Aventura Technologies
The World's Leading Manufacturer of Next Generation Video Surveillance Solutions
1-877-707-9600
Experience The Power of H.264
High Definition Quality Video
Volume 1, issue 2 February 2009

Analog vs. IP Cameras

by Jack Cabasso

The CCTV industry is all abuzz with talk of an IP ("Internet Protocol") camera takeover. Yet reports of the death of analog cameras are premature. While some IP or 'network' cameras can potentially deliver high definition megapixel images, analog CCTV cameras continue to offer greater efficiency, lower cost and higher overall reliability.

Knowledge You Need

Before deciding on IP cameras versus analog, it is advisable to first understand how the technologies work. The differences in both camera technologies and method of video transmission are critical to developing a well planned CCTV solution. It should be noted as manufacturers of both IP and analog cameras, DVRs and NVRs, I have no bias. While the opinions may not be "popular" they are just a statement of facts. It is not a matter of either or, rather use each camera appropriately as needed. They both have their place.

How a CCTV Camera Works

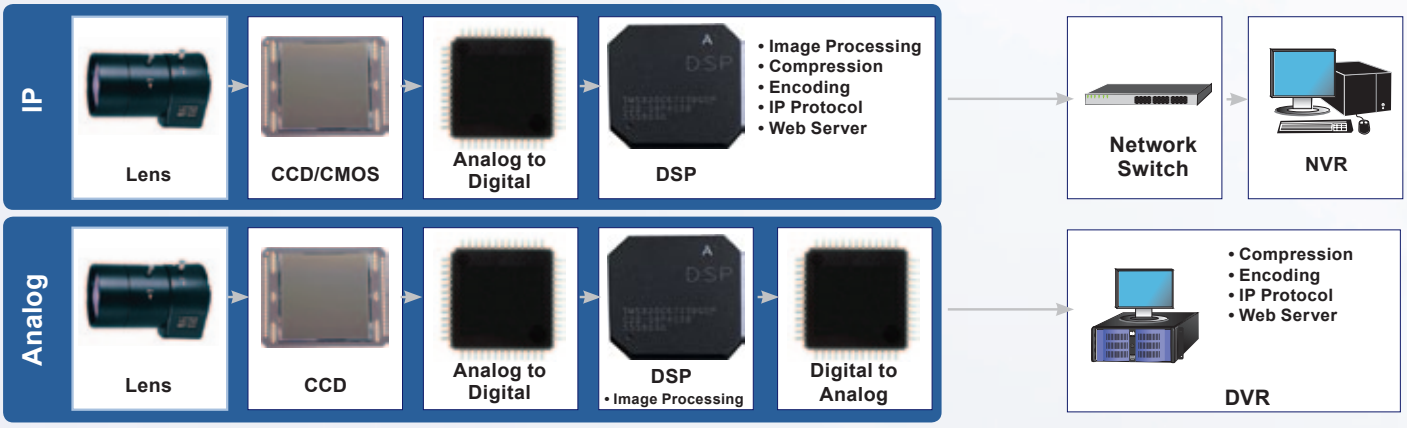
At first, IP and analog cameras may seem more alike than they are different.

Both cameras employ an analog image sensor, which is either CCD (charge coupled device) or CMOS (complementary metal oxide semiconductor). Virtually, all analog cameras use a CCD sensor and IP cameras can utilize either type. The analog signal from the sensor is then converted to digital form by an analog-to-digital converter and further processed by the camera's onboard digital circuitry (DSP).

For an IP camera the image is then compressed internally (encoded) and transmitted via an IP protocol (Ethernet) and is either stored in the camera or on a network video recorder (NVR).

For an analog camera, the image is then converted back to analog by a digital-to-analog converter so the image can be transmitted to a video monitor or a digital video recorder (DVR), where the image is encoded and stored.

At this point, it seems the difference between the two types of cameras is negligible. Primarily, the difference is where the video is compressed and what components it utilizes. There are, however, significant qualitative differences between CMOS and CCD sensors, with CCD holding a demonstrable advantage in image quality over CMOS.



180 Adams Avenue, Hauppauge, NY 11788 | Phone: (631) 300-4000 | Fax: (631) 434-7000 | www.aventuratechnologies.com

How Camera Sensors Work

CCD image sensors contain hundreds of thousands (or millions, in the case of megapixel cameras) of individual picture elements, called pixels. Each pixel contains a light sensitive element and one capacitor. The capacitor stores a charge that is proportional to the amount of light incident on the pixel's surface, which is then transferred to a circuit that converts the charge to a voltage and digitizes it.

