

# Networked Video Surveillance

by

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The video surveillance industry is experiencing a tremendous growth in demand worldwide, not only due to increased security demands, but also due to globalization. As businesses have their operations dispersed in multiple locations, it has become critical that the video surveillance systems **go beyond security** and help improve the real time remote supervision. Internet is ubiquitous and broadband is becoming available and affordable everywhere. It is required that the video and audio from any location such as a factory floor or hotel lobby be accessible by appropriate and authorized management from **anywhere** regardless of location, **anytime** and by using **any means**, such as a laptop, mobile phone or a PDA, in a very secure way. Whenever there is a situation that warrants immediate attention, an alert with relevant information needs to be sent to appropriate personnel, in real time. These requirements are being driven as much by the medium size commercial customers as by the enterprise and infrastructure projects.

Most of the solutions available currently categorized as CCTV, DVRs and NVRs often do not take adequate advantage of the Internet and do not address the critical needs of the customers. These needs include accessing their video surveillance network in a manner analogous to their IT network while constantly on the go. As a result of these compelling requirements a new category of products called Networked Video Surveillance Systems has emerged on the scene. Cradle Technologies recently introduced NVSS line of products is engineered from the ground up for the Internet, and is a leader this category.

As the industry embarks on this next generation of video surveillance solutions, it is also important to consider the rapidly growing need for Video Content Analysis (VCA). The need for automatic analysis of the video streams, live or forensically, is motivated by the reality of the explosive growth in video surveillance as well as the cost and ineffectiveness of humans watching video screens. A key market requirement is that interesting events are detected in real time and appropriate actions are enabled. Examples of interesting events include someone crossing a fence, someone walking or driving the wrong way, or unattended baggage at the airport. Although, VCA solutions are far too expensive, and undependable to be ubiquitous, technology advances continue to improve the cost and performance of these solutions. The Networked Video Surveillance Systems must also fully enable a ubiquitous deployment of relevant event detection and response management. In other words video intelligence must be **actionable**. One of the most significant factors in improving the accuracy and responsiveness is that the analysis be performed right at the camera where video is captured. This approach is often termed **“intelligence-at-the-edge”**.

In the rest of this paper we will discuss some of the technical and functional implications of this new category of video surveillance solutions we call NVSS. We will also discuss the

role of IP cameras and their limitations in networked environment, and a vision of video content analysis as a tool to implement video event based data base management systems.

## **Networked Video Surveillance Defining Capabilities**

A Networked Video surveillance system must provide the following capabilities:

1. Secure Access
2. Satisfactory remote viewing experience of live audio video streams in spite of Internet bandwidth variations
3. Location independent access to all features and functions remotely or locally
4. Support for mobile devices
5. Local storage and Network Attached Storage (NAS)
6. Local and remote archiving
7. Dynamic DNS to allow use of dynamic IP addresses
8. Variety of user classes to allow management of access authority
9. Real time alerts
10. Integration with other IT and Security applications
11. 24x7 availability as surveillance moves into a mission critical role

### Secure Access:

Surveillance audio and video from business locations such as factories, franchises or warehouses need to be transported over a network for remote supervision. These video streams should not be viewable by any one not authorized to do so. The streams must be encrypted and utilize virtual private networks to ensure completely secure access.

### Remote Viewing:

For the purposes of remote supervision, authorized individuals need to view the video over the Internet from any location worldwide. At any given moment the actual available bandwidth is unpredictable and can change at any moment. NVSS estimates the available bandwidth and adapts the compression parameters to facilitate a smooth motion video viewing experience. In addition to adjusting compression rates to the instantaneous bandwidth of the Internet, audio and video needs be in synch for a richer viewing experience.

### Location Independence:

Authorized personnel need to be able configure, change settings, view live video, and analyze stored video from anywhere on the Internet. This requires that a fully functional portable Client software be supported locally, on a LAN or on the Internet.

### Mobile Device Support:

Mobile phones and PDAs are ubiquitous and are more easily accessible than computers. NVSS must send alerts as emails or SMS text messages to portable devices as to enable prompt action if it is required.

