PELCO

by Schneider Electric

White Paper

Issue 1

Managing Bit Rate Usage and IP Cameras

October 2015

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DISCUSSION POINTS

Overview

Camera bit rates can dramatically affect overall network bandwidth and storage capacity, as well as the associated costs. Therefore, knowing your cameras' bit rate usage is a key consideration when planning and deploying an IP video management system.

Many factors affect the bit rate an IP camera imposes on both network bandwidth and data storage requirements, including:

- Scene complexity
- Level of motion including effects of weather (wind, rain, snow, and so on)
- Image rate and resolution
- Lighting conditions
- Rate control and compression-related camera settings
- GOP length / I-Frame interval settings
- Bit rate and H.264 quantization parameter settings
- Recording triggers: alarms and analytics

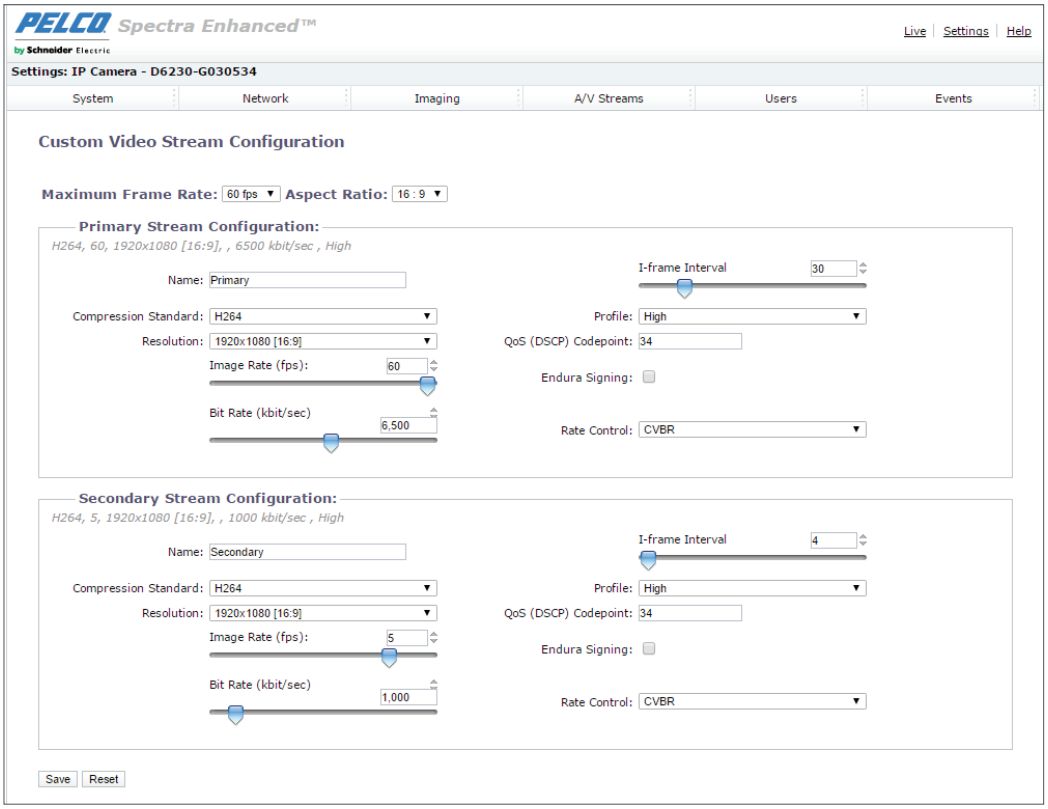
Scene Complexity and Motion Level

An IP camera surveilling a busy traffic intersection will generate a significantly higher bit rate than a similarly configured camera surveilling an empty stairwell scene. This is true when the camera is configured for either variable bit rate (VBR) or constrained variable bit rate (CVBR) control settings.

Weather conditions can also increase bit rates. For example, a scene on a windy day that contains the constant movement of tree leaves will have a significantly higher bit rate than the same scene on a calm day.

