With the emergence of experience economy, operators are performing a reevaluation of priority criteria changing from network-centric to experience-centric operation. Providing diversified services based on the basic network capability has become one of the primary requirements of operators. More and more people are readily willing to pay for a better online video experience. User experience has become an important way for operators to improve efficiency and enhance user satisfaction and loyalty. This document describes how mobile video services support core functionality and explains the video experience evaluation method used to provide guidelines on how to plan and construct the mobile network based on video experience standard. This document is aimed at providing quality assistance to operators for the creation of differentiated competitiveness through mobile video services.

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1 Introduction

- **Changed Operation Perspective**

Experience economy gradually becomes the core strategy and primary source of profit and revenue in the service industry. As basic telecom service providers, operators are altering their perspective from network-centric to experience-centric operation. Providing diversified services based on the basic network capability has become one of the primary demands of operators, and therefore, they can obtain extra operation value. As a basic service provided by operators, video service is hot. Providing good video service experience is the key to differentiated competitiveness for mobile broadband (MBB) operators.

- **Users’ Willingness to Pay**

User experience is important for improving operators’ ROI, which is worth considering even if consumers are price-sensitive. However, consumers are capable of making informed decisions in the selection of products with better service and quality and are willing to pay for better user experience when costs are acceptable. How much extra profit operators can be obtained by providing good user experience? A study about online video services in China shows that:

Approximately 36% of participants are willing to pay for better video service experience.

Depending on the economic status of the sales region, statistics reveal that users in eastern areas have the freedom to support funding for such products.

2 Video Industry Insights

- **Longest Video Watching Time Spent on Mobile Devices**

Users used to watch scheduled TV programs on TV or online videos on PC or laptop. It is apparent from research and conducted studies that among all video watching terminals, users spend most time watching videos on mobile devices.
Mobile devices have become the primary choice for information acquisition. Commercial enterprises adopt the mobile-preferred strategy, with major news pushed on mobile devices. This strategy causes higher mobile traffic requirement, accelerating the MBB network development.

**SNSs Calling for Fast Development of Video Services**

Mobile Internet leads to not only the vigorous development of social media, but also the emergence of user-generated content (UGC). With UGC, every user can be a content broadcast source. For example, the Periscope enables a user to publish live videos to users all around the world. The author of a content is the broadcast of social media. New video production content (UGC). With UGC, every user can be a content broadcast source. For example, the Periscope enables a user to publish live videos to users all around the world. The author of a content is the broadcast of social media. New video production with UGC.

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As technology develops and the cost of HD screens decreases, the resolution of smartphones becomes higher. According to the survey performed by Huawei mLAB on newly delivered smartphones during the first half of 2015, the resolution of 77% of smartphones is higher than 720p and that of the flagship models for each device manufacturer is higher than 1080p. A 720p screen has become the basic configuration of smartphones. The hardware capability of mobile devices has been fully equipped with the ability to support the display and popularity of HD videos of 720p or higher. A large proportion of videos uploaded are higher than 720p, which increase the consumption on videos. For example, the proportion of higher than 720p videos uploaded on YouTube reaches up to 51%.

From the perspective of network, the bit rate of a 720p video differs depending on encoding technologies. However, the average bit rate of 720p videos is about 1.5 Mbit/s. Networks with 3 to 5 Mbit/s bandwidth can provide favorable 720 video service experience, considering the initial waiting delay, handovers in mobile scenarios, and fast fading. The deployment of LTE network in large scale can provide a 5 Mbit/s data rate any time anywhere.

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**Mobile HD Video Is the Beginning**

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**Video Is the Strategy**

Services, such as videos are required to help operators become the industrial chain leader from pipe services. Voice, instant communication, and a small number of Internet of Things (IoT) are not enough. A large number of future services will be carried on basic videos. After several years of exploration, mature video business models are formed. For example, the South Korean LG U+ binds the main package with self-managing video content, which implements the fast go-to-market and profit of video services. Vodafone cooperates with OTT providers and implements channel service values by binding the large traffic package with OTT content. Verizon acquired AOL to build global digital media platform and ecology. AT&T becomes the leader of PayTV by the acquisition of DirectTV. The global leading operators are moving to the upstream of video industry chain with its ubiquitous high-quality network and video-based service, embracing the Internet and ecology.
User Experience Is the Standard of MBB network Construction Quality

What makes a good MBB network? What qualifies as a positive MBB experience? What is the relationship between user experience and networks? Can user experience be the evaluation standard for network construction? The answers to these questions have continually been researched and discussed. However, these issues still pose challenges to network planning and construction. Investing limited capital to network construction is the ultimate choice for operators’ strategy makers. However, there are many disputes over what should be considered the standard. From the KPI system to the KQI system, a comprehensive quality evaluation is available. However, the standard is rarely adopted because it requires complex calculation and KPIs, as well as the actuality that a good KPI result does not bring good user experience.

