Design and Realization of Cloud Service Training Platform for Intelligent Unmanned Aerial Vehicle Interaction with Edge Computing

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Abstract: In view of the common problems of low resource utilization efficiency and high user demand in the operation of the current Unmanned Aerial Vehicle (UAV) interactive cloud service training platform, this paper used edge computing technology to build a network oriented UAV cloud work platform, and provided it as a service mode to users on the network. Firstly, the input devices on the user end were virtualized to have a unified standard. Secondly, the control strategy of the UAV was studied, and the user's input was matched with the actual actions of the UAV. Finally, using technologies such as speech recognition and finger manipulation, combined with multi-channel fusion algorithms, a natural and efficient multi-channel human-machine interaction was achieved. This article categorized and summarizes the existing boundary intelligent computing technologies based on UAV from the perspective of time delay, and analyzes and predicts the future development trends. This paper tested the delay performance of edge computing and cloud computing. Under the condition of large resource load, the average response speed of the edge computing cloud platform system was 2.26 seconds. This showed that the design and implementation of intelligent UAV interactive cloud service training platform based on edge computing is more practical.

Keywords: UAV Interaction Cloud Service, Practical Training Platform, Edge Computing, Cloud Computing

1. Introduction

Today, with the popularization and rapid development of information technology, cloud has become a cutting-edge technology. In the process of using information technology, schools should combine it with the needs of students in UAV training to fully understand the functions of cloud computing, and actively build a computer teaching platform to improve teaching quality and overall improve the performance and practical use level of UAV training platforms. Cloud computing has a strong function in the teaching and practical teaching of computer basic technology, so teaching platforms should be built on the basis of cloud computing. By utilizing cloud computing teaching platforms, students can not only improve learning efficiency with

ICSETPSD 2023, November 17-18, Coimbatore, India

DOI 10.4108/eai.17-11-2023.2342819

half the effort, but also proficiently master the teaching skills of the course, and greatly improve the teaching quality of UAV training.

Experts have long conducted relevant research on interactive cloud service platforms. Due to the COVID-19 pandemic, many robot competitions have been cancelled in the past few years. To address this issue, Mizuchi Y proposed a cloud based VR (Virtual Reality) platform for showcasing human robot interactions in competitions. However, the system only proposed the feasibility of competition application, and the actual competition has not yet been held and implemented. Therefore, through demonstration experiments conducted in a mixed format of on-site and remote participation at the Robotics Competition of Asia Pacific (RCAP), he evaluated the practicality of using cloud computing on AWS (Amazon Web Services) from the perspective of whether delay time can cause human-machine interaction problems in VR environments [1]. Megalingam R K proposed an implementation method for a human-machine interactive autonomous navigation platform, which can be used to serve robots and avoid difficulties faced by people in daily activities. He used a robot operating system framework to implement algorithms used in automatic navigation, speech processing and recognition, as well as object detection and recognition. He designed a suitable robot model and tested it in the Gazebo environment to evaluate these algorithms. The confusion matrix created based on 125 different situations indicates that the model is correct [2]. Aivaliotis S introduced an augmented reality software designed to support operator interaction with flexible mobile robot workers. The developed augmented reality suite is integrated with the digital twin system in the workshop, providing operators with the following: a) virtual interface: this can facilitate their programming of mobile robots; b) Information about processes and production status; c) it can enhance safety awareness by overlaying active safety zones around the robot; d) instructions for recovering the system from unexpected events. The purpose of this application software is to simplify and accelerate industrial manufacturing processes. It uses a simple and intuitive way to interact with hardware, without requiring special programming skills or long-term training for human operators. The suggested software was developed for Microsoft's HoloLens hybrid reality headdisplay, integrated with the robot operating system, and tested in a case study in the automotive industry [3]. The above research techniques are not mature enough and their practicality is not strong.

Edge computing aims to transfer a large amount of computing load to the edge server, while the edge intelligent computing of unmanned aircraft aims to give full play to its advantages of high mobility and easy deployment to achieve efficient and convenient boundary computing for surface users. In addition, UAV can also serve as user nodes, transferring a large amount of computing tasks to edge servers for completion.

2. Edge Computing and Cloud Computing

2.1 Introduction to Edge Computing

Edge computing is a technological innovation centered on user networks [4-5]. To achieve network edge computing, a micro embedded device must be placed at the edge of the network to collect and process data, and then the user's smart devices (such as smart phones, computers, etc.) would transmit the data to the gateway. The gateway then performs calculations, analysis, processing, filtering, and other processing on the data, and finally sends the data back [6]. Through this approach, massive amounts of raw data can be directly stored on the boundary without the need to be transmitted to the cloud, saving huge network overhead and alleviating bandwidth pressure [7].

