Exploration and practice of Computing Power Network(CPN) to realize convergence of computing and network

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Abstract: For the optimum leveraging of the distributed computing, network and storage resources in the network with edge computing, we proposed a novel network technology-Computing Power Network (CPN) for the convergence of computing and network resources. © 2022 The Author(s)

1 Introduction

With the development of 5G, artificial intelligence, new services including industrial network, internet of vehicles, smart city and so on are developing rapidly. These new services also have higher requirements on bandwidth and latency. In recent years, there has been considerable research and practice on the network with Multi-Access Edge Computing (MEC) which is a technology aiming at reducing the access and transport latency by building distributed edge computing nodes. However, it is difficult for the users to wisely choose the computing resources (core and/or edge nodes) and corresponding network connections to meet their requirements on performance and cost. To solve these problems, we proposes a novel network technology- Computing Power Network (CPN), which realizes the optimum resource allocation by distributing computing, storage, network and other resource information of the service nodes through the network control plane (such as centralized controller, distributed routing protocol, etc.). It considers the network conditions and user requirements to provide the optimal distribution, association, transaction and scheduling of computing, storage and network resources, improves service quality and the utilization rate of resources. [1]

2 Functionality of CPN

CPN collects and distributes the information of the network, computing and storage resources, and provide the users latency properties and computing power properties of the computing nodes around the users by generating a computing power transaction view shown in Figure 1. The view presents the computing power of the computing nodes and the latency from those nodes to the users so that the users can choose the optimum resources.

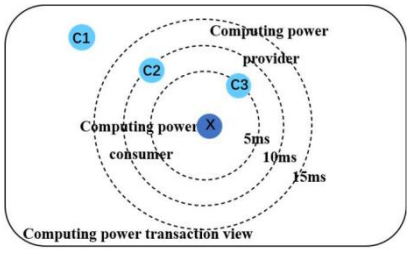

Fig. 1. CPN transaction view

This mechanism helps the users find the computing nodes with sufficient computing power and save a large amount of investment in traffic acquisition cost. The computing power providers can also take advantage of CPN to expose their computing assets to the users to make profits from their computing assets. In order to achieve the functions described above, we proposed a function architecture of CPN in ITU-T Y.2501[2] which is depicted in

Figure 2. It consists of four layers which provide the aforementioned functionalities by interacting with themselves.

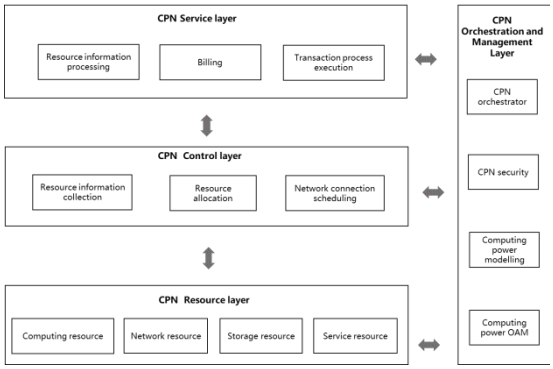

Fig. 2. Computing power network functional architecture

With the coordination of the CPN orchestration and management layer, CPN control layer (realized by CPN control plane) collects the information from CPN resource layer, and sends it to CPN service layer for further processing. After receiving the processing results from CPN service layer, CPN control layer occupies the resources and establish network connections. Then the CPN service layer can realize the functions of CPN transaction and billing after receive the information from the CPN control layer.

3 Key technologies of CPN

3.1 Computing power measurement

Quantification of computing power is the prerequisite of achieving the functionalities of CPN. Considering the different type of computing power (CPU, GPU, FPGA and ASIC etc.) [3], it is necessary to find a unified measurement for those heterogeneous computing power and demand on computing power of different services. In existing practice, VM and container are widely regarded as the basic unit of computing power.

