

Firewire Security Imaging.

We have all seen them on the TV news, a crime committed on camera, but the analog camera resolution is so poor the police can't identify the perpetrator and are hoping some member of the public can help. The old analog cameras have their place, at least as intimidation, so the signs saying "Premises under Video Surveillance" are not a lie. But just like for audio and TV, digital is the path to better performance and more capability in security imaging. The analog to digital (A/D) conversion is done inside the camera close to the CCD/CMOS imaging sensor retaining the most quality and least noise. The image is then transmitted digitally making it highly tolerant of noisy environments. Since the A/D conversion is done in the camera it does not suffer the distortion that tens of meters of cable or the electrically noisy computer can inject to distort the analog image. All of this increases the performance of the security system.

So what are the improvements that are available when a digital surveillance system is used? It depends on the transport system and protocols. Internet Protocol (IP) video based cameras can interface directly into an existing network, but can easily saturate the available bandwidth if used at higher resolution than analog cameras. If the update rate is lowered to reduce the bandwidth requirements the video updates so slowly that important details can easily be missed. But an old technology, Firewire, is being used in a new way to solve many of these problems and reduce costs at the same time. Originally used for video peripherals, external mass storage and the like for PCs and Macs, the Institute of Electrical and Electronics Engineers standard number 1394-2008 (Apple's Firewire) implementation is now being widely implemented in industrial applications. (Note: 1394-2008 is a one document consolidation of 1394-1995, 1394a, 1394b, & their errata) The key enabling technology addition was transport across long haul cables, namely UTP5/6, coax, and fiber, up to 100m at up to 800Mbps. While this enhancement enabled large-scale security imaging, many of Firewire's other features make it the eager choice of digital security systems. This is my top ten list:

1. IEEE 1394-2008 allows individual cable runs of up to 100m. This includes use of the nominal shielded twisted pair cables (STP), unshielded twisted pair cables (UTP), coaxial cables (co-ax), Plastic Optical Fiber (POF), and Glass Optical Fiber (GOF). STP has been the standard cable since the beginning of Firewire. It is very mechanically and electrically robust with excellent transmission characteristics and resistance to electromagnetic interference. UTP is the cheapest and can be used out to 100m runs, and may already be in place to support a previous control path to an analog camera installation. But UTP is also more susceptible to electromagnetic interference in industrial or high EMI conditions (such as airport RADAR). Coax cables are a well known and well shielded medium and also may already be in place from a previous analog installation. The optical cables are the most immune from EMI/ESD issues. POF is cheaper, but has limitations on distance and data rate depending on the fiber optic transceivers selected. GOF is the premium medium, its speed allows the maximum Firewire throughput, its reach can max out Firewire timing constraints, it is EMC/ESD/EMI immune, non-sparking, and non-corrosive. There is even

- work underway in the 1394 Trade Association to standardize an existing implementation that uses Gigabit Ethernet physical layer transceivers and cables to connect two 800 Mbps Firewire nodes.
2. Firewire is able to carry real time video (1394 isochronous), control data (1394 asynchronous), and power over a single cable. Analog cameras can require a two wire cable for power (hot and ground return), another cable for analog video data (coax), and another cable for digital control data (UTP). The fewer the cables the lower the material and installation costs and the shorter the schedule.
 3. Firewire may be connected in either as a bus or as a point-to-point connection. Connecting as a daisy-chained bus allows easy additions to the network. Instead of running a new connection from a hub or router, another cable may be daisy chained from an existing node with just the incremental additional length of cable.
 4. Firewire is plug_and_play, with each node having standard information in a standard format in a standard place so every other node on the network can discover and identify a node that has been added or removed. This allows configuration by software across the cable, reducing initial installation time as well as making upgrades easy.
 5. The digitally controlled Fireweed camera can vary its resolution to fit the circumstances. A lower frame rate, lower resolution image when there is nothing moving in frame, and a higher frame rate higher resolution when motion or other condition of interest is detected in frame. Besides increasing the value of the images and therefore the performance of the security system, this allows a lower bandwidth backbone network to be utilized, saving cost.
 6. The Firewire isochronous transfer timer is each node can be used to time align frames to allow seamless panoramas to be created in real-time to fully analyze a wide area without requiring multiple screens. This enables a quick natural intuitive analysis of what is happening in the scene. It enables completely attentive, one time cost machines to increase the effectiveness of somewhat attentive, recurring cost human video monitors (us).
 7. Since the data is received in digital format it can easily be computer analyzed in real-time and computer enhanced in real-time. It is easily stored on random access hard drives, not sequential access tape drives. It is easy to machine search, machine enhance, and machine analyze the video. This accelerates and enhances the effectiveness of “post-event” analysis of imaging. It can be losslessly compressed for archive or alternatively the storage space requirement can be reduced by using a lossy compression. The system can then be upgraded by addition of larger hard drives or a software enhancement to a higher quality compression. This way the system can take advantage of the drop in cost per gigabyte of hard drive storage over time. Since the data transport is digital it also means there is no need for expensive digitizer boards to be added to the PC, just use the already built-in Firewire port, or add an inexpensive Firewire host adaptor.
 8. Firewire has built-in support in Windows, MAC OS, and Linux. Several 3rd party software houses are also available to customize drivers around the industrial camera standards created by the Instrumentation & Imaging working group of the 1394 Trade Association.

