SURVEILLANCE & HIGH DEFINITION IP CAMERAS

This exclusive report looks at the impact high definition IP cameras will have on network bandwidth and runs full performance tests on switches from Allied Telesis, Cisco and Hewlett Packard.

binary testing

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UK residents are living in a surveillance society and are now the most watched people in the world. Nowhere else are there more surveillance cameras per capita than in the UK with some estimates putting the total as high as 4.2 million cameras in the British Isles – about one for every fourteen people.

CCTV cameras may be a ubiquitous feature on most of Britain's streets but their value as an aid to crime prevention has been the topic of many debates which frequently centre on inadequate image quality. Research carried out by the Government as far back as 2006 concluded that 80% of CCTV cameras don't provide clear enough evidence for prosecutions because of their poor image quality.

There is now a concerted move by many businesses to replace outdated CCTV equipment with the latest IP cameras. The move from analogue to digital has clearly defined benefits with vastly superior image quality a key factor.

IP camera technology has come on in leaps and bounds over the past few years with the latest products offering multi-megapixel resolutions, HD (high definition) video, integrated audio functions and much more. Despite higher acquisition costs, businesses are seeing immediate benefits with IP camera deployments and the move away from CCTV systems is expected to gather momentum.

There are, however, major concerns expressed by many businesses about the use of IP cameras and their impact on their computer networks and switching equipment. There is a perception that IP cameras require an excessive amount of network bandwidth to operate effectively and large deployments will be detrimental to general business IT operations.

This report looks at the impact the latest high definition IP cameras have on Ethernet networks. It runs a series of performance tests using multiple HD IP camera streams to determine the amount of bandwidth required.

Image compression techniques used by IP cameras have progressed significantly with most now supporting H.264. Tests will be run to see what benefits in reduced network bandwidth usage this has over the older M-JPEG compression method.

The latest IP cameras also support the Power over Ethernet (PoE) standard so can be powered directly over their network cable when connected to a compliant network switch. However, the majority of affordable PoE switches are designed primarily for handling wireless network deployments and so only support Fast Ethernet speeds.

This report will run all performance tests on 24-port Fast Ethernet PoE switches from Allied Telesis, Cisco and Hewlett Packard to see if they are capable of handling large numbers of HD IP cameras. Latency is also a key focus of the performance tests.

This is the time taken for a data packet to get from one point on the network to another and excessive delays will affect the quality of video transmissions. Using the latest Riverbed Cascade Shark network analysis products, the performance tests have also been designed to measure latency across the test network to determine whether the switches are adversely affecting the video streams from the cameras.

Executive Summary

Surveillance is invariably associated with CCTV cameras as there are so many of them in the UK. However, despite their prevalence, they are gradually being replaced by IP cameras which offer far more sophisticated features.

The latest IP cameras, such as the Axis Q1755 used in these tests, are even more appealing as they offer high definition (HD) video which provides far superior image quality than CCTV cameras. However, there are major concerns expressed by many businesses about the demands of these new cameras and whether today's networks can support HD video.

This report provides a briefing on the main differences between CCTV and IP cameras and examines the M-JPEG and H.264 compression techniques used by the latter to reduce network traffic.

Performance tests using multiple HD IP camera feeds show the different network requirements for M-JPEG and H.264 video streams. The tests have been conducted using four Power Over Ethernet (PoE) switches from Allied Telesis, Cisco and Hewlett Packard to determine whether these devices can cope with HD video.

