Based on 5G network, use the unmanned aerial vehicles to live stream in VR

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Abstract: 5G network has begun to step into people's horizons. The character of high transmitting speed and low latency can enable some applications to do better in their fields. This article focuses on the new application of the UAV (unmanned aerial vehicles) based on the 5G network. Live streaming is a new entertaining way that is popular worldwide. In this article, the theoretical analysis of the 5G network and VR shows the development of mobile communication technology, the essential features of 5G network, which demonstrate the advantage of 5G, and the Internet requirement of VR. To reduce network bandwidth demand, a different view information transmission can distribute the transmission data of the side angle of view into the in front version. A Popularity Balance Method(PB) for UAVs in the same area layer) method based on the division of the entire search area into multiple area layers to change the pattern of message delivery to the area layer closer to the destination node. Advanced wireless systems (AWS) can make safe, effective operations. Suggestions about using Content Delivery Network (CDN) to solve the live stream problems are also given.

Keywords: Unmanned Aerial Vehicle, 5G Network, Internet of Things, Virtual Reality.

1. Introduction

To effectively handle a large number of heterogeneous applications, 5G mobile systems combine historically independent communications and network systems and services. [16]. Through 5G network, it provides a faster speed of communication than other mobile technology presented. The usage scenarios of fifth-generation mobile technologies are divided into three parts by the standard of 3GPP, Enhanced Mobile Broadband (eMBB), Ultra Reliable Low Latency Communications (URLLC) and Massive Machine Type Communications (mMTC). Traditional mobile network architectures are unable to provide the low latency and ultra-reliable, rich quality of service that ultra-reliable low-latency communications provide, which enable unmanned aerial vehicles to transmit more time-efficient information [2].

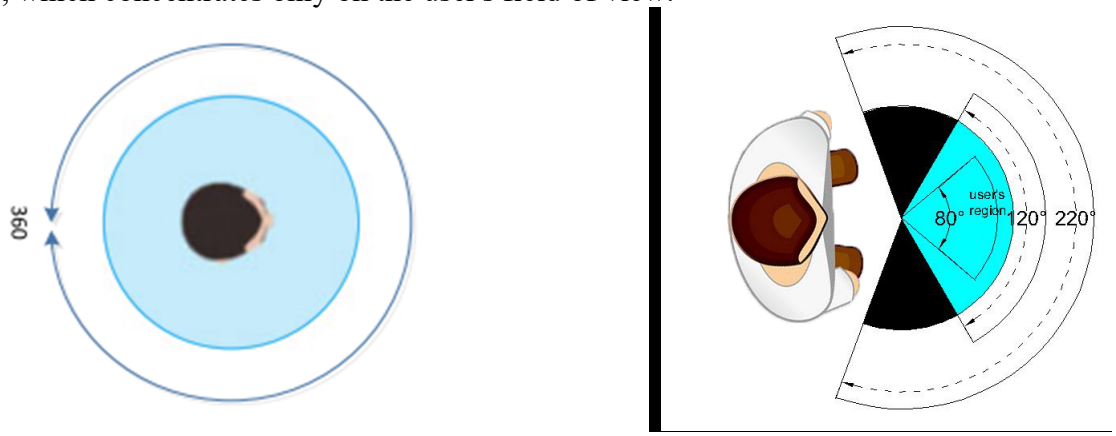
The IoT can both have made a difference to personality and specialized level. Through e-health, smart homes, and smart learning, the Internet of Things significantly raises people's quality of living [3]. Numerous studies have been conducted investigating the potential of 5G networks for DR applications in IoT and smart grids [4]. In [5], a 5G technology-based extended mobile edge computing solution is created to lessen backhaul burden and boost overall network capacity. There is a paucity of 5G commercialization, incomplete evaluation of application domains, and few DR application cases for practical research [6].

Industry and academics are paying more and more attention to communication and networking for UAS [7]. The UAS can act as user equipment (UE), base station (BS), or relay node in a variety of scenarios and use cases [7]. Applications for drones, especially flying drones, have already begun in a variety of civic and professional activities and disciplines, including package delivery, precision agriculture, remote inspection, photogrammetry, video streaming, search and rescue, and data collection for the Internet of Things [8].

UAVs are a kind of flying instruments without human controlled and can-do something humans can hardly do, such as aerial photographing and cruising the power line. The ground control station, the actual UAV, and the communication technology required to transfer command and control (C2)

information between them make up the Unmanned Aircraft System (UAS) component known as the UAV [8].

