LEADERS IN IP CCTV TECHNOLOGY
Contents

- Analogue CCTV System Architecture
- Components Basic IP CCTV System
- Possible additional Components of a system
- Bandwidth
- Compression Methods
- Transmitting Data
- IP Addressing
- Using Power over Ethernet
- IR Illumination and Megapixel Cameras
- Remote Viewing
- Closed Circuit v Open Circuit
Analogue CCTV System

- Coax Cable
- Controller to DVR
- Telemetry Data Cable
- Camera Power

EIM
Components of a Basic IP CCTV System

- Fixed Cameras (IP)
- PTZ Dome Cameras (IP)
- Ethernet cable (Cat5e/Cat6)
- PoE Switch (Power over Ethernet)
- Network Video Recorder
IP CCTV Cameras

- Types of camera
  - Standard Resolution (720 x 576) approx
  - MegaPixel (1280x1024 and upwards)
  - Static
  - MiniDome
  - PTZ Dome
  - Colour
  - Day / Night, with and without IRs
  - 180° and 360°
  - With and Without Power over Ethernet Capability
The Network Switch

- Networking switch directs traffic across the LAN, enabling the network devices to talk to each other and share resources.
- There are Managed Switches which have the capability to be configured through a web browser connection.
- There are Unmanaged Switches which have no configuration capabilities.
- The speed (bandwidth) of the switch is either 10 mega bits per second (Mbps), 100 Mbps or 1,000 Mbps (1 Gigabit). The speed refers to how many bits per second that the switch can receive and subsequently forward on to the destination.
- There will need to be 1 available port, per device connected to the switch.
Recording the Images

- A Dedicated Network Video Recorder (NVR) will be required.
- PC based, on a Microsoft Operating System (OS) or sometimes a Linux OS.
- The number of recordable IP cameras is usually licensed. Additional licences are then bought as the system expands.
- There will be a maximum number of cameras per NVR, depending upon the codec being used for recording, the frame rate and resolution, of each camera.
- The amount of on-board storage will differ between NVR’s. Record duration will depend upon picture activity, the codec being used, the frame rate and the resolution – per camera.
- Hybrids are available that record both IP and Analogue cameras
The Cable

The Cable will be Cat 5E or Cat 6 Network Cable

Max distance between the Switch and the Device (camera, NVR etc) is 100m
Basic Architecture

- 100m max between the switch and the “device”
- This is an example of a Local Area Network (LAN)
Extended Architecture

- For larger systems where a cable run of 100m is insufficient.
Possible Additional Equipment

- Network Switch
- Fixed Camera
- Cable
- PTZ Dome Camera
- Analogue camera
- Encoder
- Network Video Recorder
- Additional Storage
  - Direct Connection
  - Network Attached Storage
Additional Storage

- Extended Storage options will depend upon the NVR being used

- Storage will either be connected directly to the NVR, or be across the Network

- When using direct connection storage the connection could be by fibre or direct Cat 5E/6 cable connection.

- Fibre connection, whilst more money, offers a faster throughput.
On-Board & Additional Storage

• The amount of storage required will depend upon the following:
  • The number of days required to keep video
  • The number of cameras
  • The frames per second per camera
  • The resolution per camera
  • The codec being used, per camera

• The storage requirement must be calculated by the Network Video Recorder Calculator.
On-Board & Additional Storage

- Example of a 30 camera system, using on-board storage, with cameras at various frame rates and codecs
Network Bandwidth

- The capacity for transferring data over a network is measured in bits per second (bps), or some multiple thereof, such as:
  - Kilobits per second (Kbps),
  - Megabits per second (Mbps),
  - Gigabits per second (Gbps),
  - Terabits per second (Tbps).
- How much information you can send across a network and how fast you can send it is determined by the available bandwidth in the network.
Bandwidth

• The Bandwidth required per Camera will depend upon the following:
  • The resolution of the picture being streamed
  • The compression method (CODEC) being used by the camera (M-JPEG, MPEG4 or H.264)
  • The amount of “movement in the scene” (MPEG4 or H.264)
  • The frames per second being streamed.
Bandwidth – Camera Resolutions

- CIF (352x240)
- 2CIF (720x240)
- VGA (640 x 480)
- D1 (720x480)
- 720P HD (1280x720)
- 1.2M (1280x960)
- 1.3M (1280x1024)
- 1080P HD (1920x1080)
- 1.9M (1600x1200)
- 2.8M (1952x1472)
- 3.1M (2048x1536)
- 4.9M (2560x1920)
CCTV Codecs (Compress Decompress)

- Captured images can be streamed as:-
  - Motion JPEG
  - MPEG-4
  - H.264

- The available codecs depend upon the camera – not all cameras support all codecs.