Image Rate and Resolution

In some installations – such as Nevada casinos – certain cameras within the casino will consume more bandwidth and storage because they are legally required to record video at 30 frames per second, while other cameras are not. For example, IP cameras recording video in high-priority/high-traffic locations above gaming tables are legally required to hit 30 fps; IP cameras located in the lobby, hallways, or other lower priority/lower traffic areas are not. Users can conserve bandwidth and storage by reducing the frame rates of cameras in those lower priority/lower impact locations.



The bandwidth and processing requirements of high quality video are steep and can quickly consume your network resources. Pelco IP and other high quality IP cameras are designed to allow users to configure cameras at lower frame rates or resolutions, thus lowering the bit rate and the impact of video on network resources. Doing so, though, can make images less clear and video to jump or appear choppy. However, depending on the activity observed, a frame rate between 10–15 ips is often adequate to capture evidentiary events at reasonable quality, striking a balance between the surveillance needs of the user and the available network and storage resources within the video management system.

Suitability Disclaimer

Judgment as to the suitability of the products for users' purposes is solely the users' responsibility. Users shall determine the suitability of the products for their own intended application, picture rate and picture quality. In the event users intend to use the video for evidentiary purposes in a judicial proceeding or otherwise, users should consult with their attorney regarding any particular requirements for such use.

Lighting Conditions

Lighting is perhaps the most critical element in capturing quality images. Too much light causes an image to be overexposed with a washed out appearance; in too little light, an image will be underexposed causing unwanted shadows and dark areas. IP cameras employ different technologies to compensate for these extreme fluctuations and capture crucial evidentiary detail. Often, though, the technologies used to correct for lighting challenges result in a higher bit rate and consumption of disk space.

Some camera manufacturers use auto exposure to address lighting variances – auto exposure looks at the whole scene and averages out the bright and dark areas. In scenes where there is a wide dynamic range of light intensity, auto exposure alone is simply not enough. For example, if a white car enters a low-light scene, the average light level increases. The camera compensates by automatically stepping down the iris, causing the rest of the scene to be underexposed. Conversely, if a black car enters a low-light scene, the average light level decreases and the iris automatically opens to allow in more light. This correction results in the rest of the scene being overexposed. In either instance, critical detail can be lost causing a need for image enhancements to be added to the scene, which increases bit rate.

Other manufacturers simply increase the gain level of their cameras rather than focusing on camera performance in low-light, wide dynamic range scenes. (Gain is the electronic amplification of the video signal, which increases the brightness of an image to achieve proper exposure.) However, the higher the gain, the greater the visual noise in the scene – especially when the camera changes to black-and-white mode. The impact of visual noise in a scene results in less clear, grainy, or even snowy images. The collective impact of multiple noisy images is a higher bit rate and an increased consumption of network resources.

IR Illumination

The strategic use of infrared lighting is, perhaps, the best solution to ensure effective performance of IP cameras in low-light conditions. Infrared (IR) is used to add an artificial light source into a scene without introducing additional ambient light. IR cameras employ this technology to increase visibility and produce better images in scenes containing extreme fluctuations in light or in complete darkness. However, there are some drawbacks with traditional, non-adaptive IR including issues around field of view, oversaturation of objects near the camera, and an increase in the amount of visual noise. This increase in visual noise also causes a corresponding increase in bit rate and additional network resource consumption that results from the capture and storage these images.

