Bandwidth and Storage Space Calculations

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Introduction

Network bandwidth and storage requirements are important considerations when designing a video surveillance system. The factors include the number of cameras, the image resolution used, the compression type and ratio, frame rates and scene complexity. This document provides some guidelines on designing a system, along with information on storage solutions and various system configurations.

Bandwidth and Storage Calculations

Network video products utilize network bandwidth and storage space based on their configuration. This depends on the following:

- Number of cameras
- Whether recording will be continuous or event-based
- Number of hours per day the camera will be recording
- Frames per second
- Image resolution
- Video compression type: Motion JPEG, MPEG-4, H.264
- Scenery: Image complexity (e.g. gray wall or a forest), lighting conditions and amount of motion (office environment or crowded train stations)
- How long data must be stored

Bandwidth needs

In a small surveillance system involving 8 to 10 cameras, a basic 100-megabit (Mbit) network switch can be used without having to consider bandwidth limitations. Most companies can implement a surveillance system of this size using their existing network. When implementing 10 or more cameras, the network load can be estimated using a few rules of thumb: A camera that is configured to deliver high-quality images at high frame rates will use

approx. 2 to 3 Mbit/s of the available network bandwidth.

- With more than 12 to 15 cameras, consider using a switch with a gigabit backbone. If a gigabit-supporting switch is used, the server that runs the video management software should have a gigabit network adapter installed.

Technologies that enable the management of bandwidth consumption include the use of VLANs on a switched network, Quality of Service and event-based recordings.

Calculating storage needs

As mentioned earlier, the type of video compression used is one of the factors affecting storage requirements. The H.264 compression format is by far the most efficient video compression technique available today. Without compromising image quality, an H.264 encoder can reduce the size of a digital video file by more than 80% compared with the Motion JPEG format and as much as 50% more than with the MPEG-4 standard. This means much less network bandwidth and storage space are required for an H.264 video file. Sample storage calculations for all three compression formats are provided in the tables below. Because of a number of variables that affect average bit rate levels, calculations are not so clear cut for H.264 and MPEG-4. With Motion JPEG, there is a clear formula because Motion JPEG consists of one individual file for each image. Storage requirements for Motion JPEG recordings vary depending on the frame rate, resolution and level of compression.

H.264 calculation

Approx. bit rate / 8(bits in a byte) x 3600s = KB per hour / 1000 = MB per hour

MB per hour x hours of operation per day / 1000 = GB per day

GB per day x requested period of storage = Storage need (See Table 1)

Table 1 H.264 calculation

camera	resolution	Approx. bit rate (Kbit/s)	Frames per second	MB/hour	Hours of operation	GB/day
NO. 1	CIF	110	5	49.5	8	0.4
NO. 2	CIF	250	15	112.5	8	0.9
NO. 3	4 CIF	600	15	270	12	3.2
NO.4	D1	1536	20	691.2	12	8.3
NO. 5	HD	768	20	345.6	12	4.15
Total for the 3 cameras and 30 days of storage = 508.5 GB						

MPEG-4 calculation

Approx. bit rate / 8(bits in a byte) x 3600s = KB per hour / 1000 = MB per hour

MB per hour x hours of operation per day / 1000 = GB per day

GB per day x requested period of storage = Storage need

Note: The formula does not take into account the amount of motion, which is an important factor that can influence the size of storage required (see Table 2).

Table 2 MPEG-4 calculation

camera	resolution	Approx. bit rate (Kbit/s)	Frames per second	MB/hour	Hours of operation	GB/day
NO. 1	CIF	170	5	76.5	8	0.6
NO. 2	CIF	400	15	180	8	1.4
NO. 3	4 CIF	880	15	396	12	5
NO.4	D1	1024	20	460.8	12	5.53
NO. 5	HD	1536	20	691.2	15	10.37
Total for the 3 cameras and 30 days of storage = 687 GB						

Motion JPEG calculation

Image size x frames per second x 3600s = Kilobyte (KB) per hour/1000 = Megabyte (MB) per hour

MB per hour x hours of operation per day / 1000 = Gigabyte (GB) per day

GB per day x requested period of storage = Storage need (See Table 3).

Table 3 Motion JPEG calculation

camera	resolution	Approx. bit rate (Kbit/s)	Frames per second	MB/hour	Hours of operation	GB/day
NO. 1	CIF	13	5	234	8	1.9
NO. 2	CIF	13	15	702	8	5.6
NO. 3	4 CIF	40	15	2160	12	26
NO. 4	D1	1024	20	73728	12	884.7
NO. 5	HD	1536	20	110592	15	1658.9
Total for the 3 cameras and 30 days of storage = 2577 GB						

In order to achieve efficient video transmission, it is important to evaluate your bandwidth requirements before setting up an IP surveillance system.

Bandwidth requirements vary with the following factors.

- **Resolution:** the higher the resolution, the more bandwidth is required
- **Complexity of the scene:** the more complicated the scene, the more bandwidth is required.
- **Compression type:** the lower compression ratio, the more bandwidth is required.
- **Image quality:** the higher image quality, the more bandwidth is required.
- **Frame rate:** the higher frame rate, the more bandwidth is required.

Variable and Constant Bit rates

With MPEG-4 and H.264, users can allow an encoded video stream to have a variable or a constant bit rate. The optimal selection depends on the application and network infrastructure. With VBR (variable bit rate), a

predefined level of image quality can be maintained regardless of motion or the lack of it in a scene. This means that bandwidth use will increase when there is a lot of activity in a scene and will decrease when there is no motion. This is often desirable in video surveillance applications where there is a need for high quality, particularly if there is motion in a scene. Since the bit rate may vary, even when an average target bit rate is defined, the network infrastructure

(available bandwidth) must be able to accommodate high throughputs. With limited bandwidth available, the recommended mode is normally CBR (constant bit rate) as this mode generates a constant bit rate that can be predefined by a user. The disadvantage with CBR is that

when there is, for instance, increased activity in a scene that results in a bit rate that is higher than the target rate, the restriction to keep the bit rate constant leads to a lower image quality and frame rate. Most of the network video products allow the user to prioritize either the image quality or the frame rate if the bit rate rises above the target bit rate.

3 different video compression methods include:

- 1PASS-VBR
- 1PASS-CBR
- 2PASS-CBR

With 1PASS-VBR, you cannot know the size of the resulting file because the Bit rate is distributed depending on the amount of movement, but it is possible to encode the video in good quality. With 1PASS-CBR, you can encode the video into a set size since the same amount of bit rate is applied regardless of the video type. 2PASS-CBR is the combination of the two methods. In initial encoding it checks the status of the video and in its secondary encoding the amount of Bit rate is distributed according to the status of the video to provide good quality and fixed size for the result file.

The advantages of VBR are that it produces a better quality-to-space ratio compared to a CBR file of the same data. The available bits are used more flexibly to encode the sound or video data more accurately, with fewer bits used in less demanding passages and more bits used in difficult-to-encode passages.

The disadvantages are that it may take more time to encode, as the process is more complex, and that some hardware might not be compatible with VBR files.