HUAWEI Videoconferencing White Paper

VME+H.264HP:

Dual-Core Video Experience

Contents

1 Overview

The wide application and enormous market prospect of HD video communications have stimulated the development of video compression and transmission technologies. From SD through HD, to HD at low bandwidth, Huawei, relying on its strong R&D capability and technology advantages, has focused on the development of videoconferencing products, to continuously provide customers with optimal experience and the most cost-effective videoconferencing solutions.

At present, H.264 Baseline Profile (BP), due to its simple algorithm and low-cost hardware, is commonly used in the video communications industry. In the current network environment, however, customers are concerned about the higher bandwidth and network adaptability required to set up an HD videoconferencing system using H.264 BP.

The H.264 High Profile (HP) compression standard has therefore been developed to effectively meet the requirements mentioned above. Huawei has never ceased the research on product development using H.264 HP, and has been dedicated to providing customers with the most cost-effective H.264 HP solutions, to boost the development of the entire video communications industry.

This white paper provides a concise description of Huawei's H.264 HP solution and Huawei's proprietary and innovative video processing technology, Video Motion Enhancement (VME).

1.1 H.264 HP

H.264 is a new digital video coding standard developed by the ITU-T Video Coding Experts Group (VCEG) together with the ISO/IEC Moving Picture Experts Group (MPEG), known as the Joint Video Team (JVT).

H.264 defines four profiles: BP, Extended Profile (EP), Main Profile (MP), and HP.

1. BP: basic video quality. BP supports I-frames and P-frames, and only progressive scanning and context-adaptive variable-length coding (CAVLC). BP is mainly applicable in interactive services, such as videoconference and video call.
2. EP: advanced video quality. EP supports I-frames, P-frames, B-frames, SP-frames, and SI-frames and only progressive scanning and CAVLC. EP is mainly applicable in video broadcasting, such as television broadcasting.
3. MP: mainstream video quality. MP supports I-frames, P-frames, and B frames, both progressive and interlaced scanning, and both CAVLC and context-adaptive binary arithmetic coding (CABAC). MP is mainly applicable in streaming media, such as network video.
4. HP: advanced video quality. Apart from all the capabilities of MP, HP also supports 8 x 8 intra-prediction, custom quantity, lossless video coding, and various YUV formats. HP is

mainly applicable in fields using HD video compression technologies, such as video conferences.

To provide a broader range of applications in high standard professional application scenarios, the JVT develops some video compression standards, which are collectively known as H.264 HP. Compared with H.264 BP, the H.264 HP uses some new technologies, such as B-slice, weighted prediction, field coding, CABAC, 8 x 8 integer transform, and adaptive quantization matrix (AQM), which greatly improves the video compression ratio.

1.2 VME

As a video processing algorithm, the VME enhances the visual clearness and comfort, and effectively improves video quality by the following video processing technologies: image noise reduction, edge effect enhancement, eliminating blocking artifacts, intelligent super-HD, and video customization mode.

2 Low Bandwidth Technologies

Huawei aims to provide customers with the demand-oriented and most cost-effective solutions. In the videoconferencing industry, customers are always concerned about the network bandwidth. To effectively reduce the network investment of customers, Huawei develops the following technologies to save half of the bandwidth without affecting the video quality.

H.264 HP

In the videoconferencing industry, the compression efficiency of H.264 HP is higher than that of H.264 BP. In specific, the bit rate necessary for a given compression quality is reduced by 10% to 20 if CABAC is used, 5% if 8 x 8 integer transform is used, and reduced greatly if field coding is used in comparison to CAVLC, 4 x 4 integer transform, and frame coding of H.264 BP. By using the preceding technologies, the compression ratio is improved, residual coefficient decreases after compression, and high quality signals can be transmitted at a low network bandwidth.