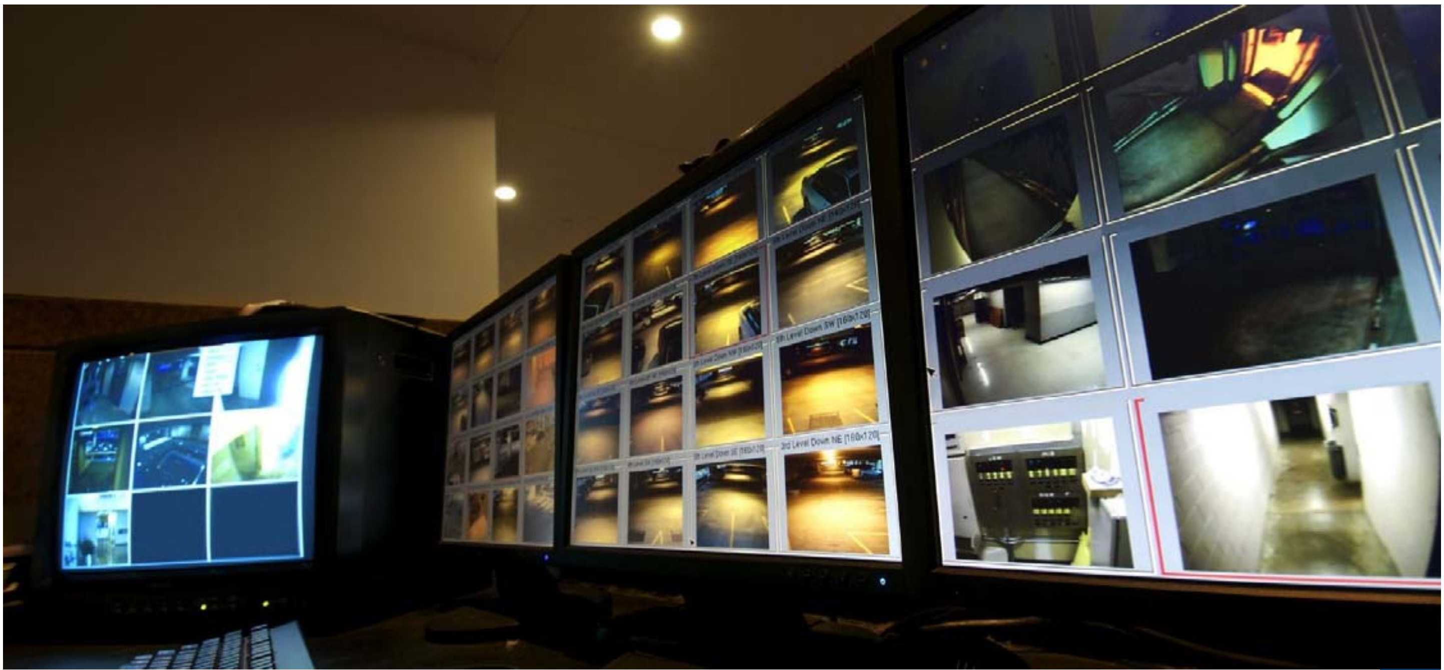
This report finds that H.264 requires significantly less network bandwidth than M-JPEG. The industry estimate is that H.264 uses less than one-fifth the bandwidth of M-JPEG which our performance tests have confirmed. Using H.264 will also result in a reduced need for capacity when recording HD video to hard disk or other storage devices.

The four switches tested were shown to be quite capable of handling HD video feeds across all Fast Ethernet ports with very little variation in performance across them. As performance is not an issue it is recommended that businesses look closely at the features offered by switches as these are an important consideration.

As the switch will be powering attached devices redundancy is essential. Only the AT-8100S/24POE+ switch from Allied Telesis has dual redundant power supplies integrated into its chassis. This avoids the need to purchase additional equipment so reducing costs further.

The new 802.3at PoE standard caters for the next generation of compliant products but these require up to 30W of power from the switch. Only the AT-8100S/24POE+ supports this and can supply up to sixteen of these new devices with up to 30W on each port.

This report shows that the new Allied Telesis AT-8100 switch is as fast as products from Cisco and Hewlett Packard when handling HD video network traffic. Along with a comparatively low price, it scores very well on features as its integrated redundant power supplies, stacking capabilities and support for the new high-power PoE standard make it a good, long term investment for HD IP camera deployments.



CCTV and IP cameras–what are the differences?

Typical CCTV camera

It is a common misconception, even within the industry itself, to refer to both analogue and digital cameras as CCTV (closed circuit television) systems as they are completely different. In this section we take a look at both technologies and clarify the main differences.

A CCTV camera sends analogue video signals directly to a destination such as a television or a bank of monitors. It may also be connected to a VCR or similar analogue device for recording purposes.

CCTV camera installations are not networked and use co-axial cable and BNC connectors to link all the components together. This type of cable is cheap but drawbacks are that as the connection distances increase there is likely to be signal quality degradation and co-axial cable is not suited to carrying signals for the newer higher resolution analogue cameras.