### Network attached storage (NAS):

Most current solutions require that video be stored locally to the DVR or NVR. There have been many cases where the system has been stolen along with the local storage. As a result, the need has developed to add storage beyond the local capacity. Network attached storage enables the NVSS to extend storage capabilities of the system allows it be located away from the system and provide RAID capabilities for added availability.

#### Archiving:

Mission Critical Video data needs to be archived on demand for later use or for audit purposes. It can be archived automatically, locally or away from the surveillance system. NVSS must enable users to archive either manually automatically, or continuously .

#### Dynamic DNS:

Most current systems require that the IP address of the DVR or the NVR be fixed. This adds additional costs and may make the cost prohibitive when the video surveillance network is made of many nodes. NVSS must support dynamic DNS capabilities so dynamic IP address can be used for each NVSS node.

#### User Classes:

Businesses require that the control and management of the surveillance systems be performed only by authorized individuals. Certain cameras should be restricted to specific personnel. NVSS must implement comprehensive user classes and authorization mechanisms to facilitate such control.

#### Alerts:

NVSS are required to generate timely alerts based on detected video events or a combination of related events from related applications from one or more locations. These alerts are to be transmitted as e-mail or SMS text messages to the appropriate personnel or invoke other actions as desired, such as the sounding of an alarm or closing of a gate.

#### Integration:

Often there are other solutions such as fire safety, or access control systems deployed in the same facility as NVSS. All these systems need to operate in harmony over multiple locations. Appropriate open programming interfaces must be made available by the NVSS to facilitate this integration to suit each situation.

#### Availability:

Since video surveillance is moving into a mission critical role and access may be required from locations spread out all over the world, it is necessary that the NVSS be available 24x7. Redundant systems can be deployed at the same location. In addition, NVSS must support intelligent UPS which communicates with the NVSS and can facilitate appropriate action, such as a graceful shutdown or sending necessary alerts, in case of unexpected power outages.

## Video Surveillance Networks

Video surveillance networks can be classified as either loosely integrated or tightly integrated networks.



Networked Video Surveillance System

### Loosely Integrated Video Surveillance Networks

Certain businesses are organized as collection of one or more physically separated locations. For example, a bank may have branches spread all over a city and also have zonal offices or headquarters. Video data from one branch has a rather weak relationship to the video data from another branch. For example, an event such as a customer-teller disagreement on a transaction, occurring in one branch is typically attended by the local management or zonal management and there is little to no involvement from another branch in real-time. In such situations video surveillance systems from each branch may be viewed and controlled by the zonal office or headquarters but there is very little need to have a simultaneous integrated view of cameras from multiple locations in real-time from one terminal.

There are many such situations in businesses that have multiple franchises, or owners that have a multiple location such as administrative offices and factories. Each location may need a modest number of cameras typically less than 100. The operations team or security management typically handles one location at a time. At each location one or more local networked video surveillance system is installed with the local video data stored locally or if needed archived remotely. Each location can be viewed by the appropriate personnel locally or remotely according. For forensic analysis purposes, data from all locations is available to the central management authorities. Events that require viewing and correlating video from multiple locations can then be analyzed by at a central facility. These networks are appropriately called “Loosely integrated video surveillance networks.” Cradle’s NVSS product line enVigil, along with its CradleWatch video management software is ideally designed for these kinds of networks. In addition to addressing all the requirements mentioned earlier, authorization together with controlled local and remote access at individual camera level provides comprehensive ability to manage this class of networks.

### Tightly Integrated Video Surveillance Network

In large airports, college campuses or city/state emergency situations, where there are a large number of cameras that need to be analyzed, there is a need for video and audio

information to be accessed simultaneously and managed from an integrated command center.

These are typically large public or private infrastructure projects. In such cases it is necessary that a closely integrated view in a command and control center is presented in real-time. It is also necessary that the video surveillance is coordinated with other systems such as dispatching of fire security and law enforcement personnel. A developing crisis needs to be tracked and resolved in real time. These projects call for a very tightly integrated view of the entire video surveillance system. TruSentry offers systems with comprehensive command, control and situation management capabilities which along with Cradle's NVSS and IP-based cameras, complete a comprehensive "tightly coupled video surveillance network."

