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Spotlight: CCTV

Wired Eyes--NVRs--the future of surveillance

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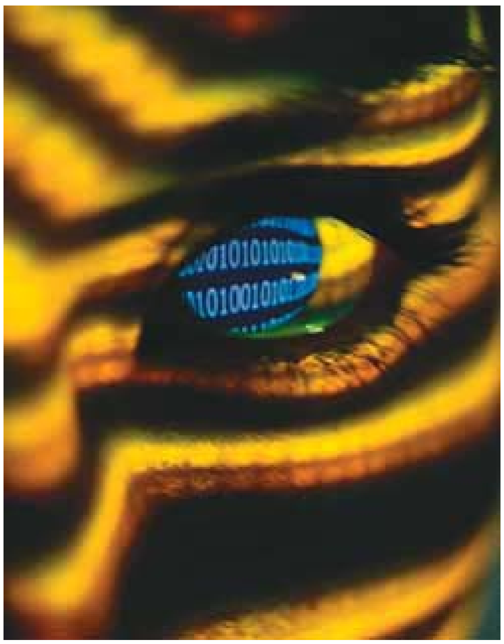

CCTV-based surveillance systems have been around for years and are the foundation of all surveillance systems. These systems can be found everywhere--in private and public business as well as public gathering sites. Systems monitoring traffic and pedestrians are fast becoming a large part of the installed base.

Surveillance Basics

The evolution of surveillance has been very slow. Many systems still in use today have changed little in the past 30 years. Whether the system consists of a single camera and monitor or a control room monitoring hundreds of video feeds, surveillance systems can be categorized into four basic groups.

Closed Circuit Television (CCTV). This is the grandfather of all surveillance systems. The video feeds can be very lengthy and sometimes require complex video amplifiers and transceivers to accommodate long cable runs, but it is the simplest of all systems and consists of the following components:

- Analog video camera (color or black and white)
- RG-6 coaxial (or similar) cable wiring, comparable to the wiring used in the average cable TV installation
- Color or black and white television or dedicated video monitor
- Off-the-shelf VCR to record video from a single camera (optional)
- Video amplifiers (optional--may be necessary on long camera distances)
- Video transceivers (optional--may be necessary on long camera distances)
- AC or DC power feed to cameras and other components

Multiplexed CCTV. This consists of the same CCTV components listed above but adds a multiplexer. In this system, the multiplexer (MUX) receives video from a group of cameras--typically up to 16. These feeds are transmitted individually via RG-6 video cables from each camera to the MUX. The feeds of video can be very lengthy and sometimes require complex video amplifiers and transceivers to accommodate the long cable runs.

The MUX cycles through each of the video feeds and outputs a single video feed to a video monitor or time-lapse VCR. This output is commonly referred to as the monitor loop out. Some of the common usage functions are:

- Cycle or touring--The first video feed is displayed for a predetermined number of seconds (or minutes), followed by a second video feed from another camera for the same length of time. This continues until all feeds are cycled and the process begins again. This can at times provide in-effective coverage due to the fact that only one camera feed is monitored at a time.
- Split, quad, hex--Video is displayed on one screen from two, four or 16 cameras simultaneously. This gives the operator a complete view of all system cameras. Other view configurations are possible and vary with manufacturer specifications. This system offers a lower resolution of each video feed when multiple cameras are displayed onscreen. The resolution is inversely proportional to the number of feeds shown on the monitor, i.e., two feeds cut video quality in half. A time-lapse VCR also records video with the same constraints. The performance of these systems is typically very low, with 1-2 fps per camera as the maximum capacity when fully implemented.

DVR system. A rack-mount box with a dedicated PC or similar computer-device receives video from attached single- or multi-port video capture cards. The cards have a video port or ports, and analog video cables plug into them from each camera in the system. The component lists are the same as the two systems above with the exception that a computer monitor or monitors display incoming video and hard disk drives record all video.

These systems require analog RG-6 cables and power to be provided to each camera--often an increased expense when long runs are necessary. Video quality also suffers over long distances. Some DVR systems allow Web access to the system, which allows remote viewing of real-time video and recorded archives.

Network video recorder (NVR) system. An NVR consists of a standard Windows®-based PC, one or more Web-based network cameras or video servers, and a standard Ethernet network. An NVR system is a model of the Internet itself. All network cameras used by an NVR are autonomous Web servers themselves. They convert video images to standard Ethernet data packets. If any portion of the interconnected network fails to a given NVR (or the NVR fails itself), access to the cameras can be achieved via alternate or parallel access points. Any PC that can run current Windows software can be an NVR.

Exploring NVRs

Network cameras can be mounted exactly as traditional systems above, but have four distinct advantages:

- Cable runs can be merged to existing TCP/IP trunk lines, keeping new cable runs very short and performance at 100 percent.
- Multiple cameras can be connected together, allowing for a single cable run back to the NVR. Image quality remains at 100 percent regardless of distance.
- Cameras can receive power directly from the Ethernet cable. This power-over-Ethernet is an emerging standard and is available as a complementary product to any off the shelf networking products.
- IP cabling companies are available everywhere, and numerous companies already have such expertise on staff, allowing for a cost savings by not needing to outsource installation of the entire system.