The fundamental difference between TV and CCTV is the former is openly broadcast to the public at large so the signal can be received by an aerial whereas the latter, as the name implies, is only transmitted across a closed system. However, despite being a closed circuit, security is minimal as the video images cannot be encrypted plus with the right equipment and access to the physical cables, the images being sent over them can be 'sniffed'.

The main benefit of CCTV systems is their price as they cost significantly less than IP cameras. There are many drawbacks, though, with poor image quality the primary reason for them to be gradually falling from favour.

IP cameras are far more sophisticated and contain their own computer and operating system (OS) software. They convert the analogue signal from the camera to digital and transmit it over IP (Internet Protocol).

The camera has an Ethernet port and is connected over standard network cabling. Its OS runs a web server allowing the video stream to be viewed using a standard browser running on any PC from anywhere with a network or even an Internet connection.

IP cameras offer many more features than CCTV as image compression using M-JPEG, MPEG4 or H.264 codecs is carried out internally and as the signal is digital it can be recorded directly to hard disk. Those that support PoE can be powered directly over their network cable when connected to a compliant Ethernet switch.

Security is much tighter as IP cameras can encrypt video over HTTPS making it extremely difficult to intercept the signal. IP cameras can be wired or wirelessly connected and those with built in motors provide PTZ (pan, tilt, zoom) functions that can be controlled directly from the browser interface.

The Q1755 high definition IP camera from Axis Communications

M-JPEG or H.264 – which is best?

The two most common compression standards used by the latest IP cameras are M-JPEG (Motion JPEG) and H.264. The two compression techniques are very different as M-JPEG takes each frame in a video stream and compresses it as a JPEG image. A video stream using M-JPEG is simply a series of individually compressed images.

The main advantage of M-JPEG is that processing overheads at the system viewing the stream aren't excessive as it has less work to do when decompressing each image. M-JPEG also claims to provide better picture quality than H.264 although for camera surveillance applications any improvements are unlikely to be noticed.

The biggest disadvantage of M-JPEG becomes apparent when recording video. The large frame sizes make it impractical and expensive to record to hard disk arrays as space requirements are very high.

H.264 only transmits the differences between successive frames. A reference frame is used to determine movement and only these pixels are sent in successive frames.

For IP cameras the biggest benefits of H.264 are greatly reduced network bandwidth usage and lower storage requirements for recordings allowing resolution and frame rates to be increased at no extra cost. Image quality is very good but the viewing station needs to be well specified as it has to do a lot more work in decompressing H.264 frames.

The graphs show bandwidth measurements for an Axis Q1755 HD IP camera taken using Riverbed's Cascade Pilot network monitoring software. Figure 1 shows network usage for a single feed set to a 1080i resolution using M-JPEG which averages at around 27Mbits/sec regardless of whether any movement occurs.

Figure 2 shows the same camera set to 1080i and H.264. The first section of the graph shows the client's web browser starting to access the camera resulting in a bandwidth usage of less than 1Mbit/sec. Movement is then introduced showing usage peaking at 4.8Mbits/sec and then dropping back when movement ceases.

Figure 3 compares the two methods. The client web browser starts with a 1080i M-JPEG view and then switches to H.264 at the same resolution. During the H.264 session movement is introduced and then stopped showing the benefits of this compression technique.

