Implementation of AVS3 Multicast System Based on eMBMS

Lingfeng Fang*, Chunhao Li* and Songlin Sun*
* Beijing University of Posts and Telecommunications, Beijing, China
E-mail: fanglingfeng@bupt.edu.cn Tel: +86-15201093898
E-mail: lichunhao@bupt.edu.cn Tel: +86-18800145672
E-mail: slsun@bupt.edu.cn Tel: +86-15601001217

Abstract—**With the development of 5G, the business needs of video are constantly expanding. Virtual reality, 4K, 8K UHD (Ultra High-Definition), and even higher resolution video content will be further popular. The development of mobile video service has brought unprecedented pressure to cellular networks. The user experience of wireless-based video streaming services mainly depends on the bandwidth and the performance of the network. Therefore, the unicast method is not suitable for transmitting UHD video to multiple users in a small area at the same time. LTE eMBMS (evolved Multimedia Broadcast Multicast Services) achieves the broadcast capability in the entire network or in the multicast area. The AVS standard is a source coding standard for Chinese independent intellectual property rights. The primary application target of the third-generation AVS standard (AVS3) is UHD. This paper uses eMBMS technology to realize the multicast of AVS3 video stream in cellular network, and this greatly saves network bandwidth compared to unicast. This paper first introduces some background information of eMBMS and AVS3. Furthermore, the service process of eMBMS will be described in detail. Finally, the architecture of the entire multicast system will be introduced.**

Keywords: eMBMS, AVS3, Multicast

I. INTRODUCTION

With the rapid development of network technology and the popularization of mobile terminals, the demand for video services, especially the demand for mobile video services, has grown exponentially. Emerging video applications such as ultra-high-definition video, virtual reality and high dynamic range video have become more popular. These types of video have higher resolution, frame rate and bit depth, which leads to an increasing amount of video data. The audio video coding standard workgroup of China (AVS[1]) has formulated AVS3 video coding standard to further improve the compression performance of the encoder. Compared with HEVC/H.265, the coding performance of AVS3 is improved by about 25%[2].

The user experience of video service largely depends on the performance and bandwidth of the network. Scarce wireless bandwidth resources restrict the development of mobile video services. Traditional wireless communication provides point-to-point unicast bearer services (such as file downloads, streaming media, etc.). For unicast bearer services, a user-level independent bearer must be established, and wireless and transmission resources of the access network cannot be shared. In densely crowded places, such as stadiums, if spectators use mobile terminals to watch live game videos online at the same time, it will lead to insufficient bandwidth resources and seriously affect their viewing experience. In this scenario, it is necessary to reduce bandwidth consumption as much as possible to improve the smoothness of video viewing. The evolved Multimedia Broadcast Multicast Services (eMBMS) technology can provide the same content to multiple users at the same time, which can greatly save the network resources. Therefore, this paper uses the eMBMS technology to realize the multicast of AVS3 video stream within a fixed area. The experiment results show that all users in this region share band-width resources, and the increase in the number of users will not lead to the increase in bandwidth usage.

A. eMBMS

LTE eMBMS[3] technology was launched by 3GPP based on R9 version in 2010. eMBMS is a technology for carrying multimedia broadcast services and multicast services in mobile network. It implements the function of simultaneously transmitting the same content to multiple users in a specific range, thereby achieving network resource sharing and improving resource utilization. eMBMS services can not only achieve message-type multicasting and broadcasting at low rate in plain text, but also multicasting and broadcasting high-speed multimedia services.

eMBMS provides differentiated, customizable, and rich data services. The service content includes text, pictures, audio and video. The biggest advantage of using eMBMS to carry services is that when there are many users using the services in a cell, a large amount of wireless transmission resources can be saved compared to the unicast services. Therefore, eMBMS is more suitable for large-data traffic and broadcast services with a certain number of user groups, such as mobile TV service and mobile radio service. eMBMS can not only be used to carry services that users actively subscribe to, but also provide users with a variety of push services. It is obvious that the more users receive the same service in the same cell, the more obvious the network resource savings brought by eMBMS.

