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Brief Introduction to Virtual Reality Session 3: VR Bandwidth Requirements of Good User Experience

iLab

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Why are some 4K VR 360 videos clear while others look like moving pixels? Is the difference related to bandwidth? Based on the VR 360 video features and compression mechanisms, this session introduces the bandwidth required for good VR experience.

1. 4K Video Quality Sacrificed Due to Low Bandwidth

1.1 4K VR 360 Video Is Being Popularized on Mainstream Platforms Both at Home and Abroad

With mature E2E technologies, 4K VR 360 videos are a new norm in VR live and VoD services.

ICP	720p	1080p	2K	4K
LeTV VR video	0.00%	99.85%	0.15%	0.00%
Storm Codec VR video	0.00%	0.00%	4.00%	96.00%
Youku VR video	9.97%	20.60%	13.95%	55.48%
YouTube VR video	8.33%	13.43%	9.72%	68.52%
Facebook VR	0.85%	7.25%	90.70%	1.20%

1.2 VR 360 Video Experience Varies with Bandwidth

First, compare the screenshots from two 4K VR 360 videos.

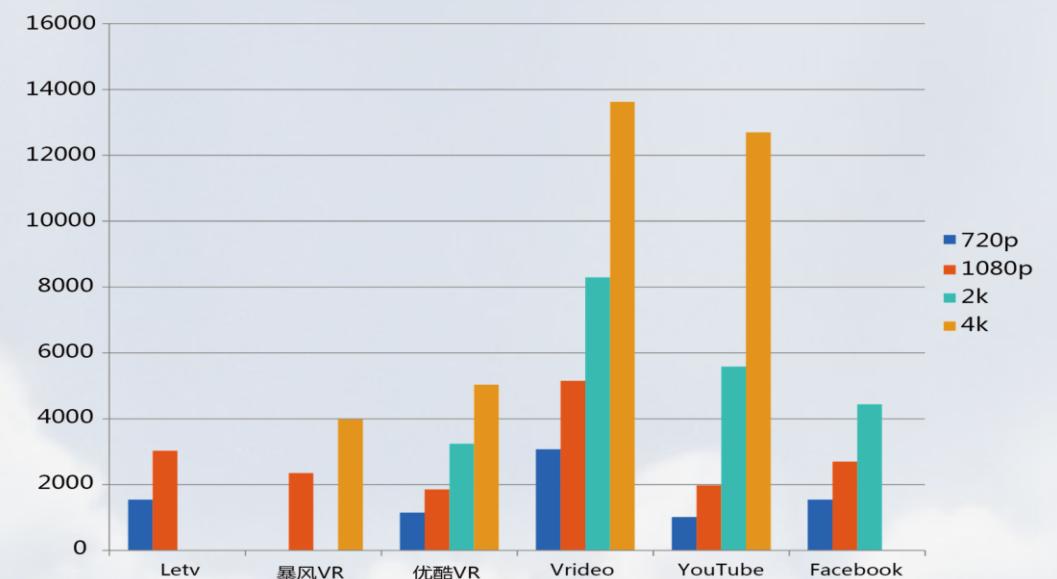


Tmall Buy+ VR 360 video



YouTube VR 360 video

Obviously, YouTube VR 360 videos are clearer than Tmall Buy+ VR 360 videos in the display of details. The reason is that the bit rate (amount of data transmitted per unit time) of YouTube VR 360 videos is higher. According to the statistics in *Huawei iLab: VR Big Data Report 2016*, the VR 360 video bit rate of platforms outside China (12 to 14 Mbit/s) is generally higher than that of Chinese platforms (less than 6 Mbit/s). For a same coding protocol, a higher bit rate translates to better details and higher quality.



The video bit rate relates to video quality and the required bandwidth. According to the conclusion in *Huawei iLab: VR Big Data Report 2016*, for smooth streaming of VR 360 video in VoD and live services, the required minimum bandwidth is 1.5 to 2.98 times of average bit rate (TCP requires higher bandwidth than UDP).

At present, 4K VR 360 video quality is watered down even in foreign platforms. The ideal 4K VR 360 video bit rate requires at least 30 Mbit/s (H.264 coding), and the required minimum bandwidth for smooth streaming is 45 to 90 Mbit/s.

	Watered-down 4K	Ideal 4K
Bit rate	5 to 15 Mbit/s	30 Mbit/s
Bandwidth requirement	10 to 40 Mbit/s	45 to 90 Mbit/s

