Deep Reinforcement Learning Based Multistage Profit Aware Task Scheduling Algorithm for Computing Power Network

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***Abstract*—Computing power network (CPN), which integrates heterogeneous computing resources and communication network, can tackle the challenges brought by the pervasiveness of mobile and Internet of Things applications. In this paper, we study the optimization of task scheduling in a CPN network by considering the unbalancing between task distribution and resource cost. The design objective is to maximize the system profit while satisfying tasks' delay requirements. We formulate this problem as an integer programming problem. To address this NP-hard problem, we propose a Deep Reinforcement Learning (DRL) based multistage profit-aware task scheduling algorithm which first makes coarse grained task allocation using DRL among regions and then determines an optimized intra-region task assignment by using profit-aware balancing algorithm. Extensive simulations are conducted for performance evaluation and the results show the high performance of the proposed algorithm as compared with baseline algorithms.**

I. Introduction

With the development of Internet of Things (IoT) [1] and the explosion of various applications based on artificial intelligence technology, such as AR [2], VR [3], object recognition [4], etc., a large amount of computation-intensive and data-intensive tasks have to be offloaded to powerful computing resources in the Internet for processing while meeting their quality of service (QoS) requirements. However, the spatial mismatch between task distribution and computing resources poses a great challenge to the development of such applications and also the efficient resource utilization [5]. Computing Power Network (CPN) [6], [7] is a promising technology to tackle the above challenge, which integrates heterogeneous computing resources and the communication network to provide application-requirement-oriented task scheduling.

The spatial mismatching between task distribution and computing cost in CPNs has big impact on the resource allocation and task offloading. In reality, resource cost is high in eastern China where there are a lot of task requests. In contrast, the situation is the opposite for western China. Taking these factors into account, a key project named "East-to-West data computation" has been initiated for the construction of a CPN, which is to guide the demand for computing power from East China to the West by optimized task scheduling while respecting applications' QoS requirements, while reducing the system cost and also improving the resource utilization efficiency.

In this paper, we study how to achieve optimized task scheduling in such a CPN network by considering the spatial difference between task distribution and resource cost. The design objective is to maximize the system profit while satisfying tasks' QoS requirements. We formulate this problem as an integer programming problem. To address this NP-hard problem, we propose a Deep Reinforcement Learning (DRL) based multistage profit-aware task scheduling algorithm, which first makes coarse-grained task allocation using DRL and then further tunes the task assignment by using profit-aware balancing algorithm. Extensive simulations are conducted and the results show the high performance of the proposed algorithm.

II. Related Work

In this section, we present a brief review of existing work related to architectures of CPNs and task scheduling in CPNs.

The architecture and applications of CPN have been studied. Ref. [8] modelled the computing power resources in a CPN from an operator's perspective and quantified both the computing and storage resources as well as the transmission time for wireless and wired connections, respectively. Ref. [9] developed a testbed of CPN based on Kubernetes with microservice architecture, which realizes a lot of key enabling technologies of CPN such as computing modeling, computing awareness, and computing offloading. Ref. [10] proposed a CPN framework called Net-in-AI for ubiquitous AI, which was aimed to establishing a networking pool for AI computing power and it focuses on the system adaptability, flexibility, and profitability.

Task scheduling plays an important role in CPN for supporting efficient resource utilization and improved QoS satisfaction at user side. Ref. [11] studied the task scheduling for the multi-user case by considering the task queue statuses and available resources at user side. The authors accordingly designed a deep reinforcement learning based algorithm for efficient task