The MBB development, especially the rapid development of video services, shows that user experience of video services can be measured as the network construction standard. The performance of mobile video services directly affects user behavior, which inevitably affects operators’ service revenue. Operators can meet the increasing user requirements of video service performance by the evaluation and planning of video services on networks. Mobile network planning is targeted from coverage- and throughput-oriented to user-experience-oriented.

• Throughput Is Not Equal to User Experience for Video Services

Mobile users expect the ability to view video without stalling at any time and place. However, the traditional throughput-based single KPI evaluation system cannot reflect user experience. According to a survey by Huawei mLAB, the top 5 factors affecting mobile video service performance are initial buffering delay, stalling times, stalling duration, video resolution, and the screen size of mobile devices.

• Experience-based Planning Target Is the Result of Market Strategy

Network planning based on video service experience should consider geographical differences. User video consumption behavior (such as video playback duration, resolution requirements, and tolerable waiting delay) differ from region to region. Therefore, consumption behavior should be analyzed prior to network planning to identify various types of video consumption areas, such as heavy video consumption area or light video consumption area. This is to set appropriate video performance targets for specific areas, mapping the planning objectives and marketing strategies.
4 Video Coverage Methodology

Faced with MBB network planning challenges, Huawei has introduced methodology based on video coverage experience for mobile network planning and construction.

• 4.1 Procedures

Video Coverage mainly covers the following three key steps:
1. Network evaluation and target setting: Quantify the mobile video performance based on objective KPIs. Analyze video consumption habits and identify the target planning areas.
2. Gap and root cause analysis: Locate the problems and causes of areas where the video performance does not meet the requirements.
3. Solution implementation and iteration-based optimization: Perform network coverage and capacity planning based on the root causes. The solution includes carrier expansion, sector splitting, site addition, and the deployment of new features. Iteration planning continuously improves the compliance ratio.

• 4.2 Network Evaluation and Target Setting

The vMOS Is Used for Mobile Video experience Evaluation
Back in 2012, the ITU-T released the vMOS evaluation standards for video services. The vMOS references the definition of the speech MOS, monitors video quality loss after the network disconnects, detects video QoE, and locates problems. The streaming media transmission mechanism changes. The adaptive streaming over HTTP replaces the progressive download over HTTP and becomes the main streaming media transmission mechanism. The vMOS standard does not consider the streaming mechanism change and the impacts of different resolution videos on user experience. Therefore, requirements for network construction based on operator experience cannot be met.

Huawei believes video evaluation standards centered on user experience should be built to evaluate user experience of various videos from different networks, screens, and scenarios. Together with ergonomic experiments, sample research, and in-depth technical research, Huawei mLAB discovers that the top3 factors applicable to all scenarios are sQuality, sLoading, and sStalling. Huawei has put forward a new evaluation standard, the U-vMOS. Therefore, video experience evaluation can be defined, measured, and managed.
\[ f(s\text{Quality}, s\text{Loading}, s\text{Stalling}) \]

Mapping Video Experience-based Planning with Business Goal

Operators also focus on investment income when user experience is improved. Accurate investments in different areas to achieve higher return on investment (ROI) becomes a main business objective for operators.

Performance requirements of mobile video services vary in different areas. Based on insights into video traffic distribution, video resolution, and mainstream video APPs, high and medium video consumption areas are discovered. Along with user behavior and operator strategy, the vMOS target is determined to plan the networks in high and medium video consumption areas. Therefore, video service performance is improved, traffic is increased, and more benefits are brought for operators.

The video coverage planning strategy is determined based on the insight results. Networks can be divided into the following areas.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Planning strategy</th>
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<tbody>
<tr>
<td>Heavy video consumption area</td>
<td>1080p/2K ultra-HD video quality is planned to build competitiveness.</td>
</tr>
<tr>
<td>Medium video consumption area</td>
<td>720p HD video quality is planned everywhere to stimulate video consumption.</td>
</tr>
<tr>
<td>Light video consumption area</td>
<td>720p HD video quality is planned everywhere to cultivate video consumption habits.</td>
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</tbody>
</table>

• 4.3 Gap and Root Cause Analysis

Grid-level Visualized Analysis

Based on the video performance evaluation on the live network, the vMOS value is geographically displayed as a 50 x 50 m grid. If the value is lower than the target vMOS value, a grid not complying with the requirements is formed. In this case, root cause analysis and specified network planning are performed.

Conversion and Mapping Between the Video Experience Target and Traditional Network KPIs

The traditional network KPIs, such as coverage, interference, and number of active users cannot be directly used for measuring video performance. By analyzing mass data on the live network, Huawei converts these traditional KPIs to vMOS KPIs of video performance using data mining. As a result, a precise mapping model of traditional KPIs to vMOS KPIs is formed.

Converting and mapping model
For example, for 720p videos, interference, transmitted carrier power, and the number of active users are used for fitting to the initial buffer delay model. This model maps traditional network KPIs and the vMOS. Then, the vMOS is used for network planning and construction.

