

# A Cloud QoS-driven Scheduler based on Deep Reinforcement Learning

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## Abstract

Task scheduling is one of the most challenging issue in cloud management. Because it is a decision-making problem, Reinforcement Learning has been utilized by several works to build an intelligent and efficient cloud task scheduler. However, while resources utilization was used as the key factor to schedule task in most studies, another crucial requirement for cloud task scheduling which is tasks' Quality-of-Service (QoS) guarantee has not been approached yet. Therefore, in this paper, we present a Deep Reinforcement Learning-based task scheduler which focus on QoS guarantee.

## I. INTRODUCTION

Nowadays, utilization of artificial intelligence in cloud management is becoming a trend and attracting lots of attention from researchers. Service scheduling or task scheduling is one of the most challenging area that can benefits from artificial intelligence models. Because the nature of this problem is a decision-making problem, Reinforcement Learning is the most suitable and ideal machine learning algorithm for the job. In general, Reinforcement Learning learns to choose the optimize action based on previous system states. By calculating the reward value after performing each action, reinforcement learning model will gradually converge and finally can provide best action for each input system states. With problems that have large state and action space such as task scheduling, Deep Learning can be used to empower Reinforcement Learning to learn faster.

There are several works that have utilized Reinforcement Learning for Cloud task scheduling problems. [1] schedules task based on optimizing usage of CPU, RAM, bandwidth and disk storage. [2] focus on achieving highest resources utilization and balancing it between clusters in multi-cluster cloud environment. [3] tries to minimize task execution time. However, task QoS time guarantee has not been mentioned in any reinforcement learning works so far. Considering service's QoS is a crucial requirement in 5G network, task scheduling algorithm should also take care of it.

In this paper, we present a cloud QoS-driven task scheduler based on Deep Reinforcement Learning, which utilize this machine learning technique to minimize the number of worker nodes needed to be created to guarantee all tasks can be accomplished before their specified deadlines.

## II. DEEP REINFORCEMENT LEARNING

In this part, we briefly introduce the technique of deep reinforcement learning.

Reinforcement Learning is the process of learning that generates an optimal action based on a given state of a dynamic environment. At each time step  $t$ , the system observes the environment and pass some state  $s_t$  as input to the agent. The agent will then choose to execute an action  $a_t$ . The chosen action will transit the environment to the new state  $s_{t+1}$  and the reward value  $r_t$  will be calculated to evaluate action  $a_t$ . The goal of learning is to maximize the expected cumulative discounted reward.

Q-Learning is a popular reinforcement learning method. The Q-Learning consists of an agent, a state set  $S$ , an action set  $A$ , a definition  $T$  of how actions change the environment, a set of rewards  $R$  for each actions, a table of utilities  $Q$  and a policy  $\pi$  that decides how to choose an action based on current states. The Q-Learning method aims to maximize the reward by choosing the best action taken from each state. After training multiple episodes, the policy  $\pi$  will be optimized by evaluating the reward value from each action.

Deep Q-Learning is the technique of combining Deep neural network and Q-Learning, which is proposed by Google DeepMind [4]. By using a function to replace  $Q$  table with  $Q$  value, the network can solve the problem that has huge and continuous dimension state and action space. It also helps Reinforcement Learning model to converge quickly and generate good output actions. In our design, we use Deep Q-Learning as the deep reinforcement learning technique for our QoS-driven task scheduler.

## III. ARCHITECTURE DESIGN

We design the system architecture by defining the states space, actions space and rewards of the reinforcement learning model. The overall

architecture of the Deep Q-Learning QoS-driven task scheduler is illustrated in Figure 1.

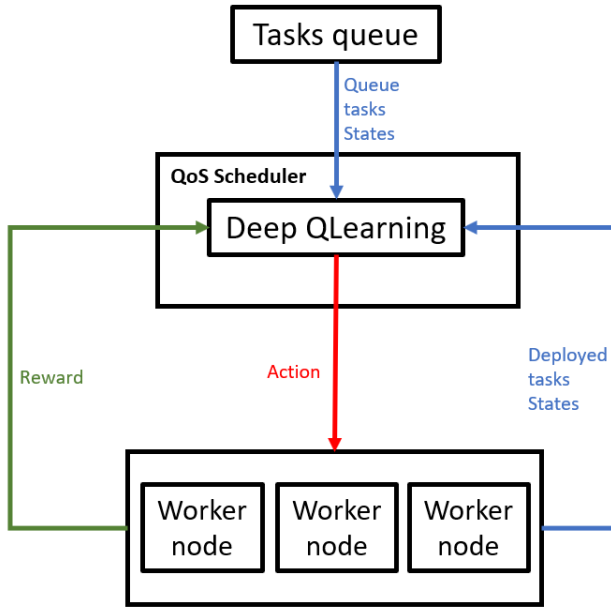


Figure 1. Deep Q-Learning QoS driven task scheduler overall design

### 1. States:

We define the environment state of the system as a one-dimensional vector, which includes the set of current deployed tasks' remaining time and used resources at each worker node  $S_n$  and set of queued tasks with their QoS time requirement, required resources  $S_q$ . At each time step  $t$ , the environment state is defined as  $S^t = [S_n, S_q]$ . For  $S_n$ , considering  $M$  nodes,  $J$  current deployed tasks each node, the states of each task are  $R_{jm}^t$  for used resources and  $T_{jm}^t$ . For  $S_q$ , considering  $Q$  tasks in the queue, each task has two states  $R_q$  and  $T_q$  represents its required resources and required QoS time.

### 2. Actions:

Actions are defined as the decision to pick a task in queue and place it on a worker node. The agent is activated for each second. Considering task  $q$  in  $Q$  tasks in the queue and node  $m$  in  $M$  worker nodes. The action is defined as  $\{q, m\}$ . If a new node need to be initiated to deploy a task then the node is defined as  $M+1$ . If at time step  $t$ , the agent decides to keep all tasks in the queue and no deployment is needed then the action is defined as  $\{0, 0\}$

### 3. Reward:

The goal of scheduling is to minimize the number of nodes needed to be initiated to guarantee all tasks can be finished before their deadlines so the reward value will be the number of new initiated nodes.

## V. CONCLUSION AND FUTURE WORKS

This paper presents the design of the QoS-driven Deep Reinforcement Learning-based task scheduler. The designed scheduler shows abilities to minimize the number of worker nodes needed to be created to guarantee all tasks can be accomplished before their specified deadlines. In the next version of this work, we plan to include our training algorithm, implementation and performance analysis of the scheduler.

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