Research on Key Technologies of VR based on MEC

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Abstract. Multi access edge computing (MEC) is an extension of 5G network on the edge side. Its network characteristics of high bandwidth and low delay provide necessary guarantee for the extreme user experience of VR (virtual reality). At the same time, the distributed architecture of 5g MEC network and the fast data exchange capability between nodes provide the hardware foundation for VR application marginalization deployment and equipment mobility access. Considering the cost and experience of VR, this paper first analyzes the advantages and disadvantages of VR based on traditional hardware architecture, and then describes the benefits of MEC on VR cost and experience. Finally, taking VR live video scene as an example, the key technologies of VR based on MEC are described.

Keywords: Multi access edge computing, VR, 5G, MEC

1. Introduction

As a well-known technology, virtual reality (VR) has been widely used in education and training, engineering, architecture and urban design, heritage and archaeology, medicine and so on. Entertainment and other fields. With the help of modern and complex computer software / hardware technology, application developers can build a more realistic virtual reality integration world, and users can obtain highly immersive, holistic and authentic interactive experience through VR terminal devices [1].

Immersion and interactivity are the most important features of VR which are different from traditional multimedia technology. Interaction delay and scene fidelity are key indicators to measure VR user experience. Low cost is the key business factor that affects the wide spread of VR technology. In order to achieve a proper balance between high user experience and low cost of VR, software and hardware manufacturers have launched a variety of solutions through a large number of technical attempts. 5G MEC's low latency, high bandwidth network characteristics and the sinking of computing nodes provide a new idea for seeking a better balance between VR user experience and cost.

This paper mainly focuses on two factors of VR user experience and cost, and analyzes the advantages and disadvantages of existing VR software / hardware form. Then, combined with the characteristics of MEC network structure, [2] taking VR live video scene as an example, this paper expounds the key technologies of VR under MEC.
2. VR experience factor and VR software / hardware form

2.1. Low interaction delay and high image quality are the key experience indicators of VR. VR builds a virtual world and uses VR external devices. The user and the virtual world will be integrated and interacted, so that the user will have the feeling of immersive. Scene fidelity and user interaction delay determine the user experience of VR. Scene fidelity is directly expressed as the image quality presented to users by VR head mounted display (HMD); interaction delay is the time interval between the user's interactive action and the final action result presented to the user. Generally, the interaction delay is not more than 20 ms, [3] otherwise the user will feel dizzy. Image quality affects the user's tolerance, thus affecting the user's VR experience time. Therefore, low latency and high image quality are the basic requirements and key indicators for users to experience VR for a long time and freely.

2.2. Traditional VR software / hardware form and its advantages and disadvantages

At present, there are mainly three VR forms, namely PC based VR, mobile based VR and cloud based VR - cloud VR.

(1) VR based on PC

The VR hardware and software architecture based on high performance PC is shown in Figure 1. In this configuration, VR application runs on the local PC host, and HMD is connected to PC host through HDMI cable. The user attitude information is captured by the external positioning base station, and the user operation instructions are transmitted to the PC through HDMI to guide VR image rendering. No display capability through HDMI.

The advantages of VR based on PC are: the rendering image is transmitted to HMD through HDMI line in real time, which can ensure the user interaction delay within 20 ms; there is no need to compress the picture during transmission, which can ensure the lossless image quality experience. Its disadvantages are: the cable connection between the host and HMD limits the user's free movement; the outside in positioning mode needs to set the user's activity range in advance, which can't realize the unlimited space mobile positioning; the high cost of single user makes it impossible to form large-scale business.

![Hardware framework](image1.png)

![Software framework](image2.png)

Figure 1. VR hardware and software architecture based on high performance PC

(2) VR based on mobile terminal

In order to solve the problem of mobility and high cost of PC VR, oculus, HTC, Microsoft, Google, Samsung and other VR manufacturers have launched mobile VR [5] products, such as oculus go, oculus quest, VIVE focus and other products, as well as VR boards used with mobile phones, such as Samsung gear VR, Huawei VR 2 and other products. The basic hardware configuration is shown in Figure 2, and its software architecture is similar to VR on PC.
The advantages of mobile VR products are that they can move freely in infinite space, and the cost is relatively low. Its disadvantages are: because the computing power of the graphics processing chip used in this kind of products is at least one order of magnitude lower than that of the PC processing chip, it can only support VR panoramic video, VR games and other lightweight applications; in addition, due to the immature mobile battery technology, and the high power consumption of 3D graphics rendering and display tasks, the mobile terminal's VR endurance is insufficient and cannot obtain long-term continuous VR experience.