A CMOS sensor is constructed from a similar array of pixels, but does not use a capacitor to store the charge for each pixel. The rows of pixels are activated sequentially, and the amount of light incident on the pixel's surface is converted to a voltage and read directly, at the time of exposure.

Of particular concern for video surveillance is picture quality across a broad spectrum of lighting conditions. In this aspect, CMOS has some significant weaknesses compared to CCD, as CMOS technology tends to have inferior low light ability, does not compensate well in strong back-lighting conditions and is prone to excessive noise and shadows in low light conditions.

To deal with these problems, a newer technology, called 'Wide Dynamic Range' (WDR), has evolved and shows great promise. A WDR camera scans the same frame twice, once by a slow sensor, and then again by a high speed sensor. The two frames are then processed, pixel by pixel, and result in a single frame output. WDR technology compensates for bright background and low light conditions, producing clear, low noise images with good contrast.

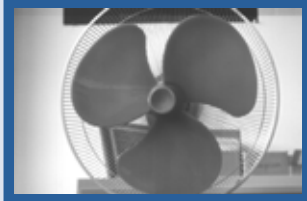
To date, WDR technology has not been applied to any IP high definition megapixel cameras.

Another area of concern to video surveillance applications are video distortions known as motion artifacts. Again, CCD performs better than CMOS in high motion conditions due to the different type of shuttering used.

Shuttering refers to the manner in which a video camera presents light to the sensor. A CCD sensor uses a "global shutter", which means that the entire sensor is enabled at once, taking a snapshot of the entire frame. Each pixel's output is stored in its capacitor and is read by the circuitry prior to taking a snapshot of the next frame.

A CMOS sensor uses a "rolling shutter". Due to the lack of charge storage in a CMOS sensor, the information from each pixel is read sequentially in small strips of pixels, starting from the top and moving down to the bottom of the array exposing only a portion of the array at a time, hence the name, "rolling shutter".

Rolling Shutter (CMOS)



Frame (global) Shutter (CCD)

Because a CMOS sensor reads different portions of a frame at different times, motion within the frame while it is being captured creates such artifacts as skew, wobble, and in some cases, partial exposure.

You may ask, what does all of this have to do with IP cameras vs. analog cameras? The point is that the two types of cameras are more similar in image capture technology than they are different. However, when it comes to the method of video transmission the differences are significant.

What is an IP Camera?

What is commonly known as an IP camera, is a camera that digitizes and processes analog images, encodes them internally, and then transmits the video information digitally over an Ethernet connection to a computer or similar device. An IP camera can have either a CMOS or a CCD sensor, and is available in the same styles as traditional surveillance cameras such as Pan/Tilt/Zoom, domes, bullets, box, infrared, covert, and wireless.