Figure 1. M-JPEG at HD 1080i

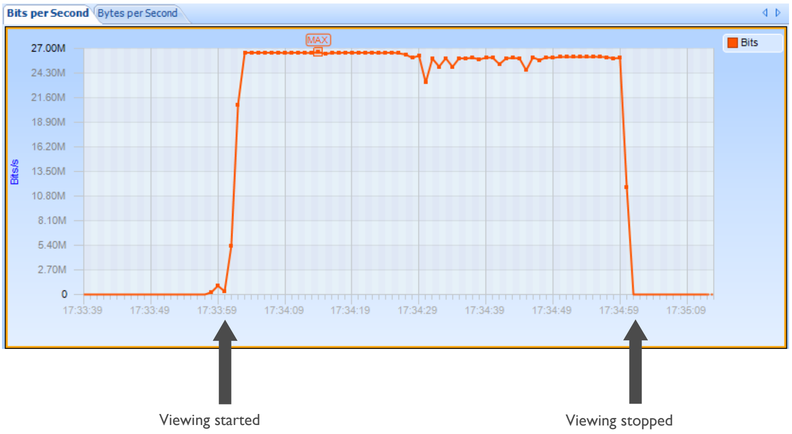


Figure 2. H.264 at HD 1080i

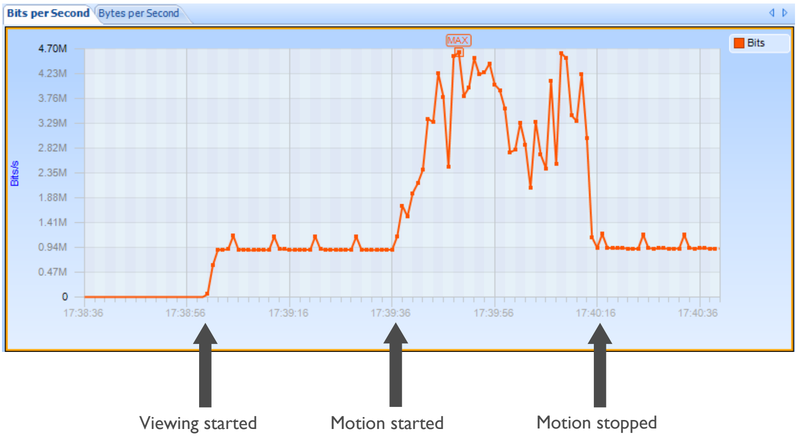
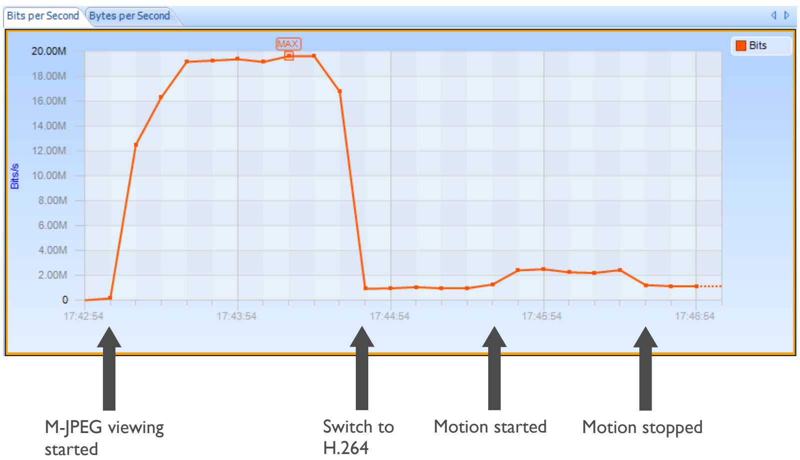


Figure 3. M-JPEG and H.264 at HD 1080i



Allied Telesis AT-8000S/24POE

The 8000S/24PoE is a low-cost managed stackable Fast Ethernet switch with PoE connectivity at the edge. It has a 1U form factor, two Gigabit Ethernet SFP combo bays and dedicated stacking interfaces. For 802.3af PoE services, it supports up to 24 Class-2 powered devices at 7.3 watts and up to 12 Class-3 powered devices at 15.4 watts. It has a throughput capacity of 9.52Mpps and a switching capacity 12.8Gbps.

Allied Telesis AT-8100S/24POE+

The AT-8100 Series of switches are the first in a line of stackable green access edge switches from Allied Telesis. The AT-8100S/24POE+ is a 24-port Fast Ethernet switch with dual fixed redundant power supplies which is a first for this class of product and specifically targets IP surveillance applications using mega-pixel IP cameras. It supports both the 802.3af and the new 802.3at PoE standards and can support up to sixteen high power devices where each requires 30W. It also has a pair of HDMI ports for stacking up to eight switches together.

Cisco Catalyst WS-C2960-24PC-L

The Catalyst C2960-24-PC-L is a basic, low-cost 24-port Fast Ethernet switch that supports 802.3af across all ports and can manage up to 24 devices where each requires a maximum of 15.4W. It does not support the new high power 802.3at PoE standard. It has two Gigabit copper and mini-GBIC slots for high-speed uplinks but is designed as a standalone device with no stacking capabilities. For power redundancy it requires Cisco's separate Redundant Power System 2300 unit.

