Networking and Bandwidth
For Video IP Systems

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Anatomy of a Typical Network Camera
Video over IP

1. Capture and Digitize Video
2. Compress Video for More Efficient Transport
3. Encapsulate Video For Network Transport
Imager Types: CMOS (Complimentary Metal Oxide Semi-Conductor)

The “Simple” Explanation

Light

Sensor made up of photodetector ‘pixels’ or picture elements
Photodetector sends signal to CMOS transistors
Signal is read at the output of one of the transistors
Other transistors buffer and reset the photodetector
Resolution: Scanning Area and Pixels

768 x 494

Interlaced Scanning

Scanning Area refers to the number of pixels on the imager
Resolution: Scanning Area and Pixels

Scanning Area refers to the number of pixels on the imager.

768 x 494

Progressive Scanning
### Pixel Count Expressed as Megapixel

**Common Megapixel Formats:**

<table>
<thead>
<tr>
<th>Megapixel</th>
<th>Resolution</th>
<th>Pixels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.3 MP</td>
<td>1280 x 960</td>
<td>1,228,800</td>
</tr>
<tr>
<td>2.0 MP</td>
<td>1600 x 1200</td>
<td>1,920,000</td>
</tr>
<tr>
<td>3.1 MP</td>
<td>2048 x 1536</td>
<td>3,145,728</td>
</tr>
</tbody>
</table>

Please note that the number of (mega) pixels do not represent picture quality!! It is simply a measure of how many H & V pixels compose the image.
What About “High Definition (HD)”?

- HD is a Picture Format; combination of Aspect Ratio, and Pixels
  - Just Because a Camera is HD it Doesn’t Mean it produces a Better Image or is Higher in Quality
- A 3.0 MP Camera has a Resolution of 2048 x 1536 or 3,145,728 Pixels
  - A 3.0 MP Camera has a Higher Resolution than “Full HD (HD1080P)”

<table>
<thead>
<tr>
<th>Format</th>
<th>VGA</th>
<th>HD720P</th>
<th>1.3 MP</th>
<th>HD1080P</th>
<th>3 MP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution (W x H)</td>
<td>640 x 480</td>
<td>1280 x 720</td>
<td>1280 x 960</td>
<td>1920 x 1080</td>
<td>2048 x 1536</td>
</tr>
<tr>
<td>Pixels</td>
<td>307,200</td>
<td>921,600</td>
<td>1,228,800</td>
<td>2,073,600</td>
<td>3,145,728</td>
</tr>
<tr>
<td>Megapixel</td>
<td>0.31 MP</td>
<td>1 MP</td>
<td>1.3 MP</td>
<td>2.1 MP</td>
<td>3.1 MP</td>
</tr>
<tr>
<td>Aspect Ratio</td>
<td>4:3</td>
<td>16:9</td>
<td>4:3</td>
<td>16:9</td>
<td>4:3</td>
</tr>
</tbody>
</table>
Bandwidth vs. Quality

Finding the Balance
Resolution: Lines of Resolution

EIA-1956 Resolution Chart
Not all Pixels are Created Equal

Actual lines of resolution achieved can be effected by

- Signal to Noise Ratio
- Imager Size
- Sensitivity
- Lenses

Megapixel cameras can be great, but make sure the gain in resolution justifies the extra bandwidth and storage needed to support them.

Pixels per foot is a minimum specification, but does not take camera image quality into account.

Finding the Balance: Is the extra bandwidth doing work?
VGA vs. Megapixel

Finding the Balance: Is it worth the extra bandwidth?
VGA vs. Megapixel

Finding the balance: Are you getting more?
Lux Ratings and Signal to Noise Ratios

- **Lux**
  - minimum luminance level at which the camera will record a satisfactory image. (=LOW)
Min Illumination
0.5lx@color, 0.04lx@BW

Min Illumination
0.5lx@color, 0.008lx@BW

Min Illumination
1.0lx@color, 0.15lx@BW
Lux Ratings and Signal to Noise Ratios

- **Lux**
  - minimum luminance level at which the camera will record a satisfactory image. (=LOW)

- **SNR**
  - the level of a desired signal to the level of background noise (=HIGH)
S/N = 44 dB
Min. Illumination 1.5 lx

- Vertical noise
- Low frequency horizontal noise

S/N = 50 dB
Megapixels and Linear Resolution

*While more pixels can improve overall image quality. The actual increase in resolution is not as dramatic as you would think.*

The ability to resolve usable information from a resolution chart is what matters most.

If a 640 x 480 VGA picture can resolve 480 lines of resolution, than a 1280 x 960 4VGA picture can resolve 960 lines of resolution.