Loosely coupled networks and tightly coupled networks are primarily introduced here for the purposes of conceptualizing solutions needed in a particular situation. Typically, one would see elements of both in a complex infrastructure project.

## **From DVRs and NVRs to NVSS**

At the heart of most video surveillance systems is an audio/video recording device called a Digital Video Recorder (DVR) or a Networked Video Recorder (NVR) and sometimes what is called a Hybrid Digital Video Recorder.

Analog cameras are connected directly to a DVR. A video capture digitizer and compression subsystem is co-located with the recording system and audio and video is recorded on hard disk drives. Videos can be either viewed live or from the recorded content. Live viewing of video and audio is enabled by compressing and streaming analog content available at the input of the DVR. This makes for simultaneous viewing of multiple cameras on a single screen easy and inexpensive.

NVRs connect to IP cameras over a LAN or a WAN and record a data stream which has been digitized and compressed either inside a particular camera called an IP camera, or in a streamer which takes in multiple analog cameras and streams video as an IP stream to the NVR. For the purposes of live viewing, the compressed streams received at the NVR need to be uncompressed and re-assembled as per viewer request. NVRs are primarily servers that run on standard x86 compatible servers. Milestone, OnSSI, Genetec are some of the key suppliers of NVR software.

Hybrid DVRs try to take the best of both worlds and support DVR functions as well as IP cameras and streamers to provide a complete video surveillance solution. Some of the leading products in the Hybrid category include Verint, TruSentry and Pilot.

DVRs, NVRs and Hybrid DVRs, all have their roots in the traditional video surveillance perspective, and are primarily focused on security. IP cameras and NVRs have taken advantage of the more modern connectivity and wiring techniques developed for LANs and WANs using the Ethernet protocol, wiring, switches and IP protocol for data transport. By

and large, networking has been an afterthought in these solutions. All these solutions fail to deliver the requirements listed above.

NVSS is the natural next step for video surveillance. However, at the heart of an NVSS is the Internet. The Internet is far more than wiring and IP protocol. The systems need to be engineered from the ground up considering the strengths and challenges of the Internet. TCP/IP protocol has certain limitations in streaming. Several techniques are available to facilitate secure audio and video streaming over the Internet.

Internet bandwidth available for a session can vary from moment to moment. Adaptive compression schemes need to be implemented which can estimate instantaneous available bandwidth and modify compression parameters in real time to facilitate a decent viewing experience. Security is a well known issue on the Internet, video and audio needs to be encrypted. Virtual private network sessions need to be used to ensure adequate security. Unauthorized access is a more serious concern if the access is to be made available from any browser anywhere. Proper authorization controls must be implemented. Video data needs to be stored away from the location of capture for archiving and protection from unintended loss by events such as: theft or fire.

NVSS represents a new category of Video Surveillance solutions. Along with the challenges, the Internet offers opportunities for broadening the application of surveillance to include management of business operations. It is also the next step towards the convergence of video surveillance data and infrastructure with the IT information and infrastructure. We can also expect that with relevant event detection, video data can be managed as a database similar to the current information databases. NVSS is now moving video surveillance from the role of security to a mission critical business operations role. Cradle Technologies leads the way in the NVSS category with its enVigil product line. This is the first product line to be engineered from the ground up specifically for the Internet and it is poised to take full advantage of the opportunities offered by the Internet for better management of customer business operations.

## **Analog and IP Cameras**

Analog cameras take advantage of TV broadcast standards and its connectivity infrastructure. They provide analog output that is connected to video surveillance equipment via coaxial cable. As a result, analog cameras remain very inexpensive and a very large variety of cameras are available in the consumer industry that can be used by the surveillance industry. There is also a very large installed base of analog cameras which are of good quality and the customers would prefer to continue to use them as they move towards the latest generation of surveillance solutions. For analog cameras, digitization and compression are handled by the surveillance equipment.

Analog cameras have a weakness which may turn out to be fatal for their future. This is the limitation of the current TV standard in terms of pixel resolution. Analog cameras are limited to standard TV resolution. In consumer electronics, high resolution mega-pixel cameras are already inexpensive and ubiquitous. HDTV is rapidly growing. For video

content analysis, higher resolution is required to increase accuracies. As the cost of storage continues to decrease it is inevitable that the surveillance industry will demand higher resolution cameras. Analog cameras have no way to keep up with this trend. There currently is no standard for high resolution cameras. High resolution cameras would most likely use the IP protocol in a very limited way to transport raw pixel data to other equipment attached in point-to-point configuration. We should call them **Digital Cameras** to differentiate them from today's IP cameras.