- The network video recorder must support the same codec(s) as the camera.
• With the Motion JPEG format, the three images in the sequence below are coded and sent as separate unique images (I-frames) with no dependencies on each other.
MPEG-4 & H.264 Codecs

- Video compression algorithms such as MPEG-4 and H.264 use interframe prediction to reduce video data between a series of frames.
**Codec Bandwidth Comparison**

- H.264 encoder can, without compromising image quality, 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.

<table>
<thead>
<tr>
<th>Name</th>
<th>Number</th>
<th>Type</th>
<th>Format</th>
<th>Resolution</th>
<th>IPS</th>
<th>Motion %</th>
<th>Frame Size*</th>
<th>Bandwidth Per Camera</th>
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</thead>
<tbody>
<tr>
<td>New Camera</td>
<td>10</td>
<td>IP</td>
<td>JPEG</td>
<td>1.3M (1280 X 1024)</td>
<td>5</td>
<td>40</td>
<td>87.89 kB</td>
<td>3.433 Mbps</td>
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<td>New Camera</td>
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<td>IP</td>
<td>MPEG4</td>
<td>1.3M (1280 X 1024)</td>
<td>5</td>
<td>40</td>
<td>24.414 kB</td>
<td>976.523 Kbps</td>
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<td>5</td>
<td>40</td>
<td>17.578 kB</td>
<td>703.085 Kbps</td>
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<table>
<thead>
<tr>
<th>Name</th>
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<th>Type</th>
<th>Format</th>
<th>Resolution</th>
<th>IPS</th>
<th>Motion %</th>
<th>Frame Size*</th>
<th>Bandwidth Per Camera</th>
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</thead>
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<tr>
<td>New Camera</td>
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<td>24.414 kB</td>
<td>2.860 Mbps</td>
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<tr>
<td>New Camera</td>
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<td>IP</td>
<td>H.264</td>
<td>1.3M (1280 X 1024)</td>
<td>15</td>
<td>40</td>
<td>17.578 kB</td>
<td>2.059 Mbps</td>
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</table>
Comparing Codecs

Doorway scene

- H.264 (Baseline profile)
- MPEG-4 Part 2 (No motion compensation)
- MPEG-4 Part 2 (With motion compensation)
- Motion JPEG

Bit rate (kbit/s)

Time (s)
A Network in Use

• The Transmission of Data (Transmission Control Protocol – TCP/IP) – recorded delivery

• Recorded delivery effects bandwidth.
• Estimate about 40% of the capacity of the switch
Bandwidth Usage

<table>
<thead>
<tr>
<th>Name</th>
<th>Number</th>
<th>Type</th>
<th>Format</th>
<th>Resolution</th>
<th>IPS</th>
<th>Motion %</th>
<th>Frame Size*</th>
<th>Bandwidth Per Camera</th>
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<tbody>
<tr>
<td>New Camera</td>
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<td>IP</td>
<td>H.264</td>
<td>1.3M (1280 X 1024)</td>
<td>10</td>
<td>50</td>
<td>17.578 kB</td>
<td>1.373 Mbps</td>
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<td>IP</td>
<td>JPEG</td>
<td>1.3M (1280 X 1024)</td>
<td>5</td>
<td>50</td>
<td>87.89 kB</td>
<td>3.433 Mbps</td>
</tr>
<tr>
<td>New Camera</td>
<td>15</td>
<td>IP</td>
<td>MPEG4</td>
<td>1.3M (1280 X 1024)</td>
<td>15</td>
<td>50</td>
<td>24.414 kB</td>
<td>2.860 Mbps</td>
</tr>
</tbody>
</table>