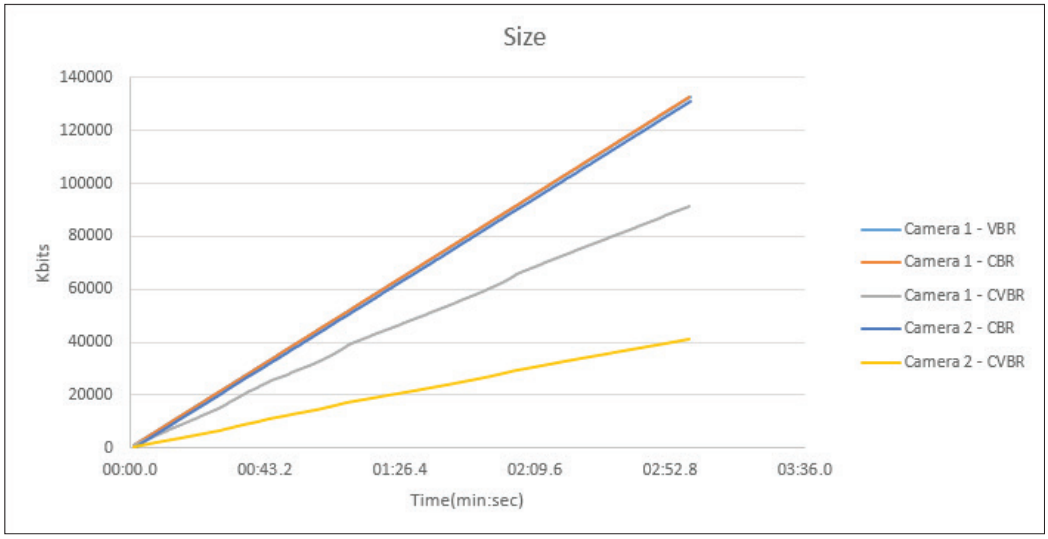
Rate Control Options

The rate control option determines the bit rate and quality of each frame in an H.264 video stream. Each rate control setting is a compromise between image quality and the resources required for video transmission and storage.
Depending on camera model, there are three rate control options available:

- **CBR:** Constant bit rate
- **VBR:** Variable bit rate
- **CVBR:** Constrained variable bit rate

Constant Bit Rate

Constant bit rate (CBR) uses the full capacity of the bit rate setting for scenes without regard for scene complexity or level of motion. Video is always streamed at the same user-specified bit rate; this option may be a good choice for bandwidth constrained channels where a constant bit rate is the best option for managing the constraint by using – but not exceeding – available bandwidth. CBR, however, may not be the best choice for storage since it is likely to make inefficient use of storage during noncomplex scenes, while not allocating enough storage to capture detail in complex- or high-motion scenes.



In the chart above, the CBR data for Cameras 1 and 2 shows the file size climbing constantly, regardless of scene complexity and amount of motion; thus, CBR has the potential to waste storage and bandwidth. The net result is a consistently higher bit rate, and a corresponding draw against storage resources.

NOTE: The data points for Camera 1 – VBR, Camera 1 – CBR and Camera 2 – CBR are overlapped in the chart above.

Variable Bit Rate

Variable bit rate (VBR) reduces or increases bit rates from a target bit rate in response to motion while maintaining high-quality video. Thus, VBR is more flexible than CBR because it makes better use of bandwidth: lowering the bit rate in simple scenes and raising it in complex scenes. The net result is a very high bit rate peak resulting from a significant jump in motion, but a more uniform quality and a lesser impact on overall storage consumption than CBR.

Constrained Variable Bit Rate

Constrained variable bit rate (CVBR) uses compression to vary the bit rate while limiting the upper bound to the specified bit rate. If the scene compresses well – as would be the case for a static scene – the camera will drop the bit rate significantly below the upper limit. This option is sometimes referred to as "variable bit rate with a cap." Depending on scene complexity and the amount of motion, bandwidth is typically reduced by 30–70 percent of the CBR, thus making CVBR the best option for most situations. In the chart on the previous page, the CVBR data for Camera 2 shows a variation in scene complexity/motion and the consistent capture of images with a maximum allowed bit rate (or maximum quality value). The specified upper limit prevents the wild fluctuations that may occur with the VBR setting. The net result is lower overall bandwidth and storage consumption, and a corresponding decrease in image quality depending on the variable maximum specified.

GOP Length / I-Frame Interval

When using H.264 as the compression standard, a video stream consists of I-Frames and P-Frames. I-Frames contain the complete image captured at a specific time interval (for example, once per second). P-Frames contain only data about changes in the image that have occurred since the preceding I-Frame.

Increasing the I-Frame interval can improve video compression rates and reduce the size of video data. Specifying a higher GOP length, the interval between I-Frames, will be more effective in reducing the bit rate in relatively static scenes. In scenes with a very high level of motion, setting a high GOP length value can actually increase the bit rate.

