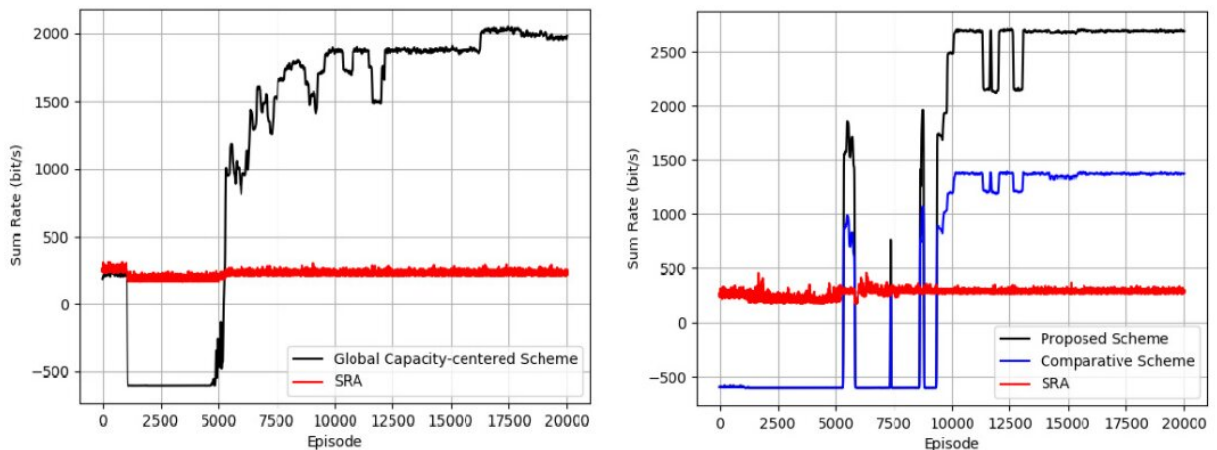
(a) Result of AP-slice association in the upper layer



(b) Cost of the upper-level DQN algorithm

Simulation results of the upper-layer control policy. Credit: Science China Press

The slicing capacity-centered scheme and double-layer deep reinforcement learning mechanism proposed in this paper are verified in the PYTHON platform. Simulation results show that compared with the traditional global capacity-centered scheme, the proposed slicing capacity-centered mode selection and resource optimization scheme not only improves the system performance, but also improves the adaptation of slicing demand and slicing utility to meet the customization requirements of users by optimizing the association scheme between APs and slices.



Sum rate of the global capacity-centered scheme and system convergence and performance comparison of different schemes. Credit: Science China Press

In addition, compared with the static resource allocation scheme and K-means-MADDPG learning mechanism, the double-layer deep reinforcement learning mechanism achieves better system performance through the cooperation between APs, which further proves that the proposed double-layer deep reinforcement learning mechanism realizes real-time optimization of the network through mutual feedback between

the upper and lower layers.

**More information:** Wang J et al. Slicing capacity-centered mode selection and resource optimization for network-assisted full-duplex cell-free distributed massive MIMO systems, *Science China Information Sciences* (2023). [DOI: 10.1007/s11432-022-3697-x](https://doi.org/10.1007/s11432-022-3697-x)

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