The concept of cloud computing has been put forward and developed for more than ten years. The shortcomings of cloud computing itself and the development of new industries have simultaneously promoted the proposal and progress of edge computing [8]. In the first decade of the 21st century, due to the small amount of terminal data, all data could be transmitted through wired or base stations, and the infrastructure could ensure the safe transmission of all data to the destination; However, since the second decade, the network has entered the era of information explosion. The development of terminal equipment, especially the huge number of Internet of Things (IoT) equipment, has overwhelmed the network infrastructure. The infrastructure construction and the growth of data transmission volume have been disproportionate, and the success rate of data transmission has been affected to a certain extent. Therefore, the concept of edge computing came into being. Edge computing can rely on edge devices to undertake some functions of cloud devices, reducing data transmission and improving the transmission efficiency of the Internet [9-10].

2.2 Introduction to Edge Computing Gateway

In the four layer architecture of the distribution IoT, the edge computing gateway belongs to the edge computing layer equipment, which is responsible for accessing the terminal nodes of the end device layer such as meters, missing guarantees, sensors, and so on. At the same time, it cooperates with cloud applications to implement edge computing, bringing the terminal nodes into the management of the cloud platform, and forming a special purpose distribution IoT solution, as shown in Figure 1 [11].

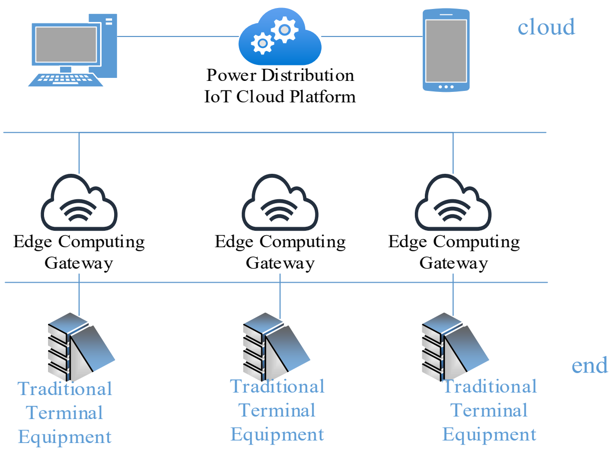

Fig 1. Distribution IoT solution structure with edge computing gateway

Compared with general LAN (Local Area Network) communication gateways, its significant difference is that it includes application scenarios of public networks, requiring comprehensive consideration of the communication cost, reliability, and security of public networks [12-13]. This gateway not only provides basic data transmission capabilities, but also has computing capabilities, which can flexibly provide cloud computing services to terminals according to user needs [14].

3. Design and Implementation of a Training Platform for Cloud Computer Systems

The cloud training platform is based on a set of virtual resources and achieves functions such as data storage, data virtualization, and online learning. The system includes 12 servers, 3 storage servers, and 2 gigabit central switches, which can better meet the needs of different businesses [15].

3.1 Core Components and Functions of the Training Platform

At present, the biggest challenge in building a training platform is computer hardware, and improving the software architecture can enhance the application of cloud technology on the training platform [16-17]. Computer hardware includes system servers, storage hardware, and other network devices. For hardware optimization in the cloud computing environment, it is proposed to use high-performance servers, high-quality network bandwidth, leasing, and other methods to improve hardware performance in the cloud computing environment, At the same time, considering the problems existing in practical applications, a plan is proposed to upgrade the computing hardware in the cloud computing environment in practical applications, Considering the actual needs in practical applications, corresponding hardware facilities can be purchased and timely updates can be made to core servers, cloud servers, etc. [18].

3.2 Cloud Storage Technology

Cloud computing is a virtualized training space where students' learning activities are stored in the cloud. It can ensure that each student has an independent learning environment, thereby achieving the independence of student learning activity records and ensuring the continuity of practice during the training period.

A. When a user starts a virtual machine resource, the system would establish an incremental mirror resource for the virtual machine based on the corresponding parent resource. The system would automatically create an incremental image based on the corresponding parent resource required by the user.

B. Each parent resource is provided with its own incremental mirror, enabling each user's experimental environment to be independent of each other. Experimental operations can be maintained in real-time, and correlations between experimental objectives can be achieved.