1.3 High Network Cost and Insufficient Bandwidth, Causing Decreased Quality of 4K VR 360 video

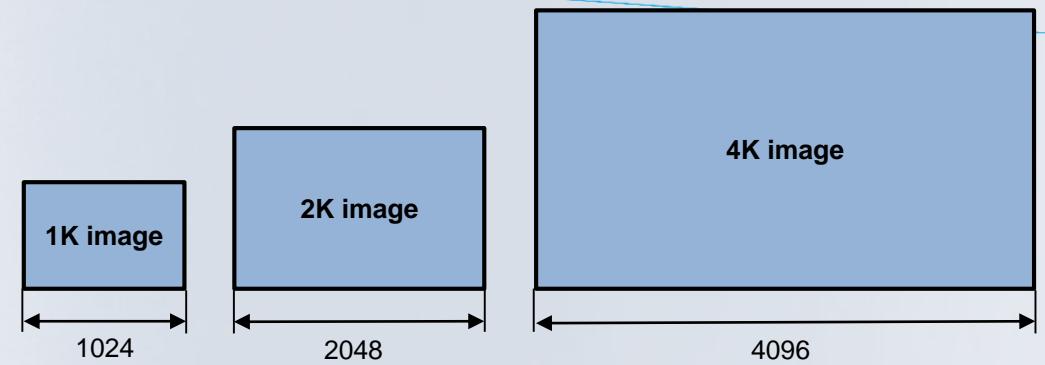
The reasons for decreased 4K VR 360 video quality are as follows: First, high-bit-rate VR 360 videos have higher requirements on server rendering and CDN distribution capability, resulting in higher costs in servers and networks. Second, a higher VR 360 video bit rate requires higher average rate of user access bandwidth. However, not every household has 100M internet access.

2. Factors Affecting VR 360 video Bandwidth Requirement

As we know, VR 360 video bit rate affects the bandwidth requirements. What factors affect VR 360 video bit rate? The following section will analyze the factors that impact the bit rate and bandwidth requirements.

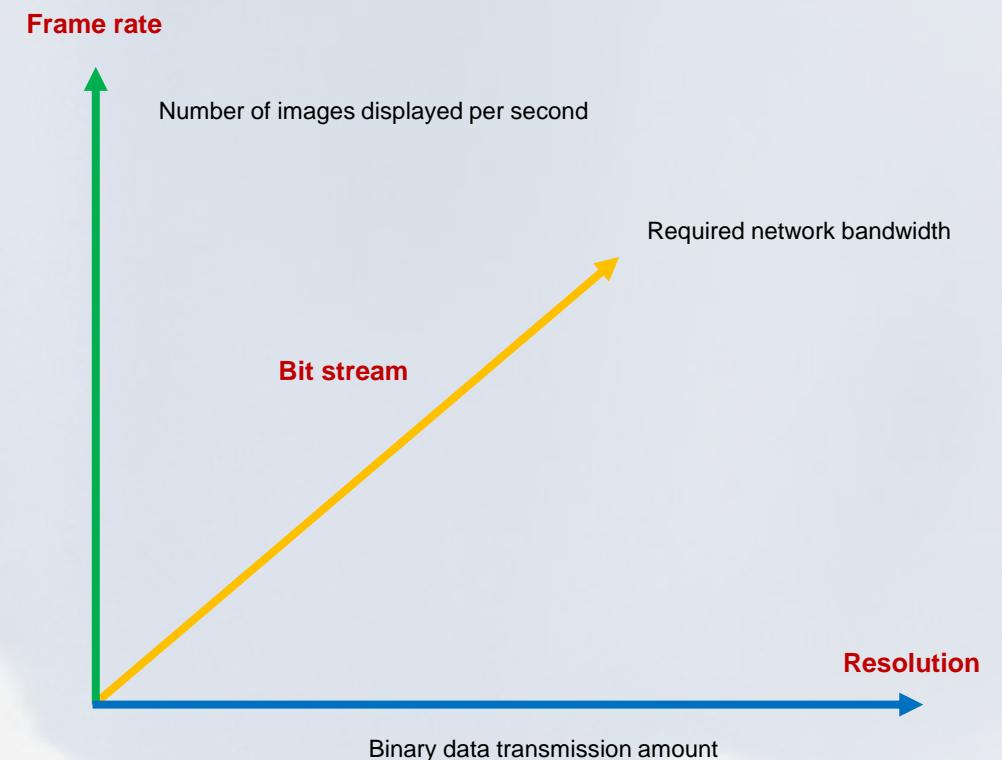
2.1 Resolution

Resolution is directly proportional to the size of the image. When shooting the same content, a higher resolution brings more pixel information, larger video image and bit rate, and higher bandwidth requirements.



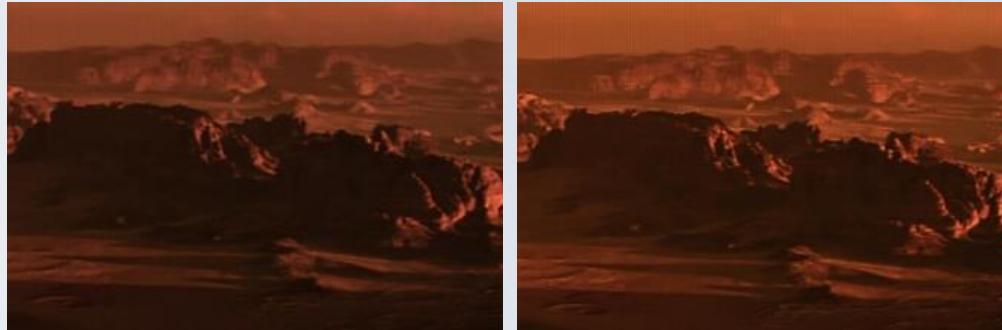
2.2 Frame Rate

Frame rate impacts the video smoothness. A higher frame rate means more images played per second and smoother streaming, and requires higher bandwidth.



