H.265+ Intelligent Encoding White Paper

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1 Overview

H.265+ is an intelligent encoding technology optimized on top of the H.265 standard. Designed for security surveillance scenarios—where video backgrounds are typically stable, and the focus is on moving objects—it significantly reduces bitrate through techniques such as background predictive encoding, noise suppression, and long-term bitrate control, saving bandwidth and storage costs.

1.1 Introduction

H.265+ intelligent encoding technology is designed specifically for video surveillance and is built upon the H.265 (HEVC) standard encoding framework. By leveraging typical surveillance characteristics (e.g., long-term stable backgrounds, relatively sparse moving targets, and 24/7 continuous recording), it applies targeted optimizations to stream bit allocation, reference frame selection, and noise-processing strategies. As a result, it further reduces bandwidth and storage pressure while maintaining image quality and compatibility.

1.2 Background

With the widespread adoption of 4MP, 8MP, and higher-resolution cameras, enterprise video surveillance systems now place greater demands on transmission links, edge devices, network video recorders (NVRs), and cloud archival resources. Traditional encoding methods can meet basic clarity requirements, but under conditions such as long-duration recording, higher nighttime noise, and uneven scene changes, bitrate and storage costs remain high.

For multi-site, centrally managed CCTV surveillance deployments, improving resource utilization while ensuring recording integrity and smooth playback experiences has become a key challenge as system scale expands.

1.3 Technology Positioning

H.265+ is not intended to replace the H.265 (HEVC) standard. Instead, it enhances encoding efficiency for surveillance workloads while remaining compatible with existing decoding ecosystems. It suits scenarios with stable backgrounds, clearly event-driven targets, long recording durations, and a need to control storage investments. It can serve as a long-term bitrate optimization capability within HD video surveillance systems.

1.4 Purpose

This white paper aims to:

1. Explain the positioning, core capabilities, and applicable boundaries of H.265+.
2. Outline the implementation logic of the technology in predictive encoding, noise

suppression, and long-term bitrate control.

3. Demonstrate its optimization effects on bandwidth and storage costs using bitrate and video data from typical surveillance scenarios.
4. List typical H.265+ application scenarios and solutions, as well as representative IPC models that support the technology.
5. Provide a unified technical understanding for solution design, product selection, and project delivery.

Through this white paper, readers can quickly understand the application value of H.265+ in surveillance systems and how it differs from standard H.265 (HEVC) encoding solutions in terms of capabilities.

2 Key Technologies

2.1 Basic Concepts

H.265 (HEVC) is the current mainstream high-efficiency video coding standard. Its core strengths lie in using finer-grained coding tree units, more efficient intra and inter prediction, and stronger entropy coding to reduce compressed data size at the same image quality.

Building on this foundation, H.265+ further optimizes encoding for surveillance video. Instead of processing all regions in every frame uniformly, it differentiates encoding strategies based on background stability, the value of moving objects, and business activity over time.

From an engineering perspective, the goal of H.265+ is not simply to lower instantaneous bitrate. Rather, it aims to deliver a more balanced and controllable average bitrate in 24/7 recording scenarios, enabling video systems to support higher resolutions and longer retention periods under limited network and storage resources.

H.265+ improves compression efficiency through three key technologies: predictive coding, background noise suppression, and long-term bitrate control.

2.1.1 Predictive Coding Optimization

Predictive coding optimization is one of the core technical pillars of H.265+. Compared with conventional methods that rely primarily on the previous frame as a reference, H.265+ preferentially selects background frames containing fewer moving objects as long-term reference frames and uses them together with the standard P-frame reference chain. This allows newly revealed background areas and static regions to find highly similar reference blocks more easily, reducing residual information and eliminating unnecessary bitrate overhead.

2.1.2 Background Noise Suppression

In surveillance scenarios, nighttime noise, low-light grain, and sensor jitter often increase bitrate consumption. H.265+ separates background regions from moving targets for differentiated processing. For background areas, it applies a higher-compression encoding strategy to suppress redundant information caused by random noise. Meanwhile, it preserves a more reasonable bitrate allocation for key moving regions so that target contours, directions, and behaviors remain recognizable.

2.1.3 Long-Term Bitrate Control

Long-term bitrate control focuses on resource allocation over the entire recording cycle rather than at a single moment. H.265+ not only limits instantaneous peaks but also ensures that the 24-hour average bitrate is under control. During busy periods, the system allows more effective bitrate to be allocated to moving targets. During idle or low-change periods, it proactively compresses background and noise information to improve overall bit utilization efficiency.

2.2 Technical Advantages

The main advantages of H.265+ include:

1. **Lower transmission bandwidth usage**
   By emphasizing moving targets and compressing static backgrounds, it effectively reduces network load in typical surveillance scenes.
2. **Higher storage efficiency**
   For 24/7 continuous recording, the optimized average bitrate can significantly reduce daily recording file sizes.
3. **Stronger scene adaptability**
   The system dynamically allocates bitrate resources between busy and idle periods based on changes in scene activity.
4. **Better engineering compatibility**
   Built on the H.265 (HEVC) standard framework, it is easier to deploy alongside existing software and hardware platforms.
5. **More stable target representation**
   By reserving a more appropriate share of encoding resources for motion regions, it helps balance detail preservation with overall cost control.

Note: H.265 (HEVC) is a general-purpose video coding standard, whereas H.265+ is an enhanced implementation tailored for surveillance scenarios. Therefore, the bitrate savings discussed in this paper should be understood as surveillance-specific gains from enhanced

encoding, rather than universal gains of the H.265 (HEVC) standard across all video types.

2.3 Market Demand

From a market perspective, video surveillance systems are facing two simultaneous pressures: higher resolution requirements and cost constraints. On one hand, enterprises, campuses, chain stores, and transportation scenarios continue to evolve toward higher pixel counts, longer retention periods, and broader coverage. On the other hand, investment in bandwidth, cloud storage, and local hard drives does not scale at the same rate. This creates a need for a technological path that improves compression efficiency without sacrificing compatibility.

For intelligent surveillance solutions, the value of H.265+ is reflected not only in reducing the bitrate of a single camera stream, but also in improving controllability of overall bandwidth and storage costs when managing multiple devices centrally, transmitting video across sites, and planning recording resources. Especially in scenarios with low-light nighttime conditions, long-term stable backgrounds, or intermittent appearances of people and vehicles, intelligent encoding optimization provides clear engineering value.

3 Key Technical Principles

3.1 Protocol

H.265+ is still built on the H.265 (HEVC) encoding framework. Therefore, its output bitstream continues to use the standard toolchain, including coding unit partitioning, prediction mechanisms, transform and quantization, and entropy coding. The focus of H.265+ is not to redefine a standalone protocol but to enhance how reference frames are organized, how refresh frames are applied, and how regions of interest are identified—so that the standard encoding process better matches the characteristics of surveillance video.