9. Firewire has Internet Engineering Task Force Standards allowing transport of IP version 6 and IP version 4 using the asynchronous and asynchronous streaming transport mechanisms of Firewire. This means IP datagrams can be transported over Firewire allowing IP communication and bridging between Ethernet carrying IP and Firewire carrying IP. Since IP utilizes the asynchronous transport, it will not interfere with any existing isochronous video being transported over Firewire.
10. The 1394 Trade Association VersaPHY specification allows, simple, no new software nodes to be created for simple isochronous cameras or low bandwidth sensors of all sorts (biometrics, biohazard, radiation, etc) to be added to the 1394 network.

While useful, the above is just a list, what does this mean in real systems? Let's answer that by looking at an existing security system that utilizes Firewire.

Pixel Velocity implements their Pixel Video Fusion™ System using a Firewire network over optical fibers or CAT 6 UTP (CATegory 6 Unshielded Twisted Pair). The Firewire network connects fixed field of view high definition 1920x1080 pixel cameras to a video recording server. The video recording server is then connected to the structure's IP network as a so called edge-of-the-network server or simply Edge server. This allows all the video streams to be isolated to the highly efficient, high bandwidth Firewire network and only selected, bandwidth controlled imaging is placed on the IP network to avoid saturating the existing Ethernet network. A software suite running on the Microsoft Windows OS on industry standard computing platforms controls and coordinates the system as well as allows intensive analysis of imagery.