The develop of generation mobile communication technology increases many kinds of devices and various information services. Some new technology such as virtual reality need high transmission data and low latency speed to get a more accurate live frame. The wireless technology of 4G cannot support the demand of the transmitted video at high frame rate. Figure 1(a) illustrates how an immersive environment for VR applications might be achieved. To complement the panoramic perspective, 360-degree-VR transmission is suggested [9]. VR transfer is highly challenging due to the exponential growth of data that can result from the transfer of intense view information. A Field-Of-View (FOV)-VR broadcast is suggested to make up for the limited bandwidth, as shown in Fig.1(b), which concentrates only on the user's field of view.



360°-VR Transmission (a)

FoV-VR Transmission (b)

Figure 1. Different VR transmission modes.

So, it is possible for the virtual reality technology to be connected with unmanned aerial vehicles to live stream in VR.

This article consturcts a connection among UAVs and VR in 5G network. Based on the essential features of 5G network, the transmission speed and bandwidth broaden to a new level compared to the previous technology. When the unmanned aerial vehicles are used to transmit messages and image from the outside scene, It is essential to guarantee prompt and effective delivery. The goal may be accomplished by working together with other UAVs, and in light of the aforementioned issues, this study suggests a Popularity Balance Method based on the split of the whole search area [10]. A wider bandwidth (up to 100 MHz in the 6-GHz frequency range) is offered by 5G New Radio (NR) in order to accommodate the high data rates of virtual reality [8]. It can provide enough data current for the high-quality live streaming. UASs can use 5G technology and advanced wireless systems (AWSs) to make safe of effective operation. Utilizing VR Equipment (VEs) enables users to walk about and engage in a totally enclosed environment that is housed in their living space [11]. In the cooperation of long-distance immersion, A 3D view of the person(s) on the other end is sent to the user through the use of a static stereo camera [12]. To ensure the stabilization of data transmission, Content Delivery Network (CDN) can be used to support the serves for live stream, which is a strategically deployed holistic system.

2.Theoretical Analysis of 5G network and VR

2.1 The development of network from 1G to 5G

From the 1G to 5G, it takes over 50 years for Mobile wireless technology evaluating [13]. Fig.2 shows the progress of the mobile communication technology and the changing of the related applications because the wavelength shortens, and the transmission speed becomes faster. 1G only has approximately 2.4 and 9.6Kbps, indicating that it is an analogue communication system capable of carrying only voice calls [13]. 2G~5G are digital communications, with 2G transmitting at

approximately 100 times the bandwidth of 1G and 270Kbps transmitting speed. However, it is only allowing the text messaging [14]. 3G technology can achieve data rates of up to 14.4 Mbps while stationary and 350 Kbps while moving [15]. This makes more applications possible, such as video calls, multimedia messages and transmission control signals for DR.

The most recent version (number twelve) of 4G technology, which is currently in widespread usage worldwide, supports speeds of 300Mbps [15]. The Internet of Things (IoT) is designed to form a intelligent system. This is accomplished by utilizing rapid transmission speeds. The problem is that 4G transmission speeds are still much below what the IoT requires, which will cause issues like a cap on the internet devices. In response to these issues, 5G technology has been proposed to support increased device connectivity, quicker transmission speeds, low communication latency, and high security. In [16], The electromagnetic spectrum is the primary distinction between 5G and earlier generations. 5G features two spectrum bands and a greater wave frequency than the spectrum currently in use. Below 6 GHz is the first spectrum range, so called "low-mid spectrum" or "sub-6". In 24-100 GHz lies the second spectrum band, sometimes known as the "high band spectrum".