At the frame-type level, the technology typically works through coordination among background frames, refresh frames, and regular predictive frames. Background frames provide a stable reference baseline; refresh frames ensure random access and playback experience while updating motion regions more aggressively; regular predictive frames seek higher compression efficiency by leveraging both background references and short-term references.

3.2 Principle

The working principle of H.265+ can be summarized as identifying stable backgrounds, emphasizing dynamic targets, and allocating bitrate over time. First, the system uses

intelligent analysis to select images with fewer moving targets from a continuous video segment as background references. During subsequent encoding, static regions are predicted at low cost using background references and forward references. In contrast, more encoding resources are allocated to newly appearing target boundaries, target displacement, and significantly changed regions.

When an object moves from position B to position A, traditional approaches that reference only the previous frame often struggle to efficiently encode newly revealed background regions. By introducing a background reference frame, those regions can more easily find matching blocks in historical background content, thereby reducing coding residuals. Similarly, under the refresh-frame mechanism, moving objects can be preserved via higher-quality updates, while static backgrounds remain highly compressed—balancing image quality and bitrate control.

The following sections analyze the principles of the three key H.265+ technologies.

3.2.1 Predictive Coding Optimization

Mainstream compression algorithms, including H.265/HEVC, are based on a hybrid coding framework. Predictive coding is one of the most critical technologies affecting compression performance, and it can be divided into inter prediction and intra prediction.

- Inter prediction uses block-based motion compensation to create a prediction model from one or more previously coded video frames or fields.
- Intra prediction uses only information from already transmitted macroblocks (i.e., processing units) within the same frame to predict the samples of the current macroblock.

Different encoding methods are applied to different frame types within a video stream. An I-frame can be coded independently using intra prediction. P-frame coding depends on preceding I/P-frames and uses inter prediction. The definitions of I-, P-, and R-frames, and how they are coded in H.265+, are summarized below:

Frame Type	Interval	Description
I-frame (Background frame)	8–12 s	Contains complete image information and can be decoded independently without relying on other frames, similar to a compressed still image. It is coded purely based on the current image using intra prediction. The frame is selected by an intelligent algorithm and contains as few moving objects as possible.

P-frame	1/frame rate (s)	Not a complete image; mainly stores changes relative to reference frames (e.g., motion vectors + residuals, etc.). Decoding requires previously decoded I/P-frames. It uses inter prediction based on the previous frame (P or R) and the I-frame.
R-frame (Refresh frame)	2 s	Functions as an "I-frame substitute" in the stream. It uses a combined intra + inter strategy: intra prediction for key targets, and inter prediction for relatively stable background regions by referencing the preceding I-frame.

P-frames use inter prediction, which reduces bitrate by encoding only the differences between the current frame and preceding reference frames.

In general, inter prediction selects the previous I- or P-frame as the reference frame. However, in surveillance scenes, a significant portion of the different areas between two frames may still have appeared earlier in the scene and do not need to be re-encoded. Taking advantage of stable surveillance backgrounds, H.265+ adds a background frame reference on top of the previous-frame reference to minimize coding cost. The following example illustrates the principle of inter prediction optimization in H.265+:

As shown in Figure 1, P0 and P1 are previous images, and P2 is the image to be encoded. P0 is the background frame, and P1 is the previous reference frame of P2.



P0 **P1** **P2**

Figure 1: Background frame, preceding frame, and frame to be encoded

With a traditional method that references only P1 to perform inter prediction for P2 (see Figure 2), region A (marked by the red dashed line) in P2 is a newly exposed background region. Since no similar region can be found in P1, encoding this region consumes more bits.

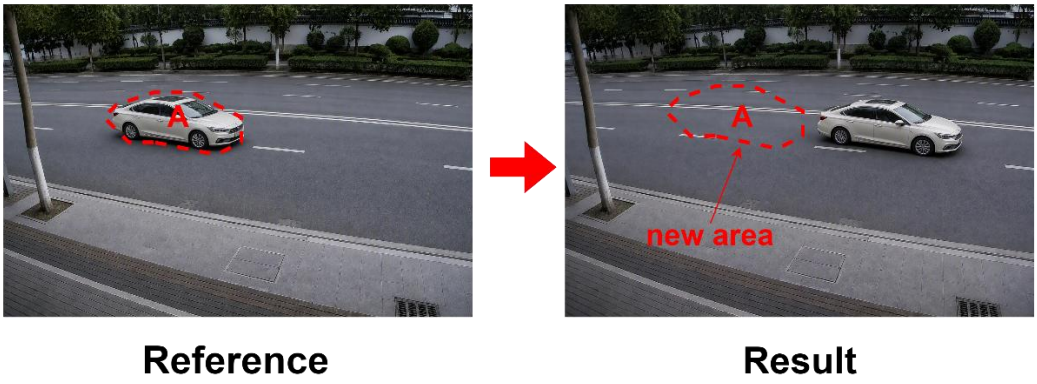


Figure 2: Inter-frame predictive coding based on the previous frame

If P2 is encoded by referencing only P0, the newly exposed region can be found in the background frame, but the vehicle itself is a new region; therefore, encoding the vehicle region consumes more bits (see Figure 3).

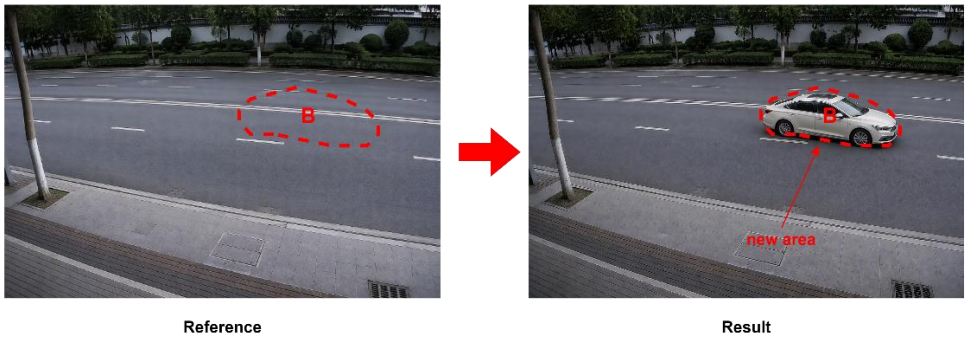


Figure 3: Inter-frame prediction coding based on background frames

As shown above, the new regions identified in the two cases are complementary. Therefore, H.265+ uses both the background frame P0 and the preceding frame P1 as reference frames, so that both the vehicle region and the newly exposed background region can be found in the references, minimizing the overall bit cost.

