Platform Profit Maximization for Space-Air-Ground Integrated Computing Power Network Supplied by Green Energy

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***Abstract*—The rapid expansion of computing needs from emerging applications pushes a large amount of deployment of computing infrastructures and corresponding energy cost and greenhouse gas emissions of computing generate great concern. In this paper, we study how to maximize the platform profit by optimizing task scheduling in the Space-Air-Ground integrated Computing Power Network supplied by green energy while considering both the user requirements and dynamics of green energy. First, we formalize the problem as a binary integer linear programming problem that is NP-hard. The problem is then further modeled as a Markov decision process. Considering the dual dynamics of user requests and the generation of green energy, we propose a task scheduling strategy based on deep reinforcement learning, which can predict power generation based on the current operating status of each hydroelectric power station and also provide a scheduling strategy. Extensive experiments demonstrate that the proposed algorithm performs better than the baseline algorithms.**

I. Introduction

With the bloom of artificial intelligence (AI) applications (e.g.augmented reality, objective recognition, video processing, etc. [1], [2], [3]) and development of industrial Internet of Things, traditional network technology with separating network and computing [4], [5] has become inefficient in meeting the requirements of computationally intensive and latency critical tasks for these applications due to the potential mismatch of resource allocation and also resulted in low utilization. In addition, training of AI model (e.g. large language model [6]) brings unprecedented computing demands. A promising technology to address the challenge mentioned above is the Space-Air-Ground Integrated Computing Power Network (SAGICPN) [7], [8], which integrates the communication network with heterogeneous computing resources including edge servers, cloud servers, and satellite servers to offer application-requirement-oriented task scheduling. This integration is not limited to terrestrial networks, but extends to space and air networks, providing a comprehensive solution for the efficient allocation of computing resources.

However, enormous energy consumption is consumed and huge amount of carbon emission is released due to the massive computing of diversified tasks. Electricity cost places great pressure on computing power service providers and increases the price of service for users. Additionally, an increase in carbon emission can be damaging to the environment. Taking these issues into consideration, hydropower is an effective solution that can be introduced to SAGICPN [9].

As a supplementary energy source to commercial thermal power, hydropower is green and low cost. However, it is also characterized by unstable power generation and deployment location dependent on the distribution of natural resources [10]. In addition, the power generated by hydropower will be dropped without being used because of the lack of practical storage medium. The system platform works to schedule the tasks to the servers whose profit equals the income of task processing minus the energy cost and time occupation cost.

As a result, it is of great significance to maximize the platform profit for the SAGICPN equipped with hydropower supply by optimizing the task scheduling and resource allocation considering the effective usage of hydropower.

In this paper, we study how to maximize the platform profit by optimizing task scheduling in the SAGICPN supplied by hydropower while considering the dynamic characteristics of both the user tasks and the generation of hydropower with task requirements satisfied. First, we formalize the problem as a binary integer linear programming problem that is NP-hard. The problem is then further modeled as a Markov decision process.

Considering the above dual dynamics, we propose a DRL-based Task Scheduling strategy for the SAGICPN Supplied by green energy to learn the corresponding patterns and achieve optimized scheduling decisions. Extensive simulations are conducted and the results show the high performance of the proposed algorithm.

II. Related Work

Task scheduling plays an important role in CPN for supporting efficient resource utilization and improved quality of service satisfaction at user side. In this section, we present a brief review of existing work related to task offloading in computing power networks equipped with energy harvesting devices.

Ref. [11] investigates traffic offloading in heterogeneous small-cell networks, small cells are powered in a hybrid way including both the conventional commercial power supply and renewable energy harvested from the environment. The authors propose a joint optimization of traffic scheduling and