HUAWEI

Best-UHD Industry Development White Paper

Embracing the Best-UHD Video Era Together

Contents

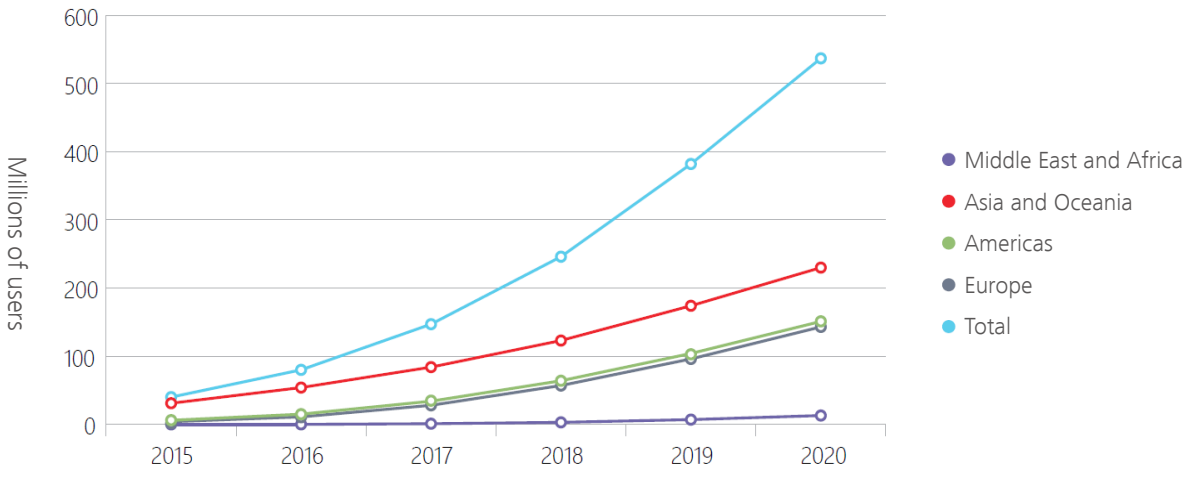
1 UHD Industry Development Trend

In the past two years, 4K TV service has developed rapidly. As ultra high definition (UHD) TV technologies and standards matured and the industry chain and ultra broadband (UBB) network improved, UHD TV service is stepping into the rapid development phase.

4K/UHD TV Service Stepping into the Rapid Development Phase

By August 2016, there were nearly 10 million 4K/UHD TV service users worldwide. The rapid sales of 4K/UHD TVs promoted the development of 4K/UHD TV service. 4K/UHD TVs account for more than 60% of large screen TVs in China, and outside of China the delivery ratio of 4K/UHD TVs is more than 40%.

According to the forecast of OVUM, the decreased price and new subscription-based UHD TV services will attract half of the TV-owning families worldwide to use 4K/UHD TVs by 2020.



Forecast of the number of families using UHD TVs worldwide (data source: OVUM)

Overall Launching of 8K and VR

The world's first 8K live broadcast was used during the 2016 Rio Olympic Games. On August 1, NHK, Japan's public broadcaster, began testing 8K TV broadcasting and broadcasted the opening and closing ceremonies, swimming events, and track and field events of the 2016 Rio Olympic Games. Additionally, NHK plans to broadcast 8K programs over the BS satellite channel in 2018 and intends to popularize 8K programs during the 2020 Tokyo Olympic Games. South Korea also plans to broadcast the 2018 PyeongChang Winter Olympics in 8K. What's more, with the booming development of virtual reality (VR) and augmented reality (AR) technologies and content, 360-degree panoramic video is becoming a new video format for UHD TVs with universal availability just on the horizon.

UBB Accelerating UHD TV Development

The global broadband industry environment is one that is continuously being optimized. More and more countries have introduced policies to support the UBB industry, which has significantly increased the broadband coverage rate. It is estimated that by 2020, 100 Mbit/s bandwidth will become the basic configuration of broadband service, and UBB networks that can be upgraded to Gigabit bandwidth will be ubiquitous.

UHD (4K/8K) and panoramic videos become the best padding content for UBB networks. UHD TV and UBB are complementary. UHD TV service will become the key service that can meet users' requirements, fully use the network capabilities, and realize carriers' business value. Therefore, UHD video services will become basic services on carriers' UBB networks.

2 Challenges of UHD Video Industry Development

Limited Consumer Perception of Quality Improvement, Hard to Attract Users to Pay Extra Money for 4K Services

4K technology only improves resolution, but the difference between a 4K video and high definition (HD) video is not obvious to most viewers. However, the price of many carriers' 4K Video On Demand (VOD) programs and 4K channels is the same as the that of HD programs and channels. This indicates that only resolution improvement hardly attract users to subscription-based 4K content. During the evolution from standard definition (SD) to HD, some users did not want to pay extra money for this type program resolution improvement. As a result, the opinion that resolution is hard to price is still relevant.

Lack of Unified UHD Standards with Good Interoperability and Effect

In the past few years, some international standard organizations (for example, the DVB, ITU-R, EBU, SMPTE, and ATSC) have been trying to define UHD-related standards. The E2E UHD TV industry chain involves many processes. A series of unified UHD standards that have good interoperability and effect for each process are unavailable. In addition, UHD standards develop and enrich as new UHD-related technologies (especially the sustainable innovation of TVs) develop. All these factors greatly affect content production, content delivery, and device production. On the other hand, no adequate tools for quantitatively evaluating E2E UHD experience are currently available today.

ROI Issue of the UHD Transmission Network

Since UHD TV involves transmission of a large amount of data, a high E2E QoS is required. Therefore, UHD TV carriers are faced with bearer network building and return on investment (ROI) issues.

Fiber-based network carriers and cable carriers who have deployed DOCSIS 3.X can provide UHD service with optimal QoS via their broadband networks. In the early phases of the UHD development, the number of users was not large. Therefore, unicast with good service quality was the best choice. However, to support large-scale UHD deployment, investment into FTTx or DOCSIS 3.X needs to increase, addressing the ROI issue. The maximum bandwidth supported by existing DSL networks is less than 25 Mbit/s, which cannot ensure UHD service quality（Netflix HDR video content need 25Mbps bandwith,， Euro & other sports event in SDR 2160p50/60 is today > 25Mbps）. As a result, DSL networks need to be reconstructed.