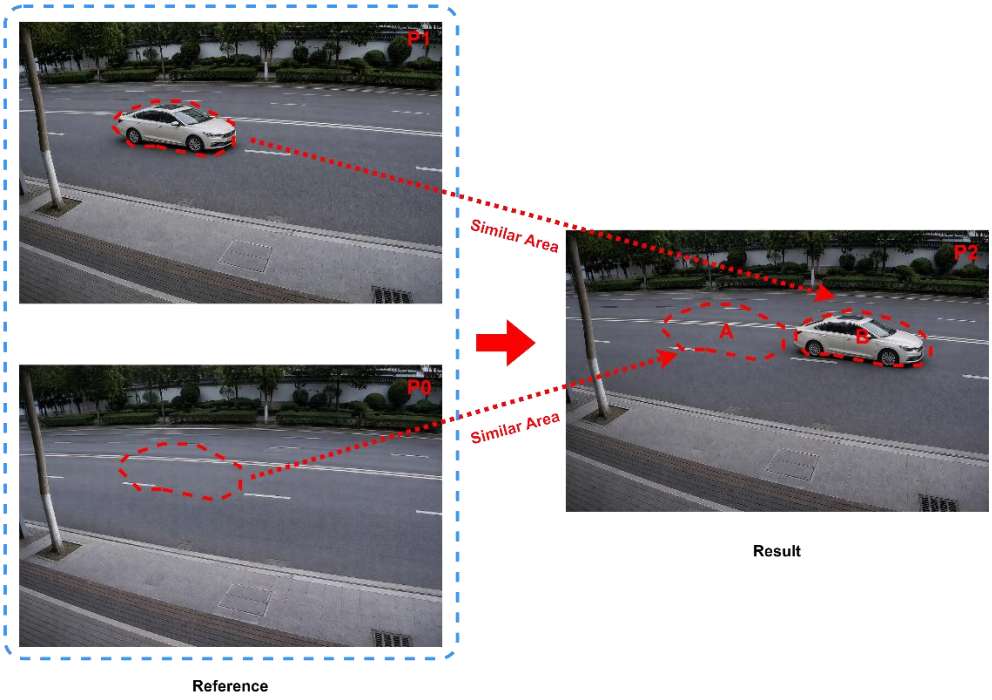


Figure 4: Inter-frame predictive coding of H.265+

Since an I-frame contains complete image information, it consumes considerable encoding resources. In surveillance scenarios, background information is relatively stable. When scenes are mostly static and the I-frame interval is short, most information in I-frames becomes repetitive, resulting in significant waste of encoding resources.

To reduce the encoding cost of I-frames, H.265+ optimizes the I-frame selection strategy and introduces the concept of R-frames (refresh frames). An intelligent algorithm selects frames with fewer moving objects and suitable for long-term reference as background frames (I-frames). The interval between two I-frames is relatively long, while R-frames act as I-frame substitutes in the stream: for background regions, they perform inter prediction by referencing the preceding I-frame; for moving objects of interest, they use intra prediction. This maximizes image quality and playback experience while reducing encoding cost and bitrate. An example of the R-frame encoding process is shown in Figure 5.

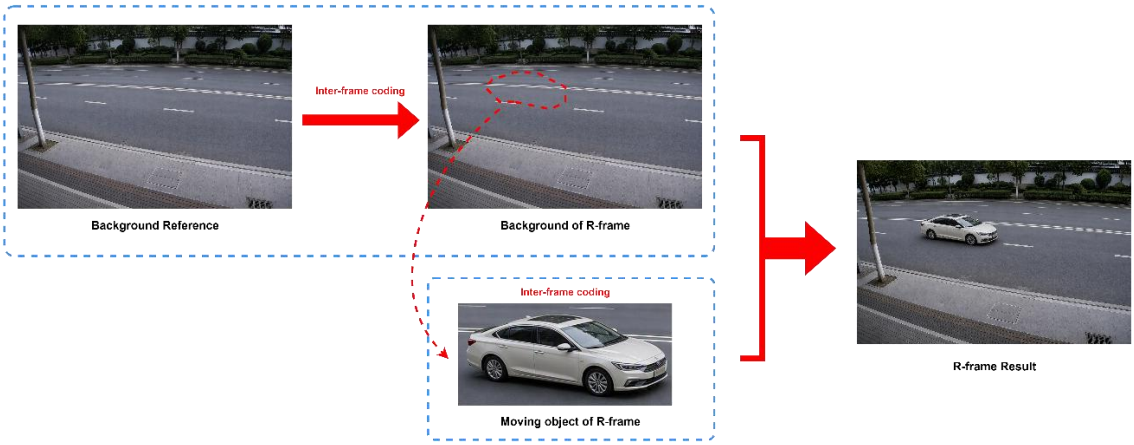


Figure 5: Encoding process of the R-frame

It can be seen that H.265+ predictive coding optimization consistently uses background frames to reduce encoding costs. In H.265+, the intelligent algorithm selects frames suitable as background references as I-frames with relatively long intervals. Between two I-frames, the backgrounds of all P-frames and R-frames reference the preceding I-frame for inter coding. This forms the H.265+ predictive coding framework based on a background model, as shown in Figure 6.

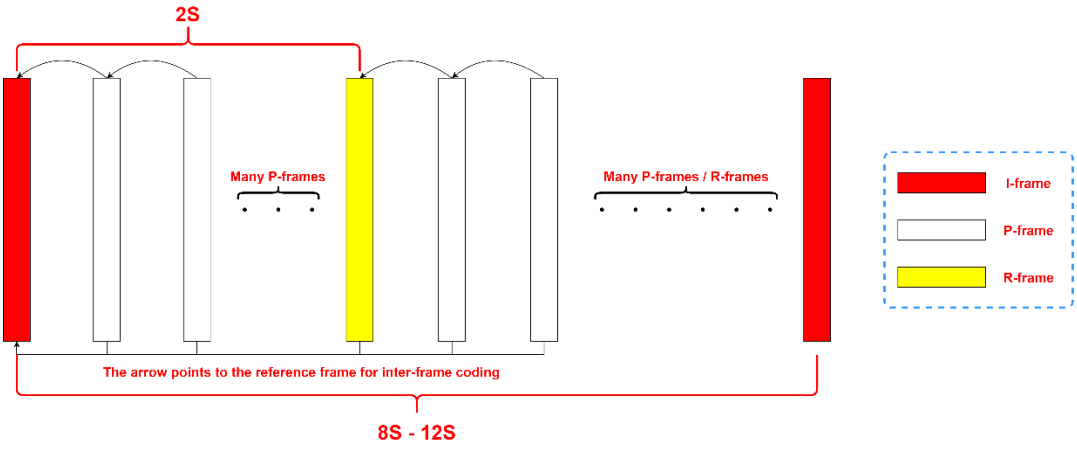


Figure 6: Predictive coding framework based on background model

3.2.2 Background Noise Suppression

Typically, to ensure the quality of objects/regions of interest, the encoder also encodes noise in the image, which wastes a large amount of bitrate. This not only consumes more bandwidth and storage but also reduces the bitrate available for moving objects/regions of interest.