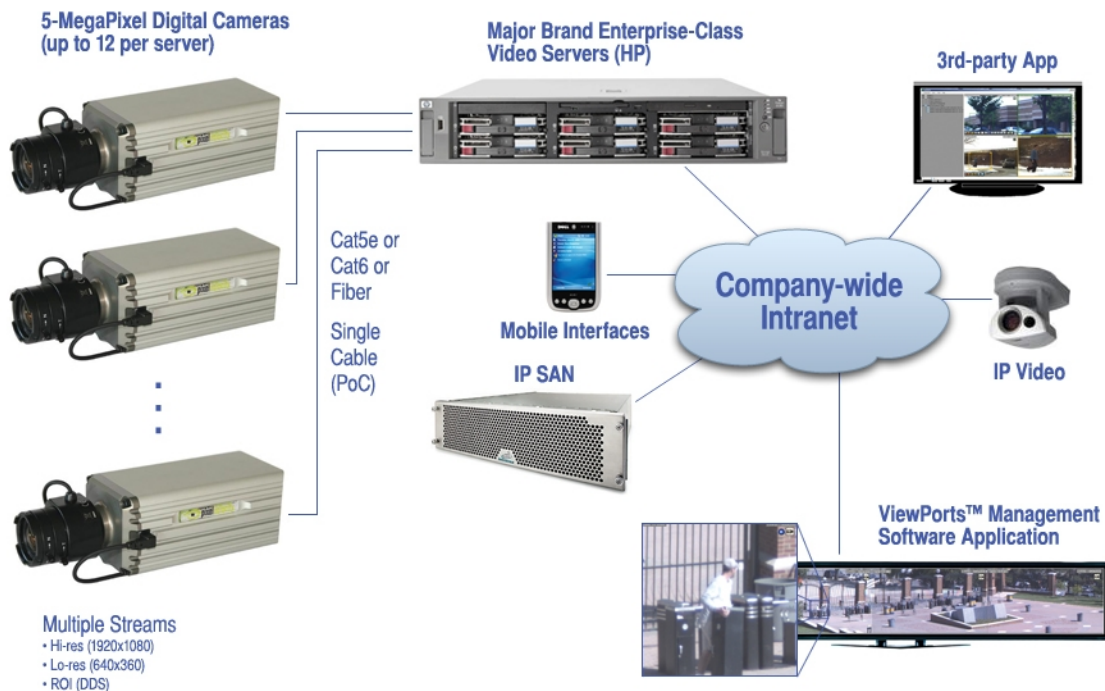


Figure 1 Pixel Video Fusion System™

The selection of the Firewire network enabled several innovations that have extended the state of the art in large area security imaging. The large bandwidth and highly efficient transport of Firewire allowed the cameras to be high enough definition that they also could be fixed field of view. The simplification to fixed field of view allows the system to be paced by the speed of computing, not the speed of mechanical pan, tilt, and zoom motors. The operators of the system can focus on what is important in scene as fast as they can select it with a pointer. The fixed field of view means the geometry of each camera is in a fixed relationship to every other camera, making creation of multiple image combination views from overlapping field of view cameras more straight forward, expanding the context of the scene to be more like how it is seen with the human eye instead of through the stovepipe of a single camera. Fewer driven mechanical moving parts means better reliability, less power consumption, and less cost. Important factors for remote cameras in hard to reach locations.

Firewire's isochronous mechanism allows a camera to source many distinct video streams at the same time. This system's cameras can source up to eight image streams at a time, with resolutions from uncompressed 1920x1080 to compressed 640x480 with the default setting to output two streams. One stream is a full resolution, motion JPEG (each individual frame is compressed independent of other frames) that is recorded on the edge server. The other is a lower resolution real-time stream suitable for monitoring by the operators. Since the highest resolution is being saved at all times, the operator does not need to worry that something will be completely missed when the real-time display is zoomed into a particular part of the image, the entire image was saved to the edge server. The other six streams per camera can be configured for particular region of interest streams in the camera field of view.

The common isochronous time-base of the Firewire network, along with the low transport latency enable all the cameras to be synchronized. This enables multiple images from individual moments in time to be retrieved easily as well as enabling real-time panoramas to be created from multiple adjacent cameras' video streams.

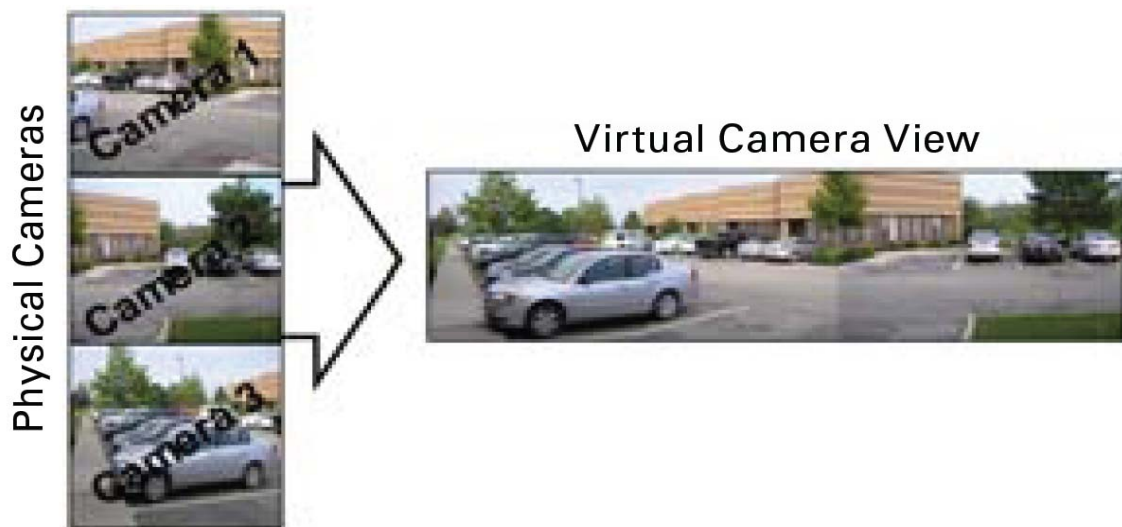


Figure 2 Three Adjacent Images to One Panorama Image

Firewire enables the cameras to be plug and play, that is they can be automatically and remotely configured by software when they are plugged into the Firewire network reducing installation time and hassle.