Lack of UHD Content

The lack of UHD content is caused by many factors. The prevailing factor is that the production cost of UHD content is higher than that of HD content. Professional UHD content production requires not only upgrading existing content collection, editing, storage, encoding, transcoding devices and tools but also the modification of production processes to comply with UHD-related standards.

As such, UHD content providers are faced with a dilemma. On one hand, traditional distributors and TV carriers have yet to provide UHD content for users on a large scale. On the other hand, OTT providers (such as Netflix and Amazon) have started to support UHD and produce UHD content. In addition, quasi-professional 4K content filming is not complicated and quasi-professional 4K content making is developing rapidly. UHD content providers find themselves in a position where they lack the medium to disperse their content in a traditional and profitable way.

Users Lack UHD TV Awareness, Industry Chain Lacks Collaboration

Most users have no clear understanding of the difference between UHD TV and HD TV and the advantages and benefits of UHD TV. On one hand, many people think that the resolution is the only difference between UHD TV and HD TV. On the other hand, TV manufacturers promote various new UHD television features, which confuses users.

When guiding users to upgrade UHD products and services, the collaboration and investment for each process in the industry chain vary. This is mainly because that from HD to UHD, the future of resolution improvement and UHD remains controversial. Some people approve of resolution increase to 8K and even 16K while others think that 4K is enough and prefer helmet-based VR videos. Judgment for the future of video and UHD affects the investments in each process of the industry chain.

3 UHD Video Services, Basic Services on UBB Networks

4K Is Not Equal to UHD that Attracts Users Through Ultimate Experience

To solve the UHD/4K content monetization issue, we must know which video services users are willing to pay for. Based on our analysis, users are willing to pay for ultimate sensory experience, interactive experience, and real-time content. Therefore, providing UHD service with an experience that is far superior to the existing HD service is the key to the success of UHD TV.

As we know, UHD TV not only improves the resolution to 4K but also brings users immersive and vivid video and audio experience based on a broader wide color gamut (WCG), larger high dynamic range (HDR), high quality surrounding audio (HQS), and high frame rate (HFR). This great overall experience will impress users and attract them to subscription-based 4K services.

Currently, more and more users are willing to pay for ultimate experience and high-quality content. With the rapid development and popularization of UHD TVs (must faster than the popularization of HD TVs), UHD TV service will become the next-generation TV service.

Industry Chain Requiring Definition of UHD Basic Features and Enhancements

UHD TV service is about to step into the rapid development phase. Therefore, the basic features and enhancements of UHD TV need to be defined for content production, content delivery, and device production. This is necessary because, aside from those UHD features mentioned above, various UHD-related features will arise, such as the Next Generation Audio (NGA), scalable coding, dynamic metadata for HDR, 12bit encoding depths, 100/120fps, and 8K. These new features require carriers to keep upgrading their set top boxes (STBs), platforms, and headend devices to support diverse TVs and content.

A good message is that most of the basic technical standards and capabilities (basic features) of UHD TV will be ready by end of year 2016. The combination of these basic features can form UHD sensory experience and services that are much better than HD services. Furthermore, these technical standards and capabilities will create a basic and stable UHD standard set in the UHD TV rapid development phase. Optional UHD enhancements can be implemented through subsequent software upgrade or product upgrade in the future.

IP Network-carried UHD Has Both Technical and Commercial Advantages

OTT suppliers have taken the lead in embracing UHD content. They have used ubiquitous broadband and adaptive streaming technology to greatly reduce the cost of content delivery. The reason behind this is that more and more new video technologies are preferentially applied to the IP network and Internet, and it is easier to deploy the multi-screen interaction feature that is widely welcomed by users based on the IP video technology.

OTT suppliers do not have networks and cannot provide UHD service with the best QoS. In contrast, carriers with optical networks or DOCSIS3.X networks have more advantages in transmitting UHD TV. On one hand, they can gain a favorable position by being the first to provide UHD video on-demand service. On the other hand, UHD TV and broadband bundled charging have been proven to be a successful business model in practice. Typical cases include China Telecom Sichuan's "012" strategy and British Telecom's 4K "BT Sport" service. With a bundled sales strategy, these carriers achieve income growths in both TV service and fixed broadband. This creates a mutually beneficial business cycle among consumers, carriers, and UHD/4K content providers.

Constructing a Mutually Beneficial Business Cycle and Solving UHD Content Problems

Improving device readiness, network readiness, broadband bundled mode, and new IP-based and cloud-based content production is the fundamental method to solving the problem of 4K/UHD content inadequacy and creating a mutually beneficial business cycle.

4K/UHD has taken the lead in achieving the scale-based commercial application on the device side (TV set). More and more consumers choose larger dimension TV sets and almost all TV sets in Chinese appliance stores are 4K/UHD TV sets. Moreover, almost all STBs collectively purchased by Chinese carriers this year are 4K STBs. In the Chinese market, tens of millions of 4K/UHD users will be developed in the upcoming years, which will have strong guiding effects on 4K/UHD content production. It is estimated that in the next five years, the sales of 4K/UHD STBs in the European market will grow rapidly, and the sales will almost double each year.

The rapid deployment of FTTx networks, DOCSIS3. X Cable broadband networks, and content delivery networks (CDN) will create favorable conditions for large-scale 4K/UHD content distribution and monetization. In addition to UHD TV carriers' promotion of the bundled sales of the 4K/UHD TV service and broadband access, the cooperation between OTT service providers with UHD/4K content (such as Netflix) and network carriers with high-quality network (such as AT&T) is also a win-win cooperation mode. Good network quality will better improve 4K/UHD TV content experience and content monetization of OTT service providers.

The adoption of new IP-based and cloud-based content production solution will greatly reduce the production cost of UHD programs. Besides, onsite production can be streamlined to considerably improve the production efficiency. The UHD compression technology is still in the start-up phase, and it is estimated that the compression efficiency will be continuously improved in the next few years. This will also facilitate the reduction of storage costs.