H.265+ noise suppression leverages intelligent analysis algorithms capable of distinguishing background images from moving objects. It also applies different encoding strategies: high-quality encoding for moving objects/key regions and high-compression encoding for background/static regions, thereby indirectly reducing the bandwidth and

storage consumed by background noise.

For example, in a scenario where a vehicle passes through the surveillance view, as shown in the figure, the intelligent analysis algorithm extracts the background portion and the moving vehicle portion. High-compression encoding is applied to the background to suppress noise and reduce bitrate.

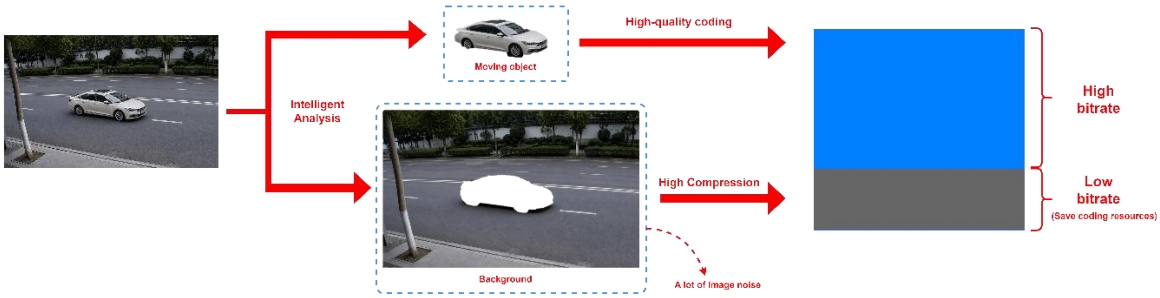


Figure 7: Noise suppression example

3.2.3 Long-Term Bitrate Control

H.265+ long-term bitrate control is a bitrate scheduling mechanism designed for longer statistical windows. Unlike traditional bitrate control, which focuses on instantaneous output per second or per group of pictures (GOP), it treats the allowed data volume over several hours or 24 hours as a unified budget and dynamically allocates it based on scene complexity.

The system continuously tracks the used budget, remaining budget, and remaining time. It reduces bitrate when the scene is static or less active, and increases bitrate when people/vehicles are active or when unexpected events occur—thereby controlling long-term average data volume while ensuring image quality during critical periods.

In the constant bitrate (CBR) mode, traditional encoding typically keeps the output bitrate fluctuating around a preset value. Even when the scene remains static for a long time, it may still generate redundant data. With long-term average bitrate control enabled, the system shifts to a control approach that bounds short-term peaks while constraining the long-term average. Bitrate during busy periods can approach the preset maximum, while bitrate during idle periods drops significantly. The actual savings depend on factors such as active time in the scene, motion intensity, environmental noise, resolution, frame rate, and GOP structure. Therefore, constant bitrate here does not mean strictly constant per second, but dynamically adjusted within peak boundaries.

In the variable bitrate (VBR) mode, instantaneous bitrate varies with scene complexity to maintain relatively stable image quality; long-term average bitrate control adds a cross-period budget constraint on top of this. When the average bitrate setting is low, intelligent

encoding reduces background and noise overhead and prioritizes limited resources for key targets, improving effective surveillance quality. When the configured value exceeds the actual scene requirements, the encoder does not fill invalid data simply to reach the target; the actual average bitrate may be lower than the preset value, reducing network load and saving recording storage space.

The long-term bitrate control mechanism works together with intelligent encoding and noise suppression technologies to maximize bandwidth and storage savings. Long-term average bitrate control mainly determines how bitrate is distributed across different time periods, while intelligent encoding determines which content should be prioritized under a limited bitrate budget.

A schematic diagram of the long-term bitrate control mechanism is shown in Figure 8.

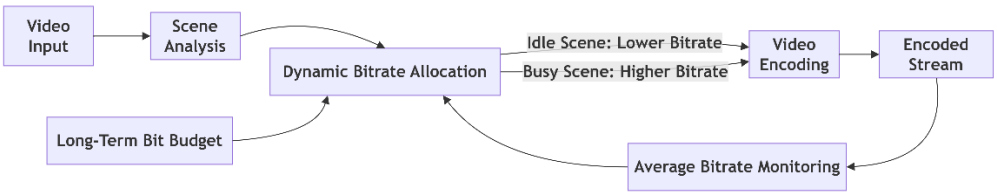


Figure 8: Long-Term Average Bitrate Control

3.3 Framework

From an implementation perspective, H.265+ can be abstracted into three collaborative processing layers. The first is the scene analysis layer, which identifies background stability, motion regions, and time-based activity characteristics. The second is the encoding decision layer, which determines the selection of background frames, refresh frames, and predictive frames; establishes their reference relationships; and applies differentiated compression strategies to different regions. The third is the long-term bitrate control layer, which balances bit usage between busy and idle periods from a long-duration recording perspective.

The advantage of this layered design is that scene analysis determines what matters, encoding decisions determine how to compress, and long-term bitrate control coordinates resource allocation. By combining these three layers, the system improves overall compression efficiency for surveillance workloads without changing the standard decoding pipeline.

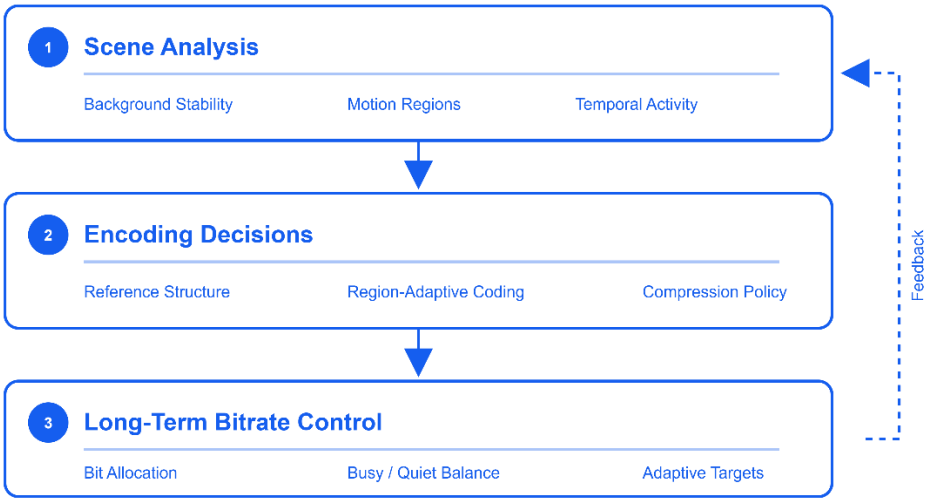


Figure 9: H.265+ technology framework

3.4 Application Scenario

H.265+ is suitable for surveillance scenarios with relatively fixed backgrounds, intermittently occurring target events, and long recording cycles—for example, campus corridors, retail areas, warehouse aisles, parking lot entrances/exits, and road intersections. In these environments, backgrounds remain stable over time while target activity is clearly time-dependent, allowing intelligent encoding optimization to effectively compress non-critical data.