(3) Cloud VR

Cloud VR uses the powerful computing power and resource sharing of the cloud to run VR applications in the cloud. The VR terminal only performs simple decoding and display and user attitude acquisition. The end-to-end architecture diagram of cloud VR is shown in Figure 3. The advantage of cloud VR is that the cloud computing power can provide users with high-quality VR content at relatively low cost. Its disadvantages are also obvious: as VR applications run in the cloud, VR images need to be encoded and transmitted to the user for decoding and display. This process will introduce encoding and decoding and network transmission delay, resulting in loss of image quality and increasing interaction delay, reducing the overall VR experience of users. The main performance is the blurring and black edge of the end side display. In addition, VR needs to occupy a lot of bandwidth. For example, 4K VR video service needs to occupy 100m bandwidth. In the case of large-scale deployment, it will cause great pressure on the network.

Although cloud VR can not achieve scale low-cost deployment due to the problems of experience and bandwidth occupation in the short term, its multi-user and multi-service sharing mode of computing resources provides a good idea for the low-cost development of VR business.

3. MEC is the best way to realize VR scale deployment

At present, with the advent of mobile 5G era, its high bandwidth and low delay characteristics will give birth to many new applications. VR will be one of the typical applications in 5G era due to its
requirements for bandwidth and delay. As an extension of 5g network, MEC is the key to carry 5g network application.

3.1. **MEC network organization structure and its value to VR**

MEC can reduce the pressure of network transmission and shorten the time cycle of data processing by sinking the computing node near the application scenario (Gateway) and placing the behavior of data collection and analysis close to the user side. MEC network architecture is shown in Figure 4.

![Figure 4. VR panoramic video end to end technology chain](image)

Under the MEC network architecture, deploying VR applications on MEC nodes will bring the following advantages: MEC computing nodes are directly deployed near the mobile gateway, which can reduce the number of device hops in network transmission between VR application data and end users, and reduce network processing delay; VR applications running on MEC nodes can realize data localization processing, for the same UPF For the access users, the data does not need to enter the Internet, which can reduce the transmission pressure on the Internet; VR content production is marginalized, such as in the VR live broadcast scene, VR video splicing, encoding, transcoding and distribution can be directly carried out on the MEC node, the local users can be unloaded nearby, and the Ott (over the top) users or users under the coverage of other MEC nodes can use the CDN (content delivery network) for rapid distribution; MEC’s distributed networking mode can realize continuous VR experience in mobile scenes, such as watching live VR on high-speed mobile carriers (such as cars and high-speed rail) or participating in video conferences.

3.2. **Key technologies of VR based on MEC**

MEC’s characteristics of high bandwidth, low delay and mobile access will be the best way to achieve high VR experience. This section takes VR live video scene as an example to elaborate the key technologies of VR extreme experience based on MEC. VR live video scene is a typical scene of VR application based on MEC. In the MEC scenario, VR video business needs the linkage of management, end and cloud to realize VR content production and distribution in the pipeline, and content management in the cloud.

1. **Key technology 1: VR video content production technology based on MEC**

The end-to-end technology chain of VR panoramic video is shown in Figure 5, including panoramic video acquisition, video splicing, projection, coding, and distribution and decoding. In MEC scene, the multi-channel images collected by VR video camera can be uploaded to MEC node by using 5g large air port bandwidth to complete panoramic video splicing, projection and streaming. In VR content production, MEC can simplify the production of content, simplify the composition and cost of VR live video equipment.
(2) The second key technology is to realize the transmission of VR content with high image quality and low delay.

After the completion of VR content production, it is necessary to achieve rapid distribution to the user side, reduce the user perspective switching delay, and ensure the image quality.