UHD Will Become the Basic Capability for Higher Bandwidth Video Services in the Future

Comprehensively judging from changes in customers' usage habits, network bandwidth popularity, and the penetration of videos into information-based social development, UHD will gradually become the basic capability for higher bandwidth video services. It is estimated that by 2020, UHD will enter more than half of the TV-owning homes in most leading markets. Additionally, immersive and vivid UHD audio-video experience will be widely welcomed by consumers, which will pave the way for the development of higher-bandwidth video services (such as TV video cloud games, TV video social application, 8K, and VR/AR). UHD video capability, which is accumulated in the pay TV service, will soon be applied to various aspects including family entertainment and industrial IT-enabled applications.

Earlier Investment and Development of UHD Brings Earlier Returns

It is an inevitable trend that videos develop from the SD to HD and then to UHD. UHD will soon enter the rapid development phase, and the phenomenon of "earlier investment and development of UHD brings earlier returns" is coming up in each part of the industrial chain. Taking carriers as an example, it is likely to repeat the scenario in the early stage of 3G/LTE development (most of carriers who developed 3G/LTE earlier achieved the leading position in the market). Developing UHD earlier will make it easier to obtain advantages such as brands, first-class supplier partners, and industrial chain supports, which will help carriers develop more users. This scenario has happened in the European, American, and Chinese markets. In the Chinese market, telecom carriers are the first to release 4K TV service on optical fiber broadband networks, which brings great competitive pressure to cable television carriers. Carriers who participate in UHD video on-demand experiments or live TV channel service deployment in advance will accumulate valuable experience and be able to verify the E2E business operation process. Besides, 4K/UHD will generate the most new user segments in the next three to five years. Taking this opportunity and in combination with multi-service bundling, traffic cooperation, and deployment of innovative cloud services, carriers will form differentiated market competitive advantages.

4 Building Best-UHD Together

Why Should We Build "Best-UHD" Together

Based on the foregoing analysis, to make UHD TV service become the next-generation video service, we must firstly develop "Best-UHD" that is far superior to the existing HD service and provides vivid and immersive best visual experience, interactive experience, and timeliness experience. Only with the cooperation of different parts of the industrial chain, solving aforementioned problems that affect the industrial development of UHD TV as soon as possible, will UHD TV service develop in a faster and better way.

How to Build "Best-UHD"

Each part of UHD TV content production and distribution will affect the "Best-UHD". Just like an iPhone, in addition to selecting each part, all parts must be assembled to reach the best experience effect. Therefore, we want to share our practical experience and thoughts with our partners. We summarize general efforts towards the "Best-UHD" into three aspects: Best experience, Best infrastructure, and Best operation. We hope we can push forward related work together with the industrial chain.

"Best-UHD" = Best Experience UHD + Best Infrastructure UHD + Best Operation UHD

Best Experience

Leading Standard

Experience Assurance

Best Infrastructure

Video Cloud SDN/NFV

IP Video Network

Best Operation

Interactive & Intelligent

Ecosystem Cooperation

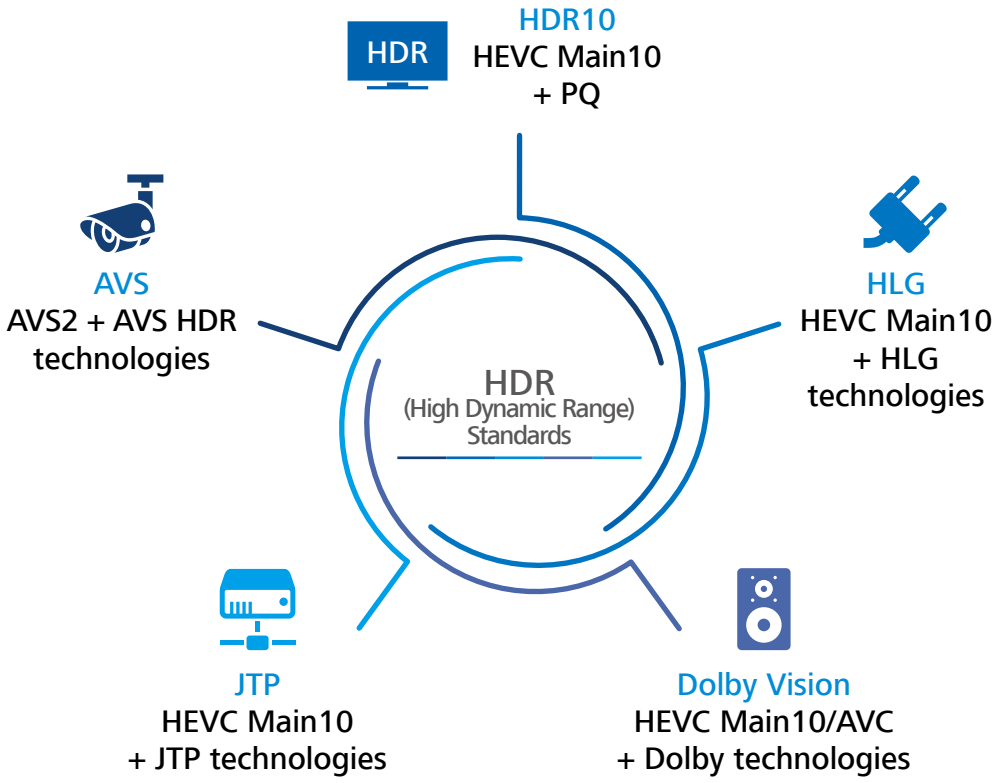
Best-UHD Experience

Basic Features and Leading Standards of the "Best-UHD"

To build the "Best-UHD", the basic features and leading standards combination of the "Best-UHD" must be defined first. This is based on the premise of achieving the best experience, focusing on the video & audio functions that primarily affect users' perception, and selecting the most relevant features and the leading standards in the current stage.