Recently, as the cost of digitization and compression technologies have reduced, a category of cameras called IP cameras have come on the scene and are rapidly gaining acceptance. The IP cameras of today digitize and compress video within the camera and stream the compressed video streams over the LAN wiring or the Internet using IP protocol. Some of these cameras also include wireless capabilities and use the WiFi network to connect to the video server. IP cameras can also be viewed directly from anywhere over the Internet. Clearly, some of the features that simplify connectivity where LAN wiring already exists and wireless access where it is needed make IP cameras a great choice. They are part of an unstoppable trend. However, in order to take full advantage of the Internet as mentioned earlier, IP cameras will need to co-exist with intelligent and powerful streamers which accept a small number of analog or IP cameras as input and connect to a network of video surveillance system. This will take full advantage of the network features and deliver video content analysis capabilities, or "intelligence-at-the-edge" of the network.

From a perspective of the Video Surveillance network, today's IP camera's have following limitations:

1. Lack of encryption
2. Lack of VPN capabilities
3. Lack of direct authorization control
4. Lack of bandwidth adaptation capabilities

In addition, from the point of view of delivering video content analysis, there is a need to analyze raw uncompressed pictures and detect events. This is necessary to improve accuracy and responsiveness. Some IP cameras companies are beginning to offer VCA integrated within the camera. However, since VCA is in its early stages, there is rapid innovation and no standardization. It is most likely that an extensible open platform is needed close to the camera for most effective deployment of real time relevant event detection using the latest and rapidly evolving video content analysis techniques. Axis Communications is one of leaders in the IP camera segment, although almost all surveillance camera providers are offering IP camera. Some of them are also providing VCA close to or integrated with the camera. I/O image is a company which perhaps has the leading product line in this segment.

When the limitations mentioned earlier are not an issue, IP cameras as we know them will probably thrive. However, in order to take full advantage of the opportunities offered by the Internet, IP cameras will most likely co-exist with what could be termed a "Two piece IP camera" solution. The two-piece IP camera solution is made up of one to four analog or digital cameras, attached to an NVSS-streamer. This streamer is fully functional NVSS

edge device and is capable of delivering all the necessary features listed above. In addition, this streamer is capable of Video Content Analysis that can be added on demand. The combination of a VCA capable NVSS with a digital or analog camera will overcome the limitations faced by traditional IP cameras.

## **Video Content Analysis and Event Driven Surveillance**

It is not very hard to see that the explosive demand for video surveillance is creating a deluge of video to be viewed live and stored for later forensic analysis. It is becoming unaffordable to employ enough people to watch out for interesting events. Furthermore, most people watching video are not able to focus with sufficient attention and miss many critical events. The challenge is undiminished, when forensic analysis is needed on stored video. It is very time consuming to view the video to tease out the relevant events for timely action. This was quite apparent in the July 5, 2005 explosions in the London Subways. Fortunately, London is a city equipped with one of the most comprehensive video surveillance networks in the world. Investigation professionals managed to extract the connected events, although it took several weeks of rather tedious effort. What is needed is an efficient event driven architecture for managing real time and stored video. Enter Video Content Analysis (VCA) to the rescue.

### **Video Content Analysis**

VCA as a technology has been around for over 10 years and is being deployed in many situations. For example, one can monitor a border fence with video surveillance cameras and automatically detect the situation where someone tries to cross the fence within the view of the camera. This can be done in real time and appropriate alerts can be sent for immediate action. There are other events including: someone walking the wrong way or entering an exit door, or an object left unattended that needs to be detected. Solutions for these situations based on the current VCA technology tend to be expensive, tedious to deploy and leave much to be desired in terms of accuracy. However, these solutions are improving, and are continuing to gain acceptance in high value situations. ObjectVideo and ActivEye are two of the leading OEM technology providers in this segment.