Camera count. The majority of CCTV systems have physical limitations as to how many cameras can be processed at one time. The majority of these systems can handle up to 16 cameras per multiplexer. NVR systems can stream camera counts of 50, 100 and even 1,000 cameras per PC. The performance capacity of an NVR system is strictly a function of the PC, the network and individual camera capabilities.

Designed for redundancy. A typical NVR is essentially an off-the-shelf PC. Duplicate systems can be made for emergency failure by installing additional copies of the NVR software onto secondary systems. In the event of a failure, the secondary system can be configured to take control of the system automatically, alert a user to system conditions or both. Any number of NVRs can be installed in multiple sites as production systems for monitoring and recording same or different image characteristics as the core systems implemented.

Value-added performance. Since the NVR is an ordinary PC, additional software can be utilized for value-added functions or advanced analysis of incoming video and data. An NVR can be used for running spreadsheets, word processing and other business software applications.

Windows-based. Windows is the majority standard for computing platforms worldwide and is an operating system already familiar to the most computer users. In terms of storage, Windows has the capability to store approximately 16 Exabytes of information. For reference:

- 1 Terabyte = 1,000 GBs
- 1 Petabyte = 1,000 Terabytes
- 1 Exabyte = 1,000 Petabytes

An NVR can be configured with multiple Terabyte or Petabyte levels of storage with simple hardware plug-ins. This can allow for multiple lifetimes of recorded video to be saved. Implementing 1 Terabyte of disk space can be performed in most any off-the-shelf PC for approximately $1,000, with the price point constantly dropping as storage capacities rise and prices fall. Storage systems can be internal, external or networked.

Image options and quality. NVR image type and resolution are effectively unlimited. NTSC and PAL video can be decoded simultaneously, and since an NVR is software-based, video can be streamed to an NVR at standard NTSC or PAL video resolutions, VGA, XGA and HDTV. Cameras are currently available with more than 16 megapixels of image data--approaching film quality.

Compatibility. NVRs are compatible with analog camera systems. Numerous manufacturers provide a video server that takes analog inputs from standard cameras and converts the video to digital format. These servers integrate directly into an NVR system. Efficiencies discussed above in wiring and power application also are capable with the video server design. Most any PTZ camera can be run from an NVR without additional keyboards or joysticks, with functions available using a mouse or other PC interface devices. PTZ signals are transmitted via the Ethernet to the video server and then converted to PTZ codes on a serial port on the video server. Many video servers support standard serial protocols such as RS-232, RS-485 and RS-422.

Frame rate. NVRs can stream video from cameras well beyond 30 fps. Manufacturers of IP cameras that process high-speed video can be utilized by NVR systems without modification. Frame rates can run from less than 1 fps to as many as 20,000 fps on common NVR hardware.

Data security. The nature of TCP/IP data traffic is far more secure than standard analog video cables. Most IP cameras utilize HTTP protocol (the same protocol used by Web pages) to communicate with the user or NVR. While TCP/IP packets can be collected from unauthorized sources, it is difficult to do so. Also, video data is much more difficult to decode. Encrypted transmissions can be utilized to effectively eliminate unauthorized receipt of video data.

Upgradeable cameras. Most network camera manufacturers publish open-programming APIs, allowing third-party vendors to create value-added functionality to network cameras. As better compression algorithms or new image formats are created, the end user can easily upgrade the camera.

Concerns and Limitations of Digital Video

Since NVR video is delivered by TCP/IP protocol, the packets of data are routed through networking hubs, routers and switches. Many networks in use today rely on sophisticated network switching hardware, which handles the day-to-day traffic of telecommunications and data processing. When video is delivered at very high frame rates, the frames of video are fragmented and delivered in chunks or packets. The timely delivery of these packets can be controlled and modified by the sophisticated switching gear mentioned above. These systems attempt to manage, load balance and schedule the raw data across the network as efficiently as possible.

What this means to the NVR user is that at very high frame rates, video frames may not be delivered at exact fixed intervals. Since the video frames are time-stamped to sub-millisecond accuracy on arrival to the NVR, computations can show slight variance in frame to frame delivery time. The value is insignificant when playing back the video and usually is below a few milliseconds of variance. For reference, a 30-fps feed delivers a frame of video at 33.3333 milliseconds each. Therefore, a 1- to 2-millisecond variance is not perceivable.

While variance is a mathematical possibility, it is benign. Careful design reduces its significance when running very large camera networks. Systems can be effectively configured with no perceivable variance.

Image quality is very important. Many DVR and NVR manufacturers have expended great efforts to increase the fps throughput. Typically, this is enhanced by reducing the image quality with image compression. By making the images smaller, the systems can process more data over the fixed available computing power of the typical DVR/NVR. This yields low quality images in most cases, which is fine when viewing at full frame view, but effectively useless when zooming in on a portion of the image, such as a subjects face.

Not all digital products are of superior quality. As in any market, successful products are eventually mimicked by competing manufacturers. While many similar products are as good or even better than the name brands, some products available today are designed to be very inexpensive and often compromise quality and performance for the sake of cost. When considering which digital cameras or DVR/NVR systems to purchase, give careful consideration to the importance of the coverage being sought. While budgets are usually the constraining factor on product selection, keep in mind that surveillance can be, in many cases, a matter of life and death. At this level, quality should always come before cost.

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