Based on the perception of the human eye, the HDR feature has more significant impact on the effects of UHD video even than the 4K resolution feature. The effect of playing HDR content on an HD TV set is better compared with that of playing common 4K content on a 4K TV set. The experience effect of playing HDR content on a 4K TV set is much better compared with that of playing common 4K content on a 4K TV set. The TV industry also attaches great importance to the HDR. Most of the high-and-medium-grade and low-grade 4K TV sets recently introduced will support the HDR. Therefore, HDR compatible mainstream standards will certainly be the basic feature selection of the "Best-UHD" (as shown in the following figure).

HDR Standards

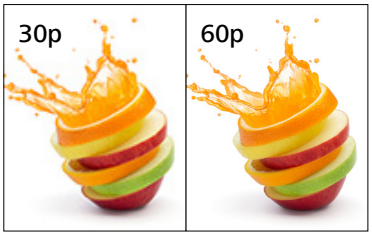


Besides visual experience enhancement, High Quality Surrounding audio (HQS) is a special function to improve accompanying audio quality and provide UHD-equivalent sound experience that is much better than HD-quality sound. This achieves excellent audio quality with high spatial resolution and immersion.

After the comprehensive analysis, basic features and leading standards of the "Best-UHD" must contain the following aspects:

"Best-UHD" Basic Features and Leading Standard
= HR (High Resolution) + HFR (High Frame Rate) + HDR (High Dynamic Range) + WCG (Wide Color Gamut) + HQS (High Quality Surrounding audio)

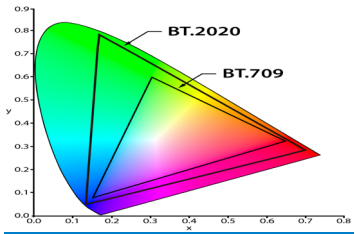
HR: More clear



HFR: More fluent

HQS: Better audio

HDR: More vivid, More details



WCG: More colorful

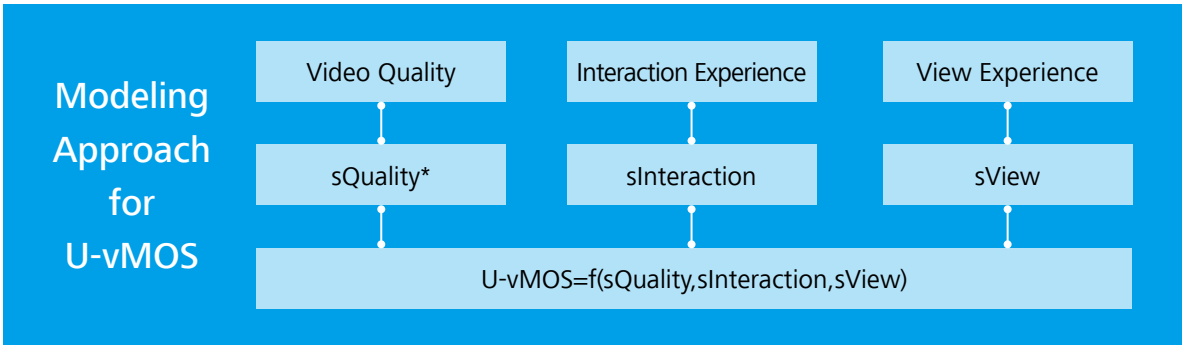
Experience Evaluation and Assurance

After selecting the basic features and leading standards of the "Best-UHD", we need to carry out quantitative evaluation of user experience brought by these feature combinations in the E2E environment. We need to check whether the final experience effect reaches the requirements of the "Best-UHD". A good experience evaluation system is very important. This can facilitate all parts of the industrial chain to reach consensus on the final experience effect, and accurately locate and solve problems.

The User, Unified, Ubiquitous – Mean Opinion Score for Video (U-vMOS) is an open evaluation system for quantitatively evaluating video service user experience. U-vMOS was cooperatively proposed by Huawei 2012 Innovative Laboratory together with industry partners. U-vMOS is used to evaluate video experience that varies depending on different networks, screens, and application scenarios, complying with ITU-R BT. 500, ITU-T P.910, ITU-T P.911.

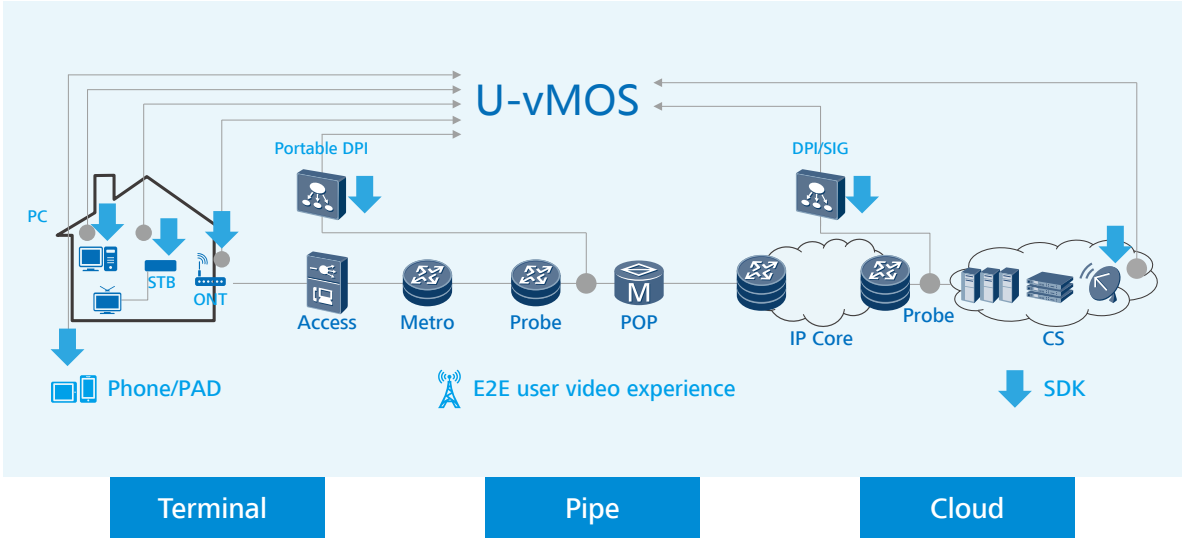
Partners can use the U-vMOS evaluation system to evaluate and rate UHD TV E2E video quality (sQuality), operation experience (sInteraction), and playback experience (sView). The modeling approach for U-vMOS is as follows:

$$U-vMOS=f\left(sQuality,sInteraction,sView\right)$$



Some key features of UHD TV, such as the HDR, have the matching video quality evaluation algorithm in the U-vMOS. By virtue of U-vMOS related tools, partners can conveniently locate and solve problems that affect "0" distortion, "0" waiting, and "0" damage of the UHD video.

