CCTV Storage and Bandwidth – Pixel, Bit, Bit Depth, Byte and Bitrates Explained.

Introduction

- This note is meant to guide CCTV designer on the actual calculation of storage and bandwidth calculation in designing a complete CCTV system. It started with the smallest bit and eventually to the sizing of storage and bandwidth.
- It's meant to be a guideline and by no means should be taken at full values. It's the process that is more important.

Pixel

- This is the smallest component of display that we can see. Look closely on a monitor or TV screen, the dot that can be seen is the pixel. Thousand of pixels make a screen resolution.
- Thus for a CIF resolution of 352 x 288, it's actually made of 352 pixels x 288 pixels.
- Now, we need to represent each of this pixel with data hence bit.

Bit

- Bit is the smallest unit used to represent a data digitally. Bit is either 1 or 0. In CCTV bit is used to represent each pixel colour but using just 2 bits to represent colour is not fun. 2 bits corresponds to 2^2 or 4 possible data (colour) representation essentially black and white. To associate colours to the pixel we need the help of bit depth (also known as colour depth).

Bit Depth

- Essentially bit depth is the number of bits used to represent the colour of each pixel. Ever heard of 256 colours, 4096 colours and 16 millions colours? Look at your PC graphic properties and most likely they are at least 16 millions colours. Bit depth is simple, to get 256 colours would require 8 bit. Thus a pixel that has 8 bit depth can display 256 colours only. What this means is that in any time each pixel can be one of these 256 colours. To get 16M colours we would need a pixel with 24 bit depth (2^{24} ~ 16M) associated with it.

- You may be wondering what do pixels, bit and bit depth have got to do with CCTV storage and bandwidth calculation? Read on.

Bitrates

- Remember that each camera has its resolution. Although the following points will be based on analogue camera, it can still be applied equally well to digital IP cameras. Most analogue camera has a 4CIF resolution or 702 x 576 pixels (determined by the image sensor CCD or CMOS). In analogue video transmission bandwidth is normally not a problem, what matters is the conversion of this analogue signal to digital before storage.

Now, 702 x 576 = 404,352 pixels or lets just call it a frame for simplicity (though technically improper).

These 404,352 pixels (1 frame) need to be converted digitally (another subject on its own) by assigning some bits to it. Lets say we want 16M so 24 bit depth representation is needed for each pixel. So how many bits are required to represent a 702 x 576 resolution or 1 frame?

So, bits required are 702 x 576 x 24 = 9,704,448 or 9.7Mb (megabits) per frame

But, this 9.7Mb still doesn't mean anything to us. We need the frame per second (fps) that is required. Suppose we want a full smooth recording and select the 25 fps to be displayed.

Then, the **RAW** data rate is 9.7Mb x 25 fps = 242.5 Mbps. This is the bitrates, referring to flow of data which should never ever be confused with bytes. This is what determined the bandwidth requirement.

Byte

- One byte (B) equals to 8 bits, that's all. Bytes are referred exclusively when we talked about storage. So how big should the storage be if we want to record the **RAW** data above? Suppose a continuous recording of 24hrs for 30 days is required.
  Then, storage = 242.5 Mbps x (60s x 60 x 24 x 30)/8 = 78.6 TB
- That's very very big, but this is raw data we're talking about.
- The important thing is by now you should have understand how resolution and bit depth contributes to storage size in every single step. You should be able to explain what pixel, bit, bit depth and bitrates are all about.

Compression

- In an IP system the fundamentals above are exactly the same. The difference are mostly where the compression is being applied. In an IP system compression is mostly done at the camera end because the digital data flow occurs right after that. In analogue system the compression mostly occurs at the recording end.
- So what would be the bitrates if we were to applied compression in the above example. I'm taking H.264 as the compressor which can be read in details at http://www.adobe.com/content/dam/Adobe/en/devnet/video/articles/h264_primer/h264_primer.pdf
- According to the simple guide in the pdf above assuming medium motion (2)
  Then, bitrates = frame x fps x motion x 0.07
  = 702 x 576 x 25 x 2 x 0.07
  = 1.4 Mbps, a more comfortable figure to look at.

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