3.2 Computing power awareness

Computing power awareness refers to the acquisition of the information of computing resources in the network and the awareness of the demands of the users. There are two schemes: firstly, the computing resource providers provide the resource information to the users through the network or resource management system; secondly, the network is enabled to detect the available computing resources in the network.

3.3 Computing power routing

CPN can integrate and spread the network resource information and computing resource information through the network by computing power routing. There are three solutions for computing power routing: centralized solution, distributed solution and hybrid solution. In distributed solution, CPN extend the IP protocol to contain the resource information (such as computing power, delay, jitter, etc.) and the demands, and spread them through the network. In centralized solution, CPN leverages centralized control unit, such as SDN controller, for network and computing power information collection. The hybrid solution combines centralized and distributed solution, distributes resource information by using distributed protocol and achieves the resource scheduling, allocation and transaction by centralized processing. [4]

3.4 Computing power transaction

With the development of the intelligent services, the demand and usage of computing resources become dynamic and change frequently. Therefore, the traditional method of resource renting on a daily or monthly basis cannot meet the requirements, hence the transaction system should be designed so that the transaction period can be shrunk.

3.5 Computing power orchestration

Computing, network and storage resources need to be provided quickly according to the transaction content. The computing resources need to be allocated quickly, while the network connections need to be established. Hence, the resources can be released quickly and the resource information can be updated.

4 The practice of CPN

To better illustrate the proposed mechanism of CPN and show its advantages, we implemented CPN on intelligent picking robot. The picking robot has higher requirements on computing power and deterministic network connections to accurately control the mechanical arms in real time. The traditional solution is deploying the computing tasks on the industrial computer embedded on the robots, by which the adjustment process of the production technique will be slow. With CPN, the AI training part of the robot can be deployed in centralized computing power pools with huge computing power (such as computing centers) to perform complex computing processes offline, while the reasoning modules, for example, the module recognizing the specified products on the shelf, can be deployed on the MEC nodes to reduce latency.

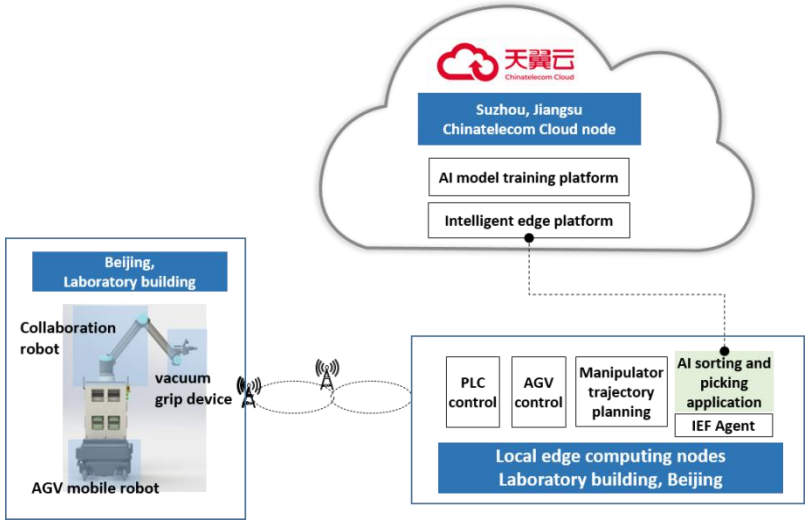

Fig. 3. The scenario of intelligent picking robot with CPN

5 Conclusion

We propose a new type of network technology- Computing Power Network, which realizes the best resources selection and flexible scheduling for users. Compared with traditional solutions, CPN can integrate the computing power of cloud, edge and terminal and improve the resources utilization rate, also meet the latency and computing power requirement of emerging services. Future work will focus on the research on the key technologies of CPN to achieve the integrated service provision of network and computing resource.

6 Reference

[1] Bo Lei and Qianying Zhao, “CPN: A joint Optimization Solution of Computing/Network Resources,” Frontiers of Data & Computing, 2020, vol. 2, pp.53-62.

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