In practical application, U-vMOS uses the SDK to complete whole network measurement, including the device, pipe, and cloud, to guarantee E2E user video experience. Some broadband measurement partners (BonRee,Samknows,etc.) have integrated U-vMOS SDK into their tools. It is a very useful tool especially for UHD. in the near future.



Best-UHD Infrastructure

All-IP Architecture, Reducing Cost and Improving Experience

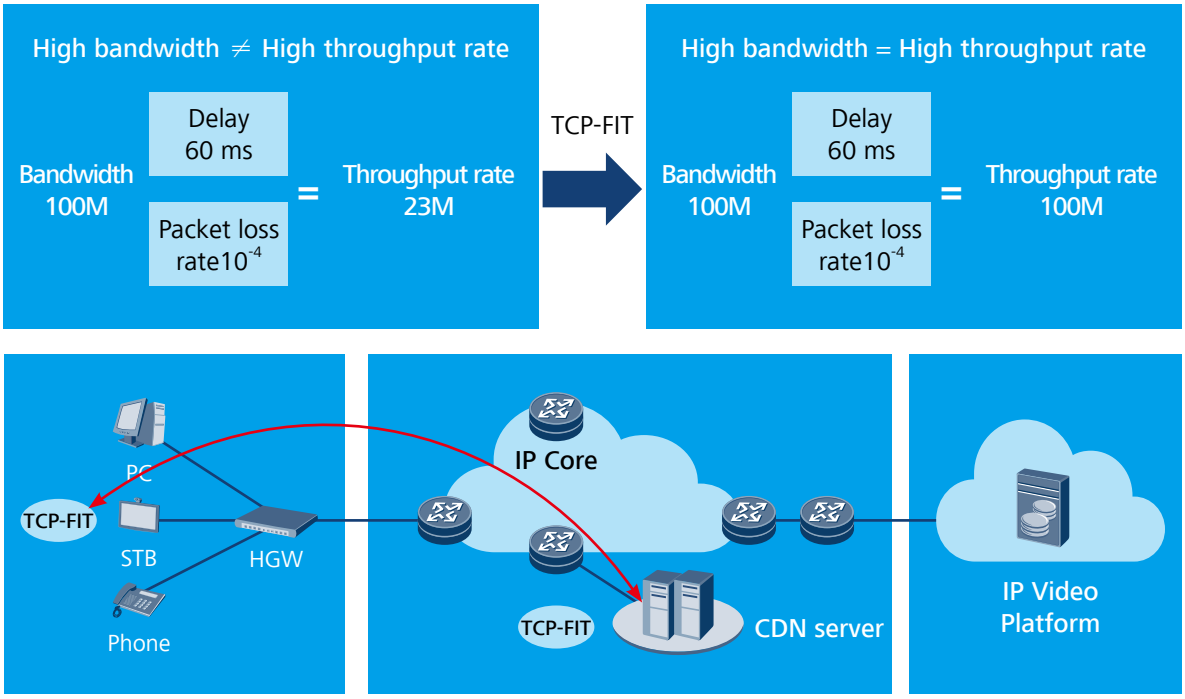
To deliver UHD programs on IP networks, the key is to solve the bandwidth consumption, video delay, UHD parameter passing, multi-terminal adaptation, and other issues.

In addition to the use of more advanced HEVC encoding, on IP networks you can adopt the variable bit rate (VBR) control mode to fully reuse the network bandwidth, compared to the CBR (constant bitrate) technology, the average network bandwidth consumption can be reduced by 20%.

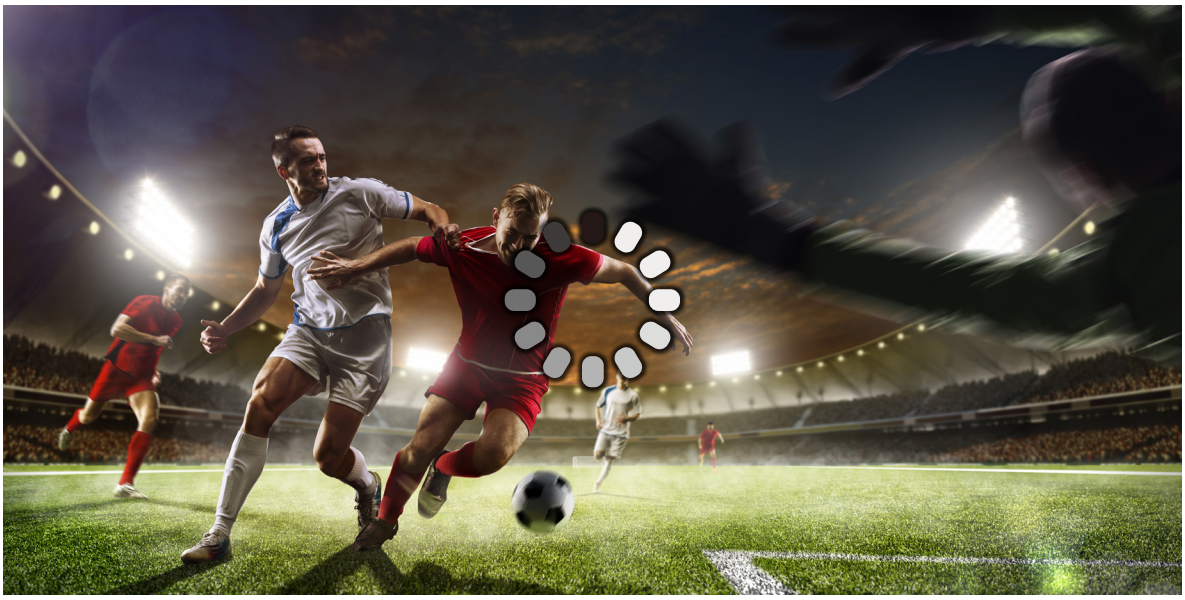
The adaptive bit rate (ABR) streaming can automatically select the best bitrate according to IP network bandwidth change so as to achieve smooth UHD TV content playback. Among the three content formats, compared to Apple's HLS and Microsoft HSS, MPEG-DASH is more standardized, more improved, and more suitable for UHD video transmission. DASH-IF developed under discussion for UHD expansion, including coding, frame rate, media package format, and how to transfer the color space, color primaries, transfer function, and other parameters, which will facilitate UHD TV faster development and usage. Meanwhile, MPEG-DASH also supports the unified format for storage and transmission on the whole network and selection of UHD video resolutions and corresponding DRM content protection mechanisms depending on the terminal equipment capacity, further reducing bandwidth requirements and storage costs.