NOTE: Higher GOP length settings may increase the time it takes to initially access the stream and view video as the video client waits for the camera to present before displaying the video stream.

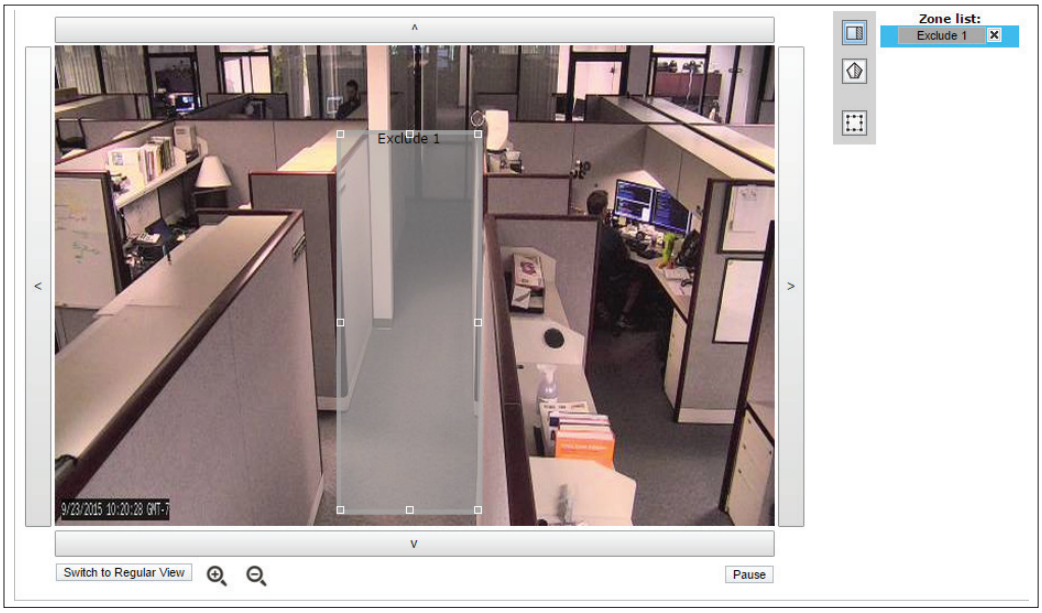
Bit Rate and H.264 Quantization Parameter Settings

Pelco IP and other high quality IP cameras allow users to set the bit rate manually. The meaning of this value is different depending on the selected rate control: CBR, VBR, or CVBR. When CVBR is selected, a maximum bit rate value is specified.

In some cases, it is possible to set an additional parameter known as the H.264 quantization parameter (QP value). This setting provides a further adjustment of the level of compression applied, which has an inverse effect on the relationship between image quality and bit rate usage.

For Pelco Sarix® Professional and Spectra® Professional cameras, you can modify the QP setting by pressing CTRL + Q on the Video Configuration page of the camera's Web interface.

Recording Triggers: Alarms and Analytics



When considering the impact of bit rate on network storage, you must understand the relationship between frame rate and image quality. Although bit rate consumption of continuous recording can be moderated by lowering the frame rate (and vice versa), doing so also decreases image quality but conserves disk space. Conversely, you may be able to save significant disk space by configuring a system to record only when triggered by alarms or analytics – available on many of Pelco's IP cameras. Recording on alarm lowers the throughput by not recording continuously, which mitigates the impact on bit rate.