HP ProCurve Switch 2610-24-PWR

The ProCurve 2610-24-PWR supports the lower power 802.3af PoE standard across all 24 Fast Ethernet ports. It includes two Gigabit and mini-GBIC ports for high-speed uplinks and a port at the rear for an optional external unit to provide redundancy in the event of a power supply failure. It has the same throughput and switching capacities as the Allied Telesis AT-8000S/24POE.

A key requirement for the performance tests was to see how well the SUT (switch under test) handled multiple high-definition camera feeds. A test was devised that generated up to 24 separate camera feeds with each one connected to an individual port on the SUT so that all Fast Ethernet ports were being utilized.

The camera feeds were created using the Virtual Camera software from Axis Communications. This has been designed as a camera testing tool and can create as many camera feeds as required and present each one on a separate IP address.

It can use live feeds from IP cameras and also recordings to create virtual cameras and we chose the latter feature. Video recording were made using the latest Q1755 HD IP Camera from Axis Communications.

Recordings were made in the lab for M-JPEG and H.264 video feeds and we ensured that movement in the viewing area was continuous during this process. Both were set at a resolution of 1080i (1920 x 1080 pixels) and the maximum 30 frames per second speed as supported by the Q1755.

To present the virtual camera feeds we used Dell PowerEdge 1950 and 2900 rack mount servers. The PE1950 was fitted with two quad-port Gigabit adapters which, combined with its dual embedded Gigabit ports, gave it a total of ten separate ports.

The 2900 was fitted with three quad-port Gigabit cards which gave it a total of fourteen ports. Each server was loaded with the Axis Virtual Camera software configured to present one high-definition camera feed on each physical network port. Both servers were connected to the SUT using CAT6 network cable so that all 24 Fast Ethernet ports were in use.

As previously mentioned in this report, IP cameras will only generate network traffic when they are being viewed. To produce this traffic we used the Axis Camera Station software which is a complete monitoring and recording system that can manage up to 50 IP cameras.

The Camera Station software was installed on a separate server connected directly to the SUT's Gigabit uplink port. A Camera Station client utility is used to view all the feeds from a single console and was installed on a dedicated high performance PC. As all 24 feeds would be going to the Camera Station server, using a Gigabit link ensured there was no bottleneck on this connection.

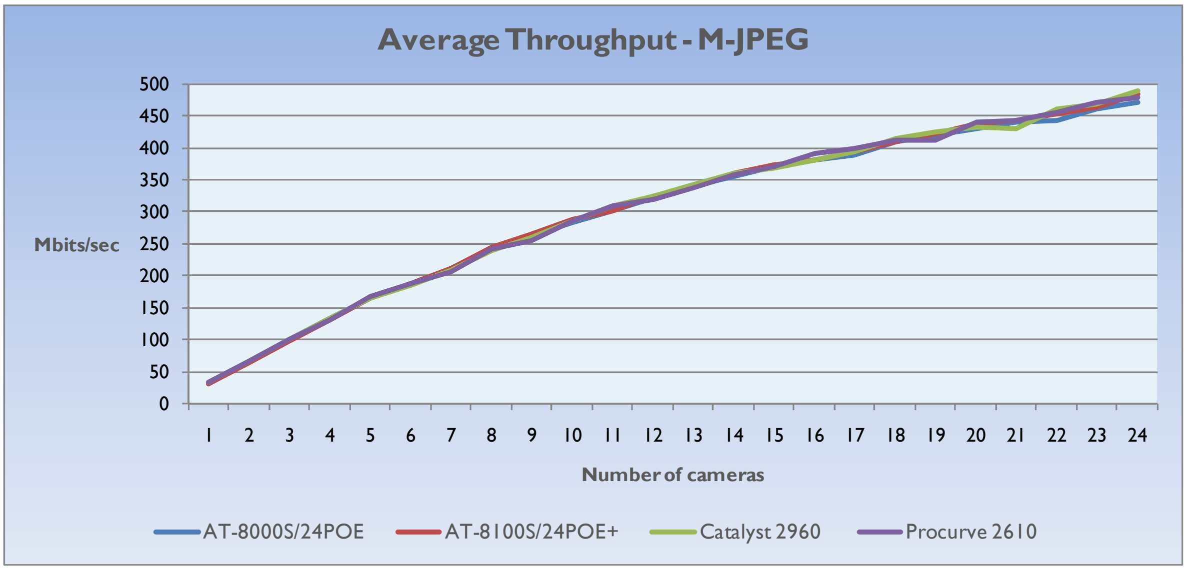
Clearly we needed a method of monitoring and measuring the traffic loads and latencies and to achieve this we used the latest Cascade Shark network analysis hardware and software from Riverbed. Our thanks go to TARCA Systems (*www.tarca.co.uk*) which supplied and configured the Cascade system in the lab.