Its value is even more pronounced in low-light or infrared night-vision scenarios. Because nighttime noise can easily increase bitrate, without dedicated background-noise control, the system would continuously incur bandwidth and storage costs for low-value information. With differentiated encoding, H.265+ can better control nighttime resource consumption without noticeably affecting playback recognizability. Chapter 4 will further introduce typical application scenarios of this technology and the corresponding solutions in detail.

4 Application Scenarios and Solutions

H.265+ is suitable for surveillance scenarios with relatively fixed backgrounds, intermittently occurring target events, and long recording cycles. Typical scenarios include:

Scenario	Scene Characteristics	Target Activity Characteristics	Key Benefits
Campus corridors /	Long-term stability	People and vehicles	Significant

industrial sites		pass periodically	reduction in bandwidth and storage
Retail store sales area	Fixed shelves and checkout counters	Customers move intermittently	Controllable cost for long-duration recording
Warehouse/logistics aisles	Fixed shelves and aisles	Forklifts/handling operations pass intermittently	Reduced link pressure under multi-channel concurrency
Parking lot entrances/exits	Fixed barrier gates and road surface	Vehicle flow concentrated in certain periods	Bitrate ensured during peak hours; compressed during idle hours
Road intersections	Fixed camera position and road surface	Relatively continuous traffic flow	Balanced 24-hour recording and backhaul costs
Low-light / IR night vision	Higher noise levels	Few targets	Suppresses bitrate increase caused by noise

Among these, low-light or IR night vision scenarios best highlight the value of H.265+: nighttime noise tends to raise bitrate, and without control of background noise, the system continuously incurs bandwidth and storage costs for low-value information.

4.1 Campus Corridors / Industrial Site Monitoring

4.1.1 Scenario Description

Cameras are deployed at campus entrances, internal corridors within industrial sites, production-area perimeters, and similar locations. The scene's primary content consists of fixed roads, walls, and building facades. People and vehicles pass through mainly during commuting and shift changes, while the scene remains static for long periods at other times. Multiple sites and cameras are typically connected to an NVR or an upper-level video management platform for centralized management. Recording retention is usually 30–90 days.

4.1.2 Requirements and Pain Points

The system requires 24/7 continuous recording to preserve evidence of key personnel and vehicle passage. Playback must keep target contours and details such as license plates recognizable. Multiple streams must be uploaded to a centralized platform over limited uplinks.

1. The scene remains static for long periods, but traditional encoding still outputs at a fixed bitrate, generating a large amount of redundant data.
2. As many cameras aggregate, uplink bandwidth and NVR storage capacity are consumed rapidly, making expansion costly.
3. Scene activity varies greatly between peak periods (e.g., commuting hours) and idle periods (e.g., nights/weekends), but traditional encoding cannot allocate resources on demand.

4.1.3 H.265+ Solution

- **Solution overview:** By leveraging long-term background stability, the system intelligently selects background frames as long-term references, significantly reducing repeated encoding of static scenes. With long-term average bitrate control, more bitrate is allocated to moving targets during peak traffic periods, while background and noise are proactively compressed during idle periods—reducing overall average bitrate and storage usage.

- **Configuration steps:**

1. **Enable H.265+ on the IPC main stream:**

   On the camera configuration page, set the main-stream codec to H.265 (HEVC) and enable H.265+. Keep the sub-stream on the default standard encoding.

2. **Resolution / frame rate:**

   For key locations such as entrances and perimeters, set 4MP @ 25 fps. For general internal corridors, set 2MP @ 15 fps.

3. **Bitrate type and maximum bitrate:**

   VBR is recommended. Set the maximum bitrate based on target clarity (e.g., for 4MP, set 4–6 Mbps as the peak limit). Under VBR, H.265+ adjusts the bitrate automatically with scene complexity. The bitrate approaches the upper limit during traffic periods and drops significantly below it during static periods (e.g., nights/weekends).

4. **Recording mode:**

   For locations with high evidentiary requirements that need 24/7 HD traceability (e.g., entrances/perimeters), choose continuous recording on the main stream. Use

H.265+'s lower average bitrate to achieve long-term HD retention.

For general internal corridors, to control storage cost, choose continuous recording on the sub-stream + event recording on the main stream: record continuously at a low bitrate via the sub-stream, and when events such as personnel/vehicle passage are triggered, record to disk in HD using the H.265+ main stream.

5. **Verification:**

   On the NVR/platform side, compare average bitrate and daily recording size before and after enabling H.265+ to confirm that the bitrate drops significantly during static periods while playback remains recognizable.

- **H.265 vs. H.265+ encoding:**

Comparison Item	H.265 Encoding	H.265+ Encoding
Static-scene handling	Outputs at a fixed bitrate; high redundancy	Background reference + higher compression; redundancy greatly reduced
Resource allocation across busy/idle periods	Even allocation; waste during idle periods	Long-term bitrate control: compression during idle periods, ensuring bitrate during peak periods
Average bitrate	Remains high	Significantly reduced; smaller 24-hour recording volume
Storage and bandwidth cost	Grows linearly with channel count	Per-channel and overall usage more controllable

4.2 Retail Store Sales Area Monitoring

4.2.1 Scenario Description

Cameras are deployed in the sales floor and cashier areas of chain stores and supermarkets. The scene mainly consists of fixed shelves, counters, and walls. Customers and staff move intermittently during business hours (typically 8–12 hours), while the scene remains static for long periods after closing. With a large number of stores and a limited number of cameras per store, recordings must be retained for dispute investigation and operational review.

4.2.2 Requirements and Pain Points

The system must clearly record customer behavior and cashier transactions during

business hours, while continuing to guard against intrusion after closing. In a chain-store system, recordings from multiple stores must be uploaded to a headquarters platform, so transmission and storage costs must be tightly controlled.