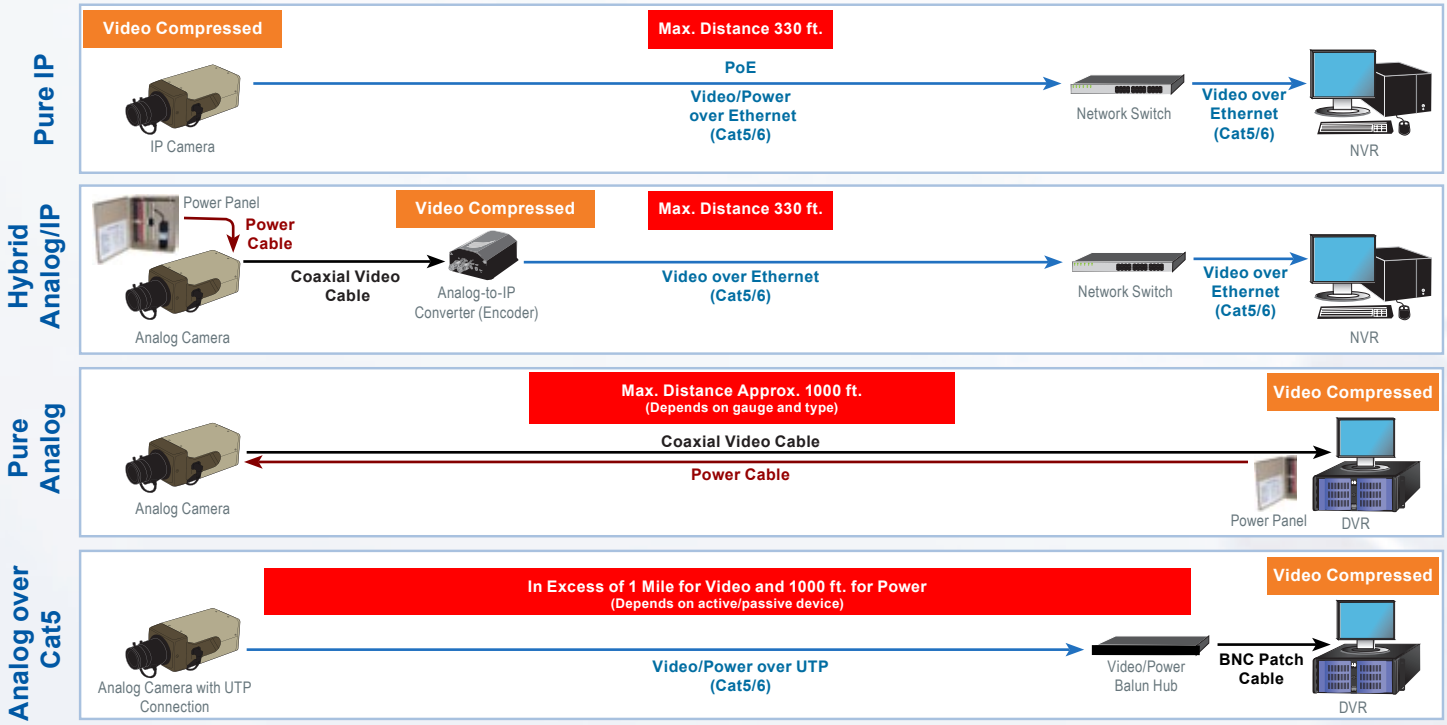
IP cameras are typically equipped with an embedded web server and can be accessed and controlled over any IP network such as a WAN, LAN, Intranet, or Internet. By utilizing a standard web browser or client software users can view an IP camera's video output from any local or remote location. IP cameras combine the capabilities of a camera with some PC functionality, do not require a direct connection to a PC to operate, and can be placed anywhere within a network. Just like any other PC on the network, an IP camera is a "network appliance".It has its own IP address, connects directly to a wired or wireless network and requires maintenance.

What is an Analog Camera?

An analog surveillance camera begins with a CCD sensor and then digitizes the image for processing. But before it can transmit the video, it needs to convert it back to analog so it can be received by an analog device, such as a video monitor or recorder. Unlike IP cameras, analog have no built-in web servers or encoders and require no technical maintenance. These functions are implemented in the recording and/or control equipment.

What is the Difference Between an Analog and an IP Camera?

The principle difference between analog and IP cameras is the method by which the video signal is transmitted and, ultimately, where the video is compressed, or 'encoded'.



180 Adams Avenue, Hauppauge, NY 11788 | Phone: (631) 300-4000 | Fax: (631) 434-7000 | www.aventuratechnologies.com

Which is Better? An IP Camera or an Analog Camera?

Video Quality

IP

IP cameras excel in capturing high definition, megapixel images but have trouble with low lighting conditions.

Dropped frames and video artifacts are commonly seen in IP CMOS cameras.

IP cameras are limited in encoding resources. As a result choices have to be made with respect to codec, frame rates and quality where the selection of one decreases quality of another.

Since the video is being compressed before monitoring, you can never have the highest quality or real time images. Encoding at the camera introduces latency, which becomes an issue when an operator needs to track something with a PTZ controller and overcorrects.

Analog

Analog CCD cameras perform well across a variety of lighting conditions and manage motion well.

Analog cameras do not have capabilities above the NTSC/PAL standards.

As analog compresses the video in the DVR there are more hardware and software resources available to provide increased video quality and frame rate.

Analog cameras transmit the video image to the DVR uncompressed where it can be viewed live with no latency pre-compression.

Cabling Infrastructure

IP

One perceived advantage of IP cameras is the ability to use an existing network wiring infrastructure to support a surveillance system. Network wiring by standard follows TIA/EIA-568-B guidelines, which limits the total distance from switch to camera to 330 feet.

Structured cable in the IP camera architecture is capable of transmitting power (PoE), video and data.

Analog

Legacy cabling for analog cameras utilized coaxial cables, which are cumbersome. Today, integrators can use 'baluns' to transmit analog video, power and data over a network wiring infrastructure beyond TIA/EIA limitations. Using baluns, analog video can be transmitted well over a mile and power over 1,000 feet. Using active baluns video can be extended well over a mile on standard Cat5 cabling.