Huawei 2012 laboratory is still researching DASH Quality Driven Streaming (QDS) technology to determine best MEPG-DASH bitrate based on results of the video quality evaluation, providing better experience while saving bandwidth.

At the same time, the use of CDN acceleration technology is the preferred to solve UHD TV video-on-demand delay and broadcast channel switching delay. According to the actual test, after using CDN TCP acceleration technology, UHD TV Video on Demand waiting time can be reduced to less than one second. With fast channel switching (FCC) technology, UHD live channel switching time can be reduced to less than 0.7 seconds.



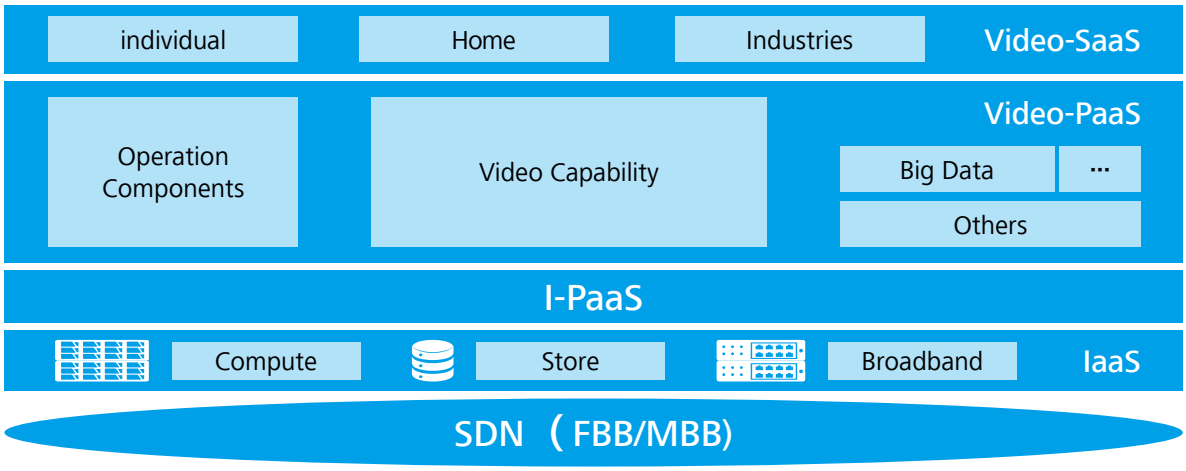
Bandwidth ⇆ Experience



Key factors of root causes: TCP throughput (Packet loss, delay)

Cloud-based Architecture for the Future

UHD video data increased. As a result, UHD content production, encoding and decoding, transcoding, ingesting, and delivery cause long latency and occupy more system resources and equipment room spaces. It is recommended that UHD content be produced and delivered based on cloud-based architecture. This helps improve E2E efficiency and content timeliness, reduce the costs, and bring better service experience to users.



Cloud-based and Autoscaling Platform

The cloud-based platform is recommended, which can componentize the video and management operation capabilities. The cloud-based platform processes and stores UHD content using the autoscaling capability of multiple vCPUs and cloud storage, achieving high-performance and autoscaling framework. In addition, the platform can also open the video capabilities to partners to create new business models, including:

- Video storage, content encryption, and content transcoding
- Delivery acceleration and streaming service
- Intelligent search and image analysis
- Video communications

Cloud-based Device Function

More and more new UHD STBs (IPTV STB or Hybrid STB) can support IP videos and the IP capability enhancement enables some functions of the STBs to be migrated to the cloud platform, accelerating the deployment and promotion of new services and functions. The new-generation UHD STBs will free carriers from the restrictions of traditional STBs.

For example, the Cloud DVR function becomes an attractive function for users when carriers promote the 4K/UHD service. With this function, the local hard disk in STBs that is used for DVR is no longer required. Instead, flexible cloud storage on the IP network is used, ensuring the storage and delivery of UHD content involving a large amount of data. Besides, this function enables users to enjoy the multi-screen service anywhere on any device.