Fig. 1 shows the network structure of the eMBMS system under the LTE network architecture. The most important logical network elements are BM-SC (Broadcast Multicast Service Center) and eMBMS GW (eMBMS Gateway). BM-SC is responsible for maintaining the service information of eMBMS, managing the relevant wireless bearer resources, and downlinking service data from the content provider[4]. The eMBMS GW is responsible for broadcasting eMBMS data to the eNBs[5]. It also assigns an IP multicast address to the eNB joining the eMBMS network, and sends the eMBMS session control signal to the eNB through the MME for eMBMS session management.

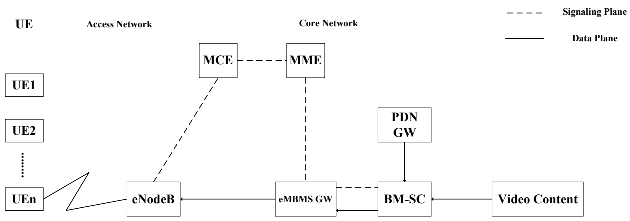

Fig. 1 eMBMS network architecture diagram.

The eMBMS service can be divided into video and non-video based on the content. Non-video service includes data, audio, text, and pictures. According to the real-time characteristics, it can be divided into two types: live and non-live[6]. Live broadcast includes video live broadcast and content live broadcast. Non-live broadcast includes group message distribution, data download, push to talk (PPT) and so on. The video live broadcast service refers to the content provider sending the video captured in a certain place to the eMBMS platform in real time[7], and then the service platform transmits the video content to the eNB through the eMBMS multicast channel. Finally, eNB broadcasts the content to the terminals that have opened the eMBMS service. This service is usually used for sports live broadcast and news broadcast. The content live broadcast refers to the content provider sending the content to the eMBMS service platform in advance. Then the platform transmits the content to the eNB through the eMBMS multicast channel according to the channel program time. Generally, the content live broadcast includes movies, TV series, TV shopping and so on.

B. AVS3

With the development of 5G, virtual reality technology and artificial intelligence technology, digital video services are further expanding. AVS Working Group in China has formulated a series of video compression coding standards since 2002, namely AVS1, AVS+, AVS2 and AVS3. Each generation standard will have at least 50% performance improvement over the previous generation. The successful application of AVS+ and AVS2 in the broadcasting and television industry is enough to prove that the AVS standard has matured. The products of the AVS Industry Alliance have covered almost all aspects in the industry chain, from hardware chips, terminal integration, system integration, to software algorithms, video editing processing, etc., which provides a complete support for the development of AVS. In January 2019, AVS3 standard performance has been improved by about 30% compared to AVS2[8], and the first version of AVS3 was finalized in March 2019. AVS3 has independent intellectual property rights and completed sufficient testing work, and AVS Working Group plans to release internationally leading UHD real-time codec software and hardware products in the future. The emergence of AVS3 will lead the development of the 8K UHD and VR video industries in the next five to ten years, and strive to play a key role in the formulation of relevant international standards.

Table 1 shows the comparison of encoding technology between AVS3 and VVC.

Table 1. The comparison of encoding technology between AVS3 and VVC

<table>
<tr><th>Encoding technology</th><th>AVS3</th><th>VVC</th></tr>
<tr><td rowspan="3">Coding unit structure</td><td colspan="2">Quadtree-binary tree recursive structure, maximum coding unit 128x128</td></tr>
<tr><td colspan="2">Intra-frame bright chroma separation tree</td></tr>
<tr><td>Extended quadtree recursive structure</td><td>Triple tree recursive structure</td></tr>
<tr><td>Intra prediction unit</td><td>Derived pattern tree: 2 or 4 subunits</td><td>Intra-frame sub-block division: symmetrical 2 or 4 sub-units</td></tr>
<tr><td>Inter prediction unit</td><td>Consistent with coding unit</td><td>Triangulation for Skip / Merge</td></tr>
<tr><td rowspan="2">Transformation unit</td><td>Intra-frame derivative mode partition: 4 symmetrical sub-units</td><td rowspan="2">Intra transform block division: symmetrical 2 or 4 sub-units</td></tr>
<tr><td>Inter Quad PBT partition</td></tr>
<tr><td rowspan="5">Intra prediction</td><td colspan="2">Chroma linear model prediction, sub-pixel 4-tap filtering</td></tr>
<tr><td>33 prediction modes + 2MPMs, 5 chroma prediction modes</td><td>67 prediction modes + 6MPMs, 5 chroma prediction modes, non-square wide-angle prediction</td></tr>
<tr><td>Single-line reference boundary prediction</td><td>Multi-line reference boundary prediction</td></tr>
<tr><td rowspan="2">Boundary pixel filtering</td><td>Position-dependent pixel filtering</td></tr>
<tr><td>Matrix weighted interpolation prediction</td></tr>
<tr><td rowspan="4">Inter prediction</td><td colspan="2">Forward, backward and bidirectional prediction</td></tr>
<tr><td colspan="2">DCT interpolation filter, brightness 8-tap, chroma 4-tap</td></tr>
<tr><td colspan="2">Skip / direct / merge space-time domain MVP export, HMVP candidate export.</td></tr>
<tr><td colspan="2">Advanced representation of motion vectors in Skip / direct / merge mode</td></tr>
</table>