- **4.4 Solution Implementation and Iteration Planning**

**Solution Implementation**

The Video Coverage method is used to perform coverage, capacity, and network structure optimization based on the root cause of each grid value lower than the vMOS value. Optimization includes capacity expansion, sector splitting, site addition, deployment of new features, and CDN sinking to ensure that each area reaches the preset video performance goal.

Edge performance improvement introduces inter-site carrier aggregation and adaptive inter-cell interference coordination to improve cell edge coverage.

Indoor performance improvement deploys micro base stations in office buildings and shopping malls to improve the indoor capacity.

The end-to-end delay optimization deploys TCP optimization, video scheduling, adaptive bit rate, and CDN sinking to reduce initial buffering delay.

**Iteration Planning Achieves Continuous Improvement**

The vMOS scores are the final target. Network planning stops until the vMOS scores meet requirements. Then, the planning simulation is determined.

**Benefits**

Iteration optimization is used to reduce network planning times and costs. Therefore, network planning efficiency is improved and network construction costs are reduced.

Precise planning implements the mapping between the market objectives and network construction.

In the previous network construction, channels were built. However, user experience has become the target objective now. With precise planning, the Video Coverage method establishes mapping between video experience and network KPIs. Therefore, a certain standard of video quality and performance can be expected. As a result, optimal mapping between business objectives and network construction is achieved, and profits are increased.

**Network Construction Case**

A leading operator in the Middle East quickly learns the importance of video services in the MBB era. The operator announced to build the regional No.1 MBB network and aimed to deliver best HD video experience to its customer. However, this operator’s video score ranked lower than its competitors during a third-party test due to long delay and low speed, leading to a poor user experience in some cases.

This operator adopts Huawei Video Coverage methodology and introduces vMOS test tools to evaluate video experience in key areas. Serving 1080p video streaming everywhere for customers is set as the network construction target. After the solution is deployed, the operator reaches its target. Grids rate with vMOS scores higher than 3.8 are improved from 60.9% to 82.4%, video initial buffer delay is reduced by 0.49 second, and customers can enjoy smooth HD video experience everywhere. As a result, mobile video service consumption is stimulated by user experience improvement, with the average data consumption in the areas increasing by 38% in 3 months, and the operator’s profit is increased.
Appendix: Global vMOS Insight

User experience is much less satisfactory. The aim of LTE networks is to provide videos with 4.0 vMOS scores.

To study the present state of video service experience, Huawei mLAB uses the Speed video client to select samples of 4G mobile networks in seven cities around the world. The study shows that the average video experience vMOS score on most networks is lower than 3.5 with unsatisfactory user experience. The evaluation score of stalling is higher than 4.0. The evaluation score of initial buffer delay is lower than 3.5.

Therefore, improving initial buffering delay is the key to improving user experience.

Test APP: SpeedVideo (Downloaded at http://mbblab.tk, supported by Huawei mLAB)
Test Time: 2015.7-2015.9
Test Results:

<table>
<thead>
<tr>
<th>City</th>
<th>Video Streaming</th>
<th>Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td>YouTube 2K* - DASH</td>
<td>4228</td>
</tr>
<tr>
<td>Dubai</td>
<td>YouTube 1080p - DASH</td>
<td>2459</td>
</tr>
<tr>
<td>Mexico City</td>
<td>YouTube 1080p - DASH</td>
<td>1883</td>
</tr>
<tr>
<td>Sydney</td>
<td>YouTube 1080p - DASH</td>
<td>103</td>
</tr>
<tr>
<td>Riyadh</td>
<td>YouTube 1080p - DASH</td>
<td>100</td>
</tr>
<tr>
<td>Chon Buri</td>
<td>YouTube 720p - HPD</td>
<td>190</td>
</tr>
<tr>
<td>Rio de Janeiro</td>
<td>YouTube 720p - HPD</td>
<td>207</td>
</tr>
</tbody>
</table>

Test samples: sampling video experience data from seven cities in the world. Sampled video are YouTube 720 HPD, YouTube 1080P Dash and YouTube 2K Dash. The initial buffer time for HPD video is 8 seconds and for Dash video is 2 seconds.
End-to-end (E2E) round trip time (RTT) becomes the constraints of video experience. The E2E RTT for a good video experience on LTE network is less than 40 ms and that on UMTS network is less than 80 ms.

Huawei mLAB finds that for the same video initial buffer delay, different E2E RTTs correspond to different bandwidth requirements. The shorter the initial buffer delay is, the greater the E2E RTT impact is and the greater bandwidth gains the RTT brings. To achieve better video experience, LTE network should support the smooth playing of videos higher than 1080p and the E2E RTT should be less than 40 ms. UMTS network should support the smooth playing of 720p videos and the E2E RTT should be less than 80 ms. The network capability requirements are as follows when the target initial buffer delay is two seconds.

Reference