The distribution of VR video content involves video coding, transcoding, packaging and streaming. The full frame VR video resolution is higher, but the resolution of the region within the field of view (FOV) is smaller, so the bandwidth utilization of full frame transmission is low.

The resolution of 4K panoramic image is 100 megabytes, while that of FOV is only tens of megabytes. Therefore, according to the user's point of view, the implementation of the content distribution of the linkage between the management and the end can make more effective use of the bandwidth resources and ensure the user experience.

In the coding process, the VR image is divided into several independent coding tiles by tile segmentation coding technology. In the video distribution phase, according to the FOV information uploaded by the user, the tile in the coverage area of the user's FOV is sent to the user for decoding, splicing and display. In order to reduce the user's view switching delay, each independent tile is encoded with GOP (group of pictures) which is short enough. In order to prevent the problem of no picture in user's view switching, the panoramic low definition video stream can be pushed to the user according to the network situation.

(3) Key technology 3: end, management and cloud linkage to achieve rapid distribution of VR content.

MEC has the ability of content forwarding, streaming and acceleration. Therefore, using MEC Intranet can realize VR content rapid distribution similar to CDN. For 5g access network users, VR content can be distributed nearby directly through MEC Intranet without uploading the content to the cloud and then distributed through CDN, which further reduces the processing delay of VR video network.

For ordinary Ott users, the MEC node of VR content production plays the role of a live source station, which can upload the produced VR video content to the cloud, and realize VR content distribution through CDN accelerated distribution network. The end-to-end technology chain of VR live broadcast based on MEC is shown in Figure 6.
3.3. **MEC is the best deployment form for VR**

Compared with the centralized resource sharing mode of cloud computing, the edge distributed sharing mode of MEC has the advantages of close to the user entrance and distributed sinking of computing resources. The network location of MEC near the user entrance provides a good network guarantee for VR low delay and high image quality experience. This is where MEC is better than VR.

On the other hand, the edge deployment of MEC computing resources also makes MEC have the advantage of cloud computing cost sharing. VR service deployment has the following two cost advantages in MEC: first, VR service shares MEC computing resources with other high-value services, which can realize cost sharing and reduce the deployment cost of VR single-way service; second, VR needs network support with high bandwidth and low delay, and deploying in MEC node can reduce network construction cost compared with deploying in cloud. In addition to this, MEC can provide continuous service experience. Considering experience and cost factors, MEC is the best deployment form of VR.

4. Conclusion

MEC extends the necessary network and computing infrastructure for 5g network, and will drive the vigorous development of VR in various industries. VR application will be one of the most important applications of MEC network because of its bandwidth and delay requirements.

Starting from the experience and cost of VR, this paper briefly analyzes the advantages and disadvantages of the three existing VR forms, and concludes that PC based VR, mobile based VR and cloud VR can not give consideration to both experience and cost, and can not be widely popularized.

Then, based on the network characteristics of MEC with high bandwidth and low delay and distributed networking architecture, the advantages of MEC for VR service development are analyzed. Taking VR live broadcast scene as an example, the key technologies of high experience for VR service operation under MEC architecture are listed. Based on this, this paper concludes that MEC is the best form to realize VR scale deployment.

In the future, with the lightweight development of VR terminal equipment, the enhancement of rendering density of VR applications, and the increase of intelligent factors of VR applications, the appeal of VR computing upward will become stronger. The demand of VR applications for low latency and high bandwidth will become more urgent with the complexity of applications and the gradual
improvement of user experience requirements. Based on this, MEC will be an indispensable part in the future VR application scenarios. The development of MEC technology will promote VR technology to the direction of extreme experience and wide popularization.

At present, Huawei and its partners have realized the commercial application of VR live broadcast, VOD and giant screen cinema based on MEC. In the coming 5g network era, based on the technical advantages of 5g network and MEC platform, Huawei will provide customers with unprecedented VR video experience. In the near future, Huawei’s MEC based VR / AR solution will gradually expand from VR video field to VR / AR / MR game, education, industry and other real-time strong interaction fields, providing ultimate VR / AR / MR experience for family, industry and individual users.

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