Federated Deep Reinforcement Learning for Continuous Improving Intradependente Task Offloading in Mobile Edge Computing Network

Abstract

Mobile edge computing often suffers from the dynamic and unknown nature of the environment such as time-varying conditions, heterogeneous devices, and frequent communication requests, imposing significant challenges on improving system performance. To meet the rapidly growing demands of computation-intensive and time-sensitive applications, Reinforcement learning [1] has been proposed as an effective tool to establish low-latency and energy-efficient networks. RL enables network entities to interact with the environment and learn an optimal decision-making policy, usually modeled as a Markov decision process [2].

Introduction

Mobile Edge Computing is emerging as a promising paradigm to enhance the computational capacity of mobile devices by offloading tasks to nearby edge servers. This paradigm aims to reduce latency, energy consumption, and improve Quality of Experience (QoE) for end-users. However, one of the major challenges in MEC is the efficient decision-making process for computation offloading, considering the dynamic nature of the network, user demands, and limited resources. Traditional offloading strategies, which often rely on heuristic or single-agent models, fail to capture the complexity and stochastic nature of modern MEC systems.

Motivation: Federated Reinforcement Learning extends traditional DRL by allowing multiple agents to collaboratively learn a global policy without sharing their local data directly. Each agent makes decisions based on its local observations while cooperating with others to achieve shared system goals. In a Mobile Edge Computing (MEC) environment, edge devices can independently train DRL models using their local data and periodically send updates to a central server. The server aggregates these updates to build a global model, optimizing task offloading across the network.

Problem Statement:

- **Dependency-Aware Task Partitioning**
  - Incorporate a **Task Call Graph Representation** to account for dependencies among tasks, improving task model accuracy and partitioning effectiveness.
- **Federated Deep Reinforcement Learning**
  - Leverage federated learning for mobile devices in training process.
  - Enable mobile devices to collectively contribute to enhancing the offloading model.
  - Support continuous learning as new mobile devices join the network.

Problem Model:

Research Methodology

1. **Algorithm Design:** Developing a federated deep reinforcement learning framework for optimizing interdependent task offloading in MEC networks, using teqnics such as DQN or DDPG, which enable network entities to collaboratively learn and adapt offloading strategies without compromising user privacy.
2. **Simulation Environment:**
3. **Key Challenges:** (a) Communication efficiency, (b) Heterogeneity

References

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[2] M. L. Puterman, *Markov decision processes: discrete stochastic dynamic programming*. John Wiley & Sons, 2014.