WHITE PAPER

# Video Solutions

# Understanding Video Image Quality

## Abstract

Many organizations are addressing the requirements for video solutions. While it is important to construct video applications support systems quickly to address immediate needs, network operators need to select the right system the first time, to minimize the total life cycle cost of these systems.

Operators need to clearly understand the requirements of their organization. This includes an understanding of the video image quality. While there are many other issues that will significantly impact network design, this paper provides information on factors that address image quality. The factors discussed include:

- Screen Resolution
- Frames per Second (FPS)
- Video Codecs
- Packets per Second
- Bandwidth

An understanding of the effect of these factors on bandwidth requirements will enable network operators to correctly design communications infrastructure networks that will support video applications.

## Intracacies of Video Solution Image Quality

Operators need to select video performance that is appropriate to the needs of the application. Different performance levels will require different cameras to collect images. In general, higher performance levels will require a higher bandwidth infrastructure to transport data from the camera to the video command center.
Network operators need to clearly understand the camera performance required in order to design the communications infrastructure appropriately. If there is not sufficient capacity at any point in the communications infrastructure, video images may be delayed or lost, defeating the purpose of a video solution.

## Screen Resolution

Resolution is the number of "pixels" (picture elements) within each picture frame. For example NTSC television is 720x486 (non-square pixels) or 720x540 (square pixels); sometimes these are termed D1. In the DVD context National Television System Committee (NTSC) and Phase Alternating Line (PAL) television is 720x480. All these have an aspect ratio of 4:3; non-square pixels can make this "wide screen" 16:9 aspect.

The resolution issue is complicated by the distinctions between computer monitor resolutions and video teleconferencing screen resolutions.

In video cameras used for surveillance, the notation of Common Intermediate Format (CIF) at 352x240 resolution is the NTSC and PAL norms. Alternatives are Quarter CIF (QCIF) 176x120, 4CIF 704x480, and 16CIF 1408x960.

The impact of different computer screens on generic video can be dramatic. By understanding the device which will be used to view the images, the network operator can know the requirement for image collection and processing.

**Table 1: Common Computer Screen Resolutions**

| Standard | Resolution | Aspect Ratio |
|---|---|---|
| QVGA | 320x240 | 4:3 |
| VGA | 640x480 | 4:3 |
| SVGA | 800x600 | 4:3 |
| XGA | 1024x768 | 4:3 |
| XGA+ | 1152x864 | 4:3 |
| SXGA | 1280x1024 | 5:4 |

## Frames per Second (FPS)

Frames per second (FPS) is the number of "snapshots" of the video scene in one second. Recall that motion pictures are 24 FPS, and NTSC and PAL television 30 FPS (although really 60 interlaced FPS). Video surveillance cameras can be configured for a range of FPS. Generally surveillance can be few FPS that "quality video" as situation assessment is the primary application. Storage costs are directly correlated to FPS as well. In many cases, 10 FPS is sufficient.

## Video Codecs

One might think that stipulating the camera's resolution and frames per second (FPS) would exactly result in a bandwidth throughput need. However, even stipulating the resolution and FPS the IP camera may be configured for a particular bandwidth within some bandwidth range.

A Codec (Compression/Decompression) device collects and produces a compressed video stream from the camera. The most common codecs used in video surveillance are Motion JPEG, MPEG and MPEG-4.

**Table 1: Common Computer Screen Resolutions**

| | Characteristics |
|---|---|
| JPEG | • Still image technology |
| MPEG | • Allows streaming video to be "stopped" on one frame<br>• Designed for motion video |
| MPEG-4 H.264 (AVC) | • Reduced bandwidth demand for image transfer |

Low quality 10 FPS MPEG consumes about 183Kbps of bandwidth using 20pps with each packet about 1200 octets. High quality 10 FPS MPEG consumes about 418Kbsp using 40pps with each packet about 1300 octets.

In particular the MPEG-4 variant called "part 10" has been additionally codified as ITU-T H.264, and as ISO/IEC 14496-10. To distinguish other variants of MPEG-4 it is always sufficient to state H.264 when meaning exactly MPEG-4 part 10. Alternately this same technology is termed Advanced Video Coding (AVC).