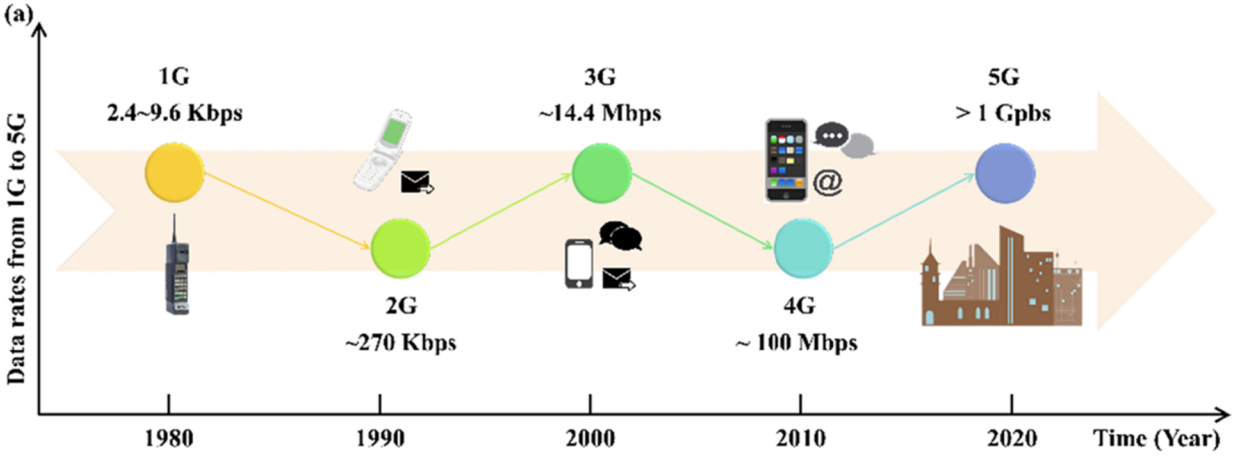


Figure 2. The development process from 1G to 5G

2.2 Important features of 5G network

(1) Millimeter wave (mm Wave)

5G works in the microwave band. With the speed of light and the vacuum medium constraint, microwaves with a frequency of 100 GHz correspond to a wavelength of 3 mm. Thus, the microwave band is also known as the millimeter wave band. Under the constraint of short wavelength, narrow beam, millimeter wave has wide bandwidth allowing high speed, low latency, high resolution and security to transmit data [28].

(2) Massive multiple-input multiple-output (MIMO)

The small components of millimeter waves usually employ massive multiple-input multiple-output (MIMO) systems to achieve high output as well as to reduce signal interferences [28]. 5G devices can have 32 to 256 antennas [16], and with this massive MIMO, the transmission bandwidth, data throughput, and spectral efficiency of 5G can be expanded.

(3) Ultra-dense cellular networks

Although the shorter wavelengths of 5G and narrower beams boost data speed and security of transmission, they put a cap on how far it can travel. The transmission range of millimeter waves is around 100 meters [17]. In addition, obstructions like walls, foliage, and the human body can easily block millimeter waves [28]. Therefore, more 5G tiny cells, also known as ultra-dense cellular networks, must be installed in order to guarantee the 5G cellular network's seamless coverage [17]. For 3G and 4G networks, respectively, macro base station (BS) densities of 4-5 BS/km^2 and 8-10 BS/km^2 are typical. However, 40–50 BS/km^2 of 5G base stations are anticipated to be deployed [17].