	Affine transform motion compensation prediction, 1/16, 1/4, 1 triple precision	
	1/4, 1/2, 1, 2, 4 motion vector accuracy	1/4, 1, 4 motion vector accuracy
	Fixed-precision HMVP candidate derivation	Subblock-level time domain MVP candidate derivation
	Motion vector 16x16 unit storage	Motion vector 8x8 unit storage
Reference frame management	Flexible configuration of reference frame configuration set	
	Support Knowledge Image	Support long-term reference frames
	Determine the reference frame list according to the decoding order index	Determine the reference frame list according to the display sequence number
Transformation	The main transform kernel: DCT2, DCT8, DST7, Maximum transform block 64x64	
	Position based transform core binding	Adaptive multi transform kernel selection
	4x4 quadratic transformation	4x4 and 8x8 low frequency inseparable quadratic transform
Quantization	Independent scalar quantized RDOQ	Dependent Scalar Quantized DSQ
Entropy coding	Logarithmic arithmetic-based adaptive arithmetic coding	Table-based adaptive arithmetic coding
	Single layer run encoding	CG-based two-layer coefficient coding
Loop filtering	Deblocking filtering, sample offset filtering	
	Region classification based adaptive loop filtering	Pixel classification based adaptive loop filtering
		Filtering for Luminance Mapping and Chroma Scaling
Parallel structure	Patch partition	Slice, Tile, Brick

II. The Implementation of the Multicast System

A. *The Implementation of eMBMS service process*

The most suitable application scenario of this system is live broadcast of venues, such as live broadcast of sports events, live broadcast of concerts, etc. The current wireless communication uses the unicast technology to transmit data, and if the audience in the stadium watch the sports live video at the same time, it will lead to insufficient bandwidth resources, video playback stuck, seriously affecting the viewing experience. Through the eMBMS broadcast technology to save the wireless downlink bandwidth, all users share bandwidth resources, which can greatly improve the video fluency and viewing experience. For example, there are live videos with 8 viewing angles at the game site, and the bandwidth of each video is 3Mbps. Using eMBMS technology only needs 24Mbps bandwidth to meet the viewing needs. However, if unicast technology is used, each user needs to occupy 24Mbps bandwidth, and 1000 users need 20Gbps bandwidth. The existing wireless bandwidth resources cannot meet the requirements.

Fig. 2 shows the service process of eMBMS[9]. The basic service flow of eMBMS is listed below.

1. Service Announcement/Discovery: During the service discovery process, the content provider calls the BM-SC's xMB control plane interface through the portal to configure service and session resource to the BM-SC, which is Service Announcement. User starts the application and passes in the service discovery parameters. Then the application obtains service information, which is Service Discovery.
2. Users visit the web homepage provided by the portal to find service of interest and open the service entry link.
3. A specific MAA (MBMS-Aware Application) program is associated with the link, and the content pointed by the link URL, which contains the service description information is passed into the MAA.
4. The MAA reads the service-class field in the service description information and records it. This is a unique identifier for the service that needs to start.
5. MAA obtains Service Information URL from the service description information and passes it to the MBMS Client.
6. MBMS Client will obtain the service discovery parameters from the portal based on the incoming Service Information URL, including the BM-SC address and port.
7. MBMS Client registers with the BM-SC to obtain detailed service information and keep it synchronized.
8. MAA obtains a list of available services from MBMS Client. (If the service information is updated, MBMS Client will notify the MAA to obtain it again.)
9. After obtaining service information, MAA compares and finds whether there is a required service in the current service list. If a required service is found, MBMS Client will establish a downlink data logical link for MAA to transmit data.
10. When the start time of a session under a service arrives or the portal manually starts a session through the xMB interface, BM-SC will start the session, receive service data from the transmission parameters specified in the session parameters, and establish the

corresponding downlink multicast bearer, which starts to multicast service data to the network.