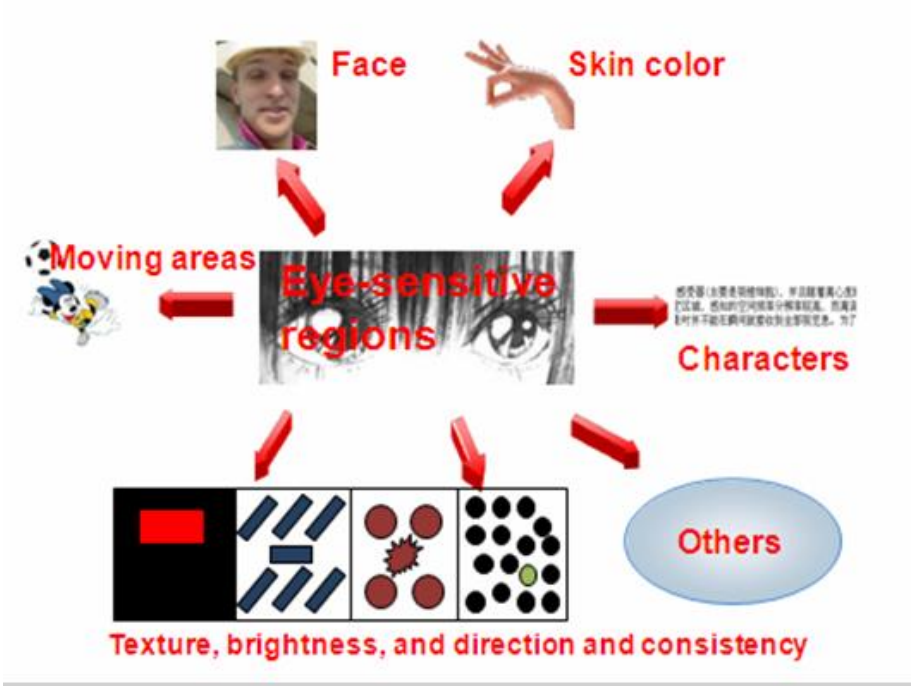
2.2 Intelligent Video Compression Technology

The core concept of the intelligent video compression technology is as follows: The coder allocates more bit rate and calculation resources to eye-sensitive regions and less resources to eye-insensitive regions based on the end user's visual perception characteristics.

In addition, by making full use of the characteristics of the Human Visual System (HVS), less bit rate is required for coding for a given compression quality, which greatly helps improve the efficiency of video compression by using a video compression algorithm. For example, in cases where the bandwidth is not sufficient, especially in low bit-rate application scenarios, the video compression algorithm can allocate more bit rate and calculation resources to eye-sensitive regions to ensure or even improve end users' subjective experience.

In the videoconferencing system, eye-sensitive regions include face, skin color, moving areas, characters, and special objects, as shown in the following figure.

Figure 2-1 Key eye-sensitive regions



Huawei's intelligent video compression technology first introduced image analysis technology to enable differentiating processing strategy of eye-sensitive and eye-insensitive regions. With this technology, more bit rate and calculation resources can be allocated to eye-sensitive regions, and intelligent super-HD technology is used to effectively improve the quality of video coding in eye-sensitive regions or reduce bit rate without affecting end users' subjective experience.

Figure 2-2 Intelligent video compression technology

Before After

2.3 Frame Rate Up-conversion

In the videoconferencing industry, it is sometimes necessary to discard some frames during coding to reduce the time resolution and interpolate these frames during decoding to enhance video quality at lower bandwidth and satisfy diverse end user needs.

The frame rate up-conversion technology is therefore developed to meet the preceding requirements. As a technology for increasing the number of frames per second, frame rate up-conversion is used to recover the frame rate of a low bit-rate video system to its original level and reconstruct lost frames in a wireless video communication system.

The number of frames per second can be increased by the following two methods:

- Duplicate the preceding frame and use it as the frame to be interpolated.

  This method causes unexpected changes to the motion profile.
- Interpolate the frame derived by linear interpolation of the preceding and following frames.

  This method causes blurred edge of moving objects.

To resolve the problems caused by frame rate increase, Huawei introduces the motion compensated frame interpolation (MCFI) algorithm to increase the number of frames per second by the following procedure:

1. Obtain motion vectors based on motion estimation.

2. Obtain the frame to be interpolated by the motion compensation frame interpolation algorithm.
3. Interpolate this frame. In this way, the frame rate of a low bit-rate video system can be recovered to its original level so that the required bandwidth can be effectively reduced without affecting end users' subjective experience.