Some video camera vendors make fine distinctions. For example the SONY SNC RX550 camera specification has "JPEG/MPEG-4" and "H.264" as separate attributes. The distinction here is that the former is capable of up to 30fps at its highest resolution (640x480) whereas the latter only 10fps at the same resolution.

In cases where 10 FPS is adequate, the reduced bandwidth of H.264 provides reliable performance.

## Data Bit Rate

Information packet size and packet transfer rate (packets per second – PPS) is significant for video applications. Any particular packet flow rate in kbps can have many different packet size/packet frequency combinations.

The overhead of encapsulating a video stream into a packet stream can be substantial depending on the data requirements and network configuration. In general, the encapsulation will be MPEG4 "frames" encapsulated in Realtime Transport Protocol (RTP), RTP encapsulated in User Datagram Protocol (UDP), and UDP encapsulated in Internet Protocol version 4 (IPv4). Additionally IP is encapsulated into some Data Link Layer protocol, such as Ethernet. The overhead sum of Ethernet/IP/UDP/RTP is 18+20+8+12 = 58 octets, plus the video payload.

While this issue may be significant with voice transmissions, where the system is transporting large numbers of small packets, for video the per-packet payload is significantly higher. This means that, for video, the overhead ratio is not nearly so significant.

The bandwidth in kbps is often stated for various video camera/codec combinations. It is important to additionally know the size of the resulting encoding and the packets per second. In general, video camera bandwidth setting is an upper bound for peak operations, with the camera typically actually consuming less bandwidth in normal operating conditions.

Data stream captures of MPEG4 transmissions show that, for a particular FPS and bandwidth configuration, variable sized packets result and that the packet frequency varies. The codec is able to manage the bit rate even in a changing video scene.

## Bandwidth

It is intuitive that bandwidth will be predominantly flowing in an uplink direction from the camera to the network. The network operator will need to allocate some bandwidth in the downlink direction from the network to the camera. This downlink bandwidth is used to control the camera for Pan, Tilt, Zoom (PTZ) and other functions.

In many networks, the network operator can designate the up/down ratio of data to the cameras in terms of a percentage. For many video surveillance applications, it is common to have 10% downstream (control signals to the camera) and 90% upstream (video images from the camera). A more conservative network design may have 25% downstream and 75% upstream.

## Putting it all Together

The following are typical image quality used in different applications:

| Application | Typical Screen Resolution (pixels) | Typical FPS (Frames per Second) | CODEC | Typical Upstream Bandwidth per Camera* (bits per second) | Image |
|---|---|---|---|---|---|
| **Monitoring** | **176x120 QCIF** | **30** | MPEG4 | **150 kbps** | • Good Image<br>• Smooth motion<br>• Some text legible |
| | **176x120 QCIF** | **10** | MPEG4 | **50 kbps** | • Cloudy Image<br>• Step Motion<br>• Some text legible |
| **Emergency Response** | **352x240 CIF** | **30** | MPEG4 | **600 kbps** | • Clear Image<br>• Full Motion<br>• Clear Text |
| | **352x240 CIF** | **5** | MPEG4 | **100 kbps** | • Some blurring<br>• Step motion<br>• Text is legible |
| **Investigations** | **640x480 4CIF** | **30** | MPEG4 | **11,200 kbps** | • Sharp Image<br>• Full motion<br>• Text is legible |
| | **640x480 4CIF** | **10** | H.264 | **350 kbps** | • Sharp Image<br>• Step motion<br>• Text is legible |

* Recommended Bandwidth Allocation set for 80% upstream and 20% upstream.

## Conclusion

An objective understanding of the requirements for video images is essential to designing a successful video surveillance application. From these requirements, the network operators can identify technical requirements for screen resolution, frames per second, and Codec equipment.

The technical requirements will also lead network operators to specify the appropriate camera for the application and the bandwidth required to support multiple cameras in the video surveillance network.

With this information, network operators will be able to design quality into the network so that the network will consistently meet performance expectations.

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