C. Incremental images separate the experience of each user from the main resources. Incremental mirroring technology can compare the behavior of each user with the original data, saving a lot of memory.

D. The open, reusable, and scalable features of this system provide support for other fields such as scientific research.

E. The training virtual cloud platform is an open platform that allows teachers to add their own training content, computing, and storage resources. A VR-based training platform based on cloud computing virtualization technology can achieve flexible configuration of various resources as needed. This system has the characteristics of openness and reusability, allowing users to fully utilize the software and hardware resources in the system to conduct research on related research topics and support experimental environments in other disciplines. At the same time, the abundant teaching resources possessed by this system can also become a high-performance computer, providing convenience for scientific research work.

3.3 Access and Access to the Training Platform

The system adopts a B/S (Browser/Server) architecture, which places all learning resources and learning environment on one server without the need for students to install them themselves. In this way, students do not need to set up a learning environment locally. What users need to do is to ensure that the network and visual environment can be directly accessed from the website, and then start the virtual machine on the server group to conduct experiments. By using targeted software, users can access virtual desktops through mobile phones, computers, and other means. As long as they enter their personal account, they can access internal information at any time to meet the requirements of practical training [19]. In addition, users also break free from the limitations of the campus network and use methods such as 5G network to access virtual desktops and conduct practical training operations at any time.

4. Delay Performance Test of Edge Computing and Cloud Computing

The research object of this study is the response delay analysis of regular processing in cloud and edge computing. Using the control variable method, the number of devices is set to 1. The device data transmission frequency is set to the time when the trigger command is issued, and the processing response delay analysis is conducted in the cloud and edge settings for single device single rule situations, single device 30 rule situations, and large resource load situations. The experimental results are shown in Figures 2, 3, and 4. In this experiment, the calculated reaction time is from the moment when the cloud and edge receive device data to the moment when the executor returns a state change.

When performing computation offloading, time delay refers to the sum of the transmission time of offloading data to the MEC (Multi-access Edge Computing) computing node, the execution processing time at the MEC computing node, and the transmission time of receiving data results from the MEC computing node. Due to the fact that the size of the calculation result is much smaller than the original task, the return time of the calculation result can be ignored.

In this article, during the i-th time slot, if the q-th ground user needs to unload the task to the UAV training platform for processing, the UAV calculates the delay time required to complete all tasks as follows:

$$t_{iq}^{c} = \frac{b_{iq}}{r_{iq}} \tag{1}$$

Among them, b_{iq} is the number of bits for the q-th ground user offloading task within the m-th time slot, and $b_{iq} = U_{iq} N_b$.

Queue waiting delay t_{iq}^{w}: the task unloaded to the UAV follows the FCFS (first come first service) processing principle, and can only handle one task unloaded by ground users at a time. Therefore, the required queue waiting delay for unloaded tasks is the start processing time of the task minus the arrival time of the task.

Task processing delay t_{iq}^{p} is:

$$t_{iq}^{p} = \frac{b_{iq} C}{f_u} \tag{2}$$

Among them, C is the number of CPU cycles required to calculate each bit of task, and f_u is the processing capacity of MES (Manufacturing Execution System) on the UAV.

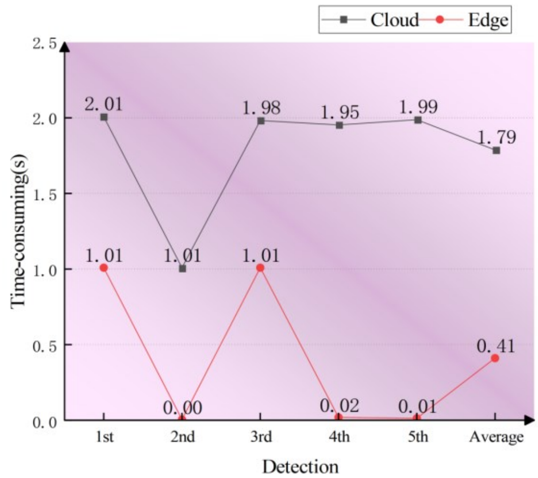

Fig 2. Comparison of time consumption between edge and cloud in single device and single rule scenarios