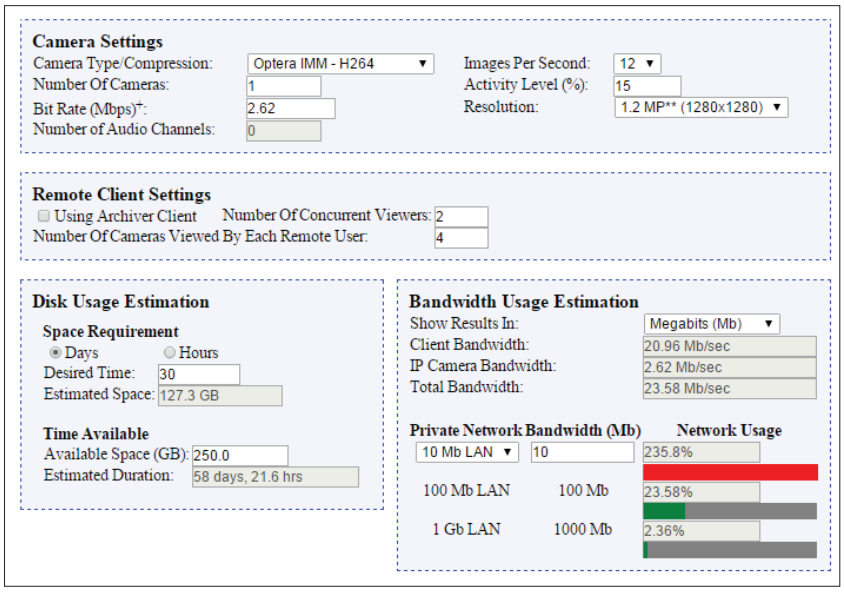
Depending on the camera model and VMS system, advanced analytics analysis may be performed on board the camera or within the VMS. Using the camera-side analytics may avoid the need for continuous streaming.

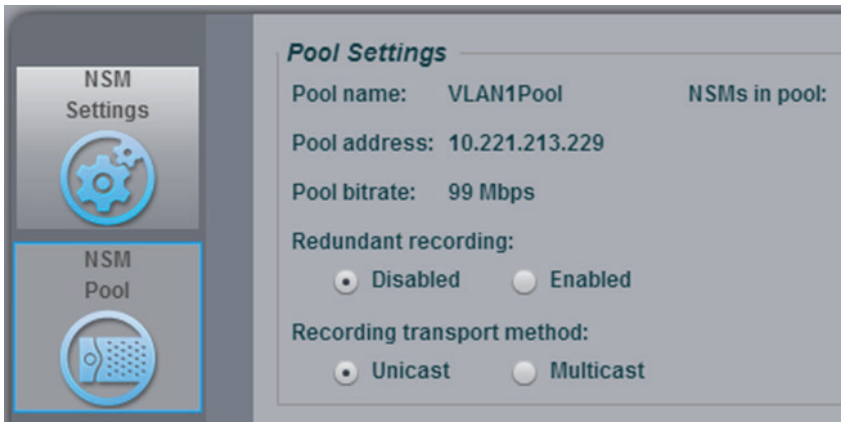
Estimating Storage and Bandwidth

Since bit rates can dramatically affect the performance and disk space of your network, it is important to consider and assess your potential storage and bandwidth requirements when planning your IP video management system.

Estimating Disk Space Requirements

If you have a Digital Sentry® (DS) system, use the DS Storage Estimator tool to calculate your storage space. For more information, visit Pelco's Tools & Calculators page.





If you have an Endura® NSM5200 or VSM, you can use the retention time to manually calculate the total bit rate of an existing installation or a new environment. When calculating using storage retention, it is important to consider load distribution, failover recording and so on. When estimating storage requirements, it is also highly recommended that you build in a storage "cushion" that will accommodate for worst-case scenarios (catastrophic failure) and to avoid exceeding the maximum bit rate. For more information, about manually calculating the total bit rate, refer to *Lessons Learned article LL#14902* in Pelco's Knowledge Base.

To ensure proper retention time, storage distribution and redundant recording, contact your Pelco sales representative.

Alternatively, you can use an online calculator to calculate storage requirements, or you can obtain a rough estimate of a camera's bit rate manually using its frame dimensions, frame rate, and compression format. The Endura 2.0 Network Design Guide gives the average bit rate of many of Pelco's IP cameras with various configurations. However, the true bit rate will vary based on factors such as the type of motion and lighting present in the scene.

Estimating Network Bandwidth Utilization

The rising resolutions of cameras increases the bandwidth needs of networks, making bit rate controls more important in limiting the impact of each individual camera on the network. Therefore, it is important to consider network bandwidth requirements when deploying an IP video management system with multiple high resolution cameras.