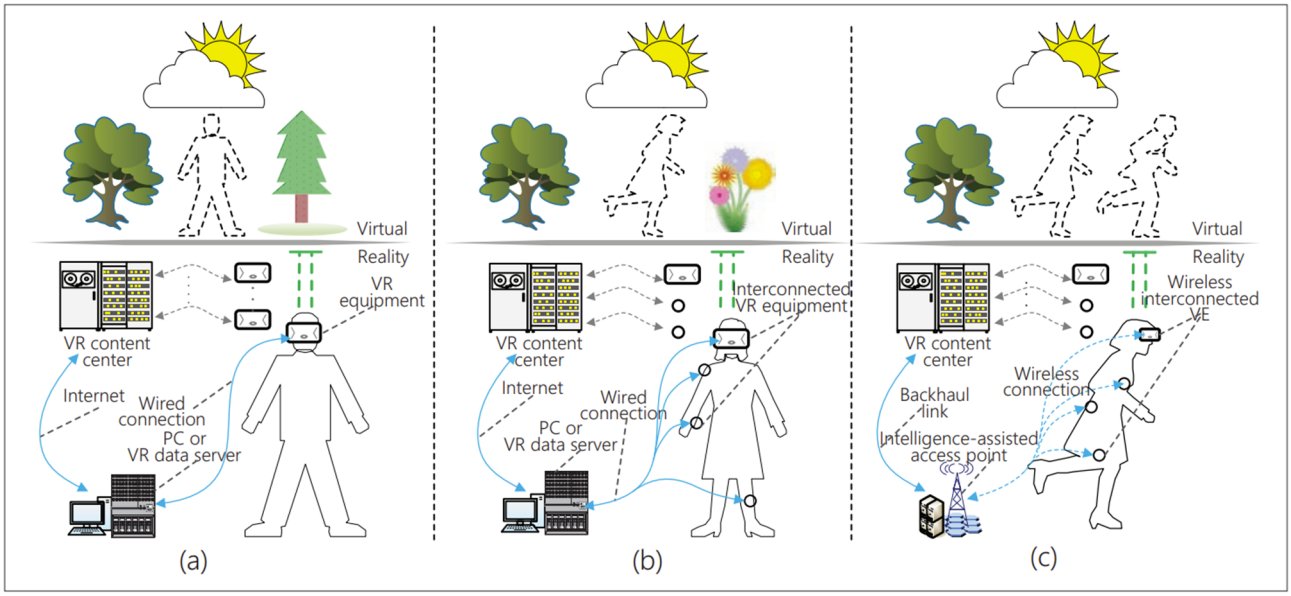


Figure 3. Evolution stages of VR: from traditional to wireless

The three stages of VR technological development are depicted in Fig.3 [11]. Virtual reality's overarching objective is to simulate an immersive experience that closely resembles the human perceptual environment. the minuscule vibrations our ears pick up, each photon our eyes see, and other cognitive components. The VE must be connected to a separate PC in order to use current VR systems (Figures 3a and 3b). Users who are participating in VR activities in this situation are constrained by a wired connection, which limits the kinds of actions they can take and the VR programs they can utilize [11].

3. Representative works

3.1 The message transmission of the UAV

The operating frequency of the antennas on the UAV should need to match with 5G network. The majority of the frequency bands below 6 GHz have already been granted licenses for wireless data transmission, therefore 5G will logically use these bands. However, 5G will also make use of the 2.5GHz frequency, which was previously only used for educational programming. Due to the instantaneous use of 5.8GHz in 4G, 2.5GHz is at the lower end of the spectrum below 6GHz, giving it wider coverage (but slower speeds) than higher bands. The 2.5GHz band will make sure that rural areas are aware of the switch to 5G and that densely populated places do not end up using the extremely slow, low frequency spectrum.

When UAVs are used to transmit information and images from external scenes, fast and efficient information interaction between the vehicles is achieved through PB technology [10]. The search area is divided using this technique into various area levels, ex. Fig.3 shows the research and rescue scenario with UAVs. The segmentation of search areas alters the way messages are delivered. Instead of the node closest to the destination, messages are sent to the region layer closest to it. DTN routing methods work well with sporadic connections. Typical multi-copy mechanisms are used by pure DTN routing techniques like epidemic routing [12]. To ensure that a message reaches the destination node as soon as feasible, it is replicated to as many nearby nodes as possible [10].

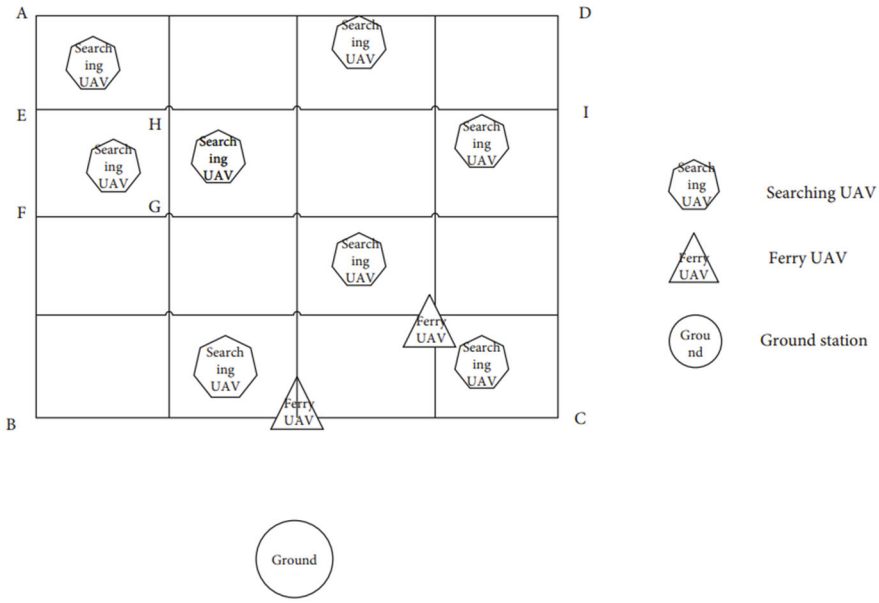


Figure 4. Massage transmission process of UAV

Wide bandwidth and low latency requirements are expected to be satisfied by 5G technology. 5G New Radios (NR) can deliver enough data current for high-quality live broadcasts with broader bandwidths to support the high data speeds of virtual reality [8] (up to 100 MHz in the 6 GHz range). High latency might make virtual reality devices less synchronized with the user. New physical layer digital technologies used by 5G NR dramatically lower wireless access network latency [8]. Two classes of service, mMTC and uRLLC, can be used to achieve high speed and low latency. Nevertheless, there is more than one category that applies to drone services. Actually, uRLLC applications are thought of as remote C2 applications for drones.