The Shark appliance was accessed with the Cascade Pilot monitoring software which is capable of providing a wealth of information about network utilization making it an excellent troubleshooting tool. Via the Shark appliance it was able to provide throughput data on the connection to the server running the Camera Station software so we could see clearly how much traffic was being generated by the cameras.

To measure latency we used two of the Shark's monitoring ports in-line between one of the camera feeds. We placed two other ports in-line between the switch and the Camera Station server. Using the Shark's packet capture tools we could record details on a selected packet detected exiting the virtual camera port and also when it was detected by the other monitoring ports after leaving the switch.

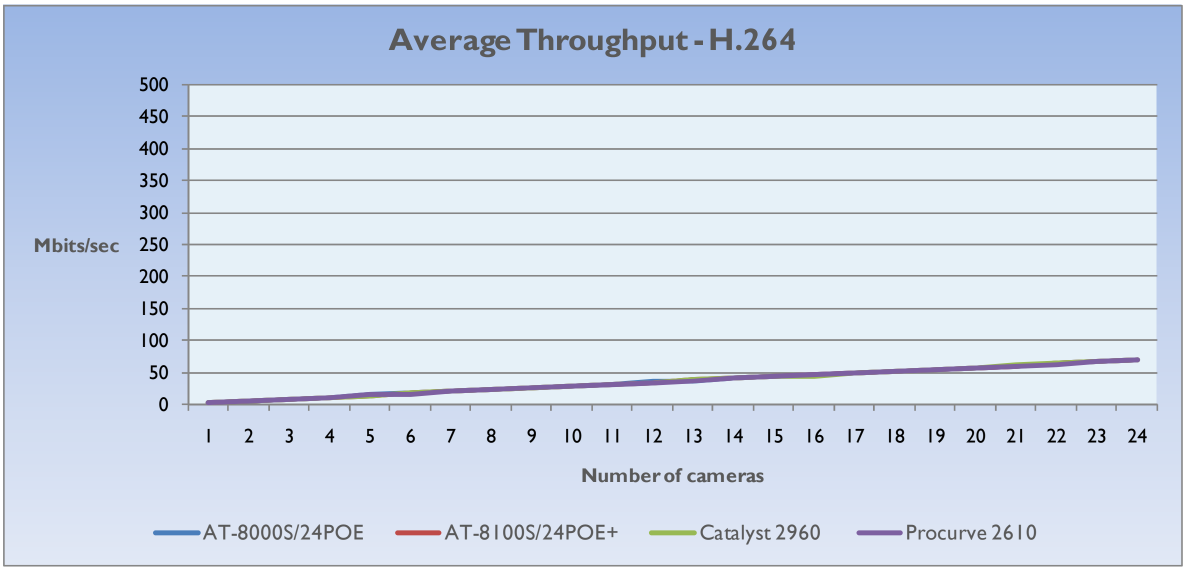
Using the Wireshark packet analysis software we could compare the timestamps for when the packet was captured leaving the client and also when it was seen leaving the switch. This allowed us to calculate the network latency for the packet.

Each test was started with one virtual camera feed and gradually ramped up one at a time to the maximum of 24 feeds with bandwidth and latency measurements taken each time. This was done for both M-JPEG and H.264 recordings and for all SUTs.