**IP Camera Upload Capacity**

<table>
<thead>
<tr>
<th>Upload Bandwidth</th>
<th>Amount Used</th>
</tr>
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<tbody>
<tr>
<td>56 Kbps (Modem)</td>
<td>134974.285%</td>
</tr>
<tr>
<td>128 Kbps (DSL)</td>
<td>59051.250%</td>
</tr>
<tr>
<td>384 Kbps (DSL or Cable)</td>
<td>19683.75%</td>
</tr>
<tr>
<td>768 Kbps (DSL or Cable)</td>
<td>9841.875%</td>
</tr>
<tr>
<td>1 Mbps (U-Verse)</td>
<td>7381.406%</td>
</tr>
<tr>
<td>1.544 Mbps (T-1)</td>
<td>4780.703%</td>
</tr>
<tr>
<td>2 Mbps (FiOS)</td>
<td>3690.703%</td>
</tr>
<tr>
<td>5 Mbps (FiOS)</td>
<td>1476.281%</td>
</tr>
<tr>
<td>10 Mbps (FiOS or Switch)</td>
<td>7381.140%</td>
</tr>
<tr>
<td>100 Mbps (Switch)</td>
<td><strong>73.814%</strong></td>
</tr>
<tr>
<td>1 Gbps (Switch)</td>
<td>7.208%</td>
</tr>
</tbody>
</table>

This configuration would probably "choke" a 100Mbs network.
IP Addressing

- An IP Address is required for every camera, network video recorder, network attached storage, encoder etc., that is on the network
- This is an example of an IP address

<table>
<thead>
<tr>
<th>192.</th>
<th>168.</th>
<th>1.</th>
<th>100</th>
</tr>
</thead>
</table>

Dotted decimal Notation
IP Addressing

- Addresses can be assigned manually

**Internet Protocol (TCP/IP) Properties**

- Obtain an IP address automatically
  - Use the following IP address:
    - IP address: 192.168.39.125
    - Subnet mask: 255.255.255.0
    - Default gateway: 192.168.33.1

- Obtain DNS server address automatically
  - Use the following DNS server addresses:
    - Preferred DNS server: 192.168.39.1
    - Alternate DNS server: 

**USB Configuration v1.03**

- DHCP: OFF
- IP Address: 192.168.112.12
- Gateway: 192.168.110.1
- HTTP Port: 80
- PPPoE Enable: OFF
- Account: 
- Mode Setting: Infrastructure
- Channel: 
- Default Key: 
- Key1: 
- Key2: 
- Key3: 
- Key4: 
- ESSID: 
- WEP Key: Disable
- Password: 

**Network Properties**

- Netmask: 255.255.255.0
- DNS Server: 168.95.1.1
- Launch(L) | Apply(A) | Exit(E)
IP Addressing

- IP addresses can be assigned automatically (DHCP – Dynamic Host Communication Protocol)
IP Addressing

- DHCP simplifies the transfer of data by assigning dynamic IP addresses (temporary addresses that are created anew for each transmission) to devices on the network.

- DHCP keeps track of both dynamic and static IP addresses, saving the network administrator the trouble of manually assigning an IP address each time a new device is added to the network.
Example of IP Addressing

- NVR: 192.168.39.5
- IP Camera 192.168.39.7
- IP Camera 192.168.39.9
- IP Camera 192.168.39.22
- IP Camera 192.168.39.36
- IP Camera 192.168.39.116
- IP Camera 192.168.39.1
- IP Camera 192.168.39.3
- IP Camera 192.168.39.6
IP Addressing

• All devices need to be in the same Network address range, pertinent to the class of network

• When IP addresses are assigned manually, you will have to ask the Network Administrator for the following:
  
i) Subnet Mask
  ii) Default Gateway
### Classes of Networks

<table>
<thead>
<tr>
<th>Class</th>
<th>Network ID</th>
<th>Host ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class A</td>
<td>10</td>
<td>116</td>
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<td></td>
<td>24</td>
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<td></td>
<td></td>
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<table>
<thead>
<tr>
<th>Class B</th>
<th>Network ID</th>
<th>Host ID</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>172</td>
<td>167</td>
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<td></td>
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<tr>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
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<th>Network ID</th>
<th>Host ID</th>
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<tbody>
<tr>
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<td>192</td>
<td>168</td>
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<tr>
<td></td>
<td></td>
<td>146</td>
</tr>
<tr>
<td></td>
<td></td>
<td>99</td>
</tr>
</tbody>
</table>

- The Network ID is the network range
Using PoE

• Power over Ethernet
  - Requires a minimum of cat 5 cable
  - IEEE 802.3af-2003 PoE standard provides up to 15.4 W of DC power
  - IEEE 802.3at-2009 PoE standard, also known as PoE+ or PoE plus, provides up to 25.5 W of DC power.