Figure 2-3 Motion compensated frame interpolation

Preceding frame In-between frame interpolation Following frame

3 VME

In the videoconferencing industry, video quality is always one of essential concerns of customers. Huawei's VME delivers cutting-edge visual effect and provides customers with immersive experience.

3.1 Noise Reduction and Enhancement

During the processing and transmission of digital images, noise is often introduced by imaging devices and ambient noise. At present, there are two noise reduction methods: spatial filtering and time-domain filtering.

Typical measures of the spatial filtering, such as median filtering and adaptive filtering, cannot bring optimal image processing effect in video application scenarios because it does not make full use of the time-domain information.

The time-domain filtering considers the correlation of interframe images but can only bring excellent effect when the object is not moving. With this method, imaging problems, such as image artifacts may occur for moving objects. For example, blurred edge or even artifacts may occur for small moving objects, and unrecognizable images for large moving objects.

The noise reduction technology of Huawei combines the time-domain filtering and spatial filtering and intelligent motion detection algorithms. With this noise reduction technology, moving images per frame and static images per frame can be effectively distinguished from each other, and different filtering strategies can be used accordingly. In addition, the filtering strategy is self-adaptive to the actual characteristics of pixels. Therefore, Huawei's noise reduction technology can bring an excellent effect that cannot be achieved by using a single algorithm.

Integrated with VME, Huawei's videoconferencing systems support end-to-end noise reduction and enhancement from video input (video captured by the camera) to video output (decoded video). Such functions greatly reduce video noise and enhance video smoothness, to display video details to the greatest extent and increase video quality at lower bandwidth.

Figure 3-1 Noise reduction effect

Before After

3.2 Video Post-Processing After Decoding

Higher compression rate results in higher loss in image information, more obvious blocking artifacts, and worse video quality. With the video post-processing technology, filtering intensity required for each pixel can be determined automatically according to the characteristics of images per frame, and different parameters can be used for filtering. In another word, high-intensity filtering can be used when necessary to remove blocking artifacts, and low-intensity filtering can be used when necessary to display video details to the greatest extent. After intelligent super-HD processing, the details are clearer than those of reconstructed images. In this way, Huawei's video post-processing technology can improve video quality and provide customers with better visual experience.

Figure 3-2 Video post-processing effect

Before After

As shown in Figure 3-2, after the video post-processing technology is used:

1. Blocking artifacts disappear.
2. Details and profile of images become clearer.

3.3 Intelligent Super-HD

Clearness describes how quickly the image detail transits at an edge. To present all image details and enhance image clearness, Huawei's VME introduces the concept of intelligent super-HD to reproduce the details that are lost. Figure 3-3 shows the effect of applying the intelligent super-HD technology.

Figure 3-3 Effect of applying the intelligent super-HD technology

Before After

This technology enhances the profile and details and enables gentle and delicate images. The picture on the right provides better visual effect than the picture on the left in terms of clearness, color, and contrast.

3.4 Rendering and Streak Elimination

The following problems encountered during video decoding at lower bandwidth are commonly recognized in the industry: ringing artifacts of video textures and edges, high QP blocking artifacts, streaking effects during video coding, and difficulty in ensuring video smoothness. Huawei's VME technology first introduced the concept of video post-processing after decoding, successfully handling the preceding difficulties. Combining Huawei's self-developed core efficiency enhancement algorithms with the H.264 standard, Huawei's VME delivers cutting-edge visual effect while ensuring interconnectivity with products of other providers.

Figure 3-4 Effect of eliminating rendering and streaks

3.5 Customized Video Adjustment

Huawei's VME, having fully considered different end users' subjective experience, provides the customization mode for end users. Huawei's VME allows end users to adjust the settings to suit their own experience, satisfying diverse user needs and meeting application requirements in various scenarios.