Best-UHD Operation

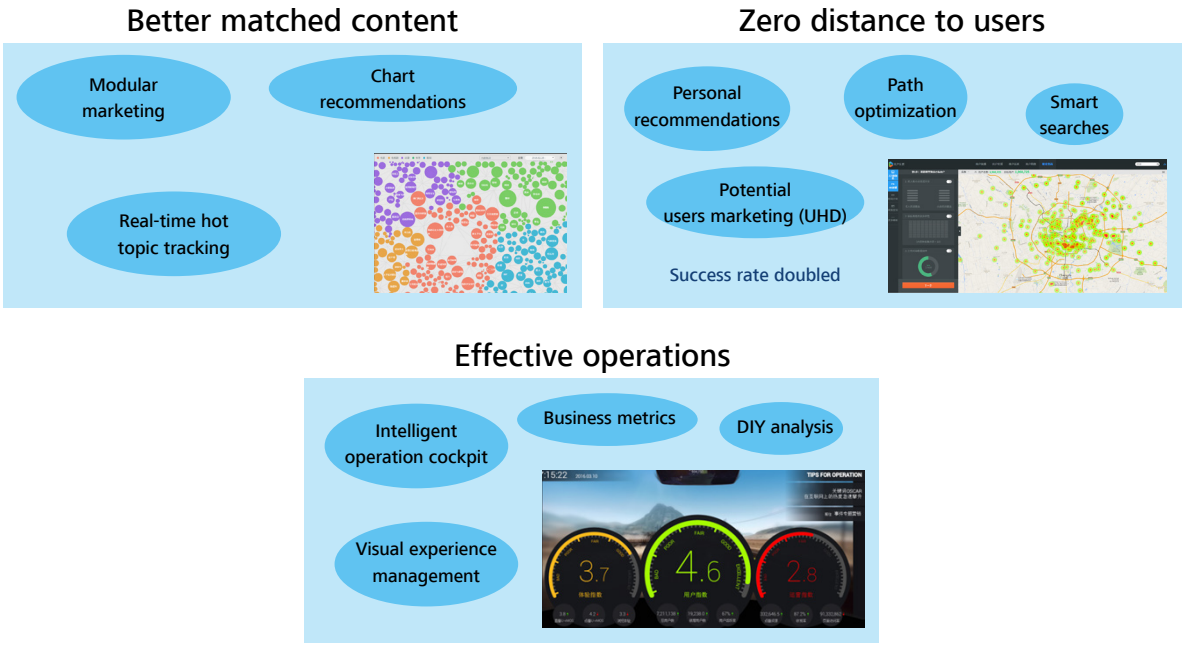
Flexible Interaction and Intelligent Operations

To achieve quick monetization for UHD premium content, the more flexible and intelligent interaction operations need to be used to improve user perception and deeply mine the user value.

Unified and Flexible Interactive Touch Points

How to organize and display UHD content? How to make UHD content easy to search? In the multi-screen video era featuring TV, tablet, phone, and VR headset, will the unified experience and collaborative operation of multi-screen touch points become possible? The touch point experience, which will directly affect user perception and UHD content operation, is a key to assess the operation capability of video service providers. Therefore, an advanced touch point management mechanism that supporting the following functions needs to be created.

- Flexible content delivery.
  This mechanism can automatically create diverse rankings by arranging contents from different content providers and supports one-stop global search for contents, information, and topics.
- Content management featuring rapid response.
  This mechanism quickly integrates scattered popular content into unified marketing subjects based on marketing operation requirements to dynamically respond to marketing requirement changes.
- Personalized touch points.
  This mechanism develops a personalized EPG. The EPG provides a unified portal and various touch points and performs precise content recommendation based on content similarity and social relationships.



Smart Operation Driven by the Big Data

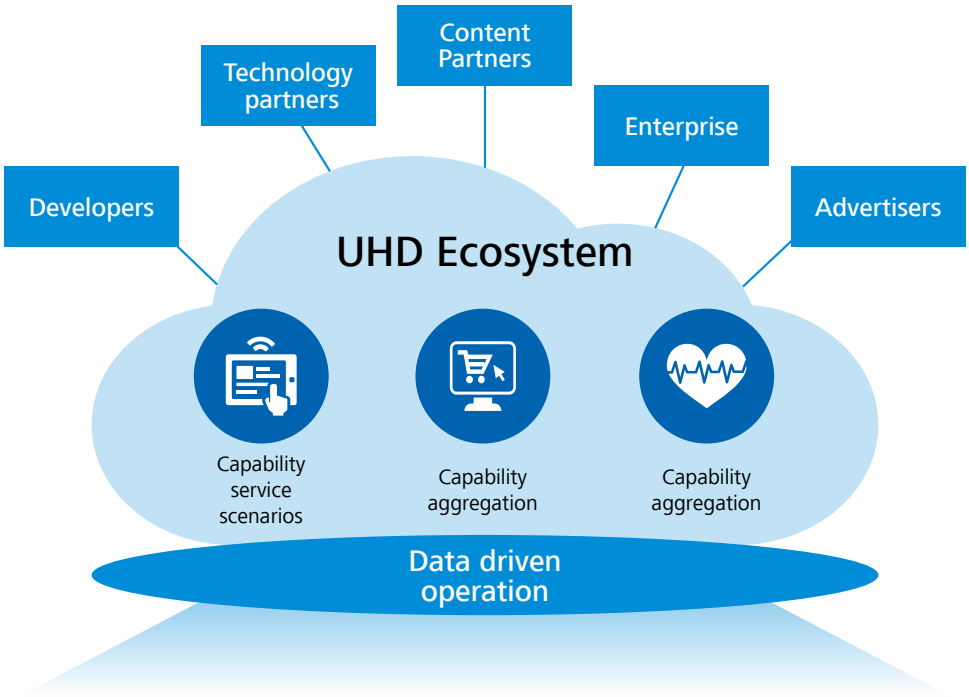
In the future, UHD content will become increasingly diversified, while users' attentions are limited. How to match UHD content to users' demands? Intelligence operations based on big data can solve this issue and help control UHD content procurement costs, implement precision advertising, and reduce subscriber churn. The following capabilities need to be constructed:

- Smart content operation capability
  Forms content subjects and diversified rankings through content tags and focus tracking and constructs a smart content operation system.
- Smart user engagement capability
  Improves user operation capability through business scenarios including personalized recommendation, path optimization, intelligent search, and potential user marketing.
- Smart operation analysis
  Enables operation personnel to check operation status in real time and visualizes and analyzes key information in operation. In this way, operation activities can be responded timely and well grounded.

UHD Ecosystem Cooperation

The UHD video era witnesses the sharing of content, users, traffic, and video technologies. Only industry cooperation can contribute to the innovation of UHD content, products, and business models. Therefore, video service providers are required to transform their traditional production methods. They need to build an optimal video ecosystem with good system openness to connect content partners, channel partners, self-media, developers, and technology and capability providers.