Unmanned Aircraft Systems (UAS) integrate into 5G networks through User Equipment (UE), Base Stations (BS), and Relay Nodes [7].There is a main problem of the unmanned aerial services that control the interface when ensuring the connection because of the wide radio frequency, and the mechanisms of UASs need to ensure it. UASs can use 5G technology and advanced wireless systems (AWSs) to make safe of effective operation. It is only partially feasible to share space and spectrum in order to co-locate numerous services at once without limiting wireless services and mobility due to the nature of over-the-air RF transmissions [7]. So, the range of movement and services of UAVs should be restricted in a certain boundary of time, space and frequency spectrum, or need to adjust the control of the interfering nodes. UAS communications will be powered, tested and standardized [7].

3.2 Remote VR immersion by UAV IoT networking

Virtual reality (VR) has become a hot topic with the development of 5G network. The immersion and diversification of VR in the vision experience can provide the users with full-version and seamless watching experience. In virtue of high transmission speed and low latency of 5G network, some new application of wireless VR emerges which develop the style of carrying out multi-party remote real-time interaction in the virtual simulation environment.. Wireless VR video streaming systems, in contrast to typical video streaming, must offer copious amounts of omnidirectional visual content with extremely low latency (less than 20 milliseconds) [11]. The specialty of VR compared with traditional video is that the program of VR should project the pixel. Viewport rendering is the term for this projection, which necessitates extensive matrix calculations. More energy is used to produce vr video than other types of video. MEC (multi-access edge computing) and caching [19] have shown promise in enabling wireless VR. In-network calculating ability can be used to deal with

some computing tasks through Mobile Edge Computing (MEC). It can also cache some calculation results of VR, which have been computed to reduce the repetitive calculation and transmission.

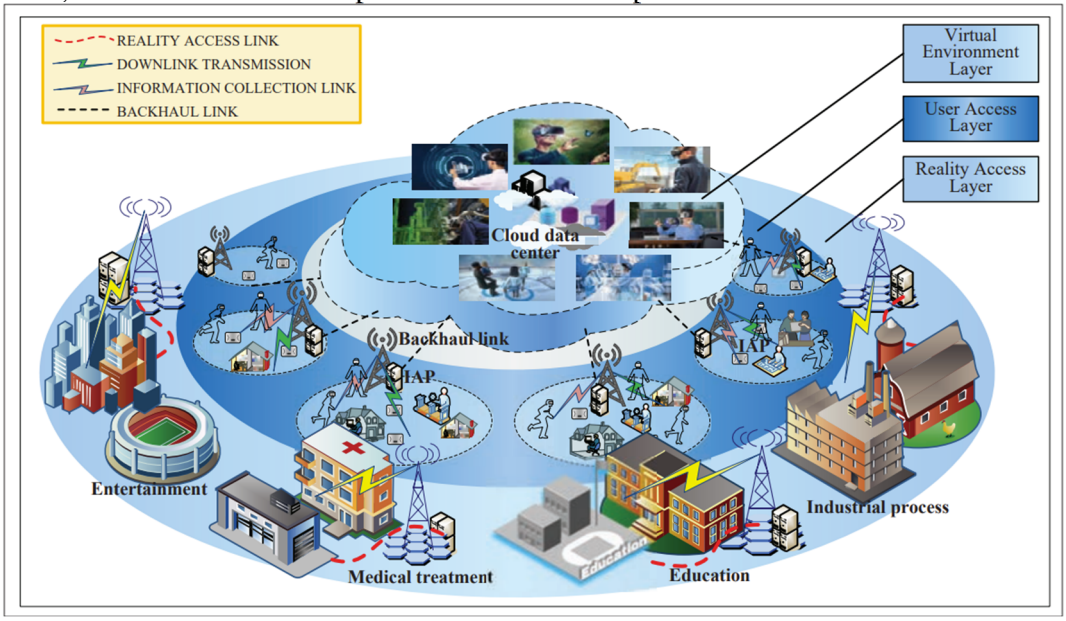


Figure 5. Illustration of a wireless fully connected VR streaming system.