NOTE: One further concern is the PoE standard limits power to 12.9 watts. As such, it is insufficient for many infra-red and outdoor cameras requiring a heater and/or blower. Even when the new PoE+ standard eventually becomes ratified, it caps out at 25 watts, far below the 70+ watts required to power and operate outdoor PTZ. Accordingly, you still need to run additional cabling for power. There are technologies on the horizon beyond PoE+ offered by companies such as Aventura Technologies, which can take power out beyond 100W, but they are not IEEE compliant at this time.

180 Adams Avenue, Hauppauge, NY 11788 | Phone: (631) 300-4000 | Fax: (631) 434-7000 | www.aventuratechnologies.com

Video Transmission

IP

IP traffic, like Voice-Over-Internet (VoIP), is subject to a myriad of potential faults, such as: bandwidth limitations, network congestion, varying bit rates, large file sizes, load balancing, viruses and latency. If the network fails, even momentarily, the recorded or monitored video will cease or degrade.

Analog

Analog video traffic is not subject to any networking issues or risks. The bandwidth is virtually unlimited. It is a passive connection, similar to an analog telephone connection, and cannot be interfered with due to problems external to the video surveillance system.

Fault Tolerance and Reliability

IP

While some IP cameras can store limited amounts of video internally, network failure will result in losing all live viewing and the recorded server video. Attempts to limit exposure to network faults by use of complex Layer 3 switches, redundant networks, etc., increases costs and management significantly. Networks can also become infected with viruses or other malware, with catastrophic results.

IP cameras are network appliances and as they are devices requiring management are less reliable.

Analog

Analog devices are limited to failures of the individual cameras or the individual devices at the point of concentration and as such the loss of a single piece of hardware will not cause a substantial degradation of the system. The video transmission is typically a “passive” connection, and once installed, requires virtually no maintenance.

Analog cameras are very mature and have a long track record for reliability.

Security

IP

IP video streams can be encrypted and are difficult to intercept. On the other hand, the network itself is subject to viruses and other types of attacks. Since each camera (and there could be 1000’s of them in a single system) and the devices which it communicates with are network appliances, they are all subject to attack from hackers from anywhere in the world.

Analog

Analog signals are less secure and can be intercepted and/or viewed by anyone with access to the cabling infrastructure. With the possible exception of the DVR, the entire video surveillance chain is immune to viruses and other types of software attacks. In order to access, or interfere with, any part of the video system other than the recording devices attached to the network, a hacker or intruder would have to physically access the specific device being tampered with.

Maintenance

IP

An IP camera is a network appliance and requires continuous “skilled” management. Estimates for the cost of maintaining a network appliance (one IP address) range from $100 to $400 per year.

Analog

Analog cameras are unmanaged devices. No IP address to manage, no worries about programming, software, IT skills, etc. It either works or it doesn’t. Once installed, they require no “skilled” maintenance, if any.

Wireless

IP

One of the clear advantages of IP cameras is the flexibility to integrate with a wireless network. Whereas wireless IP is “virtually” unlimited in terms of expansion, bandwidth and the topology is still a concern.

Analog

Analog cameras which use radio frequencies to transmit video wirelessly are limited to about a dozen cameras before it reaches capacity in the unlicensed spectrum.

Installation

IP

IP cameras require some basic networking skills for small installations and significantly more technical skill for an enterprise size installation.

Analog

Analog cameras require little to no network and configuration knowledge; just power, point, and focus, regardless of scope and size of overall system.

Compatibility

IP

IP cameras require a network video recorder (NVR) or browser that will communicate with each particular model of camera, which is proprietary and unique. Each time you add an IP camera, you have to make sure that the NVR supports that particular model. An NVR may also support only a limited number of cameras from a particular manufacturer. Many IP camera producers have a large variety of communication protocols.

Analog

Any analog camera can plug into any DVR. There are no compatibility issues when changing either the DVR or any of the cameras.

As a note, many DVRs today are hybrids wherein they have seamless communication and management with both IP and analog cameras on a common software interface.

180 Adams Avenue, Hauppauge, NY 11788 | Phone: (631) 300-4000 | Fax: (631) 434-7000 | www.aventuratechnologies.com

Obsolescence

IP

While IP cameras have been around for more than a decade, they still only represent 15% of the overall CCTV camera market.

IP cameras are technologically immature and have a long way to go. Today's models will be quickly replaced by higher quality, more efficient, feature-rich, less expensive and more reliable products.

Analog

Analog cameras are stable and mature and have a well defined history and roadmap and purpose.

Analog cameras will continue to make more sense in most applications as indicated by its continued market share dominance.