1. During closed hours (e.g., nighttime/holidays), the scene is completely static, yet traditional encoding continues to consume bitrate and storage.
2. With many stores, centralized archiving of recordings causes total storage volume to expand rapidly, and backhaul bandwidth costs are high.
3. Customer traffic varies greatly during business hours; image clarity must be ensured during peak times, but fixed bitrate settings are difficult to balance.

4.2.3 H.265+ Solution

➢ **Solution overview:** During closed hours, background predictive coding and long-term bitrate control reduce bitrate to very low levels. During business hours, background noise suppression (i.e., high compression for fixed backgrounds such as shelves, and higher-quality encoding for moving targets such as customers) prioritizes limited bitrate for key targets. This maintains event recognizability while significantly reducing per-store and chain-wide storage and backhaul costs.

➢ **Configuration steps:**

1. **Enable H.265+ on the IPC main stream:**
   Set the main-stream codec to H.265 (HEVC) and enable H.265+. Keep the sub-stream on the default standard encoding.
2. **Resolution / frame rate:**
   Configure the sales area and cashier points at 2MP–4MP @ 15–25 fps (use 4MP @ 25 fps for locations such as cashier counters where fine details are required).
3. **Bitrate type and maximum bitrate:**
   VBR is recommended. The bitrate automatically increases during busy hours to ensure target clarity, and automatically decreases during static, closed hours. Set the maximum bitrate based on clarity requirements (e.g., for 2MP, set a peak limit of 2–4 Mbps).
4. **Recording mode:**
   Recommend continuous recording on the sub-stream + event recording on the main stream. When events occur (e.g., customer behavior during business hours or intrusion after closing), record in HD using the H.265+ main stream; otherwise, only use continuous low-bitrate sub-stream recording for full-time traceability with minimal file sizes. If full-time HD recording is required for operational review, switch

to continuous recording on the main stream, and use H.265+'s low average bitrate to control storage growth.

5. **Verification:**

   On the headquarters platform, compare daily recording volume per store to confirm that the bitrate drops significantly during closed hours and low-activity periods, while event playback remains clear.

- **H.265 vs. H.265+ encoding**:

Comparison Item	H.265 Encoding	H.265+ Encoding
Static closed hours	Constant bitrate; storage waste	The bitrate drops significantly; almost only background reference information is recorded
Target clarity during peak business hours	Competes with background for bitrate	Background compressed; resources prioritized for moving targets
Per-store storage	High baseline	Daily recording size significantly reduced
Chain expansion	Bandwidth/cloud storage grows linearly	Total volume is controllable; capacity expansion investment is delayed

4.3 Warehouse and Logistics Aisle Monitoring

4.3.1 Scenario Description

Cameras are deployed in internal aisles, loading/unloading areas, and alongside sorting lines in warehouses and logistics parks. The scene is dominated by fixed shelves, aisles, and equipment. Forklifts and handling personnel pass intermittently, while the scene remains largely static late at night and during off-hours. With many cameras and dense coverage points, recordings often need to be backhauled across sites to a centralized monitoring center.

4.3.2 Requirements and Pain Points

The system requires 24/7 recording for security traceability of goods and personnel; stable transmission of multiple streams over limited uplinks; and long retention periods.

1. A large number of channels leads to tight aggregated uplink bandwidth, while traditional encoding results in both high peaks and high average bitrates.

2. Large volumes of static content (e.g., shelves/aisles) consume storage, making long-term retention costly.
3. Forklift operation periods are concentrated; moving targets must remain clear, but fixed-bitrate modes cause obvious resource waste.

4.3.3 H.265+ Solution

➢ **Solution overview:** With a background-model-based predictive coding framework, static regions such as shelves and aisles are continuously encoded at low cost by referencing background frames. Long-term bitrate control allocates cross-period budgets for multi-channel aggregation. It ensures clarity for forklifts and personnel during operating periods, while compressing background and noise during idle periods—reducing both uplink and storage pressure.

➢ **Configuration steps:**

1. **Enable H.265+ on the IPC main stream:**
   Set the main-stream codec to H.265 (HEVC) and enable H.265+. Keep the sub-stream on the default standard encoding.
2. **Resolution / frame rate:**
   Use tiered settings based on point importance: 4MP @ 25 fps for key areas (i.e., loading/unloading, high-value inventory zones), and 2MP @ 15 fps for general aisles.
3. **Bitrate type and maximum bitrate:**
   VBR is recommended. For aggregated multi-channel deployments, calculate link budgets at both levels: estimate peak usage (during operational peaks) as maximum bitrate × number of cameras, and estimate daily usage (idle/night) using the actual average bitrate under H.265+. Ensure uplink capacity covers peaks, and plan storage based on average bitrate.
4. **Recording mode:**
   Use continuous main-stream recording for key areas to ensure full-time HD traceability. For general aisles, to control total storage, use continuous sub-stream recording + event-based main-stream recording, where events such as forklift handling and personnel entry/exit trigger HD recording on the main stream.
5. **Verification:**
   In the centralized monitoring center, compare average bitrate and daily storage usage before and after enabling H.265+. Inspect bitrate curves separately during peak operating hours and idle nighttime periods to confirm that “short-term peak bounded, long-term average constrained” control is effective.

- **H.265 vs. H.265+ encoding:**

Comparison Item	Traditional H.265 Encoding	H.265+ Encoding
Aggregated uplink bandwidth for many channels	Peak rates stack up; frequent link expansion	Lower average bitrate; more link headroom
Storage for static scenes	High redundancy	Highly compressed background; significantly reduced usage
Image quality during operational peaks	Undifferentiated encoding	Target-prioritized; better detail preservation
Cross-site backhaul	High cost	Reduced backhaul bandwidth requirement

4.4 Parking Lot Entrance/Exit Monitoring

4.4.1 Scenario Description

Cameras are deployed at parking lot entrances/exits and underground garage lanes. The scene mainly contains fixed barrier gates, pillars, and road surfaces. Vehicle traffic is concentrated during morning and evening peak hours, while vehicles are sparse during other periods. Recordings are used for vehicle passage tracing, dispute evidence collection, and security management, typically requiring 24/7 continuous recording.

4.4.2 Requirements and Pain Points

License plates and vehicle-model details must be recognizable; targets must not be lost during peak hours due to bitrate constraints; and recording must continue during idle periods (e.g., late night/early morning) to guard against anomalies.

1. Vehicles are large and move quickly; during peak periods, traditional encoding may suffer quality degradation when bitrate becomes insufficient.
2. During sparse-traffic periods, the scene remains static for long durations, yet traditional encoding still consumes storage at a fixed bitrate.
3. When multiple entrance/exit channels are aggregated, bandwidth and NVR storage pressure become concentrated.