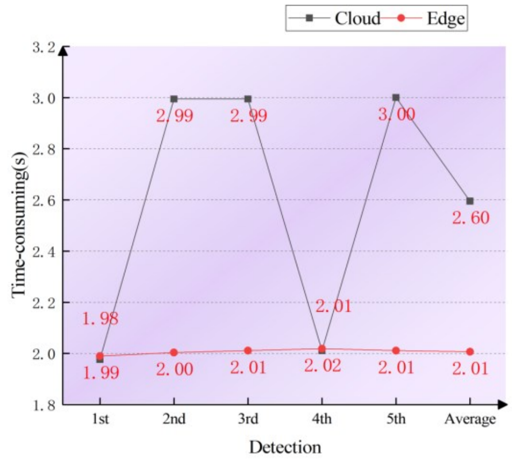

Fig 3. Time consumption of edge and cloud under 30 rules per device

From Figure 2, it can be seen that under the above experimental conditions, the average processing time of the cloud rule engine for a single rule was about 1.79 seconds, and the average response time of edge rules was less than 0.5 seconds.

From Figure 3, it can be seen that under the conditions of 30 rules, the average response time of the cloud in 5 experiments was about 2.60 seconds, and the response time of the boundary was 2.01 seconds. Through the analysis of experimental data, a conclusion very similar to that of Experiment 1 was drawn. Although there was some superiority in response speed at the end of the boundary, this superiority was not significant and has not achieved the desired effect.

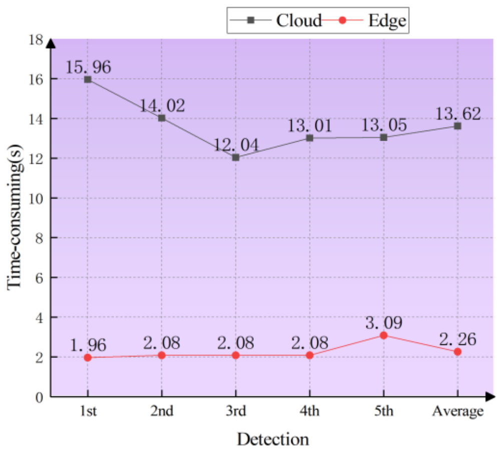

Fig 4. Time consumption of edge and cloud under high resource load

It can be seen from Figure 4 that under the condition of large resource load, the response speed of the cloud system was extremely unstable, taking 13.62 seconds on average. However, in this case, the response speed of the edge computing cloud platform system was 2.26 seconds on average. After three tests, the system's CPU (Central Processing Unit) resource utilization was greatly improved, which showed that the rules based on edge computing had better performance.

Table 1. Results of 2-hour bandwidth occupation experiment

	Cloud-only IoT Platform	Edge computing synergizes with cloud technology	Bandwidth consumption reduction rate
Total Traffic(MB)	156.13	53.12	65.99%
Average bandwidth usage (Kb/s)	22.21	7.55	

In Table 1, under the operation of cloud platform system only, the total traffic in two hours was 156.13MB, while under the operation of edge computing and cloud technology collaborative system, the total traffic in two hours was 53.12MB. This showed that the edge computing technology could save 103.01MB. When only the cloud platform was running, the average broadband usage was 22.21Kb/s. With the cooperation of edge computing and cloud platform, the two-hour broadband usage was 7.55Kb/s. Edge computing greatly alleviated the cloud data processing pressure and optimized the system's operation capability.

5. Conclusion

With the rapid development of communication technologies such as 5G and 6G, the access scale of mobile terminals has rapidly expanded, and hundreds of millions of unmanned aerial vehicle interaction cloud service platforms have interconnected intelligent terminals, forming a rich range of intelligent services and services. At the same time, the information generated by these mobile terminals and their associated applications is also constantly growing. However, most mobile terminals currently have issues such as poor computing performance and short battery life. How to provide stable and low-cost energy for terminals in massive data processing is one of the key issues that urgently need to be solved in IoT research. To solve the above problems, this paper discussed how to use edge computing to build a UAV interactive cloud service training platform to improve the efficiency of network transmission of data calculation, analysis, processing and other steps, so as to reduce costs and bandwidth pressure. The experiments in this paper verified that edge computing can effectively achieve the goal.

Acknowledgment

Fund projects: Key Research Platforms and Projects of Regular Institutions of Higher Learning in 2022 by the Department of Education of Guangdong Province(2022CJPT028); Guangzhou Huati Science and Technology Vocational College brand promotion key construction project(teaching 016);Guangzhou Huali Science and Technology Vocational College brand promotion general construction project(produced 019);Guangzhou Huati Science and Technology Vocational College -level Quality Engineering Project(HLZ102202).

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