The scenes of VR showing to people are caught by the static vidicons, which can let the user to change the scenes among different vidicons to increase the quality of using. In the cooperation of long-distance immersion, a static stereo camera captures a 3D image of the person on the other end and sends it to the user [18]. An omnidirectional camera records an offline 360-degree video stream of a faraway area. The user then receives on-demand video to give him a 360-degree perspective of the scene on his VR headset [18]. To simulate the scene of live streaming, the aerial multi-camera from the dynamic UAVs will be used to capture the scene and compound the long-distance scene to increase users' immersion. This is demonstrated by the fact that although online VR requires an interaction latency of 20 to 30 milliseconds, conversational video requires a delay of 150 milliseconds round trip [18].

4. Content Delivery Network

Content Delivery Network (CDN) supports the serves for live stream, which is a strategically deployed holistic system. It can solve the problem of slow website access due to small network bandwidth, high user traffic and uneven distribution of networks. The quality of service on the Internet can be increased with the help of CDNs. The purpose of CDNs is to fulfill requests from replication servers close to the origin of the request and replicate content from its source to replication servers dispersed around the Internet [20].

The live stream is a kind of streaming Media, a media format that uses the stream for playback on the Internet. By using certain compression techniques, streaming methods are used to break multimedia data like video and audio into discrete compressed packages that are then continuously and in real-time transferred from the server to the client. After the client has decompressed this data with decompression software, the multimedia is displayed as it was before it was sent. In contrast to traditional streaming media such as video and music sites, the data feed for live streaming is generated by the client (the host) and then pushed to the server in real time. Fig.6 shows the general stream of the live broadcast.

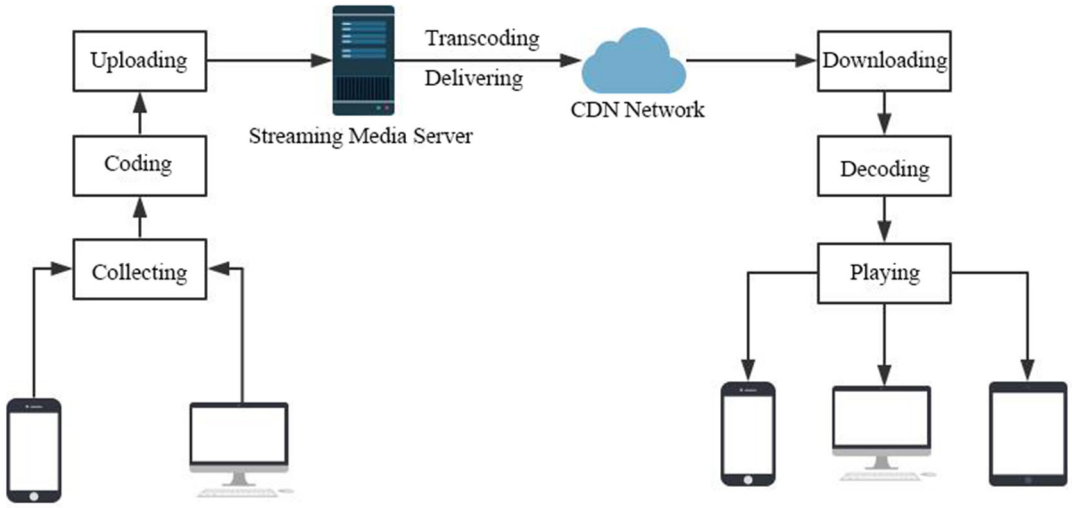


Figure 6. The general stream of live broadcast

To realize the live stream, it uses video and audio capture software to capture audio and video data from the UAVs, which is then encoded and pushed to the server. The streaming server uses a CDN network to distribute the data and the client uses players in various devices to pull the stream, decode and play it.

5. Conclusion

This article shows a new application of the UAVs and 5G network. The frequency of receiving and transmitting should be matched with 5G network. To ensure the delivery quickly and efficiently, the method PB will be used to make several layers. Two kinds of service, mMTC and uRLLC, need to combine to use and achieve the high speed and low latency. Moreover, UASs can be used to reduce the demand of user equipment, a base station, or a relay node. UASs can also take advantage of 5G technology to advance wireless systems to make safe of effective operation. At the side of receiving, VR is used to improve the experience of users. The 5G network meets the ultra-low latency of wireless VR as well as the high capacity delivery required for cloud data preservation.

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