4.4.3 H.265+ Solution

- **Solution overview:** The R-frame (refresh frame) mechanism uses intra prediction for moving targets, such as vehicles, while using inter prediction for background regions by referencing the preceding I-frame. This preserves target quality while reducing coding costs.

Long-term bitrate control keeps bitrate close to the preset maximum during peak hours and significantly lower during idle hours for protection during busy periods with no waste during idle periods.

- **Configuration steps:**

1. **Enable H.265+ on the IPC main stream:**

   Set the main-stream codec to H.265 (HEVC) and enable H.265+. Keep the sub-stream on the default standard encoding.

2. **Resolution / frame rate:**

   For license-plate recognition, set 4MP @ 25 fps (aligned with lane direction), and ensure good image quality under nighttime IR illumination.

3. **Bitrate type and maximum bitrate:**

   VBR is recommended. Set a higher maximum bitrate (e.g., for 4MP, set 6–8 Mbps as the peak limit) to ensure sufficient bitrate when vehicles pass quickly and to prevent license-plate detail degradation. During sparse-traffic periods, H.265+ automatically reduces bitrate significantly.

4. **Recording mode:**

   Recommend continuous sub-stream recording + event-based main-stream recording, where vehicle-detection events trigger HD recording via the H.265+ main stream. During low-traffic periods, only the low-bitrate sub-stream records continuously. If full-time HD evidence capture is required, choose continuous main-stream recording instead.

5. **Verification:**

   During morning/evening peaks, verify that the bitrate approaches the upper limit (confirming no compression-induced loss of plate detail). During late-night periods, verify that the bitrate drops significantly. Replay vehicle event clips to confirm license plates remain recognizable.

- **H.265 vs. H.265+ encoding:**

Comparison Item	Traditional H.265 Encoding	H.265+ Encoding
Target quality during peak periods	Degrades when the peak bitrate is constrained	Budget ensured; intra coding for targets preserves quality
Storage during idle periods	Constant consumption	The bitrate drops significantly
License plate/vehicle model recognition	Competes with background for resources	Background compressed; sufficient resources for fine

		details
Storage expansion cycle	Short	Extended; lower total cost

4.5 Road Intersection Traffic Monitoring

4.5.1 Scenario Description

Fixed-position cameras are deployed at urban intersections and main roads. The scene mainly consists of fixed road surfaces, traffic lights, and building backgrounds. Traffic flow is continuous (dense during the day and sparse at night). Recordings are used for traffic management, accident tracing, and public security prevention and control, and are typically recorded 24/7 and backhauled to a traffic management platform.

4.5.2 Requirements and Pain Points

Reliable 24/7 recording is required, with clear and traceable images during heavy-traffic periods. Long-term retention is needed for accident and incident inquiries. Aggregated backhaul bandwidth across multiple intersections must remain controllable.

1. Traffic is continuous, but the background is fixed; traditional encoding still generates a large amount of redundancy during periods when the scene changes little.
2. In low-light nighttime conditions, noise raises the bitrate. Without noise suppression, storage and bandwidth are continuously wasted.
3. With multi-intersection and multi-camera aggregation and backhaul, link and storage expansion costs are high.

4.5.3 H.265+ Solution

- **Solution overview:** In fixed-camera scenes, road surfaces and building backgrounds are continuously encoded at a low bitrate using background frames, while resources are allocated to vehicle regions as moving targets. At night, background noise suppression compresses low-light noise. Long-term bitrate control distributes budget across the day, balancing dense daytime traffic and sparse nighttime periods.

1. **Enable H.265+ on the IPC main stream:**

   Set the main-stream codec to H.265 (HEVC) and enable H.265+. Keep the sub-stream on the default standard encoding.

2. **Resolution / frame rate:**

   Configure 4MP @ 25 fps (intersection direction) based on management requirements, using the same parameters set for both day and night.

3. **Bitrate type and maximum bitrate:**

VBR is recommended. Set the maximum bitrate based on average traffic volume (e.g., for 4MP set 4–6 Mbps as the peak limit). Bitrate increases automatically during heavy-traffic periods and decreases automatically during low-activity nighttime periods. If the backhaul is a fixed-bandwidth leased line and a more predictable output stream is required, choose CBR. H.265+ still takes effect under CBR: during busy periods, the bitrate stays close to the preset value, while during idle periods it drops significantly, with the peak always bounded.

4. **Recording mode:**

   Since accident investigations require high integrity and HD quality, continuous main-stream recording is recommended, with storage and backhaul bandwidth planned based on the average bitrate achieved by H.265+. If storage pressure is high, for typical intersections choose continuous sub-stream recording + event-based main-stream recording, where traffic/anomaly detection triggers HD recording on the main stream.

5. **Verification:**

   On the platform side, compare daily recording volume and bitrate curves before and after enabling H.265+. Focus on whether nighttime bitrate is controlled via noise suppression, and whether playback during incidents remains clear and traceable.

- **H.265 vs. H.265+ encoding:**

Comparison Item	Traditional H.265 Encoding	H.265+ Encoding
Bitrate in continuous-traffic scenes	Constantly high	Background compressed; lower average bitrate
Nighttime noise overhead	Noise fully encoded	Background noise suppression; bitrate increase is controlled
24-hour recording size	Large	Significantly reduced; longer retention possible
Multi-intersection backhaul	High bandwidth cost	Controlled average bitrate; reduced aggregation pressure

4.6 Low-Light / IR Night Vision Scenarios

4.6.1 Scenario Description

In low-light environments such as nighttime conditions, underground spaces, or areas without supplemental lighting, cameras operate in low-light mode or IR night vision mode. The

scene is mainly a fixed background, while targets (i.e., people/vehicles) are sparse and appear intermittently. Such scenarios are common at campus perimeters, underground garages, and remote outdoor sites.

4.6.2 Requirements and Pain Points

Nighttime intrusions and abnormal events must be detectable and traceable, while the cost of long-duration night vision recording must remain controllable.

1. Nighttime noise (e.g., low-light grain, sensor jitter, or IR noise) significantly increases bitrate. Traditional encoding treats noise as content and encodes it in full.
2. Low-value noise data consumes bitrate and can even degrade the encoding quality of target regions.
3. Long-duration night vision recording causes storage and bandwidth costs to be continuously spent on noise.

4.6.3 H.265+ Solution

- **Solution overview:** Background noise suppression separates background regions from moving targets. For background areas (including noise), it uses a higher-compression strategy to suppress redundant information caused by random noise. For key motion regions, it preserves a reasonable bitrate allocation so that target contours, directions, and behaviors remain recognizable. This controls nighttime resource consumption without noticeably affecting playback recognizability.

- **Configuration steps**:

1. **Enable H.265+ on the IPC main stream:**

   Set the main-stream codec to H.265 (HEVC) and enable H.265+. Keep the sub-stream on the default standard encoding.