This is only a doubling of the actual amount of resolution resolved even though we quadrupled the size of the image, bandwidth and storage.

The difference between 1.3 Mpxels and 3 Mpxels is only a 2.3x increase and yields only a 60% increase in linear resolution.
1.3 Megapixel Low Light High Contrast
Sensitivity

3 Megapixel
Sensitivity

3 Megapixel
Sensitivity

1.3 Megapixel
Methods for Encoding Video for IP Transmission

• Intraframe
  – JPEG, JPEG2000
  – Code a single image on a standalone basis

• Interframe
  – MPEG1, 2, 4, H.261, H.263, H.264/AVC (also known as MPEG4 Part 10)
  – Utilizes motion compensation; Takes advantage of redundancy between nearby video frames
  – Based on motion vectors that predict frame content; Use blocks drawn from one or more nearby frames
Intraframe vs. Interframe

Intraframe
Ex: M-JPEG

Interframe
Ex: MPEG-4
H.264
Introduction to H.264

What is H.264?

- It is a Video Compression Standard
- Also know as MPEG-4 Part 10
  - Therefore understanding MPEG-4 is essential
  - H.264 is an extension of MPEG-4 with more potential features
- Additional Alias: AVC Video Compression Standard
  - Designed for the Movie Production Industry
  - Panasonic is one of the founding members
    - Use of AVC standards in Professional and Consumer Camcorders for many years

Why Do I Need H.264?

- Lower Bandwidth Requirements
- Less Video Storage Needed
- Higher Resolution
- Improved Image Compression (less artifacts, noise, better color reproduction)
H.264 – Where did it come from?

- ITU-T Video Coding Experts Group (VCEP) : H.26L

  +  

- ISO/IEC Moving Picture Experts Group (MPEG) : MPEG-4 AVC (Advanced Video Coding)

  =  

- JVT – Joint Video Team : H.264/MPEG-4 AVC
H.264 Profiles

Better Compression
Noise Reduction

Base line profile
Main profile
Extended profile
High profile

Complexity
Better Picture Quality
<table>
<thead>
<tr>
<th>Feature</th>
<th>MPEG4</th>
<th>H.264 (profiles)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline</td>
</tr>
<tr>
<td>Picture Quality</td>
<td>Low</td>
<td>Middle</td>
</tr>
<tr>
<td>P frame</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>De-blocking Filter</td>
<td>N/A</td>
<td>Yes</td>
</tr>
<tr>
<td>B frame</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>8x8 DCT</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Quantization Matrix</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>CABAC</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Please note that a profile may not include ALL the features/tools of that level for a specific implementation. A vendor can turn off certain features to save CPU and coding complexity.

- IE. Constrained Baseline Profile
Using Multiple Streams
IP-Based Centralized Recording System

Features:
- Dependence on Core Switch Operation
- Better control of key equipment
- Concentrated Network Load

Command Center
IP-Based Distributed Recording System

Features:
- Minimal Recording System
- Dependence on Core Switch Operation
- Distributed Network Load

Telecomm Rooms
Network Switches with Layer 3 Protocols
Distributed Network Disk Recorders

Command Center
Unicast vs. Multicast Transmission

**Unicast**
- MPEG4: Limited number of users based upon camera specs
  - Frame rate may drop according to # of clients

**Multicast**
- MPEG4: Virtually unlimited number of users may view camera stream
  - Bandwidth is fixed regardless of # of clients
  - Network Replicates Data
  - Client can get video stream through communication with L3 switch/router OR L2 Switch w/ IGMP Snooping

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Multicast Group

16Mbps

4Mbps
Frame Rate

What is “Real Time” Video?

highspeedcam.wmv
• An Image With a Lot of Motion, or Vastly Changing Scene – Flashing Lights, Pan/Tilt Cameras, etc.
  – Will Yield Poorer Compression
  – Factor This When Calculating Bandwidth and Storage

• Constant Bit Rate Compression will have Fewer Spikes in Bandwidth/Storage
  – Example in a School: In-Between classes
Example Storage Calculations

**VGA**
- VGA JPEG @ 10 ips ≈ 5 Mbps/1.5 TB (24 hours per day x 30 Days)
- VGA MPEG-4 @ 10 ips ≈ 512 Kbps/.18 TB
- VGA H.264 @ 10 ips ≈ 384 Kbps/.13 TB

**Megapixel**
- 1.3 Megapixel JPEG @ 10 ips ≈ 13 Mbps/4.5 TB (9x more)
- 1.3 Megapixel H.264 @ 10 ips ≈ 1.5 Mbps/.5 TB

✓ Lower Bandwidth Requirement
✓ Lower Storage Requirement
Thank You!

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