• Compatible PoE Network Switches or Midspan Units are required to inject the power into the Ethernet cable.
Using PoE

- Power over Ethernet Network Switch
Using PoE

- Power over Ethernet – with Midspan
Using a Uninterrupted Power Supply (UPS)

• If required a UPS can be used to provide short term standby power for the PoE switch or Midspan

• The total standby time and power consumption will be needed in order to calculate the correct UPS needed
Dedicated IP Lighting (Raytec)

- Plugs into PoE enabled network using standard Ethernet cable
- “Command & Control” Provides photocell, photocell adjust & power adjust
Light Sensitivity and Megapixel Cameras

1.3 Mega Pixel Camera
- Aperture F1.4
- Ray Max 25

2.0 Mega Pixel Camera
- Aperture F1.4
- Ray Max 25
Sensitivity vs Resolution

- Sensitivity: Low to High
- Number of Pixels: Low to High

1.3 M pixel
1MP Infra-Red @ 25 Metres

RayMax 25

No Illumination
Darkroom Test and Bandwidth/Storage

<table>
<thead>
<tr>
<th></th>
<th>Bit-Rate (Mbps)</th>
<th>Storage (MBps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No IR</td>
<td>11.267</td>
<td>1.408</td>
</tr>
<tr>
<td>IR</td>
<td>0.424</td>
<td>0.053</td>
</tr>
<tr>
<td>Saving (%)</td>
<td>96.2</td>
<td>96.2</td>
</tr>
</tbody>
</table>

- Totally dark images result in more electrical noise
- This noise is transmitted as data back to the NVR
Panoramic Lighting

Ultra Wide 180 degree Lighting
Even spread of illumination
All possible with a single IR unit
Multiple NVR chosen for safety & replacement rather than 1 server option
Enabling Remote Viewing (WAN or WWW)

- Port Forwarding

<table>
<thead>
<tr>
<th>Index</th>
<th>Service Name</th>
<th>Protocol</th>
<th>Public Port</th>
<th>Private IP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Emule</td>
<td></td>
<td>4662</td>
<td>192.168.39.5</td>
</tr>
<tr>
<td>2</td>
<td>Emule</td>
<td></td>
<td>4672</td>
<td>192.168.39.5</td>
</tr>
<tr>
<td>3</td>
<td>NVR</td>
<td>TCP</td>
<td>1099</td>
<td>192.168.39.123</td>
</tr>
<tr>
<td>4</td>
<td>NVR</td>
<td>TCP</td>
<td>7</td>
<td>192.168.39.123</td>
</tr>
<tr>
<td>5</td>
<td>NVR</td>
<td>TCP</td>
<td>443</td>
<td>192.168.39.123</td>
</tr>
<tr>
<td>6</td>
<td>Axis</td>
<td>TCP</td>
<td>1036</td>
<td>192.168.39.4</td>
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<tr>
<td>7</td>
<td>EntraPass</td>
<td>TCP</td>
<td>1986</td>
<td>192.168.39.5</td>
</tr>
<tr>
<td>8</td>
<td>NVR</td>
<td>UDP</td>
<td>1099</td>
<td>192.168.39.123</td>
</tr>
<tr>
<td>9</td>
<td>Sony</td>
<td></td>
<td>1066</td>
<td>192.168.39.198</td>
</tr>
<tr>
<td>10</td>
<td>NVR</td>
<td>TCP</td>
<td>80</td>
<td>192.168.39.123</td>
</tr>
</tbody>
</table>

- The ports that need forwarding will be different on each make of NVR
OCTV System (open circuit)

- Minidome Cameras (IP)
- PTZ Cameras (IP)
- Network Switch
- Business PC
- Business PC
- Business PC
- Network Video Recorder
OCTV System (open circuit)

• For
  • Cost saving - No requirement for a dedicated network switch for the cameras

• Against
  • Security – Easy to access the cameras
  • Interruption to the business – Bandwidth issues
  • Maintenance – Harder to fault find
CCTV System (closed circuit)
CCTV System (closed circuit)

• For
  • Better security- Not easy to access the camera network
  • Dedicated camera network - No impact on the operation of the business
  • Easier to diagnose video issues – no impact from the business network devices on the camera network

• Against
  • Cost – Dedicated network switch(es) required
Use of a Virtual Local Area Network (VLAN)
Use of a Virtual Local Area Network (VLAN)

• Using a “managed” Switch

  • Partition the ports (RJ45 connections) to create separate networks, on the same switch
  • Can “load balance” between VLAN’s (switch dependant)
  • Bandwidth is NOT increased, it is still the capacity of the switch.
Summary

- Basic Components of an IP CCTV System
- System Architecture
- Possible Additional Components of a System
- Bandwidth
- Compression Methods
- Transmitting Data
- IP Addressing
- Using Power over Ethernet
- Remote Viewing
- Closed Circuit v Open Circuit