This capable system is working in airports, marine ports, and border crossings today, but a particularly impressive installation is the University of Michigan's 107,000+ seat football stadium.

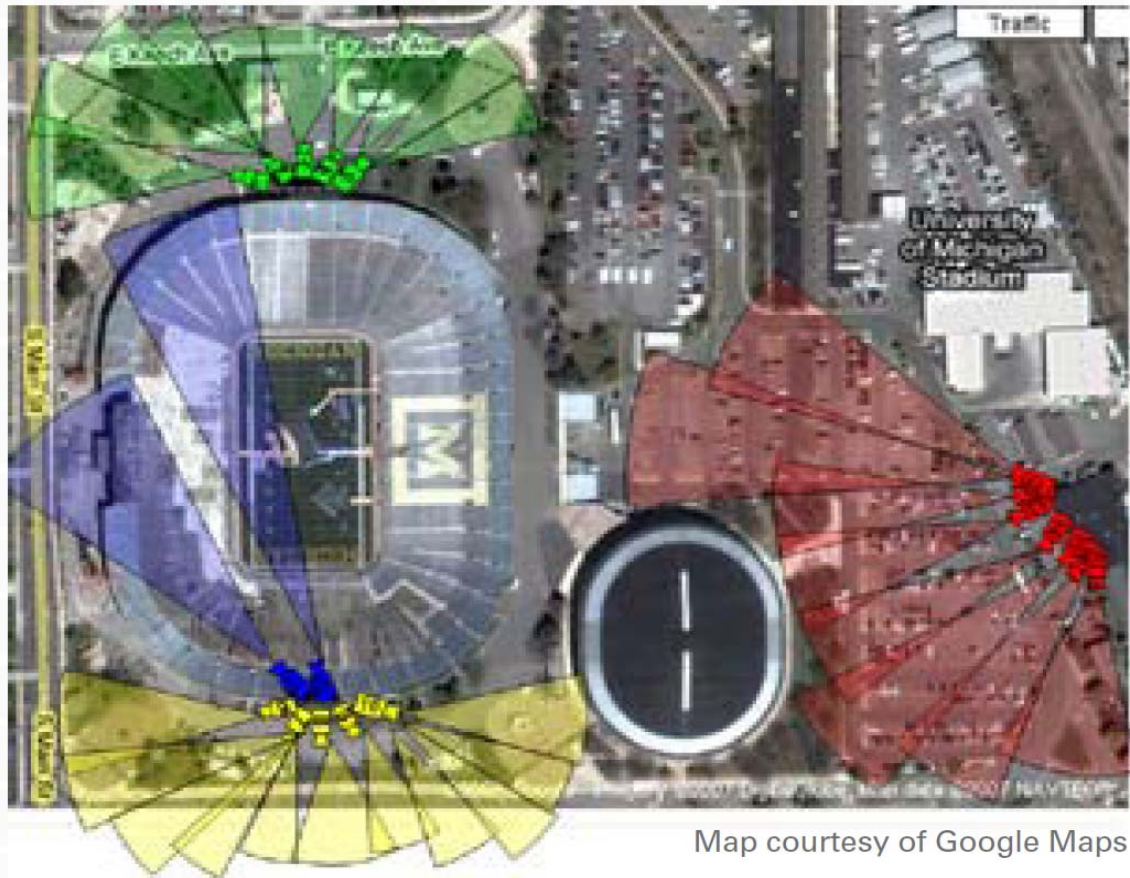


Figure 3 University of Michigan Football Stadium Camera Coverage

This system is utilized by 9 different agencies providing game day security. It connects to and utilizes the existing network used by stadium operations and the media. It was installed in stages, monitoring the parking lots, entrances & exits, and interior seating. It has face recognition resolution for all seats in the stadium and license plate resolution in the parking lots, all with 31 High Definition cameras. For similar coverage it would have required over 200 4CIF (704 x 576 pixel) cameras.



Single Pixel Camera Field-of-View

Figure 4 Pixel Velocity Camera Field of View Comparison

Selection of Firewire for the transport has enabled efficient, high performance, innovative imaging security systems to enter the market at competitive price points. But the market is just beginning, with new combinations of imaging with new sensors making future systems even more secure.

For more information on Firewire, products, and services: www.1394ta.org

For more information about Pixel Velocity www.pixel-velocity.com

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