The market requires that detection of relevant events be available for a broad set of video surveillance solutions. Businesses need the surveillance process to be driven by interesting events. VCA needs to be deployable ubiquitously and scheduled on demand. For NVSS, it means that any of the cameras could be directed to “look” for a particular event and send a real time alert if so desired or tag the video in way that it can be retrieved efficiently. Potentially interesting events in surveillance video can be classified in 3 categories: People Video Analytics, Vehicle Video Analytics, and Object Video analytics. Some examples of these are:

#### People Video Analytics

- Counting people

- Intrusion

- Cashier absent from station

- Wrong way movement
- Face capture when in view
- Falling
- Running

#### Vehicle Video Analytics

- License plate reading
- Stopped car
- Wrong way
- Speeding
- Model and make

#### Object Video Analytics

- Unattended object
- Removed object
- Object moved

Many of these kinds of events are of interest beyond security. It is required that these relevant events be detected and the video be appropriately tagged with to facilitate efficient forensic analysis.

### **Integration of a Networked Video Surveillance System with other security and operational applications**

One of the critical requirements of NVSS is to work well with other related solutions as seamlessly as possible. Most businesses have access control solutions that track entry and exits to secured areas. It is a natural requirement that the surveillance audio and video be effectively accessible and synchronized with the events associated with these systems. There are systems for building management that include fire and hazardous material safety. These systems need to be appropriately integrated with the NVSS. In addition, many establishments have point of sale transaction systems. It is required that the audio and video of a transaction be available when needed. This video would enable verification of a disputed transaction or coaching opportunity for improving customer service. Such integration with a large variety of applications is best performed by professionals with domain expertise in each vertical. It is required that an open Application Programming Interface (API) be made accessible for domain experts to effect such integration to address the needs of corresponding vertical markets. Cradle's products, enVigil, offer such an API with necessary support for such integration.

### **Intelligence-at-the-edge**

Most video surveillance solutions today store all the video captured for later forensic review. Introduction of NVSS would require all of this video to be transported over the Internet for storage or archiving especially if it is to be used for mission critical operations. What is needed is the detection of relevant events right at the camera location and transport only of the video associated with the relevant events. This could decrease the quantity of

video to be transported by a factor 10. This would lead to much more manageable demands on the required Internet bandwidth and storage. A natural consequence of this need is to place the VCA near the camera, or “intelligence-at-the-edge”. This trend of moving the intelligence to the edge of the network is inevitable. It enables the opportunity to perform the VCA at the highest quality and resolution of the picture possible and also improve the response time detected by alerts to be generated directly from the camera location instead of from some central server.

Looking forward a bit, one can easily visualize the video to be organized as Video Database with a comprehensive **Video Database Management System** to support its effective use in business.

## **Markets**

The video surveillance market is segmented into three segments. Networked Video Surveillance Systems are the next generation of solutions that would dominate all three segments.

The consumer segment has been served by webcams up until now. They are rapidly moving on to IP cameras as they are becoming more affordable. IP cameras for consumer applications use the Internet in rather simple manner. Going forward, two-piece IP cameras solutions which address the issues of encryption, VPN, authorization and bandwidth adaptation as well as relevant detection near the camera (VCA) are likely to become affordable enough to penetrate this market.

The mid-size and commercial segment is the most rapidly growing segment, as it quickly realizes the value of remote supervision. These businesses often have multiple locations and owners or senior management are often on the move. NVSS enable them to view and direct operations from anywhere, at anytime. This segment leads the way in deploying networked video surveillance to go beyond security and improve the management of business operations.

The public and private infrastructure segment is driven to use fully networked solutions by their requirement of managing complex situations. For example, a potential terrorist incident would require the video scene to be accessible by the various law enforcement agencies concurrently and coordination to be performed from a command and control center. There are solutions already being offered in this segment. The NVSS solutions will begin addressing the requirements mentioned earlier.

## **Conclusion**

All the technical pieces are in place and market demand is there for comprehensive NVSS based solutions to be made available at affordable prices to the market place. Cradle intends to take advantage of these developments with introduction of its enVigil product line and views these developments as key to enable video surveillance to take its rightful place in the operational management fully integrated with the IT systems.