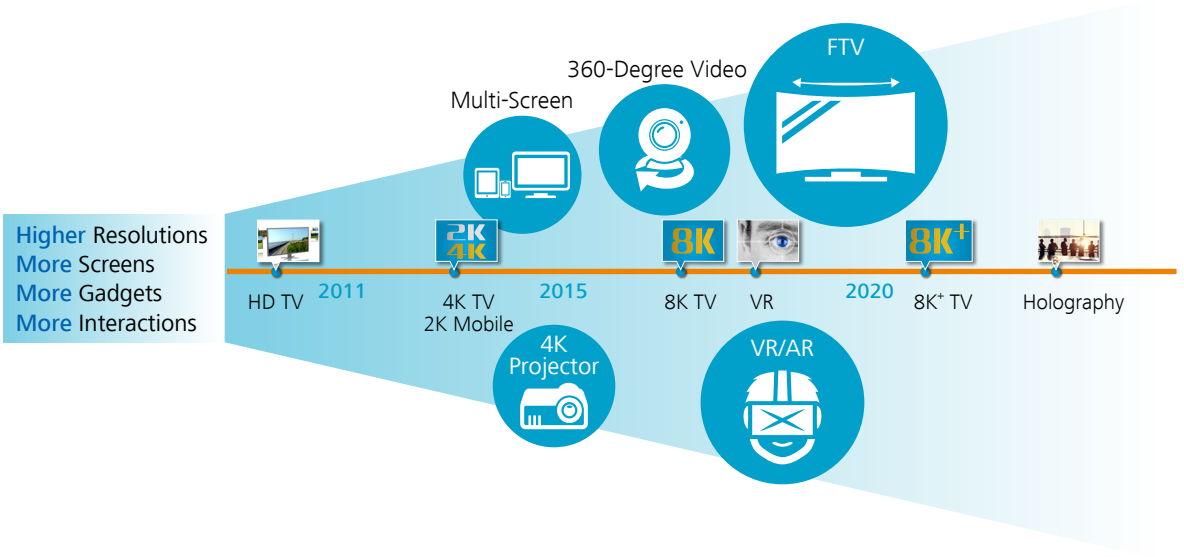
The UHD business ecosystem can be created based on an open platform. Cooperation with partners in content production, production innovation and operations, marketing, business monetization can be achieved through openness of production factors (including the video content, video capabilities, and infrastructure capacity) and operating elements (including the billing capabilities, marketing templates, user bonus points, and data), implementing resource complementation and achieving the win-win situation.



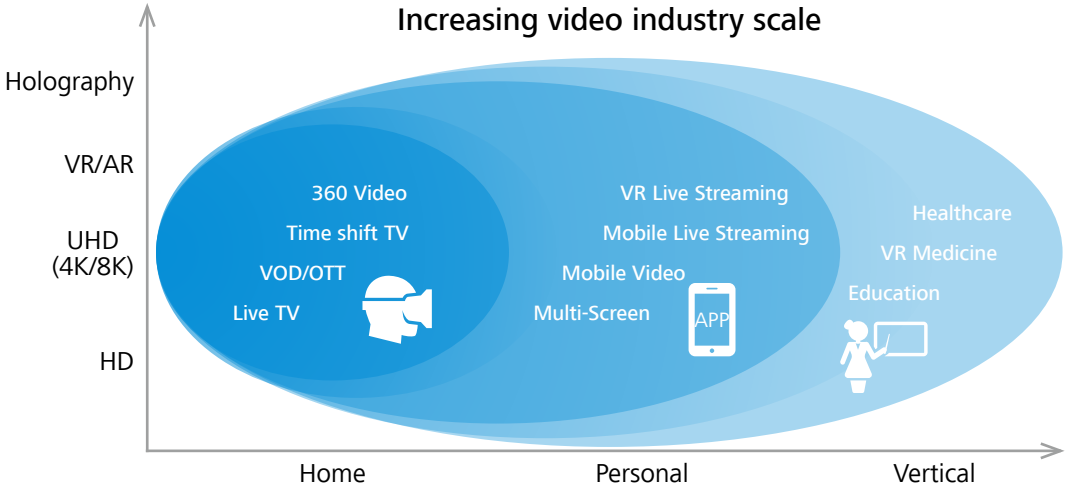
System openness is more than the openness of a single part such as content access and channel delivery. On the contrary, system openness actually opens each operation part such as content ingestion, publication, rankings, VIP service, virtual finance, user interaction, status, and data. Each part is opened to partners as a service. The UHD service gains continuous innovation driving force in production, delivery, and monetization from openness, cooperation, and resource exchange.

5 Future Prospects

Firstly, users have endless demands for better video experience. In the current technology development phase, Best-UHD can probably provide the best experience in terms of vision, interaction, and timeliness. For example, in the early promotion phase of the UHD, 360-degree panoramic videos have been broadcast on the TV. Users can watch these videos on TVs with remote control and gain unprecedented new experience. Huawei is developing the DEMO system and hopes to expand the 360-degree panoramic service with industry chain partners.



Secondly, vision extension application scenario is being upgraded and extended. As the immersing and vivid UHD audiovisual experience gains wide popularity among users, the UHD service will become the basic capability for higher bandwidth video services such as TV video cloud games, TV video social applications, 8K, and VR/AR. This capability is applied to home entertainment and will be further integrated with different industry informatization applications such as UHD monitoring, quasi-professional UHD live broadcast, and UHD medical image/education. UHD videos are not only content of information consumption. In the future, they will become the mainstream medium of information consumption, penetrating all informatization fields including individuals, families, and industries and further expanding the video industry scale.



Source：OVUM, Gartner, PWC, HIS, Huawei MI

Lastly, a new distributed video-centric network environment featuring dynamic control and autoscaling is being built using technologies including UBB, SDN/NFV, cloud computing, and Telco OS. This will transform the traditional network to a service platform with abundant functions. The video/UHD service can achieve more efficient content delivery, faster service time to market (TTM), and flexible resource orchestration. This improves superior audiovisual experience and brings more diversified business application scenarios.

Huawei is committed to build a better interconnected world. When accelerating the development of the UHD video service, Huawei is willing to cooperate with industry chain partners, open future UHD video service and network capabilities, and make contributions to social informationized video reconstruction.

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