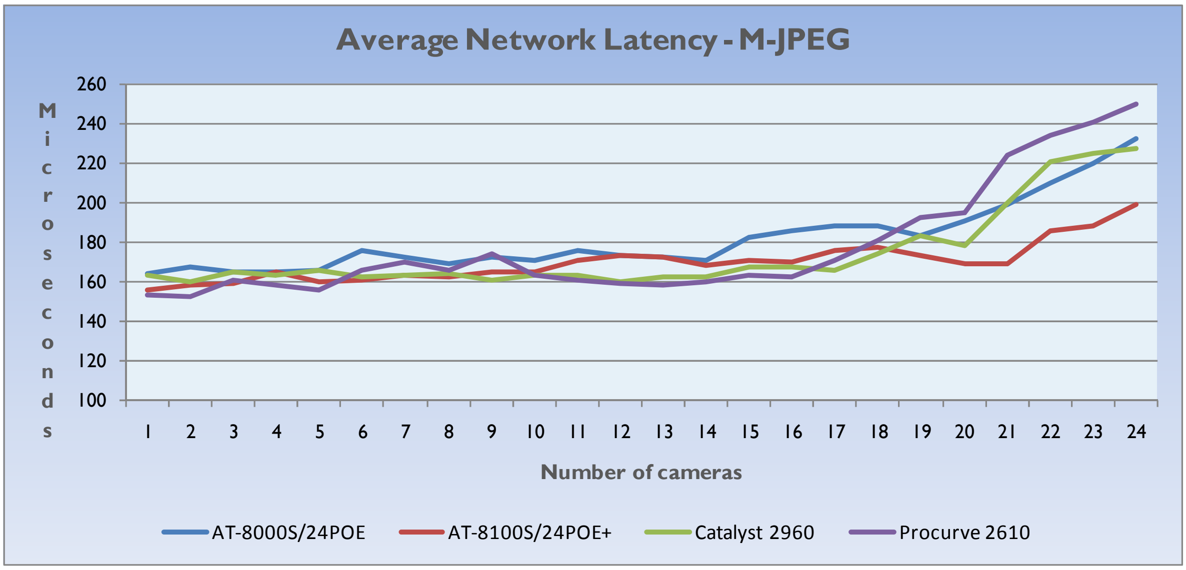
The higher demand for network bandwidth of M-JPEG video streams can be seen clearly in the above graph. Furthermore, as we increased the number of video streams we found that the system running the Axis Camera Station Network was having increased difficulty in playing each one correctly.

All four switches had no problems handling the network loads but we saw various camera feeds on the client system frequently stopping or pausing as the number of streams was increased. The load starts to rise smoothly but begins to flatten out half way through the test as the client was not replaying all feeds correctly.