2. **Resolution / frame rate:**

   Configure based on point importance, e.g., 4MP @ 25 fps or 2MP @ 15 fps for perimeter/garage locations.

3. **Bitrate type and maximum bitrate:**

   Use VBR and set a lower maximum bitrate limit. Since the nighttime scene is static for long periods, H.265+ background noise suppression will automatically reduce bitrate. If CBR is mistakenly used, the encoder may keep outputting a high constant bitrate, weakening the benefits of noise suppression. When targets (i.e., people/vehicles) appear, VBR allows the bitrate to increase automatically to keep targets recognizable.

4. **Recording mode:**

Continuous sub-stream recording + event-based main-stream recording is recommended, with motion detection/intrusion events triggering HD recording via the H.265+ main stream. During idle nighttime periods, only the low-bitrate sub-stream records continuously, minimizing storage usage for long-duration night vision recordings.

5. **Verification:**

   Compare nighttime bitrate curves and recording file sizes before and after enabling H.265+ to confirm that the bitrate increase is controlled. Replay event recordings to verify target contour/direction/behavior recognizability, balancing bitrate savings and recognizability.

➢ **H.265 vs. H.265+ encoding:**

Comparison Item	Traditional H.265 Encoding	H.265+ Encoding
Nighttime bitrate	Noise drives the bitrate up	Noise suppression; bitrate increase is controlled
Target recognizability	Noise consumes resources	Target region quality prioritized
Nighttime storage	High	Significantly reduced
Daily average bitrate	Increased by nighttime noise	More balanced day/night; controlled overall

5 Representative Models

H.265+ intelligent encoding is a standard video codec across the entire VIGI/Omada camera lineup. All models support configuring H.265+ on the main stream. For details, refer to: Cameras | TP-Link and Security Cameras | TP-Link

Video Compression	• Main Stream: H.265+/H.265/H.264+/H.264 • Sub-Stream: H.265/H.264
H.264 Type	High Profile
H.264+	Main Stream Supported
H.265 Type	Main Profile
H.265+	Main Stream Supported

6 Future Outlook

6.1 Industry Trends

1. **Enhanced intelligent scene analysis:** The introduction of lighter-weight, on-camera intelligent encoding capabilities will improve the accuracy of background-frame selection and the adaptability of refresh-frame (R-frame) strategies. This enables faster convergence of the background model and more precise separation of moving targets from the background, further reducing the bitrate in static scenes.
2. **Event-driven encoding collaboration:** Linkage mechanisms between camera encoding resources and AI event detection (e.g., human/vehicle recognition) will be explored. When an event occurs, the bitrate is prioritized for target regions. During intervals between events, the background and noise are compressed automatically—synergizing with the continuous sub-stream recording + event-based main-stream recording mode.
3. **Imaging–encoding coordination:** Coordination with 3D noise reduction and IR illumination strategies will improve input signal-to-noise ratio at the imaging source in low-light scenarios, further strengthening the benefits of nighttime background noise suppression.

6.2 Expansion of Application Scenarios

1. **Ultra-HD surveillance scenarios:** For 8MP/4K and higher resolutions, background referencing optimization and bitrate allocation strategies will keep bandwidth and storage controllable at higher pixel densities.
2. **High pedestrian/vehicle traffic scenarios:** Adaptive encoding will be explored for target-dense scenarios such as malls, stations, and campus gates, balancing target clarity and overall bitrate when target counts are high and activity is frequent.
3. **Cloud recording and video-to-cloud:** In combination with cloud storage and remote playback requirements, optimization of upstream stream structure and bitrate budgeting will reduce cloud bandwidth and storage costs.

6.3 Ecosystem and Management Integration

1. **Deeper integration with management platforms:** Further integration of cameras and management platforms will enable unified configuration and one-click provisioning of H.265+ encoding parameters, recording modes, and storage planning.
2. **Open capability interfaces:** Third-party platforms and solution integrators with

capability discovery and control interfaces for encoding parameter configuration and bitrate settings will support customized surveillance solutions.

3. **Storage and bandwidth planning tools:** Platform-side tools will be provided for scenario-based storage capacity calculation and bandwidth estimation to assist solution design, product selection, and project delivery.

6.4 User Experience Optimization

1. **Intelligent parameter recommendations:** H.265+ will be enabled by default and provide adaptive camera-side configuration, automatically recommending bitrate mode (VBR/CBR) and maximum bitrate based on the scene to reduce deployment complexity.
2. **Benefit visualization:** Estimated bitrate and storage savings before and after enabling H.265+ on the NVR/management platform will be displayed, making optimization benefits measurable and tangible.

6.5 Vision

H.265+ will continue to focus on high compression efficiency, high image quality, and easy deployment. As a standard encoding capability across the entire VIGI/Omada camera lineup, it will drive video surveillance from trading bandwidth and storage for clarity toward trading intelligent encoding for efficiency, delivering surveillance services that use less bandwidth, consume less storage, and provide clearer images.

7 Appendix

7.1 Glossary

Term	Description
H.265 (HEVC)	H.265, or High Efficiency Video Coding (HEVC), is the current mainstream high-efficiency video coding standard. It reduces compressed data size at the same image quality through finer-grained coding tree units, more efficient intra and inter prediction, and stronger entropy coding.
Intelligent Encoding Technology	A general term for encoding technologies that apply differentiated adjustments to stream bit allocation, reference frame selection, and noise-processing strategies based on video content characteristics (e.g., background stability, the value of moving objects, and time-based activity level).

H.265+	A type of intelligent encoding technology. While remaining compatible with H.265, it improves bitrate compression efficiency through predictive coding, background noise suppression, and long-term bitrate control, reducing transmission bandwidth and storage usage without sacrificing image quality.
CCTV	Closed-Circuit Television. A video surveillance system in which video signals are transmitted in a directed manner via cameras and dedicated transmission links to a designated monitoring center or recording device, rather than being broadcast publicly.
CBR	Constant Bit Rate. A bitrate control mode in which the encoder keeps the output bitrate fluctuating around a preset value.
VBR	Variable Bit Rate. A bitrate control mode in which the instantaneous bitrate varies with scene complexity to maintain relatively stable image quality.
Main Stream	The high-resolution video stream output by a camera, used for HD live view and recording storage.
Sub-Stream	The low-resolution video stream output by a camera, used for multi-view display and mobile viewing, with lower bandwidth usage. The sub-stream uses standard encoding and does not support enabling H.265+.
NVR	Network Video Recorder. A network recording device that receives, stores, and manages camera video streams. It supports multiple recording configurations, such as continuous main-stream recording, continuous sub-stream recording, continuous recording on both streams, and continuous sub-stream recording plus event-based main-stream recording.