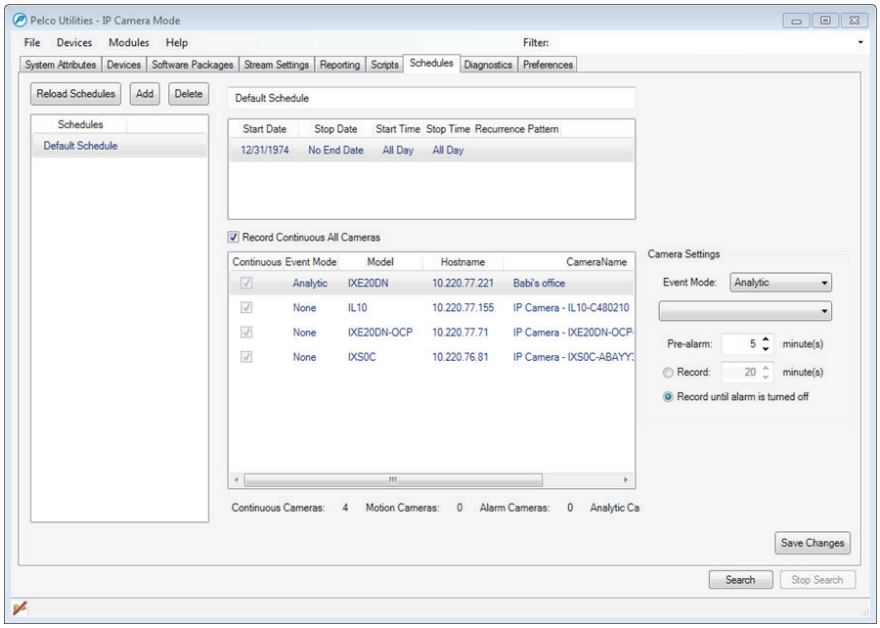
For example, network bandwidth requirements should be considered when deploying a wireless network in which multiple IP cameras connect to a shared access point (AP), with an aggregated effective upper limit of 6000 Kbps or less. Because the limited bandwidth must be shared by all cameras connected to the AP, an estimation of the network bandwidth utilization is key in limiting the aggregated impact on the system.

Another example of a system where network bandwidth requirements should be a planning consideration is one in which multiple IP cameras are connected through DSL or other slow network connection option. More than one IP camera, recording high resolution video at high frame rates, exponentially increases the required connection speed, which increases bandwidth consumption. Thus, it is important to ensure that your connection speeds are sufficient to meet the needs of the system prior to deployment.

Reducing the Impact of Video Storage

Video storage capacity can be reduced by pruning recorded video based on age and priority. Pruning refers to the actual deletion of P-Frames, leaving only the I-Frames, thereby converting recorded video to a lower frame rate and increasing storage capacity.

When video is captured, key information data frames (I-Frames) are stored at specific intervals. P-Frames are predictive frames existing between I-Frames that predict subject movement, color changes, and so on to produce the number of total desired frames per second. Pelco's Endura NSM5200 and VSM models record I-Frames and P-Frames separately, essentially branching the recorded data. When storage capacity reaches 97 percent, the unique algorithm of Pelco's EnduraStor™ Storage Management starts the pruning process of P-Frames, which allows older video to be stored at a lower frame rate at the same resolution.



NOTES:

- While EnduraStor maximizes retention periods, it does so at the cost of video quality. If you choose to use this technology, it is important to consider both the surveillance needs of the user (video quality) and the available storage resources within the IP video management system.

- Multicast technology also reduces network bandwidth in some situations by allowing a single video stream to be viewed simultaneously by multiple recipients. Essentially, there is no direct connection between the video stream and the recipients. Instead, the recipients share the same video stream over the network, thus relieving bandwidth.

For more information, please visit **pelco.com** or call (800) 289-9100 (United States and Canada) or +1 (559) 292-1981 (international). For pricing information or to purchase Pelco products, please contact your manufacturer's representative or the Pelco office in your area.

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