2.3 Bit Depth

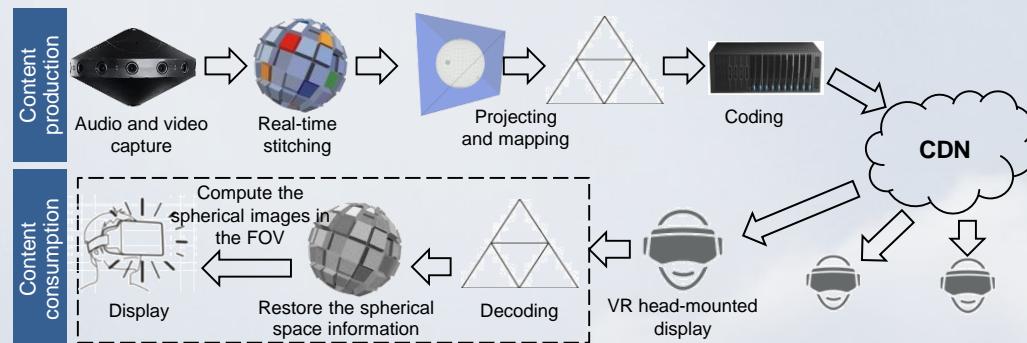
Bit depth refers to the number of bits required by each pixel, that is, the amount of color information that can be used. More information bits of each pixel bring richer color performance, higher bit rate, and larger bandwidth requirements.



Comparison between 8-bit SDR (left) and 10-bit HDR (right) images

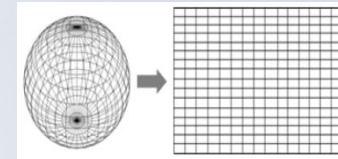
2.4 Encoding Protocol and Compression Ratio

The VR 360 video coding protocol (H.264, H.265, and VP9) and compression ratio (the compressed video bit rate/original video bit rate) also affect the required bandwidth. When compressing the same video without affecting user experience, H.265 requires lower bandwidth than H.264. For the same coding technology, a higher compression ratio requires lower bandwidth.

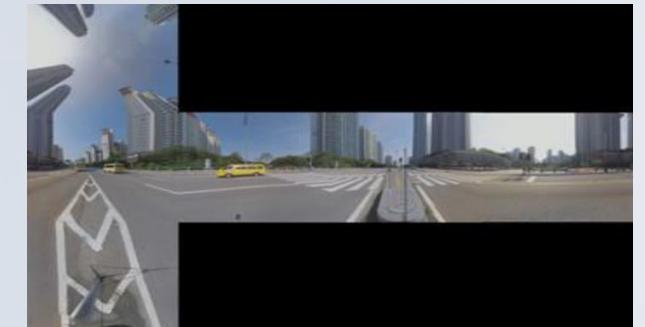
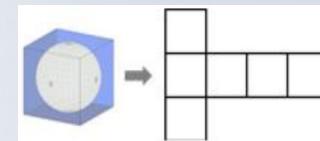


2.5 Projection Mode

Different from traditional video, VR 360 video changes the spherical space information to print media, which requires projection technology. At present, the projection modes include equiangular projection (ERP) and polyhedron projection (PSP). In ERP projection mode, quality distortion may occur, and the compression efficiency is low. The PSP mode brings low quality distortion and high compression efficiency. Compared with ERP mode, the bit rate and bandwidth requirements are lower.



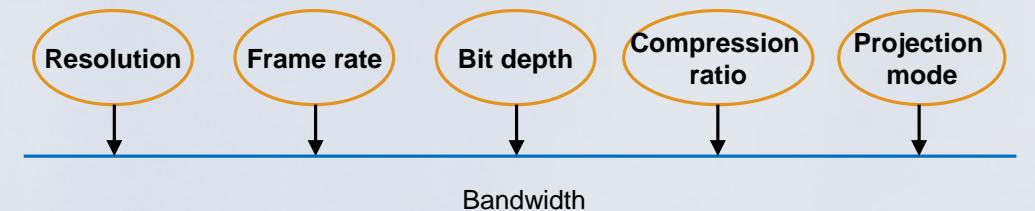
ERP projection mode



The polyhedral (hexahedral) projection mode

Conclusion:

Insufficient bandwidth may cause the decreased quality, frequent frame freezing and slow loading of VR 360 video, affecting user experience. Video resolution, frame rate, bit depth, coding protocol, and the projection mode determine the bandwidth requirements.



Currently, 4K VR 360 video is widely used, but 8K VR 360 video can provide the basic standard definition video experience. According to the released *New VR Technology at Mobile World Congress (MWC) 2017--8K VR 360 Videos Are Ready to Go*, a 8K VR 360 video needs at least 100M bandwidth. For common families that have multiple screens, the 100M bandwidth seems inefficient.