Scalability

IP

One of the advantages of IP is its ability to simply add on cameras by plugging into any network connection.

When scaling an IP camera system to an enterprise level there is a requirement for substantial managed networking equipment and significant bandwidth.

Analog

Analog cameras can be virtually expanded as there is no requirement for bandwidth or data transmission between the cameras and the recorders.

Since analog cameras do not require bandwidth they can exponentially scale with minimal network concerns as they are plugged directly into the DVR bypassing network transmission.

Cost

IP

IP cameras can be 3x more expensive than their analog equivalents. Additionally, there are per camera licensing costs for connecting them to the NVR.

In some instances, IP megapixel cameras can be more cost effective by taking the place of several analog cameras in a large open space where there are no "choke" points.

Large installations require managed network switching equipment and peripherals, which can become very costly.

Analog

Analog cameras and peripheral equipment are significantly lower in price to their IP counterparts.

Analog cameras require little to none in the way of peripheral and managed equipment, which reduce costs, especially in the enterprise.

For most typical applications, when accounting for hardware, software and installation analog is a better value proposition.

Note: While cost of ownership is more expensive for IP cameras they do have their place and should not solely be judged on price alone. Accordingly, it should not be a matter of IP vs. Analog. Utilization of the proper combination of the two as required to accomplish the customer's security objective at the most favorable price in conjunction with ongoing maintenance should be the determining factor.

Summary

Analog continues to dominate the security market representing 80% to 90% of the market (depending upon whose numbers you subscribe to.) More importantly, these figures do not take into account the significance of tens of millions of analog cameras, DVRs and the legacy infrastructure currently in service. Customers with substantial investments in analog infrastructure are interested in getting a longer useful life out of their current systems, especially in these trying economic times.

By comparison, IP based CCTV solutions are more costly than analog systems of comparable quality, more complex to install and require extensive supplementary management.

The issue we see is, for decades analog video systems, as well as access control and alarm systems were installed and you forgot them; little "technical" maintenance was required. The customer was not interested in hiring expensive professional staff to maintain esoteric systems.

Where the incentive for change to IP cameras is greatest is in applications that are not supported well by analog such as megapixel recording, analytics on the edge and large scale wireless transmission. Of the IP cameras sold, high megapixel cameras represent a fraction of 1% of the overall market.

From a "future-proofing" perspective, hybrid DVRs, which accommodate both analog and IP cameras, offer expandability without limitation to transmission method.

In regards to cabling and installation, the use of "permanent horizontal" cabling makes the most sense. More importantly, with power and video over UTP it does not really matter what type of camera or recorder is on either end of the Category cable.

IP camera technology is relatively new and underdeveloped. In time, improvements to image processing, encoding and networking technology will prevail over the cost and reliability advantages of analog CCTV cameras - but not for many years, perhaps. At the same time analog technology does not remain idle and continues to progress.

In transition, a move towards more open and uniform standards will benefit consumers who now face both backwards and forwards compatibility challenges from a marketplace crowded with a myriad of incompatible products and formats.

Today, you have to worry about which IP camera or encoder, works with which NVR and DVR. Then you have to consider will the next generation of IP cameras or encoders work with the NVRs and DVRs, in which you have already made a significant investment.

Ideally, end users should be able to connect any IP or analog camera into any DVR or NVR without complication, interoperability concerns or obsolescence fears. Thus, we are a big proponent of open standards, which seem to have evaded the CCTV industry.

In the interim, high definition and enterprise wireless applications are the IP camera's strengths. For most other CCTV applications, analog cameras are ubiquitous, more practical, reliable, easy to operate and install and are cost effective.

Aventura Technologies, Inc. *is a global industry leading New York based developer, manufacturer and solution provider of cutting-edge intelligent fixed and mobile real-time Digital and Network Video Recorders, using the latest H.264SVC Open Standard Profile technology, solutions for business, government and enterprise. Aventura manufactures a suite of products, consisting of: DVRs, NVRs, IP and Analog cameras, fiber transmitter and receivers, video transmission and network equipment, digital signage, and custom IPTV and CCTV solutions. Aventura offers the world's only one-stop-shop, end-to-end security and communications solutions across multiple platforms and interoperates with third-party hardware and software systems. In addition to an extensive line of off-the-shelf product offerings, Aventura custom designs, architects and engineers hardware and software to customer specifications.*

180 Adams Avenue, Hauppauge, NY 11788 | Phone: (631) 300-4000 | Fax: (631) 434-7000 | www.aventuratechnologies.com