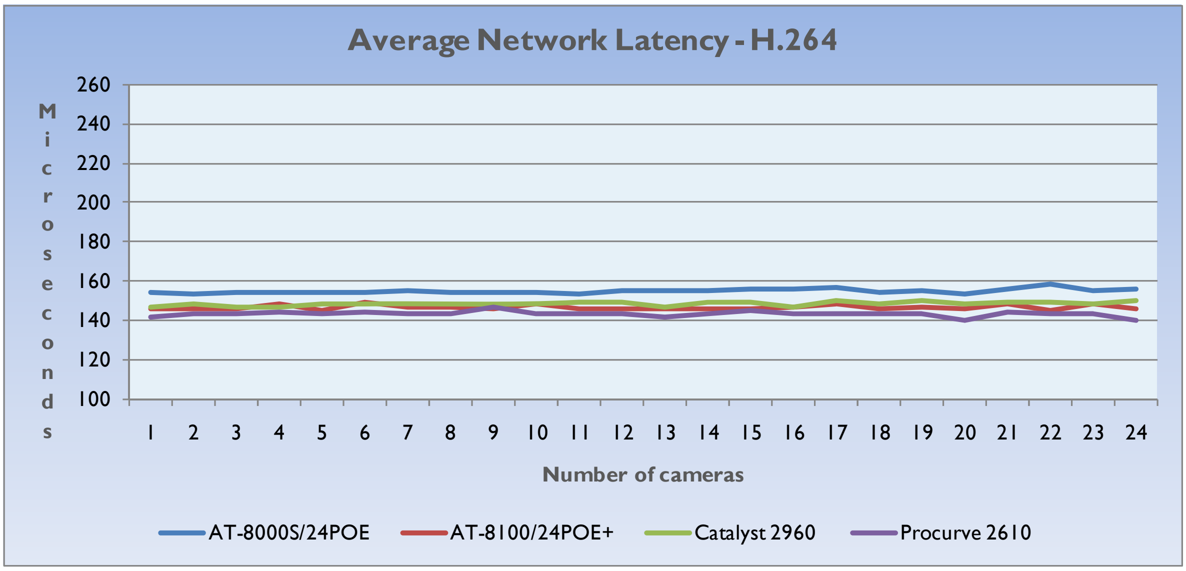


Comparing the two throughput graphs shows the dramatically reduced network requirements for the H.264 video streams. For each switch, the average throughput measured for all 24 streams was between 68Mbits/sec and 70Mbits/sec as opposed to 472Mbits/sec to 479Mbits/sec for M-JPEG.

The majority of industry estimates put the reduced bandwidth requirements for H.264 at one-fifth of M-JPEG and our performance tests confirm this.



It should be noted that these results show the time taken in microseconds (millionths of seconds) for a data packet to traverse the network and not just the switch backplane. For the M-JPEG test, network latency is slightly higher than for the H.264 feeds at the beginning but as the load increases it gradually gets worse for all switches. However, we did find that the AT-8100S/24POE+ switch consistently delivered the lowest latencies for this test.



The effects of the lower network bandwidth requirements for H.264 are also reflected in the latency tests. Unlike the M-JPEG tests where latency gradually increased, we found that the H.264 streams showed no increase in latency regardless of the number of camera feeds.

Although the differences are only a few microseconds we found the test on the ProCurve 2610 produced the lowest latency for the H.264 test with the AT-8100S/24POE+ coming a close second.

Conclusion

Despite the global recession slowing growth, there is still a concerted move away from CCTV systems to IP cameras. A recent report by IMS Research estimated that 30 per cent of surveillance cameras sold are IP and that this will increase to 50 per cent by 2014.

IP cameras have been criticized for being expensive but economies of scale in this market will undoubtedly see increased demand driving prices down so making them more affordable. The move to multi-megapixel, high definition and H.264 support are also key factors that make IP cameras far more appealing.

Detractors also claim that IP cameras require excessive network bandwidth and recording storage capacity but our test results show this isn't the case when using H.264. Industry estimates put the network requirements for H.264 at around one-fifth that of M-JPEG and we can confirm this is accurate.

Our performance tests showed that the four Fast Ethernet network switches are quite capable of handling the demands of HD IP cameras. Clearly, when choosing switches to support IP surveillance systems you need to look beyond their backplane capacity to value and the level of features on offer.

A feature appearing with increasing frequency in IP cameras is support for PoE allowing them to be powered over standard Ethernet cabling. The switches on test support the common 802.3af PoE standard and all except the Allied Telesis AT-8000S/24POE can provide up to 15.4W of power on twenty-four Fast Ethernet ports.

The 802.3at PoE standard was ratified in 2009 and high power IP cameras are already becoming available. These require 30W of power and most PoE switches don't support this as their internal power supplies are not up to these demands.

The only switch in this test that supports the new 802.3at standard is the Allied Telesis AT-8100S/24POE+. This can power sixteen devices where each requires up to 30W.

Another important consideration is power redundancy. Most PoE switches have a single, internal supply and if this fails then all the cameras will go with it. A common solution is to attach the switch to a separate redundant power supply but this increases costs further.

The Allied Telesis AT-8100S/24POE+ is the only switch on test that incorporates two internal power supplies so providing redundancy straight from the box. Furthermore, with an estimated street price of £870 it represents far better value than PoE switches with only a single supply.

Further benefits offered by the AT-8100S/24POE+ are its stacking capabilities. Up to eight switches in the new 8100 Series from Allied Telesis can be physically stacked together using high-performance HDMI cables for increased resiliency and simplified management.

There's no doubt that IP cameras are gaining in popularity as they offer so much more than outdated CCTV systems. Decreasing prices will drive this demand further and the new AT-8100S/24POE+ switch from Allied Telesis is ideally positioned to provide a cost-effective choice as a core component when deploying high definition IP camera based surveillance.

Testing conducted and report compiled by

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