11. After the network-side session starts, the media server of the content provider starts to push service data streams to the BM-SC according to the network parameters (such as address and port) specified in the session parameters. BM-SC carriers the service data to UE (User Equipment) in the network through the multicast bearer. MBMS Client in the UE receives the service data, processes it and transmits it to MAA. After receiving the service data, MAA decodes and plays it.
12. When the stop time of a session under a service arrives or the portal manually ends the session through the xMB interface, BM-SC ends the session and release the corresponding downlink multicast bearer resources.
13. MAA calls the API (Application Programming Interface) provided by the MBMS Client to stop the local service. The MBMS Client will stop transmitting corresponding service data and release the related resource.

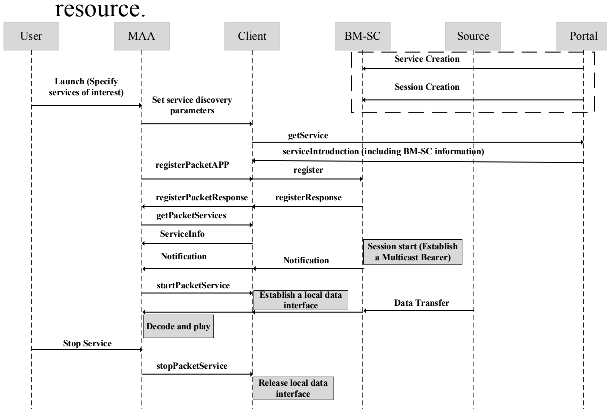

Fig. 2 The service process of eMBMS.

B. *The Architecture of the Multicast System*

Fig. 3 shows the logic architecture of the AVS3 multicast system based on eMBMS. First, the content provider calls the BM-SC's xMB control plane interface through the portal to configure services information to BM-SC, and encapsulates AVS3 video stream in TS (Transport Stream). When the eMBMS service starts, content provider uses RTP (Real-time Transport Protocol) to send TS stream. EPC (Evolved Packet Core) and eNodeB (Evolved Node B) are responsible for baseband transmission and baseband processing, and complete the multicast data transmission and radio bearer control according to the eMBMS radio scheduling information. MBMS GW (MBMS Gateway) is a logical node in the eMBMS network, which processes the eMBMS IP flow from BM-SC to all the eNodeBs. This includes: assigning an IP multicast address to the eNodeB joining the eMBMS network, and sending the eMBMS IP data stream to each eNodeB through multicast. The USRP (Universal Software Radio Peripheral) is used to simulate the transmitting and receiving functions of antenna. After receiving the video stream, the PAD is responsible for baseband processing and forwarding the stream to the mobile phone. Then the mobile phone is responsible for RTP receiving, TS decapsulation, decoding and playback.

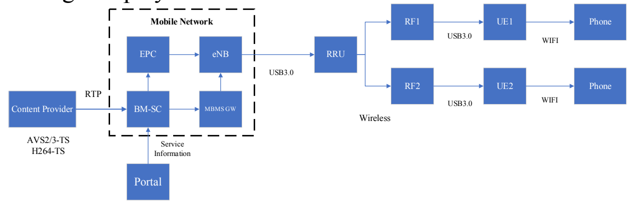

Fig. 3 The architecture of the AVS3 multicast system based on eMBMS

III. Experiment and Results

The performance of this system is tested on Ubuntu 16.04 operating system. The information of the test sequence is shown in Table 2. The encode platform is HPM, the reference software of AVS3, and the encoding configuration is set according to common test condition of AVS3[10]. In order to prevent the IP fragmentation[11] during transmission and improve transmission efficiency, the UDP data filed length of each UDP datagram is set to 1472 bytes[12]. The maximum downlink is set to 15Mbps.