Figure 3-5 Customized video adjustment

Before After

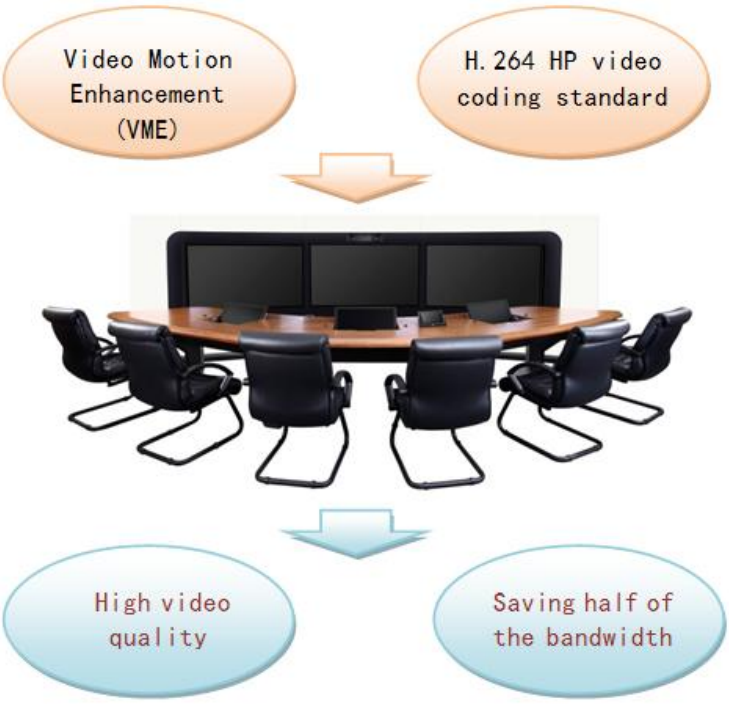
Huawei, with the most advanced dual-stream processing technology in the industry, provides excellent reproduction of the clearness, smoothness, and colors of presentations and stunning 1080p and 720p HD dual stream effects. Huawei's VME also supports dual-stream processing.

4 VME+H.264 HP: HD Video Experience at Lower Bandwidth

Huawei VME+H.264 HP technology provides customers with optimal HD video experience at lower bandwidth. The main benefits are as follows:

1. The H.264 HP video coding standard helps to achieve a 50% bit rate reduction without affecting the subjective experience.
2. The VME delivers high-quality visual clearness and comfort after decoding.

Figure 4-1 Application of VME+H.264 HP in videoconferencing system



Huawei's VME+H.264 HP dual-core driver technology, an end-to-end technology, enhances the video quality and improves the visual comfort. In addition, at least half of the bandwidth is saved, and the visual effects of 720p at 384 kbit/s and 1080p at 512 kbit/s are realized.

Huawei's videoconferencing products support "VME+HP" dual-core driver to ensure favorable interoperability with products of other vendors in the industry using H.264 HP and desirable compatibility with currently used H.164 BP.

Compared with H.264 BP, Huawei's "VME+HP" technology helps to save half of the bandwidth, enhance the video quality, and overcome the challenge in video communication. With this technology, companies do not have to upgrade the network or only have to upgrade a part of the network during deployment of the videoconferencing system, but can obtain high-quality visual clearness and comfort and improve the communication efficiency.

Table 4-1 Comparison of bandwidth requirements for the same visual effect

Resolution/ Frame Rate	H.264 BP Bandwidth	H.264 HP Bandwidth	VME+H.264 HP Bandwidth	Bandwidth Reduction
4CIF	256 kbit/s	128 kbit/s	128 kbit/s	50%
720p/30 fps	768 kbit/s	512 kbit/s	384 kbit/s	50%
720p/60 fps	1152 kbit/s	832 kbit/s	512 kbit/s	55%
1080p/30 fps	1472 kbit/s	1024 kbit/s	512 kbit/s	65%
1080p/60 fps	2.5 Mbit/s	1.5 Mbit/s	1 Mbit/s	60%

5 Summary

Huawei's VME+H.264 HP dual-core driver technology enables high-quality visual comfort, improves the people-centric video experience, and contributes to at least 50% bit rate reduction. Therefore, the customers can obtain better video experience, while reducing the investment in network upgrade.

VME+H.264 HP represents Huawei's persistent belief in driving product development with "experience" and providing customers with the most cost-effective video communications solutions.