Table 2. The information of test sequence

Sequence Name	Resolution	Frame Rate	Bit Depth	Bitrate
ParkRunning3	3840x2160	50FPS	10	10.43Mbps
Campfire	3840x2160	30FPS	10	10.13Mbps
BasketballDrive	1920x1080	50FPS	8	5.23Mbps
Cactus	1920x1080	50FPS	8	5.06Mbps
Crew	1280x720	60FPS	8	3.06Mbps
City	1280x720	60FPS	8	3.03Mbps

During the experiment, different number of UEs were used to send requests to the content provider at the same time to obtain the video stream. The content provider transmits the video stream by unicast and eMBMS broadcast respectively. The bandwidth usage in the network was recorded. The experimental results are shown in Table 3.

Table3. The bandwidth of unicast and eMBMS broadcast respectively

Sequence Name	Number of UE	Unicast	eMBMS Broadcast
ParkRunning3	1	10.76Mbps	10.76Mbps
	2	21.58Mbps	10.76Mbps
	3	32.65Mbps	10.76Mbps
Campfire	1	10.54Mbps	10.54 Mbps
	2	20.78 Mbps	10.54 Mbps
	3	30.92 Mbps	10.54 Mbps
BasketballDrive	1	5.41Mbps	5.41Mbps
	2	10.57 Mbps	5.41Mbps
	3	15.84 Mbps	5.41 Mbps
Cactus	1	5.21Mbps	5.21 Mbps
	2	10.30Mbps	5.21 Mbps
	3	15.45Mbps	5.21 Mbps
Crew	1	3.17 Mbps	3.17 Mbps
	2	6.42 Mbps	3.17 Mbps

	3	9.65 Mbps	3.17 Mbps
City	1	3.12Mbps	3.12Mbps
	2	6.16Mbps	3.12Mbps
	3	9.27Mbps	3.12Mbps

It is obvious that when transmitting the video stream by unicast technology, the bandwidth usage increases linearly with the increase of the number of users, and each user needs independent bandwidth resource. The use of eMBMS technology can achieve the broadcast and multicast in a region. All users in this region share band-width resources, and the increase in the number of users will not lead to the increase in bandwidth usage. Therefore, using eMBMS technology can save bandwidth re-sources and improve the video viewing experience.

IV. Conclusion & Prospect

With the promotion of ultra-high-definition video, a new generation of video coding standards with higher compression performance will be widely used. Ultra-high-definition video with a large amount of data will occupy more bandwidth. Currently, wireless unicast communication methods cannot meet the needs of dense crowds watching videos at the same time. Using eMBMS technology to provide the same content to multiple users at the same time can save bandwidth resources and improve user viewing quality. Therefore, this paper uses the eMBMS technology to realize the multicast of AVS3 video stream within a fixed area. The experiment results show that all users in this region share band-width resources, and the increase in the number of users will not lead to the increase in bandwidth usage.

References

[1] Audio Video coding Standard Workgroup of China[EB/OL]. http://www.avs.org.cn/. Accessed 27 September 2021.

[2] Junru Li J C a Z Y. HPM9.0 and HPM-9.1 software maintenance report, AVS M5991[R]. December 2020.

[3] 3gpp. Signaling Transport for Interfaces Supporting Multimedia Broadcast Multicast Service (MBMS) within E-UTRAN, TS 36.442 V9.1.0, 2010.

[4] Xiaorong Chen E A. Principle and capacity analysis of LTE eMBMS[J]. No.187(07), pp. 108-109 (2018).

[5] Introduction of eMBMS[EB/OL]. http://blog.sina.com.cn/s/blog_613eaa090100eskm.html. Accessed 27 September 2021.

[6] 3gpp. Multimedia Broadcast / Multicast Service (MBMS). User Service Guidelines, TS 26.946, 2011.

[7] 3gpp. Multimedia Broadcast / Multicast Service (MBMS). Architecture and Functional Description, TS 23.246, 2014.

[8] Kui Fan E A. HPM-3.0 reference software maintenance report, AVS M4705[R]. 2019.

[9] 3gpp. Multimedia Broadcast/Multicast Service (MBMS); Application Programming Interface and URL, TS 26.347, 2019.

[10] Fan K. Common test condition of AVS3-P2, AVS N2654[R]. 2019.

[11] Liu Y. Research on IP fragmentation transmission of UDP datagram[J]. China Today Forum, 2013(12): pp. 199.

[12] Restrictions on the size of TCP and UDP segments[EB/OL]. https://blog.csdn.net/hellozhxy/article/details/80280197. Accessed 27 September 2021.